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Indeck Wharton
Emergency Diesel Generator
GHG Emission Calcs

Assumptions

Fuel heat content*	140,000	Btu/gal	**A**
Max hourly fuel usage*	42.7	gal/hr	**B**
Max EDG Heat Rating (*based on max fuel usage shown on engine spec sheet)	6.0	MMBtu/hr	**D = (A)(B)/1,000,000**
Maximum annual non-emergency operation	100	hrs/yr	**E**
Maximum annual non-emergency heat input	598	MMBtu/yr	**F= (D)(E)**

	Emission Factor **(H)**	GWP per 40 CFR 98, Table A-1 **(J)**	Lbs/hr after Conversion to CO2e K**= (D)(H)(J)**	Annual Emissions After Conversion to CO2e **L = (K)(E)/2000 lb/ton**
	(lb/MMBtu)		(lb/hr)	(tpy)
CO_2	162.3 - a	1	970.23	48.51
CH_4	0.0066 - b	25	0.99	0.05
N_2O	0.0013 - b	298	2.32	0.12
CO_2e	162.87 - c		973.53	48.68

a - Equation G-4 in Appendix G of 40 CFR Part 75
b - from Table C-2 of 40 CFR Part 98
c - Sum of CO_2, CH_4 and N_2O. CH_4 assumed to have 25 and N_2O assumed to have 298 times the heat trapping capability of CO_2

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Indeck Wharton/GE Turbine
GHG Emission Calculations - Single Turbine Basis

Emissions During Normal Operations per Turbine

Max Turbine Heat Rating (HHV)[a]	2,216	MMBtu/hr	**A**
Heat Rating for use in Annual Calcs[b]	2,126	MMBtu/hr	**B**
Gross Output [b]	214,959	kW_{gross}	**kW_{gross}**
Gross Heat Rate	9,890	Btu/kW-hr_{gross}	**HR_{gross} = (B)(1,000,000)/(kW_{gross})**
Net Output (per Response No.10, 1/8/14)	212,917	kW_{net}	**kW_{net} = (kW_{gross})(0.9905)**
Net Heat Rate	9,985	Btu/kW-hr_{net}	**HR_{net} = (B)(1,000,000)/(kW_{net})**
Annual Operation (exclusive of SUSD)	2,500	hrs/yr	**D**
Maximum Annual Heat Input (including SUSD)	5,394,500	MMBtu/yr	**E = (B)(D) + (N)(O)**
Proposed CO_2 Long-term Emission Limit, gross basis	1,276	lbs CO_2/$MWhr_{gross}$	**F =(1.085[c])(L_{CO2})/[(kW_{gross})/(1000 kW/MW)]**
Proposed CO_2 Long-Term Emission Limit, net basis	1,288	lbs CO_2/$MWhr_{net}$	**G =(1.085[c])(L_{CO2})/[(kW_{net})/(1000 kW/MW)]**

Calculations for Normal Operation (per Turbine) without Startup/Shutdown

	Emission Factor **(H)**	GWP per 40 CFR 98, Table A-1 **(J)**	Per Turbine after to Conversion to CO2e for Max Heat Input **K= (A)(H)(J)**	Per Turbine prior to Conversion to CO2e for Annual Ave Heat Input **L = (B)(H)(J)**	Per Turbine after to Conversion to CO2e for Annual Ave Heat Input for 2500 hrs/year **M = (L)(E)/(2000 lbs/ton)**
	(lb/MMBtu)		(lb/hr)	(lb/hr)	(tpy)
CO_2	118.9 - d	1	263,482	252,781	315,977
CH_4	0.0022 - e	25	122	117	146
N_2O	0.00022 - e	298	145	139	174
CO_2e	119.02 - f		263,750	253,038	316,297

a - from GE performance spreadsheet - 100% load, 10°F, HHV
b - from GE performance spreadsheet - 100% load, 70°F, HHV
c - 8.5% long-term compliance allowance includes 2.5% for long term degradation, 2.0% compliance margin, 1.5% for startup/shutdown, and 2.5% for load/temperature variation
d - Equation G-4 in Appendix G of 40 CFR Part 75
e - from Table C-2 of 40 CFR Part 98
f - Sum of CO_2, CH_4 and N_2O. CH_4 has a GWP of 25 and N2O has a GWP of 298 compared to CO2 (GWP = Global Warming Potential)

Startup Emissions per Turbine

Since GHG emissions are primarily a function of fuel combusted, startup emission rates have been assumed to be equivalent on a lb/MMBtu basis, to GHG emissions during normal operations. These startup emissions have been conservatively estimated to include shutdown as well, which has a very short duration.

Each turbine is assumed to consume 265 MMBtu of fuel during startup* **(N)**
* from vendor data

Number of Start-ups (per turbine) 300 **(O)**

Calculations for Startup/Shutdown (SUSD) per Turbine

	Emission Factor **(H)**	Conversion Factor for CO2e **(J)**	Per Start after to Conversion to CO2e **P = (N)(H)(J)**	Per Turbine after to Conversion to CO2e for 300 starts per year **Q = (P)(O)/(2000 lbs/ton)**
	(lb/MMBtu)		(pounds)	(tpy)
CO_2	118.9 - d	1	31,509	4,726
CH_4	0.0022 - e	25	15	2
N_2O	0.00022 - e	310	18	3
CO_2e	119.02 - f		31,541	4,731

Total Emissions (as CO2e) per Turbine

	Normal Operations **(M)**	Startup/ Shutdown (SUSD) **(Q)**	Total **R = M + Q**
	tpy	(tpy)	(tpy)
CO_2	315,977	4,726	320,703
CH_4	146	2	148
N_2O	174	3	177
CO_2e	316,297	4,731	321,028

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Indeck Wharton/Siemens Turbine
GHG Emission Calculations - Single Turbine Basis

Emissions During Normal Operations per Turbine

Max Turbine Heat Rating (HHV)[a]	2,357	MMBtu/hr
Heat Rating for use in Annual Calcs[a]	2,357	MMBtu/hr
Gross Output [a]	227,445	kW_{gross}
Gross Heat Rate	10,363	$Btu/kW\text{-}hr_{gross}$
Net Output (per response 10, 1/8/14)	225,284	kW_{net}
Net Heat Rate	10,462	$Btu/kW\text{-}hr_{net}$
Annual Operation (exclusive of SUSD)	2,500	hrs/yr
Maximum Annual Heat Input (including SUSD)	6,024,650	MMBtu/yr
Proposed CO_2 Long-Term Emission Limit, gross basis	1,337	lbs $CO_2/MWhr_{gross}$
Proposed CO_2 Long-Term Emission Limit, net basis	1,350	lbs $CO_2/MWhr_{net}$

Calculations for Normal Operation (per Turbine) without Startup/Shutdown

	Emission Factor **(H)**	GWP per 40 CFR 98, Table A-1 **(J)**	Per Turbine after to Conversion to CO2e for Max Heat Input **K= (A)(H)(J)**	Per Turbine prior to Conversion to CO2e for Annual Ave Heat Input **L = (B)(H)(J)**
	(lb/MMBtu)		(lb/hr)	(lb/hr)
CO_2	118.9 - c	1	280,247	280,247
CH_4	0.0022 - d	25	130	130
N_2O	0.00022 - d	298	155	155
CO_2e	119.02 - e		280,531	280,531

a - from Siemens performance spreadsheet - 100% load, 70°F, HHV

b - 8.5% long-term compliance allowance includes 2.5% for long term degradation, 2.0% compliance margin, 1.5%

c - Equation G-4 in Appendix G of 40 CFR Part 75

d - from Table C-2 of 40 CFR Part 98

e - Sum of CO_2, CH_4 and N_2O. CH_4 has a GWP of 25 and N2O has a GWP of 298 compared to CO2 (GWP = Glo

Startup Emissions per Turbine

Since GHG emissions are primarily a function of fuel combusted, startup emission rates have been assumed to be equivalent on a lb/MMBtu basis, to GHG emissions during normal operations. These startup emissions have been conservatively estimated to include shutdow which has a very short duration.

Each turbine is assumed to consume	440.5	MMBtu of fuel during star
* from vendor data		
Number of Start-ups (per turbine)	300	**(O)**

Calculations for Startup/Shutdown (SUSD) per Turbine

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	Emission Factor **(H)**	Conversion Factor for CO2e **(J)**	Per Start after to Conversion to CO2e **P = (N)(H)(J)**	Per Turbine after to Conversion to CO2e for 300 starts per year **Q = (P)(O)/(2000 lbs/ton)**
	(lb/MMBtu)		(pounds)	(tpy)
CO_2	118.9 - d	1	52,375	7,856
CH_4	0.0022 - e	25	24	4
N_2O	0.00022 - e	310	30	5
CO_2e	119.02 - f		52,430	7,864

Total Emissions (as CO2e) per Turbine

	Normal Operations **(M)**	Startup/ Shutdown (SUSD) **(Q)**	Total **R = M + Q**
	tpy	(tpy)	(tpy)
CO_2	350,309	7,856	358,165
CH_4	162	4	166
N_2O	193	5	198
CO_2e	350,664	7,864	358,529

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A
B
kW_{gross}
HR_{gross} = (B)(1,000,000)/(kW_{gross})
kW_{net} = (kW_{gross})(0.9905)
HR_{net} = (B)(1,000,000)/(kW_{net})
D
E = (B)(D) + (N)(O)
F =(1.085^b)(L_{CO2})/[(kW_{gross})/(1000 kW/MW)]
G =(1.085^b)(L_{CO2})/[(kW_{net})/(1000 kW/MW)]

Per Turbine after to Conversion to CO2e for Annual Ave Heat Input for 2500 hrs/year **M = (L)(E)/(2000 lbs/ton)**
(tpy)
350,309
162
193
350,664

› for startup/shutdown, and 2.5% for load/temperature variation

›bal Warming Potential)

vn as well,

rtup* **(N)**

Indeck Wharton
Fire Pump
GHG Emission Calcs

Assumptions

Fuel heat content	140,000	Btu/gal	**A**
Max hourly fuel usage*	9	gal/hr	**B**
Max EDG Heat Rating (based on max fuel usage shown on engine spec sheet)	1.3	MMBtu/hr	**D = (A)(B)/1,000,000**
Maximum annual non-emergency operation	52	hrs/yr	**E**
Maximum annual non-emergency heat input	66	MMBtu/yr	**F= (D)(E)**

	Emission Factor **(H)**	GWP per 40 CFR 98, Table A-1 **(J)**	Lbs/hr after Conversion to CO2e K= **(D)(H)(J)**	Annual Emissions After Conversion to CO2e **L = (K)(E)/2000 lb/ton**
	(lb/MMBtu)		(lb/hr)	(tpy)
CO_2	162.3 - a	1	204.50	5.32
CH_4	0.0066 - b	25	0.21	0.01
N_2O	0.0013 - b	298	0.49	0.01
CO_2e	162.87 - c		205.19	5.34

a - Equation G-4 in Appendix G of 40 CFR Part 75
b - from Table C-2 of 40 CFR Part 98
c - Sum of CO_2, CH_4 and N_2O. CH_4 assumed to have 25 and N_2O assumed to have 298 times the heat trapping capability of CO_2

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Indeck Wharton
Pipeline Heater
GHG Emission Calcs

Assumptions

Max Pipeline Heater Heat Rating	3	MMBtu/hr	**A**
Future Annual Capacity assumed to be	3,500	hrs/yr	**B**
includes hours for startups			
Maximum Annual Heat Input	10,500	MMBtu/yr	**D = (A)(B)**

	Emission Factor **(H)**	GWP per 40 CFR 98, Table A-1 **(J)**	Lbs/hr after Conversion to CO2e K**= (A)(H)(J)**	Annual Emissions After Conversion to CO2e **L = (K)(B)/2000 lb/ton**
	(lb/MMBtu)		(lb/hr)	(tpy)
CO_2	118.9 - a	1	356.70	624.23
CH_4	0.0022 - e	25	0.17	0.29
N_2O	0.00022 - e	298	0.20	0.34
CO_2e	119.02 - f		357.06	624.86

a - Equation G-4 in Appendix G of 40 CFR Part 75
b - from Table C-2 of 40 CFR Part 98
c - Sum of CO_2, CH_4 and N_2O. CH_4 assumed to have 25 and N_2O assumed to have 298 times the heat trapping capability of CO_2

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Indeck Wharton
Pipeline Fugitives
GHG Emission Calcs

Annual Hours of Operation	3,500	**A**
includes hours for startups		
CH_4 constituent of the Nat Gas	95.97%	**B**
CO_2 constituent of the Nat Gas	0.53%	**D**

Component	No. of Components (**E**)	Emission Factor (lb/hr-component) (**F**)	Gas Pipeline Fugitive Hourly CH_4 Emissions (lb/hr) **G = (B)(E)(F)**	Gas Pipeline Fugitive Annual CH_4 Emissions (tpy) **H = (G)(A)/ 2000 lb/ton**	Gas Pipeline Fugitive Hourly CO_2 Emissions (lb/hr) **J = (D)(E)(F)**	Gas Pipeline Fugitive Annual CO_2 Emissions (tpy) **K = (J)(A)/ 2000 lb/ton**	Hourly Potential CO_2e Emissions (lb/hr) **L = 25(G) + J**	Annual Potential CO_2e Emissions (tpy) **M = (L)(A)/ (2000 lb/ton)**
Valves	103	0.00992	0.98	1.72	0.005	0.01	24.52	42.91
Flanges	309	0.00086	0.26	0.45	0.001	0.002	6.38	11.16
Pressure Relief Valves	10	0.0194	0.19	0.33	0.001	0.002	4.66	8.15
Connectors	570	0.00044	0.24	0.42	0.001	0.002	6.02	10.53
Maintenance Purges	-	-	125.00 - a	0.06 - b	0.69 - c	0.00 -d	3125.69	1.56
TOTAL			126.66	2.97	0.700	0.02	3167.26	74.31

NOTE – emissions assume a GWP of 25 for the CH_4 emissions.

a. Allowance for 125 lbs of methane in one hour per year
b. 125 lbs/(2000 lb/ton)
c. [(D)/(B)] (125 lb/hr)
d. [(D)/(B)] (125 lb/hr)/(2000 lb/ton)

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Indeck Wharton
Circuit Breaker SF_6 Fugitive Emissions
GHG Emission Calcs

Circuit Breaker Description	Amount of SF_6 at Full Charge (lbs) **(A)**	Number of Breakers **(B)**	Annual Leak Rate (%) **(D)**	Hourly SF_6 Potential Emissions (lbs/hr) **E = (A)(B)(D)/ (8760 hrs/yr)**	Annual SF_6 Potential Emissions (tpy) **F = (A)(B)(D)/ (2000 lb/ton)**	Hourly CO_2e Potential Emissions (lbs/hr) **(G) = (E)(22,800)**	Annual CO_{2e} Potential Emissions (tpy) **(H) = (F)(22,800)**
Generator Circuit Breakers	24.2	3	0.5	0.00004	0.0002	0.94	4.14
HV Power Circuit Breakers	550	11	0.5	0.0035	0.015	78.73	344.85
TOTAL		14		0.0035	0.015	79.68	348.99

NOTE – emissions assume a GWP of 22,800 for SF_6 for the CO_2e emissions, per 40 CFR 98, Table A-1.

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Indeck Wharton
Combustion Turbine Project
GHG Emission Totals

GE Turbine Scenario

	Maximum Hourly Emissions (lbs/hr)								
	Unit 1	Unit 2	Unit 3	EDG	FP	Pipeline Htr	Gas Piping Fugitives	Circuit Breaker Fugitives	TOTAL
CO_2	263,482	263,482	263,482	970	204	357	0.70	-	791,979
CH_4 (as CO2e)	122	122	122	1	0	0	3166.56	-	3,533.56
N_2O (as CO2e)	145	145	145	2	0	0	-	-	438.84
SF_6 (as CO2e)	-	-	-	-	-	-	-	79.68	79.68
CO_2e	263,750	263,750	263,750	974	205	357	3167.26	79.68	796,031

	Annual Emissions (tons/yr) - Includes Turbine Start-ups									
	Unit 1	Unit 2	Unit 3	Turb Starts	EDG	FP	Pipeline Htr	Gas Piping Fugitives	Circuit Breaker Fugitives	TOTAL
CO_2	315,977	315,977	315,977	14,179	48.51	5.32	624.23	0.02	-	962,787
CH_4 (as CO2e)	146	146	146	7	0.05	0.01	0.29	74.30	-	519.69
N_2O (as CO2e)	174	174	174	8	0.12	0.01	0.34	-	-	531.28
SF_6 (as CO2e)	-	-	-	-	-	-	-	-	348.99	348.99
CO_2e	316,297	316,297	316,297	14,194	49	5	624.51	74.31	348.99	964,187

Siemens Turbine Scenario

	Hourly Emissions (lbs/hr)								
	Unit 1	Unit 2	Unit 3	EDG	FP	Pipeline Htr	Gas Piping Fugitives	Circuit Breaker Fugitives	TOTAL
CO_2	280,247	280,247	280,247	970	204	357	0.70	-	842,274
CH_4 (as CO2e)	130	130	130	1	0	0	3166.56	-	3,556.83
N_2O (as CO2e)	155	155	155	2	0	0	-	-	466.58
SF_6 (as CO2e)	-	-	-	-	-	-	-	79.68	79.68
CO_2e	280,531	280,531	280,531	974	205	357	3167.26	79.68	846,377

	Annual Emissions (tons/yr) - Includes Turbine Start-ups									
	Unit 1	Unit 2	Unit 3	Turb Starts	EDG	FP	Pipeline Htr	Gas Piping Fugitives	Circuit Breaker Fugitives	TOTAL
CO_2	350,309	350,309	350,309	23,569	48.51	5.32	624.23	0.02	-	1,075,174
CH_4 (as CO2e)	162	162	162	11	0.05	0.01	0.29	74.30	-	571.67
N_2O (as CO2e)	193	193	193	14	0.12	0.01	0.34	-	-	593.46
SF_6 (as CO2e)	-	-	-	-	-	-	-	-	348.99	348.99
CO_2e	350,664	350,664	350,664	23,593	49	5	624.51	74.31	348.99	1,076,688

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