Pico Power Project

Appendix 8.1-A
Detailed Emissions Calculations

October 2002

Table 8.1A-1. Startup and Shutdown Emission Values for the LM6000-PC Turbine

Pollutant	Cold Start 3 Hr Duration	Hot Start 1 Hour Duration	Shutdown 1 Hr Duration	Notes
NOx	5.3 lbs/hr/unit	9.6 lbs/hr/unit	3.2 lbs/hr/unit	Las Vegas Cogen LP
CO	3.2 lbs/hr/unit	5.7 lbs/hr/unit	1.9 lbs/hr/unit	Source A329, August 2000
VOC	3.3 lbs/hr/unit	6.0 lbs/hr/unit	2.0 lbs/hr/unit	4-LM6000 PC Units

Pollutant	Startup 1 Hour Duration	Shutdown 1 Hr Duration	Notes
NOx	8.55 lbs/hr/unit	ND	Los Esteros Energy, Center, AFC Section 8.1, Appendix 8.1, August 2001
CO	6.24 lbs/hr/unit	ND	
POC	1.19 lbs/hr/unit	ND	
NOx	8.4 lbs/hr/unit	ND	Calpine-Gilroy Cogen-Phase II AFC, Section 8.1, June 2001
CO	6.13 lbs/hr/unit	ND	
POC	1.17 lbs/hr/unit	ND	

Table 8.1A-2
Detailed Calculations for Maximum Hourly, Daily and Annual Criteria Pollutant Emissions

Maximum Hourly, Daily and Annual Emissions		Base Load		Cold Start		Hot Start		NOx Base Load	NOx Cold Start	NOx Hot Start	SO2	CO Base Loa	CO Cold Start	CO Hot Start	POC Base Loa	POC Cold Start	POC Hot Start	PM10
	max. hour	hrs/day	hrs/yr	hrs/day	hrs/yr	hrs/day	hrs/yr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr.	lb/hr	lb/hr	lb/hr
Turbine 1, no DB	1	8	7108	1	52	1	200	4.40	49.00	49.00	0.32	4.29	45.00	45.00	1.20	3.00	3.00	3.00
Turbine 2, no DB	0	8	7108	1	52	1	200	4.40	49.00	49.00	0.32	4.29	45.00	45.00	1.20	3.00	3.00	3.00
Turbine 1, w/ DB&PA	0	16	1400	0	0	0	0	5.61	0	0	0.41	5.47	0	0	1.60	0.00	0.00	4.30
Turbine 2, w/ DB&PA	1	16	1400	0	0	0	0	5.61	0	0	0.41	5.47	0	0	1.60	0.00	0.00	4.30
Cooling tower	1	24	8760	0	0	0	0	0.00	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.51

	NOx			SO2			CO			POC			PM10		
	Max	Max	Total	Max	Max	Total	Max	Max	Total	Max	Max	Total	Max	Max	Total
	lb/hr	lb/day	tpy	lb/hr	lb/day	tpy	lb/hr	lb/day	tpy	lb/hr	lb/day	tpy	lb/hr	lb/day	tpy
Turbine 1, no DB	49.00	133.20	21.81	0.32	3.20	1.18	45.00	124.32	20.92	3.00	15.60	4.64	3.00	30.00	11.04
Turbine 2, no DB	0.00	133.20	21.81	0.00	3.20	1.18	0.00	124.32	20.92	0.00	15.60	4.64	0.00	30.00	11.04
Turbine 1, w/ DB	0.00	89.76	3.93	0.00	6.56	0.29	0.00	87.52	3.83	0.00	25.60	1.12	0.00	68.80	3.01
Turbine 2, w/ DB	5.61	89.76	3.93	0.41	6.56	0.29	5.47	87.52	3.83	1.60	25.60	1.12	4.30	68.80	3.01
Cooling tower	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	12.34	2.25
Total	54.61	445.92	51.48	0.73	19.52	2.93	50.47	423.68	49.49	4.60	82.40	11.53	7.81	209.94	30.35
	lb/hr	lb/day	tpy	lb/hr	lb/day	tpy	lb/hr	lb/day	tpy	lb/hr	lb/day	tpy	lb/hr	lb/day	tpy

Assumptions: Each turbine has one cold start and one hot start on worst case day; startups lag by two hours.

Notes for Table 8.1A-2
Calculation of Maximum Hourly, Daily and Annual Emissions

Calculation of Maximum Hourly Emissions

a. Turbines/HRSGs

As hourly NO_x, CO and POC emissions from the turbines are higher during startup than during full load operation, highest hourly emissions occur while one turbine is in startup mode. Except for startup, maximum hourly emissions from the turbines occur while operating at full load and 94 degF with power augmentation and duct firing. Emissions under this operating mode are higher than under part load or low temperature operations as the duct burner operates only at full load and high temperature conditions. Emissions under full and part load conditions at maximum and minimum site temperature conditions are shown in Tables 8.1A-3a and 3b.

Both turbines may be started up within the same 1-hour timeframe. Therefore highest hourly emissions from the turbines will occur when both turbines are starting up within the same 1-hour timeframe.

b. Auxiliary Boiler

No auxiliary boiler is proposed for the PPP project.

c. Emergency Generator and Fire Pump

No emergency generator set or fire pump is proposed for the PPP project.

d. Cooling Tower

Maximum hourly emissions occur while the cooling tower is operating at full capacity.

Calculation of Maximum Daily Emissions

a. Turbines/HRSGs

As discussed above for the hourly emissions calculations, hourly NO_x, CO and POC emissions are highest during startup. The operating conditions having the next highest hourly emissions are full load operation at 94 degF with power augmentation and duct firing, followed by full load operation at 34 degF. Duct burner operation will not exceed 16 hours a day. Therefore maximum daily turbine emissions will occur on a day when each turbine has one hot and one cold start, operates at full load with power augmentation and duct firing for 16 hours, and operates at full load without power augmentation and duct burning for the rest of the day. Again, both turbines can be in startup mode at the same time.

b. Auxiliary Boiler

No auxiliary boiler is proposed for the RCEC project.

c. Emergency Generator and Fire Pump

No emergency generator set or fire pump is proposed for the PICO project.

d. Cooling Tower

Maximum daily cooling tower emissions will occur while the cooling tower is in operation for 24 hours.

8.1A.1.3 Maximum Annual Emissions

a. Turbines/HRSGs

Each turbine is assumed to have a maximum of 52 cold starts (52 hours) and 200 hot starts (200 hours) each year. Duct firing will be limited to the equivalent of 1400 full load hours per year per turbine. Therefore the calculation of maximum annual emissions from each turbine is based on the following assumptions:

52 hours of cold start operation
200 hours of hot start operation
1400 hours of operation with power augmentation and duct firing
7108 hours of operation at full load

b. Auxiliary Boiler

No auxiliary boiler is proposed for the PPP project.

c. Emergency Generator and Fire Pump

No emergency generator set or fire pump is proposed for the PPP project.

Table 8.1A-3
Calculation of Noncriteria Pollutant Emissions for PICO Turbines/Duct Burners

Calculation of Noncriteria Pollutant Emissions from Gas Turbines (each turbine)					Emission Rates for Modeling (g/s each turbine)		Modeled Impacts ug/m3 (6)	
Compound	Emission Factor, lb/MMscf (1)	Maximum Hourly Emissions, lb/hr/tur (2)	Maximum Daily Emissions, lb/day/tur	Annual Emissions, ton/yr/tur (3)	One-hour g/s/turbine	Annual g/s/turbine	One-hour ug/m3	Annual ug/m3
Acetaldehyde	4.08E-02	2.48E-02	5.95E-01	8.81E-02	3.12E-03	2.53E-03	1.63E-01	1.86E-03
Acrolein	3.69E-03	2.24E-03	5.38E-02	7.97E-03	2.82E-04	2.29E-04	1.48E-02	1.69E-04
Ammonia	(4)	8.30E+00	3.47E+02	2.97E+01	1.046	8.54E-01	5.46E+01	6.28E-01
Benzene	3.33E-03	2.02E-03	4.86E-02	7.19E-03	2.55E-04	2.07E-04	1.33E-02	1.52E-04
1,3-Butadiene	1.27E-04	7.72E-05	1.85E-03	2.74E-04	9.72E-06	7.89E-06	5.08E-04	5.81E-06
Ethylbenzene	1.79E-02	1.09E-02	2.61E-01	3.87E-02	1.37E-03	1.11E-03	7.16E-02	8.18E-04
Formaldehyde	1.10E-01	6.68E-02	1.60E+00	2.38E-01	8.42E-03	6.83E-03	4.40E-01	5.03E-03
Hexane	2.59E-01	1.57E-01	3.78E+00	5.59E-01	1.98E-02	1.61E-02	1.04E+00	1.18E-02
Naphthalene	1.33E-03	8.08E-04	1.94E-02	2.87E-03	1.02E-04	8.26E-05	5.32E-03	6.08E-05
PAHs (5)	1.65E-04	1.00E-04	2.40E-03	3.56E-04	1.26E-05	1.02E-05	6.59E-04	7.53E-06
Propylene	7.70E-01	4.68E-01	1.12E+01	1.66E+00	5.89E-02	4.78E-02	3.08E+00	3.52E-02
Propylene oxide	2.96E-02	1.80E-02	4.32E-01	6.39E-02	2.27E-03	1.84E-03	1.18E-01	1.35E-03
Toluene	7.10E-02	4.31E-02	1.04E+00	1.53E-01	5.44E-03	4.41E-03	2.84E-01	3.25E-03
Xylene	2.61E-02	1.59E-02	3.81E-01	5.64E-02	2.00E-03	1.62E-03	1.04E-01	1.19E-03
NOx					0.707	0.739	36.92	0.544
SO2					0.0517	0.0517	2.70	0.038
CO					0.689		35.98	

Notes:

(1) Provided by BAAQMD from Ventura County APCD and CATEF databases.

(2) Based on maximum hourly turbine fuel use of 610.6 MMBtu/hr/turbine (with duct burner)
and fuel HHV of 1005 Btu/scf gives 0.6076 MMscf/hr/turbine.

(3) Based on maximum annual turbine fuel use of 4,341,272 MMBtu/yr/turbine (with duct burner)
and fuel HHV of 1005 Btu/scf gives 4319.6736 MMscf/yr/turbine.

(4) Based on 10 ppm ammonia slip from SCR system.

(5) Polycyclic aromatic hydrocarbons, excluding naphthalene (treated separately).

(6) Modeled impacts: 52.22044 ug/m3 per g/s/turbine (2 turbines @ 1 g/s/turbine), 1-hour average
0.73570 ug/m3 per g/s/turbine (2 turbines @ 1 g/s/turbine), annual average
except ammonia modeled at actual emission rates (includes cooling tower)

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Table 8.1A-4
Calculation of Noncriteria Pollutant Emissions from PICO Cooling Tower (1)

	Calculation of Noncriteria Pollutant Emissions from Cooling Tower (all cells)					Emission Rates for Modeling (g/s each cell)		Modeled Impacts ug/m3 (2)	
Constituent	Concentration in Cooling Tower Return Water *		Maximum Hourly Emissions, lb/hr	Maximum Daily Emissions, lb/day	Annual Emissions, ton/yr	One-hour g/s/cell	Annual g/s/cell	One-hour ug/m3	Annual ug/m3
Ammonia	7	ppm	6.12E-04	1.47E-02	2.68E-03	2.57E-05	2.57E-05	(3)	(3)
Arsenic	0.0082	ppm	7.17E-07	1.72E-05	3.14E-06	3.01E-08	3.01E-08	8.40E-06	1.00E-06
Cadmium	0.0035	ppm	3.06E-07	7.34E-06	1.34E-06	1.29E-08	1.29E-08	3.59E-06	4.28E-07
Chromium	0.007	ppm	6.12E-07	1.47E-05	2.68E-06	2.57E-08	2.57E-08	7.17E-06	8.56E-07
Copper	0.021	ppm	1.84E-06	4.41E-05	8.04E-06	7.71E-08	7.71E-08	2.15E-05	2.57E-06
Lead	0.007	ppm	6.12E-07	1.47E-05	2.68E-06	2.57E-08	2.57E-08	7.17E-06	8.56E-07
Mercury	0.000018	ppm	1.57E-09	3.78E-08	6.89E-09	6.61E-11	6.61E-11	1.84E-08	2.20E-09
Nickel	0.049	ppm	4.28E-06	1.03E-04	1.88E-05	1.80E-07	1.80E-07	5.02E-05	5.99E-06
Silver	0.007	ppm	6.12E-07	1.47E-05	2.68E-06	2.57E-08	2.57E-08	7.17E-06	8.56E-07
Zinc	0.363	ppm	3.17E-05	7.62E-04	1.39E-04	1.33E-06	1.33E-06	3.72E-04	4.44E-05

Notes:

(1) Emissions calculated from maximum total drift rate of 87.42 lb/hr for 3 cells

(2) Modeled impacts: 279.00970 ug/m3 per g/s/cell (1 g/s/cell), 1-hour average
33.30345 ug/m3 per g/s/cell (1 g/s/cell), annual average

(3) Modeled with turbines (see above).

* Based on 7 cycles of concentration for Reclaimed water use (avg constituents)

Table 8.1A-5
Ammonia Emissions Calculations

Calculation of ammonia emissions from the gas turbines and duct burners is based on the proposed ammonia slip limit of 10 ppmvd.

Gas Turbines

Data supplied by PPP pertaining to the operational scenarios for the gas turbines and duct burners indicates the following with respect to ammonia emissions for each gas turbine.

Table 8.1A-5. Ammonia Emissions (each turbine)

Scenario	Emissions
Maximum hourly, Cases 11,12 (W/Duct Burners, Pwr Aug, at 61 & 94 deg F)	8.3 lbs/hr 0.01372 lb/mmbtu
Maximum annual, based on proposed Annual operating scenario.	29.7 tons/yr
Annualized hourly emissions, at 8760 hrs/yr	6.78 lbs/hr

Additional Air Quality Data Summaries

Additional air quality data summaries for both the Bay Area region and Santa Clara County are presented in Appendix 8.1B.

Table 8.1A-6
Calculation of Cooling Tower Emissions

Cooling Tower Flow Characteristics: (from SVP-PICO)

Water Flow Rate, 10E6 lbm/hr	17.48
Water Flow Rate, gal/min	34,980
Drift Rate, %	0.0005
Drift, lbm water/hr	87.42

PM10 Emissions based on TDS Level

TDS level, ppm	5880
PM10, lb/hr	0.514
PM10, tpy	2.25

PM10 Emissions for Modeling

PM10 Emissions per cell, g/s	2.16E-02

Table 8.1A-7
Calculation of Approximate Daily and Annual Turbine/Duct Burner Fuel Use
Pico Power Project

	Operating Hours			Max Hourly Fuel Use, MMBtu
	max. hour	hrs/day	hrs/yr	
Turbine 1, no DB	0	24	7108	473.7
Turbine 2, no DB	0	24	7108	473.7
Aux Boiler*	0	0	0	0
Turbine 1, w/ DB	1	16	1400	610.6
Turbine 2, w/ DB	1	16	1400	610.6
T1-Start/Shutdown	0	0	252	473.7
T2-Start/Shutdown	0	0	252	473.7

	Fuel Use		
	MMBtu/hr	MMBtu/day	MMBtu/yr
Turbine 1, no DB	473.7	11,368.8	3,367,060
Turbine 2, no DB	473.7	11,368.8	3,367,060
Aux Boiler*	0	0.0	0
Turbine 1, w/ DB	610.6	9,769.6	854,840
Turbine 2, w/ DB	610.6	9,769.6	854,840
Startup/Shutdown	473.7	1,421.1	238,745
Total, GTs	**2,642.3**	**43,697.9**	**8,682,544.0**
Total, One GT		21,849.0	4,341,272

Due to the wide variations in the capability of the turbines and duct burners with respect to daily and annual operations, the values presented above are approximations only.

* No Aux Boiler proposed for this facility.