SITE-WIDE EMISSIONS SUMMARY FOR GHG EMISSIONS

Annual Potential GHG Emissions

EPN	Emission Point Description	Potential GHG Emissions (short tons per year) CO_2	CH_4	N_2O	SF_6	Total CO_2e [1]
1	Combustion Turbine 1/Duct Burner - Normal Operations	1,570,399.36	97.82	40.10	-	1,584,988.36
1	Combustion Turbine 1/Duct Burner - MSS Operations [2]	-	1,684.41	-	-	42,110.25
2	Combustion Turbine 2/Duct Burner - Normal Operations	1,570,399.36	97.82	40.10	-	1,584,988.36
2	Combustion Turbine 2/Duct Burner - MSS Operations [2]	-	1,684.41	-	-	42,110.25
4	Fire Pump Engine	31.20	1.27E-03	2.52E-04	-	31.31
5	Emergency Generator	155.10	6.29E-03	1.26E-03	-	155.63
7	Auxiliary Boiler	23,056.00	0.43	0.04	-	23,079.86
FUG_GHG	Fugitive SF_6 Circuit Breaker Emissions	-	-	-	0.005	116.68
FUG_GHG	Components Fugitive Leak Emissions	-	1.02	-	-	25.41
	Total GHG Emissions - 1 on 1 Scenario	**1,593,641.66**	**1,783.68**	**40.14**	**0.005**	**1,650,507.50**
	Total GHG Emissions - 2 on 1 Scenario	**3,164,041.02**	**3,565.91**	**80.24**	**0.005**	**3,277,606.11**

[1] Per 40 CFR 98 - Mandatory Greenhouse Gas Reporting, Subpart A, Table A-1 (Federal Register 71948 / Vol. 78, No. 230, November 29, 2013). Total CO_2e emissions are calculated based on the following Global Warming Potentials.

CO_2	1
CH_4	25
N_2O	298
SF_6	22,800

[2] MSS emissions for combustion turbines include emissions from startup and shutdown combustion activities as well as natural gas purging activities. Emissions of CO_2 and N_2O during normal operations are greater than the emissions during SUSD operations. Therefore, maximum annual emissions are calculated based on emissions during normal operations. However, CH_4 emissions during SUSD operations are greater than the emissions during normal operations. Therefore, CH_4 emissions during SUSD events are calculated separately and the annual CH_4 emissions from normal operations are calculated by excluding the SUSD hours.

GHG EMISSION CALCULATIONS FOR COMBUSTION TURBINES - NORMAL OPERATIONS

FIN: 1 & 2
EPN: 1 & 2
Mitsubishi MHI 501GAC Combustion Turbines in 1x1 or 2x1 Combined-Cycle Configuration

Input Data[1]

Parameter	Value	Units
Annual Hours of Operation per Turbine[1]	8,760	hr/yr
Annual Maximum Hours of Operation w/o Duct Burner[1]	3,560	hr/yr
Annual Maximum Hours of Operation w/ Duct Burner[1]	5,200	hr/yr
Annual Maximum Hours in SUSD Mode per Turbine	712	hr/yr
Rated Output of Each Combustion Turbine at 20 deg F, Unfired[2]	305	MW
Rated Output for Steam Turbine, 1x1 Fired Configuration[2]	174	MW
Rated Output of 1x1 Combined Cycle Configuration, Fired at 20 °F[2]	479	MW
Combustion Turbine Capacity (HHV basis) at 20 °F [2]	2,903	MMBtu/hr/turbine
Duct Burner Capacity (HHV basis)[2]	250	MMBtu/hr
Total Combustion Turbine Capacity (HHV basis, each turbine)[2]	3,153	MMBtu/hr/turbine
Natural Gas High Heat Value, Site-Info (HHV) [2]	1,027	btu/scf
Number of Turbines	2	(for 2 x 1 scenario)

[1] Hours of operation data provided by Mr. Larry Carlson (Tenaska) via email to Ms. Latha Kambham (Trinity Consultants) on October 24, 2012.
Hours of operation in SUSD mode is based on 356 hours in SU mode and 356 hours in SD mode.
[2] Turbine and duct burner capacity and site-specific natural gas HHV are based on MHI 501GAC model data provided by Mr. Larry Carlson (Tenaska) via email to Ms. Latha Kambham (Trinity Consultants) on January 17, 2013, February 5, 2013 and February 11, 2013.

Proposed Hourly and Annual Emissions - GHG Pollutants - Based on Vendor Data

Pollutant	Hourly Emissions per Turbine[1]		Annual Emissions for 1x1 Scenario[2]	Annual Emissions for 2x1 Scenario	Annual Emissions for 1x1 Scenario[3]	Annual Emissions for 2x1 Scenario
	Without Duct Burner (lb/hr)	With Duct Burner (lb/hr)	(metric tpy)	(metric tpy)	(short tpy)	(short tpy)
CO_2	341,162.00	370,435.00	1,424,656.95	2,849,313.90	1,570,399.36	3,140,798.7
CH_4	21.77	25.70	88.74	177.48	97.82	195.64
N_2O	8.71	9.46	36.38	72.76	40.10	80.20
CO_{2e}	344,301.83	373,896.58	1,437,892.01	2,875,784.02	1,584,988.36	3,169,976.72

[1] Emissions data for combustion turbines provided by Mr. Larry Carlson (Tenaska) via email to Ms. Latha Kambham (Trinity Consultants) on February 5, 2013. Emission data are based on MHI 501 GAC combustion turbine.
[2] Emissions of CO_2 and N_2O during normal operations are greater than the emissions during SUSD operations. Therefore, maximum annual emissions are calculated using emissions during normal operations. However, CH_4 emissions during SUSD operations are greater than the emissions during normal operations. Therefore, CH_4 emissions during SUSD events are calculated separately and the annual CH_4 emissions from normal operations are calculated by excluding the SUSD hours.
Annual emissions for CO_2 and N_2O are calculated based on the maximum hourly emissions and hours of operation with and without duct burner, as follows:
Annual Emissions (tpy) =
[Hourly Emission Rate w/o Duct Burner (lb/hr) x Hours of Operation w/o Duct Burner (hrs/yr) + Hourly Emission Rate w/ Duct Burner (lb/hr) x Hours of Operation w/ Duct Burner (hrs/yr)] x (1 ton /2,000 lb) x (1 metric ton/1.1023 short ton)

$$\text{Annual Emissions of } CO_2 \text{ (tpy)} = \left(\frac{341{,}162.00 \text{ lb}}{\text{hr}} \times \frac{3{,}560 \text{ hr}}{\text{yr}} + \frac{370{,}435.00 \text{ lb}}{\text{hr}} \times \frac{5{,}200 \text{ hr}}{\text{yr}} \right) \times \frac{1 \text{ short ton}}{2{,}000 \text{ lb}} \times \frac{\text{metric ton}}{1.1023 \text{ short ton}} = 1{,}424{,}656.95 \text{ tpy}$$

Annual emissions for CH_4 are calculated based on the maximum hourly emissions and hours of operation with and without duct burner, as follows:
Annual Emissions (tpy) =
[Hourly Emission Rate w/o Duct Burner (lb/hr) x (Hours of Operation w/o Duct Burner - SUSD Hours) (hrs/yr) + Hourly Emission Rate w/ Duct Burner (lb/hr) x Hours of Operation w/ Duct Burner (hrs/yr)] x (1 ton /2,000 lb) x (1 metric ton/1.1023 short ton)

$$\text{Annual Emissions of } CH_4 \text{ (tpy)} = \left(\frac{21.77 \text{ lb}}{\text{hr}} \times \frac{3{,}560 - 712 \text{ hr}}{\text{yr}} + \frac{25.70 \text{ lb}}{\text{hr}} \times \frac{5{,}200 \text{ hr}}{\text{yr}} \right) \times \frac{1 \text{ short ton}}{2{,}000 \text{ lb}} \times \frac{\text{metric ton}}{1.1023 \text{ short ton}} = 88.74 \text{ tpy}$$

metric ton to short ton 1.1023 short ton/metric ton
Per 40 CFR 98 - Mandatory Greenhouse Gas Reporting, Subpart A, Table A-1 (Federal Register 71948 / Vol. 78, No. 230, November 29, 2013). Total CO_2e emissions are calculated based on the following Global Warming Potentials.

CO_2	1
CH_4	25
N_2O	298

[3] Annual Emissions (short tpy) = Annual Emission (metric tpy) * 1.1023 (short ton/metric ton)
To be consistent with the reporting format in GHG Mandatory Reporting Rule, the emissions rounded as follows: CO_2 - 1 decimal place, CH_4 - 2 decimal places, N_2O - 3 decimal places, and CO_2e - rounded to nearest digit.

GHG CALCULATIONS FOR COMBUSTION TURBINES - STARTUP & SHUTDOWN ACTIVITIES

FINs: 1 & 2

EPNs: 1 & 2

Proposed Startup/Shutdown Events, Duration, and Emissions

Parameter	Value (per CT)	Units
Max Annual Starts Per Unit	356	events/yr
Max Annual Shutdowns Per Unit	356	events/yr
Max Number of Purging Events	356	events/yr
Startup and Shutdown Duration[1]	1	hr/SU or SD event
Max. Hourly Emission Rates during Startup [2]	4,710	lb CH_4/hr
Max. Hourly Emission Rates during Purging [3]	43	lb CH_4/hr

[1] Information provided by Mr. Larry Carlson (Tenaska) via email to Ms. Latha Kambham (Trinity Consultants) on September 9, 2014.
Startup period is defined as the period from the first fire to the time combustion turbine achieves 50% load and the SCR has been placed into operation.

[2] Emission rates provided by Mr. Larry Carlson (Tenaska) via email to Ms. Latha Kambham (Trinity Consultants) on September 9, 2014.

[3] Information provided by Mr. Larry Carlson (Tenaska) via email to Ms. Latha Kambham (Trinity Consultants) on August 28, 2014.

Proposed Startup/Shutdown Emissions per Combustion Turbine

Pollutant	Max. Hourly SUSD Emissions [1]	Max. Annual SUSD Emissions [2]	Max. Annual Purging Emissions [3]	Potential Annual Emissions	
				1x1 Scenario [4]	2x1 Scenario [5]
	(lb/hr/turbine)	(tpy/turbine)	(tpy/turbine)	(tpy)	(tpy)
CH_4	4,710	1,677	7.65	1,684.41	3,368.82
			Annual CO_2e (tpy) [6]	42,110.25	84,220.50

[1] Hourly emissions during a shutdown event are lower than the startup event. However, to be conservative, it is assumed that emission rates from startup and shutdown events are the same. In addition, it is assumed that only one type of event (i.e., startup or shutdown) will occur in an hour.

[2] Annual emissions are estimated based on the maximum hourly emission rate and the total number of startup and shutdown events per year.
Annual SUSD Emissions (tpy) = Hourly Emission Rate (lb/hr) x (No. of startup events/yr + No. of shutdown events/yr) x (1 ton /2,000 lb)

$$\text{Annual SUSD Emissions of } CH_4\text{, per Combustion Turbine (tpy)} = \frac{4{,}710 \text{ lb}}{\text{hr}} \times \frac{(356 \text{ startups} + 356 \text{ shutdowns})}{\text{yr}} \times \frac{1 \text{ ton}}{2{,}000 \text{ lb}} = 1{,}677 \text{ tpy}$$

[3] Annual Purging Emissions (tpy) = Hourly Emission Rate during Purging (lb/hr) x No. of Purging Events per Year (events/yr) x 1 hr / event x (1 ton /2,000 lb)

$$\text{Annual Purging Emissions of } CH_4\text{, per Combustion Turbine (tpy)} = \frac{43 \text{ lb}}{\text{hr}} \times \frac{356 \text{ events}}{\text{yr}} \times \frac{1 \text{ hr}}{\text{event}} \times \frac{1 \text{ ton}}{2{,}000 \text{ lb}} = 7.65 \text{ tpy}$$

[4] Annual emissions for 1 x1 scenario (tpy) = Max. Annual SUSD Emissions per Turbine (tpy)+ Max. Annual Purging Emissions per Turbine (tpy)

[5] Annual emissions for 2 x1 scenario = 2 * Annual emissions for 1 x 1 scenario

[6] Global Warming Potential of CH_4 = 25 per 40 CFR 98, Subpart A, Table A-1 (Federal Register 71948 / Vol. 78, No. 230, November 29, 2013)