Table A-1
GHG Emission Summary
Formosa Plastic Corporation, Texas
2012 Expansion Project: Gas Turbines
March 2014

Source Name	Operating Scenario	EPN	Detailed Calculations in	GHG Mass Emissions (tpy)	CO_2e (tpy)
Gas Turbine 1	Firing 100% Natural Gas	7K	Table A-2	463,071	463,540
Gas Turbine 2		7L		463,071	463,540
Duct Firing, Unit 1 [1]	Firing 100% Natural Gas	7K	Table A-3	61,449	61,511
	Firing 100% OL Tail Gas		Table A-4	53,041	53,103
	Firing 100% Hydrogen [2]		N/A	0	0
Duct Firing, Unit 2 [1]	Firing 100% Natural Gas	7L	Table A-3	61,449	61,511
	Firing 100% OL Tail Gas		Table A-4	53,041	53,103
	Firing 100% Hydrogen [2]		N/A	0	0
Subtotal Total, Combined Cycle Units [3] =				**1,049,040**	**1,050,103**
Turbine Startup, Fuel Line Maintenance [4]	Startup, Maintenance	7K-NGVENT, 7L-NGVENT	Table A-5	1.24	29.9
Fugitive Components [4]	N/A	NG-FUG	Table A-6	20.90	506.1
SF_6 Electrical Insulation [4]	N/A	SF6-FUG	Table A-7	<0.01	28.2
Total =				**1,049,062**	**1,050,667**

Notes:

[1] The duct burners may fire up to 100% heat input on any listed fuel or any combination thereof.

[2] Combustion of 100% hydrogen fuel stream in the duct burners does not result in any GHG emissions (carbon content is zero).

[3] Total GHG emissions are calculated as the maximum emissions from duct burner firing on any one of the three fuel types, plus GHG emission contributions from the Gas turbines.

[4] FPC TX Requests that No Emission Limit be established for this source.
Compliance will be assured with the design/work practice standard as specified in the permit.

Table A-2

GHG Emission Calculations - Natural Gas Combustion - Gas Turbines

Formosa Plastic Corporation, Texas

2012 Expansion Project: Gas Turbines

March 2014

GHG Emissions Contribution From Natural Gas Fired Combustion Turbines:

EPN	Average Heat Input (MMBtu/hr)	Annual Heat Input (MMBtu/yr)	Pollutant	Emission Factor (kg/MMBtu)[1]	GHG Mass Emissions[2] (tpy)	Global Warming Potential[3]	CO_2e (tpy)
7K	997	8,733,720	CO_2	53.02	463,062	1	463,062
			CH_4	1.0E-03	8.73	25	218.3
			N_2O	1.0E-04	0.87	298	260.3
				Totals	**463,071**		**463,540**
7L	997	8,733,720	CO_2	53.02	463,062	1	463,062
			CH_4	1.0E-03	8.73	25	218.3
			N_2O	1.0E-04	0.87	298	260.3
				Totals	**463,071**		**463,540**
Total for 2 Turbines					***926,143***		***927,081***

Notes:

1. CO_2 GHG factor from Table C-1 of 40 CFR 98 Mandatory Greenhouse Gas Reporting (GHG MRR).

CH_4 and N_2O GHG factors based on Table C-2 of GHG MRR.

2. CO_2 emissions based on 40 CFR Part 98, Subpart C, Equation C-1.

3. Global Warming Potential factors based on Table A-1 of 40 CFR 98 Mandatory Greenhouse Gas Reporting.

Sample Calculation, CO_2:

GHG Mass Emissions (metric ton/yr) = 0.001 x 8733720 (MMBtu/yr) x 53.02 kg/MMBtu = 463062

CO2e (metric ton/yr) = 463062 (tpy) x 1 = 463062

Table A-3
GHG Emission Calculations - Duct Burners Natural Gas Combustion
Formosa Plastic Corporation, Texas
2012 Expansion Project: Gas Turbines
March 2014

GHG Emissions Contribution From Natural Gas Fired Combustion:					Emissions per Unit			
Source Type	**Average Heat Input/Unit (MMBtu/hr)**	**Annual Avg Heat Input, Each Unit (MMBtu/yr)**	**Pollutant**	**Emission Factor (kg/MMBtu)[1]**	**GHG Mass Emissions[2] (metric ton/yr)**	**Global Warming Potential[3]**	**CO_2e (metric ton/yr)**	**CO_2e (tpy)**
Turbine 1 Duct Burners	120	1,051,200	CO_2	53.02	55,735	1	55,735	61,447
			CH_4	1.0E-03	1.05	25	26.3	29.0
			N_2O	1.0E-04	0.11	298	31.3	34.5
				Totals	**55,736**		**55,792**	**61,511**
Turbine 2 Duct Burners	120	1,051,200	CO_2	53.02	55,735	1	55,735	61,447
			CH_4	1.0E-03	1.05	25	26.3	29.0
			N_2O	1.0E-04	0.11	298	31.3	34.5
				Totals	**55,736**		**55,792**	**61,511**
Total, All Natural Gas Duct Firing					***111,472***		***111,584***	***123,022***

Notes:

1. CO2 GHG factor from Table C-1 of 40 CFR 98 Mandatory Greenhouse Gas Reporting (GHG MRR).
CH4 and N2O GHG factors based on Table C-2 of GHG MRR.
2. CO_2 emissions based on 40 CFR Part 98, Subpart C, Equation C-1.
3. Global Warming Potential factors based on Table A-1 of 40 CFR 98 Mandatory Greenhouse Gas Reporting.
Sample Calculation, CO_2:

GHG Mass Emissions (metric ton/yr) = 0.001 x 1051200 (MMBtu/yr) x 53.02 kg/MMBtu = 55735
CO2e (metric ton/yr) = 55735 (metric ton/yr) x 1 = 55734.6

Table A-4
GHG Emission Calculations - OL Tail Gas Combustion
Formosa Plastic Corporation, Texas
2012 Expansion Project: Gas Turbines
March 2014

Olefins (OL) Tail Gas Data:

Variable	Value	Units	Reference
Net Heating Value (LHV)	624	Btu/scf	Formosa Design Specification
Carbon Content (Annual Avg)	0.677	kg C/kg	Formosa Design Specification
Molecular Weight (Annual Avg)	9.77	kg/kg-mol	Formosa Design Specification

GHG Emissions Contribution from OL Tail Gas Combustion:

Source Type	Average Heat Input/Unit (MMBtu/hr)	Annual Average Fuel Gas Usage/Unit[1] (MMscf/hr)	Annual Average Fuel Use, Each Unit (scf/yr)	Annual Average Heat Input, Each Unit (MMBtu/yr)	Pollutant	Emission Factor (kg/MMBtu)[2]	GHG Mass Emissions[3] (metric ton/yr)	Global Warming Potential[4]	CO_2e (metric ton/yr)	CO_2e (tpy)
Turbine 1 Duct Burners	120	0.192	1.68E+09	1.05E+06	CO_2		48,109	1	48,109	53,040
					CH_4	1.0E-03	1.05	25	26.28	29
					N_2O	1.0E-04	0.11	298	31.33	35
						Totals	**48,110**		**48,166**	**53,103**
Turbine 2 Duct Burners	120	0.192	1.68E+09	1.05E+06	CO_2		48,109	1	48,109	53,040
					CH_4	1.0E-03	1.05	25	26.28	29
					N_2O	1.0E-04	0.11	298	31.33	35
						Totals	**48,110**		**48,166**	**53,103**
Total, All OL Tail Gas Combustion							***96,220***		***96,333***	***106,207***

Notes:

1. Fuel use calculated as: MMscf/hr = Firing rate (MMBtu/hr) / HHV (Btu/scf)

2. CH_4 and N_2O GHG factors based on Table C-2 of 40 CFR 98 Mandatory Greenhouse Gas Reporting.
CH_4 and N_2O emissions based on 40 CFR Part 98, Subpart C, Equation C-8.

3. CO_2 emissions based on 40 CFR Part 98, Subpart C, Equation C-5.

4. Global Warming Potential factors based on Table A-1 of 40 CFR 98 Mandatory Greenhouse Gas Reporting.

Sample Calculation: Duct Burners Turbine 1 - CO_2:

GHG Mass Emissions (metric ton/yr) = (44/12) x 1.68E+09 (scf/yr) x 0.677 kg C/kg x 9.77 kg/kg-mol / 849.5 scf/kg-mole @ std cond. x 0.001 = 4.81E+04
CO2e (metric ton/yr) = 4.81E+04 (metric ton/yr) x 1 = 4.81E+04

Table A-4A
GHG Emission Calculations - Duct Burners OL Tail Gas Combustion
Formosa Plastic Corporation, Texas
2012 Expansion Project: Gas Turbines
March 2014

OL Tail Gas Composition

Compound	Molecular Weight (lb/lbmol)	Lower Heating Value, LHV (Btu/lb)	Lower Heating Value, LHV (Btu/scf)	Molar Composition (mol %) [1]	Component Lower Heating Value, LHV (Btu/scf)	Number of carbons	Component Carbon Mass (lbC/lbmol)	Fuel Carbon Mass (lbC/lbmol)	Component Mass per Lbmol Gas (lb)	carbon content (lbC/lb)
Hydrogen	2.016	51,571	274	45.00%	123.44	0	0	0.000	0.907	**0.677**
Methane	16.04	21,504	910	55.00%	500.55	1	12	6.600	8.822	
Ethane	30.07	20,429	1,621	0.000050%	0.00	2	24	0.000	0.000	
Propane	44.09	19,923	2,318	0.000010%	0.00	3	36	0.000	0.000	
Carbon Monoxide	28.01	321	323	0.1500%	0.485	1	12	0.018	0.042	
Carbon Dioxide	44.009	0	0	0.0050%	0.000	1	12	0.001	0.002	
					Gross heating value = 624 Btu/scf				**MW = 9.77 lb/lbmol**	

Notes:
[1] Composition is representative and may vary. Estimated composition used for emission calculation purposes only.

Table A-5
GHG Emission Calculations -
Gaseous Fuel Venting During Turbine Startup and
Fuel Line Maintenance, EPNs 7K-NGVENT, 7L-NGVENT
Formosa Plastic Corporation, Texas
2012 Expansion Project: Gas Turbines
March 2014

Location	Initial Conditions			Final Conditions			Annual Frequency of Event	CO_2[3]	CH_4[4]	Total, both Turbines
	Volume[1] (ft^3)	Press. (psig)	Temp. (°F)	Press. (psig)	Temp. (°F)	Volume[2] (scf)		Annual (tpy)	Annual (tpy)	Annual (tpy)
Turbine Startup	75.0	300	90	0	68	1,635	30	0.0336	0.98	
Fuel Line Maintenance	20.0	300	90	0	68	436	24	0.00718	0.210	
GHG Mass-Based Emissions								0.0408	1.19	1.24
Global Warming Potential[5]								1	25	
CO_2e Emissions								0.0408	29.9	29.9

Notes:

1. *Initial volume is calculated by multpilying the crossectional area by the length of pipe using the following formula:* $V_i = pi * [(diameter\ in\ inches/12)/2]^2 * length\ in\ feet = ft^3$
2. *Final volume calculated using ideal gas law* $[(PV/ZT)_i = (PV/ZT)_f]$. $V_f = V_i (P_i/P_f) (T_f/T_i) (Z_f/Z_i)$, *where Z is estimated using the following equation:* $Z = 0.9994 - 0.0002P + 3E\text{-}08P^2$.
3. CO_2 *emissions based on vol% of* CO_2 *in natural gas* — *1.20% from natural gas analysis*
4. CH_4 *emissions based on vol% of* CH_4 *in natural gas* — *96.6% from natural gas analysis*
5. *Global Warming Potential factors based on Table A-1 of 40 CFR 98 Mandatory Greenhouse Gas Reporting.*

Example calculation:

1635 scf Nat Gas	*0.012 scf CO2*	*lbmole*	*44 lb* CO_2	*ton =*	=	*0.0336*	*ton/yr* CO_2
yr	*scf Nat Gas*	*385 scf*	*lbmole*	*2000 lb*			

Table A-6
GHG Emission Calculations - Fugitive Component Emissions
Formosa Plastic Corporation, Texas
2012 Expansion Project: Gas Turbines
March 2014

GHG Emissions Contribution From Fugitive Piping Components:

EPN	Source Type	Fluid State	Count	Emission Factor[1] scf/hr/comp	CO_2 Content (vol %)	CH_4 Content (vol %)	CO_2 (tpy)	Methane (tpy)	Total (tpy)
NG-FUG	Valves	Gas/Vapor	600	0.121	1.20%	96.6%	0.436	12.80	
	Flanges	Gas/Vapor	2400	0.017			0.245	7.19	
	Relief Valves	Gas/Vapor	5	0.193			5.80E-03	1.70E-01	
	Sampling Connections	Gas/Vapor	10	0.031			1.86E-03	5.46E-02	
	Compressors	Gas/Vapor	3	0.002			3.60E-05	1.06E-03	
GHG Mass-Based Emissions							0.689	20.2	***20.9***
Global Warming Potential[2]							1	25	
CO_2e Emissions							0.69	505.4	***506.1***

Notes:

1. Emission factors from Table W-1A of 40 CFR 98 Mandatory Greenhouse Gas Reporting

2. Global Warming Potential factors based on Table A-1 of 40 CFR 98 Mandatory Greenhouse Gas Reporting.

Example calculation:

600 valves	0.121 scf gas	0.012 scf CO2	lbmol	44.01 lb CO_2	8760 hr	ton	0.44	ton/yr
	hr * valve	scf gas	385 scf	lbmol	yr	2000 lb		

Table A-7

GHG Emission Calculations - Electrical Equipment Insulated with SF_6

Formosa Plastic Corporation, Texas

2012 Expansion Project: Gas Turbines

March 2014

EPN	Insulated SF_6 Circuit Breaker Capacity (pounds)	Annual Leak Rate, wt %	Annual Leak Rate (tpy)	Global Warming Potential[1]	Estimated Annual CO_2e Emission Rate (tpy)
SF6-FUG	495	0.50%	1.24E-03	22,800	28.2

Notes:

1. Global Warming Potential factors based on Table A-1 of 40 CFR 98 Mandatory Greenhouse Gas Reporting.