EMISSIONS SUMMARY
Total Emissions from: normal operations, starts/shutdowns, and dual fuel, all maximized by pollutant.

EMISSIONS INCREASES DUE TO MODIFICATION

TURBINE EMISSIONS

		Turbine Option			
		GE 7FA.05	GE 7FA.04	Siemens SGT6	GE LMS100
# of Units		1	1	1	2
Operating time (excl. SU/SD	hrs/yr/unit	2280	2280	2280	2880
Operating time (total)	hrs/yr/unit	2409	2397	2418	3202
NOX	ppmvd	2.5	2.5	2.5	2.5
CO	ppmvd	4.0	3.8	1.6	3.1
NOX	tpy	31.26	29.79	37.21	36.30
CO	tpy	57.58	38.91	159.88	30.63
VOC	tpy	6.00	4.99	20.09	8.36
PM (Front & Back Half)	tpy	42.73	43.14	32.38	44.87
CO2	tpy	309,364	272,733	299,766	325,312
CO2e	tpy	311,382	274,503	301,775	327,577
SO2	tpy	6.78	6.02	6.29	7.80
H2SO4	tpy	15.82	14.11	16.66	17.25
Pb	tpy	0.0054	0.0048	0.0046	0.0042
Maximum Fuel Use	MMBtu/yr	5,023,664	4,424,358	4,959,209	5,389,979

Notes:
Control ppmvd is shown for natural gas, full load (100%) operation. Assumed no control during startup/shutdown.
All emissions based on data from Black & Veatch, except as noted. See specific turbine data for details.
CO2e emissions include CH4 and N2O emissions, which are based on emission factors used for PSE's WAC 173-407 compliance at other facilities.
Lead (Pb) emissions estimated using heat rate and AP-42 emission factor (Table 3.1-2a)

EMISSIONS INCREASES DUE TO MODIFICATION

TOTAL EMISSIONS (including turbine option, emergency engine, and circuit breakers)

		Turbine Option				
		GE 7FA.05	GE 7FA.04	Siemens SGT6	GE LMS100	SER
NOX	tpy	32	31	38	37	40
CO	tpy	58	39	**160**	31	100
VOC	tpy	6	5	20	8	40
PM (TSP, PM10, PM2.5)	tpy	**43**	**43**	**32**	**45**	25, 15, 10
CO2	tpy	309,493	272,861	299,895	325,440	-
CO2e	tpy	311,631	274,752	302,023	327,826	-
SO2	tpy	7	6	6	8	40
H2SO4	tpy	**16**	**14**	**17**	**17**	7
Pb	tpy	0.0200	0.0194	0.0194	0.0193	0.6
HAPs	tpy	4.49	3.89	4.39	4.25	-

Notes:
Emissions from emergency generator operating for 52 hrs/yr for testing/maintenance plus emergency use, up to a total of 275 hrs/yr.
Values shown in bold indicate exceedance of Significant Emission Rate (SER).
H2SO4 for emergency generator assumed equal to SO2 emissions.
CO2e emissions include CH4 and N2O emissions from turbine option only; emergency engine emissions of these pollutants are expected to be negligible due to both the limited use of this unit, and the use of distillate fuel. Per EPA's AP-42 emission factors for turbines, both of these pollutants show non-detect (ND) for distillate use.
CO2e emissions also include SF6 emissions from the estimated 10 breakers that will be included in the expansion project (8 for new units, and 2 to replace old circuit breakers).
Pb for emergency generator assumed equal to PM emissions (conservative; for demonstration purposes only).

GREENHOUSE GAS INFO

	Turbine Option			
	GE 7FA.05	GE 7FA.04	Siemens SGT6	GE LMS100
lb CO2/MW-hr	1,290	1,302	1,270	1,130
lb CO2e/MW-hr	1,299	1,310	1,278	1,138

OPERATION PROFILES FOR EMISSIONS ANALYSIS
Worst Case Scenario

Average Monthly Worst-Case Profiles

Operation Characteristic	Units	GE 7FA.05		GE 7FA.04		Siemens SGT6		GE LMS100	
Full Load (and/or total)	hrs/mo	190	26%	190	26%	190	26%	240	33%
Medium Load (75%)	hrs/mo	75	10%	75	10%	75	10%	75	10%
Low Load (50%)	hrs/mo	50	7%	50	7%	50	7%	50	7%
Min Load (30%)	hrs/mo	-	0%	-	0%	-	0%	30	4%
Starts	starts/mo	12		12		12		20	
Total Operating Hours (excluding star	hrs/mo	190	26%	190	26%	190	26%	240	33%
Total Idle Hours	hrs/mo	540	74%	540	74%	540	74%	490	67%

Other Assumptions

Average Hours/Month	730

ULSD Operation

Assume up to 336 hrs/year (equivalent of 14 days) of baseload operation on ULSD. Startup/shutdown on ULSD is limited to 1/day (although additional startup/shutdowns can be made on NG during that period).

Short-Term Worst-Case Profiles (used in modeling)

1-Hour	Units	Starts/Unit	Total Starts
7FA.05	1	1	1
7FA.04	1	1	1
SGT6-5000F4	1	1	1
LMS-100	2	1	2

3-Hour	Units / Plant	Starts / Unit	Total Unit Starts
7FA.05	1	2	2
7FA.04	1	2	2
SGT6-5000F4	1	2	2
LMS-100	2	2	4

8-Hour	Units / Plant	Starts / Unit	Total Unit Starts
7FA.05	1	5	5
7FA.04	1	5	5
SGT6-5000F4	1	5	5
LMS-100	2	5	10

24-Hour	Units / Plant	Starts / Unit	Total Unit Starts
7FA.05	1	5	5
7FA.04	1	5	5
SGT6-5000F4	1	5	5
LMS-100	2	5	10

OTHER PROPOSED OPERATIONAL LIMITATIONS:

7FA.05	None
7FA.04	None
SGT6-5000F4	None
LMS100's	Distillate use limited to: 80% use factor over a 24-hour period for both units (total 38 hours), and up to 10% of total time (3.4 hrs) at loads below 100%. No distillate use at loads below 75%.

NOTE:
The operation profile is based on hours for the purposes of analysis only. This does not imply that permit conditions should be based on time limits (i.e. equivalent fuel usage parameters may be used).

TURBINE EMISSION DATA FOR ALL OPERATING FUELS, TEMPERATURES, AND LOADS

Equipment GE 7FA.05

Op Conditions		Natural Gas, content @ 2.25 gr/100scf (annual average)									Natural Gas, content @ 3.48 gr/100scf (short-term maximum)									ULSD								
NG Sulfur Content		2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	-	-	-	-	-	-	-	-	-
Ambient Temperature (°F)		7	7	7	51	51	51	88	88	88	7	7	7	51	51	51	88	88	88	7	7	7	51	51	51	88	88	88
Relative Humidity		40	40	40	75	75	75	30	30	30	40	40	40	75	75	75	30	30	30	40	40	40	75	75	75	30	30	30
Unit Load (%)		100	75	50	100	75	50	100	75	50	100	75	50	100	75	50	100	75	50	100	75	50	100	75	50	100	75	50
Fuel		NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.
Units		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Operation per unit:																												
hrs/mo (max by load/fuel)		190	75	50	190	75	50	190	75	50	190	75	50	190	75	50	190	75	50									
hrs/yr (max by load/fuel)		2280	900	600	2280	900	600	2280	900	600	2280	900	600	2280	900	600	2280	900	600	336	336	336	336	336	336	336	336	336
Starts (and assume shutdowns) per unit:																												
per hour		1			1			1			1			1			1			1			1			1		
per month		12			12			12			12			12			12											
per year		144			144			144			144			144			144			14			14			14		
Op Emissions - Control (SCR/CO Cat; no SO2 scrub)																												
NOX	ppmvd @ 15% O2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	5	5	5	5	5	5	5	5	5
NOX as NO2	lb/h per stack	20.70	16.30	12.70	19.40	15.50	12.30	17.90	14.60	11.90	20.70	16.30	12.70	19.40	15.50	12.30	17.90	14.60	11.90	44.10	35.20	26.70	44.10	35.00	26.90	42.40	33.90	26.00
CO	ppmvd @ 15% O2	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
CO	lb/h per stack	19.8	15.8	12.4	18.6	15.0	12.0	17.2	14.2	11.6	19.8	15.8	12.4	18.6	15.0	12.0	17.2	14.2	11.6	42.3	34.2	27.2	42.3	34.0	26.3	40.7	32.9	25.5
VOC	ppmvd @ 15% O2	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
VOC as CH4	lb/h per stack	4.00	3.20	2.50	3.70	3.00	2.40	3.50	2.80	2.30	4.00	3.20	2.50	3.70	3.00	2.40	3.50	2.80	2.30	9.30	7.50	5.90	9.30	7.50	5.80	9.00	7.20	5.60
PM10 (Front & Back Half)	lb/h per stack	37.20	33.30	30.00	36.00	32.50	29.60	34.70	31.70	29.20	47.70	41.60	36.50	45.80	40.50	35.90	43.80	39.20	35.40	38.50	37.70	36.80	38.50	37.70	36.80	38.40	37.50	36.70
CO2	lb/h per stack	262,567	209,069	163,894	246,140	199,087	158,372	228,243	187,610	153,694	262,555	209,060	163,914	246,156	199,079	158,365	228,233	187,602	153,688	367,828	296,920	227,193	367,860	295,067	228,535	353,423	285,453	221,348
SOx as SO2	lb/h per stack	5.32	4.24	3.32	4.99	4.04	3.21	4.62	3.80	3.11	8.22	6.55	5.13	7.72	6.24	4.97	7.14	5.88	4.81	1.26	1.00	0.79	1.26	0.99	0.79	1.21	0.96	0.77
NH3 slip	ppmvd @ 15% O2	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
NH3 slip	lb/h per stack	30.1	24	18.8	28.3	22.9	18.2	26.2	21.5	17.6	30.1	24	18.8	28.3	22.9	18.2	26.2	21.5	17.6	32.0	25.8	19.8	32.0	25.7	19.9	30.7	24.8	19.2
H2SO4	lb/h per stack	14.24	11.34	8.89	13.34	10.79	8.58	12.38	10.17	8.33	22.01	17.52	13.74	20.62	16.68	13.26	19.14	15.72	12.88	3.36	2.73	2.06	3.36	2.72	2.07	3.23	2.63	2.01
Pb	lb/h per stack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0315	0.0254	0.0195	0.0315	0.0253	0.0196	0.0303	0.0245	0.0190
Fuel Use	lb/hr	96,540	76,870	60,260	90,500	73,200	58,230	83,920	68,980	56,510	96,540	76,870	60,270	90,510	73,200	58,230	83,920	68,980	56,510	115,160	92,960	71,130	115,170	92,380	71,550	110,650	89,370	69,300
	MMBtu/hr	2266	1804	1414	2124	1718	1367	1970	1619	1326	2266	1804	1415	2124	1718	1367	1970	1619	1326	2251	1817	1391	2252	1806	1399	2163	1747	1355
Total Op Emissions (all units)																												
NOX	lb/yr				44,232	13,950	7,380																14,818	0	0			
CO	lb/yr				42,408	13,500	7,200																14,213	0	0			
VOC	lb/yr				8,436	2,700	1,440																3,125	0	0			
PM10 (Front & Back Half)	lb/yr				82,080	29,250	17,760																12,936	0	0			
CO2	lb/yr				561,198,180	179,178,715	95,023,466																123,600,909	0	0			
SO2	lb/yr				11,377	3,636	1,926																423	0	0			
H2SO4	lb/yr				30,415	9,711	5,148																1,129	0	0			
Pb	lb/yr				0	0	0																11	0	0			
Fuel Use	lb/yr				206,340,000	65,880,000	34,938,000																38,697,120	0	0			
	MMBtu/yr				4,843,419	1,546,401	820,100																756,529	0	0			
Start Emissions			FOR MODELING INFO lb/hr equiv.		Max w/ S/S	Max w/o		Key:													lb/hr equiv.		Max w/ S/S	Max w/o		Key:		
NOX	lb	31.5	63.00		53.55	44.10		SU/SD value is greater than normal operation (short-term).												145.7	291.40		167.75	44.10		Shutdown value is greater than normal operation (short-term).		
CO	lb	209.6	419.20		230.75	42.30														332.1	664.20		353.25	42.30				
VOC	lb	5.9																		8.6								
PM10 (Front & Back Half)	lb	9.2	18.40		33.05	47.70		SU/SD greater than normal ops, and max of fuel options.												17.00	34.00		40.85	47.70		Greater than normal operation, and max of fuel options.		
CO2	lb	69717																		109,132								
SO2	lb	10.40	20.80		14.51	8.22														1.10	2.20		5.21	8.22				
H2SO4	lb	5.82	11.64		16.83	22.01		Maximum on full hour basis by fuel type.												1.00	1.99		12.00	22.01		Maximum on full hour basis by fuel type.		
Pb	lb	0.00			0.02															0.01			0.03					
Fuel Consumption	lb	25531	51,062		83,116	115,170														34168	68,336		91,753	115,170				
	MMBtu	599	1199		1732	2266		Maximum on full hour basis; value used in short-term model.												668	1336		1,801	2266		Maximum on full hour basis; value used in short-term model.		
Time per start	hrs	0.500																		0.500								
Shutdown Emissions																												
NOX	lb	16	50.53		46.14	44.10														79	278.82		110.61	44.10				
CO	lb	189	596.84		217.91	42.30														196	691.76		226.32	42.30				
VOC	lb	4.3																		6								
PM10 (Front & Back Half)	lb	5.8	18.32		38.40	47.70														9.60	33.88		43.79	47.70				
CO2	lb	30885																		44,157								
SO2	lb	4.60	14.53		10.22	8.22														0.40	1.41		6.29	8.22				
H2SO4	lb	2.57	8.10		17.61	22.01														0.40	1.42		16.18	22.01				
Pb	lb	0.00			0.02															0.00			0.03					
Fuel Consumption	lb	11257	22,514		89,957	115,170														13825	48,794		96,364	115,170				
	MMBtu	264	528		1813	2266														270	954		1,894	2266				
Time per shutdown	hrs	0.317																		0.283								
Annual Total Start/Shutdown Emissions (all units)						Equiv. ops.																		Equiv. ops.				
NOX	lb/yr				6,840	2281		Normal operations greater w/o including SU/SD.															3,146	484		Normal operations greater w/o including SU/SD.		
CO	lb/yr				57,398	2187																	7,393	464				
VOC	lb/yr				1,469	435																	204	102				
PM10 (Front & Back Half)	lb/yr				2,160	4234																	372	422				
CO2	lb/yr				14,486,688	28,946,011																	2,146,046	4,034,196				
SO2	lb/yr				2,160	587																	21	14				
H2SO4	lb/yr				1,208	1569																	19.60	36.85				
Pb	lb/yr				0.00	0.00																	0.18	0.35				
Fuel Consumption	lb/yr				5,297,472	10,642,800																	671,902	1,263,031				
	MMBtu/yr				124,348	249,818																	13,136	24,692				
Total	hrs/yr				118																		11					
ANNUAL TOTAL EMISSIONS (Op+Start/Shut - All units)					NG Only (Max)	Op. max lb/hr basis	FOR SER Max Ann.																Dist. Only (Max)	Op. max lb/hr basis				
NOX	tpy				25.54	19.40	31.26	Maximum using all fuels.															8.98	44.10				
CO	tpy				49.90	18.60	57.58																10.80	42.30				
VOC	tpy				4.95	3.70	6.00																1.66	9.30				
PM10 (Front & Back Half)	tpy				42.12	36.00	42.73																6.65	38.50				
CO2	tpy				287,842	246,140	309,364																62,873	367,860				
SO2	tpy				6.77	4.99	6.78																0.22	1.26				
H2SO4	tpy				15.81	13.34	15.82																0.57	3.36				
Pb	tpy				0.00	0.00	0.01																0.01	0.03				
						MMBtu/hr	Max Ann.																					
Max Fuel Use (by type)	MMBtu/yr				4,967,766	2,124	5,023,664																769,664	2252				
Max Fuel Use (excl. SU/SD)	MMBtu/yr				4,886,181																							
Max Fuel Use (total)	MMBtu/yr				5,023,664																							
Max Op. Hours (excl. SU/SD)	hrs/yr/unit				2280	(includes NG and ULSD)																	336					
Max Op. Hours (total)	hrs/yr/unit				2409	(includes NG and ULSD)																						
CO2e Pollutants using Emission Factors based on Source Tests [1]		*CH4 as CO2e:*	*3.43E-04*	*lb/MMBtu*	*1*	*tpy*																						
		N2O as CO2e:	*8.12E-01*	*lb/MMBtu*	*2,017*	*tpy*																						
		Total:			*2,018*	*tpy*																						
Stack Info																												
Volume Flow (per Unit)	acfm	3,281,876	2,673,032	2,321,205	3,260,948	2,723,743	2,381,190	3,221,544	2,754,466	2,454,315	3,281,876	2,673,032	2,321,205	3,260,948	2,723,743	2,381,190	3,221,544	2,754,466	2,454,315	3,103,100	2,618,102	2,169,251	3,258,794	2,730,809	2,295,330	3,302,220	2,794,815	2,349,912
Exhaust Temperature	F	800	800	800	800	800	799	800	799	800	800	800	800	800	800	799	800	799	800	800	800	799	800	800	799	800	800	799
Stack Diameter	ft	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Stack Velocity	fps	132.00	107.00	93.00	131.00	109.00	96.00	129.00	110.00	98.00	132.00	107.00	93.00	131.00	109.00	96.00	129.00	110.00	98.00	124.00	105.00	87.00	131.00	110.00	92.00	132.00	112.00	94.00
Stack Height	ft	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145

[1] The emission factors for CH4 and N2O are based on analysis for PSE's letter reports to NWCAA, SWCAA, and Ecology re: WAC 173-407 compliance and related source test results. Values are for natural gas use only; EPA's AP-42 factors for these pollutants show non-detects for distillate use. Therefore, maximum potential emissions are based on natural gas use only. The values include the conversion to CO2e using the individual Global Warming Potential (GWP) factors for each pollutant.

TURBINE EMISSION DATA FOR ALL OPERATING FUELS, TEMPERATURES, AND LOADS

Equipment GE 7FA.04

Op Conditions		Natural Gas, content @ 2.25 gr/100scf (annual average)									Natural Gas, content @ 3.48 gr/100scf (short-term maximum)									ULSD								
NG Sulfur Content		2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	-	-	-	-	-	-	-	-	-
Ambient Temperature (°F)		7	7	7	51	51	51	88	88	88	7	7	7	51	51	51	88	88	88	7	7	7	51	51	51	88	88	88
Relative Humidity		40	40	40	75	75	75	30	30	30	40	40	40	75	75	75	30	30	30	40	40	40	75	75	75	30	30	30
Unit Load (%)		100	75	50	100	75	50	100	75	50	100	75	50	100	75	50	100	75	50	100	75	50	100	75	50	100	75	50
Fuel		NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.
Units		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Operation per unit:																												
hrs/mo (max by load/fuel)		190	75	50	190	75	50	190	75	50	190	75	50	190	75	50	190	75	50									
hrs/yr (max by load/fuel)		2280	900	600	2280	900	600	2280	900	600	2280	900	600	2280	900	600	2280	900	600	336	336	336	336	336	336	336	336	336
Starts (and assume shutdowns) per unit:																												
per hour		1			1			1			1			1			1			1			1			1		
per month		12			12			12			12			12			12											
per year		144			144			144			144			144			144			14			14			14		
Op Emissions - Control (SCR/CO Cat; no SO2 scrub)																												
NOX	ppmvd @ 15% O2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	5	5	5	5	5	5	5	5	5
NOX as NO2	lb/h per stack	17.40	14.20	11.90	16.80	13.60	11.30	15.10	12.40	11.00	17.40	14.10	11.90	16.80	13.60	11.30	15.10	12.40	11.00	39.20	31.40	26.40	39.00	30.90	25.50	36.20	29.00	25.40
CO	ppmvd @ 15% O2	3.8	3.8	3.9	3.8	3.9	3.9	3.9	3.9	4.0	3.8	3.8	3.9	3.8	3.9	3.9	3.9	3.9	4.0	7.4	7.5	7.7	7.5	7.6	7.7	7.4	7.6	7.7
CO	lb/h per stack	16.2	13.2	11.4	15.6	12.7	10.8	14.3	11.8	10.7	16.2	13.2	11.4	15.6	12.7	10.8	14.3	11.8	10.7	34.8	28.8	24.7	35.2	28.7	23.8	32.2	26.7	23.7
VOC	ppmvd @ 15% O2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.3	2.7	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
VOC as CH4	lb/h per stack	2.90	2.40	2.10	2.90	2.30	2.00	2.60	2.20	1.90	2.90	2.40	2.10	2.90	2.30	2.00	2.60	2.20	1.90	7.30	6.00	5.10	7.50	6.00	5.00	6.90	5.70	5.00
PM10 (Front & Back Half)	lb/h per stack	37.50	33.90	31.50	36.80	33.30	30.70	35.00	32.00	30.30	46.40	41.20	37.60	45.40	40.20	36.50	42.70	38.40	36.00	38.40	37.60	36.90	38.40	37.50	36.90	38.10	37.20	36.80
CO2	lb/h per stack	223,538	182,497	154,021	215,297	174,854	145,399	193,893	160,494	141,292	223,528	182,489	154,014	215,288	174,847	145,393	193,911	160,487	141,313	330,042	267,343	224,479	328,669	262,999	216,941	304,937	246,390	215,855
SOx as SO2	lb/h per stack	4.53	3.71	3.12	4.37	3.54	2.95	3.92	3.25	2.86	7.01	5.73	4.82	6.75	5.47	4.56	6.07	5.02	4.42	1.12	0.90	0.78	1.12	0.88	0.75	1.03	0.86	0.74
NH3 slip	ppmvd @ 15% O2	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
NH3 slip	lb/h per stack	25.7	21	17.7	24.7	20.1	16.7	22.3	18.4	16.2	25.7	21	17.7	24.7	20.1	16.7	22.3	18.4	16.2	28.7	23.2	19.5	28.6	22.9	18.9	26.5	21.4	18.8
H2SO4	lb/h per stack	12.11	9.88	8.35	11.66	9.48	7.88	10.52	8.71	7.66	25.23	20.58	17.39	24.28	19.75	16.41	21.91	18.14	15.96	3.02	2.47	2.04	3.01	2.43	1.97	2.80	2.23	1.96
Pb	lb/h per stack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0283	0.0229	0.0192	0.0282	0.0225	0.0186	0.0261	0.0211	0.0185
Fuel Use	lb/hr	82,190	67,100	56,630	79,160	64,290	53,460	71,290	59,010	51,950	82,190	67,100	56,630	79,160	64,290	53,460	71,300	59,010	51,960	103,330	83,700	70,280	102,900	82,340	67,920	95,470	77,140	67,580
	MMBtu/hr	1929	1575	1329	1858	1509	1255	1673	1385	1219	1929	1575	1329	1858	1509	1255	1674	1385	1220	2020	1636	1374	2012	1610	1328	1866	1508	1321
Total Op Emissions (all units)																												
NOX	lb/yr				38,304	12,240	6,780																13,104	0	0			
CO	lb/yr				35,568	11,430	6,480																11,827	0	0			
VOC	lb/yr				6,612	2,070	1,200																2,520	0	0			
PM10 (Front & Back Half)	lb/yr				83,904	29,970	18,420																12,902	0	0			
CO2	lb/yr				490,877,878	157,368,847	87,239,473																110,432,696	0	0			
SO2	lb/yr				9,964	3,186	1,770																376	0	0			
H2SO4	lb/yr				26,585	8,532	4,728																1,011	0	0			
Pb	lb/yr				0	0	0																9	0	0			
Fuel Use	lb/yr				180,484,800	57,861,000	32,076,000																34,574,400	0	0			
	MMBtu/yr				4,236,520	1,358,171	752,920																675,930	0	0			
Start Emissions			FOR MODELING INFO lb/hr equiv.		Max w/ S/S	Max w/o		Key:													lb/hr equiv.		Max w/ S/S	Max w/o		Key:		
NOX	lb	43.1	86.20		62.70	39.20			SU/SD value is greater than normal operation (short-term).											145.7	291.40		165.30	39.20			Shutdown value is greater than normal operation (short-term).	
CO	lb	106.4	212.80		124.00	35.20														332.1	664.20		349.70	35.20				
VOC	lb	6.5																		8.6								
PM10 (Front & Back Half)	lb	6	11.60		29.00	46.40			SU/SD greater than normal ops, and max of fuel options.											17.00	34.00		40.20	46.40			Greater than normal operation, and max of fuel options.	
CO2	lb	70823																		109132								
SO2	lb	10.10	20.20		13.61	7.01														1.10	2.20		4.61	7.01				
H2SO4	lb	7.96	15.93		20.58	25.23			Maximum on full hour basis by fuel type.											0.99	1.98		13.60	25.23			Maximum on full hour basis by fuel type.	
Pb	lb	0.00			0.01															0.01			0.02					
Fuel Consumption	lb	25943	51886		77,608	103,330														33,845	67690		85,510	103,330				
	MMBtu	609	1218		1,619	2,020			Maximum on full hour basis; value used in short-term model.											662	1323		1,672	2,020			Maximum on full hour basis; value used in short-term model.	
Time per start	hrs	0.500																		0.500								
Shutdown Emissions																												
NOX	lb	31	132.86		61.05	39.20														79	278.82		107.09	39.20				
CO	lb	90	385.71		116.99	35.20														196	691.76		221.23	35.20				
VOC	lb	4.8																		6								
PM10 (Front & Back Half)	lb	4	18.86		39.97	46.40														9.6	33.88		42.85	46.40				
CO2	lb	28819																		44157								
SO2	lb	4.20	18.00		9.57	7.01														0.40	1.41		5.42	7.01				
H2SO4	lb	3.22	13.82		22.57	25.23														0.40	1.42		18.49	25.23				
Pb	lb	0.00			0.02															0.00			0.02					
Fuel Consumption	lb	10504	21008		89,724	103,330														13,810	48741		87,863	103,330				
	MMBtu	247	493		1,795	2,020														270	953		1,718	2,020				
Time per shutdown	hrs	0.233																		0.283								
Annual Total Start/Shutdown Emissions (all units)						Equiv. ops.																		Equiv. ops.				
NOX	lb/yr				10,670	1774			Normal operations greater w/o including SU/SD.														3,146	428			Normal operations greater w/o including SU/SD.	
CO	lb/yr				28,282	1647																	7,393	386				
VOC	lb/yr				1,627	306																	204	82				
PM10 (Front & Back Half)	lb/yr				1,469	3886																	372	421				
CO2	lb/yr				14,348,448	22,735,396																	2,146,046	3,604,400				
SO2	lb/yr				2,059	461																	21	12				
H2SO4	lb/yr				1,611	1231																	19.50	33.01				
Pb	lb/yr				0.00	0.00																	0.18	0.31				
Fuel Consumption	lb/yr				5,248,368	8,359,296																	667,170	1,128,470				
	MMBtu/yr				123,195	196,218																	13,043	22,062				
Total	hrs/yr				106																		11					
ANNUAL TOTAL EMISSIONS (Op+Start/Shut - All units)					NG Only (Max)	Op. max lb/hr basis	FOR SER Max Ann.																Dist. Only (Max)	Op. max lb/hr basis				
NOX	tpy				24.49	16.80	29.79		Maximum using all fuels.														8.12	39.00				
CO	tpy				31.92	15.60	38.91																9.61	35.20				
VOC	tpy				4.12	2.90	4.99																1.36	7.50				
PM10 (Front & Back Half)	tpy				42.69	36.80	43.14																6.64	38.40				
CO2	tpy				252,613	215,297	272,733																56,289	328,669				
SO2	tpy				6.01	4.37	6.02																0.20	1.12				
H2SO4	tpy				14.10	11.66	14.11																0.52	3.01				
Pb	tpy				0.00	0.00	0.00																0.00	0.03				
						MMBtu/hr	Max Ann.																					
Max Fuel Use (by type)	MMBtu/yr				4,359,715	1,858	4,424,358																688,973	2012				
Max Fuel Use (excl. SU/SD)	MMBtu/yr				4,288,120																							
Max Fuel Use (total)	MMBtu/yr				4,424,358																							
Max Op. Hours (excl. SU/SD)	hrs/yr/unit				2280	(includes NG and ULSD)																	336					
Max Op. Hours (total)	hrs/yr/unit				2397	(includes NG and ULSD)																						
CO2e Pollutants using Emission Factors based on Source Tests [1]		*CH4 as CO2e:*	*3.43E-04*	*lb/MMBtu*	*1*	*tpy*																						
		N2O as CO2e:	*8.12E-01*	*lb/MMBtu*	*1,770*	*tpy*																						
		Total:			*1,771*	*tpy*																						
Stack Info																												
Volume Flow (per Unit)	acfm	2,795,240	2,366,040	2,129,021	2,864,875	2,405,641	2,146,260	2,758,547	2,380,588	2,191,245	2,795,240	2,366,040	2,129,021	2,864,875	2,405,641	2,146,260	2,758,547	2,380,588	2,191,245	2,809,584	2,372,670	2,126,090	2,926,748	2,435,732	2,162,632	2,873,029	2,426,380	2,240,680
Exhaust Temperature	F	800	799	799	800	800	799	800	799	800	800	799	799	800	800	799	800	799	800	800	799	799	800	799	799	800	799	799
Stack Diameter	ft	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
Stack Velocity	fps	135.00	114.00	102.00	138.00	116.00	103.00	133.00	115.00	105.00	135.00	114.00	102.00	138.00	116.00	103.00	133.00	115.00	105.00	135.00	114.00	102.00	141.00	117.00	104.00	138.00	117.00	108.00
Stack Height	ft	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145

[1] The emission factors for CH4 and N2O are based on analysis for PSE's letter reports to NWCAA, SWCAA, and Ecology re: WAC 173-407 compliance and related source test results. Values are for natural gas use only; EPA's AP-42 factors for these pollutants show non-detects for distillate use. Therefore, maximum potential emissions are based on natural gas use only. The values include the conversion to CO2e using the individual Global Warming Potential (GWP) factors for each pollutant.

TURBINE EMISSION DATA FOR ALL OPERATING FUELS, TEMPERATURES, AND LOADS

Equipment Siemens SGT6-5000F4

Op Conditions		Natural Gas, content @ 2.25 gr/100scf (annual average)									Natural Gas, content @ 3.48 gr/100scf (short-term maximum)									ULSD								
NG Sulfur Content		2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	-	-	-	-	-	-	-	-	-
Ambient Temperature (°F)		7	7	7	51	51	51	88	88	88	7	7	7	51	51	51	88	88	88	7	7	7	51	51	51	88	88	88
Relative Humidity		40	40	40	75	75	75	30	30	30	40	40	40	75	75	75	30	30	30	40	40	40	75	75	75	30	30	30
Unit Load (%)		100	75	60	100	75	60	100	75	60	100	75	60	100	75	60	100	75	60	100	75	70	100	75	70	100	75	70
Fuel		NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.
Units		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Operation per unit:																												
hrs/mo (max by load/fuel)		190	75	50	190	75	50	190	75	50	190	75	50	190	75	50	190	75	50									
hrs/yr (max by load/fuel)		2280	900	600	2280	900	600	2280	900	600	2280	900	600	2280	900	600	2280	900	600	336	336	336	336	336	336	336	336	336
Starts (and assume shutdowns) per unit:																												
per hour		1			1			1			1			1			1			1			1			1		
per month		12			12			12			12			12			12											
per year		144			144			144			144			144			144			14			14			14		
Op Emissions - Control (SCR/CO Cat; no SO2 scrub)																												
NOX	ppmvd @ 15% O2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	5	5	5	5	5	5	5	5	5
NOX as NO2	lb/h per stack	21.10	17.10	14.60	19.70	15.70	13.40	17.70	14.30	12.20	21.10	17.10	14.60	19.70	15.70	13.40	17.70	14.30	12.20	43.10	33.80	32.10	38.80	31.00	29.40	34.80	28.10	26.70
CO	ppmvd @ 15% O2	1.6	1.6	4.0	1.6	1.6	4.0	1.6	1.6	4.0	1.6	1.6	4.0	1.6	1.6	4.0	1.6	1.6	4.0	4.0	12.0	12.0	4.0	12.0	12.0	4.0	12.0	12.0
CO	lb/h per stack	8.4	6.8	14.4	7.6	6.0	13.2	6.8	5.6	12.0	8.4	6.8	14.4	7.6	6.0	13.2	6.8	5.6	12.0	20.8	49.6	46.8	18.8	45.2	42.8	16.8	41.2	38.8
VOC	ppmvd @ 15% O2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	3.0	1.0	3.0	3.0	1.0	3.0	3.0
VOC as CH4	lb/h per stack	2.90	2.40	2.00	2.70	2.20	1.90	2.50	2.00	1.70	2.90	2.40	2.00	2.70	2.20	1.90	2.50	2.00	1.70	3.00	7.10	6.70	2.70	6.50	6.10	2.40	5.90	5.60
PM10 (Front & Back Half)	lb/h per stack	29.00	24.30	21.90	26.70	23.00	20.80	24.90	21.60	19.70	40.00	33.20	29.50	37.00	31.10	27.70	34.10	29.00	26.00	34.60	33.60	33.40	34.10	33.30	33.10	33.70	33.00	32.80
CO2	lb/h per stack	260,228	212,142	180,620	243,583	194,246	165,797	219,078	176,704	151,383	260,217	212,133	180,639	243,599	194,238	165,790	219,068	176,723	151,403	350,804	275,679	261,753	315,797	252,075	239,427	283,569	228,886	217,484
SOx as SO2	lb/h per stack	4.78	3.90	3.32	4.47	3.57	3.04	4.02	3.24	2.78	7.39	6.02	5.13	6.91	5.51	4.71	6.22	5.02	4.30	1.09	0.85	0.81	0.98	0.78	0.74	0.88	0.71	0.67
NH3 slip	ppmvd @ 15% O2	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
NH3 slip	lb/h per stack	29.9	24.4	20.7	28	22.3	19	25.2	20.3	17.4	29.9	24.4	20.7	28	22.3	19	25.2	20.3	17.4	30.5	24.0	22.8	27.5	21.9	20.8	24.7	19.9	18.9
H2SO4	lb/h per stack	14.87	12.12	10.32	13.92	11.10	9.47	12.52	10.10	8.65	22.98	18.73	15.95	21.51	17.15	14.64	19.34	15.60	13.37	3.38	2.65	2.52	3.04	2.43	2.31	2.73	2.20	2.09
Pb	lb/h per stack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0301	0.0236	0.0224	0.0271	0.0216	0.0205	0.0243	0.0196	0.0186
Fuel Use	lb/hr	95,680	78,000	66,410	89,560	71,420	60,960	80,550	64,970	55,660	95,680	78,000	66,420	89,570	71,420	60,960	80,550	64,980	55,670	109,830	86,310	81,950	98,870	78,920	74,960	88,780	71,660	68,090
	MMBtu/hr	2246	1831	1559	2102	1676	1431	1891	1525	1307	2246	1831	1559	2102	1676	1431	1891	1525	1307	2147	1687	1602	1933	1543	1465	1736	1401	1331
Total Op Emissions (all units)																												
NOX	lb/yr				44,916	14,130	8,040																13,037	0	0			
CO	lb/yr				17,328	5,400	7,920																15,187	0	0			
VOC	lb/yr				6,156	1,980	1,140																2,184	0	0			
PM10 (Front & Back Half)	lb/yr				60,876	20,700	12,480																11,458	0	0			
CO2	lb/yr				555,369,160	174,821,637	99,478,456																106,107,684	0	0			
SO2	lb/yr				10,192	3,213	1,824																329	0	0			
H2SO4	lb/yr				31,738	9,990	5,682																1,021	0	0			
Pb	lb/yr				0	0	0																9	0	0			
Fuel Use	lb/yr				204,196,800	64,278,000	36,576,000																33,220,320	0	0			
	MMBtu/yr				4,793,111	1,508,797	858,548																649,457	0	0			
Start Emissions			FOR MODELING INFO lb/hr equiv.		Max w/ S/S	Max w/o		Key:													lb/hr equiv.		Max w/ S/S	Max w/o		Key:		
NOX	lb	92.40	158.40		110.36	43.10			SU/SD value is greater than normal operation (short-term).											146.20	230.84		162.00	43.10			Shutdown value is greater than normal operation (short-term).	
CO	lb	1347.00	2309.14		1367.67	49.60														1462.00	2308.42		1480.19	49.60				
VOC	lb	154.20																		162.20								
PM10 (Front & Back Half)	lb	4.80	8.23		21.47	40.00			SU/SD greater than normal ops, and max of fuel options.											15.60	24.63		30.27	40.00			Greater than normal operation, and max of fuel options.	
CO2	lb	81663																		88,635								
SO2	lb	11.00	18.86		14.08	7.39														1.00	1.58		3.71	7.39				
H2SO4	lb	7.19	12.32		16.76	22.98			Maximum on full hour basis by fuel type.											0.96	1.52		9.39	22.98			Maximum on full hour basis by fuel type.	
Pb	lb	0.00			0.01															0.01			0.02					
Fuel Consumption	lb	29,931	51,310		75,694	109,830														31,233	49,315		71,504	109,830				
	MMBtu	703	1204		1,638	2,246			Maximum on full hour basis; value used in short-term model.											611	964		1,434	2,246			Maximum on full hour basis; value used in short-term model.	
Time per start	hrs	0.583																		0.633								
Shutdown Emissions																												
NOX	lb	45.00	158.82		75.89	43.10														90.00	284.21		119.45	43.10				
CO	lb	443.00	1563.53		478.55	49.60														709.00	2238.95		742.89	49.60				
VOC	lb	50.00																		76.00								
PM10 (Front & Back Half)	lb	2.40	8.47		31.07	40.00														10.00	31.58		37.33	40.00				
CO2	lb	41460																		66,355								
SO2	lb	5.40	19.06		10.70	7.39														0.70	2.21		5.75	7.39				
H2SO4	lb	3.63	12.82		20.10	22.98														0.59	1.87		16.30	22.98				
Pb	lb	0.00			0.02															0.01			0.03					
Fuel Consumption	lb	15,120	25,920		93,832	109,830														19,261	60,824		94,312	109,830				
	MMBtu	355	608		1964	2,246														377	1189		1,911	2,246				
Time per shutdown	hrs	0.283																		0.317								
Annual Total Start/Shutdown Emissions (all units)						Equiv. ops.																		Equiv. ops.				
NOX	lb/yr				19,786	2459			Normal operations greater w/o including SU/SD.														3,307	516			Normal operations greater w/o including SU/SD.	
CO	lb/yr				257,760	948																	30,394	250				
VOC	lb/yr				29,405	337																	3,335	36				
PM10 (Front & Back Half)	lb/yr				1,037	3332																	358	454				
CO2	lb/yr				17,729,712	30,399,154																	2,169,856	4,200,096				
SO2	lb/yr				2,362	558																	24	13				
H2SO4	lb/yr				1,558	1737																	21.76	40.43				
Pb	lb/yr				0.00	0.00																	0.19	0.36				
Fuel Consumption	lb/yr				6,487,344	11,177,088																	706,916	1,314,971				
	MMBtu/yr				152,277	262,360																	13,820	25,708				
Total	hrs/yr				125																		13					
ANNUAL TOTAL EMISSIONS (Op+Start/Shut - All units)					NG Only (Max)	Op. max lb/hr basis	FOR SER Max Ann.																Dist. Only (Max)	Op. max lb/hr basis				
NOX	tpy				32.35	19.70	37.21		Maximum using all fuels.														8.17	38.80				
CO	tpy				138.50	8.44	159.88																22.79	45.20				
VOC	tpy				17.78	2.70	20.09																2.76	6.50				
PM10 (Front & Back Half)	tpy				30.96	26.70	32.38																5.91	34.10				
CO2	tpy				286,549	243,583	299,766																54,139	315,797				
SO2	tpy				6.28	4.47	6.29																0.18	0.98				
H2SO4	tpy				16.65	13.92	16.66																0.52	3.04				
Pb	tpy				0.00	0.00	0.00																0.00	0.03				
						MMBtu/hr	Max Ann.																					
Max Fuel Use (by type)	MMBtu/yr				4,945,389	2,102	4,959,209																663,277	1933				
Max Fuel Use (excl. SU/SD)	MMBtu/yr				4,793,111																							
Max Fuel Use (total)	MMBtu/yr				4,959,209																							
Max Op. Hours (excl. SU/SD)	hrs/yr/unit				2280	(includes NG and ULSD)																	336					
Max Op. Hours (total)	hrs/yr/unit				2418	(includes NG and ULSD)																						
CO2e Pollutants using Emission Factors based on Source Tests [1]		*CH4 as CO2e:*	*3.43E-04*	*lb/MMBtu*	*1*	*tpy*																						
		N2O as CO2e:	*8.12E-01*	*lb/MMBtu*	*2,008*	*tpy*																						
		Total:			*2,009*	*tpy*																						
Stack Info																												
Volume Flow (per Unit)	acfm	3,232,007	2,704,417	2,388,735	3,220,186	2,654,253	2,350,261	3,088,647	2,585,912	2,296,013	3,232,007	2,704,417	2,388,735	3,220,186	2,654,253	2,350,261	3,088,647	2,585,912	2,296,013	3,153,454	2,565,136	2,470,797	3,023,126	2,515,394	2,422,399	2,902,243	2,449,930	2,359,651
Exhaust Temperature	F	800	799	800	800	800	799	800	799	799	800	799	800	800	800	799	800	799	799	800	799	799	800	800	800	800	799	799
Stack Diameter	ft	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Stack Velocity	fps	130.00	108.00	96.00	129.00	106.00	94.00	124.00	104.00	92.00	130.00	108.00	96.00	129.00	106.00	94.00	124.00	104.00	92.00	126.00	103.00	99.00	121.00	101.00	97.00	116.00	98.00	95.00
Stack Height	ft	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145

[1] The emission factors for CH4 and N2O are based on analysis for PSE's letter reports to NWCAA, SWCAA, and Ecology re: WAC 173-407 compliance and related source test results. Values are for natural gas use only; EPA's AP-42 factors for these pollutants show non-detects for distillate use. Therefore, maximum potential emissions are based on natural gas use only. The values include the conversion to CO2e using the individual Global Warming Potential (GWP) factors for each pollutant.

TURBINE EMISSION DATA FOR ALL OPERATING FUELS, TEMPERATURES, AND LOADS

Equipment GE LMS100

Op Conditions		Natural Gas, content @ 2.25 gr/100scf (annual average)												Natural Gas, content @ 3.48 gr/100scf (short-term maximum)												ULSD								
NG Sulfur Content		2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	-	-	-	-	-	-	-	-	-
Ambient Temperature (°F)		7	7	7	7	51	51	51	51	88	88	88	88	7	7	7	7	51	51	51	51	88	88	88	88	7	7	7	51	51	51	88	88	88
Relative Humidity		40	40	40	40	75	75	75	75	30	30	30	30	40	40	40	40	75	75	75	75	30	30	30	30	40	40	40	75	75	75	30	30	30
Unit Load (%)		100	75	50	30	100	75	50	30	100	75	50	30	100	75	50	30	100	75	50	30	100	75	50	30	100	75	50	100	75	50	100	75	50
Fuel		NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.	Dist.
Units		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Operation per unit:																																		
hrs/mo (max by load/fuel)		240	75	50	30	240	75	50	30	240	75	50	30	240	75	50	30	240	75	50	30	240	75	50	30									
hrs/yr (max by load/fuel)		2880	900	600	360	2880	900	600	360	2880	900	600	360	2880	900	600	360	2880	900	600	360	2880	900	600	360	336	336	336	336	336	336	336	336	336
Starts (and assume shutdowns) per unit:																																		
per hour		1				1				1				1				1				1				1			1			1		
per month		20				20				20				20				20				20												
per year		240				240				240				240				240				240				14			14			14		
Op Emissions - Control (SCR/CO Cat; no SO2 scrub)																																		
NOX	ppmvd @ 15% O2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	5	5	5	5	5	5	5	5	5
NOX as NO2	lb/h per stack	7.90	6.40	4.90	3.50	8.10	6.50	5.00	3.60	7.90	6.30	4.80	3.50	7.90	6.40	4.90	3.50	8.10	6.50	5.00	3.60	7.90	6.30	4.80	3.50	16.50	13.30	10.10	16.90	13.50	10.30	15.70	12.70	9.60
CO	ppmvd @ 15% O2	3.7	3.1	3.1	4.0	3.1	2.8	3.2	4.5	3.0	2.8	3.4	5.1	3.7	3.1	3.1	4.0	3.1	2.8	3.2	4.5	3.0	2.8	3.4	5.1	2.4	2.8	3.5	2.4	2.9	3.6	2.6	3.1	3.9
CO	lb/h per stack	7.2	4.8	3.7	3.4	6.2	4.5	3.8	3.9	5.7	4.3	4.0	4.4	7.2	4.8	3.7	3.4	6.2	4.5	3.8	3.9	5.7	4.3	4.0	4.4	4.8	4.6	4.3	5.0	4.7	4.5	5.0	4.8	4.5
VOC	ppmvd @ 15% O2	2.0	2.0	2.0	2.1	2.0	2.0	2.0	2.3	2.0	2.0	2.0	2.6	2.0	2.0	2.0	2.1	2.0	2.0	2.0	2.3	2.0	2.0	2.0	2.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
VOC as CH4	lb/h per stack	2.20	1.80	1.40	1.00	2.30	1.80	1.40	1.20	2.20	1.80	1.30	1.30	2.20	1.80	1.40	1.00	2.30	1.80	1.40	1.20	2.20	1.80	1.30	1.30	6.40	5.20	3.90	6.60	5.30	4.00	6.10	4.90	3.70
PM10 (Front & Back Half)	lb/h per stack	13.40	12.00	10.60	9.30	13.60	12.10	10.60	9.40	13.40	11.90	10.50	9.30	17.50	15.30	13.00	11.10	17.80	15.40	13.20	11.20	17.40	15.10	12.90	11.00	26.70	26.40	26.00	26.70	26.40	26.10	26.60	26.30	26.00
CO2	lb/h per stack	101,638	81,947	62,392	45,230	104,195	83,660	63,425	45,883	100,876	80,886	61,412	44,577	101,661	81,970	62,416	45,228	104,190	83,657	63,422	45,881	100,872	80,883	61,410	44,575	138,814	111,920	85,186	142,200	114,252	86,527	132,138	106,745	81,193
SOx as SO2	lb/h per stack	2.06	1.66	1.26	0.92	2.11	1.70	1.29	0.93	2.04	1.64	1.24	0.90	3.18	2.57	1.96	1.42	3.26	2.62	1.99	1.44	3.16	2.53	1.92	1.40	0.49	0.39	0.30	0.50	0.40	0.30	0.46	0.37	0.28
NH3 slip	ppmvd @ 15% O2	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
NH3 slip	lb/h per stack	11.7	9.4	7.2	5.2	12	9.6	7.3	5.3	11.6	9.3	7.1	5.1	11.7	9.4	7.2	5.2	12	9.6	7.3	5.3	11.6	9.3	7.1	5.1	12.1	9.7	7.4	12.4	9.9	7.5	11.5	9.3	7.1
H2SO4	lb/h per stack	5.51	4.44	3.38	2.45	5.65	4.54	3.44	2.49	5.47	4.39	3.33	2.42	8.52	6.87	5.23	3.79	8.73	7.01	5.31	3.84	8.45	6.78	5.15	3.74	1.25	1.01	0.77	1.28	1.03	0.78	1.19	0.96	0.73
Pb	lb/h per stack	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0119	0.0096	0.0073	0.0122	0.0098	0.0074	0.0113	0.0091	0.0070
Fuel Use	lb/hr	37,370	30,130	22,940	16,630	38,310	30,760	23,320	16,870	37,090	29,740	22,580	16,390	37,380	30,140	22,950	16,630	38,310	30,760	23,320	16,870	37,090	29,740	22,580	16,390	43,460	35,040	26,670	44,520	35,770	27,090	41,370	33,420	25,420
	MMBtu/hr	877	707	538	390	899	722	547	396	871	698	530	385	877	707	539	390	899	722	547	396	871	698	530	385	850	685	521	870	699	530	809	653	497
Total Op Emissions (all units)																																		
NOX	lb/yr					46,656	11,700	6,000	2,592																				11,357	0	0			
CO	lb/yr					35,712	8,100	4,560	2,808																				3,360	0	0			
VOC	lb/yr					13,248	3,240	1,680	864																				4,435	0	0			
PM10 (Front & Back Half)	lb/yr					78,336	21,780	12,720	6,768																				17,942	0	0			
CO2	lb/yr					600,160,576	150,588,450	76,110,157	33,035,464																				95,558,088	0	0			
SO2	lb/yr					12,154	3,060	1,548	670																				336	0	0			
H2SO4	lb/yr					32,544	8,172	4,128	1,793																				860	0	0			
Pb	lb/yr					0	0	0	0																				8	0	0			
Fuel Use	lb/yr					220,665,600	55,368,000	27,984,000	12,146,400																				29,917,440	0	0			
	MMBtu/yr					5,179,684	1,299,653	656,868	285,112																				584,886	0	0			
Start Emissions			FOR MODELING INFO lb/hr equiv.			Max w/ S/S	Max w/o			Key:																	lb/hr equiv.			Max w/ S/S	Max w/o			Key:
NOX	lb	34.50	69.00			42.95	16.90			SU/SD value is greater than normal operation (short-term).																59.90	119.80		68.35	16.90			Shutdown value is greater than normal operation (short-term).
CO	lb	49.00	98.00			52.60	7.20																			39.60	79.20		43.20	7.20			
VOC	lb	0.97																								3.69							
PM10 (Front & Back Half)	lb	3.30	6.60			16.65	26.70			SU/SD greater than normal ops, and max of fuel options.																14.28	28.56		27.63	26.70			Greater than normal operation, and max of fuel options.
CO2	lb	43546																								58849							
SO2	lb	6.46	12.92			8.09	3.26																			0.55	1.10		2.18	3.26			
H2SO4	lb	3.65	7.29			8.01	8.73			Maximum on full hour basis by fuel type.																0.53	1.06		4.89	8.73			Maximum on full hour basis by fuel type.
Pb	lb	0.00				0.50																				0.01			0.51				
Fuel Consumption	lb	16001	32,002			38,261	44,520																			18425	36,850		40,685	44,520			
	MMBtu	376	751			825	899			Maximum on full hour basis; value used in short-term model.																360	720		810	899			Maximum on full hour basis; value used in short-term model.
Time per start	hrs	0.500																								0.500							
Shutdown Emissions																																		
NOX	lb	3.40	25.50			18.05	16.90																			5.70	42.75		20.35	16.90			
CO	lb	1.80	13.50			8.04	7.20																			1.70	12.75		7.94	7.20			
VOC	lb	0.03																								0.06							
PM10 (Front & Back Half)	lb	1.00	7.50			24.14	26.70																			4.70	35.25		27.84	26.70			
CO2	lb	4621																								5555							
SO2	lb	0.68	5.10			3.51	3.26																			0.05	0.38		2.88	3.26			
H2SO4	lb	0.38	2.88			7.95	8.73																			0.05	0.38		7.62	8.73			
Pb	lb	0.00				0.87																				0.00			0.87				
Fuel Consumption	lb	1684	3,368			40,268	44,520																			1739	13,043		40,323	44,520			
	MMBtu	40	79			819	899																			34	255		813	899			
Time per shutdown	hrs	0.133																								0.133							
Annual Total Start/Shutdown Emissions (all units)							Equiv. ops.																							Equiv. ops.			
NOX	lb/yr					18,192	2462			Normal operations greater w/o including SU/SD.																			1,837	300			Normal operations greater w/o including SU/SD.
CO	lb/yr					24,384	1885																						1,156	89			
VOC	lb/yr					480	699																						105	117			
PM10 (Front & Back Half)	lb/yr					2,064	4134																						531	473			
CO2	lb/yr					23,120,160	31,675,141																						1,803,312	2,521,672			
SO2	lb/yr					3,427	641																						17	9			
H2SO4	lb/yr					1,935	1718																						16	23			
Pb	lb/yr					0.00	0.00																						0.15	0.22			
Fuel Consumption	lb/yr					8,488,800	11,646,240																						564,592	789,488			
	MMBtu/yr					199,258	273,372																						11,038	15,434			
Total	hrs/yr					304																							18				
ANNUAL TOTAL EMISSIONS (Op+Start/Shut - All units)						NG Only (Max)	Op. max lb/hr basis	FOR SER Max Ann.																					Dist. Only (Max)	Op. max lb/hr basis			
NOX	tpy					32.42	16.20	36.30		Maximum using all fuels.																			6.60	33.80			
CO	tpy					30.05	12.40	30.63																					2.26	10.00			
VOC	tpy					6.86	4.60	8.36																					2.27	13.20			
PM10 (Front & Back Half)	tpy					40.20	27.20	44.87																					9.24	53.40			
CO2	tpy					311,640	208,389	325,312																					48,681	284,399			
SO2	tpy					7.79	4.22	7.80																					0.18	1.00			
H2SO4	tpy					17.24	11.30	17.25																					0.44	2.56			
Pb	tpy					0.00	0.00	0.00																					0.00	0.02			
							MMBtu/hr	Max Ann.																									
Max Fuel Use (by type)	MMBtu/yr					5,378,941	1799	5,389,979																					595,924	1741			
Max Fuel Use (excl. SU/SD)	MMBtu/yr					5,179,684																											
Max Fuel Use (total)	MMBtu/yr					5,389,979																											
Max Op. Hours (excl. SU/SD)	hrs/yr/unit					2880	(includes NG and ULSD)																						336				
Max Op. Hours (total)	hrs/yr/unit					3202	(includes NG and ULSD)																										
CO2e Pollutants using Emission Factors based on Source Tests [1]		*CH4 as CO2e:*	*3.43E-04 lb/MMBtu*			*1 tpy*																											
		N2O as CO2e:	*8.12E-01 lb/MMBtu*			*2,265 tpy*																											
		Total:				*2,266 tpy*																											
Stack Info																																	
Volume Flow (per Unit)	acfm	910,876	782,277	654,273	536,561	922,990	791,040	666,231	546,031	898,233	774,696	658,447	541,286	910,876	782,277	654,273	536,561	922,990	791,040	666,231	546,031	898,233	774,696	658,447	541,286	910,026	781,381	659,455	921,565	792,949	672,324	878,207	768,326	653,435
Exhaust Temperature	F	737	764	800	799	769	787	800	799	799	800	800	799	737	764	800	799	769	787	800	799	799	800	800	799	755	782	800	786	799	800	800	800	799
Stack Diameter	ft	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Stack Velocity	fps	134.00	115.00	96.00	79.00	136.00	117.00	98.00	80.00	132.00	114.00	97.00	80.00	134.00	115.00	96.00	79.00	136.00	117.00	98.00	80.00	132.00	114.00	97.00	80.00	134.00	115.00	97.00	136.00	117.00	99.00	129.00	113.00	96.00
Stack Height	ft	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110

[1] The emission factors for CH4 and N2O are based on analysis for PSE's letter reports to NWCAA, SWCAA, and Ecology re: WAC 173-407 compliance and related source test results. Values are for natural gas use only; EPA's AP-42 factors for these pollutants show non-detects for distillate use. Therefore, maximum potential emissions are based on natural gas use only. The values include the conversion to CO2e using the individual Global Warming Potential (GWP) factors for each pollutant.

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
General Electric 7FA.05 - Simple Cycle Emissions Summary - Natural Gas 2.25 grains/100 scf Sulfur

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	47%	100%	75%	48%	100%	75%	50%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Ambient Conditions									
Ambient Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
Ambient Relative Humidity, %	40.0	40.0	40.0	75.0	75.0	75.0	30.0	30.0	30.0
Atmospheric Pressure, psia	14.680	14.680	14.680	14.680	14.680	14.680	14.680	14.680	14.680
Combustion Turbine Performance									
CTG Performance Reference	GE	GE	GE	GE	GE	GE	GE	GE	GE
CTG Inlet Air Conditioning Effectiveness, %	0	0	0	0	0	0	0	0	0
CTG Compressor Inlet Dry Bulb Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
CTG Compr. Inlet Relative Humidity, %	40.5	40.5	40.5	75.1	75.1	75.1	30.2	30.2	30.2
Inlet Loss, in. H2O	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Exhaust Loss, in. H2O	11.3	7.2	4.6	10.3	6.6	4.7	9.5	6.0	4.8
CTG Load Level (percent of Base Load)	100%	75%	47%	100%	75%	48%	100%	75%	50%
Gross CTG Output, kW	230,500	172,900	108,300	214,400	160,800	102,900	193,800	145,400	96,900
Gross CTG Heat Rate, Btu/kWh (LHV)	8,855	9,400	11,765	8,925	9,625	11,965	9,155	10,030	12,330
Gross CTG Heat Rate, Btu/kWh (HHV)	9,831	10,436	13,062	9,909	10,686	13,284	10,164	11,135	13,689
CTG Heat Input, MBtu/h (LHV)	2,041.1	1,625.3	1,274.2	1,913.5	1,547.7	1,231.2	1,774.2	1,458.4	1,194.8
CTG Heat Input, MBtu/h (HHV)	2,266.0	1,804.4	1,414.6	2,124.4	1,718.3	1,366.9	1,969.8	1,619.1	1,326.5
CTG Water/Steam Injection Flow, lb/h	0	0	0	0	0	0	0	0	0
Injection Fluid/Fuel Ratio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTG Exhaust Flow, lb/h	4,363,000	3,470,000	2,722,000	4,139,000	3,269,000	2,727,000	3,962,000	3,107,000	2,757,000
CTG Exhaust Temperature, F	1,084	1,108	1,215	1,110	1,165	1,215	1,124	1,208	1,215
Combustion Turbine Fuel									
Total CTG Fuel Flow, lb/h	96,540	76,870	60,260	90,500	73,200	58,230	83,920	68,980	56,510
CTG Fuel Temperature, F	77	77	77	77	77	77	77	77	77
CTG Fuel LHV, Btu/lb	21,143	21,143	21,143	21,143	21,143	21,143	21,143	21,143	21,143
CTG Fuel HHV, Btu/lb	23,473	23,473	23,473	23,473	23,473	23,473	23,473	23,473	23,473
HHV/LHV Ratio	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102
CTG Fuel Composition (Ultimate Analysis by Weight)									
Ar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%
H2	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%
N2	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%
O2	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%
S	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Combustion Turbine Exhaust									
CTG Exhaust Analysis (Volume Basis - Wet)									
Ar	0.94%	0.94%	0.94%	0.93%	0.93%	0.93%	0.93%	0.93%	0.93%
CO2	3.89%	3.90%	3.90%	3.84%	3.93%	3.75%	3.71%	3.89%	3.59%
H2O	7.74%	7.75%	7.74%	8.46%	8.64%	8.29%	8.61%	8.96%	8.38%
N2	74.98%	74.98%	74.98%	74.37%	74.30%	74.44%	74.16%	74.02%	74.25%
O2	12.45%	12.44%	12.44%	12.40%	12.20%	12.59%	12.58%	12.20%	12.84%
SO2, (after SO2 oxidation)	0.00014%	0.00014%	0.00014%	0.00014%	0.00014%	0.00013%	0.00013%	0.00014%	0.00013%
SO3, (after SO2 oxidation)	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Molecular Wt, lb/mol	28.47	28.47	28.47	28.39	28.38	28.40	28.36	28.34	28.38
Specific Volume, ft^3/lb	38.55	39.54	42.51	39.41	41.18	42.61	39.88	42.38	42.63
Specific Volume, scf/lb	13.32	13.33	13.33	13.36	13.37	13.36	13.36	13.39	13.37
Exhaust Gas Flow, acfm	2,803,228	2,286,730	1,928,537	2,718,633	2,243,624	1,936,625	2,633,409	2,194,578	1,958,849
Exhaust Gas Flow, scfm	968,586	770,918	604,738	921,617	728,442	607,212	883,526	693,379	614,352
CTG NOx Emissions (Without Post Combustion Emissions Control)									
NOx Massflow Added to Match CTG Manufacturer's NOx Emissions Estimate, lb/h	1.11	0.24	0.00	1.00	0.23	0.00	0.89	0.23	0.00
Additional Percent Margin included in mass based NOx Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
NOx, ppmvd (dry, 15% O2)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
NOx, ppmvd (dry)	11.27	11.28	11.27	11.19	11.48	10.91	10.85	11.40	10.48
NOx, ppmvw (wet)	10.40	10.41	10.40	10.24	10.48	10.01	9.91	10.38	9.60
NOx, lb/h as NO2	74.4	58.6	45.8	69.7	55.8	44.2	64.6	52.6	42.9
NOx, lb/MBtu (LHV)	0.0365	0.0361	0.0359	0.0364	0.0361	0.0359	0.0364	0.0361	0.0359
NOx, lb/MBtu (HHV)	0.0328	0.0325	0.0323	0.0328	0.0325	0.0323	0.0328	0.0325	0.0323
CTG CO Emissions (Without Post Combustion Emissions Control)									
CO Massflow Added to Match CTG Manufacturer's CO Emissions Estimate, lb/h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in mass based CO Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
CO, ppmvd (dry, 15% O2)	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
CO, ppmvd (dry)	10.02	10.03	10.02	9.95	10.20	9.70	9.64	10.14	9.31
CO, ppmvw (wet)	9.24	9.25	9.25	9.10	9.32	8.89	8.81	9.23	8.53
CO, lb/h	39.7	31.6	24.8	37.2	30.1	23.9	34.5	28.3	23.2
CO, lb/MBtu (LHV)	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194
CO, lb/MBtu (HHV)	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175
CTG SO2 Emissions (After SO2 Oxydation, Without Post Combustion Emissions Control)									
SO2 massflow (lb/h) added to match CTG manufacturer's lb/h SO2 emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h SO2 Emissions below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CTG, vol%	6.3%	6.2%	6.3%	6.1%	6.2%	6.1%	6.3%	6.2%	6.2%
SO2, ppmvd (dry, 15% O2)	1.2088	1.2094	1.2088	1.2106	1.2097	1.2113	1.2083	1.2094	1.2092
SO2, ppmvd (dry)	1.5134	1.5160	1.5142	1.5051	1.5425	1.4684	1.4563	1.5323	1.4074
SO2, ppmvw (wet)	1.3963	1.3985	1.3970	1.3777	1.4092	1.3467	1.3308	1.3951	1.2894
SO2, lb/h	13.7061	10.9182	8.5553	12.8676	10.3996	8.2838	11.9096	9.7981	8.0253
SO2, lb/MBtu (LHV)	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
SO2, lb/MBtu (HHV)	0.0060	0.0061	0.0060	0.0061	0.0061	0.0061	0.0060	0.0061	0.0061
CTG UHC Emissions (Without Post Combustion Emissions Control)									
UHC massflow (lb/h) added to match CTG manufacturer's lb/h CO emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h UHC Emissions Below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UHC, ppmvd (dry, 15% O2)	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
UHC, ppmvd (dry)	8.5	8.5	8.5	8.5	8.7	8.2	8.2	8.6	7.9
UHC, ppmvw (wet)	7.9	7.9	7.9	7.7	7.9	7.6	7.5	7.8	7.3
UHC, lb/h as CH4	19.3	15.4	12.1	18.1	14.6	11.6	16.8	13.8	11.3
UHC, lb/MBtu as CH4 (LHV)	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095
UHC, lb/MBtu as CH4 (HHV)	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085
CTG VOC Emissions (Without Post Combustion Emissions Control)									
VOC Massflow (lb/h) added to match CTG manufacturer's lb/h VOC emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional percent margin included in lb/h VOC emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
VOC percentage of UHC	21%	21%	21%	21%	21%	21%	21%	21%	21%
VOC, ppmvd (dry, 15% O2)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
VOC, ppmvd (dry)	1.8	1.8	1.8	1.7	1.8	1.7	1.7	1.8	1.6
VOC, ppmvw (wet)	1.6	1.6	1.6	1.8	1.8	1.6	1.5	1.6	1.5
VOC, lb/h as CH4	4.0	3.2	2.5	3.7	3.0	2.4	3.5	2.8	2.3
VOC, lb/MBtu as CH4 (LHV)	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019
VOC, lb/MBtu as CH4 (HHV)	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
General Electric 7FA.05 - Simple Cycle Emissions Summary - Natural Gas 2.25 grains/100 scf Sulfur

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	47%	100%	75%	48%	100%	75%	50%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
CTG PM10 Emissions (without the Effects of SO2 Oxidation)									
Percent margin included in PM10 emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
PM10, lb/MBtu (LHV)	0.0044	0.0055	0.0071	0.0047	0.0058	0.0073	0.0051	0.0062	0.0075
PM10, lb/MBtu (HHV)	0.0040	0.0050	0.0064	0.0042	0.0052	0.0066	0.0046	0.0056	0.0068
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
PM10, lb/MBtu (LHV)	0.0088	0.0111	0.0141	0.0094	0.0116	0.0146	0.0101	0.0123	0.0151
PM10, lb/MBtu (HHV)	0.0079	0.0100	0.0127	0.0085	0.0105	0.0132	0.0091	0.0111	0.0136
CO2 Emissions									
CO2, lb/hr	262,567	209,069	163,894	246,140	199,087	158,372	228,243	187,610	153,694
CO2, lb/Mbtu (LHV)	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6
CO2, lb/Mbtu (HHV)	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9
Stack Emissions									
Stack Exhaust Analysis - Volume Basis - Wet									
Ar	0.95%	0.95%	0.96%	0.95%	0.95%	0.95%	0.94%	0.94%	0.95%
CO2	2.79%	2.73%	2.46%	2.63%	2.55%	2.32%	2.47%	2.37%	2.18%
H2O	5.57%	5.44%	4.92%	6.10%	5.94%	5.49%	6.18%	5.99%	5.61%
N2	75.83%	75.87%	76.08%	75.29%	75.35%	75.53%	75.11%	75.18%	75.32%
O2	14.87%	15.00%	15.58%	15.03%	15.22%	15.72%	15.30%	15.51%	15.93%
SO2 (after SO2 oxidation)	0.000040%	0.000040%	0.000030%	0.000040%	0.000040%	0.000030%	0.000030%	0.000030%	0.000030%
SO3 (after SO2 oxidation)	0.000070%	0.000070%	0.000060%	0.000060%	0.000060%	0.000060%	0.000060%	0.000060%	0.000050%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Stack Exit Temperature, F	800	800	800	800	800	799	800	799	800
Stack Diameter, ft (estimated)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Stack Flow, lb/h	6,120,993	4,986,995	4,335,996	6,064,994	5,068,995	4,436,996	5,987,994	5,122,995	4,568,996
Stack Flow, scfm	1,352,741	1,102,127	956,811	1,343,398	1,122,784	982,056	1,327,340	1,135,598	1,012,034
Stack Flow, acfm	3,281,876	2,673,032	2,321,205	3,260,948	2,723,743	2,381,190	3,221,544	2,754,466	2,454,315
Stack Exit Velocity, ft/s	132.0	107.0	93.0	131.0	109.0	96.0	129.0	110.0	98.0
Stack NOx Emissions without the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
NOx, ppmvd (dry)	7.9	7.7	6.9	7.5	7.2	6.5	7.0	6.7	6.2
NOx, ppmvw (wet)	7.4	7.3	6.6	7.0	6.8	6.2	6.6	6.3	5.8
NOx, lb/h as NO2 (includes correction adder)	74.4	58.6	45.7	69.7	55.8	44.2	64.6	52.6	42.9
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0365	0.0361	0.0359	0.0364	0.0361	0.0359	0.0364	0.0361	0.0359
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0328	0.0325	0.0323	0.0328	0.0325	0.0323	0.0328	0.0325	0.0323
Stack NOx Emissions with the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
NOx, ppmvd (dry)	2.2	2.1	1.9	2.1	2.0	1.8	2.0	1.9	1.7
NOx, ppmvw (wet)	2.1	2.0	1.8	2.0	1.9	1.7	1.8	1.8	1.6
NOx, lb/h as NO2 (includes NOx margin applied to CTG)	20.7	16.3	12.7	19.4	15.5	12.3	17.9	14.6	11.9
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0101	0.0100	0.0100	0.0101	0.0100	0.0100	0.0101	0.0100	0.0100
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0091	0.0090	0.0090	0.0091	0.0090	0.0090	0.0091	0.0090	0.0090
SCR NH3 slip, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
SCR NH3 slip, lb/h	30.1	24.0	18.8	28.3	22.9	18.2	26.2	21.5	17.6
Stack CO Emissions without the Effects of Catalytic Reduction									
CO, ppmvd (dry, 15% O2)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
CO, ppmvd (dry)	7.0	6.8	6.1	6.7	6.4	5.8	6.2	6.0	5.5
CO, ppmvw (wet)	6.6	6.5	5.8	6.2	6.0	5.5	5.9	5.6	5.2
CO, lb/h (includes CO correction as applied to CTG and margin)	39.7	31.6	24.8	37.2	30.1	23.9	34.5	28.3	23.2
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175
Stack CO Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
CO, ppmvd (dry, 15% O2)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
CO, ppmvd (dry)	3.5	3.4	3.1	3.3	3.2	2.9	3.1	3.0	2.7
CO, ppmvw (wet)	3.3	3.2	2.9	3.1	3.0	2.8	2.9	2.8	2.6
CO, lb/h (includes CO margin applied to CTG)	19.8	15.8	12.4	18.6	15.0	12.0	17.2	14.2	11.6
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0097	0.0097	0.0097	0.0097	0.0097	0.0097	0.0097	0.0097	0.0097
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0088	0.0088	0.0088	0.0088	0.0088	0.0088	0.0088	0.0088	0.0088
Stack SO2 Emissions without the Effects of SO2 Scrubber, without SO2 Oxidation									
Assumed SO2 oxidation rate in CTG, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CO Catalyst, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in SCR, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SO2, ppmvd (dry, 15% O2)	1.2894	1.2895	1.2894	1.2894	1.2895	1.2894	1.2894	1.2894	1.2894
SO2, ppmvd (dry)	1.6143	1.6164	1.6151	1.6031	1.6442	1.5631	1.5540	1.6337	1.5008
SO2, ppmvw (wet)	1.4894	1.4911	1.4901	1.4674	1.5021	1.4336	1.4201	1.4874	1.3750
SO2, lb/h	14.6198	11.6410	9.1257	13.7051	11.0853	8.8182	12.7086	10.4462	8.5578
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0064	0.0065	0.0064	0.0065	0.0065	0.0065	0.0064	0.0065	0.0065
Stack SO2 Emissions without the Effects of SO2 Scrubber, after SO2 Oxidation									
Assumed SO2 oxidation rate in CO Catalyst, vol%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
Assumed SO2 oxidation rate in SCR, vol%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SO2, ppmvd (dry, 15% O2)	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
SO2, ppmvd (dry)	0.41	0.40	0.36	0.39	0.38	0.34	0.37	0.35	0.32
SO2, ppmvw (wet)	0.39	0.38	0.34	0.37	0.35	0.32	0.34	0.33	0.30
SO2, lb/h	5.32	4.24	3.32	4.99	4.04	3.21	4.62	3.80	3.11
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0023	0.0023	0.0023	0.0024	0.0023	0.0024	0.0023	0.0023	0.0023
Stack UHC Emissions									
UHC, ppmvd (dry, 15% O2)	6.8	6.8	6.8	6.8	8.8	6.8	6.8	6.8	6.8
UHC, ppmvd	6.0	5.8	5.2	5.7	5.5	4.9	5.3	5.1	4.7
UHC, ppmvw	5.6	5.5	5.0	5.3	5.1	4.7	5.0	4.8	4.4
UHC, lb/h as CH4 (includes correction adder)	19.3	15.4	12.1	18.1	14.6	11.6	16.8	13.8	11.3
UHC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095
UHC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085
Stack VOC Emissions without the Effect of Oxidation in a CO catalyst									
VOC, ppmvd (dry, 15% O2)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
VOC, ppmvd (dry)	1.2	1.2	1.1	1.2	1.1	1.0	1.1	1.0	1.0
VOC, ppmvw (wet)	1.2	1.1	1.0	1.1	1.1	1.0	1.0	1.0	0.9
VOC, lb/h as CH4 (includes correction adder)	4.0	3.2	2.5	3.7	3.0	2.4	3.5	2.8	2.3
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018
Stack VOC Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
VOC, ppmvd (dry, 15% O2)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
VOC, ppmvd (dry)	1.2	1.2	1.1	1.2	1.1	1.0	1.1	1.0	1.0
VOC, ppmvw (wet)	1.2	1.1	1.0	1.1	1.1	1.0	1.0	1.0	0.9
VOC, lb/h as CH4 (includes VOC correction as applied to CTG)	4.0	3.2	2.5	3.7	3.0	2.4	3.5	2.8	2.3
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
General Electric 7FA.05 - Simple Cycle Emissions Summary - Natural Gas 2.25 grains/100 scf Sulfur

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	47%	100%	75%	48%	100%	75%	50%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
PM10 without the Effects of SO2 oxidation									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0044	0.0055	0.0071	0.0047	0.0058	0.0073	0.0051	0.0062	0.0075
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0040	0.0050	0.0064	0.0042	0.0052	0.0066	0.0046	0.0056	0.0068
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0088	0.0111	0.0141	0.0094	0.0116	0.0146	0.0101	0.0123	0.0151
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0079	0.0100	0.0127	0.0085	0.0105	0.0132	0.0091	0.0111	0.0136
PM10 with the Effects of SO2 Oxidation [Includes (NH4)2-(SO4)]									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	28.2	24.3	21.0	27.0	23.5	20.6	25.7	22.7	20.2
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0138	0.0149	0.0165	0.0141	0.0152	0.0167	0.0145	0.0156	0.0169
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0124	0.0135	0.0148	0.0127	0.0137	0.0150	0.0130	0.0140	0.0153
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	37.2	33.3	30.0	36.0	32.5	29.6	34.7	31.7	29.2
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0182	0.0205	0.0235	0.0188	0.0210	0.0240	0.0195	0.0217	0.0245
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0164	0.0184	0.0212	0.0169	0.0189	0.0216	0.0176	0.0196	0.0220
Total Effects of SO2 Oxidation									
Total SO2 to SO3 conversion rate, %vol	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%
Total Amount of SO2 converted to SO3, lb/h	9.30	7.40	5.81	8.71	7.05	5.60	8.09	6.64	5.44
Maximum Stack Ammonium Sulfate [(NH4)2-(SO4)] (assuming 100% conversion from SO3), lb	19.19	15.27	11.98	17.97	14.54	11.56	16.68	13.71	11.23
Maximum Stack H2SO4 (assuming 100% conversion from SO3 to H2SO4), lb/h	14.24	11.34	8.89	13.34	10.79	8.58	12.38	10.17	8.33
CO2 Emissions									
CO2, lb/hr	262,567	209,069	163,894	246,140	199,087	158,372	228,243	187,610	153,694
CO2, lb/Mbtu (LHV)	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6
CO2, lb/Mbtu (HHV)	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9
Post Combustion Emissions Control Equipment									
Catalytic Conversion in CO Catalyst									
CO removed in CO Catalyst, %wt	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
CO removed in CO Catalyst, lb/h	19.8	15.8	12.4	18.6	15.0	12.0	17.2	14.2	11.6
VOC removed in CO Catalyst, %wt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
VOC removed in CO Catalyst, lb/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selective Catalytic Reduction (SCR)									
NOx Removed in SCR, %wt	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%
NOx removed in SCR, lb/h	53.7	42.3	33.0	50.3	40.3	31.9	46.7	38.0	31.0
Ammonia Slip, lb/h	30.1	24.0	18.8	28.3	22.9	18.2	26.2	21.5	17.6

Notes:

1. EMISSIONS ARE PRELIMINARY. NO GUARANTEES APPLY. NO MARGINS APPLIED.
2. The dry air composition used is 0.96% Ar, 78.03% N2 and 20.99%O2
3. Standard conditions are defined as 60 F, 14.696 psia, Norm conditions are defined as 0 C, 1.103 bar
4. All ppm values are based on CH4 calibration gas.
5. The CTG performance and emissions are based on runs provided by GE dated 2/25/2010
6. The natural gas used in estimates contains 2.25 grains/100 SCF of sulfur content.
7. The VOC/UHC ratio of 21% is base on CTG performance data provided by GE dated 2/25/2010
8. Effect of SCR and CO catalyst are included.
9. The front half catch of particulate emissions is assumed to be half the amount of the front and back half catch.
10. Where manufacturer data of lb/h of pollutant emissions were available, the greater of the manufacturer's estimate and B&V's estimate was used in the summary table, i.e. the B&V estimates were adjusted, where applicable.
11. The estimated oxidation of SO2 in CTG is based on performance data provided by GE. The SO2 - SO3 conversion in the CO catalyst is assumed to be 60%.
12. The CO catalyst was designed to reduce the CO Stack emissions by 50% for all operating scenarios. While there was no VOC reduction.
13. The SCR was designed to reduce the NOx stack emissions to 2.5 ppmvd @ 15%O2 for natural gas
14. Tempering air mass flowrate controlled to limit stack exit temperature to 800F for all cases, with a minimum allowable flowrate of 13,500 lb/hr.
15. Tempering air has been assumed to not contribute to stack emissions.

ADDITIONAL CALCULATIONS MADE BY URS USING ABOVE DATA

Information used to compare values with emission standards (federal, state, local, and NSPS):									
lb NOx/MWhr	0.09	0.09	0.12	0.09	0.10	0.12	0.09	0.10	0.12
lb SO2/MWhr	0.02	0.02	0.03	0.02	0.03	0.03	0.02	0.03	0.03
Max lb NOx/MWhr	0.12								
Max lb SO2/MWhr	0.03								

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
General Electric 7FA.05 - Simple Cycle Emissions Summary - Naturel Gas 3.48 grains/100 scf Sulfur

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	47%	100%	75%	48%	100%	75%	50%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
Ambient Conditions									
Ambient Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
Ambient Relative Humidity, %	40.0	40.0	40.0	75.0	75.0	75.0	30.0	30.0	30.0
Atmospheric Pressure, psia	14.680	14.680	14.680	14.680	14.680	14.680	14.680	14.680	14.680
Combustion Turbine Performance									
CTG Performance Reference	GE	GE	GE	GE	GE	GE	GE	GE	GE
CTG Inlet Air Conditioning Effectiveness, %	0	0	0	0	0	0	0	0	0
CTG Compressor Inlet Dry Bulb Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
CTG Compr. Inlet Relative Humidity, %	40.5	40.5	40.5	75.1	75.1	75.1	30.2	30.2	30.2
Inlet Loss, in. H2O	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Exhaust Loss, in. H2O	11.3	7.2	4.6	10.3	6.6	4.7	9.5	6.0	4.8
CTG Load Level (percent of Base Load)	100%	75%	47%	100%	75%	48%	100%	75%	50%
Gross CTG Output, kW	230,500	172,900	108,300	214,400	160,800	102,900	193,800	145,400	96,900
Gross CTG Heat Rate, Btu/kWh (LHV)	8,855	9,400	11,765	8,925	9,625	11,965	9,155	10,030	12,330
Gross CTG Heat Rate, Btu/kWh (HHV)	9,831	10,436	13,062	9,909	10,686	13,284	10,164	11,135	13,689
CTG Heat Input, MBtu/h (LHV)	2,041.1	1,625.3	1,274.2	1,913.5	1,547.7	1,231.2	1,774.2	1,458.4	1,194.8
CTG Heat Input, MBtu/h (HHV)	2,266.0	1,804.4	1,414.6	2,124.4	1,718.3	1,366.9	1,969.8	1,619.1	1,326.5
CTG Water/Steam Injection Flow, lb/h	0	0	0	0	0	0	0	0	0
Injection Fluid/Fuel Ratio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTG Exhaust Flow, lb/h	4,363,000	3,470,000	2,722,000	4,139,000	3,269,000	2,727,000	3,962,000	3,107,000	2,757,000
CTG Exhaust Temperature, F	1,084	1,108	1,215	1,110	1,165	1,215	1,124	1,208	1,215
Combustion Turbine Fuel									
Total CTG Fuel Flow, lb/h	96,540	76,870	60,270	90,510	73,200	58,230	83,920	68,980	56,510
CTG Fuel Temperature, F	77	77	77	77	77	77	77	77	77
CTG Fuel LHV, Btu/lb	21,142	21,142	21,142	21,142	21,142	21,142	21,142	21,142	21,142
CTG Fuel HHV, Btu/lb	23,472	23,472	23,472	23,472	23,472	23,472	23,472	23,472	23,472
HHV/LHV Ratio	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102
CTG Fuel Composition (Ultimate Analysis by Weight)									
Ar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%
H2	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%
N2	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%
O2	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%
S	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
Combustion Turbine Exhaust									
CTG Exhaust Analysis (Volume Basis - Wet)									
Ar	0.94%	0.94%	0.94%	0.93%	0.93%	0.93%	0.93%	0.93%	0.93%
CO2	3.89%	3.90%	3.90%	3.84%	3.93%	3.75%	3.71%	3.89%	3.59%
H2O	7.74%	7.75%	7.74%	8.47%	8.64%	8.29%	8.61%	8.96%	8.38%
N2	74.98%	74.98%	74.98%	74.37%	74.30%	74.44%	74.16%	74.02%	74.25%
O2	12.45%	12.44%	12.44%	12.40%	12.20%	12.59%	12.59%	12.20%	12.84%
SO2, (after SO2 oxidation)	0.00022%	0.00022%	0.00022%	0.00021%	0.00022%	0.00021%	0.00021%	0.00022%	0.00020%
SO3, (after SO2 oxidation)	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Molecular Wt, lb/mol	28.47	28.47	28.47	28.39	28.38	28.40	28.36	28.34	28.38
Specific Volume, ft^3/lb	38.55	39.54	42.51	39.41	41.18	42.61	39.88	42.38	42.63
Specific Volume, scf/lb	13.32	13.33	13.33	13.36	13.37	13.36	13.38	13.39	13.37
Exhaust Gas Flow, acfm	2,803,228	2,286,730	1,928,537	2,718,633	2,243,624	1,936,625	2,633,409	2,194,578	1,958,849
Exhaust Gas Flow, scfm	968,586	770,918	604,738	921,617	728,442	607,212	883,526	693,379	614,352
CTG NOx Emissions (Without Post Combustion Emissions Control)									
NOx Massflow Added to Match CTG Manufacturer's NOx Emissions Estimate, lb/h	1.11	0.24	0.00	0.99	0.23	0.00	0.89	0.23	0.00
Additonal Percent Margin included in mass based NOx Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
NOx, ppmvd (dry, 15% O2)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
NOx, ppmvd (dry)	11.27	11.28	11.28	11.19	11.48	10.91	10.85	11.40	10.47
NOx, ppmvw (wet)	10.40	10.41	10.40	10.24	10.49	10.01	9.91	10.38	9.60
NOx, lb/h as NO2	74.4	58.6	45.8	69.7	55.8	44.2	64.6	52.6	42.9
NOx, lb/MBtu (LHV)	0.0365	0.0361	0.0359	0.0364	0.0361	0.0359	0.0364	0.0361	0.0359
NOx, lb/MBtu (HHV)	0.0328	0.0325	0.0323	0.0328	0.0325	0.0323	0.0328	0.0325	0.0323
CTG CO Emissions (Without Post Combustion Emissions Control)									
CO Massflow Added to Match CTG Manufacturer's CO Emissions Estimate, lb/h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in mass based CO Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
CO, ppmvd (dry, 15% O2)	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
CO, ppmvd (dry)	10.02	10.03	10.02	9.95	10.20	9.70	9.64	10.14	9.31
CO, ppmvw (wet)	9.24	9.25	9.25	9.10	9.32	8.89	8.81	9.23	8.53
CO, lb/h	39.7	31.6	24.8	37.2	30.1	23.9	34.5	28.3	23.2
CO, lb/MBtu (LHV)	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194
CO, lb/MBtu (HHV)	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175
CTG SO2 Emissions (After SO2 Oxydation, Without Post Combustion Emissions Control)									
SO2 massflow (lb/h) added to match CTG manufacturer's lb/h SO2 emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h SO2 Emissions below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CTG, vol%	6.3%	6.2%	6.3%	6.1%	6.2%	6.1%	6.3%	6.2%	6.2%
SO2, ppmvd (dry, 15% O2)	1.8682	1.8690	1.8682	1.8710	1.8695	1.8720	1.8675	1.8691	1.8688
SO2, ppmvd (dry)	2.3389	2.3428	2.3406	2.3263	2.3839	2.2694	2.2506	2.3682	2.1750
SO2, ppmvw (wet)	2.1579	2.1613	2.1593	2.1294	2.1779	2.0812	2.0567	2.1560	1.9927
SO2, lb/h	21.1822	16.8736	13.2240	19.8885	16.0721	12.8022	18.4058	15.1425	12.4027
SO2, lb/MBtu (LHV)	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104
SO2, lb/MBtu (HHV)	0.0093	0.0094	0.0093	0.0094	0.0094	0.0094	0.0093	0.0094	0.0094
CTG UHC Emissions (Without Post Combustion Emissions Control)									
UHC massflow (lb/h) added to match CTG manufacturer's lb/h CO emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h UHC Emissions Below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UHC, ppmvd (dry, 15% O2)	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
UHC, ppmvd (dry)	8.5	8.5	8.5	8.5	8.7	8.2	8.2	8.6	7.9
UHC, ppmvw (wet)	7.9	7.9	7.9	7.7	7.9	7.6	7.5	7.8	7.3
UHC, lb/h as CH4	19.3	15.4	12.1	18.1	14.6	11.6	16.8	13.8	11.3
UHC, lb/MBtu as CH4 (LHV)	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095
UHC, lb/MBtu as CH4 (HHV)	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085
CTG VOC Emissions (Without Post Combustion Emissions Control)									
VOC Massflow (lb/h) added to match CTG manufacturer's lb/h VOC emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional percent margin included in lb/h VOC emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
VOC percentage of UHC	21%	21%	21%	21%	21%	21%	21%	21%	21%
VOC, ppmvd (dry, 15% O2)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
VOC, ppmvd (dry)	1.8	1.8	1.8	1.7	1.8	1.7	1.7	1.8	1.6
VOC, ppmvw (wet)	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.6	1.5
VOC, lb/h as CH4	4.0	3.2	2.5	3.7	3.0	2.4	3.5	2.8	2.3
VOC, lb/MBtu as CH4 (LHV)	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019
VOC, lb/MBtu as CH4 (HHV)	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
General Electric 7FA.05 - Simple Cycle Emissions Summary - Natural Gas 3.48 grains/100 scf Sulfur

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	47%	100%	75%	48%	100%	75%	50%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
CTG PM10 Emissions (without the Effects of SO2 Oxidation)									
Percent margin included in PM10 emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
PM10, lb/MBtu (LHV)	0.0044	0.0055	0.0071	0.0047	0.0058	0.0073	0.0051	0.0062	0.0075
PM10, lb/MBtu (HHV)	0.0040	0.0050	0.0064	0.0042	0.0052	0.0066	0.0046	0.0056	0.0068
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
PM10, lb/MBtu (LHV)	0.0088	0.0111	0.0141	0.0094	0.0116	0.0146	0.0101	0.0123	0.0151
PM10, lb/MBtu (HHV)	0.0079	0.0100	0.0127	0.0085	0.0105	0.0132	0.0091	0.0111	0.0136
CO2 Emissions									
CO2, lb/hr	262,555	209,060	163,914	246,156	199,079	158,365	228,233	187,602	153,688
CO2, lb/Mbtu (LHV)	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6
CO2, lb/Mbtu (HHV)	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9
Stack Emissions									
Stack Exhaust Analysis - Volume Basis - Wet									
Ar	0.95%	0.95%	0.96%	0.95%	0.95%	0.95%	0.94%	0.94%	0.95%
CO2	2.79%	2.73%	2.46%	2.63%	2.55%	2.32%	2.47%	2.37%	2.18%
H2O	5.57%	5.44%	4.92%	6.10%	5.94%	5.49%	6.18%	5.99%	5.61%
N2	75.83%	75.87%	76.08%	75.29%	75.35%	75.53%	75.11%	75.18%	75.32%
O2	14.87%	15.00%	15.58%	15.03%	15.22%	15.72%	15.30%	15.51%	15.93%
SO2 (after SO2 oxidation)	0.000060%	0.000060%	0.000050%	0.000060%	0.000050%	0.000050%	0.000050%	0.000050%	0.000050%
SO3 (after SO2 oxidation)	0.000100%	0.000100%	0.000090%	0.000100%	0.000100%	0.000090%	0.000090%	0.000090%	0.000080%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Stack Exit Temperature, F	800	800	800	800	800	799	800	799	800
Stack Diameter, ft (estimated)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Stack Flow, lb/h	6,120,990	4,986,992	4,335,994	6,064,990	5,068,992	4,436,994	5,987,991	5,122,993	4,568,994
Stack Flow, scfm	1,352,741	1,102,127	956,811	1,343,398	1,122,784	982,056	1,327,340	1,135,598	1,012,034
Stack Flow, acfm	3,281,876	2,673,032	2,321,205	3,260,948	2,723,743	2,381,190	3,221,544	2,754,466	2,454,315
Stack Exit Velocity, ft/s	132.0	107.0	93.0	131.0	109.0	96.0	129.0	110.0	98.0
Stack NOx Emissions without the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
NOx, ppmvd (dry)	7.9	7.7	6.9	7.5	7.2	6.5	7.0	6.7	6.2
NOx, ppmvw (wet)	7.4	7.3	6.6	7.0	6.8	6.2	6.6	6.3	5.8
NOx, lb/h as NO2 (includes correction adder)	74.4	58.6	45.8	69.7	55.8	44.2	64.6	52.6	42.9
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0365	0.0361	0.0359	0.0364	0.0361	0.0359	0.0364	0.0361	0.0359
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0328	0.0325	0.0323	0.0328	0.0325	0.0323	0.0328	0.0325	0.0323
Stack NOx Emissions with the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
NOx, ppmvd (dry)	2.2	2.1	1.9	2.1	2.0	1.8	2.0	1.9	1.7
NOx, ppmvw (wet)	2.1	2.0	1.8	2.0	1.9	1.7	1.8	1.8	1.6
NOx, lb/h as NO2 (includes NOx margin applied to CTG)	20.7	16.3	12.7	19.4	15.5	12.3	17.9	14.6	11.9
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0101	0.0100	0.0100	0.0101	0.0100	0.0100	0.0101	0.0100	0.0100
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0091	0.0090	0.0090	0.0091	0.0090	0.0090	0.0091	0.0090	0.0090
SCR NH3 slip, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
SCR NH3 slip, lb/h	30.1	24.0	18.8	28.3	22.9	18.2	26.2	21.5	17.6
Stack CO Emissions without the Effects of Catalytic Reduction									
CO, ppmvd (dry, 15% O2)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
CO, ppmvd (dry)	7.0	6.8	6.1	6.7	6.4	5.8	6.2	6.0	5.5
CO, ppmvw (wet)	6.6	6.5	5.8	6.2	6.0	5.5	5.9	5.6	5.2
CO, lb/h (includes CO correction as applied to CTG and margin)	39.7	31.6	24.8	37.2	30.1	23.9	34.5	28.3	23.2
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175
Stack CO Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
CO, ppmvd (dry, 15% O2)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
CO, ppmvd (dry)	3.5	3.4	3.1	3.3	3.2	2.9	3.1	3.0	2.7
CO, ppmvw (wet)	3.3	3.2	2.9	3.1	3.0	2.8	2.9	2.8	2.6
CO, lb/h (includes CO margin applied to CTG)	19.8	15.8	12.4	18.6	15.0	12.0	17.2	14.2	11.6
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0097	0.0097	0.0097	0.0097	0.0097	0.0097	0.0097	0.0097	0.0097
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0088	0.0088	0.0088	0.0088	0.0088	0.0088	0.0088	0.0088	0.0088
Stack SO2 Emissions without the Effects of SO2 Scrubber, without SO2 Oxidation									
Assumed SO2 oxidation rate in CTG, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CO Catalyst, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in SCR, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SO2, ppmvd (dry, 15% O2)	1.9927	1.9927	1.9927	1.9928	1.9928	1.9928	1.9928	1.9927	1.9928
SO2, ppmvd (dry)	2.4948	2.4979	2.4966	2.4777	2.5411	2.4158	2.4016	2.5249	2.3193
SO2, ppmvw (wet)	2.3018	2.3044	2.3033	2.2680	2.3215	2.2155	2.1947	2.2986	2.1249
SO2, lb/h	22.5943	17.9907	14.1056	21.1830	17.1318	13.6281	19.6407	16.1441	13.2256
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0099	0.0100	0.0099	0.0100	0.0100	0.0100	0.0099	0.0100	0.0100
Stack SO2 Emissions without the Effects of SO2 Scrubber, after SO2 Oxidation									
Assumed SO2 oxidation rate in CO Catalyst, vol%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
Assumed SO2 oxidation rate in SCR, vol%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SO2, ppmvd (dry, 15% O2)	0.72	0.73	0.72	0.73	0.73	0.73	0.72	0.73	0.73
SO2, ppmvd (dry)	0.64	0.62	0.56	0.60	0.58	0.53	0.57	0.54	0.50
SO2, ppmvw (wet)	0.60	0.59	0.53	0.57	0.55	0.50	0.53	0.51	0.47
SO2, lb/h	8.22	6.55	5.13	7.72	6.24	4.97	7.14	5.88	4.81
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036
Stack UHC Emissions									
UHC, ppmvd (dry, 15% O2)	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
UHC, ppmvd	6.0	5.8	5.2	5.7	5.5	4.9	5.3	5.1	4.7
UHC, ppmvw	5.6	5.5	5.0	5.3	5.1	4.7	5.0	4.8	4.4
UHC, lb/h as CH4 (includes correction adder)	19.3	15.4	12.1	18.1	14.6	11.6	16.8	13.8	11.3
UHC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095
UHC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085
Stack VOC Emissions without the Effect of Oxidation in a CO catalyst									
VOC, ppmvd (dry, 15% O2)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
VOC, ppmvd (dry)	1.2	1.2	1.1	1.2	1.1	1.0	1.1	1.0	1.0
VOC, ppmvw (wet)	1.2	1.1	1.0	1.1	1.1	1.0	1.0	1.0	0.9
VOC, lb/h as CH4 (includes correction adder)	4.0	3.2	2.5	3.7	3.0	2.4	3.5	2.8	2.3
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018
Stack VOC Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
VOC, ppmvd (dry, 15% O2)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
VOC, ppmvd (dry)	1.2	1.2	1.1	1.2	1.1	1.0	1.1	1.0	1.0
VOC, ppmvw (wet)	1.2	1.1	1.0	1.1	1.1	1.0	1.0	1.0	0.9
VOC, lb/h as CH4 (includes VOC correction as applied to CTG)	4.0	3.2	2.5	3.7	3.0	2.4	3.5	2.8	2.3
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
General Electric 7FA.05 - Simple Cycle Emissions Summary - Natural Gas 3.48 grains/100 scf Sulfur

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	47%	100%	75%	48%	100%	75%	50%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
PM10 without the Effects of SO2 oxidation									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0044	0.0055	0.0071	0.0047	0.0058	0.0073	0.0051	0.0062	0.0075
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0040	0.0050	0.0064	0.0042	0.0052	0.0066	0.0046	0.0056	0.0068
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0088	0.0111	0.0141	0.0094	0.0116	0.0146	0.0101	0.0123	0.0151
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0079	0.0100	0.0127	0.0085	0.0105	0.0132	0.0091	0.0111	0.0136
PM10 with the Effects of SO2 Oxidation [Includes (NH4)2-(SO4)]									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	38.7	32.6	27.5	36.8	31.5	26.9	34.8	30.2	26.4
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0189	0.0201	0.0216	0.0192	0.0203	0.0218	0.0196	0.0207	0.0221
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0171	0.0181	0.0194	0.0173	0.0183	0.0197	0.0177	0.0186	0.0199
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	47.7	41.6	36.5	45.8	40.5	35.9	43.8	39.2	35.4
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0233	0.0256	0.0287	0.0239	0.0262	0.0291	0.0247	0.0269	0.0296
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0210	0.0231	0.0258	0.0215	0.0236	0.0262	0.0222	0.0242	0.0267
Total Effects of SO2 Oxidation									
Total SO2 to SO3 conversion rate, %vol	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%
Total Amount of SO2 converted to SO3, lb/h	14.38	11.44	8.97	13.47	10.90	8.66	12.50	10.27	8.41
Maximum Stack Ammonium Sulfate [(NH4)2-(SO4)] (assuming 100% conversion from SO3), lb	29.65	23.61	18.51	27.78	22.48	17.87	25.78	21.18	17.35
Maximum Stack H2SO4 (assuming 100% conversion from SO3 to H2SO4), lb/h	22.01	17.52	13.74	20.62	16.68	13.26	19.14	15.72	12.88
CO2 Emissions									
CO2, lb/hr	262,555	209,060	163,914	246,156	199,079	158,365	228,233	187,602	153,688
CO2, lb/Mbtu (LHV)	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6
CO2, lb/Mbtu (HHV)	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9
Post Combustion Emissions Control Equipment									
Catalytic Conversion in CO Catalyst									
CO removed in CO Catalyst, %wt	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
CO removed in CO Catalyst, lb/h	19.8	15.8	12.4	18.6	15.0	12.0	17.2	14.2	11.6
VOC removed in CO Catalyst, %wt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
VOC removed in CO Catalyst, lb/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selective Catalytic Reduction (SCR)									
NOx Removed in SCR, %wt	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%
NOx removed in SCR, lb/h	53.7	42.3	33.0	50.3	40.3	31.9	46.7	38.0	31.0
Ammonia Slip, lb/h	30.1	24.0	18.8	28.3	22.9	18.2	26.2	21.5	17.6

Notes:

1. EMISSIONS ARE PRELIMINARY. NO GUARANTEES APPLY. NO MARGINS APPLIED.
2. The dry air composition used is 0.98% Ar, 78.03% N2 and 20.99%O2
3. Standard conditions are defined as 60 F, 14.696 psia, Norm conditions are defined as 0 C, 1.103 bar
4. All ppm values are based on CH4 calibration gas.
5. The CTG performance and emissions are based on runs provided by GE dated 2/25/2010
6. The natural gas used in estimates contains 2.25 grains/100 SCF of sulfur content.
7. The VOC/UHC ratio is base on CTG performance data provided by GE dated 2/25/2010
8. Effect of SCR and CO catalyst are included.
9. The front half catch of particulate emissions is assumed to be half the amount of the front and back half catch.
10. Where manufacturer data of lb/h of pollutant emissions were available, the greater of the manufacturer's estimate and B&V's estimate was used in the summary table, i.e. the B&V estimates were adjusted, where applicable.
11. The estimated oxidation of SO2 in CTG is based on performance data provided by GE. The SO2 - SO3 conversion in the CO catalyst is assumed to be 60%.
12. The CO catalyst was designed to reduce the CO Stack emissions by 50% for all operating scenarios. While there was no VOC reduction.
13. The SCR was designed to reduce the NOx stack emissions to 2.5 ppmvd @ 15%O2 for natural gas
14. Tempering air mass flowrate controlled to limit stack exit temperature to 800F for all cases, with a minimum allowable flowrate of 13,500 lb/hr.
15. Tempering air has been assumed to not contribute to stack emissions.

ADDITIONAL CALCULATIONS MADE BY URS USING ABOVE DATA

Information used to compare values with emission standards (federal, state, local, and NSPS)									
Stack Flow, scfm(dry) @ 7% O2	1,169,296	952,522	825,805	1,152,532	962,746	841,115	1,134,170	969,887	863,533
PM10, grains/dscf @ 7% O2	0.0039	0.0040	0.0039	0.0037	0.0038	0.0037	0.0036	0.0036	0.0036
lb NOx/MWhr	0.09	0.09	0.12	0.09	0.10	0.12	0.09	0.10	0.12
lb SO2/MWhr	0.04	0.04	0.05	0.04	0.04	0.05	0.04	0.04	0.05
Max PM10 gr/dscf	0.0040								
Max lb NOx/MWhr	0.12								
Max lb SO2/MWhr	0.05								

06-Dec-10
Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE 7FA.05 - Distillate Revision, 2.2

Filename: 165510 PSE SC 7FA 05 Distillate Emissions Summary - Client.xls									
Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05
CTG Fuel Type	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate
CTG Load	100%	75%	50%	100%	75%	50%	100%	75%	50%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ambient Conditions									
Ambient Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
Ambient Relative Humidity, %	40.0	40.0	40.0	75.0	75.0	75.0	30.0	30.0	30.0
Atmospheric Pressure, psia	14.680	14.680	14.680	14.680	14.680	14.680	14.680	14.680	14.680
Combustion Turbine Performance									
CTG Performance Reference	GE	GE	GE	GE	GE	GE	GE	GE	GE
CTG Inlet Air Conditioning Effectiveness, %	0	0	0	0	0	0	0	0	0
CTG Compressor Inlet Dry Bulb Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
CTG Compr. Inlet Relative Humidity, %	40.5	40.5	40.5	75.1	75.1	75.1	30.2	30.2	30.2
Inlet Loss, in. H2O	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Exhaust Loss, in. H2O	10.0	6.8	5.3	10.2	6.6	4.8	9.9	6.3	4.3
CTG Load Level (percent of Base Load)	100%	75%	50%	100%	75%	50%	100%	75%	50%
Gross CTG Output, kW	222,100	166,600	111,000	220,600	165,400	110,300	207,400	155,600	103,700
Gross CTG Heat Rate, Btu/kWh (LHV)	9,520	10,245	11,765	9,585	10,255	11,910	9,795	10,545	12,270
Gross CTG Heat Rate, Btu/kWh (HHV)	10,137	10,909	12,528	10,206	10,920	12,682	10,430	11,228	13,065
CTG Heat Input, MBtu/h (LHV)	2,114.4	1,706.8	1,305.9	2,114.5	1,696.2	1,313.7	2,031.5	1,640.8	1,272.4
CTG Heat Input, MBtu/h (HHV)	2,251.4	1,817.5	1,390.6	2,251.5	1,806.1	1,398.8	2,163.2	1,747.2	1,354.9
CTG Water/Steam Injection Flow, lb/h	151,693	109,707	68,843	156,937	112,247	74,634	157,998	114,058	76,429
Injection Fluid/Fuel Ratio	1.3	1.2	1.0	1.4	1.2	1.0	1.4	1.3	1.1
CTG Exhaust Flow, lb/h	4,109,000	3,366,000	3,022,000	4,137,000	3,284,000	2,800,000	4,065,000	3,194,000	2,626,000
CTG Exhaust Temperature, F	1,080	1,112	1,042	1,101	1,156	1,148	1,113	1,186	1,214
Combustion Turbine Fuel									
Total CTG Fuel Flow, lb/h	115,160	92,960	71,130	115,170	92,380	71,550	110,650	89,370	69,300
CTG Fuel Temperature, F	77	77	77	77	77	77	77	77	77
CTG Fuel LHV, Btu/lb	18,360	18,360	18,360	18,360	18,360	18,360	18,360	18,360	18,360
CTG Fuel HHV, Btu/lb	19,550	19,550	19,550	19,550	19,550	19,550	19,550	19,550	19,550
HHV/LHV Ratio	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648
CTG Fuel Composition (Ultimate Analysis by Weight)									
Ar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%
H2	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%
N2	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
O2	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
S	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Combustion Turbine Exhaust									
CTG Exhaust Analysis (Volume Basis - Wet)									
Ar	0.90%	0.90%	0.92%	0.89%	0.89%	0.91%	0.88%	0.89%	0.90%
CO2	5.77%	5.70%	4.89%	5.71%	5.79%	5.28%	5.58%	5.74%	5.44%
H2O	10.95%	10.22%	7.98%	11.83%	11.32%	9.73%	12.22%	11.88%	10.61%
N2	71.46%	72.00%	73.47%	70.75%	71.17%	72.24%	70.40%	70.72%	71.61%
O2	10.92%	11.17%	12.74%	10.82%	10.82%	11.84%	10.92%	10.77%	11.44%
SO2, (after SO2 oxidation)	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%
SO3, (after SO2 oxidation)	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Molecular Wt, lb/mol	28.39	28.46	28.62	28.28	28.35	28.47	28.23	28.28	28.39
Specific Volume, ft^3/lb	38.69	39.70	37.86	39.34	40.99	40.79	39.75	41.88	42.64
Specific Volume, scf/lb	13.37	13.33	13.26	13.41	13.38	13.33	13.44	13.42	13.36
Exhaust Gas Flow, acfm	2,649,620	2,227,170	1,906,882	2,712,493	2,243,519	1,903,533	2,693,063	2,229,412	1,866,211
Exhaust Gas Flow, scfm	915,622	747,813	667,862	924,620	732,332	622,067	910,560	714,391	584,723
CTG NOx Emissions (Without Post Combustion Emissions Control)									
NOx Massflow Added to Match CTG Manufacturer's NOx Emissions Estimate, lb/h	7.43	2.98	0.17	7.40	3.01	0.15	7.24	2.89	0.14
Additional Percent Margin included in mass based NOx Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
NOx, ppmvd (dry, 15% O2)	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
NOx, ppmvd (dry)	61.19	59.96	50.13	61.16	61.59	55.19	59.95	61.51	57.40
NOx, ppmvw (wet)	54.49	53.83	46.13	53.93	54.61	49.82	52.62	54.20	51.31
NOx, lb/h as NO2	370.3	295.9	224.3	370.3	294.1	225.6	355.9	284.5	218.5
NOx, lb/MBtu (LHV)	0.1751	0.1734	0.1718	0.1751	0.1734	0.1717	0.1752	0.1734	0.1717
NOx, lb/MBtu (HHV)	0.1645	0.1628	0.1613	0.1645	0.1628	0.1613	0.1645	0.1628	0.1613
CTG CO Emissions (Without Post Combustion Emissions Control)									
CO Massflow Added to Match CTG Manufacturer's CO Emissions Estimate, lb/h	0.00	0.00	2.09	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in mass based CO Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
CO, ppmvd (dry, 15% O2)	16.10	16.10	16.10	16.10	16.10	16.10	16.10	16.10	16.10
CO, ppmvd (dry)	23.46	22.98	19.22	23.45	23.61	21.16	22.98	23.58	22.00
CO, ppmvw (wet)	20.89	20.63	17.68	20.67	20.94	19.10	20.17	20.78	19.67
CO, lb/h	84.7	68.4	54.4	84.7	67.9	52.6	81.4	65.7	51.0
CO, lb/MBtu (LHV)	0.0401	0.0401	0.0417	0.0401	0.0401	0.0401	0.0401	0.0401	0.0401
CO, lb/MBtu (HHV)	0.0376	0.0376	0.0391	0.0376	0.0376	0.0376	0.0376	0.0376	0.0376
CTG SO2 Emissions (After SO2 Oxidation, Without Post Combustion Emissions Control)									
SO2 massflow (lb/h) added to match CTG manufacturer's lb/h SO2 emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h SO2 Emissions below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CTG, vol%	6.1%	7.4%	5.0%	6.1%	7.4%	5.0%	6.3%	7.7%	5.0%
SO2, ppmvd (dry, 15% O2)	0.2695	0.2657	0.2726	0.2695	0.2657	0.2726	0.2690	0.2648	0.2726
SO2, ppmvd (dry)	0.3927	0.3793	0.3254	0.3925	0.3896	0.3582	0.3839	0.3879	0.3725
SO2, ppmvw (wet)	0.3497	0.3405	0.2994	0.3461	0.3455	0.3233	0.3370	0.3418	0.3330
SO2, lb/h	3.2424	2.5798	2.0253	3.2427	2.5637	2.0373	3.1091	2.4725	1.9732
SO2, lb/MBtu (LHV)	0.0015	0.0015	0.0016	0.0015	0.0015	0.0016	0.0015	0.0015	0.0016
SO2, lb/MBtu (HHV)	0.0014	0.0014	0.0015	0.0014	0.0014	0.0015	0.0014	0.0014	0.0015
CTG UHC Emissions (Without Post Combustion Emissions Control)									
UHC massflow (lb/h) added to match CTG manufacturer's lb/h CO emissions estimate	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h UHC Emissions Below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UHC, ppmvd (dry, 15% O2)	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
UHC, ppmvd (dry)	9.0	8.9	7.4	9.0	9.1	8.1	8.8	9.1	8.5
UHC, ppmvw (wet)	8.0	7.9	8.8	8.0	8.1	7.4	7.8	8.0	7.6
UHC, lb/h as CH4	18.7	15.1	11.8	18.7	15.0	11.6	17.9	14.5	11.2
UHC, lb/MBtu as CH4 (LHV)	0.0088	0.0088	0.0090	0.0088	0.0088	0.0088	0.0088	0.0088	0.0088
UHC, lb/MBtu as CH4 (HHV)	0.0083	0.0083	0.0085	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083
CTG VOC Emissions (Without Post Combustion Emissions Control)									
VOC Massflow (lb/h) added to match CTG manufacturer's lb/h VOC emissions estimate	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Additional percent margin included in lb/h VOC emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
VOC percentage of UHC	50%	50%	50%	50%	50%	50%	50%	50%	50%
VOC, ppmvd (dry, 15% O2)	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
VOC, ppmvd (dry)	4.5	4.4	3.7	4.5	4.5	4.1	4.4	4.5	4.2
VOC, ppmvw (wet)	4.0	4.0	3.4	4.0	4.0	3.7	3.9	4.0	3.8
VOC, lb/h as CH4	9.3	7.5	5.9	9.3	7.5	5.8	9.0	7.2	5.6
VOC, lb/MBtu as CH4 (LHV)	0.0044	0.0044	0.0045	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044
VOC, lb/MBtu as CH4 (HHV)	0.0041	0.0041	0.0042	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041

06-Dec-10
Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE 7FA.05 - Distillate Revision, 2.2

Filename: 165510 PSE SC 7FA 05 Distillate Emissions Summary - Client.xls									
Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05
CTG Fuel Type	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate
CTG Load	100%	75%	50%	100%	75%	50%	100%	75%	50%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CTG PM10 Emissions (without the Effects of SO2 Oxidation)									
Percent margin included in PM10 emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
PM10, lb/MBtu (LHV)	0.0080	0.0100	0.0130	0.0080	0.0100	0.0129	0.0084	0.0104	0.0134
PM10, lb/MBtu (HHV)	0.0076	0.0094	0.0122	0.0076	0.0094	0.0122	0.0079	0.0097	0.0125
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
PM10, lb/MBtu (LHV)	0.0161	0.0199	0.0260	0.0161	0.0200	0.0259	0.0167	0.0207	0.0267
PM10, lb/MBtu (HHV)	0.0151	0.0187	0.0245	0.0151	0.0188	0.0243	0.0157	0.0195	0.0251
CO2 Emissions									
CO2, lb/hr	367,828	296,920	227,193	367,860	295,067	228,535	353,423	285,453	221,348
CO2, lb/MBtu (LHV)	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0
CO2, lb/MBtu (HHV)	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.4
Stack Emissions									
Stack Exhaust Analysis - Volume Basis - Wet									
Ar	0.92%	0.93%	0.94%	0.91%	0.92%	0.93%	0.91%	0.92%	0.93%
CO2	4.13%	3.95%	3.65%	3.94%	3.77%	3.47%	3.73%	3.56%	3.28%
H2O	7.86%	7.11%	5.98%	8.44%	7.70%	6.71%	8.61%	7.87%	6.94%
N2	73.31%	73.83%	74.61%	72.79%	73.31%	73.98%	72.58%	73.10%	73.74%
O2	13.78%	14.18%	14.82%	13.92%	14.31%	14.91%	14.16%	14.55%	15.12%
SO2 (after SO2 oxidation)	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%
SO3 (after SO2 oxidation)	0.000020%	0.000020%	0.000010%	0.000020%	0.000020%	0.000010%	0.000020%	0.000010%	0.000010%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Stack Exit Temperature, F	800	800	799	800	800	799	800	800	799
Stack Diameter, ft (estimated)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Stack Flow, lb/h	5,774,998	4,882,999	4,060,999	6,045,998	5,078,999	4,280,999	6,118,998	5,189,999	4,375,999
Stack Flow, scfm	1,279,163	1,079,143	894,774	1,343,220	1,125,845	946,101	1,361,478	1,152,180	968,555
Stack Flow, acfm	3,103,100	2,618,102	2,169,251	3,258,794	2,730,809	2,295,330	3,302,220	2,794,815	2,349,912
Stack Exit Velocity, ft/s	124.0	105.0	87.0	131.0	110.0	92.0	132.0	112.0	94.0
Stack NOx Emissions without the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
NOx, ppmvd (dry)	42.3	40.2	36.6	40.6	38.5	35.1	38.5	36.5	33.3
NOx, ppmvw (wet)	39.0	37.3	34.4	37.1	35.5	32.7	35.2	33.6	31.0
NOx, lb/h as NO2 (includes correction adder)	370.3	295.9	224.3	370.3	294.1	225.6	355.9	284.5	218.5
NOx, lb/MBtu (LHV) as NO2	0.1751	0.1734	0.1718	0.1751	0.1734	0.1717	0.1752	0.1734	0.1717
NOx, lb/MBtu (HHV) as NO2	0.1645	0.1628	0.1613	0.1645	0.1628	0.1613	0.1645	0.1628	0.1613
Stack NOx Emissions with the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
NOx, ppmvd (dry)	5.0	4.8	4.4	4.8	4.6	4.2	4.6	4.3	4.0
NOx, ppmvw (wet)	4.6	4.4	4.1	4.4	4.2	3.9	4.2	4.0	3.7
NOx, lb/h as NO2 (includes NOx margin applied to CTG)	44.1	35.2	26.7	44.1	35.0	26.9	42.4	33.9	26.0
NOx, lb/MBtu (LHV) as NO2	0.0208	0.0206	0.0204	0.0208	0.0206	0.0204	0.0209	0.0206	0.0204
NOx, lb/MBtu (HHV) as NO2	0.0196	0.0194	0.0192	0.0196	0.0194	0.0192	0.0196	0.0194	0.0192
SCR NH3 slip, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
SCR NH3 slip, lb/h	32.0	25.8	19.8	32.0	25.7	19.9	30.7	24.8	19.2
Stack CO Emissions without the Effects of Catalytic Reduction									
CO, ppmvd (dry, 15% O2)	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1
CO, ppmvd (dry)	16.2	15.4	14.0	15.5	14.8	13.5	14.8	14.0	12.8
CO, ppmvw (wet)	14.9	14.3	13.2	14.2	13.6	12.6	13.5	12.9	11.9
CO, lb/h (includes CO correction as applied to CTG and margin)	84.7	68.4	54.4	84.7	67.9	52.6	81.4	65.7	51.0
CO, lb/MBtu (LHV)	0.0401	0.0401	0.0417	0.0401	0.0401	0.0401	0.0401	0.0401	0.0401
CO, lb/MBtu (HHV)	0.0376	0.0376	0.0391	0.0376	0.0376	0.0376	0.0376	0.0376	0.0376
Stack CO Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
CO, ppmvd (dry, 15% O2)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
CO, ppmvd (dry)	8.1	7.7	7.0	7.8	7.4	6.7	7.4	7.0	6.4
CO, ppmvw (wet)	7.5	7.2	6.6	7.1	6.8	6.3	6.7	6.4	5.9
CO, lb/h (includes CO margin applied to CTG)	42.3	34.2	27.2	42.3	34.0	26.3	40.7	32.9	25.5
CO, lb/MBtu (LHV)	0.0200	0.0200	0.0208	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200
CO, lb/MBtu (HHV)	0.0188	0.0188	0.0196	0.0188	0.0188	0.0188	0.0188	0.0188	0.0188
Stack SO2 Emissions without the Effects of SO2 Scrubber, without SO2 Oxidation									
Assumed SO2 oxidation rate in CTG, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CO Catalyst, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in SCR, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SO2, ppmvd (dry, 15% O2)	0.2869	0.2870	0.2869	0.2869	0.2870	0.2869	0.2869	0.2869	0.2869
SO2, ppmvd (dry)	0.4180	0.4096	0.3425	0.4178	0.4206	0.3771	0.4095	0.4202	0.3921
SO2, ppmvw (wet)	0.3723	0.3677	0.3152	0.3684	0.3731	0.3403	0.3595	0.3703	0.3505
SO2, lb/h	3.4516	2.7862	2.1319	3.4519	2.7688	2.1445	3.3164	2.6785	2.0771
SO2, lb/MBtu (LHV)	0.0016	0.0016	0.0017	0.0016	0.0016	0.0017	0.0016	0.0016	0.0017
SO2, lb/MBtu (HHV)	0.0015	0.0015	0.0016	0.0015	0.0015	0.0016	0.0015	0.0015	0.0016
Stack SO2 Emissions without the Effects of SO2 Scrubber, after SO2 Oxidation									
Assumed SO2 oxidation rate in CO Catalyst, vol%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
Assumed SO2 oxidation rate in SCR, vol%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SO2, ppmvd (dry, 15% O2)	0.10	0.10	0.11	0.10	0.10	0.11	0.10	0.10	0.11
SO2, ppmvd (dry)	0.11	0.10	0.09	0.10	0.09	0.09	0.10	0.09	0.08
SO2, ppmvw (wet)	0.10	0.09	0.09	0.09	0.09	0.08	0.09	0.08	0.08
SO2, lb/h	1.26	1.00	0.79	1.26	0.99	0.79	1.21	0.96	0.77
SO2, lb/MBtu (LHV)	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
SO2, lb/MBtu (HHV)	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0006
Stack UHC Emissions									
UHC, ppmvd (dry, 15% O2)	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
UHC, ppmvd	6.2	5.9	5.4	6.0	5.7	5.2	5.7	5.4	4.9
UHC, ppmvw	5.8	5.5	5.1	5.5	5.2	4.8	5.2	5.0	4.8
UHC, lb/h as CH4 (includes correction adder)	18.7	15.1	11.8	18.7	15.0	11.6	17.9	14.5	11.2
UHC, lb/MBtu (LHV)	0.0088	0.0088	0.0090	0.0088	0.0088	0.0088	0.0088	0.0088	0.0088
UHC, lb/MBtu (HHV)	0.0083	0.0083	0.0085	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083
Stack VOC Emissions without the Effect of Oxidation in a CO catalyst									
VOC, ppmvd (dry, 15% O2)	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
VOC, ppmvd (dry)	3.1	3.0	2.7	3.0	2.8	2.6	2.8	2.7	2.5
VOC, ppmvw (wet)	2.9	2.8	2.5	2.7	2.6	2.4	2.6	2.5	2.3
VOC, lb/h as CH4 (includes correction adder)	9.3	7.5	5.9	9.3	7.5	5.8	9.0	7.2	5.6
VOC, lb/MBtu (LHV)	0.0044	0.0044	0.0045	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044
VOC, lb/MBtu (HHV)	0.0041	0.0041	0.0042	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041
Stack VOC Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
VOC, ppmvd (dry, 15% O2)	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
VOC, ppmvd (dry)	3.1	3.0	2.7	3.0	2.8	2.6	2.8	2.7	2.5
VOC, ppmvw (wet)	2.9	2.8	2.5	2.7	2.6	2.4	2.8	2.5	2.3
VOC, lb/h as CH4 (includes VOC correction as applied to CTG)	9.3	7.5	5.9	9.3	7.5	5.8	9.0	7.2	5.6
VOC, lb/MBtu (LHV)	0.0044	0.0044	0.0045	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044
VOC, lb/MBtu (HHV)	0.0041	0.0041	0.0042	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041

06-Dec-10
Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE 7FA.05 - Distillate Revision, 2.2

Filename: 165510 PSE SC 7FA 05 Distillate Emissions Summary - Client.xls									
Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05	GE7FA.05
CTG Fuel Type	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate
CTG Load	100%	75%	50%	100%	75%	50%	100%	75%	50%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PM10 without the Effects of SO2 oxidation									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
PM10, lb/MBtu (LHV)	0.0080	0.0100	0.0130	0.0080	0.0100	0.0129	0.0084	0.0104	0.0134
PM10, lb/MBtu (HHV)	0.0076	0.0094	0.0122	0.0076	0.0094	0.0122	0.0079	0.0097	0.0125
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
PM10, lb/MBtu (LHV)	0.0161	0.0199	0.0260	0.0161	0.0200	0.0259	0.0167	0.0207	0.0267
PM10, lb/MBtu (HHV)	0.0151	0.0187	0.0245	0.0151	0.0188	0.0243	0.0157	0.0195	0.0251
PM10 with the Effects of SO2 Oxidation [includes (NH4)2-(SO4)]									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	21.5	20.7	19.8	21.5	20.7	19.8	21.4	20.5	19.7
PM10, lb/MBtu (LHV)	0.0102	0.0121	0.0151	0.0102	0.0122	0.0151	0.0105	0.0125	0.0155
PM10, lb/MBtu (HHV)	0.0096	0.0114	0.0142	0.0096	0.0114	0.0141	0.0099	0.0118	0.0145
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	38.5	37.7	36.8	38.5	37.7	36.8	38.4	37.5	36.7
PM10, lb/MBtu (LHV)	0.0182	0.0221	0.0282	0.0182	0.0222	0.0280	0.0189	0.0229	0.0288
PM10, lb/MBtu (HHV)	0.0171	0.0207	0.0264	0.0171	0.0209	0.0263	0.0177	0.0215	0.0271
Total Effects of SO2 Oxidation									
Total SO2 to SO3 conversion rate, %vol	63.6%	64.1%	63.1%	63.6%	64.1%	63.1%	63.6%	64.2%	63.1%
Total Amount of SO2 converted to SO3, lb/h	2.19	1.79	1.35	2.19	1.77	1.35	2.11	1.72	1.31
Maximum Stack Ammonium Sulfate [(NH4)2-(SO4)] (assuming 100% conversion from SO3), lb	4.52	3.68	2.78	4.53	3.66	2.79	4.35	3.55	2.71
Maximum Stack H2SO4 (assuming 100% conversion from SO3 to H2SO4), lb/h	3.36	2.73	2.06	3.36	2.72	2.07	3.23	2.63	2.01
CO2 Emissions									
CO2, lb/hr	367,828	296,920	227,193	367,860	295,067	228,535	353,423	285,453	221,348
CO2, lb/MBtu (LHV)	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0
CO2, lb/MBtu (HHV)	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.4
Post Combustion Emissions Control Equipment									
Catalytic Conversion in CO Catalyst									
CO removed in CO Catalyst, %wt	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
CO removed in CO Catalyst, lb/h	42.3	34.2	27.2	42.3	34.0	26.3	40.7	32.9	25.5
VOC removed in CO Catalyst, %wt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
VOC removed in CO Catalyst, lb/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selective Catalytic Reduction (SCR)									
NOx Removed in SCR, %wt	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%
NOx removed in SCR, lb/h	326.2	260.7	197.6	326.2	259.1	198.7	313.5	250.6	192.5
Ammonia Slip, lb/h	32.0	25.8	19.8	32.0	25.7	19.9	30.7	24.8	19.2

Notes:

1. EMISSIONS ARE PRELIMINARY. NO GUARANTEES APPLY, NO MARGINS APPLIED.
2. The dry air composition used is 0.98% Ar, 78.03% N2 and 20.99%O2
3. Standard conditions are defined as 60 F, 14.696 psia, Norm conditions are defined as 0 C, 1.103 bar
4. All ppm values are based on CH4 calibration gas.
5. The CTG performance and emissions are based on runs provided by GE dated 2/25/2010
6. The distillate oil used in estimates contains 15 ppm by weight sulfur content.
7. The VOC/UHC ratio is base on CTG performance data provided by GE dated 2/25/2010
8. Effect of SCR and CO catalyst are included.
9. The front half catch of particulate emissions is assumed to be half the amount of the front and back half catch.
10. Where manufacturer data of lb/h of pollutant emissions were available, the greater of the manufacturer's estimate and B&V's estimate was used in the summary table, i.e. the B&V estimates were adjusted, where applicable.
11. The estimated oxidation of SO2 in CTG is based on performance data provided by GE. The SO2 - SO3 conversion in the CO catalyst is assumed to be 60%.
12. The CO catalyst was designed to reduce the CO Stack emissions by 50% for all operating scenarios. While there was no VOC reduction.
13. The SCR was designed to reduce the NOx stack emissions to 5 ppmvd @ 15%O2 for distillate oil.
14. Tempering air mass flowrate controlled to limit stack exit temperature to 800F for all cases, with a minimum allowable flowrate of 13,500 lb/hr.
15. Tempering air has been assumed to not contribute to stack emissions.
16. The conceptual design does not include a SO2 scrubber because SO2 scrubbers are not applicable to simple cycle or combined cycle combustion turbine power generation facilities.
17. Editorial only changes were made by J. M. Hurt on July 21, 2010.

ADDITIONAL CALCULATIONS MADE BY URS USING ABOVE DATA

Information used to compare values with emission standards (federal, state, local, and NSPS)									
Stack Flow, scfm(dry) @ 7% O2	1,092,696	925,025	770,528	1,138,341	957,475	807,548	1,148,461	975,328	822,640
PM10, grains/dscf @ 7% O2	0.0023	0.0026	0.0030	0.0022	0.0025	0.0029	0.0022	0.0025	0.0028
lb NOx/MWhr	0.20	0.21	0.24	0.20	0.21	0.24	0.20	0.22	0.25
lb SO2/MWhr	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Max PM10 gr/dscf	0.0030								
Max lb NOx/MWhr	0.25								
Max lb SO2/MWhr	0.01								

06-Dec-10
Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE 7FA.04 - NG - 2.25 grains/100 scf Sulfur, Revision 2

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	55%	100%	75%	53%	100%	75%	59%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Ambient Conditions									
Ambient Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
Ambient Relative Humidity, %	40.0	40.0	40.0	75.0	75.0	75.0	30.0	30.0	30.0
Atmospheric Pressure, psia	14.680	14.680	14.680	14.680	14.680	14.680	14.680	14.680	14.680
Combustion Turbine Performance									
CTG Performance Reference	GE	GE	GE	GE	GE	GE	GE	GE	GE
CTG Inlet Air Conditioning Effectiveness, %	0	0	0	0	0	0	0	0	0
CTG Compressor Inlet Dry Bulb Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
CTG Compr. Inlet Relative Humidity, %	40.5	40.5	40.5	75.1	75.1	75.1	30.2	30.2	30.2
Inlet Loss, in. H2O	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Exhaust Loss, in. H2O	10.8	7.3	5.5	10.3	6.9	5.0	8.8	6.0	5.0
CTG Load Level (percent of Base Load)	100%	75%	55%	100%	75%	53%	100%	75%	59%
Gross CTG Output, kW	196,900	147,700	108,300	186,900	140,200	99,100	163,400	122,500	96,400
Gross CTG Heat Rate, Btu/kWh (LHV)	8,825	9,605	11,055	8,955	9,695	11,405	9,225	10,185	11,395
Gross CTG Heat Rate, Btu/kWh (HHV)	9,798	10,663	12,273	9,942	10,763	12,662	10,242	11,307	12,651
CTG Heat Input, MBtu/h (LHV)	1,737.6	1,418.7	1,197.3	1,673.7	1,359.2	1,130.2	1,507.4	1,247.7	1,098.5
CTG Heat Input, MBtu/h (HHV)	1,929.1	1,575.0	1,329.2	1,858.1	1,509.0	1,254.8	1,673.5	1,385.2	1,219.5
CTG Water/Steam Injection Flow, lb/h	0	0	0	0	0	0	0	0	0
Injection Fluid/Fuel Ratio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTG Exhaust Flow, lb/h	3,725,000	3,038,000	2,616,000	3,606,000	2,933,000	2,484,000	3,312,000	2,725,000	2,460,000
CTG Exhaust Temperature, F	1,082	1,119	1,165	1,118	1,150	1,204	1,147	1,194	1,215
Combustion Turbine Fuel									
Total CTG Fuel Flow, lb/h	82,190	67,100	56,630	79,160	64,290	53,460	71,290	59,010	51,950
CTG Fuel Temperature, F	77	77	77	77	77	77	77	77	77
CTG Fuel LHV, Btu/lb	21,143	21,143	21,143	21,143	21,143	21,143	21,143	21,143	21,143
CTG Fuel HHV, Btu/lb	23,473	23,473	23,473	23,473	23,473	23,473	23,473	23,473	23,473
HHV/LHV Ratio	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102
CTG Fuel Composition (Ultimate Analysis by Weight)									
Ar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%
H2	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%
N2	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%
O2	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%
S	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Combustion Turbine Exhaust									
CTG Exhaust Analysis (Volume Basis - Wet)									
Ar	0.94%	0.94%	0.94%	0.93%	0.93%	0.93%	0.93%	0.93%	0.93%
CO2	3.88%	3.89%	3.81%	3.85%	3.85%	3.78%	3.77%	3.79%	3.70%
H2O	7.72%	7.73%	7.58%	8.49%	8.48%	8.35%	8.73%	8.77%	8.59%
N2	74.99%	74.98%	75.04%	74.36%	74.36%	74.41%	74.11%	74.10%	74.17%
O2	12.47%	12.46%	12.63%	12.36%	12.38%	12.53%	12.46%	12.41%	12.61%
SO2, (after SO2 oxidation)	0.00014%	0.00014%	0.00014%	0.00014%	0.00014%	0.00014%	0.00014%	0.00014%	0.00013%
SO3, (after SO2 oxidation)	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Molecular Wt, lb/mol	28.47	28.47	28.48	28.39	28.39	28.40	28.35	28.35	28.36
Specific Volume, ft^3/lb	38.55	39.81	41.13	39.62	40.75	42.30	40.54	42.01	42.63
Specific Volume, scf/lb	13.32	13.32	13.32	13.37	13.37	13.36	13.38	13.38	13.38
Exhaust Gas Flow, acfm	2,393,313	2,015,713	1,793,268	2,381,162	1,991,996	1,751,220	2,237,808	1,907,954	1,747,830
Exhaust Gas Flow, scfm	826,950	674,436	580,752	803,537	653,570	553,104	738,576	607,675	548,580
CTG NOx Emissions (Without Post Combustion Emissions Control)									
NOx Massflow Added to Match CTG Manufacturer's NOx Emissions Estimate, lb/h	0.30	0.00	0.00	0.30	0.00	0.00	0.28	0.00	0.00
Additonal Percent Margin included in mass based NOx Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
NOx, ppmvd (dry, 15% O2)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
NOx, ppmvd (dry)	11.23	11.25	11.01	11.24	11.22	11.00	11.03	11.10	10.81
NOx, ppmvw (wet)	10.37	10.38	10.17	10.28	10.27	10.08	10.07	10.13	9.88
NOx, lb/h as NO2	62.7	50.9	43.0	60.4	48.8	40.6	54.4	44.8	39.4
NOx, lb/MBtu (LHV)	0.0361	0.0359	0.0359	0.0361	0.0359	0.0359	0.0361	0.0359	0.0359
NOx, lb/MBtu (HHV)	0.0325	0.0323	0.0323	0.0325	0.0323	0.0323	0.0325	0.0323	0.0323
CTG CO Emissions (Without Post Combustion Emissions Control)									
CO Massflow Added to Match CTG Manufacturer's CO Emissions Estimate, lb/h	0.00	0.00	0.00	0.00	0.06	0.00	0.02	0.00	0.01
Additional Percent Margin included in mass based CO Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
CO, ppmvd (dry, 15% O2)	7.21	7.20	7.36	7.21	7.22	7.38	7.34	7.29	7.49
CO, ppmvd (dry)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
CO, ppmvw (wet)	8.31	8.30	8.32	8.24	8.24	8.25	8.21	8.21	8.23
CO, lb/h	30.4	24.8	21.4	29.3	23.9	20.2	26.9	22.1	20.0
CO, lb/MBtu (LHV)	0.0175	0.0175	0.0179	0.0175	0.0176	0.0179	0.0178	0.0177	0.0182
CO, lb/MBtu (HHV)	0.0158	0.0158	0.0161	0.0158	0.0158	0.0161	0.0161	0.0160	0.0164
CTG SO2 Emissions (After SO2 Oxydation, Without Post Combustion Emissions Control)									
SO2 massflow (lb/h) added to match CTG manufacturer's lb/h SO2 emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h SO2 Emissions below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CTG, vol%	6.1%	6.0%	6.2%	6.0%	6.3%	6.1%	6.3%	6.4%	6.3%
SO2, ppmvd (dry, 15% O2)	1.2105	1.2121	1.2095	1.2116	1.2088	1.2107	1.2080	1.2075	1.2084
SO2, ppmvd (dry)	1.5110	1.5147	1.4794	1.5128	1.5069	1.4801	1.4809	1.4898	1.4517
SO2, ppmvw (wet)	1.3944	1.3976	1.3673	1.3843	1.3790	1.3565	1.3516	1.3591	1.3270
SO2, lb/h	11.6854	9.5526	8.0447	11.2648	9.1275	7.6018	10.1142	8.3684	7.3731
SO2, lb/MBtu (LHV)	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
SO2, lb/MBtu (HHV)	0.0061	0.0061	0.0061	0.0061	0.0060	0.0061	0.0060	0.0060	0.0060
CTG UHC Emissions (Without Post Combustion Emissions Control)									
UHC massflow (lb/h) added to match CTG manufacturer's lb/h CO emissions estimate	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Additional Percent Margin included in lb/h UHC Emissions Below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UHC, ppmvd (dry, 15% O2)	6.1	6.1	6.2	6.1	6.1	6.2	6.3	6.2	6.4
UHC, ppmvd (dry)	7.6	7.6	7.6	7.6	7.6	7.6	7.7	7.7	7.7
UHC, ppmvw (wet)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
UHC, lb/h as CH4	14.7	12.0	10.3	14.3	11.6	9.8	13.1	10.8	9.7
UHC, lb/MBtu as CH4 (LHV)	0.0085	0.0084	0.0086	0.0085	0.0085	0.0087	0.0087	0.0087	0.0089
UHC, lb/MBtu as CH4 (HHV)	0.0076	0.0076	0.0078	0.0077	0.0077	0.0078	0.0078	0.0078	0.0080
CTG VOC Emissions (Without Post Combustion Emissions Control)									
VOC Massflow (lb/h) added to match CTG manufacturer's lb/h VOC emissions estimate	0.00	0.00	0.04	0.00	0.00	0.04	0.00	0.04	0.00
Additional percent margin included in lb/h VOC emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
VOC percentage of UHC	20%	20%	20%	20%	20%	20%	20%	20%	20%
VOC, ppmvd (dry, 15% O2)	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.3
VOC, ppmvd (dry)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
VOC, ppmvw (wet)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
VOC, lb/h as CH4	2.9	2.4	2.1	2.9	2.3	2.0	2.6	2.2	1.9
VOC, lb/MBtu as CH4 (LHV)	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0018
VOC, lb/MBtu as CH4 (HHV)	0.0015	0.0015	0.0016	0.0015	0.0015	0.0016	0.0016	0.0016	0.0016

06-Dec-10
Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE 7FA.04 - NG - 2.25 grains/100 scf Sulfur, Revision 2

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	55%	100%	75%	53%	100%	75%	59%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
CTG PM10 Emissions (without the Effects of SO2 Oxidation)									
Percent margin included in PM10 emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	10.8	10.3	10.1	10.6	10.3	10.1	10.4	10.2	10.0
PM10, lb/MBtu (LHV)	0.0061	0.0073	0.0084	0.0063	0.0075	0.0089	0.0069	0.0081	0.0091
PM10, lb/MBtu (HHV)	0.0055	0.0065	0.0076	0.0057	0.0068	0.0080	0.0062	0.0073	0.0082
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	21.2	20.6	20.2	21.1	20.5	20.1	20.8	20.3	20.0
PM10, lb/MBtu (LHV)	0.0122	0.0145	0.0169	0.0126	0.0151	0.0178	0.0138	0.0163	0.0182
PM10, lb/MBtu (HHV)	0.0110	0.0131	0.0152	0.0114	0.0136	0.0160	0.0124	0.0147	0.0164
CO2 Emissions									
CO2, lb/hr	223,538	182,497	154,021	215,297	174,854	145,399	193,893	160,494	141,292
CO2, lb/MBtu (LHV)	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6
CO2, lb/MBtu (HHV)	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9
Stack Emissions									
Stack Exhaust Analysis - Volume Basis - Wet									
Ar	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.94%	0.94%	0.95%
CO2	2.79%	2.69%	2.52%	2.62%	2.53%	2.36%	2.45%	2.35%	2.25%
H2O	5.56%	5.37%	5.04%	6.08%	5.91%	5.57%	6.14%	5.94%	5.74%
N2	75.83%	75.90%	76.03%	75.30%	75.36%	75.49%	75.12%	75.20%	75.28%
O2	14.87%	15.09%	15.45%	15.06%	15.25%	15.62%	15.35%	15.57%	15.79%
SO2 (after SO2 oxidation)	0.000040%	0.000040%	0.000040%	0.000040%	0.000040%	0.000030%	0.000030%	0.000030%	0.000030%
SO3 (after SO2 oxidation)	0.000070%	0.000070%	0.000060%	0.000060%	0.000060%	0.000060%	0.000060%	0.000060%	0.000050%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Stack Exit Temperature, F	800	799	799	800	800	799	800	799	800
Stack Diameter, ft (estimated)	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
Stack Flow, lb/h	5,214,994	4,416,995	3,976,996	5,329,995	4,476,996	3,997,996	5,128,995	4,428,996	4,077,996
Stack Flow, scfm	1,152,515	975,421	878,254	1,180,595	991,656	884,891	1,136,928	981,762	903,277
Stack Flow, acfm	2,795,240	2,366,040	2,129,021	2,864,875	2,405,641	2,146,260	2,758,547	2,380,588	2,191,245
Stack Exit Velocity, ft/s	135.0	114.0	102.0	138.0	116.0	103.0	133.0	115.0	105.0
Stack NOx Emissions without the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
NOx, ppmvd (dry)	7.9	7.6	7.1	7.4	7.2	6.7	7.0	6.7	6.4
NOx, ppmvw (wet)	7.4	7.2	6.7	7.0	6.8	6.3	6.5	6.3	6.0
NOx, lb/h as NO2 (includes correction adder)	62.7	50.9	43.0	60.4	48.8	40.6	54.4	44.8	39.4
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0361	0.0359	0.0359	0.0361	0.0359	0.0359	0.0361	0.0359	0.0359
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0325	0.0323	0.0323	0.0325	0.0323	0.0323	0.0325	0.0323	0.0323
Stack NOx Emissions with the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
NOx, ppmvd (dry)	2.2	2.1	2.0	2.1	2.0	1.9	1.9	1.9	1.8
NOx, ppmvw (wet)	2.1	2.0	1.9	1.9	1.9	1.8	1.8	1.7	1.7
NOx, lb/h as NO2 (includes NOx margin applied to CTG)	17.4	14.2	11.9	16.8	13.6	11.3	15.1	12.4	11.0
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090
SCR NH3 slip, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
SCR NH3 slip, lb/h	25.7	21.0	17.7	24.7	20.1	16.7	22.3	18.4	16.2
Stack CO Emissions without the Effects of Catalytic Reduction									
CO, ppmvd (dry, 15% O2)	7.2	7.2	7.4	7.2	7.2	7.4	7.3	7.3	7.5
CO, ppmvd (dry)	6.3	6.1	5.8	6.0	5.8	5.5	5.7	5.4	5.3
CO, ppmvw (wet)	6.0	5.7	5.5	5.8	5.4	5.2	5.3	5.1	5.0
CO, lb/h (includes CO correction as applied to CTG and margin)	30.4	24.8	21.4	29.3	23.9	20.2	26.9	22.1	20.0
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0175	0.0175	0.0179	0.0175	0.0176	0.0179	0.0178	0.0177	0.0182
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0158	0.0158	0.0161	0.0158	0.0158	0.0161	0.0161	0.0160	0.0164
Stack CO Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
CO, ppmvd (dry, 15% O2)	3.8	3.8	3.9	3.8	3.9	3.9	3.9	3.9	4.0
CO, ppmvd (dry)	3.4	3.2	3.1	3.2	3.1	2.9	3.0	2.9	2.8
CO, ppmvw (wet)	3.2	3.1	2.9	3.0	2.9	2.8	2.8	2.7	2.7
CO, lb/h (includes CO margin applied to CTG)	16.2	13.2	11.4	15.6	12.7	10.8	14.3	11.8	10.7
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0093	0.0093	0.0095	0.0093	0.0094	0.0095	0.0095	0.0094	0.0097
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0084	0.0084	0.0086	0.0084	0.0084	0.0086	0.0086	0.0085	0.0087
Stack SO2 Emissions without the Effects of SO2 Scrubber, without SO2 Oxidation									
Assumed SO2 oxidation rate in CTG, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CO Catalyst, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in SCR, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SO2, ppmvd (dry, 15% O2)	1.2894	1.2894	1.2894	1.2894	1.2894	1.2894	1.2894	1.2895	1.2894
SO2, ppmvd (dry)	1.6094	1.6113	1.5771	1.6099	1.6074	1.5763	1.5807	1.5909	1.5490
SO2, ppmvw (wet)	1.4852	1.4867	1.4576	1.4732	1.4709	1.4447	1.4427	1.4513	1.4159
SO2, lb/h	12.4467	10.1615	8.5760	11.9879	9.7360	8.0959	10.7961	8.9364	7.8672
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0072	0.0072	0.0071
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0065	0.0065	0.0065	0.0065	0.0064	0.0065	0.0064	0.0064	0.0064
Stack SO2 Emissions without the Effects of SO2 Scrubber, after SO2 Oxidation									
Assumed SO2 oxidation rate in CO Catalyst, vol%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
Assumed SO2 oxidation rate in SCR, vol%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SO2, ppmvd (dry, 15% O2)	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
SO2, ppmvd (dry)	0.41	0.40	0.37	0.39	0.37	0.35	0.36	0.35	0.33
SO2, ppmvw (wet)	0.39	0.37	0.35	0.37	0.35	0.33	0.34	0.33	0.31
SO2, lb/h	4.53	3.71	3.12	4.37	3.54	2.95	3.92	3.25	2.86
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0024	0.0024	0.0023	0.0024	0.0023	0.0024	0.0023	0.0023	0.0023
Stack UHC Emissions									
UHC, ppmvd (dry, 15% O2)	6.1	6.1	6.2	6.1	6.1	6.2	6.3	6.2	6.4
UHC, ppmvd	5.3	5.1	4.9	5.1	4.9	4.6	4.8	4.6	4.5
UHC, ppmvw	5.0	4.8	4.6	4.8	4.6	4.4	4.5	4.3	4.2
UHC, lb/h as CH4 (includes correction adder)	14.7	12.0	10.3	14.3	11.6	9.8	13.1	10.8	9.7
UHC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0085	0.0084	0.0086	0.0085	0.0085	0.0087	0.0087	0.0087	0.0089
UHC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0076	0.0076	0.0078	0.0077	0.0077	0.0078	0.0078	0.0078	0.0080
Stack VOC Emissions without the Effect of Oxidation in a CO catalyst									
VOC, ppmvd (dry, 15% O2)	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.3
VOC, ppmvd (dry)	1.1	1.0	1.0	1.0	1.0	0.9	1.0	0.9	0.9
VOC, ppmvw (wet)	1.0	1.0	0.9	1.0	0.9	0.9	0.9	0.9	0.8
VOC, lb/h as CH4 (includes correction adder)	2.9	2.4	2.1	2.9	2.3	2.0	2.6	2.2	1.9
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0017	0.0017	0.0018	0.0017	0.0017	0.0018	0.0017	0.0018	0.0018
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0015	0.0015	0.0016	0.0015	0.0015	0.0016	0.0016	0.0016	0.0016
Stack VOC Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
VOC, ppmvd (dry, 15% O2)	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.3
VOC, ppmvd (dry)	1.1	1.0	1.0	1.0	1.0	0.9	1.0	0.9	0.9
VOC, ppmvw (wet)	1.0	1.0	0.9	1.0	0.9	0.9	0.9	0.9	0.8
VOC, lb/h as CH4 (includes VOC correction as applied to CTG)	2.9	2.4	2.1	2.9	2.3	2.0	2.6	2.2	1.9
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0017	0.0017	0.0018	0.0017	0.0017	0.0018	0.0017	0.0018	0.0018
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0015	0.0015	0.0016	0.0015	0.0015	0.0016	0.0016	0.0016	0.0016

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Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	55%	100%	75%	53%	100%	75%	59%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperatura, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
PM10 without the Effects of SO2 oxidation									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	10.6	10.3	10.1	10.6	10.3	10.1	10.4	10.2	10.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0061	0.0073	0.0084	0.0063	0.0075	0.0089	0.0069	0.0081	0.0091
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0055	0.0065	0.0076	0.0057	0.0068	0.0080	0.0062	0.0073	0.0082
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	21.2	20.6	20.2	21.1	20.5	20.1	20.8	20.3	20.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0122	0.0145	0.0169	0.0126	0.0151	0.0178	0.0138	0.0163	0.0182
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0110	0.0131	0.0152	0.0114	0.0136	0.0160	0.0124	0.0147	0.0164
PM10 with the Effects of SO2 Oxidation [Includes (NH4)2-(SO4)]									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	26.9	23.6	21.4	26.3	23.0	20.7	24.6	21.9	20.3
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0155	0.0166	0.0178	0.0157	0.0169	0.0183	0.0163	0.0175	0.0185
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0140	0.0150	0.0161	0.0141	0.0153	0.0165	0.0147	0.0158	0.0167
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	37.5	33.9	31.5	36.8	33.3	30.7	35.0	32.0	30.3
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0216	0.0239	0.0263	0.0220	0.0245	0.0272	0.0232	0.0257	0.0276
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0195	0.0215	0.0237	0.0198	0.0221	0.0245	0.0209	0.0231	0.0249
Total Effects of SO2 Oxidation									
Total SO2 to SO3 conversion rate, %vol	63.6%	63.5%	63.6%	63.5%	63.6%	63.6%	63.7%	63.7%	63.6%
Total Amount of SO2 converted to SO3, lb/h	7.91	6.46	5.45	7.62	6.19	5.15	6.87	5.69	5.01
Maximum Stack Ammonium Sulfate [(NH4)2-(SO4)] (assuming 100% conversion from SO3), lb	16.32	13.32	11.25	15.71	12.78	10.62	14.17	11.74	10.33
Maximum Stack H2SO4 (assuming 100% conversion from SO3 to H2SO4), lb/h	12.11	9.88	8.35	11.66	9.48	7.88	10.52	8.71	7.66
CO2 Emissions									
CO2, lb/hr	223,538	182,497	154,021	215,297	174,854	145,399	193,893	160,494	141,292
CO2, lb/MBtu (LHV)	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6
CO2, lb/MBtu (HHV)	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9
Post Combustion Emissions Control Equipment									
Catalytic Conversion in CO Catalyst									
CO removed in CO Catalyst, %wt	46.7%	46.7%	46.7%	46.7%	46.7%	46.7%	46.7%	46.7%	46.7%
CO removed in CO Catalyst, lb/h	14.2	11.6	10.0	13.7	11.2	9.4	12.6	10.3	9.3
VOC removed in CO Catalyst, %wt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
VOC removed in CO Catalyst, lb/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selective Catalytic Reduction (SCR)									
NOx Removed in SCR, %wt	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%
NOx removed in SCR, lb/h	45.3	36.8	31.0	43.6	35.2	29.3	39.3	32.4	28.5
Ammonia Slip, lb/h	25.7	21.0	17.7	24.7	20.1	16.7	22.3	18.4	16.2

Notes:

1. EMISSIONS ARE PRELIMINARY. NO GUARANTEES APPLY. NO MARGINS APPLIED.
2. The dry air composition used is 0.98% Ar, 78.03% N2 and 20.99%O2
3. Standard conditions are defined as 60 F, 14.696 psia, Norm conditions are defined as 0 C, 1.103 bar
4. All ppm values are based on CH4 calibration gas.
5. The CTG performance and emissions are based on runs provided by GE dated 7/15/2010
6. The natural gas used in estimates contains 2.25 grains/100 SCF of sulfur content.
7. The VOC/UHC ratio is base on CTG performance data provided by GE dated 7/15/2010
8. Effect of SCR and CO catalyst are included.
9. The front half catch of particulate emissions is assumed to be half the amount of the front and back half catch.
10. Where manufacturer data of lb/h of pollutant emissions were available, the greater of the manufacturer's estimate and B&V's estimate was used in the summary table, i.e. the B&V estimates were adjusted, where applicable.
11. The estimated oxidation of SO2 in CTG is based on performance data provided by GE. The SO2 - SO3 conversion in the CO catalyst is assumed to be 60%.
12. The CO catalyst was designed to reduce the CO Stack emissions by 46.7% for all operating scenarios. While there was no VOC reduction.
13. The SCR was designed to reduce the NOx stack emissions to 2.5 ppmvd @ 15%O2 for natural gas
14. Tempering air mass flowrate controlled to limit stack exit temperature to 800F for all cases, with a minimum allowable flowrate of 13,500 lb/hr.
15. Tempering air has been assumed to not contribute to stack emissions.

ADDITIONAL CALCULATIONS MADE BY URS USING ABOVE DATA

Information used to compare values with emission standards (federal, state, local, and NSPS):

lb NOx/MWhr	0.09	0.10	0.11	0.09	0.10	0.11	0.09	0.10	0.11
lb SO2/MWhr	0.02	0.02	0.03	0.02	0.03	0.03	0.02	0.03	0.03
Max lb NOx/MWhr	0.11								
Max lb SO2/MWhr	0.03								

06-Dec-10
Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE 7FA.04 - NG - 3.48 grains/100 scf Sulfur, Revision 2

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	55%	100%	75%	53%	100%	75%	59%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
Ambient Conditions									
Ambient Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
Ambient Relative Humidity, %	40.0	40.0	40.0	75.0	75.0	75.0	30.0	30.0	30.0
Atmospheric Pressure, psia	14.680	14.680	14.680	14.680	14.680	14.680	14.680	14.680	14.680
Combustion Turbine Performance									
CTG Performance Reference	GE	GE	GE	GE	GE	GE	GE	GE	GE
CTG Inlet Air Conditioning Effectiveness, %	0	0	0	0	0	0	0	0	0
CTG Compressor Inlet Dry Bulb Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
CTG Compr. Inlet Relative Humidity, %	40.5	40.5	40.5	75.1	75.1	75.1	30.2	30.2	30.2
Inlet Loss, in. H2O	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Exhaust Loss, in. H2O	10.8	7.3	5.5	10.3	6.9	5.0	8.8	6.0	5.0
CTG Load Level (percent of Base Load)	100%	75%	55%	100%	75%	53%	100%	75%	59%
Gross CTG Output, kW	196,900	147,700	108,300	186,900	140,200	99,100	163,400	122,500	96,400
Gross CTG Heat Rate, Btu/kWh (LHV)	8,825	9,605	11,055	8,955	9,695	11,405	9,225	10,185	11,395
Gross CTG Heat Rate, Btu/kWh (HHV)	9,798	10,664	12,273	9,942	10,763	12,662	10,242	11,307	12,651
CTG Heat Input, MBtu/h (LHV)	1,737.6	1,418.7	1,197.3	1,673.7	1,359.2	1,130.2	1,507.4	1,247.7	1,098.5
CTG Heat Input, MBtu/h (HHV)	1,929.1	1,575.0	1,329.2	1,858.1	1,509.0	1,254.8	1,673.5	1,385.2	1,219.5
CTG Water/Steam Injection Flow, lb/h	0	0	0	0	0	0	0	0	0
Injection Fluid/Fuel Ratio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTG Exhaust Flow, lb/h	3,725,000	3,038,000	2,616,000	3,606,000	2,933,000	2,484,000	3,312,000	2,725,000	2,460,000
CTG Exhaust Temperature, F	1,082	1,119	1,165	1,118	1,150	1,204	1,147	1,194	1,215
Combustion Turbine Fuel									
Total CTG Fuel Flow, lb/h	82,190	67,100	56,630	79,160	64,290	53,460	71,300	59,010	51,960
CTG Fuel Temperature, F	77	77	77	77	77	77	77	77	77
CTG Fuel LHV, Btu/lb	21,142	21,142	21,142	21,142	21,142	21,142	21,142	21,142	21,142
CTG Fuel HHV, Btu/lb	23,472	23,472	23,472	23,472	23,472	23,472	23,472	23,472	23,472
HHV/LHV Ratio	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102
CTG Fuel Composition (Ultimate Analysis by Weight)									
Ar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%
H2	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%
N2	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%
O2	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%
S	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
Combustion Turbine Exhaust									
CTG Exhaust Analysis (Volume Basis - Wet)									
Ar	0.94%	0.94%	0.94%	0.93%	0.93%	0.93%	0.93%	0.93%	0.93%
CO2	3.88%	3.89%	3.81%	3.85%	3.85%	3.78%	3.77%	3.79%	3.70%
H2O	7.72%	7.73%	7.58%	8.49%	8.48%	8.35%	8.73%	8.77%	8.59%
N2	74.99%	74.98%	75.04%	74.36%	74.36%	74.41%	74.11%	74.10%	74.17%
O2	12.47%	12.46%	12.63%	12.36%	12.38%	12.53%	12.45%	12.41%	12.61%
SO2, (after SO2 oxidation)	0.00022%	0.00022%	0.00021%	0.00021%	0.00021%	0.00021%	0.00021%	0.00021%	0.00021%
SO3, (after SO2 oxidation)	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Molecular Wt, lb/mol	28.47	28.47	28.48	28.39	28.39	28.40	28.35	28.35	28.36
Specific Volume, ft^3/lb	38.55	39.81	41.13	39.62	40.75	42.30	40.54	42.01	42.63
Specific Volume, scf/lb	13.32	13.32	13.32	13.37	13.37	13.38	13.38	13.38	13.38
Exhaust Gas Flow, acfm	2,393,313	2,015,713	1,793,268	2,381,162	1,991,996	1,751,220	2,237,808	1,907,954	1,747,830
Exhaust Gas Flow, scfm	826,950	674,436	580,752	803,537	653,570	553,104	738,576	607,675	548,580
CTG NOx Emissions (Without Post Combustion Emissions Control)									
NOx Massflow Added to Match CTG Manufacturer's NOx Emissions Estimate, lb/h	0.31	0.00	0.00	0.31	0.00	0.00	0.27	0.00	0.00
Additonal Percent Margin included in mass based NOx Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
NOx, ppmvd (dry, 15% O2)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
NOx, ppmvd (dry)	11.23	11.25	11.01	11.24	11.22	11.00	11.03	11.10	10.81
NOx, ppmvw (wet)	10.37	10.38	10.17	10.28	10.27	10.08	10.07	10.13	9.88
NOx, lb/h as NO2	62.7	50.9	43.0	60.4	48.8	40.6	54.4	44.8	39.4
NOx, lb/MBtu (LHV)	0.0361	0.0359	0.0359	0.0361	0.0359	0.0359	0.0361	0.0359	0.0359
NOx, lb/MBtu (HHV)	0.0325	0.0323	0.0323	0.0325	0.0323	0.0323	0.0325	0.0323	0.0323
CTG CO Emissions (Without Post Combustion Emissions Control)									
CO Massflow Added to Match CTG Manufacturer's CO Emissions Estimate, lb/h	0.00	0.00	0.00	0.00	0.06	0.00	0.02	0.00	0.01
Additional Percent Margin included in mass based CO Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
CO, ppmvd (dry, 15% O2)	7.21	7.20	7.36	7.21	7.22	7.36	7.34	7.29	7.49
CO, ppmvd (dry)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
CO, ppmvw (wet)	8.31	8.30	8.32	8.24	8.24	8.25	8.21	8.21	8.23
CO, lb/h	30.4	24.8	21.4	29.3	23.9	20.2	26.9	22.1	20.0
CO, lb/MBtu (LHV)	0.0175	0.0175	0.0179	0.0175	0.0176	0.0179	0.0178	0.0177	0.0182
CO, lb/MBtu (HHV)	0.0158	0.0158	0.0161	0.0158	0.0158	0.0161	0.0161	0.0160	0.0164
CTG SO2 Emissions (After SO2 Oxydation, Without Post Combustion Emissions Control)									
SO2 massflow (lb/h) added to match CTG manufacturer's lb/h SO2 emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h SO2 Emissions below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CTG, vol%	6.1%	6.0%	6.2%	6.0%	6.3%	6.1%	6.3%	6.4%	6.3%
SO2, ppmvd (dry, 15% O2)	1.8709	1.8734	1.8693	1.8726	1.8682	1.8711	1.8669	1.8661	1.8676
SO2, ppmvd (dry)	2.3352	2.3408	2.2864	2.3379	2.3288	2.2874	2.2890	2.3024	2.2441
SO2, ppmvw (wet)	2.1550	2.1600	2.1132	2.1393	2.1312	2.0965	2.0892	2.1004	2.0512
SO2, lb/h	18.0593	14.7631	12.4327	17.4092	14.1061	11.7482	15.6332	12.9329	11.3970
SO2, lb/MBtu (LHV)	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104
SO2, lb/MBtu (HHV)	0.0094	0.0094	0.0094	0.0094	0.0093	0.0094	0.0093	0.0093	0.0093
CTG UHC Emissions (Without Post Combustion Emissions Control)									
UHC massflow (lb/h) added to match CTG manufacturer's lb/h CO emissions estimate	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Additional Percent Margin included in lb/h UHC Emissions Below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UHC, ppmvd (dry, 15% O2)	6.1	6.1	6.2	6.1	6.1	6.2	6.3	6.2	6.4
UHC, ppmvd (dry)	7.6	7.6	7.6	7.6	7.6	7.6	7.7	7.7	7.7
UHC, ppmvw (wet)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
UHC, lb/h as CH4	14.7	12.0	10.3	14.3	11.6	9.8	13.1	10.8	9.7
UHC, lb/MBtu as CH4 (LHV)	0.0085	0.0084	0.0086	0.0085	0.0085	0.0087	0.0087	0.0087	0.0089
UHC, lb/MBtu as CH4 (HHV)	0.0076	0.0076	0.0078	0.0077	0.0077	0.0078	0.0078	0.0078	0.0080
CTG VOC Emissions (Without Post Combustion Emissions Control)									
VOC Massflow (lb/h) added to match CTG manufacturer's lb/h VOC emissions estimate	0.00	0.00	0.04	0.00	0.00	0.04	0.00	0.04	0.00
Additional percent margin included in lb/h VOC emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
VOC percentage of UHC	20%	20%	20%	20%	20%	20%	20%	20%	20%
VOC, ppmvd (dry, 15% O2)	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.3
VOC, ppmvd (dry)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
VOC, ppmvw (wet)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
VOC, lb/h as CH4	2.9	2.4	2.1	2.9	2.3	2.0	2.6	2.2	1.9
VOC, lb/MBtu as CH4 (LHV)	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0018
VOC, lb/MBtu as CH4 (HHV)	0.0015	0.0015	0.0016	0.0015	0.0015	0.0016	0.0016	0.0016	0.0016

06-Dec-10
Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE 7FA.04 - NG - 3.48 grains/100 scf Sulfur, Revision 2

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	55%	100%	75%	53%	100%	75%	59%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
CTG PM10 Emissions (without the Effects of SO2 Oxidation)									
Percent margin included in PM10 emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	10.6	10.3	10.1	10.6	10.3	10.1	10.4	10.2	10.0
PM10, lb/MBtu (LHV)	0.0061	0.0073	0.0084	0.0063	0.0075	0.0089	0.0069	0.0081	0.0091
PM10, lb/MBtu (HHV)	0.0055	0.0065	0.0076	0.0057	0.0068	0.0080	0.0062	0.0073	0.0082
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	21.2	20.6	20.2	21.1	20.5	20.1	20.8	20.3	20.0
PM10, lb/MBtu (LHV)	0.0122	0.0145	0.0169	0.0126	0.0151	0.0178	0.0138	0.0163	0.0182
PM10, lb/MBtu (HHV)	0.0110	0.0131	0.0152	0.0114	0.0136	0.0160	0.0124	0.0147	0.0164
CO2 Emissions									
CO2, lb/hr	223,528	182,489	154,014	215,288	174,847	145,393	193,911	160,487	141,313
CO2, lb/MBtu (LHV)	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6
CO2, lb/MBtu (HHV)	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9
Stack Emissions									
Stack Exhaust Analysis - Volume Basis - Wet									
Ar	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.94%	0.94%	0.95%
CO2	2.79%	2.69%	2.52%	2.62%	2.53%	2.36%	2.45%	2.35%	2.25%
H2O	5.56%	5.37%	5.04%	6.08%	5.91%	5.57%	6.14%	5.94%	5.74%
N2	75.83%	75.90%	76.03%	75.30%	75.36%	75.49%	75.12%	75.20%	75.28%
O2	14.87%	15.09%	15.45%	15.06%	15.25%	15.62%	15.35%	15.57%	15.79%
SO2 (after SO2 oxidation)	0.000060%	0.000060%	0.000050%	0.000060%	0.000050%	0.000050%	0.000050%	0.000050%	0.000050%
SO3 (after SO2 oxidation)	0.000100%	0.000100%	0.000090%	0.000100%	0.000100%	0.000090%	0.000090%	0.000090%	0.000080%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Stack Exit Temperature, F	800	799	799	800	800	799	800	799	800
Stack Diameter, ft (estimated)	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
Stack Flow, lb/h	5,214,991	4,416,993	3,976,994	5,329,992	4,476,993	3,997,994	5,128,992	4,428,994	4,077,994
Stack Flow, scfm	1,152,515	975,421	877,591	1,180,595	991,656	884,891	1,136,928	981,762	903,277
Stack Flow, acfm	2,795,240	2,366,040	2,129,021	2,864,875	2,405,641	2,146,260	2,758,547	2,380,588	2,191,245
Stack Exit Velocity, ft/s	135.0	114.0	102.0	138.0	116.0	103.0	133.0	115.0	105.0
Stack NOx Emissions without the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
NOx, ppmvd (dry)	7.9	7.6	7.1	7.4	7.2	6.7	7.0	6.7	6.4
NOx, ppmvw (wet)	7.4	7.2	6.7	7.0	6.8	6.3	6.5	6.3	6.0
NOx, lb/h as NO2 (includes correction adder)	62.7	50.9	43.0	60.4	48.8	40.6	54.4	44.8	39.4
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0361	0.0359	0.0359	0.0361	0.0359	0.0359	0.0361	0.0359	0.0359
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0325	0.0323	0.0323	0.0325	0.0323	0.0323	0.0325	0.0323	0.0323
Stack NOx Emissions with the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
NOx, ppmvd (dry)	2.2	2.1	2.0	2.1	2.0	1.9	1.9	1.9	1.8
NOx, ppmvw (wet)	2.1	2.0	1.9	1.9	1.9	1.8	1.8	1.7	1.7
NOx, lb/h as NO2 (includes NOx margin applied to CTG)	17.4	14.1	11.9	16.8	13.6	11.3	15.1	12.4	11.0
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090
SCR NH3 slip, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
SCR NH3 slip, lb/h	25.7	21.0	17.7	24.7	20.1	16.7	22.3	18.4	16.2
Stack CO Emissions without the Effects of Catalytic Reduction									
CO, ppmvd (dry, 15% O2)	7.2	7.2	7.4	7.2	7.2	7.4	7.3	7.3	7.5
CO, ppmvd (dry)	6.3	6.1	5.8	6.0	5.8	5.5	5.7	5.4	5.3
CO, ppmvw (wet)	6.0	5.7	5.5	5.6	5.4	5.2	5.3	5.1	5.0
CO, lb/h (includes CO correction as applied to CTG and margin)	30.4	24.8	21.4	29.3	23.9	20.2	26.9	22.1	20.0
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0175	0.0175	0.0179	0.0175	0.0176	0.0179	0.0178	0.0177	0.0182
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0158	0.0158	0.0161	0.0158	0.0158	0.0161	0.0161	0.0160	0.0164
Stack CO Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
CO, ppmvd (dry, 15% O2)	3.8	3.8	3.9	3.8	3.9	3.9	3.9	3.9	4.0
CO, ppmvd (dry)	3.4	3.2	3.1	3.2	3.1	2.9	3.0	2.9	2.8
CO, ppmvw (wet)	3.2	3.1	2.9	3.0	2.9	2.8	2.8	2.7	2.7
CO, lb/h (includes CO margin applied to CTG)	16.2	13.2	11.4	15.6	12.7	10.8	14.3	11.8	10.7
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0093	0.0093	0.0095	0.0093	0.0094	0.0095	0.0095	0.0094	0.0097
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0084	0.0084	0.0086	0.0084	0.0084	0.0086	0.0086	0.0085	0.0087
Stack SO2 Emissions without the Effects of SO2 Scrubber, without SO2 Oxidation									
Assumed SO2 oxidation rate in CTG, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CO Catalyst, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in SCR, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SO2, ppmvd (dry, 15% O2)	1.9928	1.9928	1.9927	1.9928	1.9927	1.9927	1.9928	1.9928	1.9927
SO2, ppmvd (dry)	2.4873	2.4900	2.4374	2.4880	2.4841	2.4361	2.4433	2.4587	2.3945
SO2, ppmvw (wet)	2.2954	2.2977	2.2528	2.2766	2.2733	2.2328	2.2300	2.2430	2.1887
SO2, lb/h	19.2358	15.7042	13.2537	18.5267	15.0465	12.5118	16.6871	13.8107	12.1607
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0100	0.0100	0.0100	0.0100	0.0099	0.0100	0.0099	0.0099	0.0099
Stack SO2 Emissions without the Effects of SO2 Scrubber, after SO2 Oxidation									
Assumed SO2 oxidation rate in CO Catalyst, vol%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
Assumed SO2 oxidation rate in SCR, vol%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SO2, ppmvd (dry, 15% O2)	0.73	0.73	0.73	0.73	0.72	0.73	0.72	0.72	0.72
SO2, ppmvd (dry)	0.64	0.61	0.57	0.60	0.58	0.54	0.56	0.54	0.51
SO2, ppmvw (wet)	0.60	0.58	0.54	0.56	0.54	0.51	0.53	0.50	0.48
SO2, lb/h	7.01	5.73	4.82	6.75	5.47	4.56	6.07	5.02	4.42
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036
Stack UHC Emissions									
UHC, ppmvd (dry, 15% O2)	6.1	6.1	6.2	6.1	6.1	6.2	6.3	6.2	6.4
UHC, ppmvd	5.3	5.1	4.9	5.1	4.9	4.8	4.8	4.6	4.5
UHC, ppmvw	5.0	4.8	4.6	4.8	4.6	4.4	4.5	4.3	4.2
UHC, lb/h as CH4 (includes correction adder)	14.7	12.0	10.3	14.3	11.6	9.8	13.1	10.8	9.7
UHC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0085	0.0084	0.0086	0.0085	0.0085	0.0087	0.0087	0.0087	0.0089
UHC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0076	0.0076	0.0078	0.0077	0.0077	0.0078	0.0078	0.0078	0.0080
Stack VOC Emissions without the Effect of Oxidation in a CO catalyst									
VOC, ppmvd (dry, 15% O2)	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.3
VOC, ppmvd (dry)	1.1	1.0	1.0	1.0	1.0	0.9	1.0	0.9	0.9
VOC, ppmvw (wet)	1.0	1.0	0.9	1.0	0.9	0.9	0.9	0.9	0.8
VOC, lb/h as CH4 (includes correction adder)	2.9	2.4	2.1	2.9	2.3	2.0	2.6	2.2	1.9
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0017	0.0017	0.0018	0.0017	0.0017	0.0018	0.0017	0.0018	0.0018
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0015	0.0015	0.0016	0.0015	0.0015	0.0016	0.0016	0.0016	0.0016
Stack VOC Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
VOC, ppmvd (dry, 15% O2)	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.3
VOC, ppmvd (dry)	1.1	1.0	1.0	1.0	1.0	0.9	1.0	0.9	0.9
VOC, ppmvw (wet)	1.0	1.0	0.9	1.0	0.9	0.9	0.9	0.9	0.8
VOC, lb/h as CH4 (includes VOC correction as applied to CTG)	2.9	2.4	2.1	2.9	2.3	2.0	2.6	2.2	1.9
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0017	0.0017	0.0018	0.0017	0.0017	0.0018	0.0017	0.0018	0.0018
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0015	0.0015	0.0016	0.0015	0.0015	0.0016	0.0018	0.0016	0.0016

06-Dec-10
Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE 7FA.04 - NG - 3.48 grains/100 scf Sulfur, Revision 2

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	55%	100%	75%	53%	100%	75%	59%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
PM10 without the Effects of SO2 oxidation									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	10.6	10.3	10.1	10.6	10.3	10.1	10.4	10.2	10.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0061	0.0073	0.0084	0.0063	0.0075	0.0089	0.0069	0.0081	0.0091
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0055	0.0065	0.0076	0.0057	0.0068	0.0080	0.0062	0.0073	0.0082
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	21.2	20.6	20.2	21.1	20.5	20.1	20.8	20.3	20.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0122	0.0145	0.0169	0.0126	0.0151	0.0178	0.0138	0.0163	0.0182
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0110	0.0131	0.0152	0.0114	0.0136	0.0160	0.0124	0.0147	0.0164
PM10 with the Effects of SO2 Oxidation [includes (NH4)2-(SO4)]									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	35.8	30.9	27.5	34.8	30.0	26.5	32.3	28.3	26.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0206	0.0218	0.0230	0.0208	0.0221	0.0234	0.0214	0.0227	0.0236
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0186	0.0196	0.0207	0.0187	0.0199	0.0211	0.0193	0.0204	0.0213
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	46.4	41.2	37.6	45.4	40.2	36.5	42.7	38.4	36.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0267	0.0290	0.0314	0.0271	0.0296	0.0323	0.0283	0.0308	0.0327
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0241	0.0261	0.0283	0.0244	0.0267	0.0291	0.0255	0.0277	0.0295
Total Effects of SO2 Oxidation									
Total SO2 to SO3 conversion rate, %vol	63.6%	63.5%	63.6%	63.5%	63.6%	63.6%	63.7%	63.7%	63.6%
Total Amount of SO2 converted to SO3, lb/h	12.23	9.98	8.43	11.77	9.57	7.95	10.62	8.79	7.74
Maximum Stack Ammonium Sulfate [(NH4)2-(SO4)] (assuming 100% conversion from SO3), lb	25.23	20.58	17.39	24.28	19.75	16.41	21.91	18.14	15.96
Maximum Stack H2SO4 (assuming 100% conversion from SO3 to H2SO4), lb/h	18.72	15.27	12.91	18.02	14.66	12.18	16.26	13.46	11.85
CO2 Emissions									
CO2, lb/hr	223,528	182,489	154,014	215,288	174,847	145,393	193,911	160,487	141,313
CO2, lb/MBtu (LHV)	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6
CO2, lb/MBtu (HHV)	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9
Post Combustion Emissions Control Equipment									
Catalytic Conversion in CO Catalyst									
CO removed in CO Catalyst, %wt	46.7%	46.7%	46.7%	46.7%	46.7%	46.7%	46.7%	46.7%	46.7%
CO removed in CO Catalyst, lb/h	14.2	11.6	10.0	13.7	11.2	9.4	12.6	10.3	9.3
VOC removed in CO Catalyst, %wt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
VOC removed in CO Catalyst, lb/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selective Catalytic Reduction (SCR)									
NOx Removed in SCR, %wt	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%	72.2%
NOx removed in SCR, lb/h	45.3	36.8	31.0	43.6	35.2	29.3	39.3	32.4	28.5
Ammonia Slip, lb/h	25.7	21.0	17.7	24.7	20.1	16.7	22.3	18.4	16.2

Notes:

1. EMISSIONS ARE PRELIMINARY. NO GUARANTEES APPLY. NO MARGINS APPLIED.
2. The dry air composition used is 0.98% Ar, 78.03% N2 and 20.99%O2
3. Standard conditions are defined as 60 F, 14.696 psia, Norm conditions are defined as 0 C, 1.103 bar
4. All ppm values are based on CH4 calibration gas.
5. The CTG performance and emissions are based on runs provided by GE dated 7/15/2010
6. The natural gas used in estimates contains 2.25 grains/100 SCF of sulfur content.
7. The VOC/UHC ratio is base on CTG performance data provided by GE dated 7/15/2010
8. Effect of SCR and CO catalyst are included.
9. The front half catch of particulate emissions is assumed to be half the amount of the front and back half catch.
10. Where manufacturer data of lb/h of pollutant emissions were available, the greater of the manufacturer's estimate and B&V's estimate was used in the summary table, i.e. the B&V estimates were adjusted, where applicable.
11. The estimated oxidation of SO2 in CTG is based on performance data provided by GE. The SO2 - SO3 conversion in the CO catalyst is assumed to be 60%.
12. The CO catalyst was designed to reduce the CO Stack emissions by 46.7% for all operating scenarios. While there was no VOC reduction.
13. The SCR was designed to reduce the NOx stack emissions to 2.5 ppmvd @ 15%O2 for natural gas
14. Tempering air mass flowrate controlled to limit stack exit temperature to 800F for all cases, with a minimum allowable flowrate of 13,500 lb/hr.
15. Tempering air has been assumed to not contribute to stack emissions.

ADDITIONAL CALCULATIONS MADE BY URS USING ABOVE DATA

Information used to compare values with emission standards (federal, state, local, and NSPS)									
Stack Flow, scfm(dry) @ 7% O2	996,328	842,746	757,641	1,012,718	850,279	758,152	971,309	838,349	770,955
PM10, grains/dscf @ 7% O2	0.0042	0.0043	0.0042	0.0040	0.0041	0.0041	0.0039	0.0039	0.0039
lb NOx/MWhr	0.09	0.11	0.12	0.10	0.11	0.13	0.10	0.11	0.13
lb SO2/MWhr	0.04	0.04	0.05	0.04	0.04	0.05	0.04	0.05	0.05
Max PM10 gr/dscf	0.0043								
Max lb NOx/MWhr	0.13								
Max lb SO2/MWhr	0.05								

Puget Sound Energy
PSE Permitting Support
165510
Fredonia
Simple Cycle Emissions - GE 7FA.04 - Distillate, Revision 2

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04
CTG Fuel Type	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate
CTG Load	100%	75%	55%	100%	75%	53%	100%	75%	59%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ambient Conditions									
Ambient Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
Ambient Relative Humidity, %	40.0	40.0	40.0	75.0	75.0	75.0	30.0	30.0	30.0
Atmospheric Pressure, psia	14.680	14.680	14.680	14.680	14.680	14.680	14.680	14.680	14.680
Combustion Turbine Performance									
CTG Performance Reference	GE	GE	GE	GE	GE	GE	GE	GE	GE
CTG Inlet Air Conditioning Effectiveness, %	0	0	0	0	0	0	0	0	0
CTG Compressor Inlet Dry Bulb Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
CTG Compr. Inlet Relative Humidity, %	40.5	40.5	40.5	75.1	75.1	75.1	30.2	30.2	30.2
Inlet Loss, in. H2O	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Exhaust Loss, in. H2O	10.7	7.3	5.5	11.0	7.4	5.2	9.5	6.5	5.2
CTG Load Level (percent of Base Load)	100%	75%	55%	100%	75%	53%	100%	75%	59%
Gross CTG Output, kW	196,900	147,700	108,300	196,900	147,700	104,400	178,400	133,800	105,200
Gross CTG Heat Rate, Btu/kWh (LHV)	9,635	10,405	11,915	9,595	10,235	11,945	9,825	10,585	11,795
Gross CTG Heat Rate, Btu/kWh (HHV)	10,259	11,079	12,687	10,217	10,898	12,719	10,462	11,271	12,559
CTG Heat Input, MBtu/h (LHV)	1,897.1	1,536.8	1,290.4	1,889.3	1,511.7	1,247.1	1,752.8	1,416.3	1,240.8
CTG Heat Input, MBtu/h (HHV)	2,020.1	1,636.4	1,374.0	2,011.7	1,609.7	1,327.9	1,866.4	1,508.1	1,321.3
CTG Water/Steam Injection Flow, lb/h	132,966	98,375	78,303	134,021	96,192	74,954	128,756	93,214	77,643
Injection Fluid/Fuel Ratio	1.3	1.2	1.1	1.3	1.2	1.1	1.4	1.2	1.2
CTG Exhaust Flow, lb/h	3,709,000	3,055,000	2,606,000	3,761,000	3,058,000	2,527,000	3,459,000	2,852,000	2,526,000
CTG Exhaust Temperature, F	1,084	1,111	1,163	1,091	1,116	1,189	1,135	1,161	1,204
Combustion Turbine Fuel									
Total CTG Fuel Flow, lb/h	103,330	83,700	70,280	102,900	82,340	67,920	95,470	77,140	67,580
CTG Fuel Temperature, F	77	77	77	77	77	77	77	77	77
CTG Fuel LHV, Btu/lb	18,360	18,360	18,360	18,360	18,360	18,360	18,360	18,360	18,360
CTG Fuel HHV, Btu/lb	19,550	19,550	19,550	19,550	19,550	19,550	19,550	19,550	19,550
HHV/LHV Ratio	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648
CTG Fuel Composition (Ultimate Analysis by Weight)									
Ar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%
H2	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%
N2	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
O2	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
S	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Combustion Turbine Exhaust									
CTG Exhaust Analysis (Volume Basis - Wet)									
Ar	0.90%	0.91%	0.91%	0.89%	0.90%	0.90%	0.89%	0.89%	0.90%
CO2	5.74%	5.66%	5.58%	5.62%	5.55%	5.54%	5.66%	5.56%	5.51%
H2O	10.76%	10.12%	9.72%	11.40%	10.70%	10.42%	12.04%	11.27%	10.92%
N2	71.60%	72.07%	72.35%	71.05%	71.58%	71.79%	70.57%	71.14%	71.39%
O2	11.00%	11.25%	11.44%	11.03%	11.28%	11.34%	10.85%	11.14%	11.29%
SO2, (after SO2 oxidation)	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%
SO3, (after SO2 oxidation)	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Molecular Wt, lb/mol	28.40	28.47	28.50	28.32	28.39	28.42	28.26	28.33	28.36
Specific Volume, ft^3/lb	38.70	39.62	41.06	38.96	39.84	41.86	40.31	41.15	42.33
Specific Volume, scf/lb	13.36	13.33	13.31	13.40	13.36	13.35	13.43	13.39	13.38
Exhaust Gas Flow, acfm	2,392,305	2,017,318	1,783,373	2,442,143	2,030,512	1,763,004	2,323,872	1,955,997	1,782,093
Exhaust Gas Flow, scfm	825,871	678,719	578,098	839,957	680,915	562,258	774,240	636,471	563,298
CTG NOx Emissions (Without Post Combustion Emissions Control)									
NOx Massflow Added to Match CTG Manufacturer's NOx Emissions Estimate, lb/h	3.91	0.36	0.00	3.66	0.45	0.00	3.37	0.53	0.00
Additional Percent Margin included in mass based NOx Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
NOx, ppmvd (dry, 15% O2)	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
NOx, ppmvd (dry)	60.73	59.43	58.31	59.90	58.63	58.40	60.72	59.14	58.34
NOx, ppmvw (wet)	54.20	53.41	52.64	53.07	52.35	52.32	53.41	52.48	51.97
NOx, lb/h as NO2	329.5	264.1	221.5	327.9	259.9	214.0	304.2	243.6	212.9
NOx, lb/MBtu (LHV)	0.1737	0.1718	0.1716	0.1736	0.1719	0.1716	0.1736	0.1720	0.1716
NOx, lb/MBtu (HHV)	0.1631	0.1614	0.1612	0.1630	0.1615	0.1612	0.1630	0.1615	0.1612
CTG CO Emissions (Without Post Combustion Emissions Control)									
CO Massflow Added to Match CTG Manufacturer's CO Emissions Estimate, lb/h	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Additional Percent Margin included in mass based CO Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
CO, ppmvd (dry, 15% O2)	13.83	14.13	14.41	14.02	14.33	14.38	13.83	14.20	14.40
CO, ppmvd (dry)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
CO, ppmvw (wet)	17.85	17.98	18.06	17.72	17.86	17.92	17.59	17.75	17.82
CO, lb/h	65.3	54.0	46.3	65.9	53.9	44.6	60.3	50.0	44.4
CO, lb/MBtu (LHV)	0.0344	0.0352	0.0358	0.0349	0.0357	0.0358	0.0344	0.0353	0.0358
CO, lb/MBtu (HHV)	0.0323	0.0330	0.0337	0.0328	0.0335	0.0336	0.0323	0.0332	0.0336
CTG SO2 Emissions (After SO2 Oxydation, Without Post Combustion Emissions Control)									
SO2 massflow (lb/h) added to match CTG manufacturer's lb/h SO2 emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h SO2 Emissions below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CTG, vol%	6.7%	6.0%	5.0%	6.7%	8.3%	5.3%	7.1%	4.5%	5.3%
SO2, ppmvd (dry, 15% O2)	0.2678	0.2640	0.2726	0.2678	0.2630	0.2718	0.2664	0.2739	0.2718
SO2, ppmvd (dry)	0.3872	0.3735	0.3784	0.3819	0.3671	0.3780	0.3852	0.3857	0.3776
SO2, ppmvw (wet)	0.3456	0.3357	0.3416	0.3384	0.3279	0.3386	0.3388	0.3422	0.3363
SO2, lb/h	2.8905	2.3080	2.0011	2.8785	2.2622	1.9286	2.6570	2.2069	1.9189
SO2, lb/MBtu (LHV)	0.0015	0.0015	0.0016	0.0015	0.0015	0.0015	0.0015	0.0016	0.0015
SO2, lb/MBtu (HHV)	0.0014	0.0014	0.0015	0.0014	0.0014	0.0015	0.0014	0.0015	0.0015
CTG UHC Emissions (Without Post Combustion Emissions Control)									
UHC massflow (lb/h) added to match CTG manufacturer's lb/h CO emissions estimate	0.00	0.00	0.03	0.00	0.00	0.02	0.00	0.00	0.00
Additional Percent Margin included in lb/h UHC Emissions Below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UHC, ppmvd (dry, 15% O2)	5.4	5.5	5.6	5.5	5.6	5.6	5.5	5.6	5.7
UHC, ppmvd (dry)	7.8	7.8	7.8	7.9	7.8	7.8	8.0	7.9	7.9
UHC, ppmvw (wet)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
UHC, lb/h as CH4	14.7	12.1	10.3	14.9	12.1	10.0	13.7	11.3	10.0
UHC, lb/MBtu as CH4 (LHV)	0.0077	0.0078	0.0080	0.0079	0.0080	0.0080	0.0078	0.0080	0.0081
UHC, lb/MBtu as CH4 (HHV)	0.0073	0.0074	0.0075	0.0074	0.0075	0.0075	0.0074	0.0075	0.0076
CTG VOC Emissions (Without Post Combustion Emissions Control)									
VOC Massflow (lb/h) added to match CTG manufacturer's lb/h VOC emissions estimate	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00
Additional percent margin included in lb/h VOC emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
VOC percentage of UHC	50%	50%	50%	50%	50%	50%	50%	50%	50%
VOC, ppmvd (dry, 15% O2)	2.7	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
VOC, ppmvd (dry)	3.9	3.9	3.9	4.0	3.9	3.9	4.0	3.9	3.9
VOC, ppmvw (wet)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
VOC, lb/h as CH4	7.3	6.0	5.1	7.5	6.0	5.0	6.9	5.7	5.0
VOC, lb/MBtu as CH4 (LHV)	0.0039	0.0039	0.0040	0.0039	0.0040	0.0040	0.0039	0.0040	0.0040
VOC, lb/MBtu as CH4 (HHV)	0.0036	0.0037	0.0037	0.0037	0.0038	0.0038	0.0037	0.0037	0.0038

Puget Sound Energy
PSE Permitting Support
165510
Fredonia
Simple Cycle Emissions - GE 7FA.04 - Distillate, Revision 2

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04
CTG Fuel Type	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate
CTG Load	100%	75%	55%	100%	75%	53%	100%	75%	59%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CTG PM10 Emissions (without the Effects of SO2 Oxidation)									
Percent margin included in PM10 emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	17.2	17.2	17.1	17.2	17.1	17.1	17.2	17.1	17.1
PM10, lb/MBtu (LHV)	0.0090	0.0112	0.0133	0.0091	0.0113	0.0137	0.0098	0.0121	0.0138
PM10, lb/MBtu (HHV)	0.0085	0.0105	0.0124	0.0085	0.0106	0.0129	0.0092	0.0113	0.0129
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	34.3	34.3	34.2	34.3	34.2	34.2	34.3	34.2	34.2
PM10, lb/MBtu (LHV)	0.0181	0.0223	0.0265	0.0182	0.0226	0.0274	0.0196	0.0241	0.0276
PM10, lb/MBtu (HHV)	0.0170	0.0210	0.0249	0.0171	0.0212	0.0258	0.0184	0.0227	0.0259
CO2 Emissions									
CO2, lb/hr	330,042	267,343	224,479	328,669	262,999	216,941	304,937	246,390	215,855
CO2, lb/MBtu (LHV)	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0
CO2, lb/MBtu (HHV)	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.4
Stack Emissions									
Stack Exhaust Analysis - Volume Basis - Wet									
Ar	0.92%	0.93%	0.93%	0.92%	0.92%	0.93%	0.91%	0.92%	0.92%
CO2	4.09%	3.93%	3.68%	3.91%	3.76%	3.50%	3.70%	3.54%	3.36%
H2O	7.69%	7.04%	6.43%	8.22%	7.56%	6.92%	8.33%	7.65%	7.18%
N2	73.43%	73.87%	74.27%	72.95%	73.42%	73.83%	72.79%	73.27%	73.58%
O2	13.87%	14.23%	14.69%	14.00%	14.34%	14.83%	14.26%	14.62%	14.97%
SO2 (after SO2 oxidation)	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%
SO3 (after SO2 oxidation)	0.000020%	0.000020%	0.000010%	0.000020%	0.000020%	0.000010%	0.000020%	0.000010%	0.000010%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Stack Exit Temperature, F	800	799	799	800	799	799	800	799	799
Stack Diameter, ft (estimated)	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
Stack Flow, lb/h	5,231,999	4,427,999	3,973,999	5,434,999	4,532,999	4,030,999	5,326,999	4,509,999	4,169,999
Stack Flow, scfm	1,158,016	978,588	876,929	1,206,570	1,004,060	891,523	1,183,482	1,000,468	923,655
Stack Flow, acfm	2,809,584	2,372,670	2,126,090	2,926,748	2,435,732	2,162,632	2,873,029	2,426,380	2,240,680
Stack Exit Velocity, ft/s	135.0	114.0	102.0	141.0	117.0	104.0	138.0	117.0	108.0
Stack NOx Emissions without the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
NOx, ppmvd (dry)	41.9	39.9	37.1	40.2	38.4	35.4	38.1	36.2	34.1
NOx, ppmvw (wet)	38.6	37.0	34.7	36.9	35.5	33.0	34.9	33.4	31.7
NOx, lb/h as NO2 (includes correction adder)	329.5	264.1	221.5	327.9	259.9	214.0	304.2	243.6	212.9
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.1737	0.1718	0.1716	0.1736	0.1719	0.1716	0.1736	0.1720	0.1716
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.1631	0.1614	0.1612	0.1630	0.1615	0.1612	0.1630	0.1615	0.1612
Stack NOx Emissions with the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
NOx, ppmvd (dry)	5.0	4.7	4.4	4.8	4.6	4.2	4.5	4.3	4.1
NOx, ppmvw (wet)	4.6	4.4	4.1	4.4	4.2	3.9	4.2	4.0	3.8
NOx, lb/h as NO2 (includes NOx margin applied to CTG)	39.2	31.4	26.4	39.0	30.9	25.5	36.2	29.0	25.4
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0207	0.0205	0.0204	0.0207	0.0205	0.0204	0.0207	0.0205	0.0204
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0194	0.0192	0.0192	0.0194	0.0192	0.0192	0.0194	0.0192	0.0192
SCR NH3 slip, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
SCR NH3 slip, lb/h	28.7	23.2	19.5	28.6	22.9	18.9	26.5	21.4	18.8
Stack CO Emissions without the Effects of Catalytic Reduction									
CO, ppmvd (dry, 15% O2)	13.8	14.1	14.4	14.0	14.3	14.4	13.8	14.2	14.4
CO, ppmvd (dry)	13.8	13.4	12.7	13.4	13.1	12.1	12.5	12.2	11.7
CO, ppmvw (wet)	12.7	12.5	11.9	12.3	12.1	11.3	11.5	11.3	10.9
CO, lb/h (includes CO correction as applied to CTG and margin)	65.3	54.0	46.2	65.9	53.9	44.6	60.3	50.0	44.4
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0344	0.0352	0.0358	0.0349	0.0357	0.0358	0.0344	0.0353	0.0358
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0323	0.0330	0.0337	0.0328	0.0335	0.0336	0.0323	0.0332	0.0336
Stack CO Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
CO, ppmvd (dry, 15% O2)	7.4	7.5	7.7	7.5	7.6	7.7	7.4	7.6	7.7
CO, ppmvd (dry)	7.4	7.2	6.8	7.2	7.0	6.5	6.7	6.5	6.2
CO, ppmvw (wet)	6.8	6.6	6.3	6.6	6.5	6.0	6.1	6.0	5.8
CO, lb/h (includes CO margin applied to CTG)	34.8	28.8	24.7	35.2	28.7	23.8	32.2	26.7	23.7
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0184	0.0188	0.0191	0.0186	0.0190	0.0191	0.0184	0.0188	0.0191
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0172	0.0176	0.0179	0.0175	0.0179	0.0179	0.0172	0.0177	0.0179
Stack SO2 Emissions without the Effects of SO2 Scrubber, without SO2 Oxidation									
Assumed SO2 oxidation rate in CTG, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CO Catalyst, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in SCR, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SO2, ppmvd (dry, 15% O2)	0.2869	0.2870	0.2869	0.2869	0.2869	0.2869	0.2869	0.2869	0.2869
SO2, ppmvd (dry)	0.4149	0.4060	0.3983	0.4092	0.4005	0.3990	0.4148	0.4041	0.3986
SO2, ppmvw (wet)	0.3703	0.3649	0.3596	0.3626	0.3577	0.3574	0.3649	0.3585	0.3550
SO2, lb/h	3.0970	2.5087	2.1064	3.0841	2.4679	2.0357	2.8614	2.3120	2.0255
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0016	0.0016	0.0017	0.0016	0.0016	0.0016	0.0016	0.0017	0.0016
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0015	0.0015	0.0016	0.0015	0.0015	0.0016	0.0015	0.0016	0.0016
Stack SO2 Emissions without the Effects of SO2 Scrubber, after SO2 Oxidation									
Assumed SO2 oxidation rate in CO Catalyst, vol%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
Assumed SO2 oxidation rate in SCR, vol%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SO2, ppmvd (dry, 15% O2)	0.10	0.10	0.11	0.10	0.10	0.11	0.10	0.11	0.11
SO2, ppmvd (dry)	0.10	0.10	0.09	0.10	0.09	0.09	0.09	0.09	0.09
SO2, ppmvw (wet)	0.10	0.09	0.09	0.09	0.09	0.08	0.09	0.08	0.08
SO2, lb/h	1.12	0.90	0.78	1.12	0.88	0.75	1.03	0.86	0.74
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0006	0.0005	0.0006	0.0006	0.0005	0.0006	0.0006	0.0006	0.0006
Stack UHC Emissions									
UHC, ppmvd (dry, 15% O2)	5.4	5.5	5.6	5.5	5.6	5.6	5.5	5.6	5.7
UHC, ppmvd	5.4	5.2	4.9	5.3	5.1	4.7	5.0	4.8	4.6
UHC, ppmvw	5.0	4.9	4.6	4.9	4.7	4.4	4.6	4.5	4.3
UHC, lb/h as CH4 (includes correction adder)	14.7	12.1	10.3	14.9	12.1	10.0	13.7	11.3	10.0
UHC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0077	0.0078	0.0080	0.0079	0.0080	0.0080	0.0078	0.0080	0.0081
UHC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0073	0.0074	0.0075	0.0074	0.0075	0.0075	0.0074	0.0075	0.0076
Stack VOC Emissions without the Effect of Oxidation in a CO catalyst									
VOC, ppmvd (dry, 15% O2)	2.7	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
VOC, ppmvd (dry)	2.7	2.6	2.5	2.7	2.6	2.4	2.5	2.4	2.3
VOC, ppmvw (wet)	2.5	2.4	2.3	2.4	2.4	2.2	2.3	2.2	2.1
VOC, lb/h as CH4 (includes correction adder)	7.3	6.0	5.1	7.5	6.0	5.0	6.9	5.7	5.0
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0039	0.0039	0.0040	0.0039	0.0040	0.0040	0.0039	0.0040	0.0040
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0036	0.0037	0.0037	0.0037	0.0038	0.0038	0.0037	0.0037	0.0038
Stack VOC Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
VOC, ppmvd (dry, 15% O2)	2.7	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
VOC, ppmvd (dry)	2.7	2.6	2.5	2.7	2.6	2.4	2.5	2.4	2.3
VOC, ppmvw (wet)	2.5	2.4	2.3	2.4	2.4	2.2	2.3	2.2	2.1
VOC, lb/h as CH4 (includes VOC correction as applied to CTG)	7.3	6.0	5.1	7.5	6.0	5.0	6.9	5.7	5.0
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0039	0.0039	0.0040	0.0039	0.0040	0.0040	0.0039	0.0040	0.0040
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0036	0.0037	0.0037	0.0037	0.0038	0.0038	0.0037	0.0037	0.0038

Puget Sound Energy
PSE Permitting Support
165510
Fredonia
Simple Cycle Emissions - GE 7FA.04 - Distillate, Revision 2

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04	GE7FA.04
CTG Fuel Type	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate
CTG Load	100%	75%	55%	100%	75%	53%	100%	75%	59%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PM10 without the Effects of SO2 oxidation									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	17.2	17.2	17.1	17.2	17.1	17.1	17.2	17.1	17.1
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0090	0.0112	0.0133	0.0091	0.0113	0.0137	0.0098	0.0121	0.0138
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0085	0.0105	0.0124	0.0085	0.0106	0.0129	0.0092	0.0113	0.0129
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	34.3	34.3	34.2	34.3	34.2	34.2	34.3	34.2	34.2
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0181	0.0223	0.0265	0.0182	0.0226	0.0274	0.0196	0.0241	0.0276
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0170	0.0210	0.0249	0.0171	0.0212	0.0258	0.0184	0.0227	0.0259
PM10 with the Effects of SO2 Oxidation (includes (NH4)2-(SO4))									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	21.2	20.5	19.8	21.2	20.4	19.8	20.9	20.1	19.7
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0112	0.0133	0.0154	0.0112	0.0135	0.0158	0.0119	0.0142	0.0159
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0105	0.0125	0.0144	0.0105	0.0127	0.0149	0.0112	0.0133	0.0149
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	38.4	37.6	36.9	38.4	37.5	36.9	38.1	37.2	36.8
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0202	0.0245	0.0286	0.0203	0.0248	0.0296	0.0217	0.0263	0.0297
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0190	0.0230	0.0269	0.0191	0.0233	0.0278	0.0204	0.0247	0.0279
Total Effects of SO2 Oxidation									
Total SO2 to SO3 conversion rate, %vol	63.8%	64.3%	63.1%	63.8%	64.4%	63.2%	64.0%	63.0%	63.2%
Total Amount of SO2 converted to SO3, lb/h	1.98	1.61	1.33	1.97	1.59	1.29	1.83	1.46	1.28
Maximum Stack Ammonium Sulfate [(NH4)2-(SO4)] (assuming 100% conversion from SO3), lb	4.07	3.33	2.74	4.06	3.28	2.66	3.78	3.00	2.64
Maximum Stack H2SO4 (assuming 100% conversion from SO3 to H2SO4), lb/h	3.02	2.47	2.04	3.01	2.43	1.97	2.80	2.23	1.96
CO2 Emissions									
CO2, lb/hr	330,042	267,343	224,479	328,669	262,999	216,941	304,937	246,390	215,856
CO2, lb/MBtu (LHV)	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0
CO2, lb/MBtu (HHV)	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.4
Post Combustion Emissions Control Equipment									
Catalytic Conversion in CO Catalyst									
CO removed in CO Catalyst, %wt	46.7%	46.7%	46.7%	46.7%	46.7%	46.7%	46.7%	46.7%	46.7%
CO removed in CO Catalyst, lb/h	30.5	25.2	21.6	30.8	25.2	20.8	28.2	23.4	20.7
VOC removed in CO Catalyst, %wt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
VOC removed in CO Catalyst, lb/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selective Catalytic Reduction (SCR)									
NOx Removed in SCR, %wt	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%
NOx removed in SCR, lb/h	290.3	232.7	195.1	288.9	229.0	188.5	268.0	214.6	187.6
Ammonia Slip, lb/h	28.7	23.2	19.5	28.6	22.9	18.9	26.5	21.4	18.8

Notes:

1. EMISSIONS ARE PRELIMINARY. NO GUARANTEES APPLY. NO MARGINS APPLIED.
2. The dry air composition used is 0.98% Ar, 78.03% N2 and 20.99%O2
3. Standard conditions are defined as 60 F, 14.696 psia, Norm conditions are defined as 0 C, 1.103 bar
4. All ppm values are based on CH4 calibration gas.
5. The CTG performance and emissions are based on runs provided by GE dated 7/15/2010
6. The distillate oil used in estimates contains 15 ppm by weight sulfur content.
7. The VOC/UHC ratio is base on CTG performance data provided by GE dated 7/15/2010
8. Effect of SCR and CO catalyst are included.
9. The front half catch of particulate emissions is assumed to be half the amount of the front and back half catch.
10. Where manufacturer data of lb/h of pollutant emissions were available, the greater of the manufacturer's estimate and B&V's estimate was used in the summary table, i.e. the B&V estimates were adjusted, where applicable.
11. The estimated oxidation of SO2 in CTG is based on performance data provided by GE. The SO2 - SO3 conversion in the CO catalyst is assumed to be 60%.
12. The CO catalyst was designed to reduce the CO Stack emissions by 46.7% for all operating scenarios. While there was no VOC reduction.
13. The SCR was designed to reduce the NOx stack emissions to 5 ppmvd @ 15%O2 for distillate oil.
14. Tempering air mass flowrate controlled to limit stack exit temperature to 800F for all cases, with a minimum allowable flowrate of 13,500 lb/hr.
15. Tempering air has been assumed to not contribute to stack emissions.

ADDITIONAL CALCULATIONS MADE BY URS USING ABOVE DATA

Information used to compare values with emission standards (federal, state, local, and NSPS)									
Stack Flow, scfm(dry) @ 7% O2	989,999	838,974	752,693	1,024,038	854,899	759,963	1,000,206	848,229	783,864
PM10, grains/dscf @ 7% O2	0.0025	0.0029	0.0031	0.0024	0.0028	0.0030	0.0024	0.0028	0.0029
lb NOx/MWhr	0.20	0.21	0.24	0.20	0.21	0.24	0.20	0.22	0.24
lb SO2/MWhr	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Max PM10 gr/dscf	0.0031								
Max lb NOx/MWhr	0.24								
Max lb SO2/MWhr	0.01								

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
Siemens SGT6-5000F4 - Simple Cycle Emissions Summary - Natural Gas 2.25 grains/100 scf Sulfur

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	97%	75%	60%	100%	75%	60%	100%	75%	60%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Ambient Conditions									
Ambient Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
Ambient Relative Humidity, %	40.0	40.0	40.0	75.0	75.0	75.0	30.0	30.0	30.0
Atmospheric Pressure, psia	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682
Combustion Turbine Performance									
CTG Performance Reference	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS
CTG Inlet Air Conditioning Effectiveness, %	0	0	0	0	0	0	0	0	0
CTG Compressor Inlet Dry Bulb Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
CTG Compr. Inlet Relative Humidity, %	40.5	40.4	40.3	75.1	75.1	75.1	30.2	30.1	30.1
Inlet Loss, in. H2O	4.4	3.1	2.4	4.4	3.0	2.3	3.9	2.8	2.2
Exhaust Loss, in. H2O	13.9	9.8	7.7	12.8	8.8	6.9	11.0	7.8	6.2
CTG Load Level (percent of Base Load)	97%	75%	60%	100%	75%	60%	100%	75%	60%
Gross CTG Output, kW	232,041	180,354	144,283	212,485	159,364	127,491	185,016	138,762	111,009
Gross CTG Heat Rate, Btu/kWh (LHV)	8,718	9,144	9,732	8,912	9,475	10,109	9,205	9,900	10,602
Gross CTG Heat Rate, Btu/kWh (HHV)	9,679	10,152	10,804	9,894	10,519	11,223	10,219	10,991	11,770
CTG Heat Input, MBtu/h (LHV)	2,022.9	1,649.2	1,404.2	1,893.7	1,510.0	1,288.8	1,703.1	1,373.7	1,176.9
CTG Heat Input, MBtu/h (HHV)	2,245.9	1,830.9	1,558.9	2,102.4	1,676.4	1,430.8	1,890.8	1,525.1	1,306.6
CTG Water/Steam Injection Flow, lb/h	0	0	0	0	0	0	0	0	0
Injection Fluid/Fuel Ratio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTG Exhaust Flow, lb/h	4,278,989	3,583,124	3,168,369	4,067,043	3,355,676	2,972,709	3,718,759	3,116,999	2,770,277
CTG Exhaust Temperature, F	1,088	1,088	1,088	1,115	1,115	1,115	1,144	1,144	1,144
Combustion Turbine Fuel									
Total CTG Fuel Flow, lb/h	95,680	78,000	66,410	89,560	71,420	60,960	80,550	64,970	55,660
CTG Fuel Temperature, F	77	77	77	77	77	77	77	77	77
CTG Fuel LHV, Btu/lb	21,143	21,143	21,143	21,143	21,143	21,143	21,143	21,143	21,143
CTG Fuel HHV, Btu/lb	23,473	23,473	23,473	23,473	23,473	23,473	23,473	23,473	23,473
HHV/LHV Ratio	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102
CTG Fuel Composition (Ultimate Analysis by Weight)									
Ar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%
H2	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%
N2	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%
O2	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%
S	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Combustion Turbine Exhaust									
CTG Exhaust Analysis (Volume Basis - Wet)									
Ar	0.94%	0.94%	0.94%	0.93%	0.93%	0.94%	0.93%	0.93%	0.93%
CO2	3.93%	3.83%	3.69%	3.86%	3.74%	3.60%	3.80%	3.65%	3.52%
H2O	7.82%	7.62%	7.34%	8.52%	8.27%	8.00%	8.77%	8.49%	8.24%
N2	74.95%	75.03%	75.13%	74.35%	74.45%	74.55%	74.10%	74.21%	74.31%
O2	12.36%	12.58%	12.89%	12.34%	12.62%	12.91%	12.40%	12.71%	13.00%
SO2, (after SO2 oxidation)	0.00013%	0.00012%	0.00012%	0.00013%	0.00012%	0.00012%	0.00012%	0.00012%	0.00011%
SO3, (after SO2 oxidation)	0.00002%	0.00002%	0.00002%	0.00002%	0.00002%	0.00002%	0.00002%	0.00002%	0.00002%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Molecular Wt, lb/mol	28.47	28.48	28.50	28.39	28.40	28.42	28.35	28.37	28.39
Specific Volume, ft^3/lb	38.41	38.78	38.95	39.30	39.66	39.82	40.25	40.53	40.67
Specific Volume, scf/lb	13.33	13.32	13.31	13.37	13.36	13.35	13.38	13.37	13.37
Exhaust Gas Flow, acfm	2,739,266	2,315,892	2,056,800	2,663,913	2,218,102	1,972,888	2,494,667	2,105,533	1,877,786
Exhaust Gas Flow, scfm	950,649	795,454	702,850	906,273	747,197	661,428	829,283	694,571	617,310
CTG NOx Emissions (Without Post Combustion Emissions Control)									
NOx Massflow Added to Match CTG Manufacturer's NOx Emissions Estimate, lb/h	10.02	7.78	7.15	9.47	7.32	6.02	7.75	6.55	5.54
Additonal Percent Margin included in mass based NOx Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
NOx, ppmvd (dry, 15% O2)	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00
NOx, ppmvd (dry)	35.45	34.45	33.09	35.08	33.83	32.52	34.56	33.17	31.91
NOx, ppmvw (wet)	32.68	31.83	30.66	32.09	31.03	29.92	31.52	30.36	29.28
NOx, lb/h as NO2	236.0	192.0	164.0	221.0	176.0	150.0	198.0	160.0	137.0
NOx, lb/MBtu (LHV)	0.1167	0.1164	0.1168	0.1167	0.1166	0.1164	0.1163	0.1165	0.1164
NOx, lb/MBtu (HHV)	0.1051	0.1049	0.1052	0.1051	0.1050	0.1048	0.1047	0.1049	0.1049
CTG CO Emissions (Without Post Combustion Emissions Control)									
CO Massflow Added to Match CTG Manufacturer's CO Emissions Estimate, lb/h	1.35	0.98	1.89	0.60	0.33	1.70	0.45	0.65	1.42
Additional Percent Margin included in mass based CO Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
CO, ppmvd (dry, 15% O2)	4.00	4.00	10.00	4.00	4.00	10.00	4.00	4.00	10.00
CO, ppmvd (dry)	5.06	4.92	11.82	5.01	4.83	11.61	4.94	4.74	11.39
CO, ppmvw (wet)	4.67	4.55	10.95	4.58	4.43	10.68	4.50	4.34	10.46
CO, lb/h	21.0	17.0	36.0	19.0	15.0	33.0	17.0	14.0	30.0
CO, lb/MBtu (LHV)	0.0104	0.0103	0.0256	0.0100	0.0099	0.0256	0.0100	0.0102	0.0255
CO, lb/MBtu (HHV)	0.0094	0.0093	0.0231	0.0090	0.0089	0.0231	0.0090	0.0092	0.0230
CTG SO2 Emissions (After SO2 Oxydation, Without Post Combustion Emissions Control)									
SO2 massflow (lb/h) added to match CTG manufacturer's lb/h SO2 emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h SO2 Emissions below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CTG, vol%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
SO2, ppmvd (dry, 15% O2)	1.0960	1.0960	1.0960	1.0960	1.0960	1.0960	1.0960	1.0960	1.0960
SO2, ppmvd (dry)	1.3876	1.3485	1.2954	1.3730	1.3241	1.2728	1.3526	1.2985	1.2489
SO2, ppmvw (wet)	1.2791	1.2458	1.2003	1.2560	1.2146	1.1710	1.2340	1.1882	1.1460
SO2, lb/h	12.3162	10.0403	8.5485	11.5284	9.1934	7.8469	10.3686	8.3631	7.1847
SO2, lb/MBtu (LHV)	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061
SO2, lb/MBtu (HHV)	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055
CTG UHC Emissions (Without Post Combustion Emissions Control)									
UHC massflow (lb/h) added to match CTG manufacturer's lb/h CO emissions estimate	0.17	0.21	0.09	0.13	0.20	0.21	0.26	0.18	0.13
Additional Percent Margin included in lb/h UHC Emissions Below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UHC, ppmvd (dry, 15% O2)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
UHC, ppmvd (dry)	2.5	2.5	2.4	2.5	2.4	2.3	2.5	2.4	2.3
UHC, ppmvw (wet)	2.3	2.3	2.2	2.3	2.2	2.1	2.3	2.2	2.1
UHC, lb/h as CH4	5.8	4.8	4.0	5.4	4.4	3.8	5.0	4.0	3.4
UHC, lb/MBtu as CH4 (LHV)	0.0029	0.0029	0.0028	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029
UHC, lb/MBtu as CH4 (HHV)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0027	0.0026	0.0026	0.0026
CTG VOC Emissions (Without Post Combustion Emissions Control)									
VOC Massflow (lb/h) added to match CTG manufacturer's lb/h VOC emissions estimate	0.09	0.11	0.05	0.07	0.10	0.11	0.13	0.09	0.06
Additional percent margin included in lb/h VOC emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
VOC percentage of UHC	50%	50%	50%	50%	50%	50%	50%	50%	50%
VOC, ppmvd (dry, 15% O2)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
VOC, ppmvd (dry)	1.3	1.2	1.2	1.3	1.2	1.2	1.2	1.2	1.1
VOC, ppmvw (wet)	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0
VOC, lb/h as CH4	2.9	2.4	2.0	2.7	2.2	1.9	2.5	2.0	1.7
VOC, lb/MBtu as CH4 (LHV)	0.0014	0.0015	0.0014	0.0014	0.0015	0.0015	0.0015	0.0015	0.0014
VOC, lb/MBtu as CH4 (HHV)	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
Siemens SGT6-5000F4 - Simple Cycle Emissions Summary - Natural Gas 2.25 grains/100 scf Sulfur

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	97%	75%	60%	100%	75%	60%	100%	75%	60%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
CTG PM10 Emissions (without the Effects of SO2 Oxidation)									
Percent margin included in PM10 emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
PM10, lb/MBtu (LHV)	0.0022	0.0024	0.0028	0.0021	0.0026	0.0031	0.0023	0.0029	0.0034
PM10, lb/MBtu (HHV)	0.0020	0.0022	0.0026	0.0019	0.0024	0.0028	0.0021	0.0026	0.0031
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	9.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
PM10, lb/MBtu (LHV)	0.0044	0.0049	0.0057	0.0042	0.0053	0.0062	0.0047	0.0058	0.0068
PM10, lb/MBtu (HHV)	0.0040	0.0044	0.0051	0.0038	0.0048	0.0056	0.0042	0.0052	0.0061
CO2 Emissions									
CO2, lb/hr	260,228	212,142	180,820	243,583	194,246	165,797	219,078	176,704	151,383
CO2, lb/Mbtu (LHV)	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6
CO2, lb/Mbtu (HHV)	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9
Stack Emissions									
Stack Exhaust Analysis - Volume Basis - Wet									
Ar	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.94%	0.94%	0.94%
CO2	2.81%	2.73%	2.63%	2.64%	2.55%	2.46%	2.47%	2.36%	2.30%
H2O	5.60%	5.46%	5.26%	6.11%	5.94%	5.76%	6.18%	6.00%	5.83%
N2	75.81%	75.87%	75.94%	75.28%	75.35%	75.42%	75.10%	75.18%	75.24%
O2	14.83%	14.99%	15.20%	15.02%	15.21%	15.41%	15.30%	15.50%	15.68%
SO2 (after SO2 oxidation)	0.000040%	0.000030%	0.000030%	0.000030%	0.000030%	0.000030%	0.000030%	0.000030%	0.000030%
SO3 (after SO2 oxidation)	0.000070%	0.000070%	0.000070%	0.000070%	0.000070%	0.000060%	0.000060%	0.000060%	0.000060%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Stack Exit Temperature, F	800	799	800	800	800	799	800	799	799
Stack Diameter, ft (estimated)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Stack Flow, lb/h	6,027,983	5,047,119	4,459,365	5,991,038	4,939,672	4,378,005	5,742,754	4,810,995	4,272,974
Stack Flow, scfm	1,332,186	1,115,414	984,777	1,327,016	1,094,138	968,999	1,272,978	1,066,438	946,464
Stack Flow, acfm	3,232,007	2,704,417	2,388,735	3,220,186	2,654,253	2,350,261	3,088,647	2,585,912	2,296,013
Stack Exit Velocity, ft/s	130.0	108.0	96.0	129.0	106.0	94.0	124.0	104.0	92.0
Stack NOx Emissions without the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
NOx, ppmvd (dry)	24.7	24.0	23.1	23.3	22.5	21.7	21.9	21.0	20.3
NOx, ppmvw (wet)	23.3	22.7	21.9	21.9	21.2	20.4	20.5	19.8	19.1
NOx, lb/h as NO2 (includes correction adder)	236.0	192.0	164.0	221.0	176.0	150.0	198.0	160.0	137.0
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.1167	0.1164	0.1168	0.1167	0.1166	0.1164	0.1163	0.1165	0.1164
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.1051	0.1049	0.1052	0.1051	0.1050	0.1048	0.1047	0.1049	0.1049
Stack NOx Emissions with the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
NOx, ppmvd (dry)	2.2	2.1	2.1	2.1	2.0	1.9	2.0	1.9	1.8
NOx, ppmvw (wet)	2.1	2.0	2.0	2.0	1.9	1.8	1.8	1.8	1.7
NOx, lb/h as NO2 (includes NOx margin applied to CTG)	21.1	17.1	14.6	19.7	15.7	13.4	17.7	14.3	12.2
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
SCR NH3 slip, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
SCR NH3 slip, lb/h	29.9	24.4	20.7	28.0	22.3	19.0	25.2	20.3	17.4
Stack CO Emissions without the Effects of Catalytic Reduction									
CO, ppmvd (dry, 15% O2)	4.0	4.0	10.0	4.0	4.0	10.0	4.0	4.0	10.0
CO, ppmvd (dry)	3.5	3.4	8.3	3.3	3.2	7.7	3.1	3.0	7.2
CO, ppmvw (wet)	3.3	3.2	7.8	3.1	3.0	7.3	2.9	2.8	6.8
CO, lb/h (includes CO correction as applied to CTG and margin)	21.0	17.0	36.0	19.0	15.0	33.0	17.0	14.0	30.0
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0104	0.0103	0.0256	0.0100	0.0099	0.0256	0.0100	0.0102	0.0255
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0094	0.0093	0.0231	0.0090	0.0089	0.0231	0.0090	0.0092	0.0230
Stack CO Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
CO, ppmvd (dry, 15% O2)	1.6	1.6	4.0	1.6	1.6	4.0	1.6	1.6	4.0
CO, ppmvd (dry)	1.4	1.4	3.3	1.3	1.3	3.1	1.3	1.2	2.9
CO, ppmvw (wet)	1.3	1.3	3.1	1.3	1.2	2.9	1.2	1.1	2.7
CO, lb/h (includes CO margin applied to CTG)	8.4	6.8	14.4	7.6	6.0	13.2	6.8	5.6	12.0
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0042	0.0041	0.0103	0.0040	0.0040	0.0102	0.0040	0.0041	0.0102
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0037	0.0037	0.0092	0.0036	0.0036	0.0092	0.0036	0.0037	0.0092
Stack SO2 Emissions without the Effects of SO2 Scrubber, without SO2 Oxidation									
Assumed SO2 oxidation rate in CTG, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CO Catalyst, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in SCR, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SO2, ppmvd (dry, 15% O2)	1.2894	1.2894	1.2894	1.2894	1.2894	1.2894	1.2894	1.2894	1.2894
SO2, ppmvd (dry)	1.6325	1.5865	1.5240	1.6153	1.5578	1.4974	1.5913	1.5276	1.4693
SO2, ppmvw (wet)	1.5048	1.4656	1.4121	1.4776	1.4289	1.3776	1.4518	1.3979	1.3482
SO2, lb/h	14.4896	11.8121	10.0571	13.5628	10.8158	9.2316	12.1984	9.8389	8.4291
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065
Stack SO2 Emissions without the Effects of SO2 Scrubber, after SO2 Oxidation									
Assumed SO2 oxidation rate in CO Catalyst, vol%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
Assumed SO2 oxidation rate in SCR, vol%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SO2, ppmvd (dry, 15% O2)	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
SO2, ppmvd (dry)	0.38	0.36	0.35	0.35	0.34	0.33	0.33	0.32	0.31
SO2, ppmvw (wet)	0.35	0.34	0.33	0.33	0.32	0.31	0.31	0.30	0.29
SO2, lb/h	4.78	3.90	3.32	4.47	3.57	3.04	4.02	3.24	2.78
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021
Stack UHC Emissions									
UHC, ppmvd (dry, 15% O2)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
UHC, ppmvd	1.8	1.7	1.7	1.7	1.6	1.5	1.6	1.5	1.4
UHC, ppmvw	1.7	1.6	1.6	1.6	1.5	1.5	1.5	1.4	1.4
UHC, lb/h as CH4 (includes correction adder)	5.8	4.8	4.0	5.4	4.4	3.8	5.0	4.0	3.4
UHC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0029	0.0029	0.0028	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029
UHC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0027	0.0026	0.0026	0.0026
Stack VOC Emissions without the Effect of Oxidation in a CO catalyst									
VOC, ppmvd (dry, 15% O2)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
VOC, ppmvd (dry)	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.7
VOC, ppmvw (wet)	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7
VOC, lb/h as CH4 (includes correction adder)	2.9	2.4	2.0	2.7	2.2	1.9	2.5	2.0	1.7
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0014	0.0015	0.0014	0.0014	0.0015	0.0015	0.0015	0.0015	0.0014
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
Stack VOC Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
VOC, ppmvd (dry, 15% O2)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
VOC, ppmvd (dry)	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.7
VOC, ppmvw (wet)	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7
VOC, lb/h as CH4 (includes VOC correction as applied to CTG)	2.9	2.4	2.0	2.7	2.2	1.9	2.5	2.0	1.7
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0014	0.0015	0.0014	0.0014	0.0015	0.0015	0.0015	0.0015	0.0014
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
Siemens SGT6-5000F4 - Simple Cycle Emissions Summery - Natural Gas 2.25 grains/100 scf Sulfur

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	97%	75%	60%	100%	75%	60%	100%	75%	60%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
PM10 without the Effects of SO2 oxidation									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0022	0.0024	0.0028	0.0021	0.0026	0.0031	0.0023	0.0029	0.0034
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0020	0.0022	0.0026	0.0019	0.0024	0.0028	0.0021	0.0026	0.0031
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	9.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0044	0.0049	0.0057	0.0042	0.0053	0.0062	0.0047	0.0058	0.0068
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0040	0.0044	0.0051	0.0038	0.0048	0.0056	0.0042	0.0052	0.0061
PM10 with the Effects of SO2 Oxidation [includes (NH4)2-(SO4)]									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	24.5	20.3	17.9	22.7	19.0	16.8	20.9	17.6	15.7
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0121	0.0123	0.0128	0.0120	0.0126	0.0130	0.0123	0.0128	0.0133
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0109	0.0111	0.0115	0.0108	0.0113	0.0117	0.0110	0.0115	0.0120
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	29.0	24.3	21.9	26.7	23.0	20.8	24.9	21.6	19.7
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0144	0.0148	0.0156	0.0141	0.0152	0.0161	0.0146	0.0157	0.0167
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0129	0.0133	0.0141	0.0127	0.0137	0.0145	0.0132	0.0142	0.0150
Total Effects of SO2 Oxidation									
Total SO2 to SO3 conversion rate, %vol	67.0%	67.0%	67.0%	67.0%	67.0%	67.0%	67.0%	67.0%	67.0%
Total Amount of SO2 converted to SO3, lb/h	9.71	7.92	6.74	9.09	7.25	6.19	8.18	6.59	5.65
Maximum Stack Ammonium Sulfate [(NH4)2-(SO4)] (assuming 100% conversion from SO3), lb	20.03	16.33	13.90	18.75	14.95	12.76	16.86	13.60	11.65
Maximum Stack H2SO4 (assuming 100% conversion from SO3 to H2SO4), lb/h	14.87	12.12	10.32	13.92	11.10	9.47	12.52	10.10	8.65
CO2 Emissions									
CO2, lb/hr	260,228	212,142	180,620	243,583	194,246	165,797	219,078	176,704	151,383
CO2, lb/Mbtu (LHV)	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6
CO2, lb/Mbtu (HHV)	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9
Post Combustion Emissions Control Equipment									
Catalytic Conversion in CO Catalyst									
CO removed in CO Catalyst, %wt	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
CO removed in CO Catalyst, lb/h	12.6	10.2	21.6	11.4	9.0	19.8	10.2	8.4	18.0
VOC removed in CO Catalyst, %wt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
VOC removed in CO Catalyst, lb/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selective Catalytic Reduction (SCR)									
NOx Removed in SCR, %wt	91.1%	91.1%	91.1%	91.1%	91.1%	91.1%	91.1%	91.1%	91.1%
NOx removed in SCR, lb/h	214.9	174.9	149.4	201.3	160.3	136.6	180.3	145.7	124.8
Ammonia Slip, lb/h	29.9	24.4	20.7	28.0	22.3	19.0	25.2	20.3	17.4

Notes:

1. EMISSIONS ARE PRELIMINARY. NO GUARANTEES APPLY. NO MARGINS APPLIED.
2. The dry air composition used is 0.98% Ar, 78.03% N2 and 20.99%O2
3. Standard conditions are defined as 60 F, 14.696 psia, Norm conditions are defined as 0 C, 1.103 bar
4. All ppm values are based on CH4 calibration gas.
5. The CTG performance and emissions are based on runs provided by Siemens dated 3/15/2010
6. The natural gas used in estimates contains 2.25 grains/100 SCF of sulfur content.
7. The VOC/UHC ratio is assumed to be 50%.
8. Effect of SCR and CO catalyst are included.
9. The front half catch of particulate emissions is assumed to be half the amount of the front and back half catch.
10. Where manufacturer data of lb/h of pollutant emissions were available, the greater of the manufacturer's estimate and B&V's estimate was used in the summary table, i.e. the B&V estimates were adjusted, where applicable.
11. The estimated oxidation of SO2 in CTG is assumed to be 15%. The SO2 - SO3 conversion in the CO catalyst is assumed to be 60%.
12. The CO catalyst was designed to reduce the CO Stack emissions by 60% for all operating scenarios. While there was no VOC reduction.
13. The SCR was designed to reduce the NOx stack emissions to 2.5 ppmvd @ 15%O2 for natural gas
14. Tempering air mass flowrate controlled to limit stack exit temperature to 800F for all cases, with a minimum allowable flowrate of 13,500 lb/hr.
15. Tempering air has been assumed to not contribute to stack emissions.

ADDITIONAL CALCULATIONS MADE BY URS USING ABOVE DATA

Information used to compare values with emission standards (federal, state, local, and NSPS):

lb NOx/MWhr	0.09	0.10	0.10	0.09	0.10	0.11	0.10	0.10	0.11
lb SO2/MWhr	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
Max lb NOx/MWhr	0.11								
Max lb SO2/MWhr	0.03								

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
Siemens SGT6-5000F4 - Simple Cycle Emissions Summary - Natural Gas 3.48 grains/100 scf Sulfur

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	97%	75%	60%	100%	75%	60%	100%	75%	60%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
Ambient Conditions									
Ambient Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
Ambient Relative Humidity, %	40.0	40.0	40.0	75.0	75.0	75.0	30.0	30.0	30.0
Atmospheric Pressure, psia	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682
Combustion Turbine Performance									
CTG Performance Reference	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS
CTG Inlet Air Conditioning Effectiveness, %	0	0	0	0	0	0	0	0	0
CTG Compressor Inlet Dry Bulb Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
CTG Compr. Inlet Relative Humidity, %	40.5	40.4	40.3	75.1	75.1	75.1	30.2	30.1	30.1
Inlet Loss, in. H2O	4.4	3.1	2.4	4.4	3.0	2.3	3.9	2.6	2.2
Exhaust Loss, in. H2O	13.9	9.8	7.7	12.8	8.8	6.9	11.0	7.8	6.2
CTG Load Level (percent of Base Load)	97%	75%	60%	100%	75%	60%	100%	75%	60%
Gross CTG Output, kW	232,041	180,354	144,283	212,485	159,364	127,491	185,016	138,762	111,009
Gross CTG Heat Rate, Btu/kWh (LHV)	8,718	9,144	9,732	8,912	9,475	10,109	9,205	9,900	10,602
Gross CTG Heat Rate, Btu/kWh (HHV)	9,679	10,152	10,805	9,894	10,519	11,223	10,219	10,991	11,770
CTG Heat Input, MBtu/h (LHV)	2,022.9	1,649.2	1,404.2	1,893.7	1,510.0	1,288.8	1,703.1	1,373.7	1,176.9
CTG Heat Input, MBtu/h (HHV)	2,245.9	1,830.9	1,558.9	2,102.4	1,676.4	1,430.9	1,890.8	1,525.1	1,306.6
CTG Water/Steam Injection Flow, lb/h	0	0	0	0	0	0	0	0	0
Injection Fluid/Fuel Ratio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTG Exhaust Flow, lb/h	4,278,989	3,583,124	3,168,369	4,067,043	3,355,676	2,972,709	3,718,759	3,116,999	2,770,277
CTG Exhaust Temperature, F	1,088	1,088	1,088	1,115	1,115	1,115	1,144	1,144	1,144
Combustion Turbine Fuel									
Total CTG Fuel Flow, lb/h	95,680	78,000	66,420	89,570	71,420	60,960	80,550	64,960	55,670
CTG Fuel Temperature, F	77	77	77	77	77	77	77	77	77
CTG Fuel LHV, Btu/lb	21,142	21,142	21,142	21,142	21,142	21,142	21,142	21,142	21,142
CTG Fuel HHV, Btu/lb	23,472	23,472	23,472	23,472	23,472	23,472	23,472	23,472	23,472
HHV/LHV Ratio	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102
CTG Fuel Composition (Ultimate Analysis by Weight)									
Ar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%
H2	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%
N2	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%
O2	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%
S	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
Combustion Turbine Exhaust									
CTG Exhaust Analysis (Volume Basis - Wet)									
Ar	0.94%	0.94%	0.94%	0.93%	0.93%	0.94%	0.93%	0.93%	0.93%
CO2	3.93%	3.83%	3.69%	3.86%	3.74%	3.60%	3.79%	3.65%	3.52%
H2O	7.82%	7.62%	7.34%	8.52%	8.27%	8.00%	8.77%	8.49%	8.24%
N2	74.95%	75.03%	75.13%	74.35%	74.45%	74.55%	74.10%	74.21%	74.31%
O2	12.36%	12.58%	12.89%	12.34%	12.62%	12.91%	12.40%	12.71%	13.00%
SO2, (after SO2 oxidation)	0.00020%	0.00019%	0.00019%	0.00019%	0.00019%	0.00018%	0.00019%	0.00018%	0.00018%
SO3, (after SO2 oxidation)	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Molecular Wt, lb/mol	28.47	28.48	28.50	28.39	28.40	28.42	28.35	28.37	28.39
Specific Volume, ft^3/lb	38.41	38.78	38.95	39.30	39.66	39.82	40.25	40.53	40.67
Specific Volume, scf/lb	13.33	13.32	13.31	13.37	13.36	13.35	13.38	13.37	13.37
Exhaust Gas Flow, acfm	2,739,266	2,315,892	2,056,800	2,663,913	2,218,102	1,972,888	2,494,667	2,105,533	1,877,786
Exhaust Gas Flow, scfm	950,649	795,454	702,850	906,273	747,197	661,428	829,283	694,571	617,310
CTG NOx Emissions (Without Post Combustion Emissions Control)									
NOx Massflow Added to Match CTG Manufacturer's NOx Emissions Estimate, lb/h	10.03	7.78	7.13	9.46	7.32	6.03	7.76	6.53	5.52
Additonal Percent Margin included in mass based NOx Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
NOx, ppmvd (dry, 15% O2)	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00
NOx, ppmvd (dry)	35.45	34.45	33.10	35.08	33.83	32.52	34.56	33.18	31.91
NOx, ppmvw (wet)	32.68	31.83	30.67	32.09	31.03	29.92	31.52	30.36	29.28
NOx, lb/h as NO2	236.0	192.0	164.0	221.0	176.0	150.0	198.0	160.0	137.0
NOx, lb/MBtu (LHV)	0.1167	0.1164	0.1168	0.1167	0.1166	0.1164	0.1163	0.1165	0.1164
NOx, lb/MBtu (HHV)	0.1051	0.1049	0.1052	0.1051	0.1050	0.1048	0.1047	0.1049	0.1048
CTG CO Emissions (Without Post Combustion Emissions Control)									
CO Massflow Added to Match CTG Manufacturer's CO Emissions Estimate, lb/h	1.35	0.98	1.89	0.60	0.33	1.70	0.45	0.65	1.41
Additional Percent Margin included in mass based CO Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
CO, ppmvd (dry, 15% O2)	4.00	4.00	10.00	4.00	4.00	10.00	4.00	4.00	10.00
CO, ppmvd (dry)	5.06	4.92	11.82	5.01	4.83	11.61	4.94	4.74	11.40
CO, ppmvw (wet)	4.67	4.55	10.95	4.58	4.43	10.68	4.50	4.34	10.46
CO, lb/h	21.0	17.0	36.0	19.0	15.0	33.0	17.0	14.0	30.0
CO, lb/MBtu (LHV)	0.0104	0.0103	0.0256	0.0100	0.0099	0.0256	0.0100	0.0102	0.0255
CO, lb/MBtu (HHV)	0.0094	0.0093	0.0231	0.0090	0.0089	0.0231	0.0090	0.0092	0.0230
CTG SO2 Emissions (After SO2 Oxydation, Without Post Combustion Emissions Control)									
SO2 massflow (lb/h) added to match CTG manufacturer's lb/h SO2 emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h SO2 Emissions below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CTG, vol%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
SO2, ppmvd (dry, 15% O2)	1.6939	1.6939	1.6939	1.6939	1.6939	1.6939	1.6939	1.6939	1.6939
SO2, ppmvd (dry)	2.1445	2.0841	2.0023	2.1221	2.0463	1.9671	2.0904	2.0071	1.9304
SO2, ppmvw (wet)	1.9768	1.9253	1.8553	1.9413	1.8772	1.8097	1.9070	1.8366	1.7714
SO2, lb/h	19.0341	15.5169	13.2132	17.8186	14.2079	12.1271	16.0242	12.9268	11.0747
SO2, lb/MBtu (LHV)	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
SO2, lb/MBtu (HHV)	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085
CTG UHC Emissions (Without Post Combustion Emissions Control)									
UHC massflow (lb/h) added to match CTG manufacturer's lb/h CO emissions estimate	0.17	0.21	0.09	0.13	0.20	0.21	0.26	0.18	0.13
Additional Percent Margin included in lb/h UHC Emissions Below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UHC, ppmvd (dry, 15% O2)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
UHC, ppmvd (dry)	2.5	2.5	2.4	2.5	2.4	2.3	2.5	2.4	2.3
UHC, ppmvw (wet)	2.3	2.3	2.2	2.3	2.2	2.1	2.3	2.2	2.1
UHC, lb/h as CH4	5.8	4.8	4.0	5.4	4.4	3.8	5.0	4.0	3.4
UHC, lb/MBtu as CH4 (LHV)	0.0029	0.0029	0.0028	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029
UHC, lb/MBtu as CH4 (HHV)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0027	0.0026	0.0026	0.0026
CTG VOC Emissions (Without Post Combustion Emissions Control)									
VOC Massflow (lb/h) added to match CTG manufacturer's lb/h VOC emissions estimate	0.09	0.11	0.05	0.07	0.10	0.11	0.13	0.09	0.06
Additional percent margin included in lb/h VOC emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
VOC percentage of UHC	50%	50%	50%	50%	50%	50%	50%	50%	50%
VOC, ppmvd (dry, 15% O2)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
VOC, ppmvd (dry)	1.3	1.2	1.2	1.3	1.2	1.2	1.2	1.2	1.1
VOC, ppmvw (wet)	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0
VOC, lb/h as CH4	2.9	2.4	2.0	2.7	2.2	1.9	2.5	2.0	1.7
VOC, lb/MBtu as CH4 (LHV)	0.0014	0.0015	0.0014	0.0014	0.0015	0.0015	0.0015	0.0015	0.0014
VOC, lb/MBtu as CH4 (HHV)	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013

06-Dec-10
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Siemens SGT6-5000F4 - Simple Cycle Emissions Summary - Natural Gas 3.48 grains/100 scf Sulfur

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	97%	75%	60%	100%	75%	60%	100%	75%	60%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
CTG PM10 Emissions (without the Effects of SO2 Oxidation)									
Percent margin included in PM10 emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
PM10, lb/MBtu (LHV)	0.0022	0.0024	0.0028	0.0021	0.0026	0.0031	0.0023	0.0029	0.0034
PM10, lb/MBtu (HHV)	0.0020	0.0022	0.0026	0.0019	0.0024	0.0028	0.0021	0.0026	0.0031
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	9.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
PM10, lb/MBtu (LHV)	0.0044	0.0049	0.0057	0.0042	0.0053	0.0062	0.0047	0.0058	0.0068
PM10, lb/MBtu (HHV)	0.0040	0.0044	0.0051	0.0038	0.0048	0.0056	0.0042	0.0052	0.0061
CO2 Emissions									
CO2, lb/hr	260,217	212,133	180,639	243,599	194,238	165,790	219,068	176,723	151,403
CO2, lb/Mbtu (LHV)	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6
CO2, lb/Mbtu (HHV)	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9
Stack Emissions									
Stack Exhaust Analysis - Volume Basis - Wet									
Ar	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.94%	0.94%	0.94%
CO2	2.81%	2.73%	2.64%	2.64%	2.55%	2.46%	2.47%	2.38%	2.30%
H2O	5.60%	5.46%	5.26%	6.11%	5.94%	5.76%	6.18%	6.00%	5.83%
N2	75.81%	75.87%	75.94%	75.28%	75.35%	75.42%	75.11%	75.18%	75.24%
O2	14.83%	14.99%	15.20%	15.02%	15.21%	15.41%	15.30%	15.50%	15.68%
SO2 (after SO2 oxidation)	0.000050%	0.000050%	0.000050%	0.000050%	0.000050%	0.000050%	0.000050%	0.000050%	0.000040%
SO3 (after SO2 oxidation)	0.000110%	0.000110%	0.000100%	0.000100%	0.000100%	0.000100%	0.000100%	0.000090%	0.000090%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Stack Exit Temperature, F	800	799	800	800	800	799	800	799	799
Stack Diameter, ft (estimated)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Stack Flow, lb/h	6,027,980	5,047,117	4,459,363	5,991,035	4,939,670	4,378,003	5,742,752	4,810,993	4,272,972
Stack Flow, scfm	1,332,186	1,115,414	984,777	1,327,016	1,094,138	968,999	1,272,978	1,066,438	946,464
Stack Flow, acfm	3,232,007	2,704,417	2,388,735	3,220,186	2,654,253	2,350,261	3,088,647	2,585,912	2,296,013
Stack Exit Velocity, ft/s	130.0	108.0	96.0	129.0	106.0	94.0	124.0	104.0	92.0
Stack NOx Emissions without the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
NOx, ppmvd (dry)	24.7	24.0	23.1	23.3	22.5	21.7	21.9	21.0	20.3
NOx, ppmvw (wet)	23.3	22.7	21.9	21.9	21.2	20.4	20.5	19.8	19.1
NOx, lb/h as NO2 (includes correction adder)	236.0	192.0	164.0	221.0	176.0	150.0	198.0	160.0	137.0
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.1167	0.1164	0.1168	0.1167	0.1166	0.1164	0.1163	0.1165	0.1164
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.1051	0.1049	0.1052	0.1051	0.1050	0.1048	0.1047	0.1049	0.1048
Stack NOx Emissions with the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
NOx, ppmvd (dry)	2.2	2.1	2.1	2.1	2.0	1.9	2.0	1.9	1.8
NOx, ppmvw (wet)	2.1	2.0	2.0	2.0	1.9	1.8	1.8	1.8	1.7
NOx, lb/h as NO2 (includes NOx margin applied to CTG)	21.1	17.1	14.6	19.7	15.7	13.4	17.7	14.3	12.2
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
SCR NH3 slip, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
SCR NH3 slip, lb/h	29.9	24.4	20.7	28.0	22.3	19.0	25.2	20.3	17.4
Stack CO Emissions without the Effects of Catalytic Reduction									
CO, ppmvd (dry, 15% O2)	4.0	4.0	10.0	4.0	4.0	10.0	4.0	4.0	10.0
CO, ppmvd (dry)	3.5	3.4	8.3	3.3	3.2	7.7	3.1	3.0	7.2
CO, ppmvw (wet)	3.3	3.2	7.8	3.1	3.0	7.3	2.9	2.8	6.8
CO, lb/h (includes CO correction as applied to CTG and margin)	21.0	17.0	36.0	19.0	15.0	33.0	17.0	14.0	30.0
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0104	0.0103	0.0256	0.0100	0.0099	0.0256	0.0100	0.0102	0.0255
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0094	0.0093	0.0231	0.0090	0.0089	0.0231	0.0090	0.0092	0.0230
Stack CO Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
CO, ppmvd (dry, 15% O2)	1.6	1.6	4.0	1.6	1.6	4.0	1.6	1.6	4.0
CO, ppmvd (dry)	1.4	1.4	3.3	1.3	1.3	3.1	1.3	1.2	2.9
CO, ppmvw (wet)	1.3	1.3	3.1	1.3	1.2	2.9	1.2	1.1	2.7
CO, lb/h (includes CO margin applied to CTG)	8.4	6.8	14.4	7.6	6.0	13.2	6.8	5.6	12.0
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0042	0.0041	0.0103	0.0040	0.0040	0.0102	0.0040	0.0041	0.0102
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0037	0.0037	0.0092	0.0036	0.0036	0.0092	0.0036	0.0037	0.0092
Stack SO2 Emissions without the Effects of SO2 Scrubber, without SO2 Oxidation									
Assumed SO2 oxidation rate in CTG, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CO Catalyst, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in SCR, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SO2, ppmvd (dry, 15% O2)	1.9928	1.9928	1.9928	1.9928	1.9928	1.9928	1.9928	1.9928	1.9928
SO2, ppmvd (dry)	2.5229	2.4519	2.3556	2.4966	2.4074	2.3142	2.4593	2.3613	2.2711
SO2, ppmvw (wet)	2.3256	2.2651	2.1827	2.2839	2.2085	2.1291	2.2435	2.1607	2.0840
SO2, lb/h	22.3931	18.2552	15.5449	20.9631	16.7152	14.2672	18.8520	15.2080	13.0291
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
Stack SO2 Emissions without the Effects of SO2 Scrubber, after SO2 Oxidation									
Assumed SO2 oxidation rate in CO Catalyst, vol%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
Assumed SO2 oxidation rate in SCR, vol%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SO2, ppmvd (dry, 15% O2)	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66
SO2, ppmvd (dry)	0.58	0.56	0.54	0.55	0.53	0.51	0.51	0.49	0.48
SO2, ppmvw (wet)	0.55	0.53	0.51	0.51	0.50	0.48	0.48	0.46	0.45
SO2, lb/h	7.39	6.02	5.13	6.91	5.51	4.71	6.22	5.02	4.30
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033
Stack UHC Emissions									
UHC, ppmvd (dry, 15% O2)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
UHC, ppmvd	1.8	1.7	1.7	1.7	1.6	1.5	1.6	1.5	1.4
UHC, ppmvw	1.7	1.6	1.6	1.6	1.5	1.5	1.5	1.4	1.4
UHC, lb/h as CH4 (includes correction adder)	5.8	4.8	4.0	5.4	4.4	3.8	5.0	4.0	3.4
UHC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0029	0.0029	0.0028	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029
UHC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0027	0.0026	0.0026	0.0026
Stack VOC Emissions without the Effect of Oxidation in a CO catalyst									
VOC, ppmvd (dry, 15% O2)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
VOC, ppmvd (dry)	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.7
VOC, ppmvw (wet)	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7
VOC, lb/h as CH4 (includes correction adder)	2.9	2.4	2.0	2.7	2.2	1.9	2.5	2.0	1.7
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0014	0.0015	0.0014	0.0014	0.0015	0.0015	0.0015	0.0015	0.0014
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
Stack VOC Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
VOC, ppmvd (dry, 15% O2)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
VOC, ppmvd (dry)	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.7
VOC, ppmvw (wet)	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7
VOC, lb/h as CH4 (includes VOC correction as applied to CTG)	2.9	2.4	2.0	2.7	2.2	1.9	2.5	2.0	1.7
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0014	0.0015	0.0014	0.0014	0.0015	0.0015	0.0015	0.0015	0.0014
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
Siemens SGT6-5000F4 - Simple Cycle Emissions Summary - Natural Gas 3.48 grains/100 scf Sulfur

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	97%	75%	60%	100%	75%	60%	100%	75%	60%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	No	No	No	No	No	No	No	No	No
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
PM10 without the Effects of SO2 oxidation									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0022	0.0024	0.0028	0.0021	0.0026	0.0031	0.0023	0.0029	0.0034
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0020	0.0022	0.0026	0.0019	0.0024	0.0028	0.0021	0.0026	0.0031
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	9.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0044	0.0049	0.0057	0.0042	0.0053	0.0062	0.0047	0.0058	0.0068
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0040	0.0044	0.0051	0.0038	0.0048	0.0056	0.0042	0.0052	0.0061
PM10 with the Effects of SO2 Oxidation (includes (NH4)2-(SO4))									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	35.5	29.2	25.5	33.0	27.1	23.7	30.1	25.0	22.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0175	0.0177	0.0182	0.0174	0.0180	0.0184	0.0177	0.0182	0.0187
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0158	0.0160	0.0164	0.0157	0.0162	0.0166	0.0159	0.0164	0.0168
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	40.0	33.2	29.5	37.0	31.1	27.7	34.1	29.0	26.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0198	0.0202	0.0210	0.0195	0.0206	0.0215	0.0200	0.0211	0.0221
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0178	0.0182	0.0189	0.0176	0.0186	0.0194	0.0180	0.0190	0.0199
Total Effects of SO2 Oxidation									
Total SO2 to SO3 conversion rate, %vol	67.0%	67.0%	67.0%	67.0%	67.0%	67.0%	67.0%	67.0%	67.0%
Total Amount of SO2 converted to SO3, lb/h	15.01	12.23	10.42	14.05	11.20	9.56	12.63	10.19	8.73
Maximum Stack Ammonium Sulfate [(NH4)2-(SO4)] (assuming 100% conversion from SO3), lb	30.96	25.24	21.49	28.98	23.11	19.72	26.06	21.02	18.01
Maximum Stack H2SO4 (assuming 100% conversion from SO3 to H2SO4), lb/h	22.98	18.73	15.95	21.51	17.15	14.64	19.34	15.60	13.37
CO2 Emissions									
CO2, lb/hr	260,217	212,133	180,639	243,599	194,238	165,790	219,068	176,723	151,403
CO2, lb/Mbtu (LHV)	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6	128.6
CO2, lb/Mbtu (HHV)	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9	115.9
Post Combustion Emissions Control Equipment									
Catalytic Conversion in CO Catalyst									
CO removed in CO Catalyst, %wt	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
CO removed in CO Catalyst, lb/h	12.6	10.2	21.6	11.4	9.0	19.8	10.2	8.4	18.0
VOC removed in CO Catalyst, %wt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
VOC removed in CO Catalyst, lb/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selective Catalytic Reduction (SCR)									
NOx Removed in SCR, %wt	91.1%	91.1%	91.1%	91.1%	91.1%	91.1%	91.1%	91.1%	91.1%
NOx removed in SCR, lb/h	214.9	174.9	149.4	201.3	160.3	136.6	180.3	145.7	124.8
Ammonia Slip, lb/h	29.9	24.4	20.7	28.0	22.3	19.0	25.2	20.3	17.4

Notes:

1. EMISSIONS ARE PRELIMINARY. NO GUARANTEES APPLY. NO MARGINS APPLIED.
2. The dry air composition used is 0.98% Ar, 78.03% N2 and 20.99%O2
3. Standard conditions are defined as 60 F, 14.696 psia, Norm conditions are defined as 0 C, 1.103 bar
4. All ppm values are based on CH4 calibration gas.
5. The CTG performance and emissions are based on runs provided by Siemens dated 3/15/2010
6. The natural gas used in estimates contains 3.48 grains/100 SCF of sulfur content.
7. The VOC/UHC ratio is assumed to be 50%.
8. Effect of SCR and CO catalyst are included.
9. The front half catch of particulate emissions is assumed to be half the amount of the front and back half catch.
10. Where manufacturer data of lb/h of pollutant emissions were available, the greater of the manufacturer's estimate and B&V's estimate was used in the summary table, i.e. the B&V estimates were adjusted, where applicable.
11. The estimated oxidation of SO2 in CTG is assumed to be 15%. The SO2 - SO3 conversion in the CO catalyst is assumed to be 60%.
12. The CO catalyst was designed to reduce the CO Stack emissions by 60% for all operating scenarios. While there was no VOC reduction.
13. The SCR was designed to reduce the NOx stack emissions to 2.5 ppmvd @ 15%O2 for natural gas
14. Tempering air mass flowrate controlled to limit stack exit temperature to 800F for all cases, with a minimum allowable flowrate of 13,500 lb/hr.
15. Tempering air has been assumed to not contribute to stack emissions.

ADDITIONAL CALCULATIONS MADE BY URS USING ABOVE DATA

Information used to compare values with emission standards (federal, state, local, and NSPS)									
Stack Flow, scfm(dry) @ 7% O2	1,151,703	963,915	850,715	1,138,490	938,294	830,605	1,087,719	910,830	808,099
PM10, grains/dscf @ 7% O2	0.0036	0.0035	0.0035	0.0034	0.0034	0.0033	0.0032	0.0032	0.0032
lb NOx/MWhr	0.09	0.11	0.11	0.10	0.11	0.12	0.11	0.11	0.12
lb SO2/MWhr	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Max PM10 gr/dscf	0.0036								
Max lb NOx/MWhr	0.12								
Max lb SO2/MWhr	0.04								

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
Siemens SGT6-5000F4 - Simple Cycle Emissions Summary - Distillate Oil

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4
CTG Fuel Type	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate
CTG Load	100%	75%	70%	100%	75%	70%	100%	75%	70%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ambient Conditions									
Ambient Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
Ambient Relative Humidity, %	40.0	40.0	40.0	75.0	75.0	75.0	30.0	30.0	30.0
Atmospheric Pressure, psia	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682
Combustion Turbine Performance									
CTG Performance Reference	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS
CTG Inlet Air Conditioning Effectiveness, %	0	0	0	0	0	0	0	0	0
CTG Compressor Inlet Dry Bulb Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
CTG Compr. Inlet Relative Humidity, %	40.6	40.4	40.4	75.1	75.1	75.1	30.2	30.1	30.1
Inlet Loss, in. H2O	4.8	3.2	3.0	4.4	3.1	2.9	3.9	2.8	2.7
Exhaust Loss, in. H2O	14.6	9.8	9.1	12.5	8.8	8.2	10.7	7.7	7.2
CTG Load Level (percent of Base Load)	100%	75%	70%	100%	75%	70%	100%	75%	70%
Gross CTG Output, kW	223,517	167,839	156,462	196,715	147,536	137,700	170,326	127,744	119,227
Gross CTG Heat Rate, Btu/kWh (LHV)	9,022	9,453	9,616	9,228	9,821	9,994	9,570	10,299	10,486
Gross CTG Heat Rate, Btu/kWh (HHV)	9,607	10,066	10,239	9,826	10,458	10,642	10,190	10,967	11,166
CTG Heat Input, MBtu/h (LHV)	2,016.6	1,584.7	1,504.5	1,815.3	1,449.0	1,376.2	1,630.0	1,315.6	1,250.2
CTG Heat Input, MBtu/h (HHV)	2,147.3	1,687.4	1,602.1	1,933.0	1,542.9	1,465.4	1,735.7	1,400.9	1,331.2
CTG Water/Steam Injection Flow, lb/h	43,926	25,894	20,486	39,543	23,676	18,738	35,509	21,498	17,023
Injection Fluid/Fuel Ratio	0.4	0.3	0.3	0.4	0.3	0.3	0.4	0.3	0.3
CTG Exhaust Flow, lb/h	4,498,844	3,666,318	3,534,415	4,116,907	3,432,223	3,309,381	3,764,006	3,183,930	3,070,270
CTG Exhaust Temperature, F	1,028	1,028	1,028	1,055	1,055	1,055	1,085	1,085	1,085
Combustion Turbine Fuel									
Total CTG Fuel Flow, lb/h	109,830	86,310	81,950	98,870	78,920	74,960	88,780	71,660	68,090
CTG Fuel Temperature, F	77	77	77	77	77	77	77	77	77
CTG Fuel LHV, Btu/lb	18,360	18,360	18,360	18,360	18,360	18,360	18,360	18,360	18,360
CTG Fuel HHV, Btu/lb	19,550	19,550	19,550	19,550	19,550	19,550	19,550	19,550	19,550
HHV/LHV Ratio	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648
CTG Fuel Composition (Ultimate Analysis by Weight)									
Ar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%
H2	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%
N2	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
O2	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
S	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Combustion Turbine Exhaust									
CTG Exhaust Analysis (Volume Basis - Wet)									
Ar	0.94%	0.95%	0.95%	0.93%	0.94%	0.94%	0.93%	0.94%	0.94%
CO2	5.11%	4.94%	4.87%	5.01%	4.81%	4.74%	4.92%	4.70%	4.63%
H2O	6.12%	5.54%	5.27%	6.84%	6.23%	5.98%	7.12%	6.50%	6.26%
N2	75.00%	75.40%	75.58%	74.40%	74.81%	74.98%	74.15%	74.56%	74.73%
O2	12.83%	13.18%	13.34%	12.81%	13.21%	13.36%	12.88%	13.30%	13.44%
SO2, (after SO2 oxidation)	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%
SO3, (after SO2 oxidation)	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Molecular Wt, lb/mol	28.85	28.89	28.91	28.76	28.80	28.82	28.72	28.76	28.78
Specific Volume, ft^3/lb	36.38	36.74	36.78	37.34	37.62	37.65	38.30	38.52	38.54
Specific Volume, scf/lb	13.15	13.13	13.12	13.19	13.17	13.16	13.21	13.19	13.18
Exhaust Gas Flow, acfm	2,727,799	2,245,009	2,166,596	2,562,088	2,152,004	2,076,637	2,402,690	2,044,083	1,972,137
Exhaust Gas Flow, scfm	985,997	802,313	772,859	905,033	753,373	725,858	828,709	699,934	674,436
CTG NOx Emissions (Without Post Combustion Emissions Control)									
NOx Massflow Added to Match CTG Manufacturer's NOx Emissions Estimate, lb/h	15.93	12.04	11.78	14.46	11.32	10.80	12.25	10.20	9.45
Additonal Percent Margin included in mass based NOx Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
NOx, ppmvd (dry, 15% O2)	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
NOx, ppmvd (dry)	51.37	49.31	48.47	50.77	48.37	47.55	49.94	47.41	46.63
NOx, ppmvw (wet)	48.23	46.58	45.91	47.30	45.35	44.71	46.39	44.33	43.71
NOx, lb/h as NO2	362.0	284.0	270.0	326.0	260.0	247.0	292.0	236.0	224.0
NOx, lb/MBtu (LHV)	0.1795	0.1792	0.1795	0.1796	0.1794	0.1795	0.1791	0.1794	0.1792
NOx, lb/MBtu (HHV)	0.1686	0.1683	0.1685	0.1687	0.1685	0.1686	0.1682	0.1685	0.1683
CTG CO Emissions (Without Post Combustion Emissions Control)									
CO Massflow Added to Match CTG Manufacturer's CO Emissions Estimate, lb/h	1.84	5.73	4.71	1.84	4.86	4.29	1.45	4.81	3.70
Additional Percent Margin included in mass based CO Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
CO, ppmvd (dry, 15% O2)	10.00	30.00	30.00	10.00	30.00	30.00	10.00	30.00	30.00
CO, ppmvd (dry)	12.23	35.22	34.62	12.09	34.55	33.97	11.89	33.87	33.31
CO, ppmvw (wet)	11.48	33.27	32.79	11.26	32.40	31.94	11.04	31.66	31.22
CO, lb/h	52.0	124.0	117.0	47.0	113.0	107.0	42.0	103.0	97.0
CO, lb/MBtu (LHV)	0.0258	0.0782	0.0778	0.0259	0.0780	0.0778	0.0258	0.0783	0.0776
CO, lb/MBtu (HHV)	0.0242	0.0735	0.0730	0.0243	0.0732	0.0730	0.0242	0.0735	0.0729
CTG SO2 Emissions (After SO2 Oxydation, Without Post Combustion Emissions Control)									
SO2 massflow (lb/h) added to match CTG manufacturer's lb/h SO2 emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h SO2 Emissions below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CTG, vol%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
SO2, ppmvd (dry, 15% O2)	0.2439	0.2439	0.2439	0.2439	0.2439	0.2439	0.2439	0.2439	0.2439
SO2, ppmvd (dry)	0.2983	0.2863	0.2814	0.2948	0.2809	0.2761	0.2900	0.2753	0.2706
SO2, ppmvw (wet)	0.2800	0.2705	0.2666	0.2746	0.2634	0.2596	0.2693	0.2574	0.2538
SO2, lb/h	2.7980	2.1988	2.0878	2.5188	2.0106	1.9097	2.2618	1.8256	1.7347
SO2, lb/MBtu (LHV)	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
SO2, lb/MBtu (HHV)	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
CTG UHC Emissions (Without Post Combustion Emissions Control)									
UHC massflow (lb/h) added to match CTG manufacturer's lb/h CO emissions estimate	0.25	0.65	0.54	0.23	0.61	0.43	0.16	0.55	0.51
Additional Percent Margin included in lb/h UHC Emissions Below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UHC, ppmvd (dry, 15% O2)	2.0	6.0	6.0	2.0	6.0	6.0	2.0	6.0	6.0
UHC, ppmvd (dry)	2.4	7.0	6.9	2.4	6.9	6.8	2.4	6.8	6.7
UHC, ppmvw (wet)	2.3	6.7	6.6	2.3	6.5	6.4	2.2	6.3	6.2
UHC, lb/h as CH4	6.0	14.2	13.4	5.4	13.0	12.2	4.8	11.8	11.2
UHC, lb/MBtu as CH4 (LHV)	0.0030	0.0090	0.0089	0.0030	0.0090	0.0089	0.0029	0.0090	0.0090
UHC, lb/MBtu as CH4 (HHV)	0.0028	0.0084	0.0084	0.0028	0.0084	0.0083	0.0028	0.0084	0.0084
CTG VOC Emissions (Without Post Combustion Emissions Control)									
VOC Massflow (lb/h) added to match CTG manufacturer's lb/h VOC emissions estimate	0.13	0.33	0.27	0.11	0.31	0.22	0.08	0.28	0.26
Additional percent margin included in lb/h VOC emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
VOC percentage of UHC	50%	50%	50%	50%	50%	50%	50%	50%	50%
VOC, ppmvd (dry, 15% O2)	1.0	3.0	3.0	1.0	3.0	3.0	1.0	3.0	3.0
VOC, ppmvd (dry)	1.2	3.5	3.5	1.2	3.5	3.4	1.2	3.4	3.3
VOC, ppmvw (wet)	1.1	3.3	3.3	1.1	3.2	3.2	1.1	3.2	3.1
VOC, lb/h as CH4	3.0	7.1	6.7	2.7	6.5	6.1	2.4	5.9	5.6
VOC, lb/MBtu as CH4 (LHV)	0.0015	0.0045	0.0045	0.0015	0.0045	0.0044	0.0015	0.0045	0.0045
VOC, lb/MBtu as CH4 (HHV)	0.0014	0.0042	0.0042	0.0014	0.0042	0.0042	0.0014	0.0042	0.0042

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
Siemens SGT6-5000F4 - Simple Cycle Emissions Summary - Distillate Oil

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4
CTG Fuel Type	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate
CTG Load	100%	75%	70%	100%	75%	70%	100%	75%	70%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CTG PM10 Emissions (without the Effects of SO2 Oxidation)									
Percent margin included in PM10 emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
PM10, lb/MBtu (LHV)	0.0074	0.0095	0.0100	0.0083	0.0104	0.0109	0.0092	0.0114	0.0120
PM10, lb/MBtu (HHV)	0.0070	0.0089	0.0094	0.0078	0.0097	0.0102	0.0086	0.0107	0.0113
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
PM10, lb/MBtu (LHV)	0.0149	0.0189	0.0199	0.0165	0.0207	0.0218	0.0184	0.0228	0.0240
PM10, lb/MBtu (HHV)	0.0140	0.0178	0.0187	0.0155	0.0194	0.0205	0.0173	0.0214	0.0225
CO2 Emissions									
CO2, lb/hr	350,804	275,679	261,753	315,797	252,075	239,427	283,569	228,886	217,484
CO2, lb/MBtu (LHV)	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0
CO2, lb/MBtu (HHV)	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.4
Stack Emissions									
Stack Exhaust Analysis - Volume Basis - Wet									
Ar	0.95%	0.95%	0.96%	0.94%	0.95%	0.95%	0.94%	0.95%	0.95%
CO2	3.88%	3.74%	3.69%	3.64%	3.49%	3.44%	3.40%	3.26%	3.21%
H2O	4.66%	4.22%	4.02%	5.23%	4.79%	4.60%	5.34%	4.92%	4.75%
N2	75.72%	76.02%	76.16%	75.19%	75.49%	75.62%	75.03%	75.31%	75.42%
O2	14.79%	15.06%	15.18%	14.99%	15.28%	15.39%	15.29%	15.58%	15.67%
SO2 (after SO2 oxidation)	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%
SO3 (after SO2 oxidation)	0.000020%	0.000020%	0.000020%	0.000020%	0.000020%	0.000010%	0.000010%	0.000010%	0.000010%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Stack Exit Temperature, F	800	799	799	800	800	800	800	799	799
Stack Diameter, ft (estimated)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Stack Flow, lb/h	5,936,843	4,835,317	4,660,414	5,671,906	4,725,222	4,553,380	5,440,005	4,597,929	4,431,269
Stack Flow, scfm	1,300,169	1,057,323	1,019,077	1,245,929	1,037,186	998,708	1,196,801	1,010,012	973,402
Stack Flow, acfm	3,153,454	2,565,136	2,470,797	3,023,126	2,515,394	2,422,399	2,902,243	2,449,930	2,359,651
Stack Exit Velocity, ft/s	126.0	103.0	99.0	121.0	101.0	97.0	116.0	98.0	95.0
Stack NOx Emissions without the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
NOx, ppmvd (dry)	38.4	36.9	36.3	36.3	34.6	34.1	33.9	32.3	31.8
NOx, ppmvw (wet)	36.6	35.3	34.8	34.4	33.0	32.5	32.1	30.7	30.3
NOx, lb/h as NO2 (includes correction adder)	362.0	284.0	270.0	326.0	260.0	247.0	292.0	236.0	224.0
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.1795	0.1792	0.1795	0.1796	0.1794	0.1795	0.1791	0.1794	0.1792
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.1686	0.1683	0.1685	0.1687	0.1685	0.1686	0.1682	0.1685	0.1683
Stack NOx Emissions with the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
NOx, ppmvd (dry)	4.6	4.4	4.3	4.3	4.1	4.1	4.0	3.8	3.8
NOx, ppmvw (wet)	4.4	4.2	4.1	4.1	3.9	3.9	3.8	3.7	3.6
NOx, lb/h as NO2 (includes NOx margin applied to CTG)	43.1	33.8	32.1	38.8	31.0	29.4	34.8	28.1	26.7
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0214	0.0213	0.0214	0.0214	0.0214	0.0214	0.0213	0.0214	0.0213
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0201	0.0200	0.0201	0.0201	0.0201	0.0201	0.0200	0.0201	0.0200
SCR NH3 slip, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
SCR NH3 slip, lb/h	30.5	24.0	22.8	27.5	21.9	20.8	24.7	19.9	18.9
Stack CO Emissions without the Effects of Catalytic Reduction									
CO, ppmvd (dry, 15% O2)	10.0	30.0	30.0	10.0	30.0	30.0	10.0	30.0	30.0
CO, ppmvd (dry)	9.1	26.4	25.9	8.6	24.7	24.3	8.1	23.1	22.7
CO, ppmvw (wet)	8.7	25.2	24.9	8.2	23.5	23.2	7.7	21.9	21.6
CO, lb/h (includes CO correction as applied to CTG and margin)	52.0	124.0	117.0	47.0	113.0	107.0	42.0	103.0	97.0
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0258	0.0782	0.0778	0.0259	0.0780	0.0778	0.0258	0.0783	0.0776
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0242	0.0735	0.0730	0.0243	0.0732	0.0730	0.0242	0.0735	0.0729
Stack CO Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
CO, ppmvd (dry, 15% O2)	4.0	12.0	12.0	4.0	12.0	12.0	4.0	12.0	12.0
CO, ppmvd (dry)	3.7	10.5	10.4	3.5	9.9	9.7	3.2	9.2	9.1
CO, ppmvw (wet)	3.5	10.1	10.0	3.3	9.4	9.3	3.1	8.8	8.7
CO, lb/h (includes CO margin applied to CTG)	20.8	49.6	46.8	18.8	45.2	42.8	16.8	41.2	38.8
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0103	0.0313	0.0311	0.0104	0.0312	0.0311	0.0103	0.0313	0.0310
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0097	0.0294	0.0292	0.0097	0.0293	0.0292	0.0097	0.0294	0.0291
Stack SO2 Emissions without the Effects of SO2 Scrubber, without SO2 Oxidation									
Assumed SO2 oxidation rate in CTG, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CO Catalyst, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in SCR, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SO2, ppmvd (dry, 15% O2)	0.2869	0.2869	0.2869	0.2869	0.2869	0.2869	0.2869	0.2869	0.2869
SO2, ppmvd (dry)	0.3509	0.3368	0.3311	0.3468	0.3305	0.3248	0.3412	0.3239	0.3186
SO2, ppmvw (wet)	0.3294	0.3182	0.3136	0.3231	0.3099	0.3054	0.3168	0.3028	0.2986
SO2, lb/h	3.2918	2.5868	2.4562	2.9633	2.3654	2.2467	2.6609	2.1478	2.0408
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015
Stack SO2 Emissions without the Effects of SO2 Scrubber, after SO2 Oxidation									
Assumed SO2 oxidation rate in CO Catalyst, vol%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
Assumed SO2 oxidation rate in SCR, vol%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SO2, ppmvd (dry, 15% O2)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
SO2, ppmvd (dry)	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07
SO2, ppmvw (wet)	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.07
SO2, lb/h	1.09	0.85	0.81	0.98	0.78	0.74	0.88	0.71	0.67
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Stack UHC Emissions									
UHC, ppmvd (dry, 15% O2)	2.0	6.0	6.0	2.0	6.0	6.0	2.0	6.0	6.0
UHC, ppmvd	1.8	5.3	5.2	1.7	4.9	4.9	1.6	4.6	4.5
UHC, ppmvw	1.7	5.0	5.0	1.6	4.7	4.6	1.5	4.4	4.3
UHC, lb/h as CH4 (includes correction adder)	8.0	14.2	13.4	5.4	13.0	12.2	4.8	11.8	11.2
UHC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0030	0.0090	0.0089	0.0030	0.0090	0.0089	0.0029	0.0090	0.0090
UHC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0028	0.0084	0.0084	0.0028	0.0084	0.0083	0.0028	0.0084	0.0084
Stack VOC Emissions without the Effect of Oxidation in a CO catalyst									
VOC, ppmvd (dry, 15% O2)	1.0	3.0	3.0	1.0	3.0	3.0	1.0	3.0	3.0
VOC, ppmvd (dry)	0.9	2.6	2.6	0.9	2.5	2.4	0.8	2.3	2.3
VOC, ppmvw (wet)	0.9	2.5	2.5	0.8	2.4	2.3	0.8	2.2	2.2
VOC, lb/h as CH4 (includes correction adder)	3.0	7.1	6.7	2.7	6.5	6.1	2.4	5.9	5.6
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0015	0.0045	0.0045	0.0015	0.0045	0.0044	0.0015	0.0045	0.0045
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0014	0.0042	0.0042	0.0014	0.0042	0.0042	0.0014	0.0042	0.0042
Stack VOC Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
VOC, ppmvd (dry, 15% O2)	1.0	3.0	3.0	1.0	3.0	3.0	1.0	3.0	3.0
VOC, ppmvd (dry)	0.9	2.6	2.6	0.9	2.5	2.4	0.8	2.3	2.3
VOC, ppmvw (wet)	0.9	2.5	2.5	0.8	2.4	2.3	0.8	2.2	2.2
VOC, lb/h as CH4 (includes VOC correction as applied to CTG)	3.0	7.1	6.7	2.7	6.5	6.1	2.4	5.9	5.6
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0015	0.0045	0.0045	0.0015	0.0045	0.0044	0.0015	0.0045	0.0045
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0014	0.0042	0.0042	0.0014	0.0042	0.0042	0.0014	0.0042	0.0042

06-Dec-10
Puget Sound Energy - Fredonia
B&V Project Number 165510
Siemens SGT6-5000F4 - Simple Cycle Emissions Summary - Distillate Oil

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4	SGT6-5000F4
CTG Fuel Type	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate	Distillate
CTG Load	100%	75%	70%	100%	75%	70%	100%	75%	70%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PM10 without the Effects of SO2 oxidation									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0074	0.0095	0.0100	0.0083	0.0104	0.0109	0.0092	0.0114	0.0120
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0070	0.0089	0.0094	0.0078	0.0097	0.0102	0.0086	0.0107	0.0113
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0149	0.0189	0.0199	0.0165	0.0207	0.0218	0.0184	0.0228	0.0240
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0140	0.0178	0.0187	0.0155	0.0194	0.0205	0.0173	0.0214	0.0225
PM10 with the Effects of SO2 Oxidation [includes (NH4)2-(SO4)]									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	19.6	18.6	18.4	19.1	18.3	18.1	18.7	18.0	17.8
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0097	0.0117	0.0122	0.0105	0.0126	0.0132	0.0115	0.0137	0.0143
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0091	0.0110	0.0115	0.0099	0.0118	0.0124	0.0108	0.0128	0.0134
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	34.6	33.6	33.4	34.1	33.3	33.1	33.7	33.0	32.8
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0171	0.0212	0.0222	0.0188	0.0230	0.0241	0.0207	0.0251	0.0263
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0161	0.0199	0.0208	0.0176	0.0216	0.0226	0.0194	0.0235	0.0247
Total Effects of SO2 Oxidation									
Total SO2 to SO3 conversion rate, %vol	67.0%	67.0%	67.0%	67.0%	67.0%	67.0%	67.0%	67.0%	67.0%
Total Amount of SO2 converted to SO3, lb/h	2.21	1.73	1.65	1.99	1.59	1.51	1.78	1.44	1.37
Maximum Stack Ammonium Sulfate ((NH4)2-(SO4)) (assuming 100% conversion from SO3), lb	4.55	3.58	3.40	4.10	3.27	3.11	3.68	2.97	2.82
Maximum Stack H2SO4 (assuming 100% conversion from SO3 to H2SO4), lb/h	3.38	2.65	2.52	3.04	2.43	2.31	2.73	2.20	2.09
CO2 Emissions									
CO2, lb/hr	350,804	275,679	261,753	315,797	252,075	239,427	283,569	228,886	217,484
CO2, lb/MBtu (LHV)	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0
CO2, lb/MBtu (HHV)	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.4
Post Combustion Emissions Control Equipment									
Catalytic Conversion in CO Catalyst									
CO removed in CO Catalyst, %wt	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
CO removed in CO Catalyst, lb/h	31.2	74.4	70.2	28.2	67.8	64.2	25.2	61.8	58.2
VOC removed in CO Catalyst, %wt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
VOC removed in CO Catalyst, lb/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selective Catalytic Reduction (SCR)									
NOx Removed in SCR, %wt	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%
NOx removed in SCR, lb/h	318.9	250.2	237.9	287.2	229.0	217.6	257.2	207.9	197.3
Ammonia Slip, lb/h	30.5	24.0	22.8	27.5	21.9	20.8	24.7	19.9	18.9

Notes:

1. EMISSIONS ARE PRELIMINARY. NO GUARANTEES APPLY. NO MARGINS APPLIED.
2. The dry air composition used is 0.98% Ar, 78.03% N2 and 20.99%O2
3. Standard conditions are defined as 60 F, 14.696 psia, Norm conditions are defined as 0 C, 1.103 bar
4. All ppm values are based on CH4 calibration gas.
5. The CTG performance and emissions are based on runs provided by Siemens dated 3/15/2010
6. The distillate oil used in estimates contains 15 ppm sulfur content by weight.
7. The VOC/UHC ratio is assumed to be 50%.
8. Effect of SCR and CO catalyst are included.
9. The front half catch of particulate emissions is assumed to be half the amount of the front and back half catch.
10. Where manufacturer data of lb/h of pollutant emissions were available, the greater of the manufacturer's estimate and B&V's estimate was used in the summary table, i.e. the B&V estimates were adjusted, where applicable.
11. The estimated oxidation of SO2 in CTG is assumed to be 15%. The SO2 - SO3 conversion in the CO catalyst is assumed to be 60%.
12. The CO catalyst was designed to reduce the CO Stack emissions by 60% for all operating scenarios. While there was no VOC reduction.
13. The SCR was designed to reduce the NOx stack emissions to 5 ppmvd @ 15%O2 for distillate oil.
14. Tempering air mass flowrate controlled to limit stack exit temperature to 800F for all cases, with a minimum allowable flowrate of 13,500 lb/hr.
15. Tempering air has been assumed to not contribute to stack emissions.

ADDITIONAL CALCULATIONS MADE BY URS USING ABOVE DATA

Information used to compare values with emission standards (federal, state, local, and NSPS)									
Stack Flow, scfm(dry) @ 7% O2	1,135,750	924,936	892,078	1,079,323	899,585	866,813	1,031,906	871,722	840,730
PM10, grains/dscf @ 7% O2	0.0020	0.0023	0.0024	0.0021	0.0024	0.0024	0.0021	0.0024	0.0025
lb NOx/MWhr	0.19	0.20	0.21	0.20	0.21	0.21	0.20	0.22	0.22
lb SO2/MWhr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Max PM10 gr/dscf	0.0025								
Max lb NOx/MWhr	0.22								
Max lb SO2/MWhr	0.01								

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Fredonia
Simple Cycle Emissions - GE LMS100 - NG - 2.25 grains/100 scf Sulfur, Revision 2

Case Number	1	2	3	4	5	6	7	8	9	10	11	12
CTG Model	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	50%	30%	100%	75%	50%	30%	100%	75%	50%	30%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	7	51	51	51	51	88	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Ambient Conditions												
Ambient Temperature, F	7.0	7.0	7.0	7.0	51.0	51.0	51.0	51.0	88.0	88.0	88.0	88.0
Ambient Relative Humidity, %	40.0	40.0	40.0	40.0	75.0	75.0	75.0	75.0	30.0	30.0	30.0	30.0
Atmospheric Pressure, psia	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682
Combustion Turbine Performance												
CTG Performance Reference	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE
CTG Inlet Air Conditioning Effectiveness, %	0	0	0	0	0	0	0	0	0	0	0	0
CTG Compressor Inlet Dry Bulb Temperature, F	7.0	7.0	7.0	7.0	51.0	51.0	51.0	51.0	88.0	88.0	88.0	88.0
CTG Compr. Inlet Relative Humidity, %	40.6	40.6	40.6	40.6	75.1	75.1	75.1	75.1	30.2	30.2	30.2	30.2
Inlet Loss, in. H2O	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Exhaust Loss, in. H2O	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
CTG Load Level (percent of Base Load)	100%	75%	50%	30%	100%	75%	50%	30%	100%	75%	50%	30%
Gross CTG Output, kW	100,780	75,580	50,390	30,230	102,550	76,910	51,270	30,770	97,090	72,820	48,550	29,130
Gross CTG Heat Rate, Btu/kWh (LHV)	7,841	8,430	9,627	11,634	7,898	8,457	9,615	11,594	8,077	8,634	9,832	11,899
Gross CTG Heat Rate, Btu/kWh (HHV)	8,705	9,359	10,688	12,916	8,768	9,389	10,675	12,872	8,967	9,585	10,916	13,210
CTG Heat Input, MBtu/h (LHV)	790.2	637.1	485.1	351.7	809.9	650.4	493.0	356.8	784.2	628.7	477.3	346.6
CTG Heat Input, MBtu/h (HHV)	877.3	707.4	538.6	390.5	899.2	722.1	547.3	396.1	870.6	698.0	529.9	384.8
CTG Water/Steam Injection Flow, lb/h	26,700	19,700	13,200	8,000	25,900	18,700	12,300	7,300	24,200	17,100	11,200	6,500
Injection Fluid/Fuel Ratio	0.7	0.7	0.6	0.5	0.7	0.6	0.5	0.4	0.7	0.6	0.5	0.4
CTG Exhaust Flow, lb/h	1,754,693	1,474,396	1,181,677	918,383	1,726,032	1,458,514	1,176,176	917,044	1,635,617	1,396,831	1,131,954	887,355
CTG Exhaust Temperature, F	741	769	817	860	772	792	830	868	803	812	846	882
Combustion Turbine Fuel												
Total CTG Fuel Flow, lb/h	37,370	30,130	22,940	16,630	38,310	30,760	23,320	16,870	37,090	29,740	22,580	16,390
CTG Fuel Temperature, F	77	77	77	77	77	77	77	77	77	77	77	77
CTG Fuel LHV, Btu/lb	21,143	21,143	21,143	21,143	21,143	21,143	21,143	21,143	21,143	21,143	21,143	21,143
CTG Fuel HHV, Btu/lb	23,473	23,473	23,473	23,473	23,473	23,473	23,473	23,473	23,473	23,473	23,473	23,473
HHV/LHV Ratio	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102
CTG Fuel Composition (Ultimate Analysis by Weight)												
Ar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%
H2	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%
N2	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%
O2	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%
S	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%	0.00758%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Combustion Turbine Exhaust												
CTG Exhaust Analysis (Volume Basis - Wet)												
Ar	0.92%	0.92%	0.93%	0.93%	0.91%	0.92%	0.92%	0.93%	0.91%	0.91%	0.92%	0.92%
CO2	3.72%	3.57%	3.40%	3.18%	3.86%	3.67%	3.46%	3.22%	3.94%	3.70%	3.48%	3.23%
H2O	9.77%	9.20%	8.53%	7.71%	10.83%	10.14%	9.36%	8.50%	11.33%	10.49%	9.69%	8.81%
N2	73.26%	73.59%	73.99%	74.45%	72.54%	72.94%	73.38%	73.87%	72.21%	72.69%	73.14%	73.63%
O2	12.33%	12.71%	13.16%	13.72%	11.86%	12.33%	12.87%	13.48%	11.62%	12.20%	12.77%	13.40%
SO2, (after SO2 oxidation)	0.00013%	0.00013%	0.00012%	0.00011%	0.00014%	0.00013%	0.00012%	0.00012%	0.00014%	0.00013%	0.00012%	0.00012%
SO3, (after SO2 oxidation)	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Molecular Wt, lb/mol	28.23	28.28	28.34	28.41	28.13	28.19	28.26	28.33	28.08	28.16	28.22	28.30
Specific Volume, ft^3/lb	30.18	30.83	31.97	32.96	31.09	31.51	32.39	33.27	31.91	32.05	32.84	33.65
Specific Volume, scf/lb	13.44	13.41	13.39	13.35	13.49	13.46	13.43	13.39	13.51	13.48	13.44	13.41
Exhaust Gas Flow, acfm	882,611	757,594	629,637	504,498	894,372	765,963	634,939	508,501	869,876	746,141	619,556	497,658
Exhaust Gas Flow, scfm	393,051	329,528	263,711	204,340	388,070	327,193	263,267	204,654	368,286	313,821	253,558	198,324
CTG NOx Emissions (Without Post Combustion Emissions Control)												
NOx Massflow Added to Match CTG Manufacturer's NOx Emissions Estimate, lb/h	0.61	0.47	0.33	0.23	0.63	0.49	0.33	0.22	0.63	0.47	0.33	0.23
Additonal Percent Margin included in mass based NOx Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
NOx, ppmvd (dry, 15% O2)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
NOx, ppmvd (dry)	30.55	29.18	27.57	25.55	32.10	30.32	28.33	26.11	32.92	30.70	28.57	26.27
NOx, ppmvw (wet)	27.56	26.49	25.22	23.58	28.62	27.25	25.68	23.89	29.19	27.48	25.80	23.96
NOx, lb/h as NO2	79.4	64.0	48.7	35.3	81.4	65.4	49.5	35.8	78.8	63.2	48.0	34.8
NOx, lb/MBtu (LHV)	0.1005	0.1005	0.1004	0.1004	0.1005	0.1005	0.1004	0.1004	0.1005	0.1005	0.1005	0.1004
NOx, lb/MBtu (HHV)	0.0905	0.0905	0.0904	0.0904	0.0905	0.0905	0.0905	0.0904	0.0906	0.0905	0.0905	0.0904
CTG CO Emissions (Without Post Combustion Emissions Control)												
CO Massflow Added to Match CTG Manufacturer's CO Emissions Estimate, lb/h	1.19	0.62	0.57	0.44	1.06	0.60	0.37	0.54	0.80	0.48	0.58	0.54
Additional Percent Margin included in mass based CO Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
CO, ppmvd (dry, 15% O2)	73.92	61.27	61.92	79.59	62.29	56.01	63.39	90.31	59.33	56.56	68.46	102.76
CO, ppmvd (dry)	90.31	71.50	68.29	81.35	79.96	67.94	71.84	94.30	78.12	69.45	78.24	107.98
CO, ppmvw (wet)	81.49	64.92	62.47	75.07	71.30	61.05	65.11	86.28	69.27	62.16	70.68	98.47
CO, lb/h	143.0	95.4	73.5	68.4	123.6	89.1	76.3	78.8	113.8	86.9	80.0	87.0
CO, lb/MBtu (LHV)	0.1810	0.1497	0.1516	0.1945	0.1526	0.1370	0.1548	0.2208	0.1451	0.1382	0.1675	0.2511
CO, lb/MBtu (HHV)	0.1630	0.1349	0.1365	0.1752	0.1375	0.1234	0.1394	0.1989	0.1307	0.1244	0.1509	0.2262
CTG SO2 Emissions (After SO2 Oxydation, Without Post Combustion Emissions Control)												
SO2 massflow (lb/h) added to match CTG manufacturer's lb/h SO2 emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h SO2 Emissions below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CTG, vol%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%
SO2, ppmvd (dry, 15% O2)	1.2097	1.2097	1.2097	1.2097	1.2097	1.2097	1.2097	1.2097	1.2097	1.2097	1.2097	1.2097
SO2, ppmvd (dry)	1.4781	1.4119	1.3341	1.2364	1.5530	1.4674	1.3709	1.2632	1.5929	1.4853	1.3826	1.2712
SO2, ppmvw (wet)	1.3336	1.2819	1.2203	1.1411	1.3848	1.3186	1.2426	1.1558	1.4124	1.3295	1.2486	1.1592
SO2, lb/h	5.3095	4.2808	3.2593	2.3628	5.4430	4.3703	3.3133	2.3969	5.2697	4.2254	3.2081	2.3287
SO2, lb/MBtu (LHV)	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
SO2, lb/MBtu (HHV)	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061
CTG UHC Emissions (Without Post Combustion Emissions Control)												
UHC massflow (lb/h) added to match CTG manufacturer's lb/h CO emissions estimate	0.07	0.04	0.04	0.02	0.07	0.04	0.02	0.03	0.05	0.03	0.03	0.02
Additional Percent Margin included in lb/h UHC Emissions Below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UHC, ppmvd (dry, 15% O2)	10.1	10.0	10.0	10.6	10.0	10.0	10.0	11.6	10.0	10.0	10.0	13.1
UHC, ppmvd (dry)	12.3	11.7	11.0	10.8	12.8	12.1	11.3	12.1	13.2	12.3	11.4	13.7
UHC, ppmvw (wet)	11.1	10.6	10.1	10.0	11.4	10.9	10.3	11.1	11.7	11.0	10.3	12.5
UHC, lb/h as CH4	11.1	8.9	6.8	5.2	11.3	9.1	6.9	5.8	11.0	8.8	6.7	6.3
UHC, lb/MBtu as CH4 (LHV)	0.0141	0.0140	0.0140	0.0147	0.0140	0.0140	0.0140	0.0162	0.0140	0.0140	0.0140	0.0183
UHC, lb/MBtu as CH4 (HHV)	0.0127	0.0126	0.0126	0.0133	0.0126	0.0126	0.0126	0.0146	0.0126	0.0126	0.0126	0.0164
CTG VOC Emissions (Without Post Combustion Emissions Control)												
VOC Massflow (lb/h) added to match CTG manufacturer's lb/h VOC emissions estimate	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00
Additional percent margin included in lb/h VOC emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
VOC percentage of UHC	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
VOC, ppmvd (dry, 15% O2)	2.0	2.0	2.0	2.1	2.0	2.0	2.0	2.3	2.0	2.0	2.0	2.6
VOC, ppmvd (dry)	2.5	2.3	2.2	2.2	2.6	2.4	2.3	2.4	2.6	2.5	2.3	2.7
VOC, ppmvw (wet)	2.2	2.1	2.0	2.0	2.3	2.2	2.1	2.2	2.3	2.2	2.1	2.5
VOC, lb/h as CH4	2.2	1.8	1.4	1.0	2.3	1.8	1.4	1.2	2.2	1.8	1.3	1.3
VOC, lb/MBtu as CH4 (LHV)	0.0028	0.0028	0.0028	0.0029	0.0028	0.0028	0.0028	0.0032	0.0028	0.0028	0.0028	0.0037
VOC, lb/MBtu as CH4 (HHV)	0.0025	0.0025	0.0025	0.0027	0.0025	0.0025	0.0025	0.0029	0.0025	0.0025	0.0025	0.0033

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Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE LMS100 - NG - 2.25 grains/100 scf Sulfur, Revision 2

Case Number	1	2	3	4	5	6	7	8	9	10	11	12
CTG Model	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	50%	30%	100%	75%	50%	30%	100%	75%	50%	30%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	7	51	51	51	51	88	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
CTG PM10 Emissions (without the Effects of SO2 Oxidation)												
Percent margin included in PM10 emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PM10 Emissions - Front Half Catch Only												
PM10, lb/h	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
PM10, lb/MBtu (LHV)	0.0038	0.0047	0.0062	0.0085	0.0037	0.0046	0.0061	0.0084	0.0038	0.0048	0.0063	0.0087
PM10, lb/MBtu (HHV)	0.0034	0.0042	0.0056	0.0077	0.0033	0.0042	0.0055	0.0076	0.0034	0.0043	0.0057	0.0078
PM10 Emissions - Front and Back Half Catch												
PM10, lb/h	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
PM10, lb/MBtu (LHV)	0.0076	0.0094	0.0124	0.0171	0.0074	0.0092	0.0122	0.0168	0.0077	0.0095	0.0126	0.0173
PM10, lb/MBtu (HHV)	0.0068	0.0085	0.0111	0.0154	0.0067	0.0083	0.0110	0.0151	0.0069	0.0086	0.0113	0.0156
CO2 Emissions												
CO2, lb/hr	101,638	81,947	62,392	45,230	104,195	83,660	63,425	45,883	100,876	80,886	61,412	44,577
CO2, lb/Mbtu (LHV)	128.6	128.6	128.6	128.6	128.7	128.6	128.7	128.6	128.6	128.7	128.7	128.6
CO2, lb/Mbtu (HHV)	115.9	115.8	115.8	115.8	115.9	115.9	115.9	115.8	115.9	115.9	115.9	115.8
Stack Emissions												
Stack Exhaust Analysis - Volume Basis - Wet												
Ar	0.92%	0.92%	0.93%	0.94%	0.91%	0.92%	0.92%	0.93%	0.91%	0.91%	0.92%	0.93%
CO2	3.70%	3.55%	3.32%	2.94%	3.84%	3.65%	3.32%	2.93%	3.91%	3.64%	3.25%	2.87%
H2O	9.72%	9.14%	8.34%	7.13%	10.78%	10.08%	9.01%	7.81%	11.27%	10.33%	9.14%	7.97%
N2	73.28%	73.62%	74.08%	74.72%	72.57%	72.97%	73.55%	74.18%	72.24%	72.76%	73.39%	74.01%
O2	12.38%	12.76%	13.33%	14.28%	11.91%	12.39%	13.20%	14.15%	11.67%	12.35%	13.30%	14.22%
SO2 (after SO2 oxidation)	0.000050%	0.000050%	0.000050%	0.000040%	0.000050%	0.000050%	0.000050%	0.000040%	0.000050%	0.000050%	0.000050%	0.000040%
SO3 (after SO2 oxidation)	0.000090%	0.000090%	0.000080%	0.000070%	0.000090%	0.000090%	0.000080%	0.000070%	0.000100%	0.000090%	0.000080%	0.000070%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Stack Exit Temperature, F	737	764	800	799	769	787	800	799	799	800	800	799
Stack Diameter, ft (estimated)	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Stack Flow, lb/h	1,764,690	1,484,394	1,209,375	995,782	1,736,029	1,458,512	1,228,074	1,010,543	1,645,614	1,422,329	1,213,352	1,001,454
Stack Flow, scfm	395,291	331,763	269,691	221,230	390,029	329,437	274,475	225,183	370,538	319,313	271,387	223,324
Stack Flow, acfm	910,876	782,277	654,273	536,561	922,990	791,040	666,231	546,031	898,233	774,696	658,447	541,286
Stack Exit Velocity, ft/s	134.0	115.0	96.0	79.0	136.0	117.0	98.0	80.0	132.0	114.0	97.0	80.0
Stack NOx Emissions without the Effects of Selective Catalytic Reduction (SCR)												
NOx, ppmvd (dry, 15% O2)	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
NOx, ppmvd (dry)	30.4	29.0	26.9	23.5	31.9	30.1	27.1	23.6	32.7	30.1	26.5	23.1
NOx, ppmvw (wet)	27.4	26.3	24.7	21.8	28.5	27.1	24.6	21.7	29.0	27.0	24.1	21.3
NOx, lb/h as NO2 (includes corrocion adder)	79.4	64.0	48.7	35.3	81.4	65.4	49.5	35.8	78.8	63.2	48.0	34.8
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.1005	0.1005	0.1004	0.1004	0.1005	0.1005	0.1004	0.1004	0.1005	0.1005	0.1005	0.1004
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0905	0.0905	0.0904	0.0904	0.0905	0.0905	0.0905	0.0904	0.0906	0.0905	0.0905	0.0904
Stack NOx Emissions with the Effects of Selective Catalytic Reduction (SCR)												
NOx, ppmvd (dry, 15% O2)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
NOx, ppmvd (dry)	3.0	2.9	2.7	2.3	3.2	3.0	2.7	2.4	3.3	3.0	2.7	2.3
NOx, ppmvw (wet)	2.7	2.6	2.5	2.2	2.8	2.7	2.5	2.2	2.9	2.7	2.4	2.1
NOx, lb/h as NO2 (includes NOx margin applied to CTG)	7.9	6.4	4.9	3.5	8.1	6.5	5.0	3.6	7.9	6.3	4.8	3.5
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0100	0.0100	0.0100	0.0100	0.0101	0.0100	0.0100	0.0100	0.0101	0.0100	0.0100	0.0100
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0091	0.0090	0.0090	0.0090	0.0091	0.0091	0.0090	0.0090	0.0091	0.0091	0.0090	0.0090
SCR NH3 slip, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
SCR NH3 slip, lb/h	11.7	9.4	7.2	5.2	12.0	9.6	7.3	5.3	11.6	9.3	7.1	5.1
Stack CO Emissions without the Effects of Catalytic Reduction												
CO, ppmvd (dry, 15% O2)	73.9	61.3	61.9	79.6	62.3	56.0	63.4	90.3	59.3	56.6	68.5	102.8
CO, ppmvd (dry)	89.8	71.0	66.6	74.7	79.5	67.4	68.6	85.1	77.6	68.1	72.7	95.0
CO, ppmvw (wet)	81.0	64.5	61.1	69.3	70.9	60.6	62.4	78.4	68.9	61.1	66.0	87.4
CO, lb/h (includes CO correction as applied to CTG and margin)	143.0	95.4	73.5	68.4	123.6	89.1	76.3	78.8	113.8	86.9	80.0	87.0
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.1810	0.1497	0.1516	0.1945	0.1526	0.1370	0.1548	0.2208	0.1451	0.1382	0.1675	0.2511
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.1630	0.1349	0.1365	0.1752	0.1375	0.1234	0.1394	0.1989	0.1307	0.1244	0.1509	0.2262
Stack CO Emissions with the Effects of Catalytic Reduction (CO Catalyst)												
CO, ppmvd (dry, 15% O2)	3.7	3.1	3.1	4.0	3.1	2.8	3.2	4.5	3.0	2.8	3.4	5.1
CO, ppmvd (dry)	4.5	3.5	3.3	3.7	4.0	3.4	3.4	4.3	3.9	3.4	3.6	4.8
CO, ppmvw (wet)	4.1	3.2	3.1	3.5	3.5	3.0	3.1	3.9	3.4	3.1	3.3	4.4
CO, lb/h (includes CO margin applied to CTG)	7.2	4.8	3.7	3.4	6.2	4.5	3.8	3.9	5.7	4.3	4.0	4.4
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0091	0.0075	0.0076	0.0097	0.0076	0.0068	0.0077	0.0110	0.0073	0.0069	0.0084	0.0126
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0082	0.0067	0.0068	0.0088	0.0069	0.0062	0.0070	0.0099	0.0065	0.0062	0.0075	0.0113
Stack SO2 Emissions without the Effects of SO2 Scrubber, without SO2 Oxidation												
Assumed SO2 oxidation rate in CTG, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CO Catalyst, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in SCR, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SO2, ppmvd (dry, 15% O2)	1.2894	1.2894	1.2894	1.2894	1.2894	1.2894	1.2894	1.2894	1.2894	1.2894	1.2894	1.2894
SO2, ppmvd (dry)	1.5755	1.5049	1.4220	1.3179	1.6553	1.5641	1.4612	1.3464	1.6978	1.5832	1.4737	1.3549
SO2, ppmvw (wet)	1.4215	1.3664	1.3007	1.2163	1.4760	1.4055	1.3245	1.2319	1.5054	1.4171	1.3309	1.2356
SO2, lb/h	5.6593	4.5628	3.4740	2.5185	5.8016	4.6582	3.5316	2.5548	5.6169	4.5038	3.4194	2.4821
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065
Stack SO2 Emissions without the Effects of SO2 Scrubber, after SO2 Oxidation												
Assumed SO2 oxidation rate in CO Catalyst, vol%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
Assumed SO2 oxidation rate in SCR, vol%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SO2, ppmvd (dry, 15% O2)	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
SO2, ppmvd (dry)	0.57	0.54	0.50	0.44	0.60	0.57	0.51	0.44	0.61	0.57	0.50	0.43
SO2, ppmvw (wet)	0.51	0.49	0.45	0.41	0.53	0.51	0.46	0.41	0.54	0.51	0.45	0.40
SO2, lb/h	2.06	1.66	1.26	0.92	2.11	1.70	1.29	0.93	2.04	1.64	1.24	0.90
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023
Stack UHC Emissions												
UHC, ppmvd (dry, 15% O2)	10.1	10.0	10.0	10.6	10.0	10.0	10.0	11.6	10.0	10.0	10.0	13.1
UHC, ppmvd	12.2	11.6	10.8	9.9	12.8	12.0	10.8	10.9	13.1	12.0	10.6	12.1
UHC, ppmvw	11.0	10.5	9.9	9.2	11.4	10.8	9.8	10.1	11.6	10.8	9.6	11.1
UHC, lb/h as CH4 (includes correction adder)	11.1	8.9	6.8	5.2	11.3	9.1	6.9	5.8	11.0	8.8	6.7	6.3
UHC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0141	0.0140	0.0140	0.0147	0.0140	0.0140	0.0140	0.0162	0.0140	0.0140	0.0140	0.0183
UHC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0127	0.0126	0.0126	0.0133	0.0126	0.0126	0.0126	0.0146	0.0126	0.0126	0.0126	0.0164
Stack VOC Emissions without the Effect of Oxidation in a CO catalyst												
VOC, ppmvd (dry, 15% O2)	2.0	2.0	2.0	2.1	2.0	2.0	2.0	2.3	2.0	2.0	2.0	2.6
VOC, ppmvd (dry)	2.4	2.3	2.2	2.0	2.6	2.4	2.2	2.2	2.6	2.4	2.1	2.4
VOC, ppmvw (wet)	2.2	2.1	2.0	1.8	2.3	2.2	2.0	2.0	2.3	2.2	1.9	2.2
VOC, lb/h as CH4 (includes correction adder)	2.2	1.8	1.4	1.0	2.3	1.8	1.4	1.2	2.2	1.8	1.3	1.3
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0028	0.0028	0.0028	0.0029	0.0028	0.0028	0.0028	0.0032	0.0028	0.0028	0.0028	0.0037
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0025	0.0025	0.0025	0.0027	0.0025	0.0025	0.0025	0.0029	0.0025	0.0025	0.0025	0.0033
Stack VOC Emissions with the Effects of Catalytic Reduction (CO Catalyst)												
VOC, ppmvd (dry, 15% O2)	2.0	2.0	2.0	2.1	2.0	2.0	2.0	2.3	2.0	2.0	2.0	2.6
VOC, ppmvd (dry)	2.4	2.3	2.2	2.0	2.6	2.4	2.2	2.2	2.6	2.4	2.1	2.4
VOC, ppmvw (wet)	2.2	2.1	2.0	1.8	2.3	2.2	2.0	2.0	2.3	2.2	1.9	2.2
VOC, lb/h as CH4 (includes VOC correction as applied to CTG)	2.2	1.8	1.4	1.0	2.3	1.8	1.4	1.2	2.2	1.8	1.3	1.3
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0028	0.0028	0.0028	0.0029	0.0028	0.0028	0.0028	0.0032	0.0028	0.0028	0.0028	0.0037
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0025	0.0025	0.0025	0.0027	0.0025	0.0025	0.0025	0.0029	0.0025	0.0025	0.0025	0.0033

7-Mar-11
Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE LMS100 - NG - 2.25 grains/100 scf Sulfur, Revision 2

Case Number	1	2	3	4	5	6	7	8	9	10	11	12
CTG Model	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	50%	30%	100%	75%	50%	30%	100%	75%	50%	30%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	7	51	51	51	51	88	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
PM10 without the Effects of SO2 oxidation												
PM10 Emissions - Front Half Catch Only												
PM10, lb/h	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0038	0.0047	0.0062	0.0085	0.0037	0.0046	0.0061	0.0084	0.0038	0.0048	0.0063	0.0087
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0034	0.0042	0.0056	0.0077	0.0033	0.0042	0.0055	0.0076	0.0034	0.0043	0.0057	0.0078
PM10 Emissions - Front and Back Half Catch												
PM10, lb/h	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0076	0.0094	0.0124	0.0171	0.0074	0.0092	0.0122	0.0168	0.0077	0.0095	0.0126	0.0173
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0068	0.0085	0.0111	0.0154	0.0067	0.0083	0.0110	0.0151	0.0069	0.0086	0.0113	0.0156
PM10 with the Effects of SO2 Oxidation [includes (NH4)2-(SO4)]												
PM10 Emissions - Front Half Catch Only												
PM10, lb/h	10.4	9.0	7.6	6.3	10.6	9.1	7.6	6.4	10.4	8.9	7.5	6.3
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0132	0.0141	0.0156	0.0179	0.0131	0.0140	0.0155	0.0178	0.0132	0.0142	0.0157	0.0180
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0119	0.0127	0.0140	0.0161	0.0118	0.0126	0.0139	0.0160	0.0119	0.0128	0.0141	0.0163
PM10 Emissions - Front and Back Half Catch												
PM10, lb/h	13.4	12.0	10.6	9.3	13.6	12.1	10.6	9.4	13.4	11.9	10.5	9.3
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0170	0.0188	0.0218	0.0265	0.0168	0.0186	0.0216	0.0262	0.0170	0.0189	0.0220	0.0267
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0153	0.0169	0.0196	0.0238	0.0151	0.0168	0.0194	0.0236	0.0154	0.0171	0.0198	0.0241
Total Effects of SO2 Oxidation												
Total SO2 to SO3 conversion rate, %vol	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%
Total Amount of SO2 converted to SO3, lb/h	3.60	2.90	2.21	1.60	3.69	2.96	2.25	1.62	3.57	2.86	2.17	1.58
Maximum Stack Ammonium Sulfate [(NH4)2-(SO4)] (assuming 100% conversion from SO3), lb	7.42	5.99	4.56	3.30	7.61	6.11	4.63	3.35	7.37	5.91	4.49	3.26
Maximum Stack H2SO4 (assuming 100% conversion from SO3 to H2SO4), lb/h	5.51	4.44	3.38	2.45	5.65	4.54	3.44	2.49	5.47	4.39	3.33	2.42
CO2 Emissions												
CO2, lb/hr	101,638	81,947	62,392	45,230	104,195	83,660	63,425	45,883	100,876	80,886	61,412	44,577
CO2, lb/Mbtu (LHV)	128.6	128.6	128.6	128.6	128.7	128.6	128.7	128.6	128.6	128.7	128.7	128.6
CO2, lb/Mbtu (HHV)	115.9	115.8	115.8	115.8	115.9	115.9	115.9	115.8	115.9	115.9	115.9	115.8
Post Combustion Emissions Control Equipment												
Catalytic Conversion in CO Catalyst												
CO removed in CO Catalyst, %wt	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%
CO removed in CO Catalyst, lb/h	135.9	90.6	69.8	65.0	117.4	84.6	72.5	74.8	108.1	82.5	76.0	82.7
VOC removed in CO Catalyst, %wt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
VOC removed in CO Catalyst, lb/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selective Catalytic Reduction (SCR)												
NOx Removed in SCR, %wt	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%
NOx removed in SCR, lb/h	71.5	57.6	43.8	31.8	73.3	58.8	44.6	32.2	71.0	56.9	43.2	31.3
Ammonia Slip, lb/h	11.7	9.4	7.2	5.2	12.0	9.6	7.3	5.3	11.6	9.3	7.1	5.1

Notes:

1. EMISSIONS ARE PRELIMINARY. NO GUARANTEES APPLY. NO MARGINS APPLIED.
2. The dry air composition used is 0.98% Ar, 78.03% N2 and 20.99%O2
3. Standard conditions are defined as 60 F, 14.696 psia, Norm conditions are defined as 0 C, 1.103 bar
4. All ppm values are based on CH4 calibration gas.
5. The CTG performance and emissions are based on runs provided by GE dated 2/11/2011
6. The natural gas used in estimates contains 2.25 grains/100 SCF of sulfur content.
7. The VOC/UHC ratio is base on CTG performance data provided by GE dated 2/11/2011
8. Effect of SCR and CO catalyst are included.
9. The front half catch of particulate emissions is assumed to be half the amount of the front and back half catch.
10. Where manufacturer data of lb/h of pollutant emissions were available, the greater of the manufacturer's estimate and B&V's estimate was used in the summary table, i.e. the B&V estimates were adjusted, where applicable.
11. The estimated oxidation of SO2 in CTG is based on performance data provided by GE. The SO2 - SO3 conversion in the CO catalyst is assumed to be 60%.
12. The CO catalyst was designed to reduce the CO Stack emissions by 95.0% for all operating scenarios. No VOC reduction was assumed.
13. The SCR was designed to reduce the NOx stack emissions to 2.5 ppmvd @ 15%O2 for natural gas
14. Tempering air mass flowrate controlled to limit stack exit temperature to 800F for all cases, with a minimum allowable flowrate of 10,000 lb/hr.
15. Tempering air has been assumed to not contribute to stack emissions.

ADDITIONAL CALCULATIONS MADE BY URS USING ABOVE DATA

Information used to compare values with emission standards (federal, state, local, and NSPS):

lb NOx/MWhr	0.08	0.08	0.10	0.12	0.08	0.08	0.10	0.12	0.08	0.09	0.10	0.12
lb SO2/MWhr	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.03
Max lb NOx/MWhr	0.12											
Max lb SO2/MWhr	0.03											

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Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE LMS100 - NG - 3.48 grains/100 scf Sulfur, Revision 2

Case Number	1	2	3	4	5	6	7	8	9	10	11	12
CTG Model	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	50%	30%	100%	75%	50%	30%	100%	75%	50%	30%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	7	51	51	51	51	88	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
Ambient Conditions												
Ambient Temperature, F	7.0	7.0	7.0	7.0	51.0	51.0	51.0	51.0	88.0	88.0	88.0	88.0
Ambient Relative Humidity, %	40.0	40.0	40.0	40.0	75.0	75.0	75.0	75.0	30.0	30.0	30.0	30.0
Atmospheric Pressure, psia	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682
Combustion Turbine Performance												
CTG Performance Reference	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE
CTG Inlet Air Conditioning Effectiveness, %	0	0	0	0	0	0	0	0	0	0	0	0
CTG Compressor Inlet Dry Bulb Temperature, F	7.0	7.0	7.0	7.0	51.0	51.0	51.0	51.0	88.0	88.0	88.0	88.0
CTG Compr. Inlet Relative Humidity, %	40.6	40.6	40.6	40.6	75.1	75.1	75.1	75.1	30.2	30.2	30.2	30.2
Inlet Loss, in. H2O	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Exhaust Loss, in. H2O	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
CTG Load Level (percent of Base Load)	100%	75%	50%	30%	100%	75%	50%	30%	100%	75%	50%	30%
Gross CTG Output, kW	100,780	75,580	50,390	30,230	102,550	76,910	51,270	30,770	97,090	72,820	48,550	29,130
Gross CTG Heat Rate, Btu/kWh (LHV)	7,841	8,430	9,627	11,634	7,898	8,457	9,615	11,594	8,077	8,634	9,832	11,899
Gross CTG Heat Rate, Btu/kWh (HHV)	8,705	9,359	10,688	12,916	8,768	9,389	10,675	12,872	8,967	9,586	10,916	13,210
CTG Heat Input, MBtu/h (LHV)	790.2	637.1	485.1	351.7	809.9	650.4	493.0	356.8	784.2	628.7	477.3	346.6
CTG Heat Input, MBtu/h (HHV)	877.3	707.4	538.6	390.5	899.2	722.1	547.3	396.1	870.6	698.0	530.0	384.8
CTG Water/Steam Injection Flow, lb/h	26,700	19,700	13,200	8,000	25,900	18,700	12,300	7,300	24,200	17,100	11,200	6,500
Injection Fluid/Fuel Ratio	0.7	0.7	0.6	0.5	0.7	0.6	0.5	0.4	0.7	0.6	0.5	0.4
CTG Exhaust Flow, lb/h	1,754,693	1,474,396	1,181,677	918,383	1,726,032	1,458,514	1,176,176	917,044	1,635,617	1,396,831	1,131,964	887,355
CTG Exhaust Temperature, F	741	769	817	860	772	792	830	868	803	812	846	882
Combustion Turbine Fuel												
Total CTG Fuel Flow, lb/h	37,380	30,140	22,950	16,630	38,310	30,760	23,320	16,870	37,090	29,740	22,580	16,390
CTG Fuel Temperature, F	77	77	77	77	77	77	77	77	77	77	77	77
CTG Fuel LHV, Btu/lb	21,142	21,142	21,142	21,142	21,142	21,142	21,142	21,142	21,142	21,142	21,142	21,142
CTG Fuel HHV, Btu/lb	23,472	23,472	23,472	23,472	23,472	23,472	23,472	23,472	23,472	23,472	23,472	23,472
HHV/LHV Ratio	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102	1.1102
CTG Fuel Composition (Ultimate Analysis by Weight)												
Ar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%	74.22%
H2	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%	24.51%
N2	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%
O2	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%
S	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%	0.01171%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
Combustion Turbine Exhaust												
CTG Exhaust Analysis (Volume Basis - Wet)												
Ar	0.92%	0.92%	0.93%	0.93%	0.91%	0.92%	0.92%	0.93%	0.91%	0.91%	0.92%	0.92%
CO2	3.72%	3.57%	3.40%	3.18%	3.86%	3.67%	3.46%	3.22%	3.94%	3.70%	3.48%	3.23%
H2O	9.78%	9.21%	8.53%	7.71%	10.83%	10.14%	9.36%	8.50%	11.33%	10.49%	9.69%	8.81%
N2	73.25%	73.59%	73.99%	74.45%	72.54%	72.94%	73.38%	73.87%	72.21%	72.69%	73.14%	73.63%
O2	12.33%	12.71%	13.15%	13.72%	11.86%	12.33%	12.87%	13.48%	11.62%	12.21%	12.77%	13.40%
SO2, (after SO2 oxidation)	0.00021%	0.00020%	0.00019%	0.00018%	0.00021%	0.00020%	0.00019%	0.00018%	0.00022%	0.00021%	0.00019%	0.00018%
SO3, (after SO2 oxidation)	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%	0.00001%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Molecular Wt, lb/mol	28.23	28.28	28.34	28.41	28.13	28.19	28.26	28.33	28.08	28.16	28.22	28.30
Specific Volume, ft^3/lb	30.18	30.83	31.97	32.96	31.09	31.51	32.39	33.27	31.91	32.05	32.84	33.65
Specific Volume, scf/lb	13.44	13.41	13.39	13.35	13.49	13.46	13.43	13.39	13.51	13.48	13.44	13.41
Exhaust Gas Flow, acfm	882,611	757,594	629,637	504,498	894,372	765,963	634,939	508,501	869,876	746,141	619,556	497,658
Exhaust Gas Flow, scfm	393,051	329,528	263,711	204,340	388,070	327,193	263,267	204,654	368,286	313,821	253,558	198,324
CTG NOx Emissions (Without Post Combustion Emissions Control)												
NOx Massflow Added to Match CTG Manufacturer's NOx Emissions Estimate, lb/h	0.59	0.45	0.31	0.23	0.63	0.50	0.33	0.23	0.63	0.47	0.33	0.23
Additonal Percent Margin included in mass based NOx Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
NOx, ppmvd (dry, 15% O2)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
NOx, ppmvd (dry)	30.55	29.19	27.58	25.55	32.09	30.32	28.33	26.11	32.92	30.69	28.57	26.27
NOx, ppmvw (wet)	27.57	26.50	25.23	23.58	28.62	27.25	26.68	23.89	29.19	27.47	25.80	23.95
NOx, lb/h as NO2	79.4	64.0	48.7	35.3	81.4	65.4	49.5	35.8	78.8	63.2	48.0	34.8
NOx, lb/MBtu (LHV)	0.1005	0.1005	0.1004	0.1004	0.1005	0.1005	0.1004	0.1004	0.1005	0.1005	0.1005	0.1004
NOx, lb/MBtu (HHV)	0.0905	0.0905	0.0904	0.0904	0.0905	0.0905	0.0905	0.0904	0.0906	0.0905	0.0905	0.0904
CTG CO Emissions (Without Post Combustion Emissions Control)												
CO Massflow Added to Match CTG Manufacturer's CO Emissions Estimate, lb/h	1.16	0.59	0.54	0.44	1.06	0.61	0.38	0.54	0.81	0.48	0.59	0.54
Additional Percent Margin included in mass based CO Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
CO, ppmvd (dry, 15% O2)	73.92	61.27	61.92	79.59	62.29	56.01	63.39	90.31	59.33	56.56	68.46	102.76
CO, ppmvd (dry)	90.34	71.53	68.32	81.34	79.96	67.94	71.83	94.30	78.12	69.45	78.24	107.98
CO, ppmvw (wet)	81.51	64.94	62.49	75.07	71.30	61.05	65.11	86.28	69.27	62.16	70.56	98.46
CO, lb/h	143.0	95.4	73.5	68.4	123.6	89.1	76.3	78.8	113.8	86.9	80.0	87.0
CO, lb/MBtu (LHV)	0.1810	0.1497	0.1516	0.1945	0.1526	0.1370	0.1548	0.2208	0.1451	0.1382	0.1675	0.2511
CO, lb/MBtu (HHV)	0.1630	0.1349	0.1365	0.1752	0.1375	0.1234	0.1394	0.1989	0.1307	0.1244	0.1509	0.2262
CTG SO2 Emissions (After SO2 Oxydation, Without Post Combustion Emissions Control)												
SO2 massflow (lb/h) added to match CTG manufacturer's lb/h SO2 emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h SO2 Emissions below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CTG, vol%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%
SO2, ppmvd (dry, 15% O2)	1.8696	1.8696	1.8696	1.8696	1.8696	1.8696	1.8696	1.8696	1.8696	1.8696	1.8696	1.8696
SO2, ppmvd (dry)	2.2850	2.1827	2.0627	1.9108	2.4001	2.2678	2.1186	1.9523	2.4618	2.2955	2.1367	1.9645
SO2, ppmvw (wet)	2.0616	1.9818	1.8867	1.7635	2.1402	2.0379	1.9203	1.7863	2.1829	2.0547	1.9296	1.7914
SO2, lb/h	8.2077	6.6180	5.0393	3.6515	8.4119	6.7541	5.1205	3.7042	8.1440	6.5302	4.9580	3.5988
SO2, lb/MBtu (LHV)	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104
SO2, lb/MBtu (HHV)	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
CTG UHC Emissions (Without Post Combustion Emissions Control)												
UHC massflow (lb/h) added to match CTG manufacturer's lb/h CO emissions estimate	0.06	0.03	0.03	0.02	0.07	0.04	0.02	0.03	0.05	0.03	0.03	0.02
Additional Percent Margin included in lb/h UHC Emissions Below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UHC, ppmvd (dry, 15% O2)	10.1	10.0	10.0	10.6	10.0	10.0	10.0	11.6	10.0	10.0	10.0	13.1
UHC, ppmvd (dry)	12.3	11.7	11.0	10.8	12.8	12.1	11.3	12.1	13.2	12.3	11.4	13.7
UHC, ppmvw (wet)	11.1	10.6	10.1	10.0	11.4	10.9	10.3	11.1	11.7	11.0	10.3	12.5
UHC, lb/h as CH4	11.1	8.9	6.8	5.2	11.3	9.1	6.9	5.8	11.0	8.8	6.7	6.3
UHC, lb/MBtu as CH4 (LHV)	0.0141	0.0140	0.0140	0.0147	0.0140	0.0140	0.0140	0.0162	0.0140	0.0140	0.0140	0.0183
UHC, lb/MBtu as CH4 (HHV)	0.0127	0.0126	0.0126	0.0133	0.0126	0.0126	0.0126	0.0146	0.0126	0.0126	0.0126	0.0164
CTG VOC Emissions (Without Post Combustion Emissions Control)												
VOC Massflow (lb/h) added to match CTG manufacturer's lb/h VOC emissions estimate	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00
Additional percent margin included in lb/h VOC emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
VOC percentage of UHC	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
VOC, ppmvd (dry, 15% O2)	2.0	2.0	2.0	2.1	2.0	2.0	2.0	2.3	2.0	2.0	2.0	2.6
VOC, ppmvd (dry)	2.5	2.3	2.2	2.2	2.6	2.4	2.3	2.4	2.6	2.5	2.3	2.7
VOC, ppmvw (wet)	2.2	2.1	2.0	2.0	2.3	2.2	2.1	2.2	2.3	2.2	2.1	2.5
VOC, lb/h as CH4	2.2	1.8	1.4	1.0	2.3	1.8	1.4	1.2	2.2	1.8	1.3	1.3
VOC, lb/MBtu as CH4 (LHV)	0.0028	0.0028	0.0028	0.0029	0.0028	0.0028	0.0028	0.0032	0.0028	0.0028	0.0028	0.0037
VOC, lb/MBtu as CH4 (HHV)	0.0025	0.0025	0.0025	0.0027	0.0025	0.0025	0.0025	0.0029	0.0025	0.0025	0.0025	0.0033

7-Mar-11
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PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE LMS100 - NG - 3.48 grains/100 scf Sulfur, Revision 2

Case Number	1	2	3	4	5	6	7	8	9	10	11	12
CTG Model	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	50%	30%	100%	75%	50%	30%	100%	75%	50%	30%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	7	51	51	51	51	88	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
CTG PM10 Emissions (without the Effects of SO2 Oxidation)												
Percent margin included in PM10 emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PM10 Emissions - Front Half Catch Only												
PM10, lb/h	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
PM10, lb/MBtu (LHV)	0.0038	0.0047	0.0062	0.0085	0.0037	0.0046	0.0061	0.0084	0.0038	0.0048	0.0063	0.0087
PM10, lb/MBtu (HHV)	0.0034	0.0042	0.0056	0.0077	0.0033	0.0042	0.0055	0.0076	0.0034	0.0043	0.0057	0.0078
PM10 Emissions - Front and Back Half Catch												
PM10, lb/h	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
PM10, lb/MBtu (LHV)	0.0076	0.0094	0.0124	0.0171	0.0074	0.0092	0.0122	0.0168	0.0077	0.0095	0.0126	0.0173
PM10, lb/MBtu (HHV)	0.0068	0.0085	0.0111	0.0154	0.0067	0.0083	0.0110	0.0151	0.0069	0.0086	0.0113	0.0156
CO2 Emissions												
CO2, lb/hr	101,661	81,970	62,416	45,228	104,190	83,657	63,422	45,881	100,872	80,883	61,410	44,575
CO2, lb/Mbtu (LHV)	128.7	128.7	128.7	128.6	128.6	128.6	128.6	128.6	128.6	128.7	128.7	128.6
CO2, lb/Mbtu (HHV)	115.9	115.9	115.9	115.8	115.9	115.9	115.9	115.8	115.9	115.9	115.9	115.8
Stack Emissions												
Stack Exhaust Analysis - Volume Basis - Wet												
Ar	0.92%	0.92%	0.93%	0.94%	0.91%	0.92%	0.92%	0.93%	0.91%	0.91%	0.92%	0.93%
CO2	3.70%	3.55%	3.33%	2.94%	3.84%	3.65%	3.32%	2.93%	3.91%	3.64%	3.25%	2.87%
H2O	9.72%	9.15%	8.34%	7.13%	10.78%	10.08%	9.01%	7.81%	11.27%	10.33%	9.14%	7.97%
N2	73.28%	73.62%	74.07%	74.72%	72.57%	72.97%	73.55%	74.18%	72.24%	72.76%	73.39%	74.01%
O2	12.38%	12.76%	13.33%	14.28%	11.91%	12.39%	13.20%	14.15%	11.67%	12.35%	13.30%	14.22%
SO2 (after SO2 oxidation)	0.000080%	0.000080%	0.000070%	0.000060%	0.000080%	0.000080%	0.000070%	0.000060%	0.000080%	0.000080%	0.000070%	0.000060%
SO3 (after SO2 oxidation)	0.000140%	0.000130%	0.000130%	0.000110%	0.000140%	0.000140%	0.000120%	0.000110%	0.000150%	0.000140%	0.000120%	0.000110%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Stack Exit Temperature, F	737	764	800	799	769	787	800	799	799	800	800	799
Stack Diameter, ft (estimated)	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Stack Flow, lb/h	1,764,689	1,484,393	1,209,375	995,781	1,736,028	1,468,511	1,228,074	1,010,542	1,645,613	1,422,328	1,213,352	1,001,453
Stack Flow, scfm	395,291	331,763	269,691	221,230	390,029	329,437	274,475	225,183	370,538	319,313	271,387	223,324
Stack Flow, acfm	910,876	782,277	654,273	536,561	922,990	791,040	666,231	546,031	898,233	774,696	658,447	541,286
Stack Exit Velocity, ft/s	134.0	115.0	96.0	79.0	136.0	117.0	98.0	80.0	132.0	114.0	97.0	80.0
Stack NOx Emissions without the Effects of Selective Catalytic Reduction (SCR)												
NOx, ppmvd (dry, 15% O2)	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
NOx, ppmvd (dry)	30.4	29.0	26.9	23.5	31.9	30.1	27.1	23.6	32.7	30.1	26.5	23.1
NOx, ppmvw (wet)	27.4	26.3	24.7	21.8	28.5	27.1	24.6	21.7	29.0	27.0	24.1	21.3
NOx, lb/h as NO2 (includes correction adder)	79.4	64.0	48.7	35.3	81.4	65.4	49.5	35.8	78.8	63.2	48.0	34.8
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.1005	0.1005	0.1004	0.1004	0.1005	0.1005	0.1004	0.1004	0.1005	0.1005	0.1005	0.1004
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0905	0.0905	0.0904	0.0904	0.0905	0.0905	0.0905	0.0904	0.0906	0.0905	0.0905	0.0904
Stack NOx Emissions with the Effects of Selective Catalytic Reduction (SCR)												
NOx, ppmvd (dry, 15% O2)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
NOx, ppmvd (dry)	3.0	2.9	2.7	2.3	3.2	3.0	2.7	2.4	3.3	3.0	2.7	2.3
NOx, ppmvw (wet)	2.7	2.6	2.5	2.2	2.8	2.7	2.5	2.2	2.9	2.7	2.4	2.1
NOx, lb/h as NO2 (includes NOx margin applied to CTG)	7.9	6.4	4.9	3.5	8.1	6.5	5.0	3.6	7.9	6.3	4.8	3.5
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0100	0.0100	0.0100	0.0100	0.0101	0.0100	0.0100	0.0100	0.0101	0.0100	0.0100	0.0100
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0091	0.0090	0.0090	0.0090	0.0091	0.0091	0.0090	0.0090	0.0091	0.0091	0.0090	0.0090
SCR NH3 slip, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
SCR NH3 slip, lb/h	11.7	9.4	7.2	5.2	12.0	9.6	7.3	5.3	11.6	9.3	7.1	5.1
Stack CO Emissions without the Effects of Catalytic Reduction												
CO, ppmvd (dry, 15% O2)	73.9	61.3	61.9	79.6	62.3	56.0	63.4	90.3	59.3	56.6	68.5	102.8
CO, ppmvd (dry)	89.8	71.0	66.6	74.7	79.5	67.4	68.6	85.1	77.6	68.1	72.7	95.0
CO, ppmvw (wet)	81.1	64.5	61.1	69.3	70.9	60.6	62.4	78.4	68.9	61.1	66.0	87.4
CO, lb/h (includes CO correction as applied to CTG and margin)	143.0	95.4	73.5	68.4	123.6	89.1	76.3	78.8	113.8	86.9	80.0	87.0
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.1810	0.1497	0.1516	0.1945	0.1526	0.1370	0.1548	0.2208	0.1451	0.1382	0.1675	0.2511
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.1630	0.1349	0.1365	0.1752	0.1375	0.1234	0.1394	0.1989	0.1307	0.1244	0.1509	0.2262
Stack CO Emissions with the Effects of Catalytic Reduction (CO Catalyst)												
CO, ppmvd (dry, 15% O2)	3.7	3.1	3.1	4.0	3.1	2.8	3.2	4.5	3.0	2.8	3.4	5.1
CO, ppmvd (dry)	4.5	3.6	3.3	3.7	4.0	3.4	3.4	4.3	3.9	3.4	3.6	4.8
CO, ppmvw (wet)	4.1	3.2	3.1	3.5	3.5	3.0	3.1	3.9	3.4	3.1	3.3	4.4
CO, lb/h (includes CO margin applied to CTG)	7.2	4.8	3.7	3.4	6.2	4.5	3.8	3.9	5.7	4.3	4.0	4.4
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0091	0.0075	0.0076	0.0097	0.0076	0.0068	0.0077	0.0110	0.0073	0.0069	0.0084	0.0126
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0082	0.0067	0.0068	0.0088	0.0069	0.0062	0.0070	0.0099	0.0065	0.0062	0.0075	0.0113
Stack SO2 Emissions without the Effects of SO2 Scrubber, without SO2 Oxidation												
Assumed SO2 oxidation rate in CTG, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CO Catalyst, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in SCR, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SO2, ppmvd (dry, 15% O2)	1.9928	1.9928	1.9928	1.9928	1.9928	1.9928	1.9928	1.9928	1.9928	1.9928	1.9928	1.9928
SO2, ppmvd (dry)	2.4355	2.3265	2.1986	2.0367	2.5582	2.4172	2.2582	2.0809	2.6240	2.4467	2.2775	2.0939
SO2, ppmvw (wet)	2.1974	2.1124	2.0110	1.8797	2.2812	2.1722	2.0468	1.9040	2.3267	2.1901	2.0567	1.9094
SO2, lb/h	8.7484	7.0540	5.3713	3.8921	8.9661	7.1991	5.4578	3.9482	8.6805	6.9604	5.2846	3.8359
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
Stack SO2 Emissions without the Effects of SO2 Scrubber, after SO2 Oxidation												
Assumed SO2 oxidation rate in CO Catalyst, vol%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
Assumed SO2 oxidation rate in SCR, vol%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SO2, ppmvd (dry, 15% O2)	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
SO2, ppmvd (dry)	0.88	0.84	0.78	0.68	0.93	0.87	0.78	0.68	0.95	0.87	0.77	0.67
SO2, ppmvw (wet)	0.80	0.76	0.72	0.63	0.83	0.79	0.71	0.63	0.84	0.78	0.70	0.62
SO2, lb/h	3.18	2.57	1.96	1.42	3.26	2.62	1.99	1.44	3.16	2.53	1.92	1.40
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036
Stack UHC Emissions												
UHC, ppmvd (dry, 15% O2)	10.1	10.0	10.0	10.6	10.0	10.0	10.0	11.6	10.0	10.0	10.0	13.1
UHC, ppmvd	12.2	11.6	10.8	9.9	12.8	12.0	10.8	10.9	13.1	12.0	10.6	12.1
UHC, ppmvw	11.0	10.5	9.9	9.2	11.4	10.8	9.8	10.1	11.6	10.8	9.6	11.1
UHC, lb/h as CH4 (includes correction adder)	11.1	8.9	6.8	5.2	11.3	9.1	6.9	5.8	11.0	8.8	6.7	6.3
UHC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0141	0.0140	0.0140	0.0147	0.0140	0.0140	0.0140	0.0162	0.0140	0.0140	0.0140	0.0183
UHC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0127	0.0126	0.0126	0.0133	0.0126	0.0126	0.0126	0.0146	0.0126	0.0126	0.0126	0.0164
Stack VOC Emissions without the Effect of Oxidation in a CO catalyst												
VOC, ppmvd (dry, 15% O2)	2.0	2.0	2.0	2.1	2.0	2.0	2.0	2.3	2.0	2.0	2.0	2.6
VOC, ppmvd (dry)	2.4	2.3	2.2	2.0	2.6	2.4	2.2	2.2	2.6	2.4	2.1	2.4
VOC, ppmvw (wet)	2.2	2.1	2.0	1.8	2.3	2.2	2.0	2.0	2.3	2.2	1.9	2.2
VOC, lb/h as CH4 (includes correction adder)	2.2	1.8	1.4	1.0	2.3	1.8	1.4	1.2	2.2	1.8	1.3	1.3
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0028	0.0028	0.0028	0.0029	0.0028	0.0028	0.0028	0.0032	0.0028	0.0028	0.0028	0.0037
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0025	0.0025	0.0025	0.0027	0.0025	0.0025	0.0025	0.0029	0.0025	0.0025	0.0025	0.0033
Stack VOC Emissions with the Effects of Catalytic Reduction (CO Catalyst)												
VOC, ppmvd (dry, 15% O2)	2.0	2.0	2.0	2.1	2.0	2.0	2.0	2.3	2.0	2.0	2.0	2.6
VOC, ppmvd (dry)	2.4	2.3	2.2	2.0	2.6	2.4	2.2	2.2	2.6	2.4	2.1	2.4
VOC, ppmvw (wet)	2.2	2.1	2.0	1.8	2.3	2.2	2.0	2.0	2.3	2.2	1.9	2.2
VOC, lb/h as CH4 (includes VOC correction as applied to CTG)	2.2	1.8	1.4	1.0	2.3	1.8	1.4	1.2	2.2	1.8	1.3	1.3
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0028	0.0028	0.0028	0.0029	0.0028	0.0028	0.0028	0.0032	0.0028	0.0028	0.0028	0.0037
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0025	0.0025	0.0025	0.0027	0.0025	0.0025	0.0025	0.0029	0.0025	0.0025	0.0025	0.0033

7-Mar-11
Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE LMS100 - NG - 3.48 grains/100 scf Sulfur, Revision 2

Case Number	1	2	3	4	5	6	7	8	9	10	11	12
CTG Model	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA
CTG Fuel Type	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load	100%	75%	50%	30%	100%	75%	50%	30%	100%	75%	50%	30%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	7	51	51	51	51	88	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
PM10 without the Effects of SO2 oxidation												
PM10 Emissions - Front Half Catch Only												
PM10, lb/h	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0038	0.0047	0.0062	0.0085	0.0037	0.0046	0.0061	0.0084	0.0038	0.0048	0.0063	0.0087
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0034	0.0042	0.0056	0.0077	0.0033	0.0042	0.0055	0.0076	0.0034	0.0043	0.0057	0.0078
PM10 Emissions - Front and Back Half Catch												
PM10, lb/h	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0076	0.0094	0.0124	0.0171	0.0074	0.0092	0.0122	0.0168	0.0077	0.0095	0.0126	0.0173
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0068	0.0085	0.0111	0.0154	0.0067	0.0083	0.0110	0.0151	0.0069	0.0086	0.0113	0.0156
PM10 with the Effects of SO2 Oxidation [includes (NH4)2-(SO4)]												
PM10 Emissions - Front Half Catch Only												
PM10, lb/h	14.5	12.3	10.0	8.1	14.8	12.4	10.2	8.2	14.4	12.1	9.9	8.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0183	0.0192	0.0207	0.0230	0.0182	0.0191	0.0206	0.0229	0.0183	0.0193	0.0208	0.0232
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0165	0.0173	0.0187	0.0208	0.0164	0.0172	0.0186	0.0207	0.0165	0.0174	0.0187	0.0209
PM10 Emissions - Front and Back Half Catch												
PM10, lb/h	17.5	15.3	13.0	11.1	17.8	15.4	13.2	11.2	17.4	15.1	12.9	11.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0221	0.0239	0.0269	0.0316	0.0219	0.0237	0.0267	0.0313	0.0222	0.0241	0.0271	0.0318
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0199	0.0216	0.0242	0.0284	0.0198	0.0214	0.0240	0.0282	0.0200	0.0217	0.0244	0.0287
Total Effects of SO2 Oxidation												
Total SO2 to SO3 conversion rate, %vol	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%	63.6%
Total Amount of SO2 converted to SO3, lb/h	5.56	4.49	3.42	2.48	5.70	4.58	3.47	2.51	5.52	4.43	3.36	2.44
Maximum Stack Ammonium Sulfate [(NH4)2-(SO4)] (assuming 100% conversion from SO3), lb	11.48	9.25	7.05	5.11	11.76	9.44	7.16	5.18	11.39	9.13	6.93	5.03
Maximum Stack H2SO4 (assuming 100% conversion from SO3 to H2SO4), lb/h	8.52	6.87	5.23	3.79	8.73	7.01	5.31	3.84	8.45	6.78	5.15	3.74
CO2 Emissions												
CO2, lb/hr	101,661	81,970	62,416	45,228	104,190	83,657	63,422	45,881	100,872	80,883	61,410	44,575
CO2, lb/Mbtu (LHV)	128.7	128.7	128.7	128.6	128.6	128.6	128.6	128.6	128.6	128.7	128.7	128.6
CO2, lb/Mbtu (HHV)	115.9	115.9	115.9	115.8	115.9	115.9	115.9	115.8	115.9	115.9	115.9	115.8
Post Combustion Emissions Control Equipment												
Catalytic Conversion in CO Catalyst												
CO removed in CO Catalyst, %wt	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%
CO removed in CO Catalyst, lb/h	135.9	90.6	69.8	65.0	117.4	84.6	72.5	74.8	108.1	82.5	76.0	82.7
VOC removed in CO Catalyst, %wt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
VOC removed in CO Catalyst, lb/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selective Catalytic Reduction (SCR)												
NOx Removed in SCR, %wt	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%
NOx removed in SCR, lb/h	71.5	57.6	43.8	31.8	73.3	58.8	44.6	32.2	71.0	56.9	43.2	31.3
Ammonia Slip, lb/h	11.7	9.4	7.2	5.2	12.0	9.6	7.3	5.3	11.6	9.3	7.1	5.1

Notes:

1. EMISSIONS ARE PRELIMINARY. NO GUARANTEES APPLY. NO MARGINS APPLIED.
2. The dry air composition used is 0.98% Ar, 78.03% N2 and 20.99%O2
3. Standard conditions are defined as 60 F, 14.696 psia, Norm conditions are defined as 0 C, 1.103 bar
4. All ppm values are based on CH4 calibration gas.
5. The CTG performance and emissions are based on runs provided by GE dated 2/11/2011
6. The natural gas used in estimates contains 3.48 grains/100 SCF of sulfur content.
7. The VOC/UHC ratio is base on CTG performance data provided by GE dated 2/11/2011
8. Effect of SCR and CO catalyst are included.
9. The front half catch of particulate emissions is assumed to be half the amount of the front and back half catch.
10. Where manufacturer data of lb/h of pollutant emissions were available, the greater of the manufacturer's estimate and B&V's estimate was used in the summary table, i.e. the B&V estimates were adjusted, where applicable.
11. The estimated oxidation of SO2 in CTG is based on performance data provided by GE. The SO2 - SO3 conversion in the CO catalyst is assumed to be 60%.
12. The CO catalyst was designed to reduce the CO Stack emissions by 95.0% for all operating scenarios. No VOC reduction was assumed.
13. The SCR was designed to reduce the NOx stack emissions to 2.5 ppmvd @ 15%O2 for natural gas
14. Tempering air mass flowrate controlled to limit stack exit temperature to 800F for all cases, with a minimum allowable flowrate of 10,000 lb/hr.
15. Tempering air has been assumed to not contribute to stack emissions.

ADDITIONAL CALCULATIONS MADE BY URS USING ABOVE DATA

Information used to compare values with emission standards (federal, state, local, and NSPS)												
Stack Flow, scfm(dry) @ 7% O2	336,224	282,739	230,373	189,373	329,612	279,061	233,095	191,636	312,269	259,856	229,878	189,569
PM10, grains/dscf @ 7% O2	0.0050	0.0051	0.0051	0.0050	0.0052	0.0052	0.0051	0.0050	0.0054	0.0052	0.0050	0.0049
lb NOx/MWhr	0.08	0.09	0.11	0.13	0.09	0.09	0.11	0.13	0.09	0.10	0.11	0.13
lb SO2/MWhr	0.03	0.04	0.04	0.05	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05
Max PM10 gr/dscf	0.0054											
Max lb NOx/MWhr	0.13											
Max lb SO2/MWhr	0.05											

7-Mar-11
Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE LMS100 - Distillate, Revision 2

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA
CTG Fuel Type	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil
CTG Load	100%	75%	50%	100%	75%	50%	100%	75%	50%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ambient Conditions									
Ambient Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
Ambient Relative Humidity, %	40.0	40.0	40.0	75.0	75.0	75.0	30.0	30.0	30.0
Atmospheric Pressure, psia	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682	14.682
Combustion Turbine Performance									
CTG Performance Reference	GE	GE	GE	GE	GE	GE	GE	GE	GE
CTG Inlet Air Conditioning Effectiveness, %	0	0	0	0	0	0	0	0	0
CTG Compressor Inlet Dry Bulb Temperature, F	7.0	7.0	7.0	51.0	51.0	51.0	88.0	88.0	88.0
CTG Compr. Inlet Relative Humidity, %	40.6	40.6	40.6	75.1	75.1	75.1	30.2	30.2	30.2
Inlet Loss, in. H2O	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Exhaust Loss, in. H2O	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
CTG Load Level (percent of Base Load)	100%	75%	50%	100%	75%	50%	100%	75%	50%
Gross CTG Output, kW	100,790	75,590	50,400	102,530	76,900	51,270	92,460	69,350	46,230
Gross CTG Heat Rate, Btu/kWh (LHV)	7,917	8,511	9,716	7,972	8,541	9,702	8,214	8,849	10,097
Gross CTG Heat Rate, Btu/kWh (HHV)	8,430	9,063	10,346	8,489	9,095	10,331	8,746	9,423	10,751
CTG Heat Input, MBtu/h (LHV)	798.0	643.4	489.7	817.4	656.8	497.4	759.5	613.7	466.8
CTG Heat Input, MBtu/h (HHV)	849.7	685.1	521.4	870.4	699.4	529.7	808.7	653.5	497.0
CTG Water/Steam Injection Flow, lb/h	28,900	21,400	14,400	28,100	20,500	13,400	24,500	17,800	11,500
Injection Fluid/Fuel Ratio	0.7	0.6	0.5	0.6	0.6	0.5	0.6	0.5	0.5
CTG Exhaust Flow, lb/h	1,758,186	1,476,457	1,183,413	1,730,443	1,460,735	1,177,426	1,604,446	1,363,076	1,106,180
CTG Exhaust Temperature, F	758	786	834	790	810	847	814	834	868
Combustion Turbine Fuel									
Total CTG Fuel Flow, lb/h	43,460	35,040	26,670	44,520	35,770	27,090	41,370	33,420	25,420
CTG Fuel Temperature, F	77	77	77	77	77	77	77	77	77
CTG Fuel LHV, Btu/lb	18,360	18,360	18,360	18,360	18,360	18,360	18,360	18,360	18,360
CTG Fuel HHV, Btu/lb	19,550	19,550	19,550	19,550	19,550	19,550	19,550	19,550	19,550
HHV/LHV Ratio	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648	1.0648
CTG Fuel Composition (Ultimate Analysis by Weight)									
Ar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%	87.16%
H2	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%	12.81%
N2	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
O2	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
S	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%	0.00150%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Combustion Turbine Exhaust									
CTG Exhaust Analysis (Volume Basis - Wet)									
Ar	0.93%	0.94%	0.94%	0.92%	0.93%	0.93%	0.92%	0.92%	0.93%
CO2	5.15%	4.95%	4.71%	5.35%	5.10%	4.80%	5.36%	5.10%	4.79%
H2O	7.21%	6.73%	6.15%	8.18%	7.61%	6.93%	8.42%	7.85%	7.16%
N2	74.16%	74.47%	74.84%	73.48%	73.83%	74.26%	73.29%	73.65%	74.08%
O2	12.54%	12.91%	13.36%	12.08%	12.53%	13.06%	12.02%	12.48%	13.05%
SO2, (after SO2 oxidation)	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%	0.00003%
SO3, (after SO2 oxidation)	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%	0.00000%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Molecular Wt, lb/mol	28.73	28.76	28.80	28.65	28.68	28.72	28.62	28.65	28.70
Specific Volume, ft^3/lb	30.09	30.75	31.87	30.96	31.42	32.30	31.58	32.06	32.84
Specific Volume, scf/lb	13.21	13.19	13.17	13.24	13.23	13.21	13.26	13.24	13.22
Exhaust Gas Flow, acfm	881,730	756,684	628,590	892,909	764,938	633,848	844,473	728,337	605,449
Exhaust Gas Flow, scfm	387,094	324,574	259,759	381,851	322,092	259,230	354,583	300,785	243,728
CTG NOx Emissions (Without Post Combustion Emissions Control)									
NOx Massflow Added to Match CTG Manufacturer's NOx Emissions Estimate, lb/h	1.51	1.28	0.76	1.66	1.04	0.88	1.42	1.24	0.75
Additonal Percent Margin included in mass based NOx Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
NOx, ppmvd (dry, 15% O2)	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
NOx, ppmvd (dry)	52.42	50.12	47.36	54.97	52.06	48.63	55.18	52.21	48.65
NOx, ppmvw (wet)	48.64	46.75	44.45	50.47	48.10	45.26	50.54	48.12	45.16
NOx, lb/h as NO2	138.5	111.7	84.8	141.9	113.8	86.2	131.8	106.6	80.9
NOx, lb/MBtu (LHV)	0.1735	0.1736	0.1732	0.1737	0.1732	0.1734	0.1735	0.1736	0.1732
NOx, lb/MBtu (HHV)	0.1629	0.1630	0.1626	0.1631	0.1627	0.1628	0.1629	0.1631	0.1627
CTG CO Emissions (Without Post Combustion Emissions Control)									
CO Massflow Added to Match CTG Manufacturer's CO Emissions Estimate, lb/h	1.03	1.03	0.76	1.15	0.85	0.90	1.05	1.09	0.83
Additional Percent Margin included in mass based CO Emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
CO, ppmvd (dry, 15% O2)	47.93	56.40	70.46	48.46	57.18	71.58	52.12	61.52	77.01
CO, ppmvd (dry)	59.82	67.31	79.46	63.42	70.88	82.88	68.48	76.49	89.19
CO, ppmvw (wet)	55.50	62.78	74.57	58.23	65.49	77.14	62.72	70.48	82.81
CO, lb/h	96.2	91.3	86.6	99.7	94.3	89.5	99.5	95.0	90.2
CO, lb/MBtu (LHV)	0.1205	0.1419	0.1768	0.1219	0.1435	0.1799	0.1311	0.1548	0.1933
CO, lb/MBtu (HHV)	0.1132	0.1333	0.1661	0.1145	0.1348	0.1689	0.1231	0.1454	0.1815
CTG SO2 Emissions (After SO2 Oxydation, Without Post Combustion Emissions Control)									
SO2 massflow (lb/h) added to match CTG manufacturer's lb/h SO2 emissions estimate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Additional Percent Margin included in lb/h SO2 Emissions below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CTG, vol%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%
SO2, ppmvd (dry, 15% O2)	0.2756	0.2756	0.2756	0.2756	0.2756	0.2756	0.2756	0.2756	0.2756
SO2, ppmvd (dry)	0.3439	0.3289	0.3108	0.3607	0.3416	0.3191	0.3621	0.3426	0.3192
SO2, ppmvw (wet)	0.3191	0.3067	0.2917	0.3312	0.3156	0.2970	0.3316	0.3157	0.2963
SO2, lb/h	1.2511	1.0087	0.7678	1.2816	1.0297	0.7798	1.1909	0.9621	0.7318
SO2, lb/MBtu (LHV)	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016
SO2, lb/MBtu (HHV)	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015
CTG UHC Emissions (Without Post Combustion Emissions Control)									
UHC massflow (lb/h) added to match CTG manufacturer's lb/h CO emissions estimate	0.10	0.08	0.05	0.11	0.06	0.06	0.09	0.08	0.05
Additional Percent Margin included in lb/h UHC Emissions Below	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UHC, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
UHC, ppmvd (dry)	12.5	11.9	11.3	13.1	12.4	11.6	13.1	12.4	11.6
UHC, ppmvw (wet)	11.6	11.1	10.6	12.0	11.5	10.8	12.0	11.5	10.8
UHC, lb/h as CH4	11.5	9.3	7.0	11.8	9.4	7.1	10.9	8.8	6.7
UHC, lb/MBtu as CH4 (LHV)	0.0144	0.0144	0.0143	0.0144	0.0143	0.0144	0.0144	0.0144	0.0143
UHC, lb/MBtu as CH4 (HHV)	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135
CTG VOC Emissions (Without Post Combustion Emissions Control)									
VOC Massflow (lb/h) added to match CTG manufacturer's lb/h VOC emissions estimate	0.08	0.07	0.04	0.09	0.05	0.04	0.07	0.07	0.04
Additional percent margin included in lb/h VOC emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
VOC percentage of UHC	80%	80%	80%	80%	80%	80%	80%	80%	80%
VOC, ppmvd (dry, 15% O2)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
VOC, ppmvd (dry)	10.0	9.5	9.0	10.5	9.9	9.3	10.5	9.9	9.3
VOC, ppmvw (wet)	9.3	8.9	8.5	9.6	9.2	8.6	9.6	9.2	8.6
VOC, lb/h as CH4	9.2	7.4	5.6	9.4	7.5	5.7	8.7	7.1	5.4
VOC, lb/MBtu as CH4 (LHV)	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115
VOC, lb/MBtu as CH4 (HHV)	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108

7-Mar-11
Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE LMS100 - Distillate, Revision 2

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA
CTG Fuel Type	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil
CTG Load	100%	75%	50%	100%	75%	50%	100%	75%	50%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CTG PM10 Emissions (without the Effects of SO2 Oxidation)									
Percent margin included in PM10 emissions below	0%	0%	0%	0%	0%	0%	0%	0%	0%
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
PM10, lb/MBtu (LHV)	0.0157	0.0194	0.0255	0.0153	0.0190	0.0251	0.0165	0.0204	0.0268
PM10, lb/MBtu (HHV)	0.0147	0.0182	0.0240	0.0144	0.0179	0.0236	0.0155	0.0191	0.0251
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
PM10, lb/MBtu (LHV)	0.0313	0.0389	0.0511	0.0306	0.0381	0.0503	0.0329	0.0407	0.0536
PM10, lb/MBtu (HHV)	0.0294	0.0365	0.0479	0.0287	0.0357	0.0472	0.0309	0.0383	0.0503
CO2 Emissions									
CO2, lb/hr	138,814	111,920	85,186	142,200	114,252	86,527	132,138	106,745	81,193
CO2, lb/MBtu (LHV)	174.0	174.0	174.0	174.0	174.0	174.0	174.0	173.9	173.9
CO2, lb/MBtu (HHV)	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.3	163.4
Stack Emissions									
Stack Exhaust Analysis - Volume Basis - Wet									
Ar	0.93%	0.94%	0.94%	0.92%	0.93%	0.94%	0.92%	0.93%	0.93%
CO2	5.13%	4.92%	4.50%	5.32%	5.02%	4.49%	5.25%	4.84%	4.33%
H2O	7.17%	6.69%	5.88%	8.13%	7.51%	6.55%	8.27%	7.52%	6.61%
N2	74.18%	74.49%	74.98%	73.50%	73.88%	74.45%	73.37%	73.82%	74.35%
O2	12.59%	12.96%	13.70%	12.13%	12.66%	13.58%	12.19%	12.89%	13.78%
SO2 (after SO2 oxidation)	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%	0.000010%
SO3 (after SO2 oxidation)	0.000020%	0.000020%	0.000020%	0.000020%	0.000020%	0.000020%	0.000020%	0.000020%	0.000020%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Stack Exit Temperature, F	755	782	800	786	799	800	800	800	799
Stack Diameter, ft (estimated)	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Stack Flow, lb/h	1,768,185	1,486,457	1,238,413	1,740,442	1,483,534	1,259,426	1,638,445	1,435,676	1,223,280
Stack Flow, scfm	389,296	326,773	271,832	384,058	327,119	277,074	361,823	316,806	269,529
Stack Flow, acfm	910,026	781,381	659,455	921,565	792,949	672,324	878,207	768,326	653,435
Stack Exit Velocity, ft/s	134.0	115.0	97.0	136.0	117.0	99.0	129.0	113.0	96.0
Stack NOx Emissions without the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
NOx, ppmvd (dry)	52.1	49.8	45.1	54.6	51.2	45.3	54.0	49.4	43.7
NOx, ppmvw (wet)	48.4	46.4	42.5	50.2	47.4	42.3	49.5	45.7	40.9
NOx, lb/h as NO2 (includes correction adder)	138.5	111.7	84.8	141.9	113.8	86.2	131.8	106.5	80.9
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.1735	0.1736	0.1732	0.1737	0.1732	0.1734	0.1735	0.1736	0.1732
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.1629	0.1630	0.1626	0.1631	0.1627	0.1628	0.1629	0.1631	0.1627
Stack NOx Emissions with the Effects of Selective Catalytic Reduction (SCR)									
NOx, ppmvd (dry, 15% O2)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
NOx, ppmvd (dry)	6.2	5.9	5.4	6.5	6.1	5.4	6.4	5.9	5.2
NOx, ppmvw (wet)	5.8	5.5	5.1	6.0	5.6	5.0	5.9	5.4	4.9
NOx, lb/h as NO2 (includes NOx margin applied to CTG)	16.5	13.3	10.1	16.9	13.5	10.3	15.7	12.7	9.6
NOx, lb/MBtu (LHV) as NO2 (incl. duct burner fuel)	0.0207	0.0207	0.0206	0.0207	0.0206	0.0206	0.0207	0.0207	0.0206
NOx, lb/MBtu (HHV) as NO2 (incl. duct burner fuel)	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194	0.0194
SCR NH3 slip, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
SCR NH3 slip, lb/h	12.1	9.7	7.4	12.4	9.9	7.5	11.5	9.3	7.1
Stack CO Emissions without the Effects of Catalytic Reduction									
CO, ppmvd (dry, 15% O2)	47.9	56.4	70.5	48.5	57.2	71.6	52.1	61.5	77.0
CO, ppmvd (dry)	59.5	66.8	75.7	63.0	69.7	77.2	67.0	72.4	80.2
CO, ppmvw (wet)	55.2	62.4	71.3	57.9	64.5	72.1	61.4	66.9	74.9
CO, lb/h (includes CO correction as applied to CTG and margin)	96.2	91.3	86.6	99.7	94.3	89.5	99.5	95.0	90.2
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.1205	0.1419	0.1768	0.1219	0.1435	0.1799	0.1311	0.1548	0.1933
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.1132	0.1333	0.1661	0.1145	0.1348	0.1689	0.1231	0.1454	0.1815
Stack CO Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
CO, ppmvd (dry, 15% O2)	2.4	2.8	3.5	2.4	2.9	3.6	2.6	3.1	3.9
CO, ppmvd (dry)	3.0	3.3	3.8	3.2	3.5	3.9	3.3	3.6	4.0
CO, ppmvw (wet)	2.8	3.1	3.6	2.9	3.2	3.6	3.1	3.3	3.7
CO, lb/h (includes CO margin applied to CTG)	4.8	4.6	4.3	5.0	4.7	4.5	5.0	4.8	4.5
CO, lb/MBtu (LHV) (incl. duct burner fuel)	0.0060	0.0071	0.0088	0.0061	0.0072	0.0090	0.0066	0.0077	0.0097
CO, lb/MBtu (HHV) (incl. duct burner fuel)	0.0057	0.0067	0.0083	0.0057	0.0067	0.0084	0.0062	0.0073	0.0091
Stack SO2 Emissions without the Effects of SO2 Scrubber, without SO2 Oxidation									
Assumed SO2 oxidation rate in CTG, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in CO Catalyst, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Assumed SO2 oxidation rate in SCR, vol%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SO2, ppmvd (dry, 15% O2)	0.2869	0.2869	0.2869	0.2869	0.2869	0.2869	0.2869	0.2869	0.2869
SO2, ppmvd (dry)	0.3581	0.3424	0.3236	0.3755	0.3557	0.3322	0.3770	0.3567	0.3323
SO2, ppmvw (wet)	0.3322	0.3193	0.3037	0.3448	0.3286	0.3092	0.3452	0.3287	0.3085
SO2, lb/h	1.3026	1.0502	0.7994	1.3343	1.0721	0.8119	1.2399	1.0017	0.7619
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016
Stack SO2 Emissions without the Effects of SO2 Scrubber, after SO2 Oxidation									
Assumed SO2 oxidation rate in CO Catalyst, vol%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
Assumed SO2 oxidation rate in SCR, vol%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SO2, ppmvd (dry, 15% O2)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
SO2, ppmvd (dry)	0.13	0.13	0.11	0.14	0.13	0.12	0.14	0.13	0.11
SO2, ppmvw (wet)	0.12	0.12	0.11	0.13	0.12	0.11	0.13	0.12	0.10
SO2, lb/h	0.49	0.39	0.30	0.50	0.40	0.30	0.46	0.37	0.28
SO2, lb/MBtu (LHV) (incl. duct burner fuel)	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
SO2, lb/MBtu (HHV) (incl. duct burner fuel)	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
Stack UHC Emissions									
UHC, ppmvd (dry, 15% O2)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
UHC, ppmvd	12.4	11.8	10.7	13.0	12.2	10.8	12.8	11.8	10.4
UHC, ppmvw	11.5	11.1	10.1	11.9	11.3	10.1	11.8	10.9	9.7
UHC, lb/h as CH4 (includes correction adder)	11.5	9.3	7.0	11.8	9.4	7.1	10.9	8.8	6.7
UHC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0144	0.0144	0.0143	0.0144	0.0143	0.0144	0.0144	0.0144	0.0143
UHC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135
Stack VOC Emissions without the Effect of Oxidation in a CO catalyst									
VOC, ppmvd (dry, 15% O2)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
VOC, ppmvd (dry)	9.9	9.5	8.6	10.4	9.8	8.6	10.3	9.4	8.3
VOC, ppmvw (wet)	9.2	8.8	8.1	9.6	9.0	8.1	9.4	6.7	7.8
VOC, lb/h as CH4 (includes correction adder)	9.2	7.4	5.6	9.4	7.5	5.7	8.7	7.1	5.4
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108
Stack VOC Emissions with the Effects of Catalytic Reduction (CO Catalyst)									
VOC, ppmvd (dry, 15% O2)	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
VOC, ppmvd (dry)	6.9	6.6	6.0	7.3	6.8	6.0	7.2	6.6	5.8
VOC, ppmvw (wet)	6.4	6.2	5.7	6.7	6.3	5.6	6.6	6.1	5.4
VOC, lb/h as CH4 (includes VOC correction as applied to CTG)	6.4	5.2	3.9	6.6	5.3	4.0	6.1	4.9	3.7
VOC, lb/MBtu (LHV) (incl. duct burner fuel)	0.0080	0.0081	0.0080	0.0081	0.0080	0.0080	0.0080	0.0081	0.0080
VOC, lb/MBtu (HHV) (incl. duct burner fuel)	0.0076	0.0076	0.0075	0.0076	0.0075	0.0076	0.0076	0.0076	0.0075

7-Mar-11
Puget Sound Energy
PSE Permitting Support
Fredonia
Simple Cycle Emissions - GE LMS100 - Distillate, Revision 2

Case Number	1	2	3	4	5	6	7	8	9
CTG Model	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA	LMS100 PA
CTG Fuel Type	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil	Distillate Oil
CTG Load	100%	75%	50%	100%	75%	50%	100%	75%	50%
CTG Inlet Air Cooling	Off	Off	Off	Off	Off	Off	Off	Off	Off
CTG Steam/Water Injection	Water	Water	Water	Water	Water	Water	Water	Water	Water
Ambient Temperature, F	7	7	7	51	51	51	88	88	88
HRSG Duct Firing	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired	Unfired
Fuel Sulfur Content (grains/100 standard cubic feet)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PM10 without the Effects of SO2 oxidation									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0157	0.0194	0.0255	0.0153	0.0190	0.0251	0.0165	0.0204	0.0268
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0147	0.0182	0.0240	0.0144	0.0179	0.0236	0.0155	0.0191	0.0251
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0313	0.0389	0.0511	0.0306	0.0381	0.0503	0.0329	0.0407	0.0536
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0294	0.0365	0.0479	0.0287	0.0357	0.0472	0.0309	0.0383	0.0503
PM10 with the Effects of SO2 Oxidation [includes (NH4)2-(SO4)]									
PM10 Emissions - Front Half Catch Only									
PM10, lb/h	14.2	13.9	13.5	14.2	13.9	13.6	14.1	13.8	13.5
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0178	0.0215	0.0276	0.0174	0.0211	0.0272	0.0186	0.0225	0.0289
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0167	0.0202	0.0260	0.0163	0.0199	0.0256	0.0174	0.0211	0.0271
PM10 Emissions - Front and Back Half Catch									
PM10, lb/h	26.7	26.4	26.0	26.7	26.4	26.1	26.6	26.3	26.0
PM10, lb/MBtu (LHV) (incl. duct burner fuel)	0.0334	0.0410	0.0532	0.0327	0.0402	0.0524	0.0350	0.0428	0.0557
PM10, lb/MBtu (HHV) (incl. duct burner fuel)	0.0314	0.0385	0.0499	0.0307	0.0377	0.0492	0.0329	0.0402	0.0523
Total Effects of SO2 Oxidation									
Total SO2 to SO3 conversion rate, %vol	62.7%	62.7%	62.7%	62.7%	62.7%	62.7%	62.7%	62.7%	62.7%
Total Amount of SO2 converted to SO3, lb/h	0.82	0.66	0.50	0.84	0.67	0.51	0.78	0.63	0.48
Maximum Stack Ammonium Sulfate [(NH4)2-(SO4)] (assuming 100% conversion from SO3), lb	1.69	1.36	1.03	1.73	1.39	1.05	1.60	1.30	0.99
Maximum Stack H2SO4 (assuming 100% conversion from SO3 to H2SO4), lb/h	1.25	1.01	0.77	1.28	1.03	0.78	1.19	0.96	0.73
CO2 Emissions									
CO2, lb/hr	138,814	111,920	85,186	142,200	114,252	86,527	132,138	106,745	81,193
CO2, lb/MBtu (LHV)	174.0	174.0	174.0	174.0	174.0	174.0	174.0	173.9	173.9
CO2, lb/MBtu (HHV)	163.4	163.4	163.4	163.4	163.4	163.4	163.4	163.3	163.4
Post Combustion Emissions Control Equipment									
Catalytic Conversion in CO Catalyst									
CO removed in CO Catalyst, %wt	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%
CO removed in CO Catalyst, lb/h	91.4	86.7	82.3	94.7	89.6	85.0	94.6	90.3	85.7
VOC removed in CO Catalyst, %wt	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
VOC removed in CO Catalyst, lb/h	2.8	2.2	1.7	2.8	2.3	1.7	2.6	2.1	1.6
Selective Catalytic Reduction (SCR)									
NOx Removed in SCR, %wt	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%	88.1%
NOx removed in SCR, lb/h	122.0	98.4	74.7	125.0	100.2	76.0	116.1	93.9	71.2
Ammonia Slip, lb/h	12.1	9.7	7.4	12.4	9.9	7.5	11.5	9.3	7.1

Notes:

1. EMISSIONS ARE PRELIMINARY. NO GUARANTEES APPLY. NO MARGINS APPLIED.
2. The dry air composition used is 0.98% Ar, 78.03% N2 and 20.99%O2
1.103 bar
4. All ppm values are based on CH4 calibration gas.
5. The CTG performance and emissions are based on runs provided by GE dated 2/11/2011
6. The distillate oil used in estimates contains 15 ppm sulfur content by weight
7. The VOC/UHC ratio is base on CTG performance data provided by GE dated 2/11/2011
8. Effect of SCR and CO catalyst are included.
9. The front half catch of particulate emissions is assumed to be half the amount of the front and back half catch.
10. Where manufacturer data of lb/h of pollutant emissions were available, the greater of the manufacturer's estimate and B&V's estimate was used in the summary table, i.e. the B&V estimates were adjusted, where applicable.
11. The estimated oxidation of SO2 in CTG is based on performance data provided by GE. The SO2 - SO3 conversion in the CO catalyst is assumed to be 60%.
12. The CO catalyst was designed to reduce the CO Stack emissions by 95% for all operating scenarios. While the VOC reduction was 30%.
13. The SCR was designed to reduce the NOx stack emissions to 5 ppmvd @ 15%O2 for distillate oil.
14. Tempering air mass flowrate controlled to limit stack exit temperature to 800F for all cases, with a minimum allowable flowrate of 10,000 lb/hr.
15. Tempering air has been assumed to not contribute to stack emissions.

ADDITIONAL CALCULATIONS MADE BY URS USING ABOVE DATA

Information used to compare values with emission standards (federal, state, local, and NSPS)									
Stack Flow, scfm(dry) @ 7% O2	339,662	285,371	237,416	333,371	284,139	240,606	313,378	274,427	233,362
PM10, grains/dscf @ 7% O2	0.0049	0.0057	0.0066	0.0050	0.0057	0.0066	0.0052	0.0059	0.0067
lb NOx/MWhr	0.16	0.18	0.20	0.17	0.18	0.20	0.17	0.18	0.21
lb SO2/MWhr	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01
Max PM10 gr/dscf	0.0067								
Max lb NOx/MWhr	0.21								
Max lb SO2/MWhr	0.01								

Thermal Performance Detail by Turbine Option
(Data From Black & Veatch)

Puget Sound Energy
B&V Project Number 165510
Preliminary Simple Cycle Performance Summary
BY MJ Swofford

Case #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Revision #	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Run Date	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010	3/30/2010
	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle
Ambient Temperature, °F	7	7	7	51	51	51	88	88	88	7	7	7	51	51	51	88	88	88
Relative Humidity, %	40	40	40	75	75	75	30	30	30	40	40	40	75	75	75	30	30	30
Inlet Conditioning	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
CTG Model	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05	GE 7FA.05
CTG Fuel	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil
CTG Load Level (percent of base load)	100	75	47	100	75	48	100	75	50	100	75	50	100	75	50	100	75	50
NEW & CLEAN PERFORMANCE																		
Number of Units in operation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gross CTG Output, kW (each)	230,500	172,900	108,300	214,400	160,800	102,900	193,800	145,400	96,900	222,100	166,600	111,000	220,600	165,400	110,300	207,400	155,600	103,700
Gross CTG Output, kW (total)	230,500	172,900	108,300	214,400	160,800	102,900	193,800	145,400	96,900	222,100	166,600	111,000	220,600	165,400	110,300	207,400	155,600	103,700
Gross CTG Heat Rate, Btu/kWh (LHV)	8,855	9,400	11,765	8,925	9,625	11,965	9,155	10,030	12,330	9,520	10,245	11,765	9,585	10,255	11,910	9,795	10,545	12,270
Gross CTG Heat Rate, Btu/kWh (HHV)	9,831	10,436	13,062	9,909	10,686	13,284	10,164	11,135	13,689	10,139	10,911	12,530	10,208	10,922	12,684	10,432	11,230	13,068
CTG Heat Input, MBtu/h (LHV) each CTG	2,041.1	1,625.3	1,274.1	1,913.5	1,547.7	1,231.2	1,774.2	1,458.4	1,194.8	2,114.4	1,706.8	1,305.9	2,114.5	1,696.2	1,313.7	2,031.5	1,640.8	1,272.4
CTG Heat Input, MBtu/h (HHV) each CTG	2,266.0	1,804.4	1,414.6	2,124.4	1,718.3	1,366.9	1,969.8	1,619.1	1,326.4	2,251.8	1,817.8	1,390.8	2,251.9	1,806.4	1,399.1	2,163.5	1,747.5	1,355.1
CTG Heat Input, MBtu/h (LHV) total	2,041.1	1,625.3	1,274.1	1,913.5	1,547.7	1,231.2	1,774.2	1,458.4	1,194.8	2,114.4	1,706.8	1,305.9	2,114.5	1,696.2	1,313.7	2,031.5	1,640.8	1,272.4
CTG Heat Input, MBtu/h (HHV) total	2,266.0	1,804.4	1,414.6	2,124.4	1,718.3	1,366.9	1,969.8	1,619.1	1,326.4	2,251.8	1,817.8	1,390.8	2,251.9	1,806.4	1,399.1	2,163.5	1,747.5	1,355.1
Auxiliary Power/Losses, kW (estimated)	5,000	4,300	3,700	5,000	4,400	3,800	4,900	4,400	3,800	4,600	4,100	3,400	4,800	4,300	3,700	4,800	4,400	3,900
Auxiliary Power/Losses Percent of Gross Power, %	2.2%	2.5%	3.4%	2.3%	2.7%	3.7%	2.5%	3.0%	3.9%	2.1%	2.5%	3.1%	2.2%	2.6%	3.4%	2.3%	2.8%	3.8%
WATER ACCOUNTING																		
Combustion Turbine Water Injection for NOx Control, lb/hr	0	0	0	0	0	0	0	0	0	151,700	109,800	68,900	157,000	112,300	74,700	158,000	114,100	76,500
Combustion Turbine Water Injection for NOx Control, GPM	0	0	0	0	0	0	0	0	0	303	220	138	314	225	149	316	228	153
NET PLANT PERFORMANCE																		
Net Power Plant Output, kW	225,500	168,600	104,600	209,400	156,400	99,100	188,900	141,000	93,100	217,500	162,500	107,600	215,800	161,100	106,600	202,600	151,200	99,800
Net Power Plant Heat Rate, Btu/kWh (LHV)	9,051	9,640	12,181	9,138	9,896	12,424	9,392	10,343	12,833	9,721	10,503	12,137	9,798	10,529	12,323	10,027	10,852	12,749
Net Power Plant Heat Rate, Btu/kWh (HHV)	10,049	10,702	13,524	10,145	10,986	13,793	10,428	11,483	14,247	10,353	11,186	12,926	10,435	11,213	13,124	10,679	11,557	13,578
Net Power Plant Efficiency (LHV)	37.7%	35.4%	28.0%	37.3%	34.5%	27.5%	36.3%	33.0%	26.6%	35.1%	32.5%	28.1%	34.8%	32.4%	27.7%	34.0%	31.4%	26.8%
Net Power Plant Efficiency (HHV)	34.0%	31.9%	25.2%	33.6%	31.1%	24.7%	32.7%	29.7%	23.9%	33.0%	30.5%	26.4%	32.7%	30.4%	26.0%	32.0%	29.5%	25.1%

1) PERFORMANCE IS PRELIMINARY. NO GUARANTEES APPLY.
2) The fuel gas is assumed to have a sulfur content of 6 grains/100scf.
3) Fuel gas pressure has been assumed to be 320 psia and compressed to the gas turbine requirements.
4) Performance assumes estimated tempering air fan auxiliary power required to temper exhaust to 800 degrees F.
5) Site barometric pressure = 14.68 psia.
6) The gas turbine data used in the above estimates was obtained from GE.
Revision Comments - Rev 0 ISO; Rev 1 Site Specific; Rev 2 Added Water Accounting and revised Aux Power

Puget Sound Energy
B&V Project Number 165510
Preliminary Simple Cycle Performance Summary
BY MJ Swofford

Case #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Revision #	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Run Date	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010	7/19/2010
	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle
Ambient Temperature, °F	7	7	7	51	51	51	88	88	88	7	7	7	51	51	51	88	88	88
Relative Humidity, %	40	40	40	75	75	75	30	30	30	40	40	40	75	75	75	30	30	30
Inlet Conditioning	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
CTG Model	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04	GE 7FA.04
CTG Fuel	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil
CTG Load Level (percent of base load)	100	75	55	100	75	53	100	75	59	100	75	55	100	75	53	100	75	59
NEW & CLEAN PERFORMANCE																		
Number of Units in operation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gross CTG Output, kW (each)	196,900	147,700	108,300	186,900	140,200	99,100	163,400	122,500	96,400	196,900	147,700	108,300	196,900	147,700	104,400	178,400	133,800	105,200
Gross CTG Output, kW (total)	196,900	147,700	108,300	186,900	140,200	99,100	163,400	122,500	96,400	196,900	147,700	108,300	196,900	147,700	104,400	178,400	133,800	105,200
Gross CTG Heat Rate, Btu/kWh (LHV)	8,825	9,605	11,055	8,955	9,695	11,405	9,225	10,185	11,395	9,635	10,405	11,915	9,595	10,235	11,945	9,825	10,585	11,795
Gross CTG Heat Rate, Btu/kWh (HHV)	9,798	10,663	12,273	9,942	10,763	12,662	10,242	11,307	12,651	10,261	11,081	12,689	10,219	10,900	12,721	10,464	11,273	12,562
CTG Heat Input, MBtu/h (LHV) each CTG	1,737.6	1,418.7	1,197.3	1,673.7	1,359.2	1,130.2	1,507.4	1,247.7	1,098.5	1,897.1	1,536.8	1,290.4	1,889.3	1,511.7	1,247.1	1,752.8	1,416.3	1,240.8
CTG Heat Input, MBtu/h (HHV) each CTG	1,929.1	1,575.0	1,329.2	1,858.1	1,509.0	1,254.8	1,673.5	1,385.2	1,219.5	2,020.4	1,636.7	1,374.3	2,012.1	1,610.0	1,328.1	1,866.7	1,508.3	1,321.5
CTG Heat Input, MBtu/h (LHV) total	1,737.6	1,418.7	1,197.3	1,673.7	1,359.2	1,130.2	1,507.4	1,247.7	1,098.5	1,897.1	1,536.8	1,290.4	1,889.3	1,511.7	1,247.1	1,752.8	1,416.3	1,240.8
CTG Heat Input, MBtu/h (HHV) total	1,929.1	1,575.0	1,329.2	1,858.1	1,509.0	1,254.8	1,673.5	1,385.2	1,219.5	2,020.4	1,636.7	1,374.3	2,012.1	1,610.0	1,328.1	1,866.7	1,508.3	1,321.5
Auxiliary Power/Losses, kW (estimated)	4,500	3,900	3,500	4,600	4,000	3,600	4,500	4,000	3,700	4,200	3,800	3,500	4,400	3,900	3,600	4,500	4,000	3,800
Auxiliary Power/Losses Percent of Gross Power, %	2.3%	2.6%	3.2%	2.5%	2.9%	3.6%	2.8%	3.3%	3.8%	2.1%	2.6%	3.2%	2.2%	2.6%	3.4%	2.5%	3.0%	3.6%
WATER ACCOUNTING																		
Combustion Turbine Water Injection for NOx Control, lb/hr	0	0	0	0	0	0	0	0	0	133,000	98,400	78,400	134,100	96,200	75,000	128,800	93,300	77,700
Combustion Turbine Water Injection for NOx Control, GPM	0	0	0	0	0	0	0	0	0	266	197	157	268	192	150	258	187	155
NET PLANT PERFORMANCE																		
Net Power Plant Output, kW	192,400	143,800	104,800	182,300	136,200	95,500	158,900	118,500	92,700	192,700	143,900	104,800	192,500	143,800	100,800	173,900	129,800	101,400
Net Power Plant Heat Rate, Btu/kWh (LHV)	9,031	9,865	11,424	9,181	9,980	11,835	9,486	10,529	11,850	9,845	10,680	12,313	9,814	10,513	12,372	10,079	10,911	12,237
Net Power Plant Heat Rate, Btu/kWh (HHV)	10,027	10,953	12,683	10,193	11,079	13,139	10,532	11,689	13,156	10,485	11,374	13,113	10,452	11,196	13,176	10,734	11,620	13,032
Net Power Plant Efficiency (LHV)	37.8%	34.6%	29.9%	37.2%	34.2%	28.8%	36.0%	32.4%	28.8%	34.7%	31.9%	27.7%	34.8%	32.5%	27.6%	33.9%	31.3%	27.9%
Net Power Plant Efficiency (HHV)	34.0%	31.2%	26.9%	33.5%	30.8%	26.0%	32.4%	29.2%	25.9%	32.5%	30.0%	26.0%	32.6%	30.5%	25.9%	31.8%	29.4%	26.2%

1) PERFORMANCE IS PRELIMINARY. NO GUARANTEES APPLY.
2) The fuel gas is assumed to have a sulfur content of 6 grains/100scf.
3) Fuel gas pressure has been assumed to be 320 psia and compressed to the gas turbine requirements.
4) Performance assumes estimated tempering air fan auxiliary power required to temper exhaust to 800 degrees F.
5) Site barometric pressure = 14.68 psia.
6) The gas turbine data used in the above estimates was obtained from GE.
Revision Comments - Rev 0 Fredonia Site Specific 7FA.04; Rev 1 - Incorporates revised gas turbine data from GE based on minimum load levels GE would be willing to guarantee emissions compliance.

Puget Sound Energy
B&V Project Number 165510
Preliminary Simple Cycle Performance Summary
BY MJ Swofford

Case #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Revision #	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Run Date	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010	4/1/2010
	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle
Ambient Temperature, °F	7	7	7	51	51	51	88	88	88	7	7	7	51	51	51	88	88	88
Relative Humidity, %	40	40	40	75	75	75	30	30	30	40	40	40	75	75	75	30	30	30
Inlet Conditioning	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
CTG Model	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4	Siemens SGT6-5000F4
CTG Fuel	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil
CTG Load Level (percent of base load)	96.5	75	60	100	75	60	100	75	60	100	75	70	100	75	70	100	75	70
NEW & CLEAN PERFORMANCE																		
Number of Units in operation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gross CTG Output, kW (each)	232,000	180,400	144,300	212,500	159,400	127,500	185,000	138,800	111,000	223,500	167,600	156,500	196,700	147,500	137,700	170,300	127,700	119,200
Gross CTG Output, kW (total)	232,000	180,400	144,300	212,500	159,400	127,500	185,000	138,800	111,000	223,500	167,600	156,500	196,700	147,500	137,700	170,300	127,700	119,200
Gross CTG Heat Rate, Btu/kWh (LHV)	8,718	9,144	9,732	8,912	9,475	10,109	9,205	9,900	10,602	9,022	9,453	9,616	9,228	9,821	9,994	9,570	10,299	10,486
Gross CTG Heat Rate, Btu/kWh (HHV)	9,679	10,152	10,804	9,894	10,519	11,223	10,219	10,991	11,770	9,608	10,067	10,241	9,828	10,459	10,644	10,192	10,968	11,168
CTG Heat Input, MBtu/h (LHV) each CTG	2,022.6	1,649.6	1,404.3	1,893.8	1,510.3	1,288.9	1,702.9	1,374.1	1,176.8	2,016.4	1,584.3	1,504.9	1,815.1	1,448.6	1,376.2	1,629.8	1,315.2	1,249.9
CTG Heat Input, MBtu/h (HHV) each CTG	2,245.5	1,831.4	1,559.1	2,102.5	1,676.8	1,430.9	1,890.6	1,525.5	1,306.5	2,147.5	1,687.3	1,602.7	1,933.1	1,542.8	1,465.6	1,735.7	1,400.7	1,331.2
CTG Heat Input, MBtu/h (LHV) total	2,022.6	1,649.6	1,404.3	1,893.8	1,510.3	1,288.9	1,702.9	1,374.1	1,176.8	2,016.4	1,584.3	1,504.9	1,815.1	1,448.6	1,376.2	1,629.8	1,315.2	1,249.9
CTG Heat Input, MBtu/h (HHV) total	2,245.5	1,831.4	1,559.1	2,102.5	1,676.8	1,430.9	1,890.6	1,525.5	1,306.5	2,147.5	1,687.3	1,602.7	1,933.1	1,542.8	1,465.6	1,735.7	1,400.7	1,331.2
Auxiliary Power/Losses, kW (estimated)	5,400	4,700	4,200	5,400	4,600	4,100	5,200	4,500	4,000	4,600	4,100	4,000	4,600	4,100	4,000	4,500	4,000	3,900
Auxiliary Power/Losses Percent of Gross Power, %	2.3%	2.6%	2.9%	2.5%	2.9%	3.2%	2.8%	3.2%	3.6%	2.1%	2.4%	2.6%	2.3%	2.8%	2.9%	2.6%	3.1%	3.3%
WATER ACCOUNTING																		
Combustion Turbine Water Injection for NOx Control, lb/hr	0	0	0	0	0	0	0	0	0	43,900	25,900	20,500	39,500	23,700	18,700	35,500	21,500	17,000
Combustion Turbine Water Injection for NOx Control, GPM	0	0	0	0	0	0	0	0	0	88	52	41	79	47	37	71	43	34
NET PLANT PERFORMANCE																		
Net Power Plant Output, kW	226,600	175,700	140,100	207,100	154,800	123,400	179,800	134,300	107,000	218,900	163,500	152,500	192,100	143,400	133,700	165,800	123,700	115,300
Net Power Plant Heat Rate, Btu/kWh (LHV)	8,926	9,389	10,024	9,144	9,757	10,445	9,471	10,232	10,998	9,212	9,690	9,868	9,449	10,102	10,293	9,830	10,632	10,841
Net Power Plant Heat Rate, Btu/kWh (HHV)	9,909	10,423	11,128	10,152	10,832	11,596	10,515	11,359	12,210	9,810	10,320	10,510	10,063	10,758	10,962	10,469	11,323	11,545
Net Power Plant Efficiency (LHV)	38.2%	36.3%	34.0%	37.3%	35.0%	32.7%	36.0%	33.3%	31.0%	37.0%	35.2%	34.6%	36.1%	33.8%	33.2%	34.7%	32.1%	31.5%
Net Power Plant Efficiency (HHV)	34.4%	32.7%	30.7%	33.6%	31.5%	29.4%	32.5%	30.0%	27.9%	34.8%	33.1%	32.5%	33.9%	31.7%	31.1%	32.6%	30.1%	29.6%

1) PERFORMANCE IS PRELIMINARY. NO GUARANTEES APPLY.
2) The fuel gas is assumed to have e sulfur content of 6 grains/100scf.
3) Fuel gas pressure has been assumed to be 320 psia and compressed to the gas turbine requirements.
4) Performance assumes estimated tempering air fan auxiliary power required to temper exhaust to 800 degrees F.
5) Site barometric pressure = 14.68 psia.
6) The gas turbine data used in the above estimates was obtained from Siemens.
Revision Comments - Rev 0 ISO; Rev 1 Site Specific with Water Accounting

Puget Sound Energy
B&V Project Number 165510
Preliminary Simple Cycle Performance Summary
BY SVDM

Case #	1	2	3	4	5	6	7	8	9	10	11	12
Revision #	1	1	1	1	1	1	1	1	1	1	1	1
Run Date	3/7/2011	3/7/2011	3/7/2011	3/7/2011	3/7/2011	3/7/2011	3/7/2011	3/7/2011	3/7/2011	3/7/2011	3/7/2011	3/7/2011
	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle
Ambient Temperature, °F	7	7	7	7	51	51	51	51	88	88	88	88
Relative Humidity, %	40	40	40	40	75	75	75	75	30	30	30	30
Inlet Conditioning	None	None	None	None	None	None	None	None	None	None	None	None
CTG Model	GE LMS100	GE LMS100	GE LMS100	GE LMS100	GE LMS100	GE LMS100	GE LMS100	GE LMS100	GE LMS100	GE LMS100	GE LMS100	GE LMS100
CTG Fuel	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas
CTG Load Level (percent of base load)	100	75	50	30	100	75	50	30	100	75	50	30
NEW & CLEAN PERFORMANCE												
Number of Units in operation	1	1	1	1	1	1	1	1	1	1	1	1
Gross CTG Output, kW (each)	100,777	75,578	50,387	30,233	102,550	76,909	51,274	30,765	97,094	72,819	48,552	29,129
Gross CTG Output, kW (total)	100,777	75,578	50,387	30,233	102,550	76,909	51,274	30,765	97,094	72,819	48,552	29,129
Gross CTG Heat Rate, Btu/kWh (LHV)	7,841	8,430	9,627	11,634	7,898	8,457	9,615	11,594	8,077	8,634	9,832	11,899
Gross CTG Heat Rate, Btu/kWh (HHV)	8,705	9,359	10,688	12,916	8,768	9,388	10,675	12,872	8,967	8,585	10,915	13,210
CTG Heat Input, MBtu/h (LHV) each CTG	790.2	637.1	485.1	351.7	809.9	650.4	493.0	356.7	784.2	628.7	477.4	346.6
CTG Heat Input, MBtu/h (HHV) each CTG	877.3	707.3	538.5	390.5	899.2	722.1	547.3	396.0	870.7	698.0	530.0	384.8
CTG Heat Input, MBtu/h (LHV) total	790.2	637.1	485.1	351.7	809.9	650.4	493.0	356.7	784.2	628.7	477.4	346.6
CTG Heat Input, MBtu/h (HHV) total	877.3	707.3	538.5	390.5	899.2	722.1	547.3	396.0	870.7	698.0	530.0	384.8
Auxiliary Power/Losses, kW (estimated)	2,668	2,244	1,851	1,577	2,714	2,278	1,918	1,632	2,635	2,244	1,940	1,658
Auxiliary Power/Losses Percent of Gross Power, %	2.6%	3.0%	3.7%	5.2%	2.6%	3.0%	3.7%	5.3%	2.7%	3.1%	4.0%	5.7%
WATER ACCOUNTING												
Water Injection for NOx Control, lb/h	26,640	18,652	13,118	7,982	25,830	18,876	12,276	7,224	24,156	17,057	11,133	6,434
Estimated Cooling Tower Evaporation Rate, lb/h	38,739	26,598	16,098	9,015	66,584	48,724	32,401	20,430	94,350	71,501	49,832	33,127
Total Estimated Water Usage, gpm	131	93	58	34	185	135	89	55	237	177	122	79
NET PLANT PERFORMANCE												
Net Power Plant Output, kW	98,109	73,334	48,536	28,656	99,836	74,633	49,356	29,133	94,459	70,575	46,612	27,471
Net Power Plant Heat Rate, Btu/kWh (LHV)	8,054	8,688	9,994	12,274	8,113	8,715	9,989	12,243	8,302	8,909	10,241	12,617
Net Power Plant Heat Rate, Btu/kWh (HHV)	8,942	9,645	11,095	13,627	9,007	9,675	11,088	13,593	9,217	9,890	11,370	14,008
Net Power Plant Efficiency (LHV)	42.4%	39.3%	34.1%	27.8%	42.1%	39.2%	34.2%	27.9%	41.1%	38.3%	33.3%	27.0%
Net Power Plant Efficiency (HHV)	38.2%	35.4%	30.8%	25.0%	37.9%	35.3%	30.8%	25.1%	37.0%	34.5%	30.0%	24.4%

Case #	13	14	15	16	17	18	19	20	21
Revision #	1	1	1	1	1	1	1	1	1
Run Date	3/7/2011	3/7/2011	3/7/2011	3/7/2011	3/7/2011	3/7/2011	3/7/2011	3/7/2011	3/7/2011
	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle	Simple Cycle
Ambient Temperature, °F	7	7	7	51	51	51	88	88	88
Relative Humidity, %	40	40	40	75	75	75	30	30	30
Inlet Conditioning	None	None	None	None	None	None	None	None	None
CTG Model	GE LMS100	GE LMS100	GE LMS100	GE LMS100	GE LMS100	GE LMS100	GE LMS100	GE LMS100	GE LMS100
CTG Fuel	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil
CTG Load Level (percent of base load)	100	75	50	100	75	50	100	75	50
NEW & CLEAN PERFORMANCE									
Number of Units in operation	1	1	1	1	1	1	1	1	1
Gross CTG Output, kW (each)	100,794	75,589	50,398	102,530	76,899	51,267	92,460	69,347	46,227
Gross CTG Output, kW (total)	100,794	75,589	50,398	102,530	76,899	51,267	92,460	69,347	46,227
Gross CTG Heat Rate, Btu/kWh (LHV)	7,917	8,511	9,716	7,972	8,541	8,702	8,214	8,848	10,097
Gross CTG Heat Rate, Btu/kWh (HHV)	8,432	9,064	10,348	8,490	9,096	10,333	8,748	9,424	10,753
CTG Heat Input, MBtu/h (LHV) each CTG	798.0	643.3	489.7	817.4	656.8	497.4	759.5	613.7	466.8
CTG Heat Input, MBtu/h (HHV) each CTG	849.9	685.2	521.5	870.5	699.5	529.7	808.8	653.5	497.1
CTG Heat Input, MBtu/h (LHV) total	798.0	643.3	489.7	817.4	656.8	497.4	759.5	613.7	466.8
CTG Heat Input, MBtu/h (HHV) total	849.9	685.2	521.5	870.5	699.5	529.7	808.8	653.5	497.1
Auxiliary Power/Losses, kW (estimated)	1,661	1,472	1,358	1,676	1,507	1,424	1,649	1,552	1,467
Auxiliary Power/Losses Percent of Gross Power, %	1.6%	1.9%	2.7%	1.6%	2.0%	2.8%	1.8%	2.2%	3.2%
WATER ACCOUNTING									
Water Injection for NOx Control, lb/h	28,870	21,315	14,370	28,017	20,416	13,306	24,442	17,726	11,488
Estimated Cooling Tower Evaporation Rate, lb/h	38,600	26,476	16,036	66,454	46,515	32,288	91,379	68,546	47,991
Total Estimated Water Usage, gpm	135	96	61	189	138	91	232	173	118
NET PLANT PERFORMANCE									
Net Power Plant Output, kW	99,133	74,117	49,040	100,854	75,392	49,843	90,811	67,795	44,780
Net Power Plant Heat Rate, Btu/kWh (LHV)	8,050	8,680	9,985	8,104	8,712	8,979	8,363	9,052	10,428
Net Power Plant Heat Rate, Btu/kWh (HHV)	8,573	9,244	10,634	8,631	9,278	10,828	8,907	9,640	11,106
Net Power Plant Efficiency (LHV)	42.4%	39.3%	34.2%	42.1%	39.2%	34.2%	40.8%	37.7%	32.7%
Net Power Plant Efficiency (HHV)	39.8%	36.9%	32.1%	39.5%	36.8%	32.1%	38.3%	35.4%	30.7%

1) PERFORMANCE IS PRELIMINARY. NO GUARANTEES APPLY.
2) The fuel gas is assumed to have a sulfur content of 8 grains/100scf.
3) Fuel gas pressure has been assumed to be 320 psia and compressed to the gas turbine requirements.
4) Performance assumes estimated tempering air fan auxiliary power required to temper exhaust to 800 degrees F, with a minimum tempering air flowrate of 10,000 lb/hr.
5) Site barometric pressure = 14.68 psia.
6) The gas turbine data used in the above estimates was obtained from GE.
Revision Comments - Rev 1 Site Specific Release of LMS100 Wet Cooling Tower Intercooler Heat Rejection Design

About the new 7FA

About
History
Tech Specs
Features

Reliability, availability, and flexibility—just a few of the attributes that have traditionally defined GE's 7FA gas turbine. Now, add improved output and efficiency to the list.

The power output of the new 7FA will increase to 211 MW—a 36 MW increase over today's 7FA—in simple cycle operation. In combined cycle configuration (two gas turbines and one steam turbine), the power output will increase to 627 MW—a 98 MW increase in power generation. We have also increased the efficiency in each configuration: thermal efficiency will increase to 38.5% in simple cycle operation, and to 57.5% in combined cycle operation. Each point of efficiency increase translates to major savings in fuel costs for each megawatt of power produced.

The new 7FA is part of GE's ecomagination portfolio because of its improved efficiency and higher output compared to earlier 7FA models. To become an ecomagination product, the new 7FA must meet the rigorous standards of GE's commitment to imagine and build innovative technologies that help our customers address their environmental and financial needs, such as the need for cleaner, more efficient sources of energy.

Read the news about GE's latest and greatest heavy duty gas turbine! Advanced technology to power our future!

Read More

The new 7FA gas turbine is part of GE's ecomagination portfolio

ecomagination

Wondering how a gas turbine makes electricity? And just what is a combined cycle power plant? Find out the answers here!

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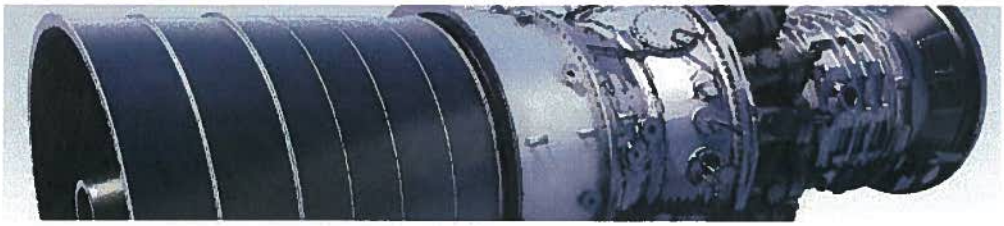
7FA history

About
History
Tech Specs
Features



For more than two decades, GE's F-technology gas turbines have been the turbines of choice for power generators around the world. Built upon a rich history of ongoing enhancements gained from real world experience, our success continues with the new 7FA. With more than 700 units in worldwide service and logging more than 16 million operating hours and over 470,000 fired starts, the 7FA continues to make history by delivering record-setting performance, reliability and availability while achieving superior emission levels. GE's F-class gas turbines are first in class, delivering an impressive list of record-setting firsts such as:

- First to achieve 99.2% operating reliability
- First to achieve single digit NOx and CO emissions
- First to reach 55% thermal efficiency in combined cycle operation
- First to achieve 98.4% starting reliability
- First to achieve 96% availability
- First to achieve 40% load with single digit NOx and CO emissions
- First to surpass 16 million fired hours of operation

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7FA technical specifications

About
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Features

	CC	SC
Output (MW)	627	211
Efficiency (%, LHV)	57.5	38.5
Heat rate (Btu/kw-hr, LHV)	5934	8872
NOx (ppmvd @ 15% O_2)	2	9
NOx per start (lbs) – conventional start	373 lbm/start[2]	27 lbm/start[3]
CO per start (lbs) - conventional start	2142 lbm/start[2]	126 lbm/start [3]
CO (ppmvd)	9	9
PM 10 lb/hr, total/front-half only	36/18	18/9
VOC (ppmv)	1.4	1.4
UHC (ppmv)	7	7
Liquid fuel capabilityn	Yes	Yes
GT turndown (% baseload)	49	49
Fast Start capability (10 minutes)	50% GT load	160 MW
NOx per start (lbs) – CC Rapid Response/SC Fast Start[4]	32 lbm/start[5]	14 lbm/start[6]
CO per start (lbs) - CC Rapid Response/SC Fast Start[4]	162/lbm/start[5]	58 lbm/start [6]

1 Provided as estimates only.
2 207FA configuration, conventional warm start w/o Rapid Response.
3 Single GT, conventional start, ignition to bottom of mode 6.
4 The 7FA gas turbine with the improved startup capability will be capable of dispatching in ten minutes after a start signal, and will achieve stable combustion with steady state NOx and CO emissions of 9 ppm within this time period. In simple cycle operation the 7FA will have the capability of dispatching more than 70% of baseload power output.
5 207FA configuration, Rapid Response, ignition to bottom of mode 6.
6 Single GT, Fast Start, ignition to bottom of mode 6.

Performance – Simple Cycle Basis

Description	Details

ISO ambient conditions	14.696 psia, 59°F, 60% relative humidity, 0 ft elevation, 1.5" HgA steam turbine backpressure
Fuel	100% methane
Generator	GT: 7FH2B generator

Performance – Combined-Cycle Basis

Description	Details
ISO ambient conditions	14.696 psia, 59°F, 60% relative humidity, 0 ft elevation
Fuel	100% methane
HRSG	Natural circulation HRSG with an SCR for NOx, and no CO catalyst, 3 pressure reheat cycle, pressure drop of 15" H_2O
Generator	GT: 7FH2B generator
Steam turbine	207D flow 40" LSB
Cooling tower	Mechanical draft evaporative cooling tower

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7FA features

About
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Features

Compressor

Performance

3D aerodynamic airfoils - an advanced aviation-style high-efficiency, 14-stage compressor that increases airflow and robustness

Operability

Inlet guide vanes - three variable stator vane stages with additional variable geometry stages that enhance operability and flexibility

Maintainability

Field replaceable blades - reduced outage times for improved availability
Improved borescope access - additional borescope port locations to enhance inspection capability
Blade health monitoring - prognostic system to enable early detection of blade characteristic changes

Combustor

Experience

DLN 2.6 combustor – proven combustion system with more than 14 million hours of service and 380,000 starts

Turbine

Performance

Hot gas path evolution - builds upon 7FA and 7FB experience to provide improved output and efficiency
Low emissions – single digit NOx and CO emissions across entire operating range

Durability

FB materials – proven materials used in a less severe environment (lower firing temperature)

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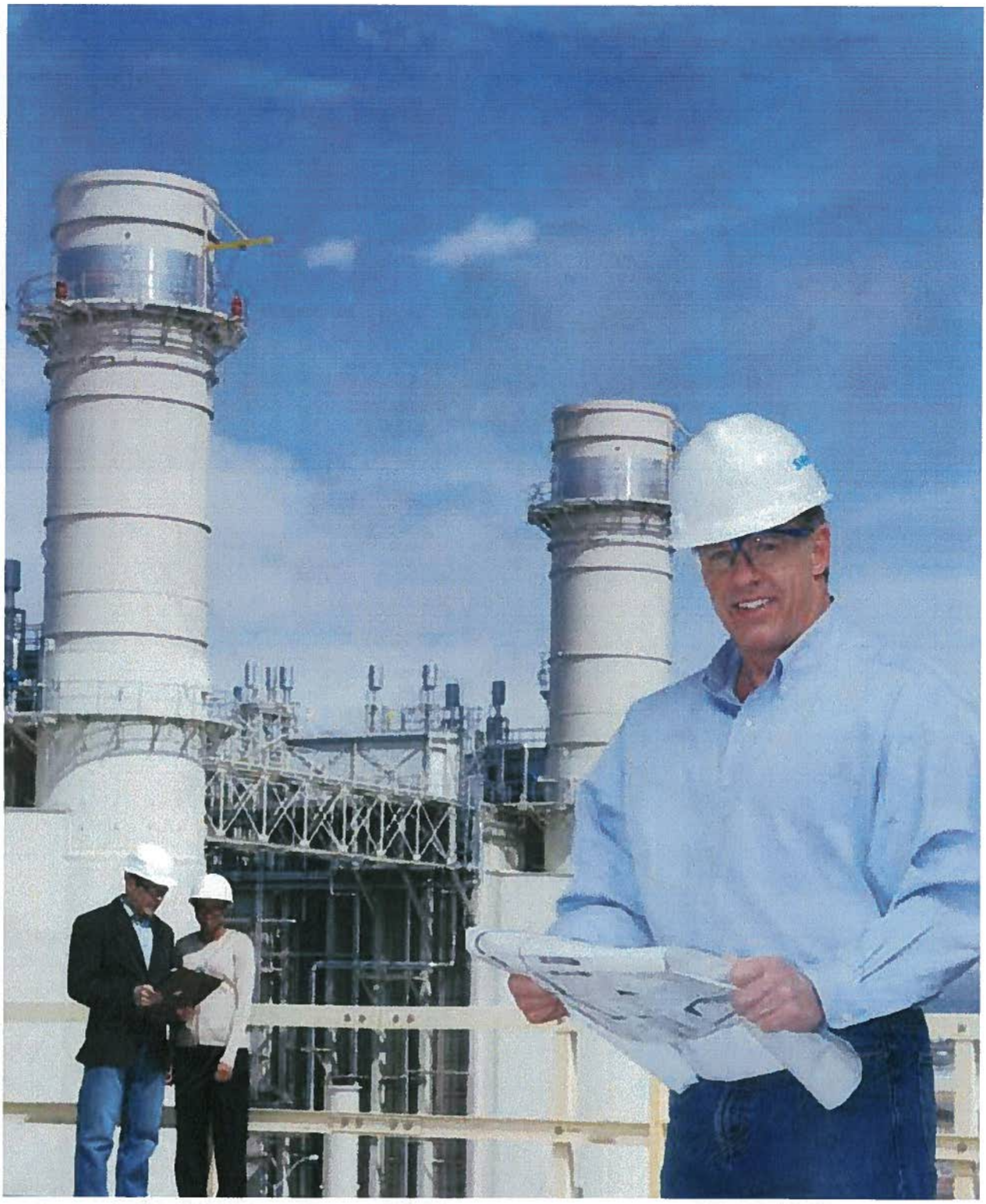

Siemens SGT6-5000F Gas Turbine

Application overview

Answers for energy.

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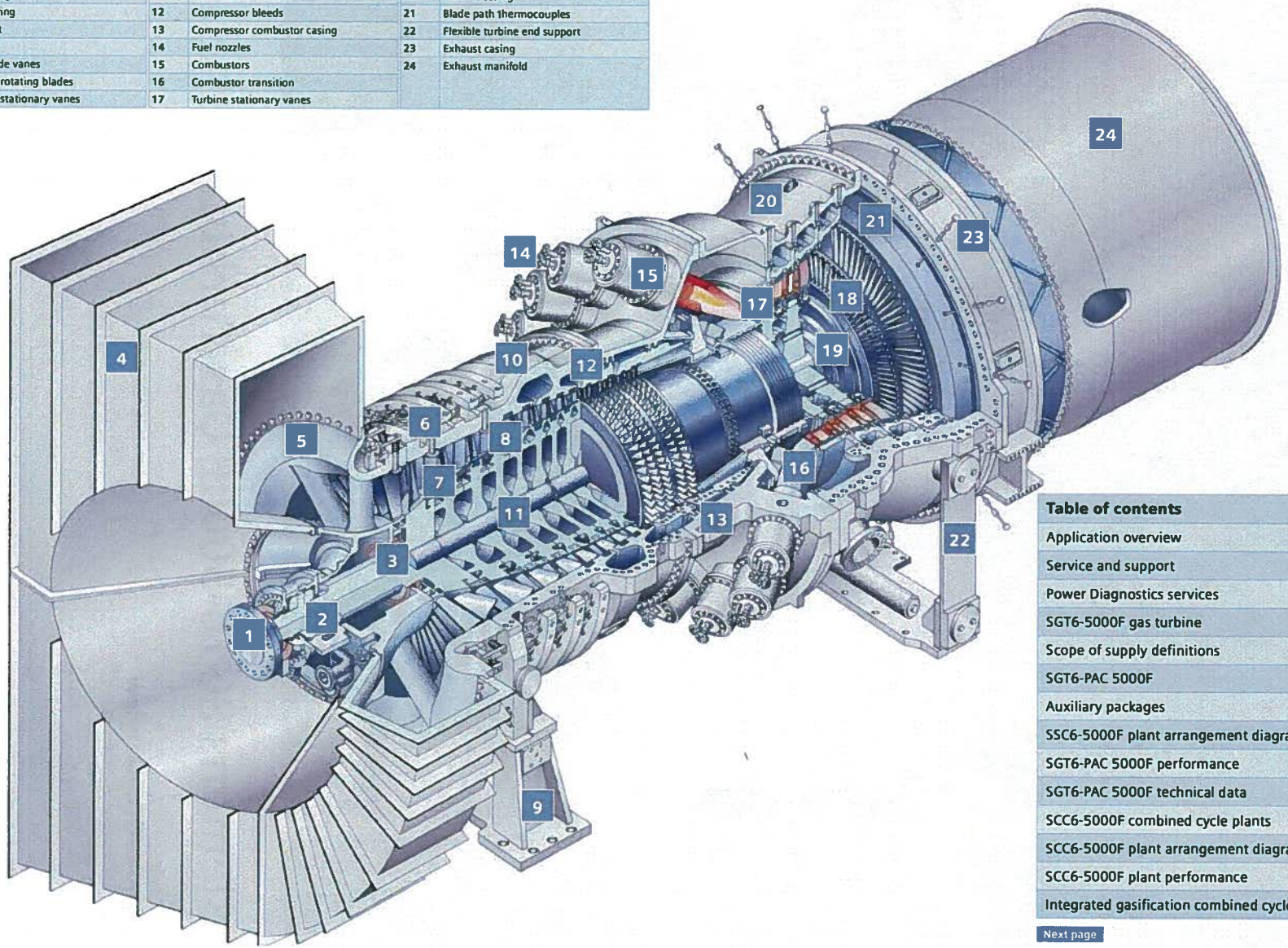
	Key				
1	Generator coupling	9	Fixed compressor end support	18	Turbine rotating blades
2	Thrust bearing	10	Compressor casing	19	Turbine discs
3	Journal bearing	11	Rotor central tie bolt	20	Turbine casing
4	Inlet air duct	12	Compressor bleeds	21	Blade path thermocouples
5	Inlet casing	13	Compressor combustor casing	22	Flexible turbine end support
6	Variable guide vanes	14	Fuel nozzles	23	Exhaust casing
7	Compressor rotating blades	15	Combustors	24	Exhaust manifold
8	Compressor stationary vanes	16	Combustor transition		
		17	Turbine stationary vanes		



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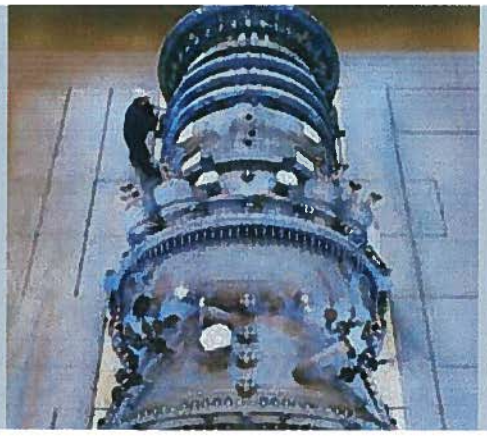

SGT6-5000F application overview

Siemens SGT6-5000F gas turbine engine

The advanced technology of the SGT6-5000F gas turbine continues to satisfy the worldwide needs of the power generation marketplace for 60 Hz projects. Siemens introduced the first unit in this series in 1968. Since that time, over 560 units of Siemens Gas Turbines (SGT™) have been sold. Siemens evolutionary design philosophy maintains continuity by building on our proven gas turbine technology. To attain high engine reliability, upgrades or new engine designs are based on technologies proven by engine operation or by extensive component testing.

The SGT6-5000F gas turbine exemplifies this evolutionary process. It combines the efficient, proven design concepts of the Westinghouse and Siemens gas turbines with the addition of advanced cooling technologies and improved compressor construction. The advanced cooling technologies allow higher flow-path gas temperatures while keeping metal temperatures at the level of previous engines. The technology upgrades applied to the SGT6-5000F gas turbine have resulted in an engine with a rated output that is among the highest of the F-class gas turbines. The SGT6-5000F gas turbine fleet has achieved over 5.3 million hours of reliable operation and net combined cycle efficiencies of 57.5%.

This gas turbine is ideally suited for simple cycle and heat recovery applications, including Integrated Gasification Combined Cycle (IGCC), cogeneration, combined cycle and repowering. Flexible fuel capabilities include natural gas, LNG, distillate oil, syngas and other fuels, such as low- or medium-Btu gas.

The low emissions SGT6-5000F gas turbine engine consists of a 13-stage axial-flow compressor, a combustion system composed of 16 can-annular baskets and a four-stage turbine. Packaged with the generator and other auxiliary modules, the SGT6-PAC 5000F power generation system provides economical power for peaking duty, operational flexibility and load following capabilities for intermediate duty, while maintaining high efficiencies for continuous service. Regardless of the application, the SGT6-5000F gas turbine is the basic building block for a wide variety of power generation systems.

Siemens simple cycle applications

The Siemens Simple Cycle (SSC™) SSC6-5000F power plant, nominally rated at 208 MW, is a self-contained, electric power generating system suited for simple cycle applications. The design of the SSC6-5000F includes over 50 years of experience in gas turbine technology and power plant design. The following proven features, incorporated into the SSC6-5000F power plant include:

- Factory assembled fuel, auxiliary, lubricating and electrical packages
- Walk-around enclosures for turbine and auxiliary packages
- SPPA™-T3000 Web-based control system
- Air-cooled generator
- Normal start time - 29.5 minutes to base load
- Fast-start capable - 10 minutes to 150 MW.

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Siemens combined cycle applications

Siemens has more than four decades of experience in combined cycle plant design. Our first combined cycle experience came in the early 1960s with the installation of the West Texas Utilities plant using a W301, a 30-MW gas turbine. The second generation of combined cycle plants were the PACE (Power at Combined Efficiencies) plants introduced in the early 1970s. The PACE plants used an earlier W501 model, the W501B, as their prime mover and were pre-engineered, standardized combined cycle plants.

The Siemens Combined Cycle (SCC™) SCC6-5000F plant design (as shown in Figure 1) is built on the strong knowledge base derived from these previous design efforts. With 1x1 (~304 MW) and 2x1 (~615 MW) configurations, the SCC6-5000F family of combined cycle plants is sized to meet the various base and cyclic load requirements of utilities, independent power producers (IPPs) and merchant plant operators. The development of these designs allows for cost-effective plants that require minimal project-specific engineering.

Figure 1 - SCC6-5000F combined cycle plant design

Project capabilities

Siemens is experienced in producing successful power projects. Our comprehensive scope of capabilities includes:

- Total turnkey power plants
- Integrated project management
- Plant engineering and design
- Plant permitting assistance
- Equipment installation
- Plant operation and maintenance.

When Siemens takes responsibility for a project, or any portion of it, an integrated project management approach is applied to the task. The planning techniques used are among the most advanced in the industry. Project goals are clearly developed and well-communicated. Work packages are created that include drawings, material lists and sign-off sheets. Personal accountability means a personal commitment to quality. Siemens has achieved an impressive record for building plants on schedule and within budget.

Service and support

A global network for service and support

Siemens is equally committed to providing comprehensive service programs that truly support and optimize the performance of your equipment. We begin with technical assistance provided during the installation and start-up of your equipment and continue with a multitude of service options. These include turnkey maintenance inspections, technical field assistance, modernizations and upgrades, repair and refurbishment, and control system service and upgrades.

We have established a powerful and responsive service network with more than 4,000 field engineers and technicians in regional service offices around the globe. So wherever you are, wherever your plant is located, we speak the language, we know the market and we are available when you need us...with rapid-response solutions that can translate into measurable benefits for you.

Total Maintenance Services

Our comprehensive service approach also means that we have the ability to track unit trends in our global fleet through leading-edge diagnostics technology to help promote maximum unit performance and availability. Total Maintenance Services (TMS) is a structured outage planning, implementation and lessons-learned process. It enables our customers to receive regular notifications of the latest engine design improvements and upgrades, as well as notices regarding inspection and maintenance activities. Pre-outage planning is a standard feature to ensure preparedness by identifying necessary parts, recommending modifications and upgrades that are available, suggesting new training programs, addressing customer questions and concerns, and offering a comprehensive scope of recommendations.

By analyzing data and trends from the entire operating fleet, we have the ability to identify issues before they impact your plant performance. The constant flow of information and documented pre-outage planning initiatives enable our customers to be better informed and prepared for a more efficient and timely outage that meets their goals of unit reliability, outage duration and budget.

Service programs

Our service programs link performance with customer objectives, providing turnkey outage services, as well as parts and repairs for scheduled and unscheduled maintenance.

This performance-based approach provides incentives for both parties to benefit from on-time completion, high-quality maintenance, project management and advanced, remote monitoring and diagnostics systems. A dedicated program manager is on-call to provide support, and a dedicated team of locally based district managers, home office personnel and factory-trained technicians understand and are closely aligned to your objectives. Our flexible service approach enables us to work with you to create a service program that truly meets your requirements.

We develop an ongoing partnership to help ensure your project's long-term success. We are committed to serving our customers well after plant commissioning. That is why we offer comprehensive service options, backed by a global network of resources, to support your equipment throughout its entire life-cycle.

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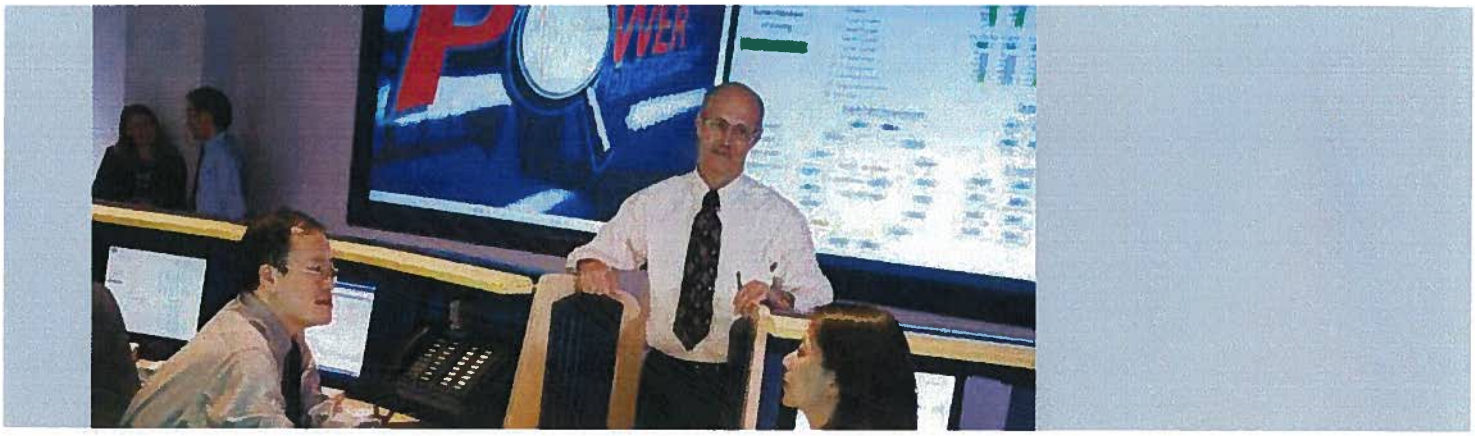


Power Diagnostics services

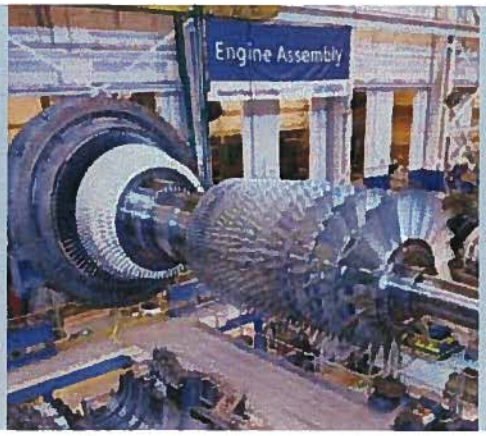
Power Diagnostics®

Siemens has provided diagnostic systems design and implementation since the early 1980s. Whether you are a plant owner or operator, our Power Diagnostics services can help you maximize your plant performance, availability and profitability.

Your power business is unique and your business requirements demand the most innovative and effective solutions available. We meet these challenging requirements with one of the most effective monitoring and diagnostics services available to power plant owners.

Our Power Diagnostics centers in the United States and Germany are monitored around the clock with experienced professionals who understand the complexity of your turbine systems and the demands placed on them. These highly skilled and trained engineers recognize the importance you place on keeping your plant on-line to meet business demands. If an abnormal trend is detected, your data will be analyzed, compared to our vast historical operating fleet database and presented in an understandable manner to your plant staff for timely trend assessment. Analysis results also can help you to schedule outages with more precision. If required, quick-response technical resources also can be dispatched for on-site problem resolution.

To help you optimize your plant operating availability and enhance your bottom line, Power Diagnostics is invaluable in assisting with the detection of impending operational problems, thereby helping to minimize unplanned outages and maximize power generation availability.



SGT6-5000F gas turbine

General description

Designed for both simple and combined cycle applications, the SGT6-5000F gas turbine can operate on conventional gas turbine fuels and a wide range of alternate fuels subject to review by Siemens. The gas turbine consists of a 13-stage, high efficiency axial compressor tied to the four-stage turbine using a single tie bolt rotor design. The combustion chamber is equipped with 16 ultra low NO_x (ULN) or dry low NO_x (DLN) combustors arranged in a circular array around the engine centerline. The gas turbine is coupled directly to the generator at the compressor end.

Ambient air is drawn through the inlet manifold and inlet casing into the compressor. It is pressurized to approximately 17 atmospheres and guided into the combustors, where it is mixed with fuel and ignited, raising the temperature of the mixture. The compressed and heated mixture then expands through the turbine, dropping in pressure and temperature as the heat energy is converted into mechanical work. A portion of the power developed by the turbine is used for driving the compressor, with the balance of power used to drive the generator. Expanded gases are then exhausted into the atmosphere through an exhaust stack for a simple cycle application or through a heat recovery steam generator (HRSG) and exhaust stack in a combined cycle application.

Design features

SGT6-5000F gas turbine features, such as cold-end generator drive, two-bearing design, horizontally split casings, can-annular combustors and tangential strut supports, have been used in this gas turbine family since the early 1950s.

The axial exhaust concept, introduced in 1970 on the W501AA, improves performance and provides greater flexibility for multiple unit plant arrangements especially when applied to combined cycle power plants.

Design features summary:

- A two-bearing rotor used to simplify alignment
- Bearings that operate at below atmospheric pressure to prevent shaft seal leakage
- Readily accessible bearings that can be removed and replaced without lifting the gas turbine covers
- Compressor blades that can be removed for inspection and re-installed disturbing blades in other rows or removing the rotor from its casing
- Low temperature environment of the exhaust bearing permits the use of less expensive and readily available lubricating oil
- Individual turbine blades that can be removed for inspection or replaced with the rotor in place and without disturbing other blades
- Compressor stators and turbine vane carriers that can be taken out for inspection or be replaced with the rotor in place
- Field balancing with two end and one center balance planes that are easily accessible
- Multiple boroscopic inspection ports in the compressor and turbine flow paths to permit inspection of the blading without lifting covers
- Turbine supports for free expansion and contraction without disturbing the shaft alignment
- Cooling circuits designed to protect the gas turbine parts from the high temperature gas stream for better reliability and longer life

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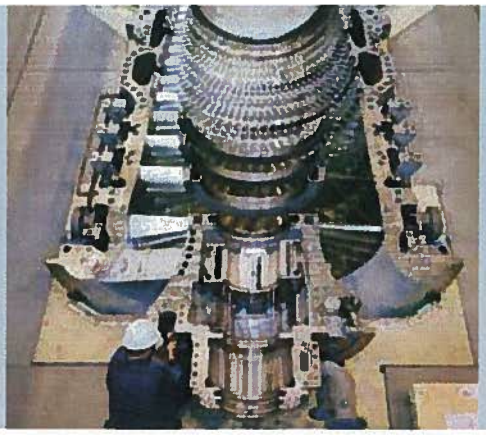
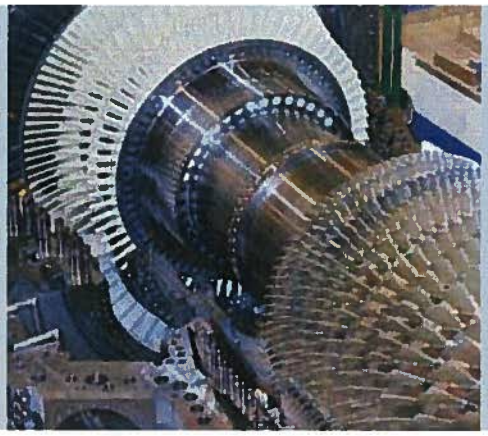




- A tangential strut support system for the turbine-end bearing – a Siemens patented feature – for maintaining the bearing on centerline for all conditions of load and temperature.

Major assemblies

Casings

Engine casings are horizontally split to facilitate maintenance with the rotor in place. Inlet casings are cast from nodular iron or fabricated from cast steel. The compressor section casings are cast from nodular iron while the combustor, turbine and exhaust casings are alloy steel.

Eight radial struts support the inlet bearing housing while six tangential struts support the exhaust-end bearing housing. Airfoil-shaped covers protect the tangential struts from the blade path gases and support the inner and outer diffuser cones.

Tangential struts maintain alignment of the turbine end bearing housing by allowing it to rotate to accommodate thermal expansion. Individual inner casings (vane carriers) are used for each turbine stationary stage and can be readily replaced or serviced with the rotor in place. Similar vane carriers are in the compressor for stages 9 through 13. The vane carriers have a thermal response independent of the outer casing, thereby permitting them to remain concentric to the rotor. This allows for a minimum clearance between rotating and stationary airfoils in order to increase flowpath efficiency.

Rotor assembly

The rotor consists of the compressor and turbine rotor components on a single tie bolt and supported by two tilting-pad bearings. A direct lubricated, double acting thrust bearing located at the compressor end of the gas turbine accommodates engine thrust.

The rotor is a single tie bolt design comprised of multiple discs equipped with Hirth serrations for torque transmission.

Any turbine or compressor blade can be removed for inspection and replaced without lifting the rotor.

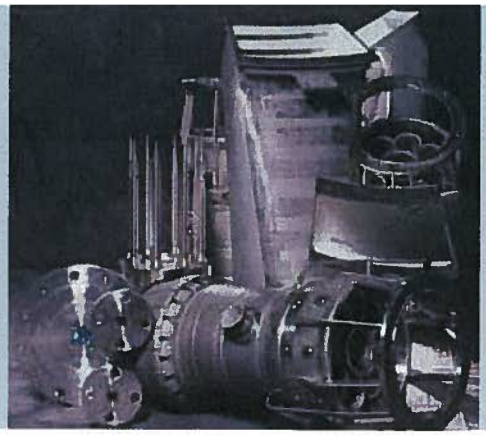
Air inlet system and compressor

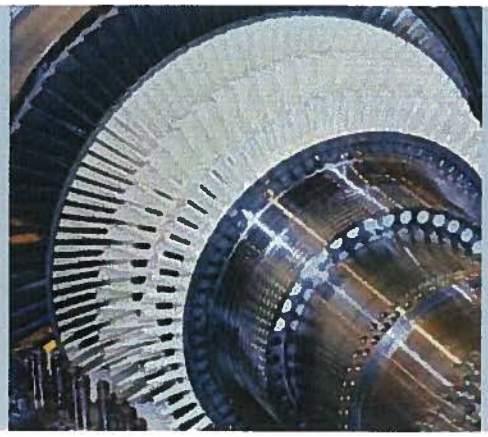
The air inlet system, consisting of the inlet filter, inlet silencer, associated ductwork and inlet manifold delivers air to the compressor. The compressor is a 13-stage axial flow design and achieves a 17-to-1 pressure ratio. Inter-stage bleeds for starting and cooling flows are located at the 5th, 8th and 11th stages. The compressor is equipped with four stages of variable guide vanes to improve the compressor surge characteristics and part load performance.

The compressor flow path design is based on an advanced three-dimensional flow field analysis computer model. The blades of the first four stages are 17-4 PH (17% Cr precipitation hardened stainless steel). Rows five through 13 blades use AISI 616 stainless steel.

Compressor vane rows four through eight consist of mechanically assembled 60° segments while rows nine through 13 are individually removable from a t-root section of the vane carriers. One row of exit guide vanes is used to direct the flow leaving the compressor. Stationary airfoils utilize corrosion and heat-resistant stainless steel throughout.

Compressor rotating and stationary airfoils are coated to improve aerodynamic performance and provide corrosion protection.





SGT6-5000F gas turbine

Combustion system

The combustion system consists of 16 can-annular, ultra low emissions or dry low emissions (9 ppm or 25 ppm NO_x systems are available) combustors.

The presence or absence of flame and the uniformity of the fuel distribution between combustors are monitored by thermocouples located downstream of the last stage turbine blades. These are also used to detect ignition at start-up and can detect combustor malfunctions when at load.

Transition ducts, one for each combustor, direct the hot gases from the combustors to the turbine blade path. The transitions are air-cooled and the same design is used in both simple and combined cycle applications.

Turbine section

The turbine design of the SGT6-5000F gas turbine maintains moderate aerodynamic loading by the use of a four-stage turbine. Furthermore, improvements in aerodynamic airfoil shapes have been made possible by using a fully three-dimensional flow analysis computer model. A sophisticated airfoil design approach was utilized to target high aerodynamic efficiency.

The 1st and 2nd stages on the turbine rotor contain 72 and 66 freestanding blades, respectively. The 3rd and 4th stages contain 112 and 84 blades, which incorporate integral tip shrouds. The shrouding of blades allows increases in mass flow and thus an increase in the power output. The shrouded blade design prevents flow induced non-synchronous vibration due to aero-elastic interaction between blade structure and flow.

All rotating blades are precision cast of equiaxed alloy 247 and have long blade root extensions to minimize the stress concentration factor that results when load is transferred between cross sections of different size and shape. Roots are multiple serration type with four serrations used on the first two stages and five serrations on the last two stages.

The 1st turbine stationary row consists of 32 precision-cast, single-vane segments of IN-939 alloy coated with thermal barrier coating (TBC) for improved thermal resistance. Consistent with previous proven W501 designs, 1st row single vanes are removable, without lifting any covers, through access ports in the combustor shell. Inner shrouds are supported from the torque tube casing to limit flexural stresses and distortion, thus maintaining control of critical 1st row vane angles. In the 2nd turbine stationary row, there are 24 two-vane segments precision-cast of IN-939 alloy, which are also treated with TBC. The 3rd turbine stationary row consists of 16 three-vane segments and the 4th turbine stationary row consists of 14 four-vane segments. Both are precision cast of IN-939.

Each row of vane segments is supported in a separate vane carrier, which is keyed and supported to permit radial and axial thermal response independent of possible external cylinder displacements. Segmented isolation rings support the vane segments. Ring segments located over the rotating blades form the flow path outer annulus. Isolation and ring segments both act to limit thermal conduction between the flow path and the vane carrier, thus mitigating clearance changes in the turbine section. The interstage seal housings are uniquely supported from the inner shrouds of rows two, three and four vane segments by radial keys. This permits the thermal response of the seal housings to be independent of the more rapid thermal response of the vane segments.

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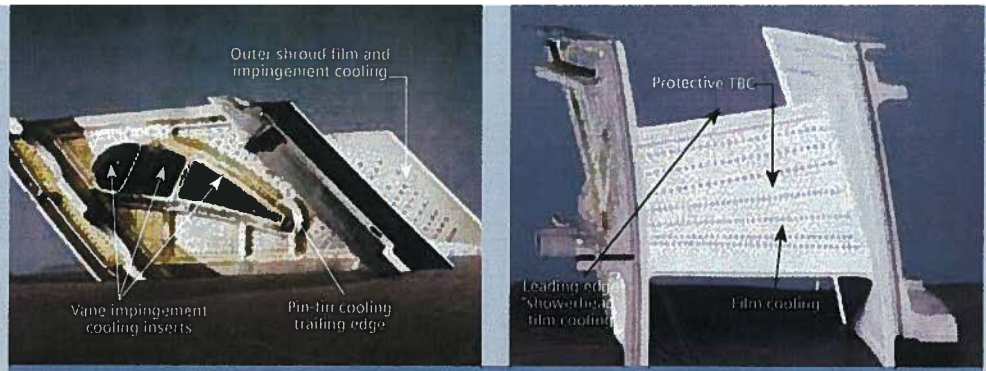


Figure 2 - Row 1 vane cooling

Cooling system

Comprehensive cooling methods enable the SGT6-5000F gas turbine to operate at high performance firing temperatures while using conventional materials.

Compressor bleed air from the 11th, 8th and 5th stages are used to provide cooling air to turbine vane carrier cavities at the 2nd, 3rd and 4th stages, respectively. This supply of bleed air also cools the 2nd, 3rd and 4th stage vanes and ring segments, and provides cooling air for the turbine interstage disc cavities to shield the interstage seals and disc faces from hot blade path gases.

Direct compressor discharge air is used to cool the 1st row vane. The 1st row vane cooling design uses state-of-the art concepts with three impingement inserts in combination with an array of film-cooling holes and a trailing edge pin-fin system. "Showerhead" cooling is used at the leading edge of the 1st row vane, while film cooling is used at selected pressure and suction side locations. This limits vane wall thermal gradients and external surface temperatures, while providing an efficient re-entry for spent cooling air. Pin-fins, used successfully for the first time on the W501D5 1st row vane, are used to increase turbulence and surface area, thereby optimizing the overall trailing edge cooling effectiveness (see Figure 2). The design of the 1st row vane is such that the low cycle fatigue (LCF) design criteria is satisfied by control of wall thermal gradients.

For the 2nd row vane, 11th stage compressor bleed air is ducted directly to the twin insert system. The 2nd row vane cooling is a less complex version of 1st row vane cooling. It uses twin impingement inserts with film-cooling holes and a trailing edge pin-fin system. Film cooling is used at one location on the suction side and at the exit of the aft insert on the pressure side.

Compressor bleed air from the 8th stage is used to supply cooling air to the 3rd stage vane carrier cavity. Cooling air is directed to the inlet cavity of a three-cavity multipass convective-cooled vane airfoil. Leading edge cavity flow also supplies the interstage seal and cooling system, while the third pass cavity exits at pressure side gill holes on the vane surface. The 4th stage vane is uncooled, but does transport 5th stage compressor bleed air for the 4th row inter-stage seal (Figure 3 depicts the cooling system).

Rotor cooling air is extracted from the combustor shell. The air is externally cooled and returned to the torque tube seal housing to be used for seal air supply and for cooling of the turbine discs and 1st, 2nd and 3rd stage turbine rotor blades. This provides a blanket of protection from hot blade path gases.

The 1st row blade is cooled by a combination of convection techniques via multipass serpentine passages and pin-fin cooling in the trailing edge exit slots (see Figure 4). Air supply for blade cooling is high-pressure compressor discharge air that has been cooled and returned to the turbine rotor via four supply pipes in the combustor shell. Cooling air flows outward through slots in the root and is conveyed radially through the blade shank. Showerhead film cooling is used for the leading edge region. The 2nd row rotor blade is also precision cast and is cooled by a combination of convection techniques via serpentine passage and pin-fin cooling in the trailing edge exit slots. The 3rd row blade is precision cast with single pass convective cooling holes.

The cooling system maintains the steel turbine discs at a temperature sufficient to keep the disc below the creep range.

Figure 3 - Turbine cooling air system

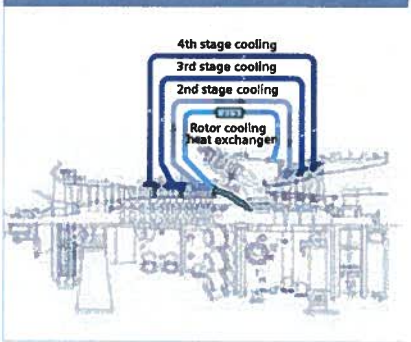
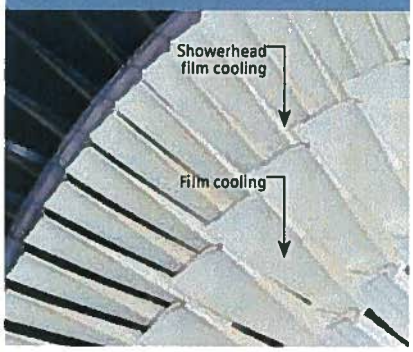


Figure 4 - Row 1 blade cooling



SGT6-5000F gas turbine

Exhaust cylinder section

The exhaust cylinder fabrication is composed of the bearing housing, inner and outer cones of the exhaust diffuser and outer case, all joined together by means of a strut system. The strut system consists of six bearing struts equally spaced around the circumference but positioned tangentially with respect to the bearing housing.

These struts extend from the bearing housing to the outer case. In the hot gas section of the exhaust diffuser, the bearing struts are shielded inside another set of struts, which are hollow and serve as supports for the exhaust diffuser cones. Thus, the bearing struts are protected from the hot exhaust gas by envelopes of cooler air around them. This results in a strut system that is less sensitive to transient temperatures. Growth of the outer case and struts is accommodated by bearing housing rotation.

The system provides a low stress, rigid support, capable of holding the bearing on center for variations of load and temperature.

Axial exhaust manifold section

The exhaust manifold section consists of the exhaust manifold, expansion joint with flow liner and exhaust transition. The exhaust gas flows through the manifold and flow liner into the transition and is then discharged into the stack.

The manifold acts like a muffler in which the flow is slowed down without becoming excessively turbulent. This flow stabilization further improves the gas turbine performance. All parts of the exhaust flowpath, with the exception of the expansion joint, are fabricated from high temperature stainless steel.

The exhaust manifold is composed of one outer and inner cylinder held together by means of three hollow struts. The outer cylinder has the shape of a truncated cone. The inner cylinder, in conjunction with the inner cone of the exhaust diffuser, forms an enclosed chamber around the gas turbine centerline. An access passage to this chamber and a channel for the pipe and conduit lines going to the bearing area are provided through the hollow struts.

The manifold is connected to the exhaust transition by means of an expansion joint made from a high temperature-resistant material. The expansion joint's primary function is to accommodate the axial growth of the unit due to thermal expansion and to prevent any external load from being imposed upon the exhaust manifold.

The axial exhaust configuration is ideally suited for waste heat recovery applications, such as combined cycle, cogeneration and repowering.

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Scope of supply definitions

SGT-PAC	SCC thermal equipment	SCC power island	SCC turnkey
■ Gas turbines for fuel gas, including auxiliaries ■ Air intake/exhaust system ■ Fuel gas system - skids - connecting pipes ■ Gas turbine generators, including auxiliaries ■ Fire protection GT ■ GT electrical and I&C ■ Further options	■ **SGT-PAC** ■ SST-PAC without condenser - Steam turbine, including auxiliaries without piping - Generator, including auxiliaries - ST electrical and I&C ■ HRSG ■ Further options	■ **SCC thermal equipment** ■ Condenser, including air removal system ■ Boiler feed pumps ■ Condensate pumps ■ Critical valves ■ Fuel pre-heater with filter, metering station, etc. ■ Power island controls ■ Further options	■ **SCC power island** ■ Building/structures ■ Cranes and HVAC (turbine hall) ■ Plant cooling systems ■ Water treatment ■ Raw water system ■ Tanks ■ Plant piping/valves ■ Electrical equipment ■ Plant control system ■ Additional fire protection/fighting ■ Erection/commissioning ■ Further options
Performance/delivery	**Cycle optimization/ performance wrap**	**System integration/ optimized operability**	**Total EPC plant wrap**

SGT-PAC	SCC power island	SCC turnkey
Gas turbine, generator, auxiliaries and controls for supplied scope, inlet and exhaust systems.	*SGT-PAC plus HRSG, steam turbine, condenser, major pumps, critical valves and controls for supplied scope.* **Remark** Visible differences between thermal equipment and power island are small and, therefore, not shown.	*SCC power island plus buildings, structures, plant cooling, plant control centers, electrical, switchyard, fuel delivery, piping, plant control system, balance of plant construction, erection and commissioning.*

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SGT6-PAC 5000F

General description

The SGT6-PAC 5000F is designed to provide the user with a complete power generating system. Components and subsystems are selected to form a compact plant housed within enclosures as required.

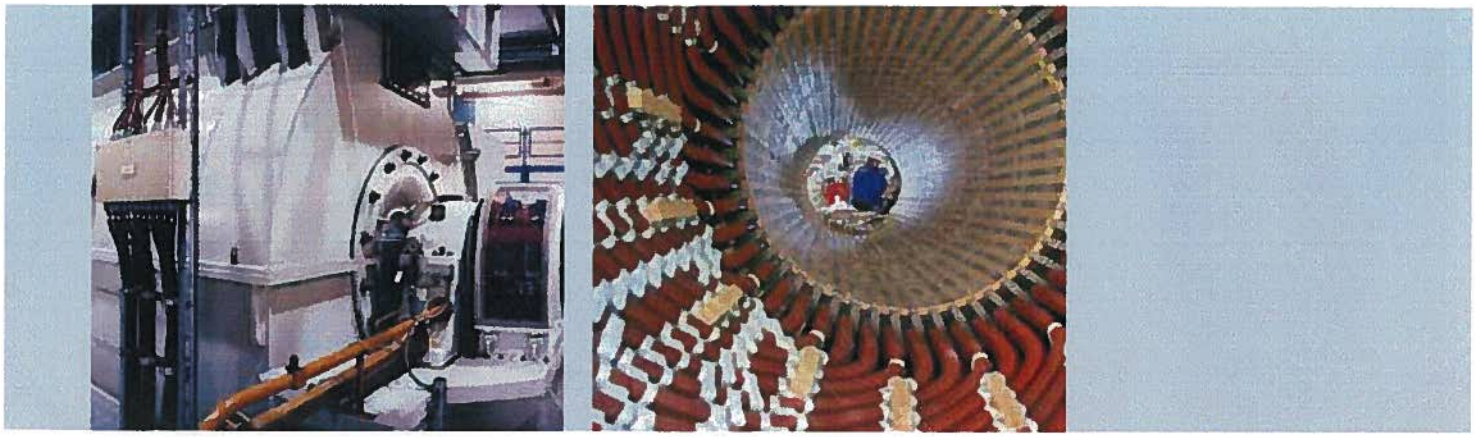
The SGT6-PAC 5000F features modular construction to facilitate shipment and field assembly. Each component of the SGT6-PAC 5000F plant is factory assembled to the extent permitted by shipping limitations to minimize field assembly. A pipe rack assembly and interconnecting piping between the components is supplied, eliminating the need for extensive piping fabrication during construction.

The basic bill of materials for an SGT6-PAC 5000F typically includes the following equipment and assemblies:

- SGT6-5000F gas turbine
- Open air-cooled generator
- Static excitation system
- Static frequency converter starting system
- Electrical package
- Lubricating oil system package
- Instrument air system
- Hydraulic oil system
- Gas fuel system
- Inlet air (static filtration) and exhaust gas systems
- Compressor water wash skid
- Piping packages
- Cooling systems
- FM-2000® fire protection
- Voltage transformer and surge cubicle
- SFC and static excitation equipment (SEE) transformers
- Turning gear
- Control system.

Optional equipment:

- Evaporative cooling system
- Dual fuel combustion system
- Liquid fuel system
- Totally Enclosed Water-to-Air-Cooled (TEWAC) generator
- Water injection package (supplied with liquid fuel system for NO_x control)
- SFC for fast start configuration
- Part load low CO system
- Power augmentation system with steam injection
- Pulse filtration system
- Starting package with brushless excitation
- Exhaust stack (for SSC6-5000F simple cycle power plant)
- Fire protection (LP CO_2 or HP CO_2)
- Inlet heating system.



Generator

The open air-cooled (OAC) Siemens Generator (SGen™) is equipped with a cooling air filter, silencers, inlet and exhaust ducting, collector ring assembly, acoustical enclosure and necessary instrumentation. The isolated phase bus interfaces are near the non-drive end of the generator and the top of the enclosure. There are three main (line side) leads and three neutral leads. Internal cooling is provided via shaft-mounted blowers, which direct filtered ambient air through the generator's major internal components. A solid coupling connects the generator to the compressor at the cold end of the gas turbine.

A totally enclosed water-to-air-cooled (TEWAC) generator (as shown in Figure 5) is available as an option.

Generator cooling system

For open air-cooled generators the cooling air is drawn into the generator through a pad or pulse type filter and a silencing section contained in the inlet duct. The cooling air is forced through the generator via shaft-mounted blower fans located on either end of the generator shaft. As the forced air passes through the generator's major internal components, the heat is absorbed into the air and exhausted through the exhaust duct.

When selected, a TEWAC system provides a closed cooling air circuit. Cooling water is circulated through tube banks to exchange heat energy between the closed circuit generator cooling air and water. The internal active cooling paths, including the shaft-mounted blowers, are identical in both OAC and TEWAC designs. The generator is equipped with interface points for supply and return cooling water.

Static excitation system

The static excitation system is designed to provide control, protection and monitoring functions for a synchronous generator. The system includes the static exciter (housed in a temperature-controlled and weather-resistant container), voltage regulator (housed in the electrical package), collector ring assembly and brush rigging. The collector ring assembly and brush rigging are supplied with the generator.

Brushless excitation is available as an option.

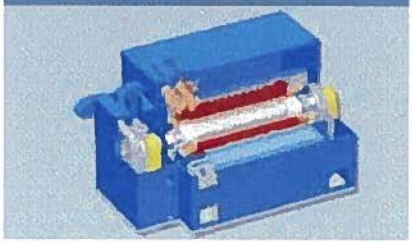
Static frequency converter starting system

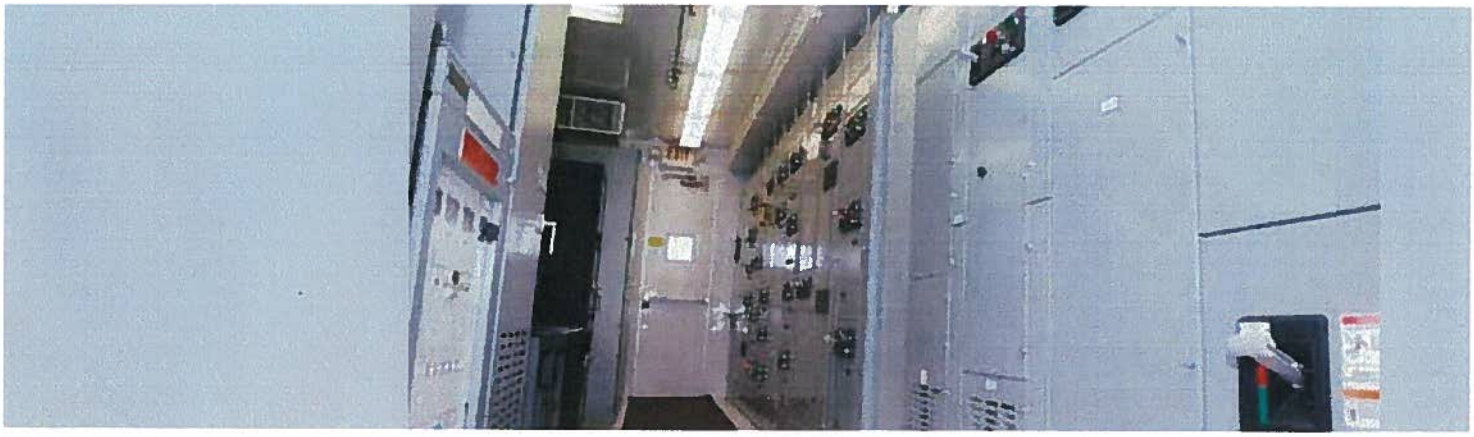
The static frequency converter (SFC), also known as a load commuted inverter, is used for starting the gas turbine. The SFC generates a rotating magnetic field in the generator stator that interacts with the magnetic field generated by the static excitation equipment (SEE) in the generator rotor to provide the torque required to rotate the turbine. The SFC power output is rated to bring the unit to the speed needed for turbine combustor ignition. After ignition the SFC is used only partially to assist the turbine to achieve the rated speed. The SFC and SEE are housed in temperature-controlled and weather-resistant containers.

The SFC is also used to turn the turbine for compressor cleaning and for heat recovery steam generator purging in combined cycle power plants.

In order to achieve fast-start capabilities, a larger capacity SFC system is available as an option. A starting package with brushless excitation is also available as an option.

Figure 5 - TEWAC generator





Auxiliary packages

Electrical package

The electrical package contains equipment necessary for sequencing, control and monitoring of the gas turbine and generator. This includes the gas turbine control system, motor control centers, generator protective relay panels, fire protection system, battery and battery charger. The batteries are in an isolated section of the package and are readily accessible from the outside. Redundant HVAC units are provided in the electrical package to ensure a clean environment for the temperature sensitive electrical and control equipment.

Lubricating oil system package

The lube oil package is a factory manufactured weather-resistant skid for the lubricating oil system. The lubrication system provides clean, filtered oil at the required temperature and pressure for lubricating bearings of the gas turbine and generator as well as for the lubrication requirements of the turning gear. The lube oil package includes a lube oil reservoir, which provides a mounting base for the following lube oil system components:

- Main and alternate AC motor-driven pumps
- Emergency DC motor-driven pump
- Vapor extraction blowers
- Duplex filter assembly
- Accumulators
- Lift oil equipment.

The fin fan lube oil cooler assembly is located on top of the lube oil package. The lube oil system is supplied complete with interconnecting piping, valves and instrumentation.

A duplex plate and frame cooler is available as an option.

Instrumentation air system

The turbine enclosure houses the compressed air reservoir and a pressure switch and gauge panel. The pressure switch and gauge panel contains all of the required pressure switches, gauges, regulating and safety valves, air filters and desiccants. These components clean, dry, control, monitor and direct the instrument air to various valves and instruments. For combined cycle installations, the most efficient source of compressed air is typically the plant service air compressors. For simple cycle installation, an optional reciprocating air compressor can be provided.

Hydraulic oil system

A hydraulic oil power unit (HPU) is supplied. The HPU provides medium pressure hydraulic oil to operate the gas fuel stage throttle valve and the inlet and variable guide vane actuators. The HPU is a self-contained unit mounted on a fabricated steel skid assembly and is located outdoors adjacent to the gas turbine enclosure and the mechanical package enclosure.

The major components are:

- Stainless steel fabricated oil reservoir
- AC motor-driven high pressure charge pumps; fully redundant (2 x 100%) mounted and driven by the high pressure pump motor spindle shaft
- Hydraulic oil cooler, radiator type fan
- Filter (100% redundant) housing assembly
- Safety relief valves, pressure regulating valves
- Hydraulic accumulators
- Electric immersion heaters
- Instrumentation for local and remote monitoring of pressure and temperature
- Interconnect tubing assemblies (stainless steel).

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Gas fuel system

The principal components of the gas fuel system are located inside the turbine enclosure. For the base unheated fuel design, the fuel filter/separator is installed outdoors adjacent to the gas turbine enclosure. The piping assemblies and valves are supplied as spool sections for field erection. The major components of the base fuel system include:

- Fuel filter/separator system
- Fuel throttle valves for each fuel stage with associated instrumentation
- Overspeed trip and shut-off valve(s)
- Vent valve
- Fuel flow monitoring orifices with associated instrumentation.

Instrumentation to monitor the critical parameters is centralized and mounted on a fuel control panel located inside the turbine enclosure. Pressure gauges to locally monitor the fuel pressure are typically located on this panel. Field installed interconnecting piping assemblies that direct the fuel to the turbine-mounted fuel manifolds are supplied.

For the optional heated fuel design, an additional filter/separator for the pilot stage and a pilot overspeed trip/shut-off valve are supplied. The pilot filter separator is also located outdoors adjacent to the turbine enclosure.

The heated fuel option is typically applied in combined cycle applications.

Liquid fuel system (optional)

For liquid fuel applications (either dual or single fuel), a liquid fuel system is supplied. The liquid fuel system consists of factory-assembled components, including an AC motor-driven fuel pump, a suction side duplex fuel filter with transfer valve and a control valve installed on a bedplate. Interconnecting piping to the gas turbine is also included.

Liquid fuel/water injection system (optional)

When a liquid fuel system is included a factory-assembled demineralized water injection skid is furnished. This water injection skid is assembled on a bedplate and includes an AC motor-driven injection pump with suction strainer, manifolds, control valves and instrumentation.

When liquid fuel and water injection systems are included, an additional skid for the primary fuel and water distributing components is provided and is located inside the turbine enclosure. In a typical liquid fuel installation, this skid contains liquid fuel flow dividers, liquid fuel control valves, water injection valves and a local instrument panel.

Inlet air and exhaust gas systems

Air that is drawn into the gas turbine is filtered via a two-stage pad filter. A self-cleaning pulse filter is also an available option. After passing through the filter and inlet silencer for sound attenuation, the inlet air duct guides the air into the compressor inlet manifold. This manifold is designed to provide a smooth flow pattern into the axial flow compressor. After passing through the combustor and turbine section, combustion gas discharges axially through a transition section which is an interface on the exhaust system.

An exhaust stack can be provided as an option for simple cycle applications.

Auxiliary packages

Compressor water wash skid

The compressor water wash skid is provided for both on-line and off-line compressor cleaning. It incorporates an AC motor-driven pump, piping, valves, strainer junction box, cabling, flowmeter and a detergent storage tank. These are assembled on a portable skid trailer with steel wheels attachable to a trailer hitch or clevis.

As an option, a fixed compressor cleaning skid can be provided for remote on- and off-line control.

Piping packages

SGT6-PAC 5000F piping is designed and manufactured to minimize field work. Each of the major pipe assemblies is factory fabricated to reduce field connections.

The turbine pipe package is located adjacent to the gas turbine and in the gas turbine enclosure. It contains valves and piping assemblies for the turbine cooling air system and the lube oil system.

Lube oil cooler

An air-to-oil fin-fan lube oil cooler (water-to-oil cooler, optional) and the associated temperature control valve are mounted on top of the lube oil package roof. The temperature control valve maintains the lube oil temperature within the design range by controlling the flow of oil through the cooler.

Rotor air cooler

Rotor cooling air is extracted from the combustor shell, cooled by an external cooler, and introduced into the turbine section via the torque tube seal housing to be used for sealing purposes and to cool the appropriate rotating discs and rotating blades.

The rotor air cooler system supplied for simple cycle applications is an air-to-air fin-fan heat exchanger fitted with a variable speed motor-driven fan. The energy removed from the cooling air is released to the surrounding air.

For SGT6-PAC 5000F package or SCC6-5000F turnkey combined cycle applications, the rotor air cooling system may include an air-to-water heat exchanger (kettle boiler) instead of a fin-fan cooler. With the kettle boiler, the energy removed from the cooling air is recovered and used to produce intermediate- and low-pressure steam. This steam is introduced into the steam circuit to improve the plant efficiency.

Fire protection system

The fire protection system gives a visual indication of actuation at the local control panel. The FM-200® fire suppressant system is provided for total flooding protection of the turbine enclosure and the electrical control package in accordance with the U.S. National Fire Protection Agency standards.

The CO_2-based fire suppressant system is also available as an option.

VT and surge cubicle

A voltage transformer (VT) and surge cubicle is provided as a separate unit for connection to an isolated phase bus. It contains two three-phase sets of voltage transformers and one set of surge arresters.

Transformers for SEE and SFC

The transformers for power supply to the SEE and SFC are three-phase, two winding, dry-type power transformers. The SEE transformer is rated for continuous duty whereas the SFC transformer is rated for short-time duty. The transformers have a self-cooled ventilation system with vent filters.

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Turning gear

The turning gear provides a capability for remote, automatic, unattended spinning of the turbine-generator drive train. The turning gear is used to breakaway the turbine-generator from rest and to spin the drive train up to the normal 120 rpm turning gear speed. The turning gear will maintain this shaft speed for activation of the SFC and successful start of the gas turbine until synchronous speed has been achieved.

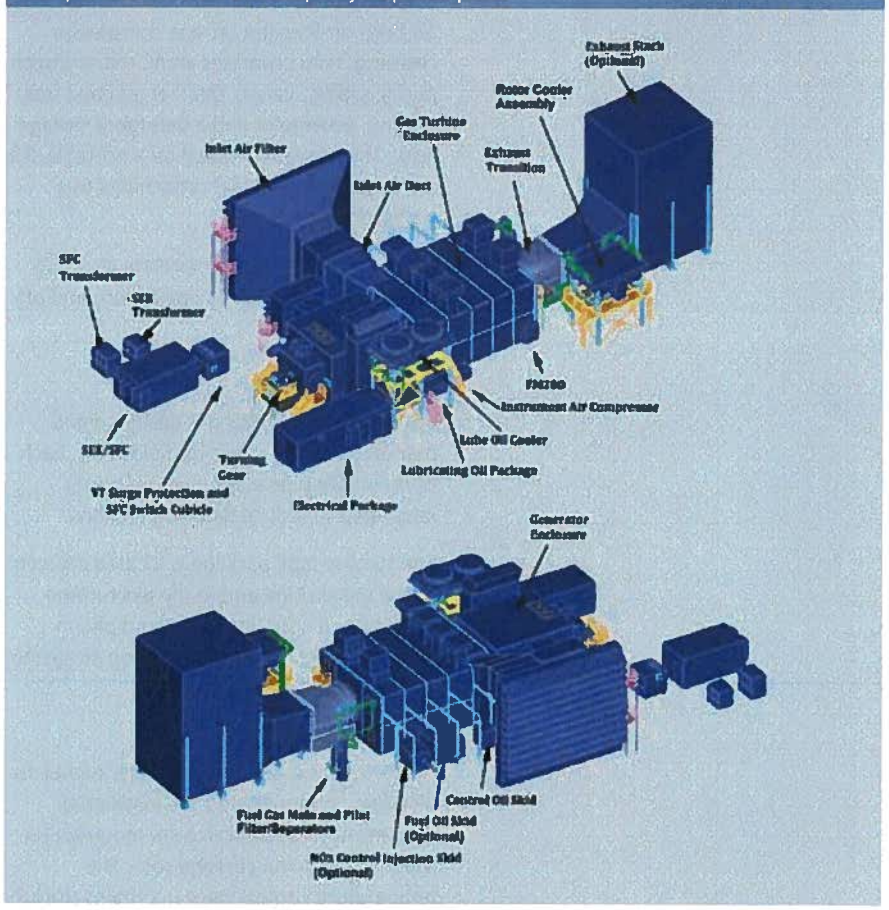
The turning gear is coupled to the exciter end of the generator rotor with a flexible coupling. The turning gear assembly comprises a double reduction worm gear, an overrunning clutch and two AC motors. A small AC motor is connected to the primary gear and is used for clutch engagement and slow breakaway of the turbine-generator drive train. A larger AC motor is connected to the secondary gear and is used to spin the drive train up to a normal turning gear speed of 120 rpm. The turning gear can be engaged while the turbine-generator shaft is at rest or coasting down (synchronization feature).

Control system

Instrumentation and control system cabinets located in the electrical package perform tasks such as:

- Open-loop control of step sequences for startup and shutdown of the gas turbine and its subsystems, sub-loop and individual drive control circuits
- Closed-loop control of fuel valves or pitch variation of the compressor inlet guide vanes
- Protection of plant equipment
- Operation and monitoring of the GT via the human-machine interface
- Engineering and diagnostics of the I&C system.

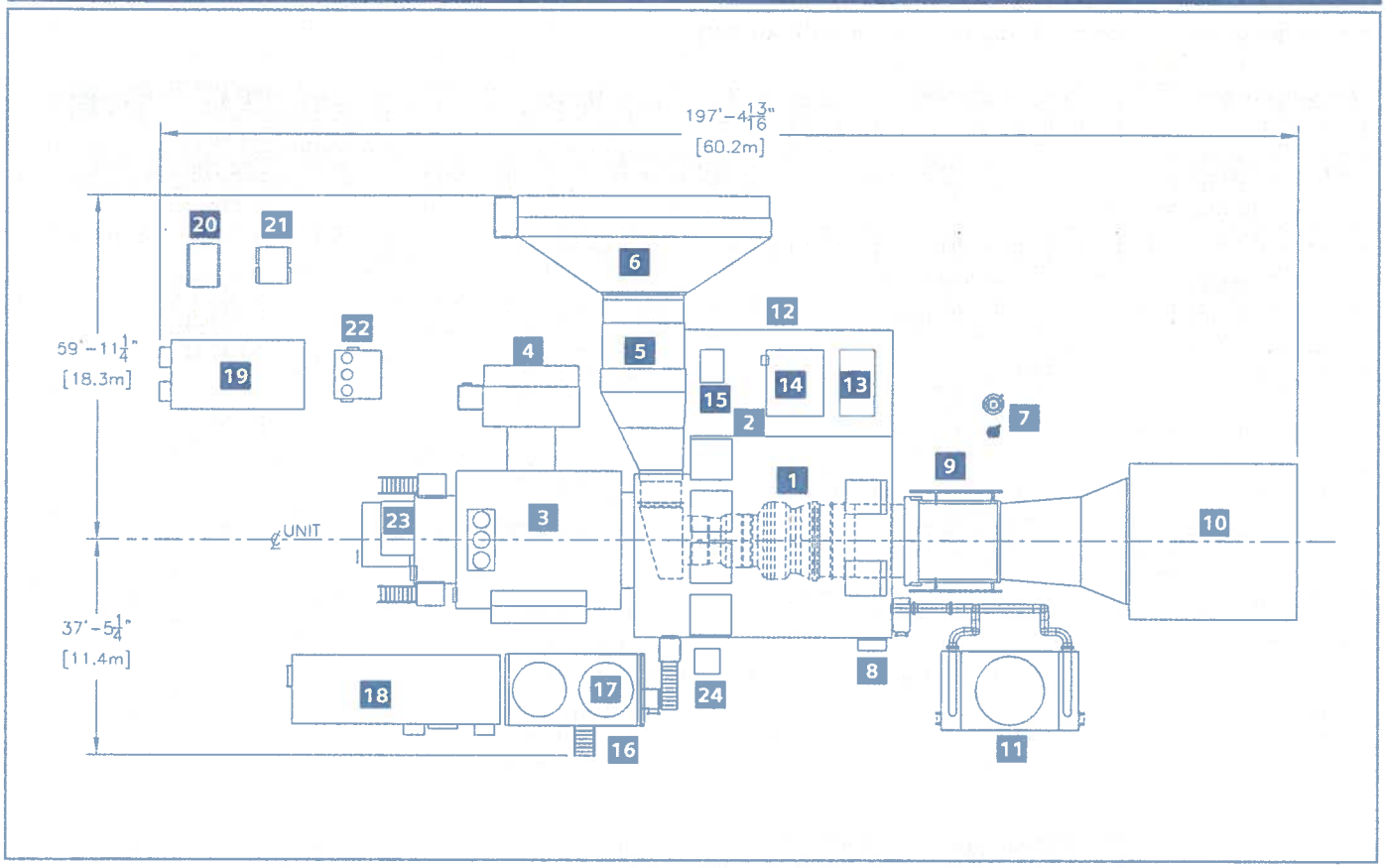
Figure 6 - SSC6-5000F arrangement diagram depicts the location of the major components in a Siemens simple cycle power plant



The Siemens Power Plant Automation SPPA-T3000 is the installed turbine I&C system that reliably performs all these tasks.

SSC6-5000F plant arrangement diagram

Figure 7 - SGT6-PAC 5000F simple cycle plant general arrangement drawing



	Key		
1	Gas turbine (GT)	13	NO_x control injection skid
2	GT enclosure	14	Fuel oil skid
3	Generator (OAC)	15	Control oil skid
4	Generator air inlet filter	16	Lube oil package
5	Turbine air inlet duct and silencer	17	Lube oil cooler (fin-fan)
6	Turbine air inlet filter	18	Electrical package
7	Fuel gas main and pilot filter/separators	19	SEE/SFC
8	FM-200® fire protection	20	SFC transformer
9	Exhaust transition	21	SEE transformer
10	Exhaust stack	22	VT surge protection and SFC switch cubicle
11	Rotor air cooler (fin-fan)	23	Turning gear
12	FOWI acoustic wall	24	Instrument air compressor

Comment: Items 13 and 14 only required with dual fuel.
Notes: The equipment shown is representative information. This design is subject to change at the discretion of Siemens. All dimensions shown are in feet and inches (metric).

SGT6-PAC 5000F performance

The following is the net reference performance for the SGT6-PAC 5000F.

Combustor type	ULN dry	DLN* dry	Steam augmentation
Fuel	Natural gas	Natural gas	Natural gas
Net power output (kW)	199,600	205,900	224,700
Net heat rate (Btu/kWh) LHV	9,102	9,081	8,802
Net heat rate (kJ/kWh) LHV	9,604	9,582	9,287
Exhaust temperature (°F/°C)	1,088/587	1,113/601	1,114/601
Exhaust flow (lb/hr)	3,995,800	3,997,900	4,130,300
Exhaust flow (kg/hr)	1,812,400	1,814,400	1,873,400
Fuel flow (lb/hr)	84,500	86,900	91,971
Fuel flow (kg/hr)	38,340	39,400	41,717
Fuel	Liquid	Liquid	Liquid**
Net power output (kW)	190,700	191,100	
Net heat rate (Btu/kWh) LHV	9,377	9,301	
Net heat rate (kJ/kWh) LHV	9,893	9,813	
Exhaust temperature (°F/°C)	1,052/567	1,045/563	
Exhaust flow (lb/hr)	4,048,400	4,048,200	
Exhaust flow (kg/hr)	1,836,300	1,836,200	
Fuel flow (lb/hr)	96,946	96,741	
Fuel flow (kg/hr)	43,974	43,881	

*Steam injected through the combustor section casing into the compressor discharge air to increase output.
**Steam augmentation with liquid fuel available on a case-by-case basis.

Conditions: Natural gas or liquid fuel meeting Siemens' fuel specifications. Elevation: Sea level; 14.696 psia barometric pressure, 60% relative humidity, 59° F (15° C) inlet air temperature, 3.4 in. water (87 mm water) inlet loss, 5 in. water (127 mm water) exhaust loss, air-cooled generator and .90 power factor (pf).

Correction curves

To estimate thermal performance of the SSC6-5000F plant at conditions other than those noted above, the following correction curves are provided:

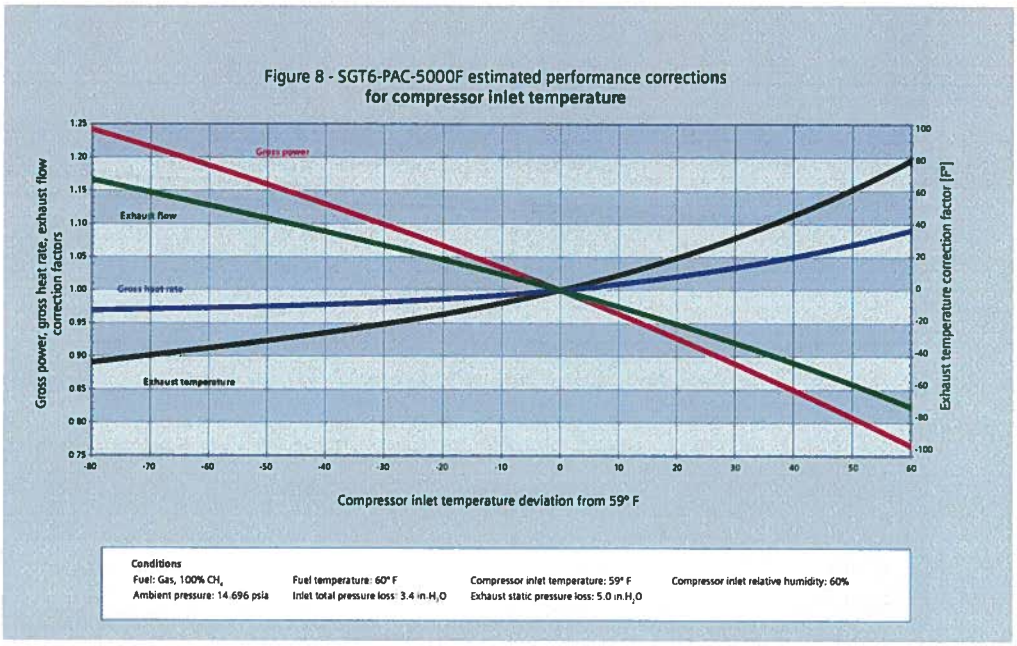
- Correction for compressor inlet temperature (Figure 8)
- Correction for excess exhaust pressure loss (Figure 9)
- Correction for excess inlet pressure loss (Figure 10)
- Correction for barometric pressure.***(Figure 11)

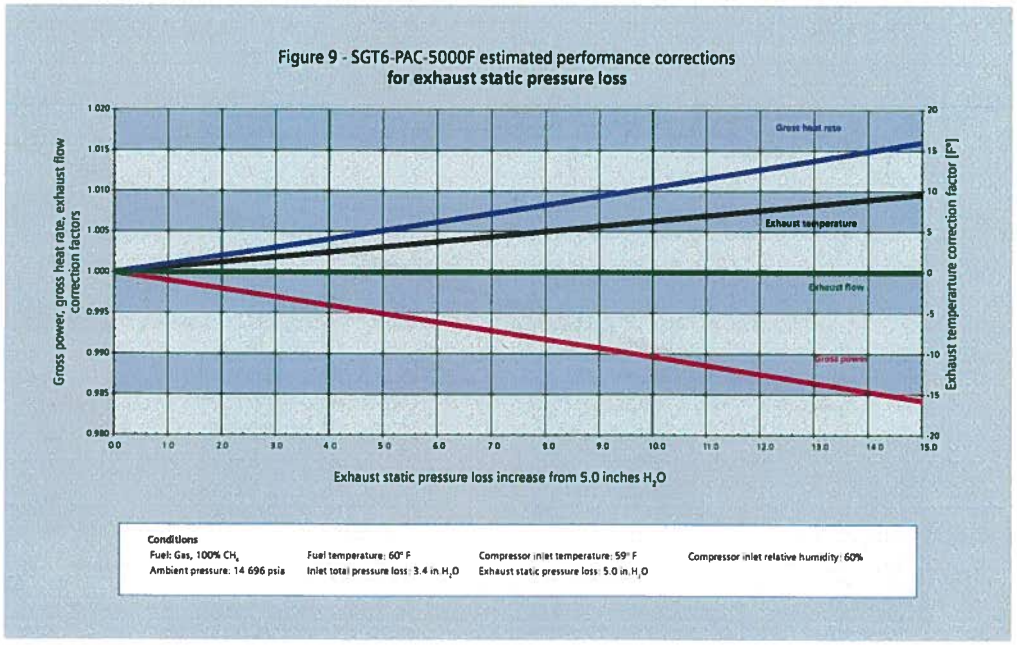
***Barometric pressure (BP) can be calculated from the site elevation (ELE) using:
$BP = 7.08601\ E\text{-}09 \times ELE_2 - 5.29221\ E\text{-}04 \times ELE + 14.696$

Note: BP in psia and ELE in ft.

Correction curves

To estimate thermal performance of the SGT6-PAC 5000F at conditions other than those noted, the following correction curves may be used.





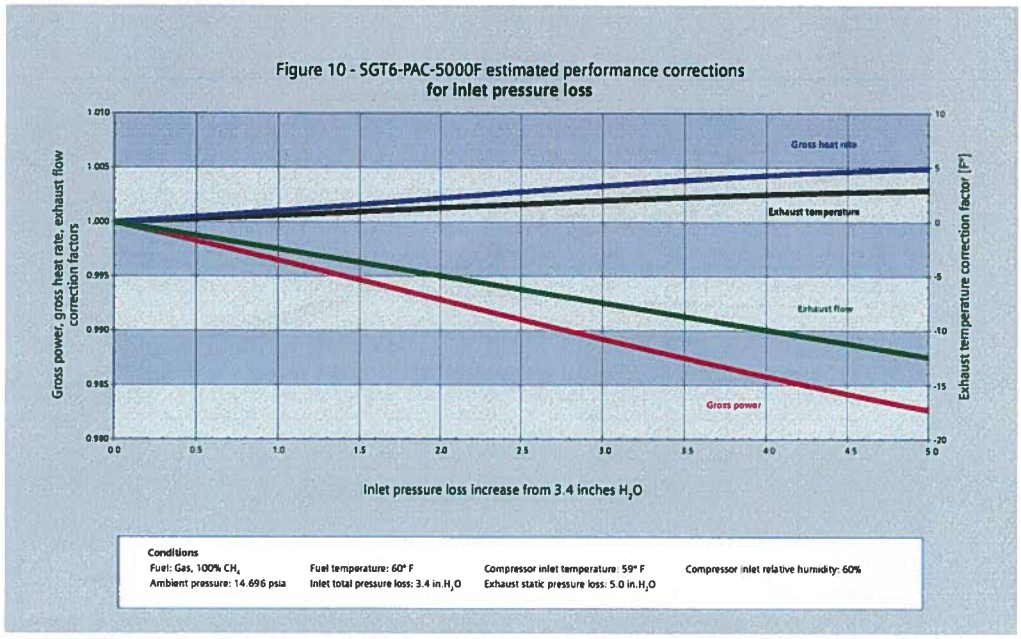


Figure 10 - SGT6-PAC-5000F estimated performance corrections for inlet pressure loss
Gross power, gross heat rate, exhaust flow correction factors
Exhaust temperature correction factor [F°]
Gross heat rate
Exhaust temperature
Exhaust flow
Gross power
Inlet pressure loss increase from 3.4 inches H_2O
Conditions
Fuel: Gas, 100% CH_4
Ambient pressure: 14.696 psia
Fuel temperature: 60° F
Inlet total pressure loss: 3.4 in.H_2O
Compressor inlet temperature: 59° F
Exhaust static pressure loss: 5.0 in.H_2O
Compressor inlet relative humidity: 60%

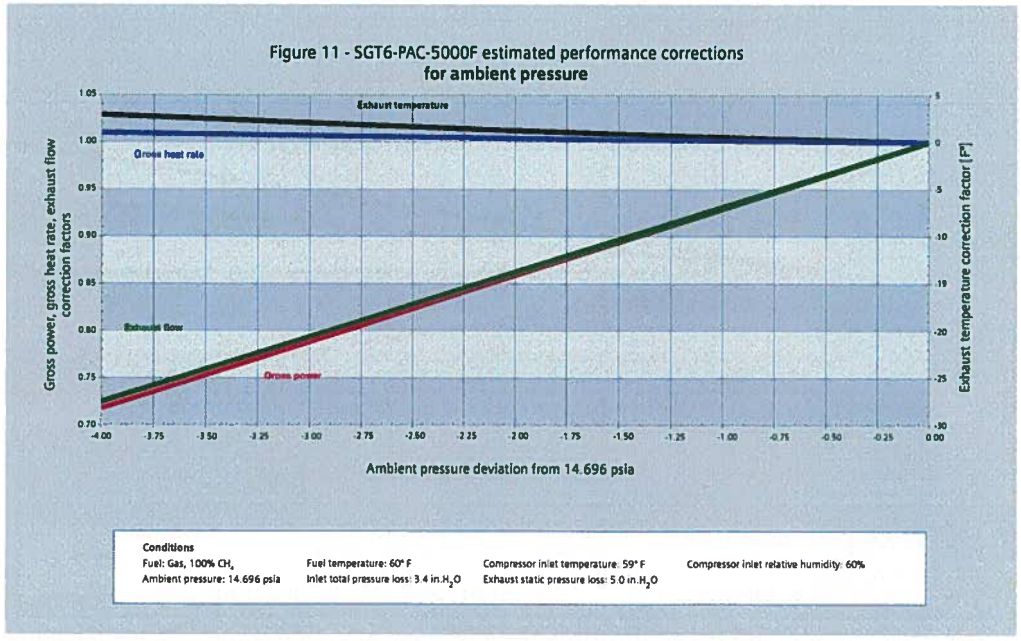


Figure 11 - SGT6-PAC-5000F estimated performance corrections for ambient pressure
Gross power, gross heat rate, exhaust flow correction factors
Exhaust temperature correction factor [F°]
Exhaust temperature
Gross heat rate
Exhaust flow
Gross power
Ambient pressure deviation from 14.696 psia
Conditions
Fuel: Gas, 100% CH_4
Ambient pressure: 14.696 psia
Fuel temperature: 60° F
Inlet total pressure loss: 3.4 in.H_2O
Compressor inlet temperature: 59° F
Exhaust static pressure loss: 5.0 in.H_2O
Compressor inlet relative humidity: 60%

SGT6-PAC 5000F technical data

SGT6-5000F gas turbine			**Generator**	
Compressor			Standard	ANSI/IEC
Type	Axial flow		Type	
Number of stages	13		Base	Open air-cooled (OAC)
Rotor speed	3600 rpm		Option	TEWAC
Pressure ratio	17:1		Excitation	
Inlet guide vanes	Variable		Base	
Combustion system			Option	Static
Combustors			Nameplate rating	Brushless
Type	Ultra Low NO_x		MVA	249 MVA
Configuration	Can-annular		Power factor	0.90
Fuel (base)	Gas fuel only		Voltage	16.5 kV
Fuel (option)	Gas fuel and liquid fuel		Current	8200 A
Number	16		Frequency	60 Hz
Fuels			Speed	3600 RPM
Natural gas pressure range	475 to 500 psig – Nominal @ gas turbine filter/separator inlet flange		Field current	1544 A
Liquid fuel (option)	50 to 90 psig @ fuel oil skid interface flange (demineralized water injection required)		Field voltage	270 V
Turbine			Ambient temperature	59° F / 15° C
Number of stages	4		Cold gas temperature	32° C
Number of cooled stages	3		Insulation class	Class F
Bearings			Operation class	Class F
Journal bearing			Short circuit ration	0.45
Type	Tilting pad		Direct axis impedance	Saturated
Quantity	2			X'd= 2.13 per unit
Thrust bearing	Drive end			X'd= 0.26 per unit
Type	Tilting pad			X'd= 0.19 per unit
Quantity	1		Starting system	
Drive	Cold end, direct coupled		Electric motor started	SFC / SCC
			Starting time to base load*	30 min (base)
			Turning gear	DC Drive
Recommended inspection interval				
Inspection type - gas fuel	Hours	Starts		
Combustor	12,500	N/A		
Hot gas path	25,000	900		
Major overhaul	50,000	1,800		
** A fast-start option is available to provide 150 MW in 10 minutes*				

SGT6-PAC 5000F

Plant weights and dimensions

Shown below is a typical list of the major pieces of equipment along with their approximate shipping weights and nominal dimensions.

Item	Weight	Length	Width	Height	Remarks
Gas turbine	462,700 lbs	32 ft 8 in	13 ft 0 in	15 ft 0 in	not including beam and lifting saddle
Electrical package	50,000 lbs	36 ft 0 in	12 ft 0 in	11 ft 6 in	
Lube oil package	48,700 lbs	24 ft 6 in	10 ft 6 in	10 ft 6 in	
Lube oil cooler (fin-fan)	31,000 lbs	29 ft 1 in	14 ft 4 in	12 ft 2 in	with support structure
Turbine piping package	38,500 lbs	40 ft 0 in	8 ft 0 in	12 ft 0 in	
Rotor air cooler (fin-fan)	39,350 lbs	22 ft 10 in	15 ft 0 in	13 ft 6 in	
Generator Aeropac II	530,000 lbs	41 ft 0 in	12 ft 3 in	13 ft 0 in	without enclosure
Heaviest piece lifted		**Weight**			
During construction	Air-cooled generator	530,000 lbs			including lifting beam
After construction	Bladed gas turbine rotor	205,800 lbs			

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SCC6-5000F combined cycle plants

General description

Combined cycle plants can be made up of various combinations of gas turbines, HRSGs and steam turbines. The scope of supply can be an SGT6-PAC 5000F package, SCC6-PAC 5000F power island or SCC6-5000F turnkey plant.

A typical 2x1 combined cycle power plant consists of two SGT6-5000F gas turbines each with a dedicated HRSG that supplies steam to a shared steam turbine. The gas turbines will primarily burn natural gas with optional provisions to burn liquid fuel as a backup. Each gas turbine will be coupled with a three-pressure reheat HRSG, which will generate steam to operate the steam turbine. Generators attached to the two gas turbines and the steam turbine will supply electrical power to the grid.

Major equipment

A typical 2x1 turnkey combined cycle plant consists of the following major equipment:

- Two SGT6-5000F gas turbines with air-cooled generators
- Two three-pressure level reheat HRSGs with stacks (fired as an option)
- One multi-cylinder reheat condensing steam turbine with air-cooled generator
- One water-cooled condenser using a forced-draft cooling tower
- One integrated plant distribution control system
- Balance of plant (BOP) equipment consisting of pumps, transformers, power electrics, etc.
- HV switchyard.

Major equipment descriptions

Gas turbine

The SGT6-5000F gas turbine as outlined in the general description can be applied in a combined cycle application.

Heat recovery steam generator

The three-pressure, reheat HRSGs produce steam, which drives the steam turbine. The exhaust gas flows horizontally through the HRSGs releasing heat through the finned tubes to the water/steam cycle.

Depending on specific project requirements, the high pressure section of the HRSG can be either a drum-type or a once-through design.

The sections of the drum-type HRSG contain economizer tube bundles, evaporator tube bundles with associated steam drums and a superheater tube bundle. Feedwater is pumped through the economizer sections for optimized performance.

The once-through, BENSON® technology HRSG has an advanced superheater outlet design to enhance fast-start capability, making the plant better suited for operating regimes between intermediate and continuous duty. The feedwater is passed through a condensate polishing system and pumped through the sections of the boiler.

Either HRSG design can be supplied with provisions for SCR and/or CO catalyst.

Steam turbine

The steam generated in the HRSG is supplied to a two-cylinder, reheat, condensing steam turbine with high efficiency blading. Depending on the back pressure or the amount of HRSG supplemental firing, the steam turbine is optimized as a single-flow axial exhaust condensing type, a dual-flow side or a down exhaust condensing type.

The single-flow turbine consists of a single-flow HP turbine element and a combined IP/LP element. The dual-flow turbine consists of a combined HP/IP turbine element and a double flow LP turbine element.

Main steam is supplied directly to the HP turbine inlet valves. Hot reheat steam and IP induction steam enters through the IP turbine inlet valves. In the dual-flow steam turbine, LP induction steam enters the steam path through a port normally located in the crossover pipe. In the single-flow steam turbine, LP steam enters the steam path through an induction port appropriately located in the turbine blade path. Upon exiting the LP turbine, steam exhausts into a water-cooled or air-cooled condenser.

100% steam turbine bypass system

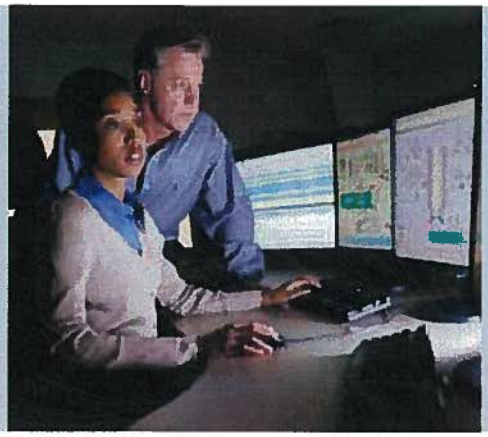
The condenser is designed to accommodate the exhaust from the steam turbine, plus the miscellaneous drains from the steam system. The condenser also is designed to allow 100% steam bypass of the steam turbine.

Condensate pumps

Condensate is pumped from the condenser hotwell by 2x50% condensate pumps (one full capacity pump for each HRSG). The condensate then passes through the low temperature economizer section in the HRSG prior to entering the LP steam drum and boiler feedpump section. For redundancy, an optional 3x50% arrangement is available.

Boiler feedwater pump island

A boiler feedwater pump island concept is employed using 2x50% pumps (one full capacity pump for each HRSG) headered together. These pumps supply feedwater to the HP and LP boiler sections of the HRSGs. The pumps are electric motor-driven and are located adjacent to the HRSG nearest the steam turbine. The pumps take suction from the condensate pump discharge after the low temperature economizer raises the pressure to the appropriate level to supply the feedwater to the boiler section(s).



Cooling system

A typical combined cycle plant incorporates a water-cooled condenser using a forced-draft wet cooling tower. Additional arrangements include a condenser with once-through cooling or air-cooling.

Control, protection and monitoring

Control, protection and monitoring functions for the SGT6-5000F gas turbine-based power plant are performed by the innovative Siemens Power Plant Automation (SPPA™) control system known as the SPPA-T3000. This secured Web-based distributed control system located within the electrical package has the expandability and flexibility to accommodate a wide range of plant configurations and interface options.

Although the SGT6-PAC 5000F power plant control system is provided specifically for the gas turbine-generator unit and its direct auxiliaries, it is expandable to control other elements, such as the steam turbines, HRSG and balance of plant (BOP), within the entire plant. The SPPA-T3000 system can be located in a central control room or any other location.

BOP functions may include thermal equipment, circulating water loops, switchyard monitoring and SCADA interface for a complete combined cycle plant.

Supplemental HRSG firing (option)

Supplemental HRSG firing (duct firing) is available as an option to increase the plant output by introducing additional heat energy into the gas turbine exhaust stream. By adding burners strategically located in the HRSG, plant output can be increased by over 6% with moderate duct firing and over 20% with heavy duct firing.

Site layout and arrangement of equipment

Using a modular approach, the Siemens reference power plant (RPP) can readily be configured to satisfy a number of site or customer-specific requirements.

Figure 12 - SCC6-5000F 2x1 combined cycle plant general arrangement drawing (as shown on page 28) illustrates the base design configuration for a single fuel (natural gas only), outdoor arrangement with a cooling tower.

BOP equipment will be provided in accordance with Siemens RPP designs as modified to suit site-specific requirements. Pre-engineered options are available to address customer requirements.

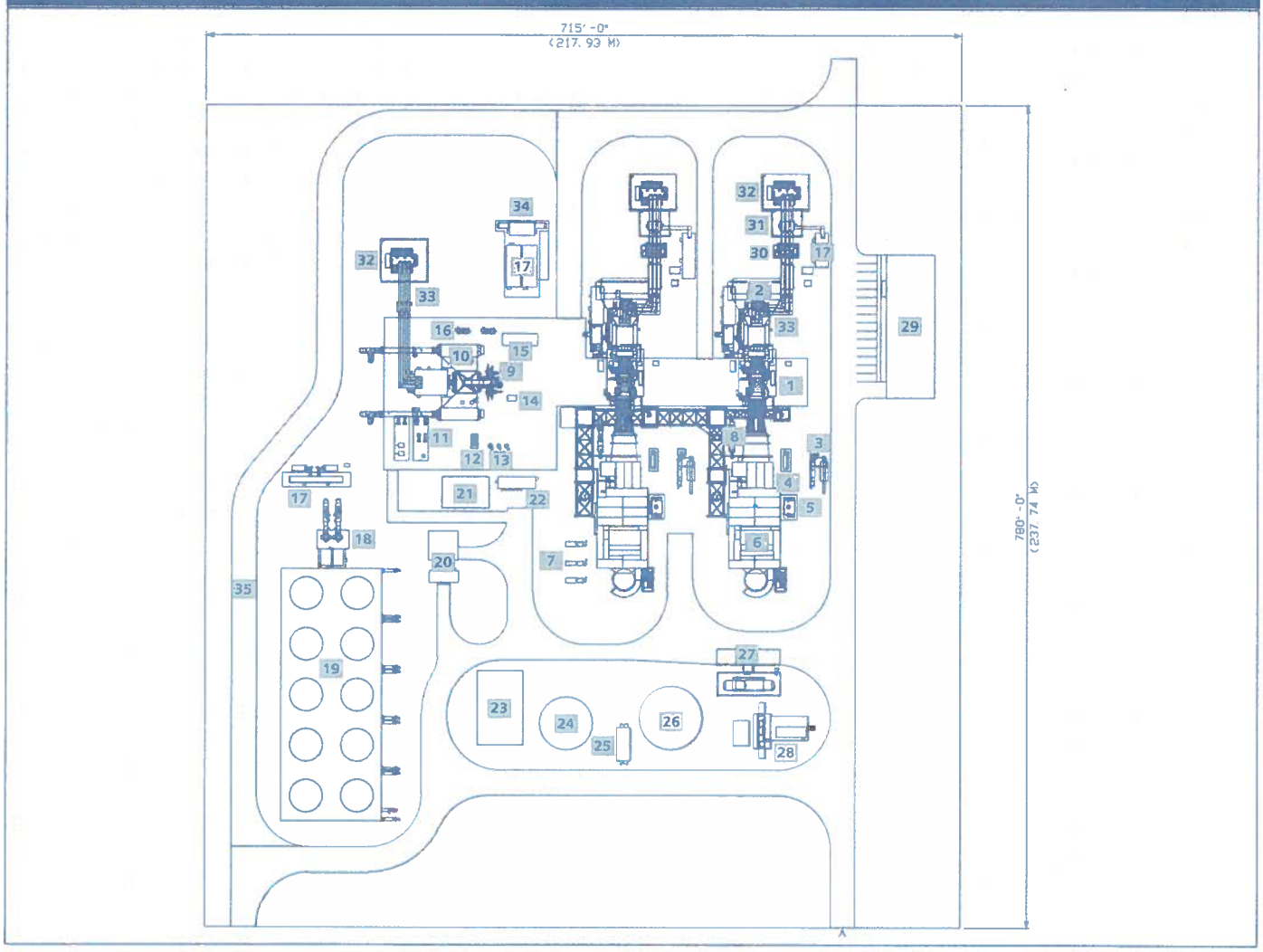
The overall site and building arrangements were developed to optimize space requirements while maintaining ample access for operation and maintenance activities.

The gas turbine-generators, steam turbine-generator, condenser and associated auxiliaries are normally located outdoors but can also be placed in a building as an option. The HRSG and associated auxiliary equipment are located outdoors.

Figure 13 - SCC6-5000F 1x1 combined cycle plant general arrangement drawing (as shown on page 29) illustrates the base design configuration for a single fuel (natural gas only), outdoor arrangement with a cooling tower.

SCC6-5000F plant arrangement diagrams

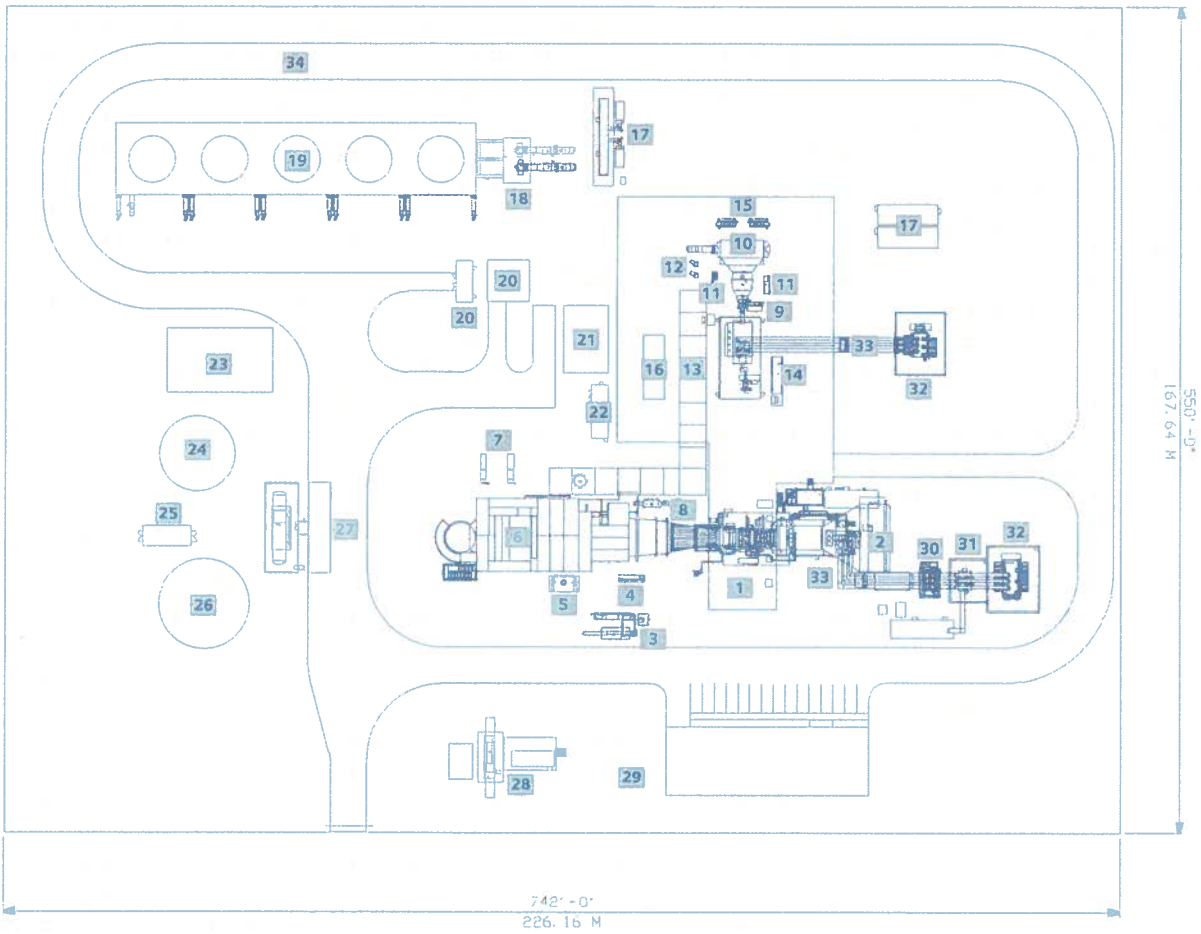
Figure 12 - SCC6-5000F 2x1 combined cycle plant general arrangement drawing



	Key				
1	Gas turbine enclosure	15	Lube oil skid	29	Admin building
2	Turbine air inlet filter	16	Vacuum pump	30	Generator circuit breaker
3	Fuel gas preheater	17	Power control center	31	Auxiliary transformer
4	Duct firing skid	18	Circulating water pumps	32	Generator step-up transformer
5	SCR skid	19	Cooling tower	33	Isophase bus duct
6	HRSG	20	Cooling tower chemical dosing system/ storage area	34	LV transformers
7	Boiler feed water pump	21	Condensate polishing	35	Road
8	Rotor air cooler	22	Steam turbine chemical dosing system		
9	Steam turbine	23	Water treatment building		
10	Surface condenser	24	Demin. water storage tank		
11	Closed cooling water pump	25	Fire water pump		
12	Gland steam system	26	Raw/fire water storage tank		
13	Condensate extraction pump	27	Ammonia storage/unloading area		
14	Hydraulic supply skid	28	Fuel gas conditioning/metering area		

Notes: The equipment shown is representative information. This design is subject to change at the discretion of Siemens. All dimensions shown are in feet and inches (metric). Cooling tower location to be determined by prevailing winds.

Figure 13 - SCC6-5000F 1x1 combined cycle plant general arrangement drawing



	Key				
1	Gas turbine enclosure	16	Closed cooling water pump	31	Auxiliary transformer
2	Turbine air inlet filter	17	Power control center	32	Generator step-up transformer
3	Fuel gas preheater	18	Circulating water pumps	33	Isophase bus duct
4	Duct firing skid	19	Cooling tower	34	Road
5	SCR skid	20	Cooling tower chemical dosing system/ storage area		
6	HRSG	21	Condensate polishing		
7	Boiler feed water pump	22	Steam turbine chemical dosing system		
8	Rotor air cooler	23	Water treatment building		
9	Steam turbine	24	Demin. water storage tank		
10	Surface condenser	25	Fire water pump		
11	Gland steam system	26	Raw/fire water storage tank		
12	Condensate extraction pump	27	Ammonia storage/unloading area		
13	Hydraulic supply skid	28	Fuel gas conditioning/metering area		
14	Lube oil skid	29	Admin building		
15	Vacuum pump	30	Generator circuit breaker		

Notes: The equipment shown is representative information. This design is subject to change at the discretion of Siemens. All dimensions shown are in feet and inches (metric). Cooling tower location to be determined by prevailing winds.

SCC6-5000F plant performance

Combined cycle performance

The performance of combined cycle power plants varies with the site conditions, the equipment selected and the thermal cycle design. For the SGT6-5000F gas turbine-based combined cycle turnkey plant, the components and the cycle have been selected to provide increased performance.

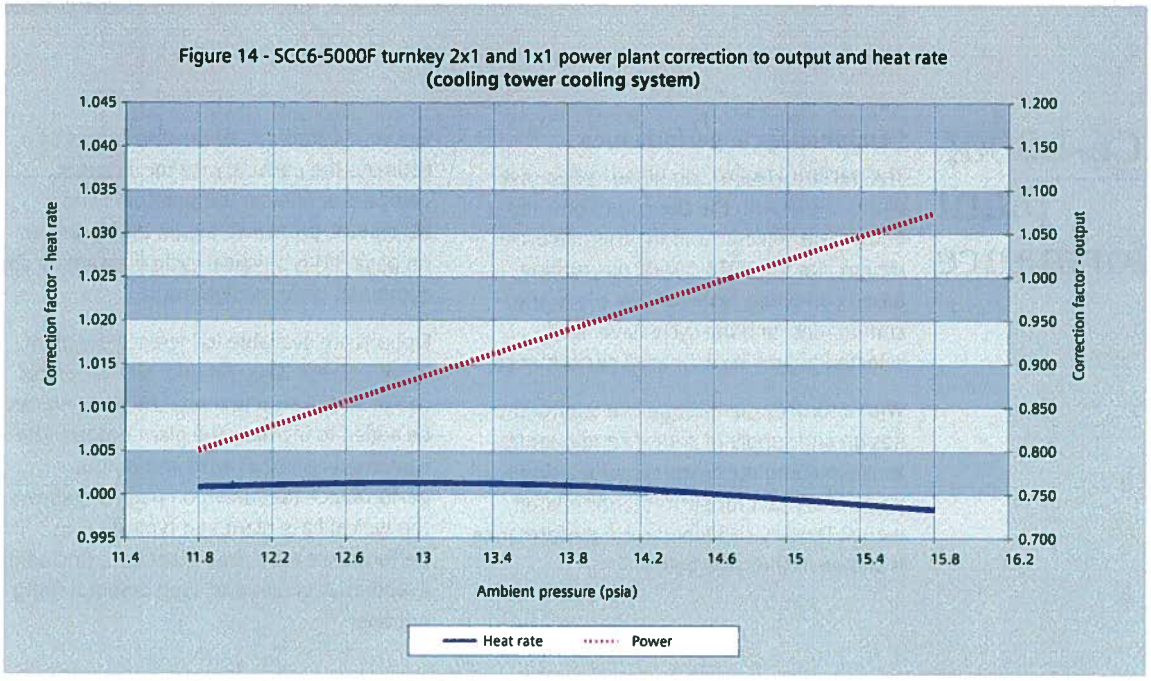
With a turnkey plant scope, we control the design and supply of critical components, thus providing the customer with a single point of contact for performance related issues. Turnkey combined cycle performance is shown in the table below.

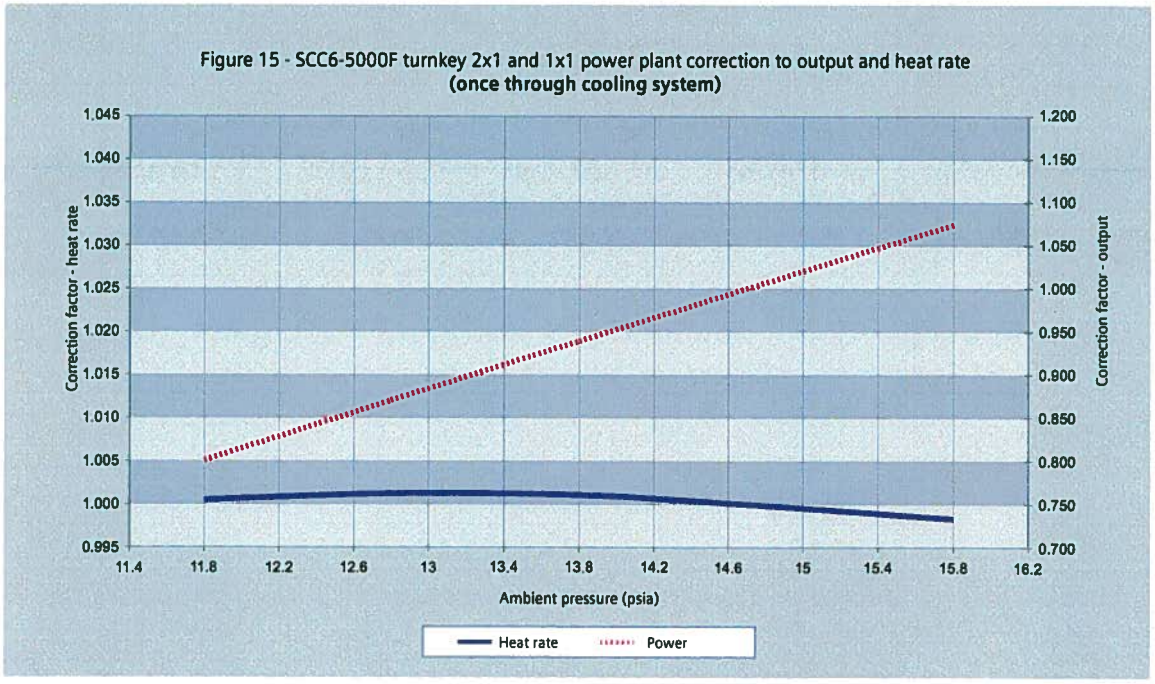
Figures 14 through 19 provide factors to estimate the performance for different compressor inlet air temperatures and barometric pressures. Figure 20 (as shown on page 34) is a typical cycle diagram for 2x1 combined cycle configuration.

Options are available to increase the plant output on hot days. An inlet air evaporator cooler and/or supplemental HRSG firing can be added to increase the plant output. The combined cycle 2x1 base and output performance (as shown on page 34) shows the typical base plant and typical performance enhanced plant data (including evaporative cooler and supplemental firing options).

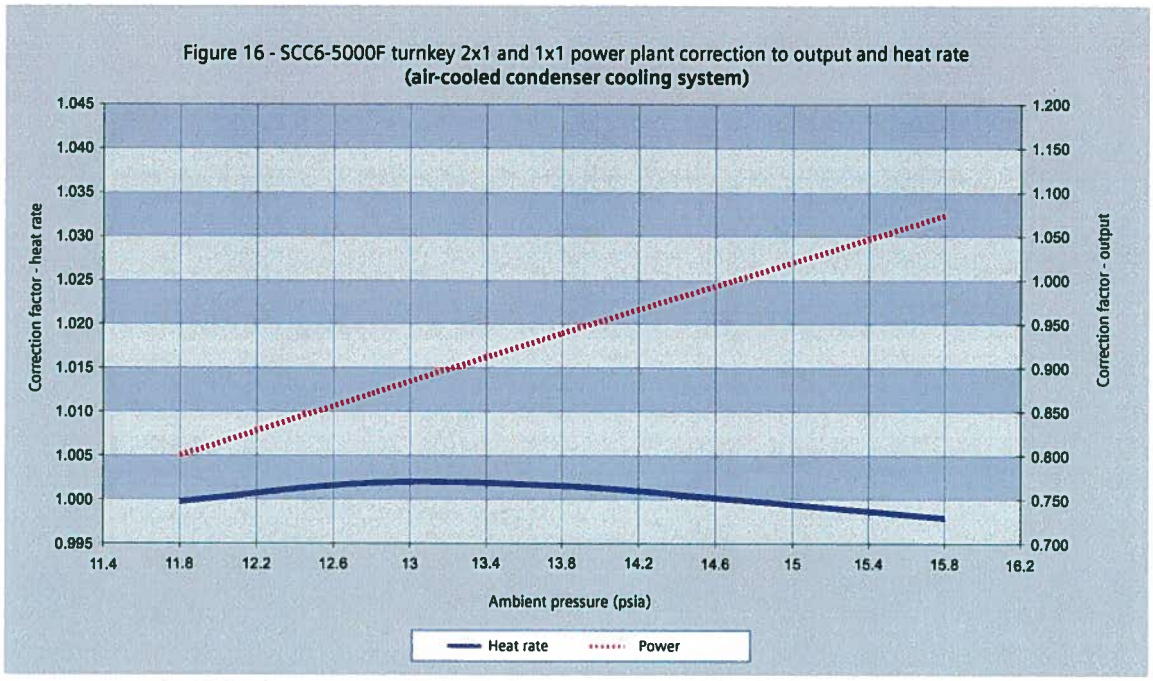
Plant designation	SCC6-5000F 2x1 turnkey			SCC6-5000F 1x1 turnkey		
Cooling configuration	Cooling tower	Once through	Air-cooled	Cooling tower	Once through	Air-cooled
Net power (MW)	615	620	607	304	308	301
Net heat rate Btu/kWh (kJ/kWh)	5,960 (6,290)	5,910 (6,230)	6,040 (6,380)	5,980 (6,310)	5,930 (6,250)	6,060 (6,400)
Steam turbine back pressure psia (mbar)	.75 (52)	.64 (44)	1.17 (80)	.75 (52)	.64 (44)	1.17 (80)

Correction curves





Correction curves



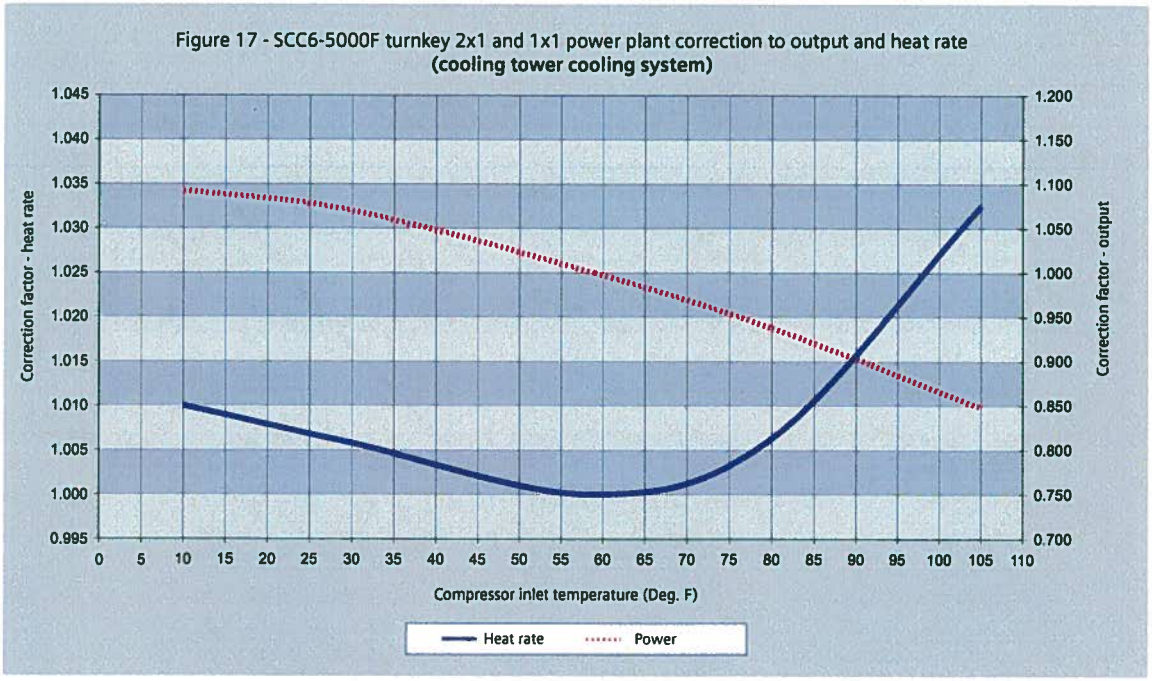


Figure 18 - SCC6-5000F turnkey 2x1 and 1x1 power plant correction to output and heat rate
(once through cooling system)

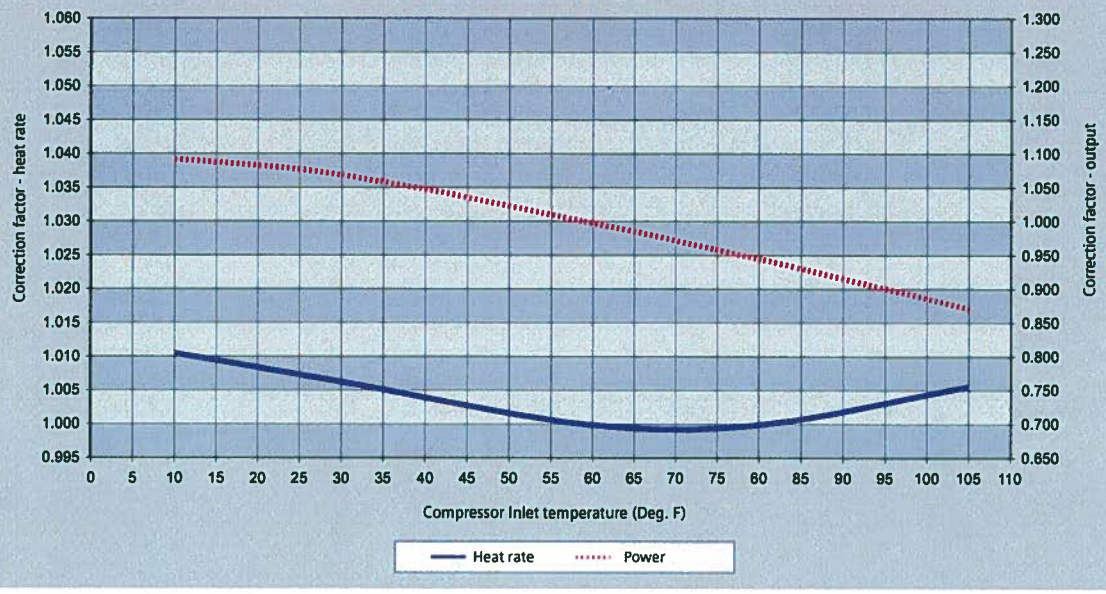
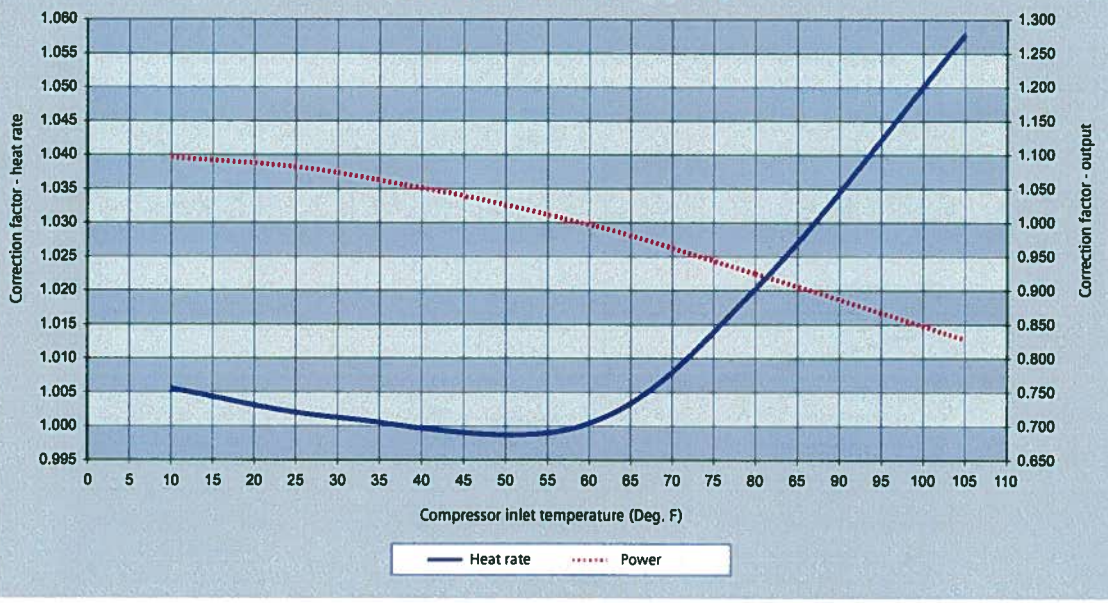


Figure 19 - SCC6-5000F turnkey 2x1 and 1x1 power plant correction to output and heat rate
(air-cooled condenser cooling system)

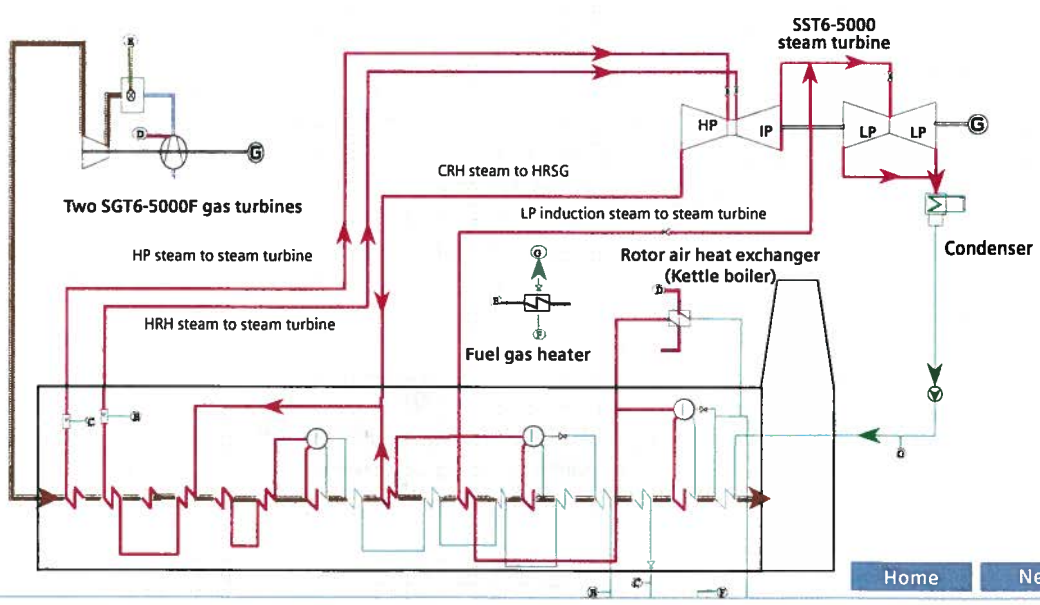


Combined cycle 2x1 base and output enhanced performance

Operating conditions	Base plant	Plant with performance options
Evaporator cooler	No	Yes
Supplemental firing	No	Yes
Ambient temperature (°F/°C)	59/15	105/35
Relative humidity (%)	60	35
Barometric pressure (psia/bars)	14.69/1.033	14.69/1.033
Fuel	Natural gas	Natural gas
Fuel heating value (LHV)	20,981 Btu/lb	20,981 Btu/lb
Fuel heating value (LHV)	48,802 kJ/kg	48,802 kJ/kg
Fuel HHV/LHV ratio	1.1	1.1
Generator power factor	0.9	0.9
ST backpressure (psia/mbar)	.64/44	1.50/103
ST throttle pressure (psia/bars)	1,780/122.7	2,131/147
ST throttle temperature (°F/°C)	1,043/561.8	1,049/564.8
ST reheat pressure (psia/bars)	373/25.7	426/29.4
ST reheat temperature (°F/°C)	1,044/562.1	1,049/565.3
Gross plant output (MW)	630 (1)	620 (2)
Net plant output (MW)	620 (1)	605 (2)
Net plant heat rate (Btu/kWh)	5910 (1)	6140 (2)
Net plant efficiency	57.8% (1)	55.5% (2)

(1) based on once through cooling (2) based on cooling tower

Figure 20 - Cycle diagram with drum-type boiler



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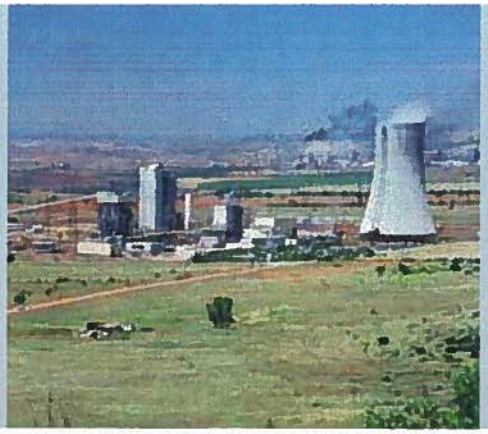

Integrated gasification combined cycle plant application

The reliable SGT6-5000F gas turbine technology can be used in low-Btu fuel (syngas) applications, such as Integrated Gasification Combined Cycle (IGCC) with or without carbon capture and bitumen upgrader projects where syngas fuel is available.

Based on a complete analysis for operation in syngas applications, minimal changes are needed to a typical natural gas fueled SGT6-5000F. The major change is the use of a dual fuel (syngas and natural gas) syngas combustion system specifically designed for IGCC and other syngas applications. Ports for air-side integration are also available at the center of the gas turbine, which can support up to 50% of the air separation units air needs during operation.

The modified combustion system was designed to operate on high H_2 syngas (IGCC with carbon capture), syngas or natural gas. At the heart of the syngas combustion system is a diffusion flame combustor. This combustion system was derived from the proven SGT6-5000F DF42 combustion system and the syngas combustors in two W501D5 gas turbines at the LGTI IGCC project, which operated from 1987 to 1995. The syngas combustion system is designed to accommodate multi-fuel operation, diluent injection, fuel transfers and co-firing. The principal control and mixing components of the syngas combustion system are located outside the turbine enclosure.

During the start up process at 30% load, the gas turbine is transitioned to high H_2 syngas or syngas and then ramped to base load. The high H_2 syngas or syngas flows through the syngas saturator and heater in the BOP piping; it is then blended with N_2 (as a diluent) at the blending station and supplied to the inlet of the syngas strainer. Exiting the syngas strainer, the high H_2 syngas or syngas is routed through similar components as the natural gas system, including the overspeed trip, throttle and isolation valves, and into the syngas manifold.

The standard SGT6-PAC 5000F has been modified for IGCC and other syngas applications with the addition of a syngas fuel mixing skid, local N_2 storage for purging the fuel system during start up and shut down, control system changes and additional monitoring systems needed due to the H_2 and CO content in the fuel.

In addition to the SGT6-PAC 5000F, Siemens equipment scope of supply also can include selected gasification island components, most of the major compression solutions for today's IGCC plants, including air separation units, main air compressors, O_2, N_2 and CO_2 compression solutions and IGCC plant controls.

The SPPA-T3000 control system normally supplied with a SGT6-PAC 5000F can be expanded to control the entire IGCC plant, including the gasification island(s), gas clean-up systems and the air separation unit(s).

For more information, please contact your local Siemens representative.

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Fossil Power Generation Division
Order No. E50001-F220-A113-X-4A00
Printed in USA
TD 20092101728757G BR 0709.5

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The required technical options should therefore
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GE
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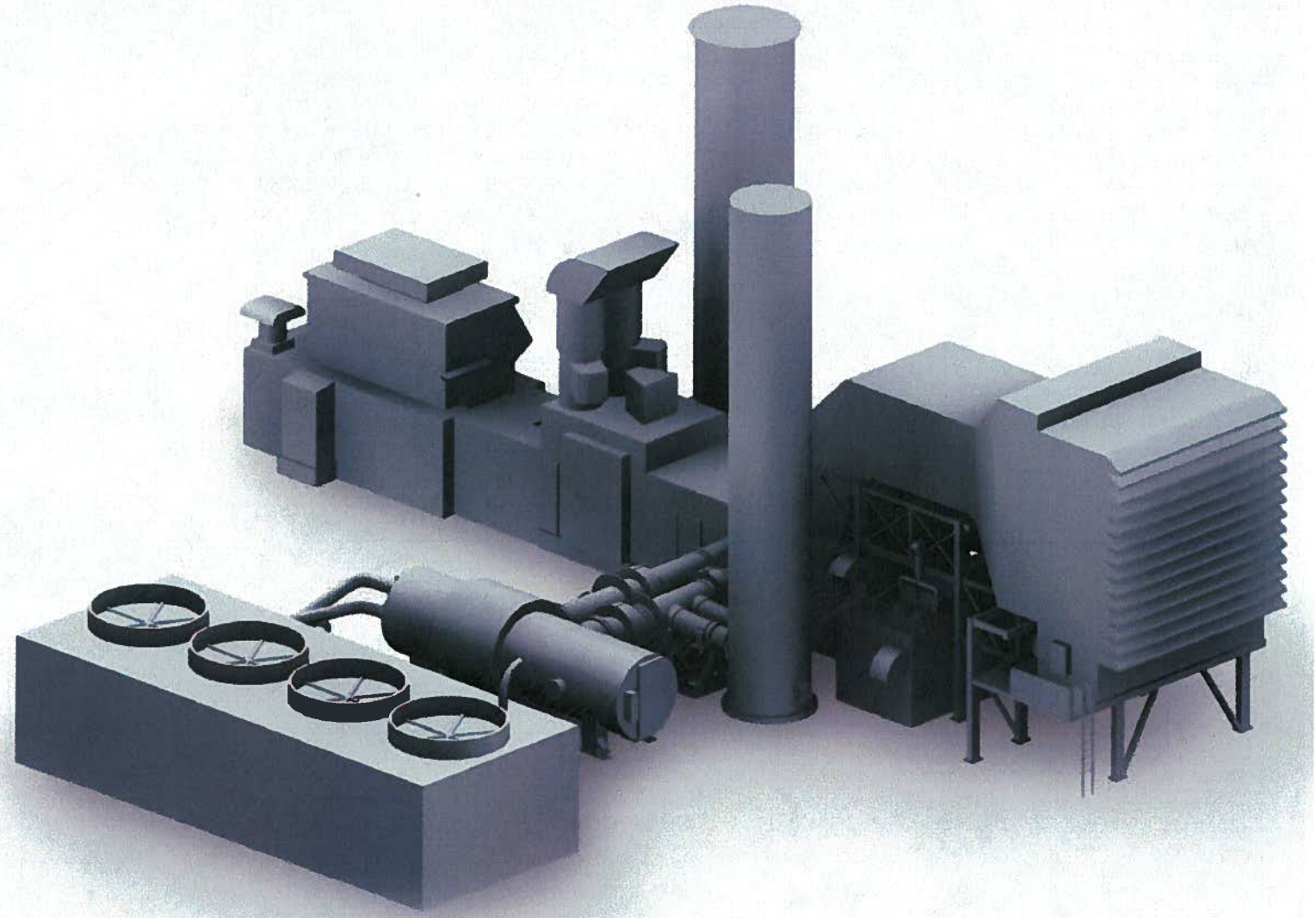
LMS100®
Flexible Power



imagination at work

GE Energy is a leading supplier of aeroderivative gas turbines and packaged generator sets for industrial and marine applications. We provide power-generating equipment to utilities, industries and marine fleets throughout the world and are the world's largest, most experienced gas turbine service provider.

A Single Solution for Your Needs

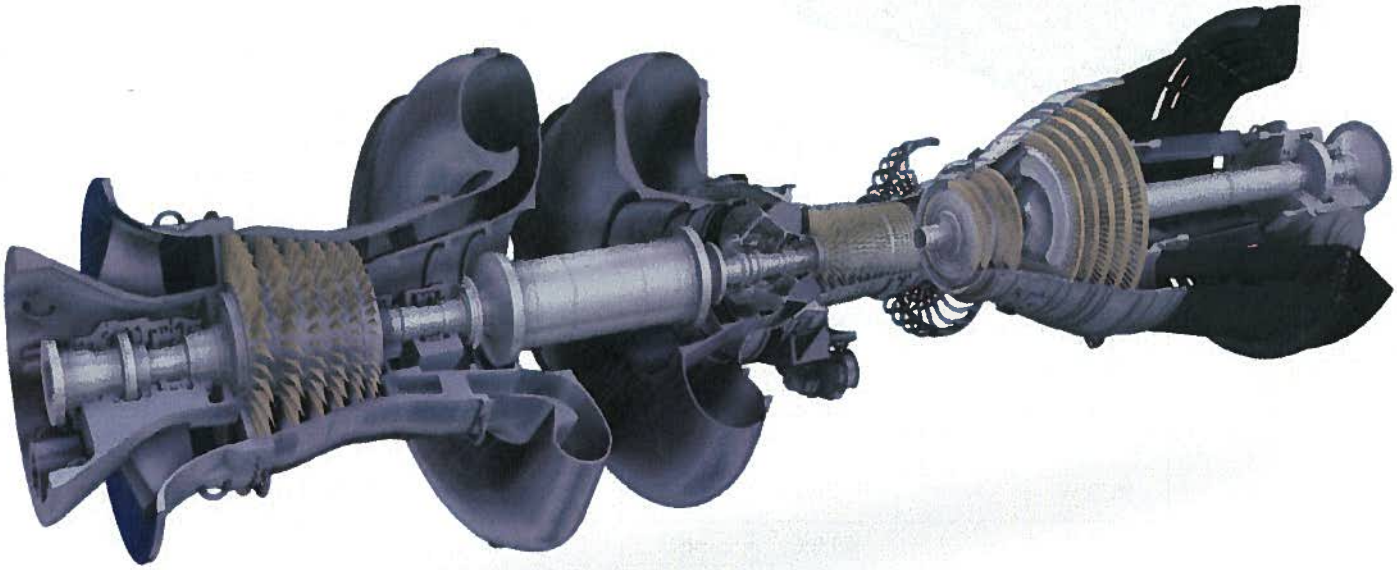
Defining a new era of flexible power generation, GE's revolutionary LMS100 provides a single, economical solution for the dispatch needs of nearly every market condition. With unparalleled efficiency, 10-minute start times, unmatched hot day performance, load following and cycling capabilities, and reliability derived from proven architecture and technology, the LMS100 is the ideal solution for power generation planners and developers.

A combination of frame and aeroderivative gas turbine technologies, this powerful machine represents the most extensive collaboration of design and manufacturing expertise in the history of GE—delivering over 100 MW with thermal efficiency in excess of 44%.

Offering superior value unavailable in other 80–160 MW gas turbines through high part-power efficiency, cycling capability without maintenance impact, dispatch reliability, turndown capability, and low emissions, the LMS100 gives dispatchers confidence they can meet customer and business needs at any time, day or night.

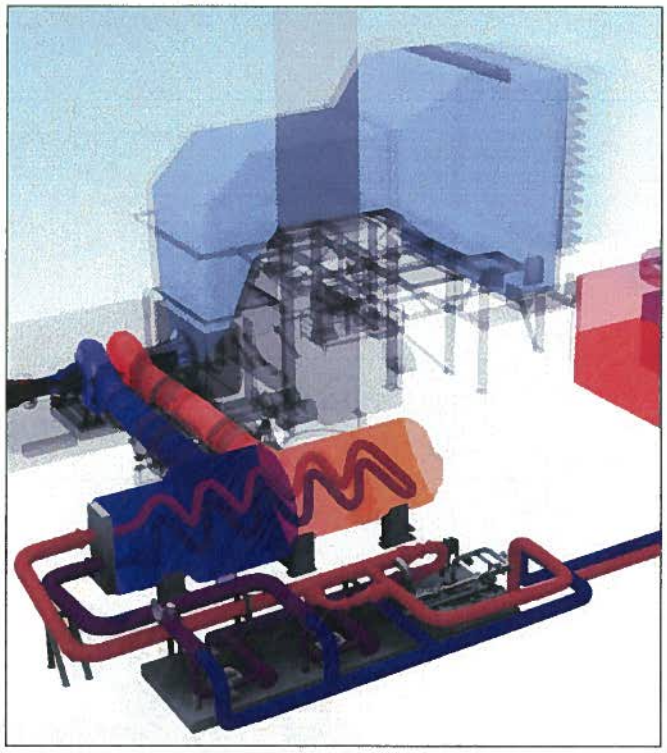
Efficiency
+ Fast starts
+ Hot day performance
+ Load following and cycling capabilities
+ Reliability
+ No maintenance penalties

= LMS100® Flexible Power



Our Foundation for Flexibility

The LMS100 provides unsurpassed simple-cycle efficiency and increased power output thanks to an innovative intercooling system.



The intercooling system takes compressed air from the low-pressure compressor, cools it to optimal temperatures and then redelivers it to the high-pressure compressor. In providing a near constant stream of low temperature air to the high pressure compressor, the work of compression is reduced. The result is a higher pressure ratio (42:1) and increased mass flow (460 lb/sec).

In simple-cycle applications, the LMS100 can achieve thermal efficiency in excess of 44%. That's nearly a 10 point improvement over every turbine in its size range. The impressive level of efficiency—when combined with the ability to cycle without maintenance interval impact—may translate into $4-7 MM in Net Present Value Savings over 15 years.*

LMS100 ISO Performance Data

Model	ISO Base Rating (kW)	Heat Rate (Btu/kWh)	Efficiency%	Mass Flow (lb/sec)	Turbine Speed (RPM)	Exhaust Temp (F)	Comments
LMS100PB	97,718	7,592	45.0%	453	3,600	783	DLE, 25 ppm NO_X
LMS100PB	97,878	7,579	45.0%	453	3,000	784	DLE, 25 ppm NO_X
LMS100PA	103,112	7773	43.9%	469	3,600	770	water injected to 25 ppm NO_X
LMS100PA	103,162	7769	43.9%	469	3,000	767	water injected to 25 ppm NO_X

Conditions: *Performance at the generator terminals: NO_X = 25 ppm or 50 mg/Nm3; 59F or 15C, 60% Relative Humidity; No Losses; Fuel Spec. Gas (LHV= 19,000 BTU/lb)*

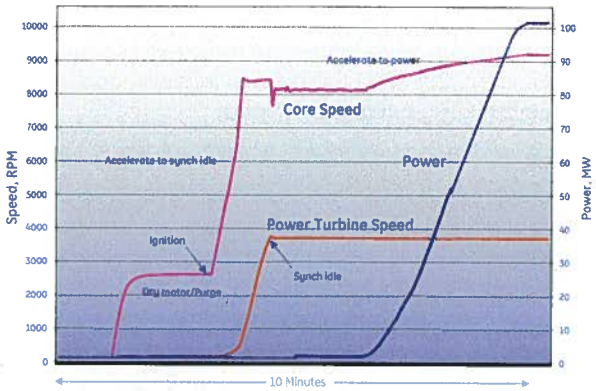
* 5¢/mmBtu gas

Features of Flexibility

As the only company with the necessary technology base and product experience to bring this innovative product to the power generation industry, GE has incorporated extensive customer feedback into the LMS100 development program—ensuring it has the flexibility to meet current and future needs. The resulting breakthrough system delivers 100 MW of power with:

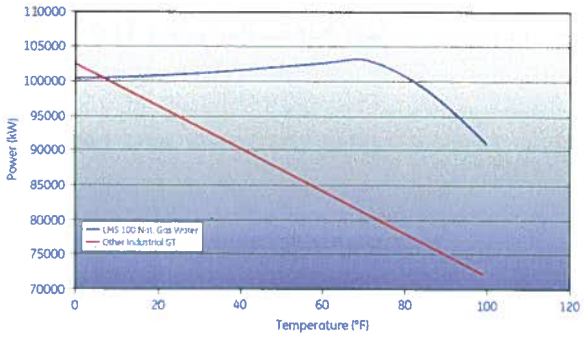
10-minute fast starts with cycling capability

The flexibility of aircraft engine technology—with 10-minute starts from cold iron to full power—and the ability to start and stop in short 15 minute cycles (several times per day, if needed) **without impacting maintenance intervals**.



Incredible hot day performance

The flexibility to sustain power levels on hot days when demand is greatest. The LMS100 will increase in power as the temperature rises—up to 75°F (~24°C)—and then fall off in power at a much slower rate than conventional gas turbines. When the temperature again increases demand on the grid, the LMS100 will be at the top of the list to dispatch

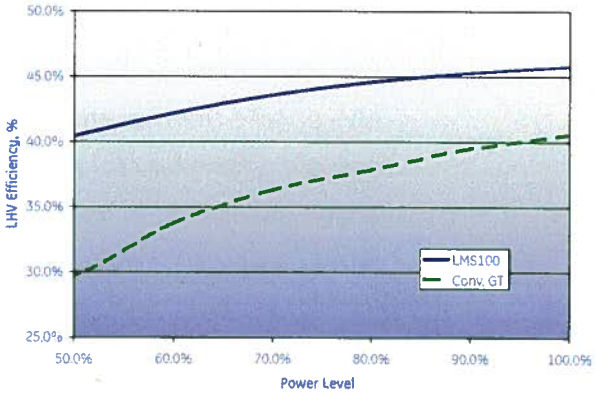


Improved load following and part load efficiency

The flexibility to provide 50 MW of power in less than one minute. When operating at 50% power, the LMS100 can ramp to full power in less than 60 seconds, providing fast response to load demand variations.

The flexibility to provide power at part load as efficiently as most gas turbines at full load—enabling efficient operation anywhere between 50 and 100 MW, as demand requires. At 50% load, the LMS100 can deliver power at 40% simple-cycle efficiency.

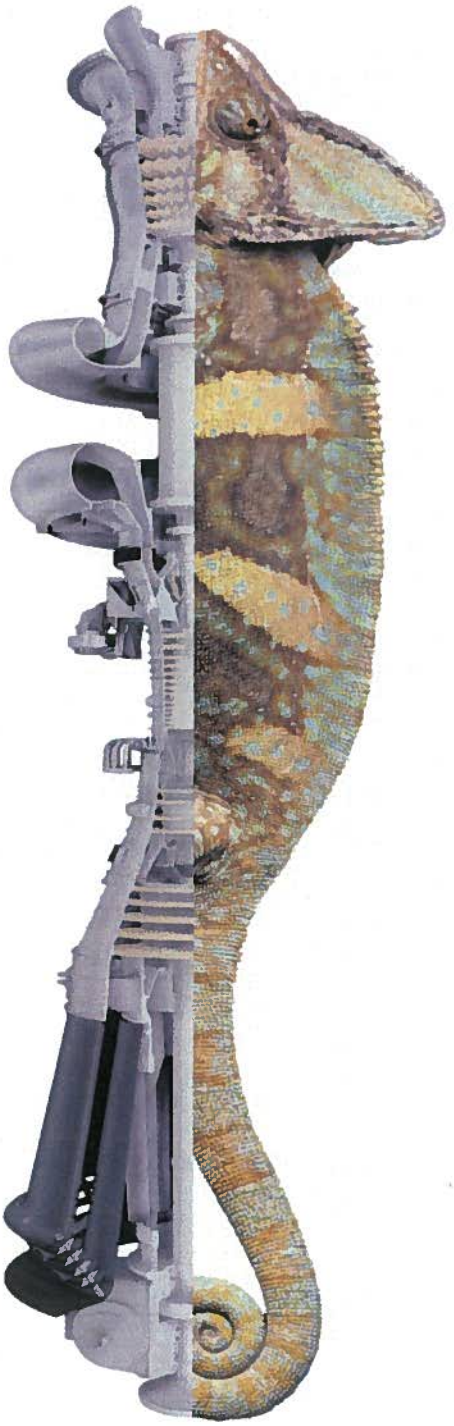
The flexibility to provide grid support without load reduction. Even with up to 5% grid frequency variation, the LMS100 can operate with very little power loss—making it uniquely capable of supporting the grid in times of high demand and load fluctuations.



Efficient Performance

Better efficiency also means less fuel burned per megawatt generated and less CO_2 emissions. The efficiency advantage of the LMS100 offers potential savings in terms of CO_2 taxes through reduced greenhouse gas emissions of as much as $0.6 MM each year when compared to a typical simple-cycle gas turbine plant.

Based on an average peaking season of 2,184 hours, the LMS100 reduces CO_2 emissions by more than 30,000 tons when compared to a typical simple-cycle 100 MW gas turbine plant. This CO_2 reduction is equal to the amount of carbon dioxide absorbed by approximately 7,400 acres of forest.



ecomagination[s]
a GE commitment

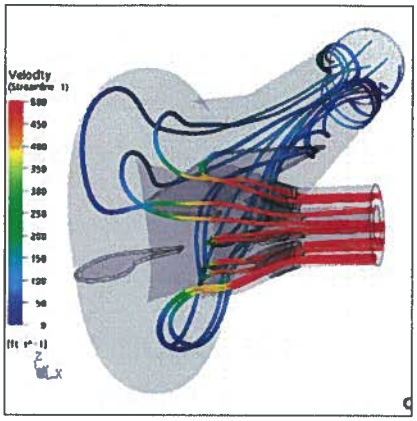
Ecomagination is GE's commitment to aggressively bring to market new technologies that will help customers meet pressing environmental challenges. Ecomagination technologies offer improved efficiency, lower emissions and/or improved operating performance compared to other similar power generation technologies in the same power class. The LMS100, as one of the newest products in the ecomagination portfolio offers our customers 100 MW at 46% thermal efficiency with a wide range of operating flexibility for peaking, mid-range and base-load operation with lower start up emissions and 10-minute starts.

Proven, Reliable Technology

Sound heritage

The LMS100 core engine is derived from the CF6 family of aircraft engines, the same baseline architecture as the LM6000®. The current LM6000 fleet includes 588 operating engines with over 10.5 million accumulated fired hours of operation. Reliability for the LM6000 fleet is currently 99.14% and availability is currently 97.76%. The low-pressure compressor (LPC) is derived from GE's MS6001FA gas turbine which has 65 units in operation with more than 1,000,000 hours of operation.

*Based on ORAP® reliability data, using current sample, which includes 151 operating units.ORAP®. All rights reserved: SPS®



Customer-designed controls

The LMS100 control system employs the Mark VIe and fiber optics for signal transmission between the package and control system. This system reduces the number of signal interconnects by 90% and the number of mechanical interconnects by 25%—which yields a simpler and more reliable design with a faster, more efficient installation and startup.

Designed for reliability

In addition, the integrated control system includes redundant sensors with smart selection logic to reduce single sensor failure trips. The fiberoptic distributed I/O (input/output) system is located outside the module to prevent electromagnetic or radio frequency interference and minimize false trips. Reliability of the LMS100 is further enhanced by redundant fans, fuel pumps, resistance temperature detectors (RTDs) and remote monitoring and diagnostics.

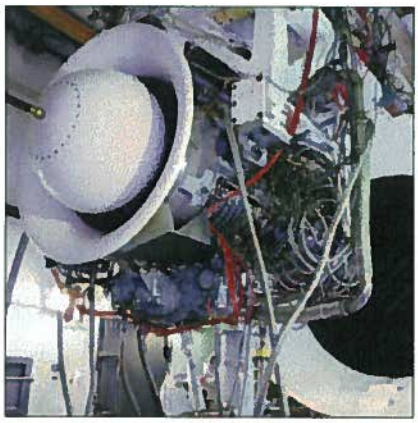
Comprehensive full scale validation tests

Consistent with GE's practice for design validation, extensive design assurance and validation tests were established and executed for both the engine and balance of plant equipment.

The core engine, a gas generator consisting of the LMS100 high-pressure compressor, single annular combustor and high-pressure turbine, completed testing in December 2004 at the high altitude test cell in GE's aircraft engine facility in Ohio. More than 1500 pieces of instrumentation were used to measure key design parameters. The testing confirmed aeromechanics, mechanical design and variable geometry optimization for performance, paving the way for full scale power plant validation testing.

Extensive, full scale testing of an LMS100 simple-cycle power plant was conducted at GE's packaging facility in Houston, Texas. More than 2,500 pieces of instrumentation were used to validate performance, emissions, intercooler operation and sub-system capability at the most extreme operating conditions expected in commercial service.

The LMS100 full load power plant test, completed in November 2005, confirmed performance, operability, emissions, mechanical and electrical operations all successfully met or exceeded the requirements. Testing demonstrated 10-minute starts, fast load following, transient capability and efficiency—all hallmark characteristics of the LMS100.



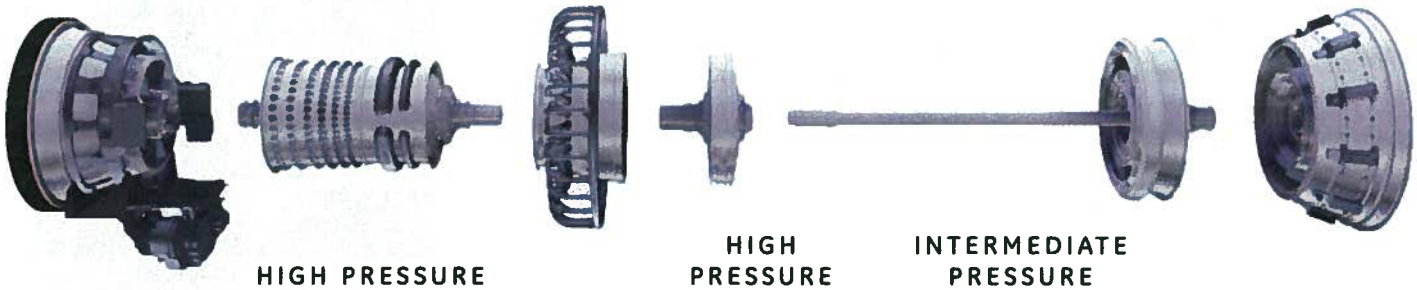
Designed for Availability and Main

Maintainability features

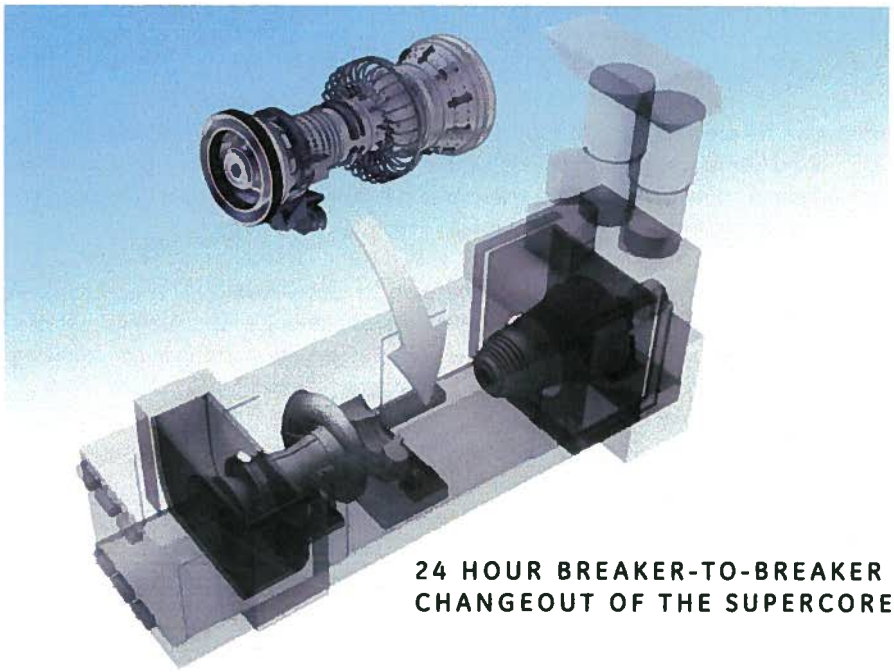
- Modular construction permits replacement of the aero components without total disassembly
- Multiple borescope ports allow on-condition monitoring without turbine disassembly
- Condition-based maintenance and remote diagnostics
- Split casing construction of the booster (LPC) and aeroderivative compressor allows detailed on-site inspection and blade replacement
- Package accessory systems are externally mounted for ease of on-site replacement
- Package mounted maintenance cranes in auxiliary module

Modular "supercore" enhances power plant availability

GE has established a target availability of 97.5% and 98.5% target reliability for a mature LMS100 power plant. The "supercore" consists of the HPC, Combustor, HPT and IPT rotable modules, which can be exchanged in less than **four** days during on-site maintenance to optimize plant availability.



FRONT FRAME | HIGH PRESSURE COMPRESSOR (HPC) | COMBUSTOR | HIGH PRESSURE TURBINE (HPT) | INTERMEDIATE PRESSURE TURBINE (IPT) | TURBINE MID FRAME



24 HOUR BREAKER-TO-BREAKER CHANGEOUT OF THE SUPERCORE

tainability

LMS100 service intervals

Interval	Scheduled Maintenance Action	Outage Duration
4,000 hours (every 4K h)	Borescope inspection (includes cool-down time)	12 hours
25,000 hours	Hot section interval* 1) On-site hot section replacement (combustor, HPT, IPT)	4 days[a]
50,000 hours	Depot maintenance[b] 1) Major hot section overhaul (combustor, HPT, IPT) 2) Inspect booster, intercooler, scroll frames, HPC, aft shaft and bearings[c] 3) Power turbine overhaul	4 days[a]
75,000 hours	Hot section interval[b] 1) On-site hot section replacement (combustor, HPT, IPT)	4 days[a]
100,000 hours	Depot maintenance[b] 1) Major hot section overhaul (combustor, HPT, IPT) 2) Inspect booster, intercooler, scroll frames, HPC, aft shaft and bearings[c] 3) Power turbine overhaul	4 days[a]

(a) Rotable module installed during maintenance period.
(b) Lease/spare "supercore" and Power Turbine modules are installed during maintenance period. For depot maintenance, outage duration is 60 days if no spare/lease module(s) are used.
(c) Roller and ball bearings are replaced at 50,000 hours; hydrodynamic bearings are inspected.

Maintenance services

All warranty and follow-on services for the LMS100 will be provided by GE Energy either on site or at one of several service center locations around the world. These services can include Contractual Service Agreements (CSAs), lease engines, spare parts, rotable modules, training resources and user conferences.

GE Energy's Contractual Services Agreements provide the field service, labor, parts and repairs necessary for equipment maintenance while protecting your investment and minimizing your costs. CSA programs can be structured to include unplanned maintenance events with guarantee incentives on reliability and availability.

GE's lease engine program provides a spare "supercore" that can be installed in 24 hours when service center maintenance is required. The power turbine module can also be replaced within an additional 24 hours.

Flexible Growth Platform

The LMS100 is a flexible growth platform designed to meet your changing energy needs. While actual plant layout depends on specific customer needs and site requirements, there are four basic LMS100 configurations available when combined with intercooler selection and combustion technology.

- *LMS100 Single Annular Combustor with Water* – Water or steam can be injected into the combustor to provide emission reduction and achieve 25 ppm NO_X levels while operating on natural gas fuels between 50% and 100% power.

- *LMS100 DLE* – An advanced dry low emission (DLE) combustor will be available for sites that have a restriction on water usage. Using the DLE combustor, customers will be able to achieve 25 ppm for both NO_X and CO emissions while operating on natural gas fuels.

LMS100 System Configurations

Product Offerings	Fuel	Combustor	Diluent	Power Augmentation	NOx Level
LMS100 SAC, 50/60 Hz	Gas, Liquid or Dual Fuel	Single Annular (SAC)	Water	None	25 ppm
LMS100 DLE, 50/60 Hz	Gas	DLE2	None	None	25 ppm

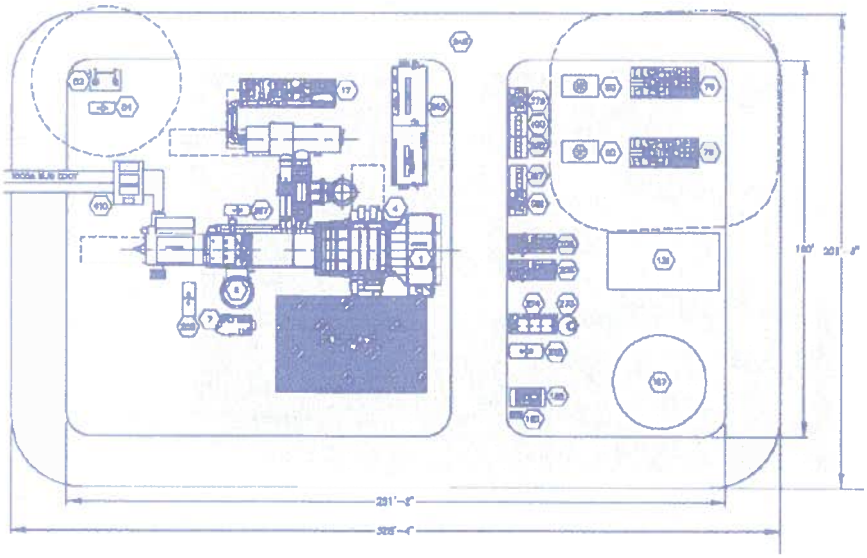
Four basic LMS100 configurations are available as this product is introduced. When combined with intercooler selection and duty applications the LMS100 offers 20 different configuration choices

- *Intercooler Options* – Water is the primary cooling agent in the shell and tube heat exchanger available with the LMS100. In areas with an abundant water supply, a standard evaporative cooling tower can be integrated. An optional closed-loop wet intercooler can be provided with a secondary dry, fin-fan cooler if water usage is restricted.

Applications

- *Feed Water Applications*—Increased efficiency, improved flexibility and better economics are among the potential benefits of integrating the LMS100 gas turbine for feed water heating in a coal fired steam plant. The improved efficiency and increased output are achieved through minor modifications of the steam cycle to reduce or eliminate steam extractions in lieu of the gas turbine exhaust and intercooler to heat the feed water.

- *Wind Farm Integration* – The operating characteristics of the LMS100 make it an ideal solution for firming variable wind power. Alternative power sources require high maneuverability, high efficiency (even at partial load), fast starting, low initial capital costs (consistent with moderate to low capacity factors) and good environmental characteristics. The LMS100 simple-cycle gas turbine has all of these characteristics, making a high performance hybrid wind-GT system now economically possible.



GE Energy
1333 West Loop South
Houston, Texas 77027
713.803.0900
www.ge-energy.com/lms100

For more information on the LMS100 gas turbine system, contact your GE Energy representative or email us at energy.aeromarketing@ge.com.

imagination at work

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GEA-14355 A (09/06)

CIRCUIT BREAKERS - SF6 (FOR GHG EMISSION CALCULATIONS)

SF6 Circuit Breakers for 230 kV substation (based on data from current units which will be replaced during this expansion project)

Make:	Mitsubishi		(per PSE; exact units unknown at this time)
Number of Units:	10		(8 for new units, and 2 to replace existing ones (Mitsubishi 3000's), per PSE)
SF6 per Model Unit:	117	lb/unit	Mitsubishi 200-SFMT-40E
	201	lb/unit	Mitsubishi 200-SFMT-63F
Total SF6:	1170	lb	Minimum
	2010	lb	Maximum
Leakage Rate:	0.5	%	Annual leakage (per PSE; conservative estimate)
SF6 Leakage:	5.85	lb/yr	Minimum
	10.05	lb/yr	Maximum
SF6 GWP:	23,900		
CO2e:	139,815	lb/yr	Minimum
	69.91	tpy	
	240,195	lb/yr	Maximum
	120.10	tpy	

Notes:

GWP (Global Warming Potential) from 40CFR98, Subpart A, Table A-1.

From: Dana, Fusato [mailto:Fusato.Dana@mpshq.com]
Sent: Monday, April 04, 2011 4:11 PM
To: Reinhart, Brian C.
Cc: Adams, Nathan; Leslie, Patrick; Gettinger, James E.; Henderson, Joey; William_Steiner@URSCorp.com; 165510 PSE; Drake, Rand; Kuroda, Yasuyuki; Ikeda, Takeshi
Subject: RE: 14.4100 110404 PSE - SCR Correspondence Email in Support of Response #2 to Department of Ecology's Incompleteness Determination MPSA - BCR

Brian,

MPSA can supply emissions control equipment that will meet the stack emissions limits listed below.

Thank you,
Fusato

****

Fusato Dana
Manager, Commercial
Mitsubishi Power Systems Americas, Inc.
100 Bayview Circle, Suite 6000
Newport Beach, CA 92660
Tel: (949) 856-8416 / Fax: (949) 856-4481
Cel: (949) 275-8368
****

From: Reinhart, Brian C. [mailto:ReinhartBC@bv.com]
Sent: Monday, April 04, 2011 11:52 AM
To: Dana, Fusato
Cc: Adams, Nathan; Leslie, Patrick; Gettinger, James E.; Henderson, Joey; William_Steiner@URSCorp.com; 165510 PSE
Subject: 14.4100 110404 PSE - SCR Correspondence Email in Support of Response #2 to Department of Ecology's Incompleteness Determination MPSA - BCR

Fusato,

The Washington Department of Ecology has requested Puget Sound Energy provide adequate information to establish a basis for stack exhaust parameters as presented in Puget Sound Energy's PSD Permit Application. Black & Veatch initially developed the exhaust emissions estimates and stack parameters in support of the application for the General Electric 7FA.04, 7FA.05, and LMS100PA gas turbines and the Siemens SGT6-5000F4 gas turbine. Black & Veatch developed these estimates based on past experience, research into similar projects, and informal discussions with equipment suppliers such as yourself. Please confirm that, for an expected commercial operations date in 2014, your company would be willing to supply a system with the criteria listed in the table below for the gas turbine models referenced above.

Puget Sound Energy: Fredonia Peaking Expansion Proposed Permit Limits

Steady-State Operating Conditions

	7FA.04		7FA.05		SGT6-5000F4		LMS100	
	NG	ULSD	NG	ULSD	NG	ULSD	NG	ULSD
Controlled Stack Temperature, °F, **Note 1**	800	800	800	800	800	800	800	800
Max CTG NO_x Emissions, ppmvd @ 15% O_2	9	42	9	42	28	42	25	42
Stack NO_x Emissions, ppmvd @ 15% O_2	2.5	5.0	2.5	5.0	2.5	5.0	2.5	5.0
Max CTG CO Emissions, ppmvd @ 15% O_2	7.5	14.4	8.0	16.1	10.0	30.0	102.8	77.0
Stack CO Emissions, ppmvd @ 15% O_2	4.0	**Note 2**	4.0	**Note 2**	4.0	**Note 2**	95% reduction	**Note 2**
Max CTG VOC Emissions, ppmvd @ 15% O_2	1.3	2.8	1.4	3.1	1.0	3.0	2.6	8.0
Stack VOC Emissions, ppmvd @ 15% O_2	1.3	2.8	1.4	3.1	1.0	3.0	2.6	5.6
Allowable NH_3 Slip, ppmvd @ 15% O_2	10	10	10	10	10	10	10	10

Notes:
(1) Stack temperature controlled using a tempering air blower, not needed for all LMS100 conditions
(2) CO reduction percentage when operating on ULSD equal to CO reduction percentage for NG.
CTG - combustion turbine/generator, NG - Natural Gas, ULSD - Ultra Low Sulfur Diesel, NO_x - Nitrogen Oxides,
CO - Carbon Monoxide, VOC - Volatile Organic Compounds, NH_3 - Ammonia, °F - Degrees Fahrenheit,
ppmvd @ 15% O_2 - parts-per-million volumetric dry basis and corrected to 15 volumetric percent oxygen content

Please call or email with questions.

Regards,

Brian Reinhart, P.E.* | Mechanical Engineer, B&V Energy
Black & Veatch | 11401, Overland Park, KS 66211
+1 913-458-7679 **p** | +1 913-458-2934 **f** | +1 913-475-8331 m | reinhartbc@BV.com
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Mark Daniel <mdaniel@braden.com>

05/03/2011 08:22 AM

To "Reinhart, Brian C." <ReinhartBC@bv.com>

cc "Adams, Nathan" <nathan.adams@pse.com>, "Leslie, Patrick" <Patrick.Leslie@pse.com>, "Gettinger, James E." <GettingerJE@bv.com>, "William_Steiner@URSCorp.com" <William_Steiner@URSCorp.com>, 165510 PSE <165510PSE@bv.com>, "Henderson, Joey" <Joey.Henderson@pse.com>, "Bruning, Armin Paul" <paul.bruning@pse.com>

Subject RE: 14.4100 110404 PSE - SCR Correspondence Email in Support of Response #2 to Department of Ecology's Incompleteness Determination Braden - BCR

Brian,

I'm sorry this slipped through the cracks.

Braden Manufacturing is willing to supply an exhaust system to meet the criteria listed in the table below for any of the gas turbines listed.

Please let us know what else we can do.

Regards,

Mark Daniel, P.E.
SCR Sales Manager
BRADEN MANUFACTURING, LLC
(918) 274-2215 phone
(918) 261-1135 cell
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From: Reinhart, Brian C. [mailto:ReinhartBC@bv.com]
Sent: Monday, April 04, 2011 1:56 PM

To: Mark Daniel
Cc: Adams, Nathan; Leslie, Patrick; Gettinger, James E.; William_Steiner@URSCorp.com; 165510 PSE; Henderson, Joey; Bruning, Armin Paul
Subject: FW: 14.4100 110404 PSE - SCR Correspondence Email in Support of Response #2 to Department of Ecology's Incompleteness Determination Braden - BCR

Mark,

The Washington Department of Ecology has requested Puget Sound Energy provide adequate information to establish a basis for stack exhaust parameters as presented in Puget Sound Energy's PSD Permit Application. Black & Veatch initially developed the exhaust emissions estimates and stack parameters in support of the application for the General Electric 7FA.04, 7FA.05, and LMS100PA gas turbines and the Siemens SGT6-5000F4 gas turbine. Black & Veatch developed these estimates based on past experience, research into similar projects, and informal discussions with equipment suppliers such as yourself. Please confirm that, for an expected commercial operations date in 2014, your company would be willing to supply a system with the criteria listed in the table below for the gas turbine models referenced above.

Puget Sound Energy: Fredonia Peaking Expansion Proposed Permit Limits

Steady-State Operating Conditions

	7FA.04		7FA.05		SGT6-5000F4		LMS100	
	NG	ULSD	NG	ULSD	NG	ULSD	NG	ULSD
Controlled Stack Temperature, °F, **Note 1**	800	800	800	800	800	800	800	800
Max CTG NO_x Emissions, ppmvd @ 15% O_2	9	42	9	42	28	42	25	42
Stack NO_x Emissions, ppmvd @ 15% O_2	2.5	5.0	2.5	5.0	2.5	5.0	2.5	5.0
Max CTG CO Emissions, ppmvd @ 15% O_2	7.5	14.4	8.0	16.1	10.0	30.0	102.8	77.0
Stack CO Emissions, ppmvd @ 15% O_2	4.0	**Note 2**	4.0	**Note 2**	4.0	**Note 2**	95% reduction	**Note 2**
Max CTG VOC Emissions, ppmvd @ 15% O_2	1.3	2.8	1.4	3.1	1.0	3.0	2.6	8.0
Stack VOC Emissions, ppmvd @ 15% O_2	1.3	2.8	1.4	3.1	1.0	3.0	2.6	5.6
Allowable NH_3 Slip, ppmvd @ 15% O_2	10	10	10	10	10	10	10	10

Notes:
(1) Stack temperature controlled using a tempering air blower, not needed for all LMS100 conditions
(2) CO reduction percentage when operating on ULSD equal to CO reduction percentage for NG.
CTG - combustion turbine/generator, NG - Natural Gas, ULSD - Ultra Low Sulfur Diesel, NO_x - Nitrogen Oxides,
CO - Carbon Monoxide, VOC - Volatile Organic Compounds, NH_3 - Ammonia, °F - Degrees Fahrenheit,
ppmvd @ 15% O_2 - parts-per-million volumetric dry basis and corrected to 15 volumetric percent oxygen content

Please call or email with questions.

Regards,

Brian Reinhart, P.E.* | Mechanical Engineer, B&V Energy
Black & Veatch | 11401, Overland Park, KS 66211
+1 913-458-7679 **p** | +1 913-458-2934 **f** | +1 913-475-8331 m | reinhartbc@BV.com
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Puget Sound Energy

Fredonia Simple Cycle

Emissions Estimating Process Description

Black & Veatch Corporation

July 16, 2010

B&V Project No. 165510.0031

BLACK & VEATCH
Building a world of difference.

1 Objective

This document describes the process of estimating combustion turbine emissions including post combustion controls. The description is written specific to a simple cycle with Carbon Monoxide (CO) and Selective Catalytic Reduction (SCR) emission control systems. The description includes unit pollutants typically included in a simple cycle combustion turbine air permit within the United States.

2 Background

Beginning in September 2009 Black & Veatch has supported Puget Sound Energy (PSE) in their technology selection process and later in their pursuit of an Air Permit for the Fredonia simple cycle project. PSE has requested a description of the emission estimating/calculation process in anticipation of inquiries from the air permitting entities of the state of Washington and the Environmental Protection Agency (EPA).

3 High Level Overview

The following is a high level description of the sequence of steps followed during the emissions estimating process.

1) Determine which combustion turbine manufacturers and models fitting the project goals and site size restrictions.
2) Determine fuel type, fuel composition, load targets/minimum load targets, and site ambient conditions for average, cold and hot day cases.
3) Determine which pollutants will be limited in the air permit based on the site location.
4) Procure thermal performance and emissions performance from the combustion turbine manufacturers for each candidate combustion turbine model for the fuel, load and ambient conditions.
5) Determine Best Available Control Technology (BACT) limits by auditing various sources including EPA websites – In the case of this effort with PSE these values were established by URS.
6) Determine catalyst effectiveness to achieve BACT limits.
7) Evaluate the feasibility of required catalyst effectiveness by coordination with catalyst vendors to determine if controlled values are "guaranteeable".
8) Calculate controlled emissions values based on achievable catalyst effectiveness.

4 Specific Pollutant Process Description

To bring the exhaust temperatures down to a level suitable for the SCR's, tempering air has been added to the exhaust stream before the catalyst banks. This tempering air contribution is accounted for in the calculations, but is not a contributor to emissions.

4.1 Oxides of Nitrogen - NOx

The guaranteeable NOx emissions performance values from the Original Equipment Manufacturer (OEM) are typically provided on a parts per million volumetric dry (ppmvd) basis at 15% O2 and a mass flow rate basis of pounds/hour (lb/hr).

Determine catalyst effectiveness to achieve BACT limits provided by the permitting consultant. Evaluate the feasibility of the SCR catalyst effectiveness by coordination with catalyst vendors to determine if controlled values are "guaranteeable".

Determine the stack NOx after the SCR on a ppmvd@15% O2 concentration at the subject catalyst effectiveness.

Determine the stack NOx after the SCR on a parts per million volumetric wet (ppmvw) basis. This is calculated from the mol/h of NOx on a wet basis after control by the SCR.

Determine the stack NOx after the SCR on a lb/h basis as NO2. This is calculated from the mass flow of NOx as NO2 from the combustion turbine less the removal rate of the SCR.

Determine the stack NOx after the SCR on a lb/MBtu basis as NO2. This is calculated from the ratio of pounds of NOx as NO2 after the SCR to the fuel heat input supplied to the combustion turbine.

4.2 Carbon Monoxide - CO

The guaranteeable CO emissions performance values from the OEM are typically provided on a parts ppmvd basis (at 15% O2 or other O2 concentration) and a mass flow rate basis of lb/hr.

Determine catalyst effectiveness to achieve BACT limits provided by the permitting consultant. Evaluate the feasibility of the catalyst effectiveness by coordination with catalyst vendors to determine if controlled values are "guaranteeable".

Determine the stack CO after the CO catalyst on a ppmvd@15% O2 concentration at the subject CO catalyst effectiveness.

Determine the stack CO after the CO catalyst on a parts per million volumetric wet (ppmvw) basis. This is calculated from the mol/h of CO on a wet basis after control by the CO catalyst.

Determine the stack CO after the CO catalyst on a lb/h basis. This is calculated from the mass flow of CO from the combustion turbine less the removal rate of the CO catalyst.

Determine the stack CO after the CO catalyst on a lb/MBtu basis. This is calculated from the ratio of pounds of CO after the CO catalyst to the fuel heat input supplied to the combustion turbine.

4.3 Volatile Organic Compounds - VOC

The estimated VOC emissions performance values from the OEM are typically provided on a ppmvd basis (at 15% O2 or other O2 concentration) or parts per million volumetric wet (ppmvw) basis and a mass flow rate basis of lb/hr.
VOC are not a target design parameter of the SCR/CO catalyst system design, but the CO catalyst has a reducing effect on VOC's. For machines with very low VOC's (1-3 ppmvd) it is conservatively estimated that no reduction occurs in the CO catalyst. For machines with higher VOC's approaching double digits it is estimated that a 30% reduction occurs in the CO catalyst. This is based on CO catalyst vendor information.
Determine the stack VOC's after the CO catalyst on a ppmvd@15% O2 concentration at the subject CO catalyst effectiveness.
Determine the stack VOC's after the CO catalyst on a parts per million volumetric wet (ppmvw) basis. This is calculated from the mol/h of VOC's on a wet basis after reduction in the CO catalyst.
Determine the stack VOC's after the CO catalyst on a lb/h basis. This is calculated from the mass flow of VOC's from the combustion turbine less the removal rate of the CO catalyst.
Determine the stack VOC's after the CO catalyst on a lb/MBtu basis. This is calculated from the ratio of pounds of VOC's to the fuel heat input supplied to the combustion turbine.
Since VOC's are a combination of a variety of compounds of unknown molecular weight the industry standard of applying a molecular weight of methane - CH4 is used.

4.4 Particulate Matter 10 Microns – PM10

4.4.1 PM10 Filterable (Front Half)

The estimated filterable PM10 emissions performance values from the OEM are provided solely on a mass flow rate basis of lb/h.
There is currently no technology option that reduces PM10 emissions. Consequently, all the PM10 exhausted from the combustion turbine is passed out the stack. Additionally, there are contributions to the PM10 emissions that occur in the process due to sulfur content in the fuel. It is conservatively assumed that the SO2 to SO3 conversion rate in the CO catalyst is 60% in simple cycle operation.
Determine the stack PM10 including the contribution of SO2 to SO3 conversion in the CO catalyst and SCR and the contribution of ammonium sulfates in the SCR on a lb/h basis. This is calculated from the mass flow of PM10 from the combustion turbine plus the mass contribution of the oxidized sulfur from SO2 to SO3 conversion plus the mass contribution of NH4SO4 formed.
Determine the stack PM10 including the SO2 to SO3 conversion in the CO catalyst and the NH4SO4 formed on lb/MBtu basis. This is calculated from the ratio of pounds of PM10 to the fuel heat input supplied to the combustion turbine.

4.4.2 PM10 Condensable (Back Half)

Combustion turbine OEM's may provide front half or front and back half PM10 emissions. In the event that only front half PM10 values are provided, the industry standard assumption that the back half mass flow rate is equal to the front half mass flow rate from the combustion turbine is applied. Likewise, in the event only total front and back half PM10 emissions are provided, the industry standard assumption that the total PM10 emissions from the combustion turbine is made up of one half back half mass flow rate and one half front half mass flow rate is applied. Note that this 1 to 1 ratio of front half and back half PM10 only applies to the PM10 from the combustion turbine and does not apply to the PM10 contribution from SO2 to SO3 conversion and ammonium sulfates occurring in the emissions reduction equipment, which are included only in front half values after the combustion turbine.

Front and back half catch emissions are presented which are made up of the sum of the front half catch (combustion turbine and post combustion contribution) and back half catch (combustion turbine).

TURBINE STARTUP AND SHUTDOWN EMISSION DATA								
	7FA.05		7FA.04		SGT6-5000F4		LMS100	
	Natural Gas	Distillate Oil	Natural Gas	Distillate Oil	Natural Gas	Distillate Oil	Natural Gas	Distillate Oil
START								
Time (min)	30	30	30	30	35	38	30	30
Fuel Consumption (lb)	25531	34168	25943	33845	29931	31233	16001	18425
Emissions (lb)								
NOx (as NO2)	31.5	145.7	43.1	168.1	92.4	146.2	34.50	59.90
CO	209.6	332	106.4	140.1	1347.0	1462.0	49.00	39.60
VOC	5.9	8.6	6.5	5	154.2	162.2	0.97	3.69
PM10	9.2	17	5.8	17.4	4.8	15.6	3.30	14.28
CO2	69,717	109,132	70,823	108,102	81,663	99,757	43,546	58,849
SO2	10.40	1.10	10.10	1.10	11.0	1.0	6.46	0.55
SHUTDOWN								
Time (min)	19	17	14	14	17	19	8	8
Fuel Consumption (lb)	11257	13825	10504	13810	15120	19261	1684	1739
Emissions (lb)								
NOx (as NO2)	16	79	31	107	45.0	90.0	3.40	5.70
CO	189	196.0	90	95	443.0	709.0	1.80	1.70
VOC	4.3	6	4.8	2	50.0	76.0	0.03	0.06
PM10	5.8	9.6	4.4	8.4	2.4	10.0	1.00	4.70
CO2	30,885	44,157	28,819	44,110	41,460	61,518	4,621	5,555
SO2	4.60	0.40	4.20	0.40	5.4	0.7	0.68	0.05

Notes:
7FA.05 - Natural Gas data from B&V 11/5/10; distillate data from B&V 2/15/11
7FA.04 Natural Gas and distillate data from B&V 11/5/10.
SGT6 Natural Gas and distillate data from B&V 11/5/10.
LMS100 Natural Gas and distillate data for Shutdowns from B&V 11/10/10; Natural Gas and distillate data for Startups from B&V 3/14/11.

LOAD CHECKS - MODELED W/ NO START/SHUTDOWNS (Normal Receptors)

REVISION - 4/21/11 NEW LOCATION AND RAISED STACK HEIGHT; 2/4/11 EMISSION DATA

GE 7FA5 - 7F

							Emis (lb/hr) [Based on 1 unit/1 src]					Max Impact (ug/m3) (All Years)					
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	CO	PM	SO2	Notes:	UNIT*1000	NOx	CO	PM	SO2	MODEL
1-hr	NG-100	7F5-G100	145	800	132	23	20.70	19.80	47.70	8.22	NG; 3.48 gr/dscf; 7 deg F; 100% load.	42.36	0.88	0.84	2.02	0.35	--
1-hr	NG-75	7F5-G75	145	800	107	23	16.30	15.80	41.60	6.55	NG; 3.48 gr/dscf; 7 deg F; 75% load.	51.94	0.85	0.82	2.16	0.34	--
1-hr	NG-50	7F5-G50	145	800	93	23	12.70	12.40	36.50	5.13	NG; 3.48 gr/dscf; 7 deg F; 50% load.	61.53	0.78	0.76	2.25	0.32	--
1-hr	D-100	7F5-D100	145	800	124	23	44.10	42.30	38.50	1.26	Distillate; 7 deg F; 100% load.	45.65	2.01	1.93	1.76	0.06	--
1-hr	D-75	7F5-D75	145	800	105	23	35.20	34.20	37.70	1.00	Distillate; 7 deg F; 75% load.	52.56	1.85	1.80	1.98	0.05	--
1-hr	D-50	7F5-D50	145	799	87	23	26.70	27.20	36.80	0.79	Distillate; 7 deg F; 50% load.	69.54	1.86	1.89	2.56	0.05	24-hr PM

GE 7FA5 - 51F

							Emis (lb/hr) [Based on 1 unit/1 src]					Max Impact (ug/m3) (All Years)					
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	CO	PM	SO2	Notes:	UNIT*1000	NOx	CO	PM	SO2	MODEL
1-hr	NG-100	7F5-G100	145	800	131	23	19.40	18.60	45.80	7.72	NG; 3.48 gr/dscf; 51 deg F; 100% load.	42.53	0.83	0.79	1.95	0.33	--
1-hr	NG-75	7F5-G75	145	800	109	23	15.50	15.00	40.50	6.24	NG; 3.48 gr/dscf; 51 deg F; 75% load.	51.33	0.80	0.77	2.08	0.32	--
1-hr	NG-50	7F5-G50	145	799	96	23	12.30	12.00	35.90	4.97	NG; 3.48 gr/dscf; 51 deg F; 50% load.	57.82	0.71	0.69	2.08	0.29	--
1-hr	D-100	7F5-D100	145	800	131	23	44.10	42.30	38.50	1.26	Distillate; 51 deg F; 100% load.	42.53	1.88	1.80	1.64	0.05	--
1-hr	D-75	7F5-D75	145	800	110	23	35.00	34.00	37.70	0.99	Distillate; 51 deg F; 75% load.	51.03	1.79	1.73	1.92	0.05	--
1-hr	D-50	7F5-D50	145	799	92	23	26.90	26.30	36.80	0.79	Distillate; 51 deg F; 50% load.	62.85	1.69	1.65	2.31	0.05	--

GE 7FA5 - 88F

							Emis (lb/hr) [Based on 1 unit/1 src]					Max Impact (ug/m3) (All Years)					
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	CO	PM	SO2	Notes:	UNIT*1000	NOx	CO	PM	SO2	MODEL
1-hr	NG-100	7F5-G100	145	800	129	23	17.90	17.20	43.80	7.14	NG; 3.48 gr/dscf; 88 deg F; 100% load.	43.41	0.78	0.75	1.90	0.31	--
1-hr	NG-75	7F5-G75	145	799	110	23	14.60	14.20	39.20	5.88	NG; 3.48 gr/dscf; 88 deg F; 75% load.	51.05	0.75	0.72	2.00	0.30	--
1-hr	NG-50	7F5-G50	145	800	98	23	11.90	11.60	35.40	4.81	NG; 3.48 gr/dscf; 88 deg F; 50% load.	55.38	0.66	0.64	1.96	0.27	--
1-hr	D-100	7F5-D100	145	800	132	23	42.40	40.70	38.40	1.21	Distillate; 88 deg F; 100% load.	42.36	1.80	1.72	1.63	0.05	--
1-hr	D-75	7F5-D75	145	800	112	23	33.90	32.90	37.50	0.96	Distillate; 88 deg F; 75% load.	50.43	1.71	1.66	1.89	0.05	--
1-hr	D-50	7F5-D50	145	799	94	23	26.00	25.50	36.70	0.77	Distillate; 88 deg F; 50% load.	60.31	1.57	1.54	2.21	0.05	--

REVISION - 4/21/11 NEW LOCATION AND RAISED STACK HEIGHT

GE 7FA4 - 7F

							Emis (lb/hr) [Based on 1 unit/1 src]					Max Impact (ug/m3) (All Years)					
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	CO	PM	SO2	Notes:	UNIT*1000	NOx	CO	PM	SO2	MODEL
1-hr	NG-100	7F4-G100	145	800	135	21	17.40	16.20	46.40	7.01	NG; 3.48 gr/dscf; 7 deg F; 100% load.	50.27	0.87	0.81	2.33	0.35	--
1-hr	NG-75	7F4-G75	145	799	114	21	14.10	13.20	41.20	5.73	NG; 3.48 gr/dscf; 7 deg F; 75% load.	55.85	0.79	0.74	2.30	0.32	--
1-hr	NG-50	7F4-G50	145	799	102	21	11.90	11.40	37.60	4.82	NG; 3.48 gr/dscf; 7 deg F; 50% load.	63.46	0.76	0.72	2.39	0.31	24-hr PM
1-hr	D-100	7F4-D100	145	800	135	21	39.20	34.80	38.40	1.12	Distillate; 7 deg F; 100% load.	50.27	1.97	1.75	1.93	0.06	--
1-hr	D-75	7F4-D75	145	799	114	21	31.40	28.80	37.60	0.90	Distillate; 7 deg F; 75% load.	55.85	1.75	1.61	2.10	0.05	--
1-hr	D-50	7F4-D50	145	799	102	21	26.40	24.70	36.90	0.78	Distillate; 7 deg F; 50% load.	63.46	1.68	1.57	2.34	0.05	--

GE 7FA4 - 51F

							Emis (lb/hr) [Based on 1 unit/1 src]					Max Impact (ug/m3) (All Years)					
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	CO	PM	SO2	Notes:	UNIT*1000	NOx	CO	PM	SO2	MODEL
1-hr	NG-100	7F4-G100	145	800	138	21	16.80	15.60	45.40	6.75	NG; 3.48 gr/dscf; 51 deg F; 100% load.	49.55	0.83	0.77	2.25	0.33	--
1-hr	NG-75	7F4-G75	145	800	116	21	13.60	12.70	40.20	5.47	NG; 3.48 gr/dscf; 51 deg F; 75% load.	55.26	0.75	0.70	2.22	0.30	--
1-hr	NG-50	7F4-G50	145	799	103	21	11.30	10.80	36.50	4.56	NG; 3.48 gr/dscf; 51 deg F; 50% load.	62.33	0.70	0.67	2.28	0.28	--
1-hr	D-100	7F4-D100	145	800	141	21	39.00	35.20	38.40	1.12	Distillate; 51 deg F; 100% load.	48.59	1.90	1.71	1.87	0.05	--
1-hr	D-75	7F4-D75	145	799	117	21	30.90	28.70	37.50	0.88	Distillate; 51 deg F; 75% load.	55.00	1.70	1.58	2.06	0.05	--
1-hr	D-50	7F4-D50	145	799	104	21	25.50	23.80	36.90	0.75	Distillate; 51 deg F; 50% load.	61.22	1.56	1.46	2.26	0.05	--

GE 7FA4 - 88F

							Emis (lb/hr) [Based on 1 unit/1 src]					Max Impact (ug/m3) (All Years)					
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	CO	PM	SO2	Notes:	UNIT*1000	NOx	CO	PM	SO2	MODEL
1-hr	NG-100	7F4-G100	145	800	133	21	15.10	14.30	42.70	6.07	NG; 3.48 gr/dscf; 88 deg F; 100% load.	50.77	0.77	0.73	2.17	0.31	--
1-hr	NG-75	7F4-G75	145	799	115	21	12.40	11.80	38.40	5.02	NG; 3.48 gr/dscf; 88 deg F; 75% load.	55.56	0.69	0.66	2.13	0.28	--
1-hr	NG-50	7F4-G50	145	800	105	21	11.00	10.70	36.00	4.42	NG; 3.48 gr/dscf; 88 deg F; 50% load.	60.07	0.66	0.64	2.16	0.27	--
1-hr	D-100	7F4-D100	145	800	138	21	36.20	32.20	38.10	1.03	Distillate; 88 deg F; 100% load.	49.55	1.79	1.60	1.89	0.05	--
1-hr	D-75	7F4-D75	145	799	117	21	29.00	26.70	37.20	0.86	Distillate; 88 deg F; 75% load.	55.00	1.59	1.47	2.05	0.05	--
1-hr	D-50	7F4-D50	145	799	108	21	25.40	23.70	36.80	0.74	Distillate; 88 deg F; 50% load.	57.61	1.46	1.37	2.12	0.04	--

REVISION - 4/21/11 NEW LOCATION AND RAISED STACK HEIGHT

Siemens SGT6-5000F4 - 7F

							Emis (lb/hr) [Based on 1 unit/1 src]					Max Impact (ug/m3) (All Years)					
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	CO	PM	SO2	Notes:	UNIT*1000	NOx	CO	PM	SO2	MODEL
1-hr	NG-100	SM-G100	145	800	130	23	21.10	8.40	40.00	7.39	NG; 3.48 gr/dscf; 7 deg F; 100% load.	42.97	0.91	0.36	1.72	0.32	--
1-hr	NG-75	SM-G75	145	799	108	23	17.10	6.80	33.20	6.02	NG; 3.48 gr/dscf; 7 deg F; 75% load.	51.65	0.88	0.35	1.71	0.31	--
1-hr	NG-50	SM-G50	145	800	96	23	14.60	14.40	29.50	5.13	NG; 3.48 gr/dscf; 7 deg F; 60% load.	57.78	0.84	0.83	1.70	0.30	--
1-hr	D-100	SM-D100	145	800	126	23	43.10	20.80	34.60	1.09	Distillate; 7 deg F; 100% load.	44.75	1.93	0.93	1.55	0.05	--
1-hr	D-75	SM-D75	145	799	103	23	33.80	49.60	33.60	0.85	Distillate; 7 deg F; 75% load.	53.21	1.80	2.64	1.79	0.05	1-hr, 8-hr CO
1-hr	D-50	SM-D50	145	799	99	23	32.10	46.80	33.40	0.81	Distillate; 7 deg F; 70% load.	54.51	1.75	2.55	1.82	0.04	--

Siemens SGT6-5000F4 - 51F

							Emis (lb/hr) [Based on 1 unit/1 src]					Max Impact (ug/m3) (All Years)					
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	CO	PM	SO2	Notes:	UNIT*1000	NOx	CO	PM	SO2	MODEL
1-hr	NG-100	SM-G100	145	800	129	23	19.70	7.60	37.00	6.91	NG; 3.48 gr/dscf; 51 deg F; 100% load.	43.41	0.86	0.33	1.61	0.30	--
1-hr	NG-75	SM-G75	145	800	106	23	15.70	6.00	31.10	5.51	NG; 3.48 gr/dscf; 51 deg F; 75% load.	52.25	0.82	0.31	1.62	0.29	--
1-hr	NG-50	SM-G50	145	799	94	23	13.40	13.20	27.70	4.71	NG; 3.48 gr/dscf; 51 deg F; 60% load.	60.31	0.81	0.80	1.67	0.28	--
1-hr	D-100	SM-D100	145	800	121	23	38.80	18.80	34.10	0.98	Distillate; 51 deg F; 100% load.	47.01	1.82	0.88	1.60	0.05	--
1-hr	D-75	SM-D75	145	800	101	23	31.00	45.20	33.30	0.78	Distillate; 51 deg F; 75% load.	53.83	1.67	2.43	1.79	0.04	--
1-hr	D-50	SM-D50	145	800	97	23	29.40	42.80	33.10	0.74	Distillate; 51 deg F; 70% load.	56.57	1.66	2.42	1.87	0.04	--

Siemens SGT6-5000F4 - 88F

							Emis (lb/hr) [Based on 1 unit/1 src]					Max Impact (ug/m3) (All Years)					
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	CO	PM	SO2	Notes:	UNIT*1000	NOx	CO	PM	SO2	MODEL
1-hr	NG-100	SM-G100	145	800	124	23	17.70	6.80	34.10	6.22	NG; 3.48 gr/dscf; 88 deg F; 100% load.	45.65	0.81	0.31	1.56	0.28	--
1-hr	NG-75	SM-G75	145	799	104	23	14.30	5.60	29.00	5.02	NG; 3.48 gr/dscf; 88 deg F; 75% load.	52.89	0.76	0.30	1.53	0.27	--
1-hr	NG-50	SM-G50	145	799	92	23	12.20	12.00	26.00	4.30	NG; 3.48 gr/dscf; 88 deg F; 60% load.	62.85	0.77	0.75	1.63	0.27	--
1-hr	D-100	SM-D100	145	800	116	23	34.80	16.80	33.70	0.88	Distillate; 88 deg F; 100% load.	49.27	1.71	0.83	1.66	0.04	--
1-hr	D-75	SM-D75	145	799	98	23	28.10	41.20	33.00	0.71	Distillate; 88 deg F; 75% load.	55.42	1.56	2.28	1.83	0.04	--
1-hr	D-50	SM-D50	145	799	95	23	26.70	38.80	32.80	0.67	Distillate; 88 deg F; 70% load.	59.06	1.58	2.29	1.94	0.04	24-hr PM

REVISIONS - 4/5/11 EMISSIONS, LOWER STACK HEIGHT

LMS100 - 7F

							Emis (lb/hr) [Based on 2 units/2 srcs]					Max Impact (ug/m3) (All Years)					
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	CO	PM	SO2	Notes:	UNIT*1000	NOx	CO	PM	SO2	MODEL
1-hr	NG-100	LM-G100	110	737	134	12	7.90	7.20	17.50	3.18	NG; 3.48 gr/dscf; 7 deg F; 100% load.	291.38	2.30	2.10	5.10	0.927	--
1-hr	NG-75	LM-G75	110	764	115	12	6.40	4.80	15.30	2.57	NG; 3.48 gr/dscf; 7 deg F; 75% load.	314.56	2.01	1.51	4.81	0.81	--
1-hr	NG-50	LM-G50	110	800	96	12	4.90	3.70	13.00	1.96	NG; 3.48 gr/dscf; 7 deg F; 50% load.	354.59	1.74	1.31	4.61	0.69	--
1-hr	NG-30	LM-G30	110	799	79	12	3.50	3.40	11.10	1.42	NG; 3.48 gr/dscf; 7 deg F; 30% load.	432.89	1.52	1.47	4.81	0.61	--
1-hr	D-100	LM-D100	110	755	134	12	16.50	4.80	26.70	0.49	Distillate; 7 deg F; 100% load.	289.46	4.78	1.39	7.73	0.14	24-hr PM - 90% of time
1-hr	D-75	LM-D75	110	782	115	12	13.30	4.60	26.40	0.39	Distillate; 7 deg F; 75% load.	312.89	4.16	1.44	8.26	0.12	24-hr PM - 10% of time
1-hr	D-50	LM-D50	110	800	97	12	10.10	4.30	26.00	0.30	Distillate; 7 deg F; 50% load.	351.77	3.55	1.51	9.15	0.11	(No op. time at 50% load on Distillate)

LMS100 - 51F

							Emis (lb/hr) [Based on 2 units/2 srcs]					Max Impact (ug/m3) (All Years)					
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	CO	PM	SO2	Notes:	UNIT*1000	NOx	CO	PM	SO2	MODEL
1-hr	NG-100	LM-G100	110	769	136	12	8.10	6.20	17.80	3.26	NG; 3.48 gr/dscf; 51 deg F; 100% load.	285.35	2.31	1.77	5.08	0.930	--
1-hr	NG-75	LM-G75	110	787	117	12	6.50	4.50	15.40	2.62	NG; 3.48 gr/dscf; 51 deg F; 75% load.	309.59	2.01	1.39	4.77	0.81	--
1-hr	NG-50	LM-G50	110	800	98	12	5.00	3.80	13.20	1.99	NG; 3.48 gr/dscf; 51 deg F; 50% load.	348.97	1.74	1.33	4.61	0.69	--
1-hr	NG-30	LM-G30	110	799	80	12	3.60	3.90	11.20	1.44	NG; 3.48 gr/dscf; 51 deg F; 30% load.	426.86	1.54	1.66	4.78	0.61	--
1-hr	D-100	LM-D100	110	786	136	12	16.90	5.00	26.70	0.50	Distillate; 51 deg F; 100% load.	283.62	4.79	1.42	7.57	0.14	24-hr PM - 90% of time
1-hr	D-75	LM-D75	110	799	117	12	13.50	4.70	26.40	0.40	Distillate; 51 deg F; 75% load.	308.50	4.16	1.45	8.14	0.12	24-hr PM - 10% of time
1-hr	D-50	LM-D50	110	800	99	12	10.30	4.50	26.10	0.30	Distillate; 51 deg F; 50% load.	346.17	3.57	1.56	9.04	0.10	(No op. time at 50% load on Distillate)

LMS100 - 88F

							Emis (lb/hr) [Based on 2 units/2 srcs]					Max Impact (ug/m3) (All Years)					
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	CO	PM	SO2	Notes:	UNIT*1000	NOx	CO	PM	SO2	MODEL
1-hr	NG-100	LM-G100	110	799	132	12	7.90	5.70	17.40	3.16	NG; 3.48 gr/dscf; 88 deg F; 100% load.	287.71	2.27	1.64	5.01	0.91	--
1-hr	NG-75	LM-G75	110	800	114	12	6.30	4.30	15.10	2.53	NG; 3.48 gr/dscf; 88 deg F; 75% load.	312.70	1.97	1.34	4.72	0.79	--
1-hr	NG-50	LM-G50	110	800	97	12	4.80	4.00	12.90	1.92	NG; 3.48 gr/dscf; 88 deg F; 50% load.	351.77	1.69	1.41	4.54	0.68	--
1-hr	NG-30	LM-G30	110	799	80	12	3.50	4.40	11.00	1.40	NG; 3.48 gr/dscf; 88 deg F; 30% load.	426.86	1.49	1.88	4.70	0.60	--
1-hr	D-100	LM-D100	110	800	129	12	15.70	5.00	26.60	0.46	Distillate; 88 deg F; 100% load.	291.69	4.58	1.46	7.76	0.13	24-hr PM - 90% of time
1-hr	D-75	LM-D75	110	800	113	12	12.70	4.80	26.30	0.37	Distillate; 88 deg F; 75% load.	314.14	3.99	1.51	8.26	0.12	24-hr PM - 10% of time
1-hr	D-50	LM-D50	110	799	96	12	9.60	4.50	26.00	0.28	Distillate; 88 deg F; 50% load.	354.67	3.40	1.60	9.22	0.10	(No op. time at 50% load on Distillate)

Maximum fuel/load for each temperature condition.
Maximum, as above, over all temperatures; this scenario used for refined analysis.
Real maximum, but not used due to operations during averaging period.

REFINED MODELING FOR TURBINES (Emergency generator model input shown on separate sheet)

GE 7FA.05

							Emis (lb/hr) [Based on 1 unit/1 src]										
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	NOx-1	CO-1	CO-8	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	Notes:
Ann	NG-all	7F5-A	145	800	120	23					9.755						Annual NG and Distillate - all loads based on predicted use (op scenarios); NG at 2.25 gr/100dscf; ave temp (51F).
24-hr	D-50	7F5-24	145	799	87	23						36.80					Distillate; 50% load; 7 deg F; no SU/SD.
1-hr	D-100	7F5-1N	145	800	124	23		234.26	537.27								FOR 1-HR NOX AND CO FOR TOXICS (ASIL COMP) - Distillate; 100% load; 7 deg F; 1 SU/SD.
1-hr	NG-100	7F5-1S	145	800	132	23								16.51			FOR 1-HR SO2 FOR TOXICS (ASIL COMP) - NG; 100% load; 7 deg F; 1 SU/SD.

GE 7FA.04

							Emis (lb/hr) [Based on 1 unit/1 src]										
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	NOx-1	CO-1	CO-8	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	Notes:
Ann	NG-all	7F4-A	145	800	127	21					9.850						Annual NG and Distillate - all loads based on predicted use (op scenarios); NG at 2.25 gr/100dscf; ave temp (51F).
24-hr	NG-50	7F4-24	145	799	102	21						37.60					NG at 3.48 gr/100 dscf; 50% load; 7 deg F; no SU/SD.
1-hr	D-100	7F4-1	145	800	135	21		233.19	535.64								FOR 1-HR NOX AND CO FOR TOXICS (ASIL COMP) - Distillate; 100% load; 7 deg F; 1 SU/SD.
1-hr	NG-100	7F4-1S	145	800	135	21								16.17			FOR 1-HR SO2 FOR TOXICS (ASIL COMP) - NG; 100% load; 7 deg F; 1 SU/SD.

Siemens SGT6-5000F4

							Emis (lb/hr) [Based on 1 unit/1 src]										
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	NOx-1	CO-1	CO-8	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	Notes:
Ann	NG-all	SG-A	145	800	118	23					7.392						Annual NG and Distillate - all loads based on predicted use (op scenarios); NG at 2.25 gr/100dscf; ave temp (51F).
1-hr, 8-hr	D-75	SG-1	145	799	103	23			2173.48	1202.65							Distillate; 75% load; 7 deg F; 1 Distillate SU/SD over 1 hr, and additional 4 NG SU/SD over 8 hr period.
24-hr	D-50	SG-24	145	799	95	23						32.80					Distillate; 70% load; 88 deg F; no SU/SD.
1-hr	D-100	SG-1N	145	800	126	23		238.36									FOR 1-HR NOX FOR TOXICS (ASIL COMP) - Distillate; 100% load; 7 deg F; 1 SU/SD.
1-hr	D-100	SG-1S	145	800	130	23								17.39			FOR 1-HR SO2 FOR TOXICS (ASIL COMP) - NG; 100% load; 7 deg F; 1 SU/SD.

LMS100

							Emis (lb/hr) [Based on 2 units/2 srcs]										
Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	NOx-1	CO-1	CO-8	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	Notes:
Ann	NG-all	LMS-A	110	776.95	126.89	12					5.122						Annual NG and Distillate - all loads based on predicted use (op scenarios); NG at 2.25 gr/100dscf; ave temp (51F).
24-hr	D-100	LMS-24/10	110	800.00	129.00	12						18.52					Distillate 80% (combined for 2 units) use factor over 24 hr period; 90% use at 100% load; 88 deg F.
24-hr	D-75	LMS-24/75	110	800.00	113.00	12						2.83					Distillate 80% (combined for 2 units) use factor over 24 hr period; 10% use down to 75% load; 88 deg F; 1 Distillate SU/SD.
1-hr	D-100	LMS-1N	110	786.00	136.00	12		71.80									FOR 1-HR NOX FOR TOXICS (ASIL COMP) - Distillate; 100% load; 51 deg F; 1 SU/SD.
1-hr	NG-100	LMS-1C	110	737.00	134.00	12			53.44								FOR 1-HR CO FOR TOXICS (ASIL COMP) - NG; 100% load; 7 deg F; 1 SU/SD.
1-hr	NG-100	LMS-1S	110	769.00	136.00	12								8.34			FOR 1-HR SO2 FOR TOXICS (ASIL COMP) - NG; 100% load; 51 deg F; 1 SU/SD.

FOR AQRV ANALYSES (No operational limitations; worst-case for all turbine options)

MAXIMUM EMISSION RATE DETERMINATION (NG only):

GE 7FA.05 — Emis (lb/hr) [Total]

NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
5.830			9.616		1.545				
	51.30	27.07		47.70		16.51	13.74	9.95	NOx SU/SD; No SU/SD for PM (normal ops are worse); SO2 SU/SD.

GE 7FA.04 — Emis (lb/hr) [Total]

NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
5.591			9.746		1.372				
	78.74	30.18		46.40		16.17	13.12	8.92	NOx SU/SD; No SU/SD for PM (normal ops are worse); SO2 SU/SD.

SM SGT6 — Emis (lb/hr) [Total]

NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
7.386			7.068		1.433				
	140.21	45.92		40.00		17.39	14.05	9.47	NOx SU/SD; No SU/SD for PM (normal ops are worse); SO2 SU/SD.

LMS100 — Emis (lb/hr) [Total]

NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
7.403			9.178		1.779				
	81.74	29.85		35.60		16.67	13.29	8.63	NOx SU/SD; No SU/SD for PM (normal ops are worse); SO2 SU/SD.

AQRV - Model Stack Info for Worst-Case NG

Emis (lb/hr) [Total]

Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
Ann	NG-all	7FA5	145	800	120	23	7.403			9.746		1.779				7FA5: Annual, all NG - all loads based on predicted use (op scenarios); Ave temp (51F).
Short-term	NG-100/7	7FA5-ST	145	800	132	23		140.213	45.915		47.700		17.385	14.054	9.946	7FA5: NG; 100% load; 7 deg F. 1-hr: 1 SU/SD; 3-hr: 2 SU/SD; 24-hr: 5 SU/SD (each unit, where SU/SD higher emissions than normal op).

MAXIMUM EMISSION RATE DETERMINATION (Distillate only Short-term; Annual w/ max Distillate and remainder NG):

GE 7FA.05 — Emis (lb/hr) [Total]

	NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
Dist	2.051			1.519		0.051				
NG	5.086			8.236		1.497				
Dist		234.26	52.02		38.41		1.26	1.26	1.260	NOx SU/SD; PM SU only; No SU/SD for SO2 (normal ops are worse). Limit of 1 SU/SD on Distillate per 24 hr period.

GE 7FA.04 — Emis (lb/hr) [Total]

	NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
Dist	1.855			1.515		0.045				
NG	4.946			8.334		1.330				
Dist		233.19	47.28		38.31		1.12	1.12	1.120	NOx SU/SD; PM SU only; No SU/SD for SO2 (normal ops are worse). Limit of 1 SU/SD on Distillate per 24 hr period.

SM SGT6 — Emis (lb/hr) [Total]

	NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
Dist	1.866			1.349		0.040				
NG	6.630			6.044		1.395				
Dist		238.36	51.24		34.60		1.09	1.09	1.090	NOx SU/SD; No SU/SD for PM or SO2 (normal ops are worse). Limit of 1 SU/SD on Distillate per 24 hr period.

LMS100 — Emis (lb/hr) [Total]

	NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
Dist	1.296			2.109		0.040				
NG	6.781			8.135		1.740				
Dist		143.59	38.37		53.57		1.00	1.00	0.750	NOx and PM SU/SD; No SU/SD for SO2 (normal ops are worse). Limit of 1 SU/SD on Distillate per 24 hr period.

AQRV - Model Stack Info for Worst-Case Distillate (w/ NG fill in for annual)

Emis (lb/hr) [Total]

Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
Ann	Dist-14	7FA5-A/D	145	800	132	23	2.051			2.109		0.051				7FA5: Annual Distillate - 14 Days (336 hrs max); Worst-Case Ops (100% load, 88F)
Ann	NG-remain	7FA5	145	800	120	23	6.781			8.334		1.740				7FA5: Annual NG - remainder NG (total op time - 336 hrs); all loads based on predicted use (op scenarios); Ave temp (51F).
Short-term	Dist-100/88	7FA5-ST	145	800	132	23		238.355	52.023		53.573		1.260	1.260	1.260	7FA5: Distillate; 100% load; 88 deg F. 1-hr: 1 SU/SD; 3-hr: 1 SU/SD; 24-hr: 1 SU/SD (each unit, where SU/SD higher emissions than normal op).

MAXIMUM EMISSION RATE DETERMINATION (Distillate primary Short-term, with worst-case NG for SU/SD; Annual w/ max Distillate and remainder NG):

GE 7FA.05 — Emis (lb/hr) [Total]

	NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
Dist	2.051			1.519		0.051				
NG	5.086			8.236		1.497				
Dist		234.26	46.02		38.41		0.23	1.11	1.21	NOx SU/SD; PM SU only; NG SU/SD for SO2.
NG		0.00	7.92		0.00		15.00	10.00	3.13	

GE 7FA.04 — Emis (lb/hr) [Total]

	NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
Dist	1.855			1.515		0.045				
NG	4.946			8.334		1.330				
Dist		233.19	42.49		38.31		0.30	0.92	1.06	NOx SU/SD; PM SU only; NG SU/SD for SO2.
NG		0.00	12.35		0.00		14.30	9.53	2.98	

SM SGT6 — Emis (lb/hr) [Total]

	NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
Dist	1.866			1.349		0.040				
NG	6.630			6.044		1.395				
Dist		238.36	45.01		34.60		0.15	0.78	0.92	NOx SU/SD; No SU/SD for PM; NG SU/SD for SO2.
NG		0.00	22.90		0.00		16.40	10.93	3.42	

LMS100 — Emis (lb/hr) [Total]

	NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
Dist	1.296			2.109		0.040				
NG	6.781			8.135		1.740				
Dist		143.59	34.81		53.40		0.37	0.76	0.92	NOx and PM SU/SD; NG SU/SD for SO2.
NG		0.00	12.63		0.00		14.28	4.76	2.98	

AQRV - Model Stack Info for Worst-Case Distillate/NG Mix

Emis (lb/hr) [Total]

Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	
Ann	Dist-14	7FA5-A/D	145	800	132	23	2.051			2.109		0.051				7FA5: Annual Distillate - 14 Days (336 hrs max); Worst-Case Ops (100% load, 88F)
Ann	NG-remain	7FA5	145	800	120	23	6.781			8.334		1.740				7FA5: Annual NG - remainder NG (total op time - 336 hrs); all loads based on predicted use (op scenarios); Ave temp (51F).
Short-term	Dist-100/88	7FA5-ST	145	800	132	23		238.355	46.021		53.400		0.367	1.106	1.212	7FA5: Distillate; 100% load; 88 deg F. 1-hr: 1 SU/SD; 3-hr: 1 SU/SD; 24-hr: 1 SU/SD (each unit, where SU/SD higher emissions than normal op).
Short-term	NG-100/7	7FA5-ST	145	800	132	23		0.000	22.900		0.000		16.400	10.933	3.417	7FA5: NG; 100% load; 7 deg F. 1-hr: 1 SU/SD; 3-hr: 2 SU/SD; 24-hr: 5 SU/SD (each unit, where SU/SD higher emissions than normal op).

MAXIMUM EMISSION RATE DETERMINATION (Max of either NG or Distillate, by turbine option):

GE 7FA.05 — Emis (lb/hr) [Total]

NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24
7.137			9.755		1.548			
	234.26	52.02		47.70		16.51	13.74	9.95

GE 7FA.04 — Emis (lb/hr) [Total]

NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24
6.801			9.850		1.375			
	78.74	30.18		46.40		16.17	13.12	8.92

SM SGT6 — Emis (lb/hr) [Total]

NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24
8.496			7.392		1.436			
	238.36	51.24		40.00		17.39	14.05	9.47

LMS100 — Emis (lb/hr) [Total]

NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24
8.078			10.244		1.781			
	143.59	38.37		53.57		16.67	13.29	8.63

AQRV - Model Stack Info for Worst-Case Distillate and/or NG (by turbine option)

Emis (lb/hr) [Total]

Ave Time	Op	Unit ID	ht (ft)	T (F)	v (fps)	d (ft)	NOx	NOx-1	NOx-24	PM	PM-24	SO2	SO2-1	SO2-3	SO2-24	Notes:
Ann	NG-all	7FA5	145	800	120	23	8.496			10.244		1.781				7FA5: Annual, all NG - all loads based on predicted use (op scenarios); Ave temp (51F).
Short-term	Dist-100/88	7FA5-ST	145	800	132	23		238.355	52.023		53.573		17.385	14.054	9.946	7FA5: NG; 100% load; 7 deg F. 1-hr: 1 SU/SD; 3-hr: 2 SU/SD; 24-hr: 3 SU/SD (each unit, where SU/SD higher emissions than normal op).

EMERGENCY DIESEL GENERATOR

Caterpillar C18

Rating:	600	kW	(Caterpillar Tier 2 Specification Sheet, May 6, 2009)
Exhaust Temperature:	994	F	(Black & Veatch, 8/5/10)
Exhaust Flow Rate:	146	fps	(Black & Veatch, 8/5/10)
Stack Diameter:	10	inches	(Black & Veatch, 8/5/10)
Fuel Use (100% load):	42.7	Gal/hr	(Caterpillar Tier 2 Specification Sheet, May 6, 2009)
Stack Height:	50	ft	(PSE)
Fuel Sulfur Content:	0.0015	%	
Operation:	275	hrs/yr	(includes 52 hrs of testing/maintenance plus emergency use, up to 275 hrs/yr total)

	Emission Factor		Emission Rate		MODELING RATES (lb/hr): Short Term	Long Term
Pollutant	g/hp-hr	lb/hp-hr	lb/hr	lb/yr	(1-hr to 24-hr)	(Annual)
NOX	4.32		7.65	2105	7.653	0.2403
CO	0.6		1.06	292.3	1.063	0.03337
VOC	0.01		0.02	4.87		
PM	0.06		0.11	29.2	0.1063	0.00334
CO2		1.16	933	256568		
SO2		1.2E-05	0.01	2.68	0.00976	0.00031

Notes:

NOx, CO, VOC (HC), and PM emission factors from California Air Resources Board (CARB) Tier 2 Certified Diesel Generator sheet (Executive Order U-R-001-0380-1, New Off-Road Compression-Ignition Engines (August 30, 2010); CO2 and SO2 emission factors from AP-42, Table 3.4.1.

Note: this CO2e calculation is for information only; emissions are negligible and are not included in total CO2e emissions (shown in Attachment A-1)

CO2e Pollutants	lb/hp-hr	lb/hr	lb/yr	GWP	CO2e (tpy)
CH4	6.35E-05	0.05	14	21	0.1474
N2O	--	--	--	310	--

CH4 emission factor from AP-42, Table 3.4.1; following note for distillate emission factor, methane is 9% of TOC.

There are no N2O emission factors provided in AP-42 for diesel engines. The N2O emission factor for distillate use in turbines shows non-detect (ND) values. Therefore, N2O emissions are expected to be negligible for diesel engines.

GWP (Global Warming Potential) from 40CFR98, Subpart A, Table A-1.

DIESEL GENERATOR SET

CATERPILLAR®

Image shown may not reflect actual package.

STANDBY
600 ekW 750 kVA
60 Hz 1800 rpm 480 Volts

Caterpillar is leading the power generation marketplace with Power Solutions engineered to deliver unmatched flexibility, expandability, reliability, and cost-effectiveness.

FEATURES

FUEL/EMISSIONS STRATEGY
- EPA Tier 2

DESIGN CRITERIA
- The generator set accepts 100% rated load in one step per NFPA 110 and meets ISO 8528-5 transient response.

UL 2200
- UL 2200 listed packages available. Certain restrictions may apply. Consult with your Caterpillar Dealer.

FULL RANGE OF ATTACHMENTS
- Wide range of bolt-on system expansion attachments, factory designed and tested
- Flexible packaging options for easy and cost effective installation

SINGLE-SOURCE SUPPLIER
- Fully prototype tested with certified torsional vibration analysis available

WORLDWIDE PRODUCT SUPPORT
- Caterpillar® dealers provide extensive post sale support including maintenance and repair agreements
- Caterpillar dealers have over 1,600 dealer branch stores operating in 200 countries
- The Cat® S•O•S℠ program cost effectively detects internal engine component condition, even the presence of unwanted fluids and combustion by-products

CAT ® C18 ATAAC DIESEL ENGINE
- Utilizes ACERT™ Technology
- Reliable, rugged, durable design
- Field-proven in thousands of applications worldwide
- Four-stroke-cycle diesel engine combines consistent performance and excellent fuel economy with minimum weight
- Electronic controlled governor

CAT GENERATOR
- Matched to the performance and output characteristics of Caterpillar engines
- Load adjustment module provides engine relief upon load impact and improves load acceptance and recovery time
- UL 1446 Recognized Class H insulation

CAT EMCP 3 SERIES CONTROL PANELS
- Simple user friendly interface and navigation
- Scalable system to meet a wide range of customer needs
- Integrated Control System and Communications Gateway

STANDBY 600 ekW 750 kVA

60 Hz 1800 rpm 480 Volts

CATERPILLAR®

FACTORY INSTALLED STANDARD & OPTIONAL EQUIPMENT

System	Standard	Optional
Air Inlet	• Light Duty Air Cleaner • Service indicator	• Single element canister type air cleaner • Dual element air cleaner • Heavy-duty air cleaner with precleaner • Air inlet shutoff
Cooling	• Radiator with guard sized for 50° C • Coolant level sight window • Coolant drain line with valve • Fan and belt guards • Caterpillar® Extended Life Coolant	• Radiator duct flange • Low Coolant Level Sensor • Radiator removal
Exhaust	• Stainless steel exhaust flex and ANSI weld flange • Turbo outlet elbow	• Industrial, residential and critical mufflers • 35 dBA muffler • Engine mounted muffler • Mounting and through-wall installation kits • Manifold and turbocharger guards
Fuel	• Primary fuel filter with integral water separtor • Secondary fuel filters • Fuel cooler • Fuel priming pump • Fuel pressure gauge • Flexible fuel lines	• Dual Wall Integral Fuel Tanks • Dual Wall Sub-base Fuel Tanks • Manual Fuel Fill Pump • Automatic Fuel Fill Options
Generator	• Class H insulation • Class H Temperature Rise • R448 Voltage Regulator • Power terminal strip connections • IP23 Protection • Power Center	• Oversize and premium generators • Three phase sensing • Quadrature droop kit • Digital voltage Regulator • Space heaters • RFI filter • 80% & 100% UL Breakers • IEC compliant 3 or 4-pole • Floor standing circuit breakers with auxiliary contacts & cabling kits
Governor	• Electronic ADEM A4	• Load Share Module
Control Panels	• EMCP 3.1 (package mounted)	• EMCP 3.2 • EMCP 3.3 • Local alarm and remote annunciator modules • Protective devices
Lube	• Lubricating oil and filter • Oil drain line with valves • Fumes disposal • Lube oil level indicator	• Oil temperature sensor • Manual sump pump
Mounting	• Formed steel narrow base frame • Linear vibration isolators between base and engine generator	• Formed steel wide base frame • Oil field skid base
Starting/Charging	• 45 amp charging alternator • 24 volt starting motor(s) • Batteries with rack and cables	• Jacket water heater • Block heater • Ether starting aid • Battery disconnect switch • Battery charger(5A, 10A) • Oversized batteries • Battery removal

STANDBY 600 ekW 750 kVA

60 Hz 1800 rpm 480 Volts

CATERPILLAR®

SPECIFICATIONS

CAT GENERATOR

Frame size.....LC7024F
Excitation..... Internal Excited
Pitch.....0.6667
Number of poles.....4
Number of bearings..... Single Bearing
Number of leads..... 12
Insulation..... UL 1446 Recognized Class H with tropicalization and antiabrasion
- Consult your Caterpillar dealer for available voltages
IP rating.....Drip Proof IP23
Alignment.....Pilot Shaft
Overspeed capability..... 125% of rated
Wave form deviation (Line to Line)..... 2%
Paralleling kit droop transformer..... Standard
Voltage regulator.3 Phase sensing with selectible volts/Hz
Voltage Regulator.....Single phase sensing with load adjustable module
Voltage Regulation.....Less than +/- 1/2% (steady state)
Less than +/- 1/2% (w/ 3% speed change)
Telephone Influence Factor..... Less than 50
Harmonic distortion..... Less than 5%

CAT ENGINE

C18 ATAAC, I-6, 4-stroke watercooled diesel
Bore - mm..... 145.00 mm (5.71 in)
Stroke - mm..... 183.00 mm (7.2 in)
Displacement - L..... 18.13 L (1106.36 in³)
Compression ratio..... 14.5:1
Aspiration..... Air-to-Air Aftercooled
Fuel system.....MEUI
Governor type..... Caterpillar ADEM control system

CAT EMCP 3 SERIES CONTROLS

- EMCP 3.1 (Standard)
- EMCP 3.2 / EMCP 3.3 (Option)
- Single location customer connector point
- True RMS metering, 3-phase
- Controls
  - Run / Auto / Stop control
  - Speed Adjust
  - Voltage Adjust
  - Emergency Stop Pushbutton
  - Engine cycle crank
- Digital Indication for:
  - RPM
  - Operating hours
  - Oil Pressure
  - Coolant temperature
  - System DC volts
  - L-L volts, L-N volts, phase amps, Hz
  - ekW, kVA, kVAR, kW-hr, %kW, PF (EMCP 3.2 / 3.3)
- Shutdowns with common indicating light for:
  - Low oil pressure
  - High coolant temperature
  - Low coolant level
  - Overspeed
  - Emergency stop
  - Failure to start (overcrank)
- Programmable protective relaying functions: (EMCP 3.2 & 3.3)
  - Under and over voltage
  - Under and over frequency
  - Overcurrent (time and inverse time)
  - Reverse power (EMCP 3.3)
- MODBUS isolated data link, RS-485 half-duplex (EMCP 3.2 & 3.3)
- Options
  - Vandal door
  - Local annunciator module
  - Remote annunciator module
  - Input / Output module
  - RTD / Thermocouple Modules
  - Monitoring software

STANDBY 600 ekW 750 kVA

60 Hz 1800 rpm 480 Volts

CATERPILLAR®

TECHNICAL DATA

Open Generator Set - - 1800 rpm/60 Hz/480 Volts	DM8518	
EPA Certified Tier 2		
Generator Set Package Performance		
Genset Power rating @ 0.8 pf	750 kVA	
Genset Power rating with fan	600 ekW	
Coolant to aftercooler		
Coolant to aftercooler temp max	49 ° C	120 ° F
Fuel Consumption		
100% load with fan	161.6 L/hr	42.7 Gal/hr
75% load with fan	129.8 L/hr	34.3 Gal/hr
50% load with fan	91.7 L/hr	24.2 Gal/hr
Cooling System[1]		
Air flow restriction (system)	0.12 kPa	0.48 in. water
Air flow (max @ rated speed for radiator arrangement)	804 m³/min	28393 cfm
Engine Coolant capacity with radiator/exp. tank	81.8 L	21.6 gal
Engine coolant capacity	20.8 L	5.5 gal
Radiator coolant capacity	61.0 L	16.1 gal
Inlet Air		
Combustion air inlet flow rate	47.4 m³/min	1673.9 cfm
Exhaust System		
Exhaust stack gas temperature	534.6 ° C	994.3 ° F
Exhaust gas flow rate	135.4 m³/min	4781.6 cfm
Exhaust flange size (internal diameter)	203 mm	8 in
Exhaust system backpressure (maximum allowable)	10.0 kPa	40.2 in. water
Heat Rejection		
Heat rejection to coolant (total)	189 kW	10748 Btu/min
Heat rejection to exhaust (total)	610 kW	34691 Btu/min
Heat rejection to aftercooler	145 kW	8246 Btu/min
Heat rejection to atmosphere from engine	119 kW	6768 Btu/min
Heat rejection to atmosphere from generator	41.0 kW	2331.7 Btu/min
Alternator[2]		
Motor starting capability @ 30% voltage dip	1633 skVA	
Frame	LC7024F	
Temperature Rise	150 ° C	270 ° F
Emissions (Nominal)[3]		
NOx g/hp-hr	5.84 g/hp-hr	
CO g/hp-hr	.48 g/hp-hr	
HC g/hp-hr	.01 g/hp-hr	
PM g/hp-hr	.035 g/hp-hr	

[1] For ambient and altitude capabilities consult your Caterpillar dealer. Air flow restriction (system) is added to existing restriction from factory.

[2] Generator temperature rise is based on a 40° C (104° F) ambient per NEMA MG1-32.

[3] Emissions data measurement procedures are consistent with those described in EPA CFR 40 Part 89, Subpart D & E and ISO8178-1 for measuring HC, CO, PM, NOx. Data shown is based on steady state operating conditions of 77°F, 28.42 in HG and number 2 diesel fuel with 35° API and LHV of 18,390 btu/lb. The nominal emissions data shown is subject to instrumentation, measurement, facility and engine to engine variations. Emissions data is based on 100% load and thus cannot be used to compare to EPA regulations which use values based on a weighted cycle.

RATING DEFINITIONS AND CONDITIONS

Meets or Exceeds International Specifications: AS1359, CSA, IEC60034-1, ISO3046, ISO8528, NEMA MG 1-22, NEMA MG 1-33, UL508A, 72/23/EEC, 98/37/EC, 2004/108/EC

Standby - Output available with varying load for the duration of the interruption of the normal source power. Average power output is 70% of the standby power rating. Typical operation is 200 hours per year, with maximum expected usage of 500 hours per year. Standby power in accordance with ISO8528. Fuel stop power in accordance with ISO3046. Standby ambients shown indicate ambient temperature at 100% load which results in a coolant top tank temperature just below the shutdown temperature.

Ratings are based on SAE J1349 standard conditions. These ratings also apply at ISO3046 standard conditions. **Fuel rates** are based on fuel oil of 35° API [16° C (60° F)] gravity having an LHV of 42 780 kJ/kg (18,390 Btu/lb) when used at 29° C (85° F) and weighing 838.9 g/liter (7.001 lbs/U.S. gal.). Additional ratings may be available for specific customer requirements, contact your Caterpillar representative for details. For information regarding Low Sulfur fuel and Biodiesel capability, please consult your Caterpillar dealer.

STANDBY 600 ekW 750 kVA

60 Hz 1800 rpm 480 Volts

CATERPILLAR®

DIMENSIONS

Package Dimensions		
Length	3933.4 mm	154.86 in
Width	1536.0 mm	60.47 in
Height	2165.8 mm	85.27 in
Weight	3720 kg	8,201 lb

NOTE: For reference only - do not use for installation design. Please contact your local dealer for exact weight and dimensions. (General Dimension Drawing #2859356).

Performance No.: DM8518

Feature Code: C18DE97

Gen. Arr. Number: 2476127

Source: U.S. Sourced

May 06 2009

14165110

www.CAT-ElectricPower.com

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Materials and specifications are subject to change without notice. The International System of Units (SI) is used in this publication.

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California Environmental Protection Agency AIR RESOURCES BOARD	CATERPILLAR INC.	EXECUTIVE ORDER U-R-001-0380-1 New Off-Road Compression-Ignition Engines

Pursuant to the authority vested in the Air Resources Board by Sections 43013, 43018, 43101, 43102, 43104 and 43105 of the Health and Safety Code; and

Pursuant to the authority vested in the undersigned by Sections 39515 and 39516 of the Health and Safety Code and Executive Order G-02-003;

IT IS ORDERED AND RESOLVED: That the following compression-ignition engines and emission control systems produced by the manufacturer are certified as described below for use in off-road equipment. Production engines shall be in all material respects the same as those for which certification is granted.

MODEL YEAR	ENGINE FAMILY	DISPLACEMENT (liters)	FUEL TYPE	USEFUL LIFE (hours)
2010	ACPXL18.1ESW	18.1	Diesel	8000

SPECIAL FEATURES & EMISSION CONTROL SYSTEMS	TYPICAL EQUIPMENT APPLICATION
Direct Diesel Injection, Turbocharger, Charge Air Cooler, Engine Control Module	Generator

The engine models and codes are attached.

The following are the exhaust certification standards (STD), or family emission limit(s) (FEL) as applicable, and certification levels (CERT) for hydrocarbon (HC), oxides of nitrogen (NOx), or non-methane hydrocarbon plus oxides of nitrogen (NMHC+NOx), carbon monoxide (CO), and particulate matter (PM) in grams per kilowatt-hour (g/kw-hr), and the opacity-of-smoke certification standards and certification levels in percent (%) during acceleration (Accel), lugging (Lug), and the peak value from either mode (Peak) for this engine family (Title 13, California Code of Regulations, (13 CCR) Section 2423):

RATED POWER CLASS	EMISSION STANDARD CATEGORY		EXHAUST (g/kw-hr)					OPACITY (%)		
			HC	NOx	NMHC+NOx	CO	PM	ACCEL	LUG	PEAK
KW > 560	Tier 2	STD	N/A	N/A	6.4	3.5	0.20	N/A	N/A	N/A
		FEL	N/A	N/A	6.2	N/A	0.09	N/A	N/A	N/A
		CERT	--	--	5.8	0.8	0.08	--	--	--

BE IT FURTHER RESOLVED: That the family emission limit(s) (FEL) is an emission level declared by the manufacturer for use in any averaging, banking and trading program and in lieu of an emission standard for certification. It serves as the applicable emission standard for determining compliance of any engine within this engine family under 13 CCR Sections 2423 and 2427.

BE IT FURTHER RESOLVED: That for the listed engine models, the manufacturer has submitted the information and materials to demonstrate certification compliance with 13 CCR Section 2424 (emission control labels), and 13 CCR Sections 2425 and 2426 (emission control system warranty).

This Executive Order hereby cancels and replaces Executive Order U-R-001-0380 dated October 23, 2009.

Engines certified under this Executive Order must conform to all applicable California emission regulations.

This Executive Order is only granted to the engine family and model-year listed above. Engines in this family that are produced for any other model-year are not covered by this Executive Order.

Executed at El Monte, California on this 30th day of August 2010.

J. Lawrence

Annette Hebert, Chief
Mobile Source Operations Division

ATTACHMENT 1 OF 1

U-R-001-0380-1
8/18/2010

Engine Family	1.Engine Code	2.Engine Model	3.BHP@RPM (SAE Gross)	4.Fuel Rate: mm/stroke @ peak HP (for diesel only)	5.Fuel Rate: (lbs/hr) @ peak HP (for diesels only)	6.Torque @ RPM (SEA Gross)	7.Fuel Rate: mm/stroke@peak torque	8.Fuel Rate: (lbs/hr)@peak torque	9.Emission Control Device Per SAE J1930
CPXL18.1ESW	Cert Test 2	C18	923@1800	532	322.3	NA	NA	NA	EM, DI, TC, CAC, ECM
CPXL18.1ESW	1 Cert Engine	C18	923@1800	517	313.1	NA	NA	NA	EM, DI, TC,
CPXL18.1ESW	2	C18	923@1800	510	309	NA	NA	NA	EM, DI, TC,
CPXL18.1ESW	3	C18	923@1800	510	309	NA	NA	NA	EM, DI, TC,
CPXL18.1ESW	4	C18	861@1800	479	289.7	NA	NA	NA	EM, DI, TC,
CPXL18.1ESW	5	C18	861@1800	479	289.7	NA	NA	NA	EM, DI, TC,
CPXL18.1ESW	6	C18	923@1800	510	309	NA	NA	NA	EM, DI, TC,
CPXL18.1ESW	7	C18	861@1800	479	289.7	NA	NA	NA	EM, DI, TC,
CPXL18.1ESW	8	C18	923@1800	510	309	NA	NA	NA	EM, DI, TC,
CPXL18.1ESW	9	C18	861@1800	479	289.7	NA	NA	NA	EM, DI, TC,
CPXL18.1ESW	10	C18	923@1800	510	309	NA	NA	NA	EM, DI, TC,

Telephone Record

December 3, 2010
10:20 am and 3:40 pm

Steve Cushman
Chief Engineer
Peterson Caterpillar
San Leandro, CA
(510) 618-5504.

Bill Steiner
URS Corp

Subject: Fredonia Expansion Project – Caterpillar Model C18 emissions and status of California BACT/TBACT

Notes:

California BACT vs. TBACT/ATCM

- CARB's proposed ATCM (Air Toxic Control Measure) rule change to more closely parallel federal NSPS
    - Does CARB's proposal also change California's approach to BACT?
      Technically the ATCM does not mention BACT, but indirectly it affects BACT because the ATCM addresses NOx, CO, and VOC/POC.
    - Does CARB's BACT rule also arrive at Tier 2 for engines 560-900 bKW.
      Yes.

Model 18C Tier 2 Engine Specs and Compliance

- Convert nominal bKW and bHP.
  The C18 e-generator has a nominal (full load) 890 bhp engine.
- The nominal emission rates in Cat's spec sheet for the C18 e-gen look high (e.g., 0.035 g/hp-hr PM is way over the 0.015 CA BACT.
  These nominal emissions are at full load. EPA Tier compliance is based on weighed-average emission testing, which are typically much lower than full load, especially for NOx.[1] He thinks air districts typically allow applicants to rely on the weighted average emissions numbers for permitting. He explained that 50% load emissions are given a 50% weighting in the in average, and full load emissions have only about 10% weighting.
  Steve suggested that I go to CARB's on-line compliance testing database for weighted-average emissions.[2] The Model C18 is listed in the 18 liter category, and

[1] Steve explained that market pressures result in high emission numbers at full load. Customers typically base purchase decisions on full load fuel consumption, so manufacturers tune the engine for optimal fuel consumption at full load, which leads to higher emissions – particularly NOx.

[2] From my 3:40 followup call to Steve, the url is: http://arb.ca.gov/msprog/offroad/cert/cert.php. The Executive Order number for this engine is U-R-001-0380-1. Data are not yet available for Cat engines after 2010. The 2010 certified emission rates (g/kw-h) are: NOx+NMHC=5.80, CO=0.8, PM=0.08. The CARB certificate is attached. Given that 1 kw = 0.746 hp, these numbers convert to 4.33 g/hp-hr NOx+NMHC, 0.6 g/hp-hr CO, and 0.06 g/hp-hr PM. Assuming 0.01 g/hp-hr for NMHC, the NOx value is 4.32 g/hp-hr.

make sure to use the genset numbers[3]. If needed, he can provide emissions numbers at various loads.
Steve indicated that VOC is minimal for diesel engines. It would be acceptable to subtract 0.01 g/hp-hr (from the spec sheet) from the certified NOx+NMHC total to get NOx emission rate.

- What engine is Cat selling in CA that meets BACT?
  The C18 emergency generator is certified Tier 2 and meets BACT.

- Confirm the emergency generator size cutoff for Tier 2 vs Tier 3.
  Above 560 bkW, EPA Tier 2 applies to all emergency engines. Tier 3 applies below 560 bKW.

[3] Genset engine loading is more constant than other engine applications, so emissions are different.

Nonroad Diesel Engines

Background
Applicability
Tier 1-3 Emission Standards
Tier 4 Emission Standards
Test Cycles and Fuels
Engine Useful Life
Environmental Benefit and Cost

Background

Tier 1-3 Standards. The first federal standards (Tier 1) for new nonroad (or off-road) diesel engines were adopted in 1994 for engines over 37 kW (50 hp), to be phased-in from 1996 to 2000. In 1996, a Statement of Principles (SOP) pertaining to nonroad diesel engines was signed between EPA, California ARB and engine makers (including Caterpillar, Cummins, Deere, Detroit Diesel, Deutz, Isuzu, Komatsu, Kubota, Mitsubishi, Navistar, New Holland, Wis-Con, and Yanmar). On August 27, 1998, the EPA signed the final rule reflecting the provisions of the SOP. The 1998 regulation introduced Tier 1 standards for equipment under 37 kW (50 hp) and increasingly more stringent Tier 2 and Tier 3 standards for all equipment with phase-in schedules from 2000 to 2008. The Tier 1-3 standards are met through advanced engine design, with no or only limited use of exhaust gas aftertreatment (oxidation catalysts). Tier 3 standards for NOx+HC are similar in stringency to the 2004 standards for highway engines, however Tier 3 standards for PM were never adopted.

Tier 4 Standards. On May 11, 2004, the EPA signed the final rule introducing Tier 4 emission standards, which are to be phased-in over the period of 2008-2015 *[69 FR 38957-39273, 29 Jun 2004]*. The Tier 4 standards require that emissions of PM and NOx be further reduced by about 90%. Such emission reductions can be achieved through the use of control technologies—including advanced exhaust gas aftertreatment—similar to those required by the 2007-2010 standards for highway engines.

Nonroad Diesel Fuel. At the Tier 1-3 stage, the sulfur content in nonroad diesel fuels was not limited by environmental regulations. The oil industry specification was 0.5% (wt., max), with the average in-use sulfur level of about 0.3% = 3,000 ppm. To enable sulfur-sensitive control technologies in Tier 4 engines—such as catalytic particulate filters and NOx adsorbers—the EPA mandated reductions in sulfur content in nonroad diesel fuels, as follows:

- 500 ppm effective June 2007 for nonroad, locomotive and marine (NRLM) diesel fuels
- 15 ppm (ultra-low sulfur diesel) effective June 2010 for nonroad fuel, and June 2012 for locomotive and marine fuels

California. In most cases, federal nonroad regulations also apply in California, whose authority to set emission standards for new nonroad engines is limited. The federal Clean Air Act Amendments of 1990 (CAA) preempt California's authority to control emissions from new farm and construction equipment under 175 hp *[CAA Section 209(e)(1)(A)]* and require California to receive authorization from the federal EPA for controls over other off-road sources *[CAA Section 209 (e)(2)(A)]*.

The US nonroad emission standards are harmonized to a certain degree with European nonroad emission standards.

EPA emission standards for nonroad diesel engines are published in the US Code of Federal Regulations, Title 40, Part 89 *[40 CFR Part 89]*.

Applicability

The nonroad standards cover mobile *nonroad diesel engines* of all sizes used in a wide range of construction, agricultural and industrial equipment. The EPA definition of the *nonroad engine* is based on the principle of mobility/portability, and includes

engines installed on (1) self-propelled equipment, (2) on equipment that is propelled while performing its function, or (3) on equipment that is portable or transportable, as indicated by the presence of wheels, skids, carrying handles, dolly, trailer, or platform *[40 CFR 1068.30]*. In other words, nonroad engines are all internal combustion engines except motor vehicle (highway) engines, stationary engines (or engines that remain at one location for more than 12 months), engines used solely for competition, or engines used in aircraft.

Effective May 14, 2003, the definition of nonroad engines was changed to also include all diesel powered engines—including stationary ones—used in agricultural operations in California. This change applies only to engines sold in the state of California; stationary engines sold in other states are not classified as nonroad engines.

The nonroad diesel emission regulations are not applicable to all nonroad diesel engines. Exempted are the following nonroad engine categories:

- Engines used in railway locomotives; those are subject to separate EPA regulations.
- Engines used in marine vessels, also covered by separate EPA regulations. Marine engines below 37 kW (50 hp) are subject to Tier 1-2—but not Tier 4—nonroad standards. Certain marine engines that are exempted from marine standards may be subject to nonroad regulations.
- Engines used in underground mining equipment. Diesel emissions and air quality in mines are regulated by the Mine Safety and Health Administration (MSHA).
- Hobby engines (below 50 cm^3 per cylinder)

Examples of regulated applications include farm tractors, excavators, bulldozers, wheel loaders, backhoe loaders, road graders, diesel lawn tractors, logging equipment, portable generators, skid steer loaders, or forklifts.

A new definition of a compression-ignition (diesel) engine is used in the regulatory language since the 1998 rule, that is consistent with definitions established for highway engines. The definition focuses on the engine cycle, rather than the ignition mechanism, with the presence of a throttle as an indicator to distinguish between diesel-cycle and otto-cycle operation. Regulating power by controlling the fuel supply in lieu of a throttle corresponds with lean combustion and diesel-cycle operation. This language allows the possibility that a natural gas-fueled engine equipped with a sparkplug is considered a compression-ignition engine.

Tier 1-3 Emission Standards

The 1998 nonroad engine regulations are structured as a 3-tiered progression. Each tier involves a phase in (by horsepower rating) over several years. Tier 1 standards were phased-in from 1996 to 2000. The more stringent Tier 2 standards take effect from 2001 to 2006, and yet more stringent Tier 3 standards phase-in from 2006 to 2008 (Tier 3 standards apply only for engines from 37-560 kW).

Tier 1-3 emissions standards are listed in Table 1. Nonroad regulations are in the metric system of units, with all standards expressed in grams of pollutant per kWh.

Table 1
EPA Tier 1-3 Nonroad Diesel Engine Emission Standards, g/kWh (g/bhp·hr)

Engine Power	Tier	Year	CO	HC	NMHC+NOx	NOx	PM
kW < 8 (hp < 11)	Tier 1	2000	8.0 (6.0)	-	10.5 (7.8)	-	1.0 (0.75)
	Tier 2	2005	8.0 (6.0)	-	7.5 (5.6)	-	0.8 (0.6)
8 ≤ kW < 19 (11 ≤ hp < 25)	Tier 1	2000	6.6 (4.9)	-	9.5 (7.1)	-	0.8 (0.6)
	Tier 2	2005	6.6 (4.9)	-	7.5 (5.6)	-	0.8 (0.6)
19≤ kW < 37 (25 ≤ hp < 50)	Tier 1	1999	5.5 (4.1)	-	9.5 (7.1)	-	0.8 (0.6)
	Tier 2	2004	5.5 (4.1)	-	7.5 (5.6)	-	0.6 (0.45)
37 ≤ kW < 75 (50 ≤ hp < 100)	Tier 1	1998	-	-	-	9.2 (6.9)	-

(50 ≤ hp < 100)	Tier 2	2004	5.0 (3.7)	-	7.5 (5.6)	-	0.4 (0.3)
	Tier 3	2008	5.0 (3.7)	-	4.7 (3.5)	-	-†
75 ≤ kW < 130 (100 ≤ hp < 175)	Tier 1	1997	-	-	-	9.2 (6.9)	-
	Tier 2	2003	5.0 (3.7)	-	6.6 (4.9)	-	0.3 (0.22)
	Tier 3	2007	5.0 (3.7)	-	4.0 (3.0)	-	-†
130 ≤ kW < 225 (175 ≤ hp < 300)	Tier 1	1996	11.4 (8.5)	1.3 (1.0)	-	9.2 (6.9)	0.54 (0.4)
	Tier 2	2003	3.5 (2.6)	-	6.6 (4.9)	-	0.2 (0.15)
	Tier 3	2006	3.5 (2.6)	-	4.0 (3.0)	-	-†
225 ≤ kW < 450 (300 ≤ hp < 600)	Tier 1	1996	11.4 (8.5)	1.3 (1.0)	-	9.2 (6.9)	0.54 (0.4)
	Tier 2	2001	3.5 (2.6)	-	6.4 (4.8)	-	0.2 (0.15)
	Tier 3	2006	3.5 (2.6)	-	4.0 (3.0)	-	-†
450 ≤ kW < 560 (600 ≤ hp < 750)	Tier 1	1996	11.4 (8.5)	1.3 (1.0)	-	9.2 (6.9)	0.54 (0.4)
	Tier 2	2002	3.5 (2.6)	-	6.4 (4.8)	-	0.2 (0.15)
	Tier 3	2006	3.5 (2.6)	-	4.0 (3.0)	-	-†
kW ≥ 560 (hp ≥ 750)	Tier 1	2000	11.4 (8.5)	1.3 (1.0)	-	9.2 (6.9)	0.54 (0.4)
	Tier 2	2006	3.5 (2.6)	-	6.4 (4.8)	-	0.2 (0.15)
† Not adopted, engines must meet Tier 2 PM standard.							

Manufacturers who signed the 1998 Consent Decrees with the EPA may be required to meet the Tier 3 standards one year ahead of schedule (i.e. beginning in 2005).

Voluntary, more stringent emission standards that manufacturers could use to earn a designation of "Blue Sky Series" engines (applicable to Tier 1-3 certifications) are listed in Table 2.

Table 2
EPA Voluntary Emission Standards for
Nonroad Diesel Engines, g/kWh (g/bhp·hr)

Rated Power (kW)	NMHC+NOx	PM
kW < 8	4.6 (3.4)	0.48 (0.36)
8 ≤ kW <19	4.5 (3.4)	0.48 (0.36)
19 ≤ kW <37	4.5 (3.4)	0.36 (0.27)
37 ≤ kW < 75	4.7 (3.5)	0.24 (0.18)
75 ≤ kW <130	4.0 (3.0)	0.18 (0.13)
130 ≤ kW < 560	4.0 (3.0)	0.12 (0.09)
kW ≥ 560	3.8 (2.8)	0.12 (0.09)

Engines of all sizes must also meet smoke standards of 20/15/50% opacity at acceleration/lug/peak modes, respectively.

The regulations include several other provisions, such as averaging, banking and trading of emission credits and maximum "family emission limits" (FEL) for emission averaging.

Tier 4 Emission Standards

The Tier 4 emission standards—to be phased-in from 2008-2015— introduce substantial reductions of NOx (for engines above 56 kW) and PM (above 19 kW), as well as more stringent HC limits. CO emission limits remain unchanged from the Tier 2-3 stage.

Engines up to 560 kW. Tier 4 emission standards for engines up to 560 kW are listed in Table 3.

Table 3
Tier 4 Emission Standards—Engines up to 560 kW, g/kWh (g/bhp-hr)

Engine Power	Year	CO	NMHC	NMHC+NO_x	NO_x	PM
kW < 8 (hp < 11)	2008	8.0 (6.0)	-	7.5 (5.6)	-	0.4[a] (0.3)
8 ≤ kW < 19 (11 ≤ hp < 25)	2008	6.6 (4.9)	-	7.5 (5.6)	-	0.4 (0.3)
19 ≤ kW < 37 (25 ≤ hp < 50)	2008	5.5 (4.1)	-	7.5 (5.6)	-	0.3 (0.22)
	2013	5.5 (4.1)	-	4.7 (3.5)	-	0.03 (0.022)
37 ≤ kW < 56 (50 ≤ hp < 75)	2008	5.0 (3.7)	-	4.7 (3.5)	-	0.3[b] (0.22)
	2013	5.0 (3.7)	-	4.7 (3.5)	-	0.03 (0.022)
56 ≤ kW < 130 (75 ≤ hp < 175)	2012-2014[c]	5.0 (3.7)	0.19 (0.14)	-	0.40 (0.30)	0.02 (0.015)
130 ≤ kW ≤ 560 (175 ≤ hp ≤ 750)	2011-2014[d]	3.5 (2.6)	0.19 (0.14)	-	0.40 (0.30)	0.02 (0.015)

a - hand-startable, air-cooled, DI engines may be certified to Tier 2 standards through 2009 and to an optional PM standard of 0.6 g/kWh starting in 2010
b - 0.4 g/kWh (Tier 2) if manufacturer complies with the 0.03 g/kWh standard from 2012
c - PM/CO: full compliance from 2012; NOx/HC: Option 1 (if banked Tier 2 credits used)—50% engines must comply in 2012-2013; Option 2 (if no Tier 2 credits claimed)—25% engines must comply in 2012-2014, with full compliance from 2014.12.31
d - PM/CO: full compliance from 2011; NOx/HC: 50% engines must comply in 2011-2013

In engines of 56-560 kW rated power, the NOx and HC standards are phased-in over a few year period, as indicated in the notes to Table 3. The initial standards (PM compliance) are sometimes referred to as the 'interim Tier 4' (or 'Tier 4i'), 'transitional Tier 4' or 'Tier 4 A', while the final standards (NOx/HC compliance) are sometimes referred to as 'Tier 4 B'.

As an alternative to introducing the required percentage of Tier 4 compliant engines, manufacturers may certify all their engines to an *alternative NOx limit* in each model year during the phase-in period. These alternative NOx standards are:

- Engines 56-130 kW:
  - Option 1: NOx = 2.3 g/kWh = 1.7 g/bhp-hr (Tier 2 credits used to comply, MY 2012-2013)
  - Option 2: NOx = 3.4 g/kWh = 2.5 g/bhp-hr (no Tier 2 credits claimed, MY 2012-2014)
- Engines 130-560 kW: NOx = 2.0 g/kWh = 1.5 g/bhp-hr (MY 2011-2013)

Engines Above 560 kW. Tier 4 emission standards for engines above 560 kW are listed in Table 4. The 2011 standards are sometimes referred to as 'transitional Tier 4', while the 2015 limits represent final Tier 4 standards.

Table 4
Tier 4 Emission Standards—Engines Above 560 kW, g/kWh (g/bhp-hr)

Year	Category	CO	NMHC	NO_x	PM
2011	Generator sets > 900 kW	3.5 (2.6)	0.40 (0.30)	0.67 (0.50)	0.10 (0.075)
	All engines except gensets > 900 kW	3.5 (2.6)	0.40 (0.30)	3.5 (2.6)	0.10 (0.075)
2015	Generator sets	3.5 (2.6)	0.19 (0.14)	0.67 (0.50)	0.03 (0.022)

	All engines except gensets	3.5 (2.6)	0.19 (0.14)	3.5 (2.6)	0.04 (0.03)

Other Provisions. Existing Tier 2-3 smoke opacity standards and procedures continue to apply in some engines. Exempted from smoke emission standards are engines certified to PM emission standards at or below 0.07 g/kWh (because an engine of such low PM level has inherently low smoke emission).

The Tier 4 regulation does not require closed crankcase ventilation in nonroad engines. However, in engines with open crankcases, crankcase emissions must be measured and added to exhaust emissions in assessing compliance.

Similarly to earlier standards, the Tier 4 regulation includes such provisions as averaging, banking and trading of emission credits and FEL limits for emission averaging.

Test Cycles and Fuels

Nonroad engine emissions are measured on a steady-state test cycle that is nominally the same as the ISO 8178 C1, 8-mode steady-state test cycle. Other ISO 8178 test cycles are allowed for selected applications, such as constant-speed engines (D2 5-mode cycle), variable-speed engines rated under 19 kW (G2 cycle), and marine engines (E3 cycle).

Transient Testing. Tier 4 standards have to be met over both the steady-state test and the nonroad transient cycle, NRTC. The transient testing requirements begin with MY 2013 for engines below 56 kW, in 2012 for 56-130 kW, and in 2011 for 130-560 kW engines. Engines above 560 kW are not tested on the transient test. Also constant-speed, variable-load engines of any power category are not subject to transient testing. The NRTC protocol includes a cold start test. The cold start emissions are weighted at 5% and hot start emissions are weighted at 95% in calculating the final result.

Tier 4 nonroad engines will also have to meet not-to-exceed standards (NTE), which are measured without reference to any specific test schedule. The NTE standards become effective in 2011 for engines above 130 kW; in 2012 for 56-130 kW; and in 2013 for engines below 56 kW. In most engines, the NTE limits are set at 1.25 times the regular standard for each pollutant (in engines certified to NOx standards below 2.5 g/kWh or PM standards below 0.07 g/kWh, the NTE multiplier is 1.5). The NTE standards apply to engines at the time of certification, as well as in use throughout the useful life of the engine. The purpose of the added testing requirements is to prevent the possibility of "defeating" the test cycle by electronic engine controls and producing off-cycle emissions.

Certification Fuels. Fuels with sulfur levels no greater than 0.2 wt% (2,000 ppm) are used for certification testing of Tier 1-3 engines. From 2011, all Tier 4 engines will be tested using fuels of 7-15 ppm sulfur content. A transition from the 2000 ppm S specification to the 7-15 ppm specification will occur in the 2006-2010 period (see Certification Diesel Fuel).

A change from measuring total hydrocarbons to nonmethane hydrocarbons (NMHC) has been introduced in the 1998 rule. Since there is no standardized EPA method for measuring methane in diesel engine exhaust, manufacturers can either use their own procedures to analyze nonmethane hydrocarbons or measure total hydrocarbons and subtract 2% from the measured hydrocarbon mass to correct for methane.

Engine Useful Life

Emission standards listed in the above tables must be met over the entire useful life of the engine. EPA requires the application of deterioration factors (DFs) to all engines covered by the rule. The DF is a factor applied to the certification emission test data to represent emissions at the end of the useful life of the engine.

The engine useful life and the in-use testing liability period, as defined by the EPA for emission testing purposes, are listed in Table 5 for different engine categories. The Tier 4 rule maintains the same engine useful life periods.

Table 5
Useful Life and Recall Testing Periods

Power Rating	Rated Engine Speed	Useful Life		Recall Testing Period	
		hours	*years*	*hours*	*years*

< 19 kW	all	3000	5	2250	4
19-37 kW	constant speed engines ≥3000 rpm	3000	5	2250	4
	all others	5000	7	3750	5
>37 kW	all	8000	10	6000	7

Environmental Benefit and Cost

1998 Regulation

At the time of signing the 1998 rule, the EPA estimated that by 2010 NO_x emissions would be reduced by about a million tons per year, the equivalent of taking 35 million passenger cars off the road.

The costs of meeting the emission standards were expected to add under 1% to the purchase price of typical new nonroad diesel equipment, although for some equipment the standards may cause price increases on the order of 2-3%. The program was expected to cost about $600 per ton of NO_x reduced.

Tier 4 Regulation

When the full inventory of older nonroad engines are replaced by Tier 4 engines, annual emission reductions are estimated at 738,000 tons of NOx and 129,000 tons of PM. By 2030, 12,000 premature deaths would be prevented annually due to the implementation of the proposed standards.

The estimated costs for added emission controls for the vast majority of equipment was estimated at 1-3% as a fraction of total equipment price. For example, for a 175 hp bulldozer that costs approximately $230,000 it would cost up to $6,900 to add the advanced emission controls and to design the bulldozer to accommodate the modified engine.

EPA estimated that the average cost increase for 15 ppm S fuel will be 7 cents per gallon. This figure would be reduced to 4 cents by anticipated savings in maintenance costs due to low sulfur diesel.

CIRCUIT BREAKERS - SF6 (FOR GHG EMISSION CALCULATIONS)

SF6 Circuit Breakers for 230 kV substation (based on data from current units which will be replaced during this expansion project)

Make:	Mitsubishi		(per PSE; exact units unknown at this time)
Number of Units:	10		(8 for new units, and 2 to replace existing ones (Mitsubishi 3000's), per PSE)
SF6 per Model Unit:	117	lb/unit	Mitsubishi 200-SFMT-40E
	201	lb/unit	Mitsubishi 200-SFMT-63F
Total SF6:	1170	lb	Minimum
	2010	lb	Maximum
Leakage Rate:	0.5	%	Annual leakage (per PSE; conservative estimate)
SF6 Leakage:	5.85	lb/yr	Minimum
	10.05	lb/yr	Maximum
SF6 GWP:	23,900		
CO2e:	139,815	lb/yr	Minimum
	69.91	tpy	
	240,195	lb/yr	Maximum
	120.10	tpy	

Notes:

GWP (Global Warming Potential) from 40CFR98, Subpart A, Table A-1.