# Appendix D

# Air Quality Emissions and Calculations

# Appendix D1.1

# Construction Emissions

EMISSION FACTORS FOR ON-SITE CONSTRUCTION EQUIPMENT
Hydrogen Energy International LLC, Kern County Power Project

| | | | Emission Factors (lbs/hr) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Equipment Description* | **EMFAC designation** | **HP** | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_x$** | **ROG[1]** |
| **On-Road Vehicles** | | | | | | | | | | | |
| Concrete Pumper Truck | HHD-DSL | | 0.32 | 69.79 | 0.0017 | 0.0011 | 0.69 | 0.043 | 0.039 | 0.00066 | 0.15 |
| Dump Truck | HHD-DSL | | 0.32 | 69.79 | 0.0017 | 0.0011 | 0.69 | 0.043 | 0.039 | 0.00066 | 0.15 |
| Service Truck - 1 ton | HHD-DSL | | 0.32 | 69.79 | 0.0017 | 0.0011 | 0.69 | 0.043 | 0.039 | 0.00066 | 0.15 |
| Pile Driver Truck | HHD-DSL | | 0.32 | 69.79 | 0.0017 | 0.0011 | 0.69 | 0.043 | 0.039 | 0.00066 | 0.15 |
| Truck - Fuel/Lube | MHD-DSL | | 0.15 | 33.18 | 0.0017 | 0.0011 | 0.28 | 0.017 | 0.015 | 0.00031 | 0.014 |
| Tractor Truck 5th Wheel | HHD-DSL | | 0.32 | 69.79 | 0.0017 | 0.0011 | 0.69 | 0.043 | 0.039 | 0.00066 | 0.15 |
| Trucks - Pickup 3/4 ton | MHD-DSL | | 0.15 | 33.18 | 0.0017 | 0.0011 | 0.28 | 0.017 | 0.015 | 0.00031 | 0.014 |
| Trucks - 3 ton | HHD-DSL | | 0.32 | 69.79 | 0.0017 | 0.0011 | 0.69 | 0.043 | 0.039 | 0.00066 | 0.15 |
| Truck - Water | HHD-DSL | | 0.32 | 69.79 | 0.0017 | 0.0011 | 0.69 | 0.043 | 0.039 | 0.00066 | 0.15 |
| **Off Road Vehicles** | | | | | | | | | | | |
| Air Compressor 185 CFM | Diesel | 50 | 0.287 | 22.27 | 0.0017 | 0.00056 | 0.242 | 0.027 | 0.0253 | 0.00029 | 0.1220 |
| Air Compressor 750 CFM | Diesel | 120 | 0.338 | 46.95 | 0.0041 | 0.0014 | 0.625 | 0.056 | 0.0518 | 0.00055 | 0.1066 |
| Articulating Boom Platform | Diesel | 75 | 0.217 | 26.21 | 0.0025 | 0.00084 | 0.298 | 0.026 | 0.0239 | 0.00032 | 0.0779 |
| Bulldozer D10R | Diesel | 250 | 0.936 | 130.96 | 0.0084 | 0.0028 | 1.582 | 0.070 | 0.0643 | 0.00119 | 0.1852 |
| Bulldozer D4C | Diesel | 120 | 0.927 | 89.87 | 0.0041 | 0.0014 | 1.364 | 0.104 | 0.0960 | 0.00101 | 0.2211 |
| Concrete Trowel Machine | Diesel | 50 | 0.156 | 14.11 | 0.0017 | 0.00056 | 0.147 | 0.015 | 0.0138 | 0.00018 | 0.063 |
| Concrete Vibrators | Diesel | 50 | 0.156 | 14.11 | 0.0017 | 0.00056 | 0.147 | 0.015 | 0.0138 | 0.00018 | 0.063 |
| Cranes - Mobile 35 ton | Diesel | 120 | 0.376 | 50.15 | 0.0041 | 0.0014 | 0.690 | 0.063 | 0.0583 | 0.00059 | 0.119 |
| Cranes - Mobile 45 ton | Diesel | 175 | 0.491 | 80.34 | 0.0059 | 0.0020 | 0.985 | 0.056 | 0.0519 | 0.00090 | 0.128 |
| Crane - Mobile 65 ton | Diesel | 200 | 0.449 | 90.95 | 0.0068 | 0.0023 | 1.093 | 0.054 | 0.0499 | 0.00102 | 0.129 |
| Cranes 100 / 150 ton cap | Diesel | 250 | 0.366 | 112.16 | 0.0084 | 0.0028 | 1.310 | 0.050 | 0.0461 | 0.00126 | 0.131 |
| Diesel Powered Welder | Diesel | 25 | 0.0685 | 11.29 | 0.0008 | 0.00028 | 0.111 | 0.008 | 0.0074 | 0.00014 | 0.0268 |
| Excavator - Backhoe/loader | Diesel | 120 | 0.366 | 51.73 | 0.0041 | 0.0014 | 0.607 | 0.055 | 0.0510 | 0.00061 | 0.099 |
| Excavator - Earth Scraper | Diesel | 150 | 0.758 | 96.73 | 0.0051 | 0.0017 | 1.064 | 0.075 | 0.0693 | 0.00109 | 0.158 |
| Excavator - loader | Diesel | 120 | 0.366 | 51.73 | 0.0041 | 0.0014 | 0.607 | 0.055 | 0.0510 | 0.00061 | 0.099 |
| Excavator - Motor Grader (CAT140H) | Diesel | 120 | 0.537 | 73.62 | 0.0041 | 0.0014 | 0.900 | 0.084 | 0.0774 | 0.00086 | 0.152 |
| Excavator - Trencher (CAT320) | Diesel | 120 | 0.537 | 73.62 | 0.0041 | 0.0014 | 0.900 | 0.084 | 0.0774 | 0.00086 | 0.152 |
| Fired Heaters | Diesel | 25 | 0.055 | 13.22 | 0.0008 | 0.00028 | 0.107 | 0.006 | 0.0055 | 0.00017 | 0.0167 |
| Forklift | Diesel | 50 | 0.192 | 14.67 | 0.0017 | 0.00056 | 0.157 | 0.018 | 0.0163 | 0.00019 | 0.076 |
| Fusion Welder | Diesel | 50 | 0.303 | 27.99 | 0.0017 | 0.00056 | 0.283 | 0.028 | 0.0260 | 0.00036 | 0.1136 |
| Heavy Haul / Cranes | Diesel | 350 | 0.201 | 154.58 | 0.0118 | 0.0039 | 1.745 | 0.042 | 0.0385 | 0.00174 | 0.136 |
| Light Plants | Diesel | 25 | 0.055 | 13.22 | 0.0008 | 0.00028 | 0.107 | 0.006 | 0.0055 | 0.00017 | 0.017 |
| Portable Compaction Roller | Diesel | 100 | 0.554 | 36.68 | 0.0034 | 0.0011 | 0.482 | 0.046 | 0.0426 | 0.00041 | 0.094 |
| Portable Compaction - Vibratory Plate | Diesel | 15 | 0.156 | 14.11 | 0.0005 | 0.00017 | 0.147 | 0.015 | 0.0138 | 0.00018 | 0.063 |
| Portable Compaction - Vibratory Ram | Diesel | 50 | 0.156 | 14.11 | 0.0017 | 0.00056 | 0.147 | 0.015 | 0.0138 | 0.00018 | 0.063 |
| Pumps | Diesel | 25 | 0.055 | 13.22 | 0.0008 | 0.00028 | 0.107 | 0.006 | 0.0055 | 0.00017 | 0.017 |
| Portable Power Generators | Diesel | 50 | 0.297 | 30.62 | 0.0017 | 0.00056 | 0.311 | 0.030 | 0.0273 | 0.00040 | 0.118 |
| Truck Crane - Greater than 300 ton | Diesel | 175 | 0.491 | 80.34 | 0.0059 | 0.0020 | 0.985 | 0.056 | 0.0519 | 0.00090 | 0.128 |
| Truck Crane - Greater than 200 ton | Diesel | 150 | 0.532 | 69.74 | 0.0051 | 0.0017 | 0.876 | 0.058 | 0.0538 | 0.00078 | 0.126 |
| Vibratory Roller Ingersol-Rand 20 ton | Diesel | 150 | 0.462 | 75.77 | 0.0051 | 0.0017 | 0.897 | 0.057 | 0.0521 | 0.00087 | 0.120 |

**Notes:**

[1] Assuming ROGs are equivalent to VOCs

- Emission factors for on-road vehicles are based on results from Emfac Emissions Model 2007 Version 2.3 (HHDT-DSL=heavy heavy-duty trucks-diesel; MHD-DSL=medium heavy duty-diesel). EMFAC scenario year was 2010 and the selected area was Kern County. $PM_{10}$ values include break wear and tire wear.
- Emission factors for off-road vehicles are based on the maximum emission factors from 2009 to 2012 of the South Coast Air Quality Management District (AQMD) data . Linear interpolation was used to calculate the emission factor for horse power values that were not listed.
- $CO_2$ emissions for off-road vehicles were estimated using USEPA AP-42 Chapter 3.3 - Gasoline and Diesel Industrial Engines, and Chapter 3.4 - Large Stationary Diesel and All Stationary Dual-fuel Engines
- $PM_{2.5}$ emission factors were determined by multiplying $PM_{10}$ numbers by a "$PM_{2.5}$ fraction of $PM_{10}$" value. Fractional values for $PM_{2.5}$ were taken from the SCAQMD guidance: Final - Methodology to Calculate $PM_{2.5}$ and $PM_{2.5}$ Significance Thresholds, October 2006: Appendix A - Updated CEIDARS Table with $PM_{2.5}$ Fractions.

On-Road Vehicles:

- $PM_{2.5}$ Fraction of $PM_{10}$, Brake wear: 0.429
- $PM_{2.5}$ Fraction of $PM_{10}$, Diesel: 0.920
- PM2.5 Fraction of PM10, Tire wear: 0.250

Off-Road Vehicles:

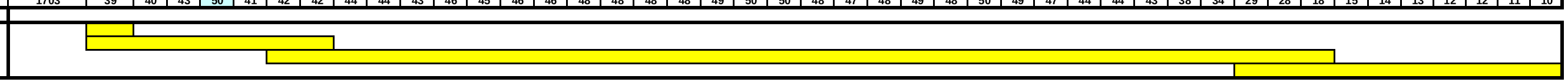
- PM2.5 Fraction of PM10, Diesel: 0.920

- $CH_4$ and $N_2O$ factors are derived from California Climate Action Registry General Reporting Protocol Version 2.2 (March 2007), Table C.4 using the mileage accrual rates by age table from EMFAC2007 Version 2.3, November 1, 2006, California Air Resources Board, normalized accrual rates (annual odometer mileage weighted by population) for LDT, MHD, and HHD diesel fueled trucks in the San Joaquin Valley Air Basin. These emissions are in g/mile. On-road vehicles are limited to 10 mph, which is used to convert to lb/hr
- $CH_4$ and $N_2O$ factors for off-road vehicles are derived from California Climate Action Registry General Reporting Protocol Version 2.2 (March 2007), Table C.6 (distillate fuel factors for the industrial sector) using the following to convert from kg/gallon to lb/hp-hour, and then multiplying by the rated horsepower rating: 1 gallon/137,000 Btu, 7,000 Btu/hp-hour, and 2.2046

# ON-SITE CONSTRUCTION EQUIPMENT USE PER MONTH
## Hydrogen Energy International LLC, Kern County Power Project

| | | Month | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *EQUIPMENT* | *# of units* | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *13* | *14* | *15* | *16* | *17* | *18* | *19* | *20* | *21* | *22* | *23* | *24* | *25* | *26* | *27* | *28* | *29* | *30* | *31* | *32* | *33* | *34* | *35* | *36* | *37* | *38* | *39* | *40* | *41* | *42* | *43* | *44* |
| **On Road Vehicles** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Concrete Pumper Truck | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dump Truck | 31 | 3 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pile Driver Truck | 15 | 0 | 0 | 1 | 3 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Trucks - Pickup 3/4 ton | 121 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Trucks - 3 ton | 68 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 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 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| Truck - Water | 48 | 4 | 4 | 4 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Off Road Vehicles** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Air Compressor 750 CFM | 97 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Articulating Boom Platform | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bulldozer D10R | 24 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bulldozer D4C | 26 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Concrete Trowel Machine | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cranes - Mobile 35 ton | 129 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Cranes 100 / 150 ton cap | 76 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Diesel Powered Welder | 113 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| Excavator - Backhoe/loader | 56 | 2 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Excavator - Earth Scraper | 26 | 7 | 7 | 7 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Excavator - loader | 24 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Excavator - Motor Grader (CAT140H) | 18 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fired Heaters | 114 | 0 | 0 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Forklift | 79 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Heavy Haul / Cranes | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Light Plants | 206 | 0 | 0 | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 |
| Portable Compaction Roller | 49 | 0 | 0 | 2 | 3 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Portable Compaction - Vibratory Plate | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pumps | 67 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| Portable Power Generators | 124 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| Truck Crane - Greater than 200 ton | 68 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Vibratory Roller Ingersol-Rand 20 ton | 38 | 5 | 5 | 5 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***on road total*** | *296* | *9* | *10* | *11* | *13* | *11* | *11* | *11* | *11* | *11* | *9* | *8* | *8* | *8* | *8* | *8* | *7* | *7* | *7* | *7* | *7* | *7* | *6* | *6* | *6* | *6* | *5* | *5* | *5* | *5* | *5* | *5* | *5* | *5* | *5* | *5* | *5* | *4* | *4* | *4* | *4* | *3* | *3* | *3* | *3* |
| ***off road total*** | *1407* | *30* | *30* | *32* | *37* | *30* | *31* | *31* | *33* | *33* | *34* | *38* | *37* | *38* | *38* | *40* | *41* | *41* | *41* | *42* | *43* | *43* | *42* | *41* | *42* | *43* | *43* | *45* | *44* | *42* | *39* | *39* | *38* | *33* | *29* | *24* | *23* | *14* | *11* | *10* | *9* | *9* | *9* | *8* | *7* |
| **Project Total** | **1703** | **39** | **40** | **43** | **50** | **41** | **42** | **42** | **44** | **44** | **43** | **46** | **45** | **46** | **46** | **48** | **48** | **48** | **48** | **49** | **50** | **50** | **48** | **47** | **48** | **49** | **48** | **50** | **49** | **47** | **44** | **44** | **43** | **38** | **34** | **29** | **28** | **18** | **15** | **14** | **13** | **12** | **12** | **11** | **10** |

Schedule




**Notes:**

1 These are approximate values

2 Misc. equip for off plot include preliminary estimates for work that may be performed outside of the plot (plot linears, facility upgrades, site interfaces, etc.

UNMITIGATED ANNUAL EMISSIONS FROM ON SITE CONSTRUCTION EQUIPMENT
Hydrogen Energy International LLC, Kern County Power Project

| | CO | | $CO_2$ | | $CH_4$ | | $N_2O$ | | $NO_x$ | | $PM_{10}$ | | $PM_{2.5}$ | | $SO_x$ | | ROG[1] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) |
| 1 | 2.18 | NA | 314.04 | NA | 0.0166 | NA | 0.0060 | NA | 3.63 | NA | 0.250 | NA | 0.229 | NA | 0.0034 | NA | 0.58 | NA |
| 2 | 2.21 | NA | 321.72 | NA | 0.0167 | NA | 0.0062 | NA | 3.70 | NA | 0.255 | NA | 0.233 | NA | 0.0034 | NA | 0.60 | NA |
| 3 | 2.37 | NA | 337.47 | NA | 0.0177 | NA | 0.0065 | NA | 3.89 | NA | 0.270 | NA | 0.247 | NA | 0.0036 | NA | 0.63 | NA |
| 4 | 2.39 | NA | 340.48 | NA | 0.0178 | NA | 0.0067 | NA | 3.90 | NA | 0.277 | NA | 0.253 | NA | 0.0036 | NA | 0.67 | NA |
| 5 | 1.62 | NA | 234.32 | NA | 0.0128 | NA | 0.0049 | NA | 2.68 | NA | 0.195 | NA | 0.178 | NA | 0.0025 | NA | 0.47 | NA |
| 6 | 1.63 | NA | 235.77 | NA | 0.0129 | NA | 0.0049 | NA | 2.69 | NA | 0.195 | NA | 0.179 | NA | 0.0025 | NA | 0.48 | NA |
| 7 | 1.63 | NA | 235.77 | NA | 0.0129 | NA | 0.0049 | NA | 2.69 | NA | 0.195 | NA | 0.179 | NA | 0.0025 | NA | 0.48 | NA |
| 8 | 1.55 | NA | 221.66 | NA | 0.0123 | NA | 0.0047 | NA | 2.51 | NA | 0.180 | NA | 0.164 | NA | 0.0024 | NA | 0.45 | NA |
| 9 | 1.44 | NA | 217.82 | NA | 0.0120 | NA | 0.0046 | NA | 2.45 | NA | 0.174 | NA | 0.159 | NA | 0.0023 | NA | 0.44 | NA |
| 10 | 1.35 | NA | 199.10 | NA | 0.0116 | NA | 0.0044 | NA | 2.27 | NA | 0.171 | NA | 0.156 | NA | 0.0022 | NA | 0.42 | NA |
| 11 | 1.31 | NA | 192.79 | NA | 0.0117 | NA | 0.0044 | NA | 2.16 | NA | 0.164 | NA | 0.151 | NA | 0.0021 | NA | 0.41 | NA |
| 12 | 1.31 | 20.98 | 196.84 | 3,047.80 | 0.0123 | 0.167 | 0.0046 | 0.0629 | 2.22 | 34.77766 | 0.164 | 2.489 | 0.151 | 2.280 | 0.0022 | 0.0328 | 0.42 | 6.054 |
| 13 | 1.19 | 19.99 | 192.28 | 2,926.03 | 0.0121 | 0.163 | 0.0045 | 0.0614 | 2.11 | 33.26 | 0.148 | 2.387 | 0.136 | 2.187 | 0.0022 | 0.0316 | 0.39 | 5.866 |
| 14 | 1.19 | 18.97 | 192.28 | 2,796.59 | 0.0121 | 0.158 | 0.0045 | 0.0597 | 2.11 | 31.67 | 0.148 | 2.281 | 0.136 | 2.089 | 0.0022 | 0.0303 | 0.39 | 5.661 |
| 15 | 1.21 | 17.82 | 193.03 | 2,652.15 | 0.0124 | 0.153 | 0.0046 | 0.0578 | 2.13 | 29.92 | 0.151 | 2.162 | 0.139 | 1.980 | 0.0022 | 0.0289 | 0.40 | 5.430 |
| 16 | 1.26 | 16.68 | 204.92 | 2,516.59 | 0.0137 | 0.149 | 0.0050 | 0.0561 | 2.30 | 28.32 | 0.161 | 2.047 | 0.148 | 1.875 | 0.0023 | 0.0276 | 0.41 | 5.169 |
| 17 | 1.27 | 16.33 | 208.06 | 2,490.33 | 0.0139 | 0.150 | 0.0050 | 0.0562 | 2.35 | 27.99 | 0.161 | 2.014 | 0.148 | 1.845 | 0.0024 | 0.0275 | 0.41 | 5.108 |
| 18 | 1.27 | 15.97 | 208.06 | 2,462.62 | 0.0139 | 0.151 | 0.0050 | 0.0563 | 2.35 | 27.64 | 0.161 | 1.979 | 0.148 | 1.814 | 0.0024 | 0.0273 | 0.41 | 5.045 |
| 19 | 1.32 | 15.67 | 216.90 | 2,443.75 | 0.0145 | 0.152 | 0.0052 | 0.0566 | 2.45 | 27.41 | 0.168 | 1.951 | 0.154 | 1.788 | 0.0025 | 0.0272 | 0.43 | 4.996 |
| 20 | 1.37 | 15.49 | 237.87 | 2,459.97 | 0.0162 | 0.156 | 0.0058 | 0.0576 | 2.71 | 27.61 | 0.177 | 1.9492 | 0.163 | 1.787 | 0.0027 | 0.0276 | 0.45 | 4.995 |
| 21 | 1.37 | 15.42 | 237.87 | 2,480.01 | 0.0162 | 0.161 | 0.0058 | 0.0588 | 2.71 | 27.87 | 0.177 | 1.953 | 0.163 | 1.790 | 0.0027 | 0.0279 | 0.45 | 4.998 |
| 22 | 1.27 | 15.35 | 230.75 | 2,511.67 | 0.0159 | 0.165 | 0.0057 | 0.0601 | 2.63 | 28.23 | 0.169 | 1.951 | 0.155 | 1.789 | 0.0026 | 0.0284 | 0.43 | 5.007 |
| 23 | 1.25 | 15.29 | 229.20 | 2,548.07 | 0.0160 | 0.169 | 0.0057 | 0.0614 | 2.62 | 28.69 | 0.167 | 1.954 | 0.154 | 1.792 | 0.0026 | 0.0288 | 0.42 | 5.012 |
| 24 | 1.26 | 15.24 | 230.44 | 2,581.67 | 0.0161 | 0.173 | 0.0057 | 0.0626 | 2.63 | 29.09 | 0.168 | 1.958 | 0.154 | 1.796 | 0.0026 | 0.0292 | 0.42 | 5.017 |
| 25 | 1.27 | 15.31 | 231.68 | 2,621.07 | 0.0162 | 0.177 | 0.0057 | 0.0638 | 2.64 | 29.62 | 0.169 | 1.979 | 0.155 | 1.815 | 0.0026 | 0.0297 | 0.43 | 5.050 |
| 26 | 1.21 | 15.33 | 219.87 | 2,648.66 | 0.0157 | 0.181 | 0.0055 | 0.0648 | 2.51 | 30.02 | 0.160 | 1.991 | 0.147 | 1.827 | 0.0025 | 0.0300 | 0.40 | 5.063 |
| 27 | 1.22 | 15.34 | 222.77 | 2,678.40 | 0.0159 | 0.184 | 0.0056 | 0.0658 | 2.54 | 30.42 | 0.161 | 2.001 | 0.148 | 1.836 | 0.0026 | 0.0304 | 0.41 | 5.069 |
| 28 | 1.20 | 15.28 | 205.77 | 2,679.26 | 0.0146 | 0.185 | 0.0052 | 0.0660 | 2.34 | 30.47 | 0.157 | 1.996 | 0.144 | 1.832 | 0.0024 | 0.0305 | 0.39 | 5.052 |
| 29 | 1.21 | 15.22 | 186.06 | 2,657.25 | 0.0131 | 0.184 | 0.0047 | 0.0657 | 2.13 | 30.25 | 0.152 | 1.987 | 0.140 | 1.824 | 0.0021 | 0.0302 | 0.37 | 5.010 |
| 30 | 1.11 | 15.06 | 174.12 | 2,623.31 | 0.0121 | 0.183 | 0.0043 | 0.0650 | 1.98 | 29.88 | 0.138 | 1.964 | 0.127 | 1.803 | 0.0020 | 0.0299 | 0.34 | 4.936 |
| 31 | 1.11 | 14.84 | 174.12 | 2,580.52 | 0.0121 | 0.180 | 0.0043 | 0.0640 | 1.98 | 29.40 | 0.138 | 1.935 | 0.127 | 1.776 | 0.0020 | 0.0294 | 0.34 | 4.848 |
| 32 | 1.06 | 14.53 | 165.28 | 2,507.93 | 0.0114 | 0.175 | 0.0041 | 0.0623 | 1.87 | 28.56 | 0.132 | 1.889 | 0.121 | 1.734 | 0.0019 | 0.0286 | 0.33 | 4.725 |
| 33 | 1.00 | 14.16 | 156.10 | 2,426.16 | 0.0109 | 0.170 | 0.0039 | 0.0604 | 1.79 | 27.64 | 0.126 | 1.838 | 0.116 | 1.687 | 0.0018 | 0.0277 | 0.31 | 4.582 |
| 34 | 0.85 | 13.73 | 128.36 | 2,323.76 | 0.0086 | 0.163 | 0.0032 | 0.0579 | 1.45 | 26.46 | 0.106 | 1.775 | 0.097 | 1.629 | 0.0015 | 0.0265 | 0.26 | 4.411 |
| 35 | 0.60 | 13.08 | 103.74 | 2,198.30 | 0.007 | 0.153 | 0.0025 | 0.0547 | 1.11 | 24.96 | 0.075 | 1.683 | 0.069 | 1.544 | 0.0012 | 0.0251 | 0.20 | 4.187 |
| 36 | 0.57 | 12.39 | 100.37 | 2,068.23 | 0.006 | 0.144 | 0.0024 | 0.0514 | 1.08 | 23.41 | 0.072 | 1.586 | 0.066 | 1.456 | 0.0011 | 0.0236 | 0.18 | 3.948 |
| 37 | 0.39 | 11.51 | 61.76 | 1,898.31 | 0.004 | 0.131 | 0.0016 | 0.0472 | 0.67 | 21.43 | 0.050 | 1.467 | 0.046 | 1.346 | 0.0007 | 0.0217 | 0.12 | 3.645 |
| 38 | 0.26 | 10.57 | 44.04 | 1,722.49 | 0.003 | 0.118 | 0.0011 | 0.0428 | 0.45 | 19.37 | 0.034 | 1.341 | 0.031 | 1.230 | 0.0005 | 0.0197 | 0.08 | 3.323 |
| 39 | 0.26 | 9.60 | 42.80 | 1,542.51 | 0.003 | 0.105 | 0.0011 | 0.0383 | 0.44 | 17.27 | 0.033 | 1.212 | 0.030 | 1.112 | 0.0005 | 0.0176 | 0.08 | 2.994 |
| 40 | 0.25 | 8.66 | 41.35 | 1,378.09 | 0.002 | 0.093 | 0.0011 | 0.0342 | 0.42 | 15.35 | 0.032 | 1.088 | 0.029 | 0.998 | 0.0005 | 0.0157 | 0.08 | 2.678 |
| 41 | 0.22 | 7.66 | 33.67 | 1,225.70 | 0.002 | 0.082 | 0.0009 | 0.0305 | 0.35 | 13.56 | 0.027 | 0.963 | 0.025 | 0.883 | 0.0004 | 0.0139 | 0.06 | 2.368 |
| 42 | 0.22 | 6.77 | 33.67 | 1,085.25 | 0.002 | 0.072 | 0.0009 | 0.0271 | 0.35 | 11.94 | 0.027 | 0.852 | 0.025 | 0.781 | 0.0004 | 0.0123 | 0.06 | 2.089 |
| 43 | 0.21 | 5.87 | 32.22 | 943.35 | 0.002 | 0.062 | 0.0009 | 0.0237 | 0.34 | 10.30 | 0.027 | 0.741 | 0.025 | 0.679 | 0.0004 | 0.0107 | 0.06 | 1.809 |
| 44 | 0.18 | 4.99 | 28.85 | 806.91 | 0.002 | 0.053 | 0.0008 | 0.0204 | 0.30 | 8.73 | 0.024 | 0.632 | 0.022 | 0.579 | 0.0003 | 0.0091 | 0.05 | 1.529 |
| Maximum | **2.39** | **20.98** | **340.48** | **3,047.80** | **0.0178** | **0.185** | **0.0067** | **0.0660** | **3.90** | **34.78** | **0.277** | **2.489** | **0.253** | **2.280** | **0.0036** | **0.0328** | **0.67** | **6.05** |
| Average (7 | **1.80** | **15.74** | **255.36** | **2,285.85** | **0.01** | **0.139** | **0.0050** | **0.0495** | **2.93** | **26.08** | **0.207** | **1.867** | **0.190** | **1.710** | **0.0027** | **0.02** | **0.50** | **4.54** |

**Notes:**

[1] Assuming ROGs are equivalent to VOCs

- Assuming 75% operational average load

TABLE 2.a
EMISSION FACTORS FOR MISC. EQUIPMENT FOR OFF PLOT CONSTRUCTION
Hydrogen Energy International LLC, Kern County Power Project

| | | | Emission Factors (lbs/hr) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Equipment Description* | **EMFAC designation** | **HP** | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_x$** | **ROG[1]** |
| **On-Road Vehicles** | | | | | | | | | | | |
| Dump Truck | HHD-DSL | | 0.373 | 69.786 | 0.0017 | 0.001 | 0.691 | 0.055 | 0.050 | 0.00066 | 0.173 |
| Service Truck - 1 ton | HHD-DSL | | 0.373 | 69.786 | 0.0017 | 0.001 | 0.691 | 0.055 | 0.050 | 0.00066 | 0.173 |
| Pipe Haul Truck and Trailer (HHDT-DSL) | HHD-DSL | | 0.373 | 69.786 | 0.0017 | 0.001 | 0.691 | 0.055 | 0.050 | 0.00066 | 0.173 |
| Trucks - Pickup 3/4 ton | MHD-DSL | | 0.163 | 33.180 | 0.0017 | 0.001 | 0.291 | 0.019 | 0.017 | 0.00031 | 0.015 |
| Truck - Water | HHD-DSL | | 0.373 | 69.786 | 0.0017 | 0.001 | 0.691 | 0.055 | 0.050 | 0.00066 | 0.173 |
| **Off Road Vehicles** | | | | | | | | | | | |
| Air Compressor (185 CFM) | Diesel | 50 | 0.287 | 22.271 | 0.0017 | 0.0006 | 0.242 | 0.027 | 0.0253 | 0.00029 | 0.122 |
| Bore Machine (Hydraulic) | Diesel | 50 | 0.261 | 31.037 | 0.0017 | 0.0006 | 0.286 | 0.022 | 0.0204 | 0.00040 | 0.067 |
| Crane (12 Ton Hydra ) | Diesel | 250 | 0.366 | 112.159 | 0.0084 | 0.0028 | 1.310 | 0.050 | 0.0461 | 0.00126 | 0.131 |
| Excavator - Backhoe/loader | Diesel | 175 | 0.589 | 101.387 | 0.0059 | 0.0020 | 1.040 | 0.060 | 0.0549 | 0.00114 | 0.131 |
| Excavator - Trencher (CAT320) | Diesel | 120 | 0.537 | 73.623 | 0.0041 | 0.0014 | 0.900 | 0.084 | 0.0774 | 0.00086 | 0.152 |
| Forklift | Diesel | 50 | 0.192 | 14.672 | 0.0017 | 0.0006 | 0.157 | 0.018 | 0.0163 | 0.00019 | 0.076 |
| 561 Side boom | Diesel | 120 | 0.548 | 80.859 | 0.0041 | 0.0014 | 0.924 | 0.079 | 0.0727 | 0.00095 | 0.144 |
| Generator (Welding) | Diesel | 50 | 0.297 | 30.623 | 0.0017 | 0.0006 | 0.311 | 0.030 | 0.0273 | 0.00040 | 0.118 |
| Roller (3 to 5 Ton AC) | Diesel | 50 | 0.326 | 25.983 | 0.0017 | 0.0006 | 0.279 | 0.031 | 0.0283 | 0.00034 | 0.135 |
| Pipe Bending Machine | Diesel | 50 | 0.303 | 27.990 | 0.0017 | 0.0006 | 0.283 | 0.028 | 0.0260 | 0.00036 | 0.114 |

**Notes:**

[1] Assuming ROGs are equivalent to VOCs

- Emission factors for on-road vehicles are based on results from Emfac Emissions Model 2007 Version 2.3 (LDT-DSL=light duty class II trucks-diesel; HHDT-DSL=heavy heavy-duty trucks-diesel; MHD-DSL=medium heavy duty-diesel). EMFAC scenario year was 2007 and
- Emission factors for off-road vehicles are based on the maximum emission factors from 2006 to 2008 of the South Coast Air Quality Management District (AQMD) data . Linear interpolation was used to calculate the emission factor for horse power values
- $CO_2$ emissions for off-road vehicles were estimated using USEPA AP-42 Chapter 3.3 - Gasoline and Diesel Industrial Engines, and Chapter 3.4 - Large Stationary Diesel and All Stationary Dual-fuel Engines
- $PM_{2.5}$ emission factors were determined by multiplying $PM_{10}$ numbers by a "$PM_{2.5}$ fraction of $PM_{10}$" value. Fractional values for $PM_{2.5}$ were taken from the SCAQMD guidance: Final - Methodology to Calculate $PM_{2.5}$ and $PM_{2.5}$ Significance Thresholds, October

On-Road Vehicles:
- $PM_{2.5}$ Fraction of $PM_{10}$, Brake wear: 0.429
- $PM_{2.5}$ Fraction of $PM_{10}$, Diesel: 0.920
- PM2.5 Fraction of PM10, Tire wear: 0.250

Off-Road Vehicles:
- PM2.5 Fraction of PM10, Diesel: 0.920

- $CH_4$ and $N_2O$ factors are derived from California Climate Action Registry General Reporting Protocol Version 2.2 (March 2007), Table C.4 using the mileage accrual rates by age table from EMFAC2007 Version 2.3, November 1, 2006, California Air Resources Bo
- $CH_4$ and $N_2O$ factors for off-road vehicles are derived from California Climate Action Registry General Reporting Protocol Version 2.2 (March 2007), Table C.6 (distillate fuel factors for the industrial sector) using the following to convert from kg/gallo

MISC. EQUIPMENT FOR OFF PLOT CONSTRUCTION USE PER MONTH
Hydrogen Energy International LLC, Kern County Power Project

| | | month | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *13* | *14* | *15* | *16* | *17* | *18* | *19* | *20* | *21* | *22* | *23* | *24* | *25* | *26* | *27* | *28* | *29* | *30* | *31* | *32* | *33* | *34* | *35* | *36* | *37* | *38* | *39* | *40* | *41* | *42* | *43* | *44* |
| *EQUIPMENT* | *# of units* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **ON ROAD** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dump Truck | 11 | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pipe Haul Truck and Trailer (HHDT-DSL | 11 | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Truck (Pickup 3/4 Ton) - MHD-DSL | 30 | 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 | 1 | 1 | 1 | | | | | | | | | | | | | | | |
| Truck - water | 30 | 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 | 1 | 1 | 1 | | | | | | | | | | | | | | | |
| **OFF ROAD** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bore Machine (Hydraulic) | 5 | | | | | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 Ton Hydra Crane | 5 | | | | | | | | | | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Excavator - Backhoe/loader | 34 | 2 | 2 | 2 | 2 | 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 | | | | | | | | | | | | | | | |
| Excavator - Trencher (CAT320) | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Forklift | 27 | | | | 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 | | | | | | | | | | | | | | | |
| 561 Side boom | 10 | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Welding Generator | 27 | | | | 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 | | | | | | | | | | | | | | | |
| 3 to 5 Ton AC Roller | 10 | | | | | | | | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | |
| Pipe Bending Machine | 5 | | | | | | | | | | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **TOTAL** | **214** | **5** | **5** | **5** | **9** | **10** | **10** | **10** | **10** | **10** | **10** | **10** | **10** | **10** | **10** | **6** | **6** | **6** | **6** | **6** | **6** | **6** | **6** | **6** | **6** | **5** | **5** | **5** | **5** | **5** | **5** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

Notes:
1 These are approximate values
2 Misc. equip for off plot include preliminary estimates for work that may be performed outside of the plot (plot linears, facility upgrades, site interfaces, etc.)

UNMITIGATED ANNUAL EMISSIONS FROM MISC. EQUIPMENT FOR OFF-PLOT CONSTRUCTION
Hydrogen Energy International LLC, Kern County Power Project

| | CO | | $CO_2$ | | $CH_4$ | | $N_2O$ | | $NO_x$ | | $PM_{10}$ | | $PM_{2.5}$ | | $SO_x$ | | ROG[1] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | Monthly Emissions (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) | Monthly Emissions (tons) | 12-Month Total (tons) |
| 1 | 0.25 | 41.73 | NA | 0.0021 | NA | 0.0008 | NA | 0.44 | NA | 0.030 | NA | 0.028 | NA | 0.0005 | NA | 0.07 | NA |
| 2 | 0.25 | 41.73 | NA | 0.0021 | NA | 0.0008 | NA | 0.44 | NA | 0.030 | NA | 0.028 | NA | 0.0005 | NA | 0.07 | NA |
| 3 | 0.25 | 41.73 | NA | 0.0021 | NA | 0.0008 | NA | 0.44 | NA | 0.030 | NA | 0.028 | NA | 0.0005 | NA | 0.07 | NA |
| 4 | 0.38 | 62.07 | NA | 0.0029 | NA | 0.001191 | NA | 0.64 | NA | 0.048 | NA | 0.044 | NA | 0.0007 | NA | 0.126 | NA |
| 5 | 0.41 | 63.22 | NA | 0.0029 | NA | 0.0012 | NA | 0.66 | NA | 0.052 | NA | 0.048 | NA | 0.0007 | NA | 0.13 | NA |
| 6 | 0.41 | 63.22 | NA | 0.0029 | NA | 0.0012 | NA | 0.66 | NA | 0.052 | NA | 0.048 | NA | 0.0007 | NA | 0.13 | NA |
| 7 | 0.41 | 63.22 | NA | 0.0029 | NA | 0.0012 | NA | 0.66 | NA | 0.052 | NA | 0.048 | NA | 0.0007 | NA | 0.13 | NA |
| 8 | 0.41 | 63.22 | NA | 0.0029 | NA | 0.0012 | NA | 0.66 | NA | 0.052 | NA | 0.048 | NA | 0.0007 | NA | 0.13 | NA |
| 9 | 0.41 | 63.22 | NA | 0.0029 | NA | 0.0012 | NA | 0.66 | NA | 0.052 | NA | 0.048 | NA | 0.0007 | NA | 0.13 | NA |
| 10 | 0.39 | 67.12 | NA | 0.0033 | NA | 0.001346 | NA | 0.70 | NA | 0.049 | NA | 0.045 | NA | 0.0007 | NA | 0.137 | NA |
| 11 | 0.39 | 67.12 | NA | 0.0033 | NA | 0.001346 | NA | 0.70 | NA | 0.049 | NA | 0.045 | NA | 0.0007 | NA | 0.137 | NA |
| 12 | 0.39 | 67.12 | 704.74 | 0.0033 | 0.034 | 0.001346 | 0.0136 | 0.70 | 7.34 | 0.049 | 0.549 | 0.045 | 0.502 | 0.0007 | 0.008 | 0.137 | 1.409 |
| 13 | 0.39 | 67.12 | 730.13 | 0.0033 | 0.035 | 0.001346 | 0.0142 | 0.70 | 7.61 | 0.049 | 0.568 | 0.045 | 0.519 | 0.0007 | 0.008 | 0.137 | 1.480 |
| 14 | 0.39 | 67.12 | 755.53 | 0.0033 | 0.0360 | 0.001346 | 0.01467 | 0.70 | 7.88 | 0.049 | 0.587 | 0.045 | 0.536 | 0.0007 | 0.0082 | 0.137 | 1.551 |
| 15 | 0.21 | 30.32 | 744.12 | 0.0016 | 0.0354 | 0.0006 | 0.01449 | 0.30 | 7.75 | 0.023 | 0.579 | 0.021 | 0.530 | 0.0003 | 0.0080 | 0.07 | 1.557 |
| 16 | 0.21 | 30.32 | 712.37 | 0.0016 | 0.0342 | 0.0006 | 0.0139 | 0.30 | 7.41 | 0.023 | 0.555 | 0.021 | 0.507 | 0.0003 | 0.008 | 0.07 | 1.502 |
| 17 | 0.21 | 30.32 | 679.47 | 0.0016 | 0.033 | 0.0006 | 0.0134 | 0.30 | 7.06 | 0.023 | 0.526 | 0.021 | 0.481 | 0.0003 | 0.007 | 0.07 | 1.439 |
| 18 | 0.21 | 30.32 | 646.57 | 0.0016 | 0.032 | 0.0006 | 0.0129 | 0.30 | 6.71 | 0.023 | 0.497 | 0.021 | 0.454 | 0.0003 | 0.007 | 0.07 | 1.376 |
| 19 | 0.21 | 30.32 | 613.66 | 0.0016 | 0.030 | 0.0006 | 0.0123 | 0.30 | 6.35 | 0.023 | 0.468 | 0.021 | 0.427 | 0.0003 | 0.007 | 0.07 | 1.313 |
| 20 | 0.21 | 30.32 | 580.76 | 0.0016 | 0.029 | 0.0006 | 0.0118 | 0.30 | 6.00 | 0.023 | 0.438 | 0.021 | 0.401 | 0.0003 | 0.006 | 0.07 | 1.250 |
| 21 | 0.21 | 30.32 | 547.86 | 0.0016 | 0.028 | 0.0006 | 0.0112 | 0.30 | 5.65 | 0.023 | 0.409 | 0.021 | 0.374 | 0.0003 | 0.006 | 0.07 | 1.186 |
| 22 | 0.21 | 30.32 | 511.05 | 0.0016 | 0.026 | 0.0006 | 0.0105 | 0.30 | 5.25 | 0.023 | 0.383 | 0.021 | 0.350 | 0.0003 | 0.006 | 0.07 | 1.120 |
| 23 | 0.21 | 30.32 | 474.25 | 0.0016 | 0.024 | 0.0006 | 0.0098 | 0.30 | 4.85 | 0.023 | 0.357 | 0.021 | 0.327 | 0.0003 | 0.005 | 0.07 | 1.054 |
| 24 | 0.21 | 30.32 | 437.44 | 0.0016 | 0.023 | 0.0006 | 0.0091 | 0.30 | 4.45 | 0.023 | 0.331 | 0.021 | 0.303 | 0.0003 | 0.005 | 0.07 | 0.988 |
| 25 | 0.18 | 27.46 | 397.78 | 0.0014 | 0.021 | 0.0006 | 0.0084 | 0.27 | 4.02 | 0.020 | 0.302 | 0.018 | 0.276 | 0.0003 | 0.004 | 0.06 | 0.907 |
| 26 | 0.18 | 27.46 | 358.12 | 0.0014 | 0.019 | 0.0006 | 0.0076 | 0.27 | 3.59 | 0.020 | 0.272 | 0.018 | 0.249 | 0.0003 | 0.004 | 0.06 | 0.826 |
| 27 | 0.18 | 27.46 | 355.26 | 0.0014 | 0.018 | 0.0006 | 0.0076 | 0.27 | 3.56 | 0.020 | 0.269 | 0.018 | 0.246 | 0.0003 | 0.004 | 0.06 | 0.812 |
| 28 | 0.18 | 27.46 | 352.40 | 0.0014 | 0.018 | 0.0006 | 0.0075 | 0.27 | 3.53 | 0.020 | 0.266 | 0.018 | 0.243 | 0.0003 | 0.004 | 0.06 | 0.797 |
| 29 | 0.18 | 27.46 | 349.54 | 0.0014 | 0.018 | 0.0006 | 0.0074 | 0.27 | 3.50 | 0.020 | 0.262 | 0.018 | 0.240 | 0.0003 | 0.004 | 0.06 | 0.782 |
| 30 | 0.18 | 27.46 | 346.68 | 0.0014 | 0.018 | 0.0006 | 0.0074 | 0.27 | 3.47 | 0.020 | 0.259 | 0.018 | 0.237 | 0.0003 | 0.004 | 0.06 | 0.767 |
| 31 | 0.00 | 0.00 | 316.36 | 0.0000 | 0.016 | 0.0000 | 0.0067 | 0.00 | 3.17 | 0.000 | 0.236 | 0.000 | 0.215 | 0.0000 | 0.003 | 0.00 | 0.695 |
| 32 | 0.00 | 0.00 | 286.04 | 0.0000 | 0.015 | 0.0000 | 0.0061 | 0.00 | 2.86 | 0.000 | 0.212 | 0.000 | 0.194 | 0.0000 | 0.003 | 0.00 | 0.624 |
| 33 | 0.00 | 0.00 | 255.73 | 0.0000 | 0.013 | 0.0000 | 0.0054 | 0.00 | 2.56 | 0.000 | 0.189 | 0.000 | 0.173 | 0.0000 | 0.003 | 0.00 | 0.553 |
| 34 | 0.00 | 0.00 | 225.41 | 0.0000 | 0.012 | 0.0000 | 0.0048 | 0.00 | 2.25 | 0.000 | 0.166 | 0.000 | 0.152 | 0.0000 | 0.002 | 0.00 | 0.481 |
| 35 | 0.00 | 0.00 | 195.09 | 0.0000 | 0.010 | 0.0000 | 0.0041 | 0.00 | 1.95 | 0.000 | 0.143 | 0.000 | 0.130 | 0.0000 | 0.002 | 0.00 | 0.410 |
| 36 | 0.00 | 0.00 | 164.77 | 0.0000 | 0.008 | 0.0000 | 0.0035 | 0.00 | 1.64 | 0.000 | 0.119 | 0.000 | 0.109 | 0.0000 | 0.002 | 0.00 | 0.339 |
| 37 | 0.00 | 0.00 | 137.31 | 0.0000 | 0.007 | 0.0000 | 0.0029 | 0.00 | 1.37 | 0.000 | 0.099 | 0.000 | 0.091 | 0.0000 | 0.001 | 0.00 | 0.282 |
| 38 | 0.00 | 0.00 | 109.84 | 0.0000 | 0.006 | 0.0000 | 0.0023 | 0.00 | 1.10 | 0.000 | 0.080 | 0.000 | 0.073 | 0.0000 | 0.001 | 0.00 | 0.226 |
| 39 | 0.00 | 0.00 | 82.38 | 0.0000 | 0.004 | 0.0000 | 0.0017 | 0.00 | 0.82 | 0.000 | 0.060 | 0.000 | 0.054 | 0.0000 | 0.001 | 0.00 | 0.169 |
| 40 | 0.00 | 0.00 | 54.92 | 0.0000 | 0.003 | 0.0000 | 0.0012 | 0.00 | 0.55 | 0.000 | 0.040 | 0.000 | 0.036 | 0.0000 | 0.001 | 0.00 | 0.113 |
| 41 | 0.00 | 0.00 | 27.46 | 0.0000 | 0.001 | 0.0000 | 0.0006 | 0.00 | 0.27 | 0.000 | 0.020 | 0.000 | 0.018 | 0.0000 | 0.000 | 0.00 | 0.056 |
| 42 | 0.00 | 0.00 | 0.00 | 0.0000 | 0.000 | 0.0000 | 0.0000 | 0.00 | 0.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0000 | 0.000 | 0.00 | 0.000 |
| 43 | 0.00 | 0.00 | 0.00 | 0.0000 | 0.000 | 0.0000 | 0.0000 | 0.00 | 0.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0000 | 0.000 | 0.00 | 0.000 |
| 44 | 0.00 | 0.00 | 0.00 | 0.0000 | 0.000 | 0.0000 | 0.0000 | 0.00 | 0.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0000 | 0.000 | 0.00 | 0.000 |
| Maximum (100 % load) | **0.41** | **67.12** | **755.53** | **0.0033** | **0.0360** | **0.001346** | **0.0147** | **0.70** | **7.88** | **0.052** | **0.587** | **0.048** | **0.536** | **0.0007** | **0.0082** | **0.14** | **1.56** |
| Average (75 % load) | **0.31** | **50.34** | **566.64** | **0.0025** | **0.03** | **0.0010** | **0.0110** | **0.53** | **5.91** | **0.039** | **0.440** | **0.036** | **0.402** | **0.0005** | **0.0061** | **0.10** | **1.17** |

**Note:**
[1] Assuming ROGs are equivalent to VOCs
- Assuming 75% operational average load

HECA
Fugitive Dust Emissions Calculations

| Fugitive Dust PM10 and PM2.5 Calculation | | |
|---|---|---|
| Emission factor | 1.3 | lb/hr-acre |
| Hours per day | 10 | hr/day |
| Days per month | 22 | days/month |
| Months per year | 12 | months/year |
| Total acreage disturbed | 310 | acres |
| Percent disturbed | 25% | |
| Average acreage | 77.5 | acre |
| PM10 emissions | 133 | tons/year |
| PM2.5 emissions | 27.7 | tons/year |
| Mitigation factor | 83.2 | percent |
| Controlled PM10 emissions | 22.3 | tons/year |
| Controlled PM2.5 emissions | 4.68 | tons/year |

Note:

- Emission factor: 1.3 lb/hour-acre of ground disturbance - emission factor for fugitive dust emissions recommended in a study conducted by Midwest Research Institute (MRI, 1996) for an average level of earthmoving construction activities based on 0.11 ton/acre-month and 168 hours per month of construction.
- Assumed work schedule: 10 (hours/day), 22 (days/month), and 12 (months/year) (or 2,640 work hours/year) (Information provided by Applicant)
- Total acreage disturbed: 68 (acres) (Information provided by Applicant)
- Daily ground disturbance: 17 (acres) - based on the assumption that 25 percent of total acreage is disturbed per day (URBEMIS2002 (Version 8.7) model) (Jones & Stokes Associates, 2003)
- Earthmoving activity is expected to last for 13 months, which means that in one year it is possible for earthmoving activities to take place each month. Therefore, the worst-case annual fugitive dust emissions, were calculated by multiplying the monthly fugitive dust emission rate by 12 months.
- PM2.5 values were calculated according to the South Coast AQMD's recommended method, which is to use a conversion factor to obtain the PM2.5 emissions directly from PM10 emissions. Conversion factors are published as Appendix A of the Methodology to Calculate Particulate Matter (PM) 2.5 and PM 2.5 Significance Thresholds from October 2006.

- Limiting vehicle speed to 15 mph or less: about 57% control efficiency for unpaved roads (WRAP Fugitive Dust Handbook)
- Watering (every 3 hours to the disturbed areas): at least 61% efficiency for general construction activities (WRAP Fugitive Dust Handbook)
- Mitigated emissions calculated as unmitigated emissions (ton/year) x (100 - 85)/100

HECA
Emissions from Vehicle Traffic Emissions

**EMISSION FACTOR FOR ONROAD VEHICLES**

| Onroad Vehicle | Fuel Type | Vehicle Count | Weight (lbs) | Vehicle Type | EF (lbs/mile) TOC | CO | NOx | $PM_{10}$ | $SO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Passenger Vehicles | G/D | 52.8 | 4000 | LDA | 1.38E-03 | 1.28E-02 | 1.36E-03 | 8.00E-05 | 9.00E-06 |

note: Emission factors from SCAQMD Emission Factors for Onroad Vehicles for 2007 from EMFAC2002 (version 2.2)

**EMISSION CALCULATION FOR ONROAD VEHICLES**

| | Total Op. Hours / Project | Trips or Hours/Day/Unit | Round Trip Distance (miles) | Daily Total VMT | Daily Emissions (lbs) TOC | CO | NOx | $PM_{10}$ | $SO_2$ | PM2.5 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Highway Vehicles** | **Total Days** | | | | | | | | | |
| Passenger Vehicles | 264 | 1 | 40 | 2112 | 2.9 | 27.1 | 2.9 | 0.2 | 1.90E-02 | 0.0 |

| Annual Emission Rate (tons/year) TOC | CO | NOx | PM10 | SO2 | PM2.5 |
|---|---|---|---|---|---|
| 0.39 | 3.57 | 0.38 | 0.02 | 0.00 | 0.00 |

**Passenger vehicle travel on paved roads** 0.0064 PM10 lb/VMT note: from Table A9-9-B-1 for major streets/highways

| Equipment | Average Number of Employee Vehicles (Monthly) | Hours/Day | Days/year (mos 1-12) | Miles travelled per trip | Total miles travelled per year | PM10 Emissions (lb/hr) | PM10 Emissions (lb/day) | PM10 Emissions (tons/yr) | PM2.5 Emissions (lb/hr) | PM2.5 Emissions (lb/day) | PM2.5 Emissions (tons/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All Employee Vehicles | 53 | 2 | 264 | 40 | 557568 | 6.7584 | 13.5168 | 1.784 | 1.14 | 2.28 | 0.30 |

notes:
Assumed average distance travelled off site for all employees commuting will be 20 miles
(approximate distance to Bakersfield) times 2 for return trip 40 miles
Employee numbers based on total employees on site during Month 4 (66)
Assumed 1.3 employees per vehicle

## Worker/Delivery Annual Emissions (Month 1 through 12)

**COMBUSTION EMISSION FACTOR FOR ONROAD VEHICLES**

| Onroad Vehicle Combustion | Fuel Type | Daily Vehicle Count | Vehicle Type | EF (lbs/mile)[1] $PM_{10}$ | $PM_{2.5}$ | CO | VOC | NOx | $SO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Heavy Truck (concrete, fuel, water, dump trucks) | Diesel | 80 | HHD | 0.0020 | 0.0018 | 0.0128 | 0.0033 | 0.0418 | 0.00004 |
| Light Truck (service truck) | Gasoline | 7 | Delivery | 0.0008 | 0.0007 | 0.0202 | 0.0028 | 0.0224 | 0.00003 |
| Personal Commuting Vehicles | Gasoline | 53 | Passenger | 0.0001 | 0.0001 | 0.0097 | 0.0010 | 0.0010 | 0.00001 |
| Light delivery truck (e.g. Fed-Ex) | Gasoline | 2 | Delivery | 0.0008 | 0.0007 | 0.0202 | 0.0028 | 0.0224 | 0.00003 |
| eavy delivery truck (e.g. flat beds carrying construction eqp) | Diesel | 11 | HHD | 0.0020 | 0.0018 | 0.0128 | 0.0033 | 0.0418 | 0.00004 |
| | | | **Total** | 0.0057 | 0.0049 | 0.0757 | 0.0132 | 0.1294 | 0.0001 |

Daily vehicle count based on 100 truck trips per day during construction (300 PCE/3).

**EMISSION CALCULATION FOR ONROAD VEHICLES**

| | Total Days / Year | Daily VMT / Vehicle | Annual VMT | Daily Emissions (lbs/day) $PM_{10}$ | $PM_{2.5}$ | CO | VOC | NOx | $SO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Heavy Truck (concrete, fuel, water, dump trucks) | 264 | 40 | 844,800 | 6.39 | 5.61 | 41.03 | 10.54 | 133.91 | 0.13 |
| Light Truck (service truck) | 264 | 40 | 73,920 | 0.23 | 0.19 | 5.65 | 0.78 | 6.26 | 0.01 |
| Personal Commuting Vehicles | 264 | 40 | 557,568 | 0.18 | 0.11 | 20.46 | 2.10 | 2.12 | 0.02 |
| Light delivery truck (e.g. Fed-Ex) | 264 | 40 | 21,120 | 0.06 | 0.06 | 1.61 | 0.22 | 1.79 | 0.00 |
| eavy delivery truck (e.g. flat beds carrying construction eqp) | 264 | 40 | 116,160 | 0.88 | 0.77 | 5.64 | 1.45 | 18.41 | 0.02 |
| | | | **Total** | 7.74 | 6.74 | 74.39 | 15.09 | 162.49 | 0.18 |

| Onroad Vehicle Combustion | Annual Emission Rate (tons/year) $PM_{10}$ | $PM_{2.5}$ | CO | VOC | NOx | $SO_2$ |
|---|---|---|---|---|---|---|
| Heavy Truck (concrete, fuel, water, dump trucks) | 0.84 | 0.74 | 5.42 | 1.39 | 17.68 | 0.02 |
| Light Truck (service truck) | 0.03 | 0.03 | 0.75 | 0.10 | 0.83 | 0.00 |
| Personal Commuting Vehicles | 0.02 | 0.02 | 2.70 | 0.28 | 0.28 | 0.00 |
| Light delivery truck (e.g. Fed-Ex) | 0.01 | 0.01 | 0.21 | 0.03 | 0.24 | 0.00 |
| eavy delivery truck (e.g. flat beds carrying construction eqp) | 0.12 | 0.10 | 0.74 | 0.19 | 2.43 | 0.00 |
| **Total** | **0.90** | **0.78** | **8.86** | **1.77** | **18.78** | **0.02** |

**Note 1:** SCAQMD Prepared - Highest (Most Conservative) Emfac 2007 (version 2.3)
Emission Factors for On-Road Personal Commuting Vehicles and Trucks
Scenario Year: 2009
All model years in the range 1965 to 2009

**FUGITIVE EMISSION FACTOR FOR ONROAD VEHICLES**

Personal Commuting Vehicles EF= 0.0064 PM10 lb/VMT (from CEQA Handbook, Table A9-9-B-1 for major streets/highways)
Truck Travel on paved roads EF = 0.1491 PM10 lb/VMT (from CEQA Handbook Table A9-9-C-1 for major streets/highways)

| Onroad Vehicle Fugitive | Daily PM10 Emissions (lb/day) | Annual PM10 Emissions (tons/yr) | Daily PM2.5 Emissions (lb/day) | Annual PM2.5 Emissions (tons/yr) |
|---|---|---|---|---|
| Heavy Truck (concrete, fuel, water, dump trucks) | 477.1 | 62.98 | 80.63 | 10.64 |
| Light Truck (service truck) | 41.7 | 5.51 | 7.06 | 0.93 |
| Personal Commuting Vehicles | 13.5 | 1.78 | 2.28 | 0.30 |
| Light delivery truck (e.g. Fed-Ex) | 11.9 | 1.57 | 2.02 | 0.27 |
| eavy delivery truck (e.g. flat beds carrying construction eqp) | 65.6 | 8.66 | 11.09 | 1.46 |
| **Total** | **609.90** | **80.51** | **103.07** | **13.61** |

**Assumptions:**
"Heavy Truck" assumes the average number of concrete, water, & dump trucks onsite for the daily vehicle count, which are used during an average 12 month period per the equip. schedule
"Light Truck" assumes the average number of service trucks for the daily vehicle count, which are used during a travelling 12 month period per the equip. schedule
Assumed average distance travelled off site for all employees commuting will be 20 miles
times 2 for return trip = 40 miles
22 days per month of construction, average
Employee numbers based on average employees on site in Month 4 66
Average daily vehicles 53
Number of workers per communter vehicle = 1.25

MODEL EMISSION RATES (lb/hr)

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Month 4 (Peak Month of Construction) Modeled Emissions Values

| | CO | | $NO_x$ | | $PM_{10}$ | | $PM_{2.5}$ | | $SO_2$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Equipment Description** | **1-hr** | **8-hr** | **1-hr** | **Annual** | **24-hr** | **Annual** | **24-hr** | **Annual** | **1-hr** | **3-hr** | **24-hr** | **Annual** |
| **On-Road Vehicles** | | | | | | | | | | | | |
| Dump Truck | 0.320 | 0.320 | 0.694 | 0.094 | 1.43E-02 | 5.87E-03 | 1.30E-02 | 5.27E-03 | 1.00E-03 | 1.00E-03 | 3.33E-04 | 9.01E-05 |
| Pile Driver Truck | 0.320 | 0.320 | 0.694 | 0.061 | 1.43E-02 | 3.78E-03 | 1.30E-02 | 3.41E-03 | 1.00E-03 | 1.00E-03 | 3.33E-04 | 5.81E-05 |
| Trucks - Pickup 3/4 ton | 0.155 | 0.155 | 0.279 | 0.016 | 5.67E-03 | 3.65E-04 | 5.00E-03 | 3.79E-03 | 3.09E-04 | 3.09E-04 | 1.03E-04 | 9.41E-05 |
| Trucks - 3 ton | 0.320 | 0.320 | 0.694 | 0.195 | 1.43E-02 | 1.21E-02 | 1.30E-02 | 1.09E-02 | 1.00E-03 | 1.00E-03 | 3.33E-04 | 1.86E-04 |
| Truck - Water | 0.320 | 0.320 | 0.694 | 0.098 | 1.43E-02 | 6.05E-03 | 1.30E-02 | 5.45E-03 | 1.00E-03 | 1.00E-03 | 3.33E-04 | 9.31E-05 |
| **Off Road Vehicles** | | | | | | | | | | | | |
| Air Compressor 750 CFM | 0.338 | 0.338 | 0.625 | 0.176 | 1.88E-02 | 1.58E-02 | 1.73E-02 | 1.45E-02 | 5.51E-04 | 5.51E-04 | 1.84E-04 | 1.55E-04 |
| Bulldozer D10R | 0.936 | 0.936 | 1.582 | 0.472 | 2.33E-02 | 2.01E-02 | 2.14E-02 | 1.85E-02 | 1.19E-03 | 1.19E-03 | 3.97E-04 | 3.65E-04 |
| Bulldozer D4C | 0.927 | 0.927 | 1.364 | 0.208 | 3.48E-02 | 1.59E-02 | 3.20E-02 | 1.46E-02 | 1.01E-03 | 1.01E-03 | 3.37E-04 | 1.54E-04 |
| Cranes - Mobile 35 ton | 0.376 | 0.376 | 0.690 | 0.182 | 2.11E-02 | 1.67E-02 | 1.94E-02 | 1.53E-02 | 5.88E-04 | 5.88E-04 | 1.96E-04 | 2.57E-05 |
| Diesel Powered Welder | 0.069 | 0.069 | 0.111 | 0.018 | 2.70E-03 | 1.28E-03 | 2.48E-03 | 1.16E-03 | 1.43E-04 | 1.43E-04 | 4.77E-05 | 2.27E-05 |
| Excavator - Backhoe/loader | 0.366 | 0.366 | 0.607 | 0.109 | 1.85E-02 | 9.99E-03 | 1.70E-02 | 9.19E-03 | 6.07E-04 | 6.07E-04 | 2.02E-04 | 1.09E-04 |
| Excavator - Earth Scraper | 0.758 | 0.758 | 1.064 | 0.118 | 2.51E-02 | 6.94E-03 | 2.31E-02 | 6.38E-03 | 1.09E-03 | 1.09E-03 | 3.63E-04 | 1.24E-04 |
| Excavator - loader | 0.366 | 0.366 | 0.607 | 0.128 | 1.85E-02 | 1.17E-02 | 1.70E-02 | 1.07E-02 | 6.07E-04 | 6.07E-04 | 2.02E-04 | 1.28E-04 |
| Excavator - Motor Grader | 0.537 | 0.537 | 0.900 | 0.095 | 2.80E-02 | 8.87E-03 | 2.58E-02 | 8.15E-03 | 8.64E-04 | 8.64E-04 | 2.88E-04 | 9.11E-05 |
| Fired Heaters | 0.055 | 0.055 | 0.107 | 0.047 | 1.98E-03 | 1.51E-03 | 1.82E-03 | 1.37E-03 | 1.68E-04 | 1.68E-04 | 5.59E-05 | 4.21E-05 |
| Forklift | 0.192 | 0.192 | 0.157 | 0.030 | 5.92E-03 | 3.44E-03 | 5.45E-03 | 3.20E-03 | 1.90E-04 | 1.90E-04 | 6.32E-05 | 3.67E-05 |
| Light Plants | 0.055 | 0.055 | 0.107 | 0.032 | 1.98E-03 | 1.76E-03 | 1.82E-03 | 1.60E-03 | 1.68E-04 | 1.68E-04 | 5.59E-05 | 5.01E-05 |
| Portable Compaction Roller | 0.554 | 0.554 | 0.482 | 0.114 | 1.54E-02 | 5.78E-03 | 1.42E-02 | 5.33E-03 | 4.13E-04 | 4.13E-04 | 1.38E-04 | 1.13E-04 |
| Pumps | 0.055 | 0.055 | 0.107 | 0.021 | 1.98E-03 | 1.17E-03 | 1.82E-03 | 1.09E-03 | 1.68E-04 | 1.68E-04 | 5.59E-05 | 3.33E-05 |
| Portable Power Generators | 0.297 | 0.297 | 0.311 | 0.068 | 9.88E-03 | 6.51E-03 | 9.09E-03 | 5.99E-03 | 3.96E-04 | 3.96E-04 | 1.32E-04 | 8.71E-05 |
| Vibratory Roller Ingersol-Rand 20 ton | 0.462 | 0.462 | 0.897 | 0.199 | 1.89E-02 | 1.01E-02 | 1.74E-02 | 9.32E-03 | 8.66E-04 | 8.66E-04 | 2.89E-04 | 1.98E-04 |

notes:

Annual values incorporate a 70% average load factor, except heaters and pickup trucks which use a 40% load factor

24-hour values use a 80% average load factor

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Emission Factors for Dump Trucks, Scrapers, and Dozers with the Physical Properties of Soil used for PM10 Emissions Calculations

| Emission Factors | | Units |
|---|---|---|
| Unloading of trucks | **0.00041** | lb PM10/ton |
| Unloading of trucks | 0.22 | lb PM10/hr |
| Dozer Tractor Crawler | **1.71** | lb PM10/hr |
| Dump Truck transportation on unpaved road (unloaded) | **3.31** | lb PM10/VMT |
| Dump Truck transportation on unpaved road (unloaded) | 157.09 | lb PM10/day/truck |
| Dump Truck transportation on unpaved road (loaded) | **4.81** | lb PM10/VMT |
| Dump Truck transportation on unpaved road (loaded) | 228.52 | lb PM10/day/truck |
| Unloading of Scrapers | **0.00041** | lb PM10/ton |
| Unloading of Scrapers | 0.16 | lb PM10/hr |
| Scrapers transportation (unloaded) | **2.03** | lb PM10/VMT |
| Scrapers transportation (unloaded) | 205.51 | lb PM10/day |
| Scrapers transportation (loaded) | **3.63** | lb PM10/VMT |
| Scrapers transportation (loaded) | 366.44 | lb PM10/day |

| Physical Properties | | *units* |
|---|---|---|
| s (silt content) | 9 | % |
| M (moisture content) | 5.83 | % |
| u (mean wind speed) | 7.29 | mph |
| amount of earth moved | 1,678,050 | tons |
| density | 113 | lbs/ft3 (pcf) |
| density | 1.53 | tons/yd3 |
| vol moved | 1,100,000 | yd3 |
| days per month | 22 | days/month |
| hours per day | 7 | hours/day |
| duration | 12 | months |
| Round Trip Miles (Bull Dozer) | 0.4 | Miles/trip |
| Round Trip Miles (Trucks and Scrapers) | 1 | Miles/trip |

**Dump Trucks**

| | | |
|---|---|---|
| Total # of truck-months | 2 | |
| Truck Capacity | 26.3 | yd3 |
| Wt (Truck Weight) | 30.87 | tons |
| Ws (Soil Weight) | 40.12 | tons |
| Wl (Truck + Soil Weight) | 70.99 | tons |
| percentage of soil moved with dump trucks | 10% | % |
| Trips Required | 4,183 | total trips |
| Truck Trips (per truck to move 50% of soil) | 13.6 | trips/hr/truck |
| Truck VMT/day | 95.1 | miles/day/truck |

**Scrapers**

| | | |
|---|---|---|
| Total # of scraper-months | 22 | |
| Scraper Capacity | 18 | yd3 |
| St (Scraper Weight) | 10.5 | tons |
| Ss (Soil Weight) | 27.5 | tons |
| Sl (Truck + Soil Weight) | 38.0 | tons |
| percentage of soil moved with scrapers | 80% | % |
| Trips Required | 48,889 | total trips |
| Scraper Trips (per scraper to move 50% of soil) | 14.43 | trips/hr/scraper |
| Scraper (VMT/day) | 101.0 | miles/day/scraper |

**Dozer**

| | | |
|---|---|---|
| D10R Blade Capacity | 10.25 | yd3 |
| Total Dozer Trips Req (for 100% of soil) | 107,317.1 | trips |
| percentage of soil moved using dozers | 10% | % |
| D10R hours of operation | 462 | hrs |
| percentage of the soil moved by dozers, using D10R | 80% | |
| Total # of D10R-months | 3 | |
| D10R Trips | 8,585.4 | trips |
| D10R Trips/hr | 18.6 | trips/hr |
| D10R Distance | 52.0 | miles/day |
| D4C Blade Capacity | 2.51 | yd3 |
| D4C hours of operation | 616 | hrs |
| percentage of the soil moved by dozers, using D4C | 20% | |
| Total # of D4C-months | 4 | |
| D4C Trips | 8,764.9 | trips |
| D4C Trips/hr | 14.2 | trips/hr |
| D4C Distance | 39.8 | miles/day |

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Construction Equipment List for Earthmoving Activities

| **Construction Equipment** | **Total** | **Average Units On Site Per Month** | | | |
|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** |
| Dump Truck | **2** | | 1 | 1 | |
| Fuel/Lube Truck | **2** | | 1 | 1 | |
| Water Truck | **8** | 2 | 2 | 2 | 2 |
| Dozer (D10R+D4C) | **7** | 2 | 2 | 2 | 1 |
| Excavator - Earth Scraper | **22** | 6 | 6 | 4 | 6 |
| Backhoe/Loader | **1** | | | 1 | |
| Grader | **2** | 1 | 1 | | |
| Vibratory Roller Ingersol-Rand 20 ton | **12** | 3 | 3 | 3 | 3 |
| | | | | | |
| Bulldozer D10R | **3** | 1 | 1 | 1 | |
| Bulldozer D4C | **4** | 1 | 1 | 1 | 1 |

HECA
Controlled and Uncontrolled PM10 Emissions from Earthmoving Activities

**Construction Equipment** **PM10 Emissions Per Month (lbs)**

| Uncontrolled | 1 | 2 | 3 | 4 | Total |
|---|---|---|---|---|---|
| Unloading of trucks | - | 19 | 19 | - | 37.4 |
| Dump Truck transportation on unpaved road (loaded) | - | 1,885 | 1,885 | - | 3,770.2 |
| Dump Truck transportation on unpaved road (unloaded) | - | 2,742 | 2,742 | - | 5,484.5 |
| Dozer Tractor Crawler | 288 | 288 | 288 | 144 | 1,008.1 |
| Unloading of scrapers | 112 | 112 | 75 | 112 | 411.7 |
| Scraper transportation on unpaved road (loaded) | 26,383 | 26,383 | 17,589 | 26,383 | 96,739.1 |
| Scraper transportation on unpaved road (unloaded) | 14,797 | 14,797 | 9,865 | 14,797 | 54,255.7 |
| **Total** | **41,581** | **46,227** | **32,463** | **41,437** | **161,707** |

| 12 month emissions | Month 1-12 | Month 2-13 | Month 3-14 | Month 4-15 |
|---|---|---|---|---|
| | 161,707 | 120,126 | 73,899 | 41,437 |

| | |
|---|---|
| **Worst Month** | 46,227 |
| **Worst 1-hr** | 300 |
| **Worst 12 -mo** | 161,707 |

| Controlled | 1 | 2 | 3 | 4 | Total |
|---|---|---|---|---|---|
| Unloading of trucks | - | 3 | 3 | - | 5.6 |
| Dump Truck transportation on unpaved road (loaded) | - | 283 | 283 | - | 565.5 |
| Dump Truck transportation on unpaved road (unloaded) | - | 411 | 411 | - | 822.7 |
| Dozer Tractor Crawler | 43 | 43 | 43 | 22 | 151.2 |
| Unloading of scrapers | 17 | 17 | 11 | 17 | 81.0 |
| Scraper transportation on unpaved road (loaded) | 3,958 | 3,958 | 2,638 | 3,958 | 19,024.4 |
| Scraper transportation on unpaved road (unloaded) | 2,220 | 2,220 | 1,480 | 2,220 | 10,669.8 |
| **Total** | **6,237** | **6,934** | **4,869** | **6,216** | **31,320** |

note:
Control efficiency of 85% based on the WRAP Fugitive Dust Handbook, November 15, 2004.

| 12 month emissions | Month 1-12 | Month 2-13 | Month 3-14 | Month 4-15 |
|---|---|---|---|---|
| | 24,256 | 18,019 | 11,085 | 6,216 |

| | |
|---|---|
| **Worst Month** | 6,934 |
| **Worst 1-hr** | 45 |
| **Worst 12 -mo** | 24,256 |

**Grading Emissions Factor**
**To be used for all grading activities**

**Sources:**
USEPA AP42 Chapter 13.2.3 (Heavy Construction Operations), Table 13.2.3-1 - refers to
USEPA AP42 Chapter 11.9 (Western Surface Coal Mining), Table 11.9-1

**EF:**

TSP ≤ 30 µm: $0.040(S)^{2.5}$ multiply by 0.031 for $PM_{2.5}$
S = mean vehicle speed (mph)

≤ 15 µm: $0.051(S)^{2.0}$ multiply by 0.60 for $PM_{10}$
S = mean vehicle speed (mph)

| | | |
|---|---|---|
| S = | 4.3 | mph |
| TSP ≤ 30 µm = | 1.55 | lb TSP/VMT |
| ≤ 15 µm = | 0.95 | ≤ 15 µm/VMT |
| **$PM_{10}$ =** | **0.57** | **lb $PM_{10}$/VMT** |
| $PM_{2.5}$ = | 0.05 | lb $PM_{2.5}$/VMT |

| | | |
|---|---|---|
| Average Grading Speed = | 6.95 | km/hr |
| Average Grading Speed = | 4.32 | mile/hr |
| Productivity = | 537.89 | m3/hr |
| Productivity = | 703.53 | cy/hr |

Assumption: the grader is a large size common grader (16 ft blade), data taken from 16M Motor Grader Caterpillar Spec Sheet
Source: Nunnally, S. W. 2000 . Managing construction equipment, 2nd Ed.,Prentice Hall, Upper Saddle River, N.J.

**Loading Emissions Factor**
**To be used for all loaders**

**Sources:**
**In travel**

USEPA AP42 Chapter 13.2.2 (Unpaved Roads)
BAAQMD Permit Handbook Chapter 5.11-07
EF:

In travel = $k*(s/12)^a(W/3)^b$
k = empirical constant
s = surface material silt content %
a = empirical constant
b = empirical constant
W = mean vehicle weight (tons)

| | | |
|---|---|---|
| k = | 4.9 | |
| s = | 9 | % |
| a = | 0.70 | |
| b = | 0.45 | |
| W = | 10.00 | tons |
| TSP ≤ 30 µm = | 6.89 | lb TSP/VMT |

Silt content shown above is for example only. It can vary depending on the localized conditions.

| | | |
|---|---|---|
| k = | 1.5 | |
| s = | 9 | % |
| a = | 0.90 | |
| b = | 0.45 | |
| W = | 10.00 | tons |
| **$PM_{10}$ =** | **1.99** | **lb $PM_{10}$/VMT** |

Silt content shown above is for example only. It can vary depending on the localized conditions.

| | | |
|---|---|---|
| k = | 0.15 | |
| s = | 9 | % |
| a = | 0.90 | |
| b = | 0.45 | |
| W = | 10.00 | tons |
| $PM_{2.5}$ = | 0.20 | lb $PM_{2.5}$/VMT |

Silt content shown above is for example only. It can vary depending on the localized conditions.

**Batch Dropping**

USEPA AP42 Chapter 13.2.4 (Aggregate Handling And Storage Piles)
BAAQMD Permit Handbook Chapter 5.11-07
EF:

Batch dropping = $k(0.0032) \times (U/5)^{1.3} / (M/2)^{1.4}$
k = particle size multiplier
M = material moisture content %
U = mean wind speed (mph)

| | | |
|---|---|---|
| k (≤ 30 µm) = | 0.74 | |
| k (≤ 15 µm) = | 0.48 | |
| k ($PM_{10}$) = | 0.35 | |
| k ($PM_{2.5}$) = | 0.053 | |
| M = | 5.83 | % |
| U = | 3.26 | mph |
| TSP ≤ 30 µm = | 0.00030 | lb TSP/ton |
| ≤ 15 µm = | 0.00020 | ≤ 15 µm/ton |
| **$PM_{10}$ =** | **0.00014** | **lb $PM_{10}$/ton** |
| $PM_{2.5}$ = | 0.00002 | lb $PM_{2.5}$/ton |

Mean wind speed and moisture content shown above are for example only. They can vary depending on the localized conditions

| | | |
|---|---|---|
| Average Blade Capacity = | 2.0 | cy/loader |
| Average Loader Weight = | 10.0 | ton |

Source: Specification from Caterpillar Loader (average of 988H and 990H Series)

**Bull Dozing Emissions Factor**

**To be used for all bull dozing and all general land clearing/grubbing during demolition and site preparation**

**Sources:**

USEPA AP42 Chapter 13.2.3 (Heavy Construction Operations), Table 13.2.3-1 - refers to
USEPA AP42 Chapter 11.9 (Western Surface Coal Mining), Table 11.9-1, 11.9-3
Note: The overburden emission factor equation is used.

**EF:**

TSP ≤ 30 µm: $5.7(s)^{1.2}/(M)^{1.3}$ multiply by 0.105 for $PM_{2.5}$

s = material silt content %
M = material moisture content %

≤ 15 µm: $1.0(s)^{1.5}/(M)^{1.4}$ multiply by 0.75 for $PM_{10}$

s = material silt content %
M = material moisture content %

| | | |
|---|---|---|
| s = | 9.0 | % |
| M = | 5.83 | % |
| TSP ≤ 30 µm = | 8.04 | lb TSP/hr |
| ≤ 15 µm = | 2.29 | ≤ 15 µm/hr |
| **$PM_{10}$ =** | **1.71** | **lb $PM_{10}$/hr** |
| $PM_{2.5}$ = | 0.84 | lb $PM_{2.5}$/hr |

Silt and moisture content shown above are for example only. They can vary depending on the localized conditions.

**Average Dozer Specifications**

| | | |
|---|---|---|
| Average Ground Speed = | 2.0 | mph |
| Average Blade Capacity = | 8.8 | cy/dozer |

Source: Specification from Caterpillar Track Type Tractors (Average of D8T and D9T Series)

**Hauling Emissions Factor**
**To be used for all truck hauling**

**Sources:**

**In travel TRUCKS UNLOADED**

| | | |
|---|---|---|
| USEPA AP42 Chapter 13.2.2 (Unpaved Roads) | s | 9 |
| BAAQMD Permit Handbook Chapter 5.11-07 | W | 30.865 |

EF:

In travel = $k*(s/12)^a(W/3)^b$

k = empirical constant (for industrial roads)
s = surface material silt content %
a = empirical constant
b = empirical constant
W = mean vehicle weight (tons)

| | | |
|---|---|---|
| k = | 4.9 | |
| s = | 9 | % |
| a = | 0.70 | |
| b = | 0.45 | |
| W = | 30.87 | tons |
| TSP ≤ 30 µm = | 11.44 | lb TSP/VMT |

Silt content shown above is for example only. It can vary depending on the localized conditions.

| | | |
|---|---|---|
| k = | 1.5 | |
| s = | 9 | % |
| a = | 0.90 | |
| b = | 0.45 | |
| W = | 30.87 | tons |
| **$PM_{10}$ =** | **3.31** | **lb $PM_{10}$/VMT** |

Silt content shown above is for example only. It can vary depending on the localized conditions.

| | | |
|---|---|---|
| k = | 0.15 | |
| s = | 9 | % |
| a = | 0.90 | |
| b = | 0.45 | |
| W = | 30.87 | tons |
| $PM_{2.5}$ = | 0.33 | lb $PM_{2.5}$/VMT |

Silt content shown above is for example only. It can vary depending on the localized conditions.

**In travel TRUCKS LOADED**

| | | |
|---|---|---|
| USEPA AP42 Chapter 13.2.2 (Unpaved Roads) | s | 9 |
| BAAQMD Permit Handbook Chapter 5.11-07 | W | 70.98565 |

EF:

In travel = $k*(s/12)^a(W/3)^b$

k = empirical constant
s = surface material silt content %
a = empirical constant
b = empirical constant
W = mean vehicle weight (tons)

| | | |
|---|---|---|
| k = | 4.9 | |
| s = | 9 | % |
| a = | 0.70 | |
| b = | 0.45 | |
| W = | 70.99 | tons |
| TSP ≤ 30 µm = | 16.64 | lb TSP/VMT |

Silt content shown above is for example only. It can vary depending on the localized conditions.

| | | |
|---|---|---|
| k = | 1.5 | |
| s = | 9 | % |
| a = | 0.90 | |
| b = | 0.45 | |
| W = | 70.99 | tons |
| **$PM_{10}$ =** | **4.81** | **lb $PM_{10}$/VMT** |

Silt content shown above is for example only. It can vary depending on the localized conditions.

| | | |
|---|---|---|
| k = | 0.15 | |
| s = | 9 | % |
| a = | 0.90 | |
| b = | 0.45 | |
| W = | 70.99 | tons |
| $PM_{2.5}$ = | 0.48 | lb $PM_{2.5}$/VMT |

Silt content shown above is for example only. It can vary depending on the localized conditions.

**In travel SCRAPERS UNLOADED**

| | | |
|---|---|---|
| USEPA AP42 Chapter 13.2.2 (Unpaved Roads) | s | 9 |
| BAAQMD Permit Handbook Chapter 5.11-07 | W | 10.5 |

EF:

In travel = $k*(s/12)^a(W/3)^b$

k = empirical constant
s = surface material silt content %
a = empirical constant
b = empirical constant
W = mean vehicle weight (tons)

| | | |
|---|---|---|
| k = | 4.9 | |
| s = | 9 | % |
| a = | 0.70 | |
| b = | 0.45 | |
| W = | 10.50 | tons |
| TSP ≤ 30 µm = | 7.04 | lb TSP/VMT |

Silt content shown above is for example only. It can vary depending on the localized conditions.

| | | |
|---|---|---|
| k = | 1.5 | |
| s = | 9 | % |
| a = | 0.90 | |
| b = | 0.45 | |
| W = | 10.50 | tons |
| **$PM_{10}$ =** | **2.03** | **lb $PM_{10}$/VMT** |

Silt content shown above is for example only. It can vary depending on the localized conditions.

| | | |
|---|---|---|
| k = | 0.15 | |
| s = | 9 | % |
| a = | 0.90 | |
| b = | 0.45 | |
| W = | 10.50 | tons |
| $PM_{2.5}$ = | 0.20 | lb $PM_{2.5}$/VMT |

Silt content shown above is for example only. It can vary depending on the localized conditions.

**In travel SCRAPERS LOADED**

| | | |
|---|---|---|
| USEPA AP42 Chapter 13.2.2 (Unpaved Roads) | s | 9 |
| BAAQMD Permit Handbook Chapter 5.11-07 | W | 37.959 |

EF:

In travel = $k*(s/12)^a(W/3)^b$

k = empirical constant
s = surface material silt content %
a = empirical constant
b = empirical constant
W = mean vehicle weight (tons)

| | | |
|---|---|---|
| k = | 4.9 | |
| s = | 9 | % |
| a = | 0.70 | |
| b = | 0.45 | |
| W = | 37.96 | tons |
| TSP ≤ 30 µm = | 12.55 | lb TSP/VMT |

Silt content shown above is for example only. It can vary depending on the localized conditions.

| | | |
|---|---|---|
| k = | 1.5 | |
| s = | 9 | % |
| a = | 0.90 | |
| b = | 0.45 | |
| W = | 37.96 | tons |
| **$PM_{10}$ =** | **3.63** | **lb $PM_{10}$/VMT** |

Silt content shown above is for example only. It can vary depending on the localized conditions.

| | | |
|---|---|---|
| k = | 0.15 | |
| s = | 9 | % |
| a = | 0.90 | |
| b = | 0.45 | |
| W = | 37.96 | tons |
| $PM_{2.5}$ = | 0.36 | lb $PM_{2.5}$/VMT |

Silt content shown above is for example only. It can vary depending on the localized conditions.

**Batch Dropping**

USEPA AP42 Chapter 13.2.4 (Aggregate Handling And Storage Piles)
BAAQMD Permit Handbook Chapter 5.11-07

EF:

Batch dropping = $k(0.0032) \times (U/5)^{1.3} / (M/2)^{1.4}$

k = particle size multiplier
M = material moisture content %
U = mean wind speed (mph)

**Example Only**

| | | |
|---|---|---|
| k (≤ 30 µm) = | 0.74 | |
| k (≤ 15 µm) = | 0.48 | |
| k ($PM_{10}$) = | 0.35 | |
| k ($PM_{2.5}$) = | 0.053 | |
| M = | 5.83 | % |
| U = | 7.29 | mph |
| TSP ≤ 30 µm = | 0.00086 | lb TSP/ton |
| ≤ 15 µm = | 0.00056 | ≤ 15 µm/ton |
| **$PM_{10}$ =** | **0.00041** | **lb $PM_{10}$/ton** |
| $PM_{2.5}$ = | 0.00006 | lb $PM_{2.5}$/ton |

Mean wind speed and moisture content shown above are for example only. They can vary depending on the localized conditions.

| | | |
|---|---|---|
| Average Truck Capacity = | 22.8 | cy/truck |
| Average Loader Weight = | 42.00 | ton |

Source: Caterpillar Off-Highway Trucks (740 series with a struck load)

# Appendix D1.2

# Operating Emissions

## Modeling Parameters for Emission Sources — Summary

*Hydrogen Energy International LLC* — *7/24/2008*
*HECA Project*

| Parameter | | CTG/HRSG , H2-rich Fuel | | | CTG/HRSG , Natural Gas Fuel | | | CTG/HRSG Co-Firing ** | Auxiliary CTG | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 100% Load (2) | 80% Load | 60% Load | 100% Load(3) | 80% Load | 60% Load | 100% Load | 100% Load | 75% Load | 50% Load |
| **English Units** | | | | | | | | | | | |
| Stack height above grade(1) | ft | 213 | 213 | 213 | 213 | 213 | 213 | 213 | 110 | 110 | 110 |
| Stack diameter | ft | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 16 | 16 | 16 |
| Stack outlet temperature | $^oF$ | 200 | 190 | 180 | 180 | 170 | 160 | 190 | 740 | 740 | 760 |
| Stack exit flow, act | $ft^3/s$ | 19,900 | 16,300 | 13,400 | 16,700 | 14,300 | 11,900 | 18,300 | 14,100 | 12,400 | 10,100 |
| **Metric Units** | | | | | | | | | | | |
| Stack height above grade(1) | m | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 65.0 | 33.5 | 33.5 | 33.5 |
| Stack diameter | m | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | 4.9 | 4.9 | 4.9 |
| Stack outlet temperature | K | 366.5 | 360.9 | 355.4 | 355.4 | 349.8 | 344.3 | 360.9 | 666.5 | 666.5 | 677.6 |
| Stack exit flow, act | $m^3/s$ | 563.5 | 461.6 | 379.4 | 472.9 | 404.9 | 337.0 | 518.2 | 399.3 | 351.1 | 286.0 |
| Stack Area | $m^2$ | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 18.7 | 18.7 | 18.7 |
| Stack exit velocity, act | m/s | 19.3 | 15.8 | 13.0 | 16.2 | 13.9 | 11.5 | 17.8 | 21.4 | 18.8 | 15.3 |

| Parameter | | Aux Boiler | Ground Flare(4) | Elevated Flare(6) | Tail Gas Oxidizer(7) | Gasifier Warming Vent (ea.) | Cooling Towers (per cell)(5) | Diesel Generator (ea.) | Fire Pump Engine | $CO_2$ Vent |
|---|---|---|---|---|---|---|---|---|---|---|
| **English Units** | | | | | | | | | | |
| Stack height above grade(1) | ft | 80 | 80 | 213 | 165 | 210 | 57 | 20 | 20 | 288 |
| Stack diameter | ft | 4.5 | 50 | (NA) | 2.5 | 1.0 | 30 | 1.2 | 0.7 | 3.5 |
| Stack outlet temperature | $^oF$ | 300 | 1600 | (NA) | 1200 | 150 | 75 | 760 | 850 | 65 |
| Stack exit flow, act | $ft^3/s$ | 480 | 64,000 | 17 | 120 | 68 | 18,500 | 250 | 60 | 1,765 |
| **Metric Units** | | | | | | | | | | |
| Stack height above grade(1) | m | 24.4 | 24.4 | 65.0 | 50.3 | 64.0 | 17.2 | 6.1 | 6.1 | 87.8 |
| Stack diameter | m | 1.4 | 15.2 | (NA) | 0.8 | 0.3 | 9.1 | 0.4 | 0.2 | 1.1 |
| Stack outlet temperature | K | 422.0 | 1,144.3 | (NA) | 922.0 | 338.7 | 297.0 | 677.6 | 727.6 | 291.5 |
| Stack exit flow, act | $m^3/s$ | 13.6 | 1,812.3 | 0.5 | 3.4 | 1.9 | 523.9 | 7.1 | 1.7 | 50.0 |
| Stack Area | $m^2$ | 1.5 | 182.4 | (NA) | 0.5 | 0.1 | 65.7 | 0.1 | 0.0 | 0.9 |
| Stack exit velocity, act | m/s | 9.2 | 9.9 | (NA) | 7.5 | 26.4 | 8.0 | 67.4 | 47.5 | 55.9 |

**Notes:**

(1) Minimum stack height assumed for worst-case dispersion.

(2) Volume Flow Value shown in table for H2-rich fuel is based on full load syn gas combustion (relatively constant for varying ambient temperatures). Duct firing of the HSRG changes the stack volumetric flow by about 1% or less.

(3) Full load stack flow for natural gas combustion will vary from the value shown in the table during warm summer ambient temperatures to about 18,000 act ft3/sec for winter ambient temperatures. Stack flow rates for co-firing of H2-rich gas and natural gas will range between the values shown for the two fuels separately.

(4) Based on gasifier startup; stack parameters estimated from a previous project, to be confirmed by current flare suppliers.

(5) Thirteen cells estimated for power block cooling tower; four cells estimated for process cooling tower, and four cells estimated for the ASU cooling tower.

(6) Waste gas heat release, 10^6 Btu/hr, HHV.
(7) Estimated oxidizer stack outlet flow for normal operating case of miscellaneous vent gas disposal; SRU startup case will be about 50% greater.
** HRSG Stack Cofiring is estimated assuming 47% Syngas and the balance natural gas

| | | Feed Stock - Dust Collection Units | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | | **DC-1** | **DC-2** | **DC-3** | **DC-4** | **DC-5** | **DC-6** | **DC-7** | **DC-8** | **DC-9** |
| **English Units** | | | | | | | | | | |
| Ground elevation | ft | 399 | 357 | 357 | 357 | 351 | 351 | 390 | 390 | 390 |
| Stack elevation | ft | 448 | 555 | 555 | 380 | 430 | 430 | 585 | 529 | 585 |
| Stack height above grade | ft | 49 | 198 | 198 | 23 | 79 | 79 | 195 | 139 | 195 |
| Stack diameter | ft | 2.5 | 3.0 | 3.0 | 0.8 | 2.2 | 2.0 | 1.8 | 1.8 | 1.3 |
| Stack outlet temperature (1) | $^{o}$F | Ambient | Ambient | Ambient | Ambient | Ambient | Ambient | Ambient | Ambient | Ambient |
| Stack exit flow, act | $ft^3/s$ | 338 | 502 | 502 | 33 | 152 | 225 | 187 | 69 | 104 |
| **Metric Units** | | | | | | | | | | |
| Stack height above grade | m | 15.0 | 60.4 | 60.4 | 7.0 | 24.1 | 24.1 | 59.4 | 42.4 | 59.4 |
| Stack diameter | m | 0.8 | 0.9 | 0.9 | 0.2 | 0.7 | 0.6 | 0.6 | 0.6 | 0.4 |
| Stack outlet temperature (1) | K | Ambient | Ambient | Ambient | Ambient | Ambient | Ambient | Ambient | Ambient | Ambient |
| Stack exit flow, act | $m^3/s$ | 9.6 | 14.2 | 14.2 | 0.9 | 4.3 | 6.4 | 5.3 | 2.0 | 2.9 |
| Stack Area | $m^2$ | 0.5 | 0.7 | 0.7 | 0.0 | 0.3 | 0.3 | 0.2 | 0.2 | 0.1 |
| Stack exit velocity, act | m/s | 21.0 | 21.7 | 21.7 | 22.7 | 12.6 | 21.8 | 21.6 | 8.0 | 22.6 |

(1) Assume ambient temperature

## Total Project Modeling Emission Rates — Summary

*Hydrogen Energy International LLC* — *7/24/2008*
*HECA Project*

### Modeling Worst-Case 1 hr Emissions per Turbine

| | CTG/HRSG Maximum (1) | Auxiliary CTG | Cooling Towers (2) | | | Auxiliary Boiler | Emergency Generators (3) | Fire Water Pump | Ground Flare | Elevated Flare | Tg Thermal Oxidizer | $CO_2$ Vent | Gasifier (4) | Feedstock | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Power Block | Process Area | ASU | | | | | | | | | DC-1 | DC-2 | DC-3 | DC-4 | DC-5 | DC-6 | DC-7 | DC-8 | DC-9 |
| | (g/sec) | (g/sec) | (g/sec/cell) | (g/sec/cell) | (g/sec/cell) | (g/sec) | (g/sec/gen) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) |
| NOx | 21.0 | 2.6 | -- | -- | -- | 0.2 | 0.4 | 0.2 | 7.9 | 0.544 | 0.3 | -- | 0.3 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| CO | 211.6 | 8.7 | -- | -- | -- | 0.7 | 0.2 | 0.4 | 113.4 | 0.363 | 0.1 | 53.4 | 0.1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| $SO_2$ | 0.9 | 0.2 | -- | -- | -- | 0.04 | 0.004 | 0.0007 | 0.0001 | 2.19 | 0.3 | -- | 0.05 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| $H_2S$ | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.6 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(1) HRSG modeling emission rates represents the maximum emissions rate from a composite firing scenario (all thee fuels)
(2) There are three separate cooling towers. The modeling rates are per cell.
(3) There are two separate generators. Modeling rates are shown per individual generator.
(4) There are three gasifiers. The modeling rate shown is per individual gasifier. However, only one gasifier warming will be operational at any one time.

### Modeling Worst-Case 3 hr Emissions per Turbine

| | CTG/HRSG Maximum (1) | Auxiliary CTG | Cooling Towers (2) | | | Auxiliary Boiler | Emergency Generators (3) | Fire Water Pump | Ground Flare | Elevated Flare | Tg Thermal Oxidizer | $CO_2$ Vent | Gasifier (4) | Feedstock | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Power Block | Process Area | ASU | | | | | | | | | DC-1 | DC-2 | DC-3 | DC-4 | DC-5 | DC-6 | DC-7 | DC-8 | DC-9 |
| | (g/sec) | (g/sec) | (g/sec/cell) | (g/sec/cell) | (g/sec/cell) | (g/sec) | (g/sec/gen) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) |
| $SO_2$ | 0.9 | 0.2 | -- | -- | -- | 0.04 | 0.002 | 0.0005 | 0.0001 | 2.19 | 0.3 | -- | 0.05 | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(1) HRSG modeling emission rates represents the maximum emissions rate from a composite firing scenario (all thee fuels)
(2) There are three separate cooling towers. The modeling rates are per cell.
(3) There are two separate generators. Modeling rates are shown per individual generator.
(4) There are three gasifiers. The modeling rate shown is per individual gasifier. However, only one gasifier warming will be operational at any one time.

### Modeling Worst-Case 8 hr Emissions per Turbine

| | CTG/HRSG Maximum (1) | Auxiliary CTG | Cooling Towers (2) | | | Auxiliary Boiler | Emergency Generators (3) | Fire Water Pump | Ground Flare | Elevated Flare | Tg Thermal Oxidizer | $CO_2$ Vent | Gasifier (4) | Feedstock | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Power Block | Process Area | ASU | | | | | | | | | DC-1 | DC-2 | DC-3 | DC-4 | DC-5 | DC-6 | DC-7 | DC-8 | DC-9 |
| | (g/sec) | (g/sec) | (g/sec/cell) | (g/sec/cell) | (g/sec/cell) | (g/sec) | (g/sec/gen) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) |
| CO | 164.9 | 2.7 | -- | -- | -- | 0.7 | 0.06 | 0.1 | 113.4 | 0.138 | 0.1 | 53.4 | 0.1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(1) HRSG modeling emission rates represents the maximum emissions rate from a composite firing scenario (all thee fuels)
(2) There are three separate cooling towers. The modeling rates are per cell.
(3) There are two separate generators. Modeling rates are shown per individual generator.
(4) There are three gasifiers. The modeling rate shown is per individual gasifier. However, only one gasifier warming will be operational at any one time.

## Total Project Modeling Emission Rates — Summary

*Hydrogen Energy International LLC* — *7/24/2008*
*HECA Project*

### Modeling Worst-Case 24 Hour Emission Rate

| | CTG/HRSG Maximum (1) | Auxiliary CTG | Cooling Towers (2) | | | Auxiliary Boiler | Emergency Generators (3) | Fire Water Pump | Ground Flare | Elevated Flare | Tg Thermal Oxidizer | $CO_2$ Vent | Gasifier (4) | Feedstock | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Power Block | Process Area | ASU | | | | | | | | | DC-1 | DC-2 | DC-3 | DC-4 | DC-5 | DC-6 | DC-7 | DC-8 | DC-9 |
| | (g/sec) | (g/sec) | (g/sec/cell) | (g/sec/cell) | (g/sec/cell) | (g/sec) | (g/sec/gen) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) |
| $SO_2$ | 0.9 | 0.2 | -- | -- | -- | 0.04 | 0.0003 | 0.0001 | 0.0001 | 0.2742 | 0.3 | -- | 0.05 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| $PM_{10}$ | 3.0 | 1.3 | 0.038 | 0.030 | 0.028 | 0.09 | 0.002 | 0.0002 | 0.0002 | 0.0018 | 0.02 | -- | 0.02 | 0.051 | 0.076 | 0.076 | 0.001 | 0.014 | 0.013 | 0.010 | 0.013 | 0.0003 |
| $PM_{2.5}$ (5) | 3.0 | 1.3 | 0.023 | 0.018 | 0.017 | 0.09 | 0.002 | 0.0002 | 0.0002 | 0.0018 | 0.02 | -- | 0.02 | 0.015 | 0.022 | 0.022 | 0.000 | 0.004 | 0.004 | 0.003 | 0.004 | 0.0001 |

(1) HRSG modeling emission rates represents the maximum emissions rate from a composite firing scenario (all thee fuels)
(2) There are three separate cooling towers. The modeling rates are per cell.
(3) There are two separate generators. Modeling rates are shown per individual generator.
(4) There are three gasifiers. The modeling rate shown is per individual gasifier. However, only one gasifier warming will be operational at any one time.
(5) Where $PM_{10}$ = $PM_{2.5}$, it is assumed that $PM_{10}$ is 100% $PM_{2.5}$

### Modeling Annual Average Emission Rate

| | CTG/HRSG Maximum (1) | Auxiliary CTG | Cooling Towers (2) | | | Auxiliary Boiler | Emergency Generators (3) | Fire Water Pump | Ground Flare | Elevated Flare | Tg Thermal Oxidizer | $CO_2$ Vent | Gasifier (4) | Feedstock | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Power Block | Process Area | ASU | | | | | | | | | DC-1 | DC-2 | DC-3 | DC-4 | DC-5 | DC-6 | DC-7 | DC-8 | DC-9 |
| | (g/sec) | (g/sec) | (g/sec/cell) | (g/sec/cell) | (g/sec/cell) | (g/sec) | (g/sec/gen) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) | (g/sec) |
| $NO_X$ | 4.8 | 0.5 | -- | -- | -- | 0.05 | 0.002 | 0.003 | 0.1 | 0.005 | 0.2 | -- | 0.1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| CO | 4.3 | 0.8 | -- | -- | -- | 0.2 | 0.001 | 0.005 | 1.3 | 0.003 | 0.05 | 3.1 | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| VOC | 0.9 | 0.1 | -- | -- | -- | 0.02 | 0.0005 | 0.0002 | 0.0001 | 0.00005 | 0.01 | 0.1 | 0.00 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| $SO_2$ | 0.8 | 0.1 | -- | -- | -- | 0.01 | 0.00002 | 0.00001 | 0.0001 | 0.0016 | 0.3 | -- | 0.01 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| $PM_{10}$ | 2.9 | 0.6 | 0.036 | 0.028 | 0.027 | 0.02 | 0.0001 | 0.00003 | 0.0002 | 0.0001 | 0.01 | -- | 0.004 | 0.011 | 0.016 | 0.016 | 0.001 | 0.011 | 0.010 | 0.008 | 0.010 | 0.0003 |
| $PM_{2.5}$ (5) | 2.9 | 0.6 | 0.022 | 0.017 | 0.016 | 0.02 | 0.0001 | 0.00003 | 0.0002 | 0.0001 | 0.01 | -- | 0.004 | 0.003 | 0.005 | 0.005 | 0.0003 | 0.003 | 0.003 | 0.002 | 0.003 | 0.0001 |
| $H_2S$ | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(1) HRSG modeling emission rates represents the maximum emissions rate from a composite firing scenario (all thee fuels)
(2) There are three separate cooling towers. The modeling rates are per cell.
(3) There are two separate generators. Modeling rates are shown per individual generator.
(4) There are three gasifiers. The modeling rate shown is per individual gasifier. However, only one gasifier warming will be operational at any one time.
(5) Where $PM_{10}$ = $PM_{2.5}$, it is assumed that $PM_{10}$ is 100% $PM_{2.5}$

## Total Annual Project Emissions

**Emissions Summary**

*Hydrogen Energy International LLC*
*HECA Project*

*7/24/2008*

| Pollutant | Total Annual (ton/yr) | CTG/HRSG Maximum (1) (ton/yr) | Auxiliary CTG (ton/yr) | Cooling Towers (2) (ton/yr) | Auxiliary Boiler (ton/yr) | Emergency Generators (3) (ton/yr) | Fire Water Pump (ton/yr) | Ground Flare (ton/yr) | Elevated Flare (ton/yr) | Tg Thermal Oxidizer (ton/yr) | $CO_2$ Vent (ton/yr) | Gasifier (ton/yr) | Feedstock (4) (ton/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $NO_X$ | 199.0 | 167.2 | 17.4 | -- | 1.7 | 0.2 | 0.1 | 4.3 | 0.2 | 5.9 | -- | 2.1 | -- |
| CO | 337.9 | 150.2 | 27.6 | -- | 5.8 | 0.1 | 0.2 | 44.9 | 0.1 | 1.6 | 106.9 | 0.6 | -- |
| VOC | 40.7 | 32.5 | 4.6 | -- | 0.6 | 0.03 | 0.01 | 0.003 | 0.002 | 0.3 | 2.4 | 0.1 | -- |
| $SO_2$ | 42.5 | 29.2 | 3.8 | -- | 0.3 | 0.001 | 0.0003 | 0.004 | 0.1 | 8.8 | -- | 0.3 | -- |
| $PM_{10}$ | 148.6 | 99.7 | 20.6 | 24.1 | 0.8 | 0.01 | 0.001 | 0.01 | 0.004 | 0.4 | -- | 0.1 | 2.9 |
| $PM_{2.5}$ (5) | 136.9 | 99.7 | 20.6 | 14.5 | 0.8 | 0.01 | 0.001 | 0.01 | 0.004 | 0.4 | -- | 0.1 | 0.9 |
| $NH_3$ | 100.0 | 75.9 | 24.1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| $H_2S$ | 1.3 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1.3 | -- | -- |

(1) Total annual HRSG emissions represents the maximum emissions rate from a composite firing scenario (all thee fuels)

(2) Includes contributions from all three cooling towers

(3) Includes contributions from both emergency generators

(4) Feedstock emissions are shown as the contribution of all dust collection points.

(5) Where $PM_{10}$ = $PM_{2.5}$, it is assumed that $PM_{10}$ is 100% $PM_{2.5}$

## CTG/HRSG Stack - Comparison of all Firing Scenarios — Emissions Summary

*Hydrogen Energy International LLC* — *7/24/2008*
*HECA Project*

**Summary of CTG/HRSG Emission Rates Under the Three Different Firing Scenarios**

| Average Annual Emissions per Turbine | | | | |
|---|---|---|---|---|
| | **CTG/HRSG - Nat Gas** (ton/yr/CT) | **CTG/HRSG - Syn Gas** (ton/yr/CT) | **CTG/HRSG - Co Firing** (ton/yr/CT) | **Maximum** (ton/yr/CT) |
| $NO_X$ | 148.0 | 167.2 | 162.9 | 167.2 |
| CO | 138.9 | 103.5 | 150.2 | 150.2 |
| VOC | 30.0 | 19.0 | 32.5 | 32.5 |
| $SO_2$ | 20.0 | 28.4 | 29.2 | 29.2 |
| $PM_{10} = PM_{2.5}$ | 74.9 | 99.7 | 99.7 | 99.7 |
| $NH_3$ | 67.1 | 75.9 | 73.9 | 75.9 |

| Modeling Worst-Case 1 hr Emissions per Turbine | | | | |
|---|---|---|---|---|
| | **CTG/HRSG - Nat Gas** (g/sec/CT) | **CTG/HRSG - Syn Gas** (g/sec/CT) | **CTG/HRSG - Co Firing** (g/sec/CT) | **Maximum** (g/sec/CT) |
| NOx | 21.0 | 21.0 | 21.0 | 21.0 |
| CO | 211.6 | 211.6 | 211.6 | 211.6 |
| $SO_2$ | 0.6 | 0.86 | 0.93 | 0.9 |

| Modeling Worst-Case 3 hr Emissions per Turbine | | | | |
|---|---|---|---|---|
| | **CTG/HRSG - Nat Gas** (g/sec/CT) | **CTG/HRSG - Syn Gas** (g/sec/CT) | **CTG/HRSG - Co Firing** (g/sec/CT) | **Maximum** (g/sec/CT) |
| $SO_2$ | 0.6 | 0.86 | 0.93 | 0.9 |

## CTG/HRSG Stack - Comparison of all Firing Scenarios — Emissions Summary

*Hydrogen Energy International LLC* — *7/24/2008*
*HECA Project*

| Modeling Worst-Case 8 hr Emissions per Turbine | | | | |
|---|---|---|---|---|
| | **CTG/HRSG - Nat Gas** (g/sec/CT) | **CTG/HRSG - Syn Gas** (g/sec/CT) | **CTG/HRSG - Co Firing** (g/sec/CT) | **Maximum** (g/sec/CT) |
| CO | 164.9 | 164.8 | 164.9 | 164.9 |

| Modeling Worst-Case 24 Hour Emission Rate | | | | |
|---|---|---|---|---|
| | **CTG/HRSG - Nat Gas** (g/sec/CT) | **CTG/HRSG - Syn Gas** (g/sec/CT) | **CTG/HRSG - Co Firing** (g/sec/CT) | **Maximum** (g/sec/CT) |
| $SO_2$ | 0.6 | 0.86 | 0.93 | 0.9 |
| $PM_{10} = PM_{2.5}$ | 2.4 | 3.0 | 3.0 | 3.0 |

| Modeling Annual Average Emission Rate per Turbine | | | | |
|---|---|---|---|---|
| | **CTG/HRSG - Nat Gas** (g/sec/CT) | **CTG/HRSG - Syn Gas** (g/sec/CT) | **CTG/HRSG - Co Firing** (g/sec/CT) | **Maximum** (g/sec/CT) |
| $NO_X$ | 4.3 | 4.8 | 4.7 | 4.8 |
| CO | 4.0 | 3.0 | 4.3 | 4.3 |
| VOC | 0.9 | 0.5 | 0.9 | 0.9 |
| $SO_2$ | 0.6 | 0.82 | 0.84 | 0.8 |
| $PM_{10} = PM_{2.5}$ | 2.2 | 2.9 | 2.9 | 2.9 |

## CTG/HRSG Stack - Natural Gas

**Emissions Summary**

*Hydrogen Energy International LLC*
*HECA Project*

*7/24/2008*

**CTG Operating Parameters**

| Ambient Temperature | UNITS | Winter Minimum - 20°F | | | | Yearly Average- 65°F | | | | Summer Maximum - 97°F | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CTG Load Level** | Percent Load (%) | 100% | 100% | 80% | 60% | 100% | 100% | 80% | 60% | 100% | 100% | 80% | 60% |
| **Evap Cooling Status** | off / on | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **Duct Burner Status** | off / on | On | Off | Off | Off | On | Off | Off | Off | On | Off | Off | Off |

**Average Emission Rates from CTG (lbs/hr/turbine) - Normal Operation**

| | UNITS | Winter Minimum - 20°F | | | | Yearly Average- 65°F | | | | Summer Maximum - 97°F | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$NO_X$ (@ 4.0 ppm)** | lbm/hr | 36.3 | 29.0 | 24.8 | 20.8 | 35.1 | 27.0 | 23.1 | 19.4 | 33.3 | 26.1 | 22.4 | 18.7 |
| **CO (@ 5.0 ppm)** | lbm/hr | 27.6 | 22.1 | 18.8 | 15.8 | 26.7 | 20.5 | 17.6 | 14.8 | 25.3 | 19.8 | 17.0 | 14.2 |
| **VOC (@ 2.0 ppm)** | lbm/hr | 6.3 | 5.0 | 4.3 | 3.6 | 6.1 | 4.7 | 4.0 | 3.4 | 5.8 | 4.5 | 3.9 | 3.2 |
| **$SO_2$ (@ 12.65 ppmv in fuel)** | lbm/hr | 5.1 | 4.1 | 3.5 | 3.0 | 4.8 | 3.8 | 3.3 | 2.8 | 4.7 | 3.7 | 3.2 | 2.7 |
| **$PM_{10} = PM_{2.5}$** | lbm/hr | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 |
| **$NH_3$ (@ 5.0 ppm slip)** | lbm/hr | 16.7 | 13.4 | 11.4 | 9.6 | 16.2 | 12.5 | 10.7 | 9.0 | 15.4 | 12.1 | 10.3 | 8.6 |

All turbine operating parameters and emissions data provided by FLUOR based on expected operating parameters.

**Startup / Shutdown Emissions from Turbine (1CT)**

| Cold Startup | | | Hot Startup | | | Shutdown | | |
|---|---|---|---|---|---|---|---|---|
| 180 (min. in cold startup) | Max 1-hr. (lb/hr) | Total (lb/180min) | 60 (min. in hot startup) | Max 1-hr. (lb/hr) | Total (lb/60min) | 30 (min. in shutdown) | Max 1-hr. (lb/hr) | Total (lb/30min) |
| **$NO_X$** | 90.7 | 272.0 | **NOx** | 167.0 | 167.0 | **NOx** | 62.0 | 62.0 |
| **CO** | 1,679.7 | 5,039.0 | **CO** | 394.0 | 394.0 | **CO** | 126.0 | 126.0 |
| **VOC** | 266.7 | 800.0 | **VOC** | 98.0 | 98.0 | **VOC** | 21.0 | 21.0 |
| **$SO_2$ (@ 12.65 ppmv in fuel)** | 5.1 | 15.3 | **$SO_2$ (@ 12.65 ppmv in fuel)** | 5.1 | 5.1 | **$SO_2$ (@ 12.65 ppmv in fuel)** | 2.6 | 2.6 |
| **$PM_{10} = PM_{2.5}$** | 21.3 | 64.0 | **$PM_{10} = PM_{2.5}$** | 23.0 | 23.0 | **$PM_{10} = PM_{2.5}$** | 5.0 | 5.0 |

All turbine operating parameters and emissions data provided by FLUOR based on expected operating parameters.
Startup and shutdown $SO_2$ emissions will always be lower than normal operation $SO_2$ emissions. Startup and shutdown emissions are assumed equal to the normal operations max emission rate.

**Average Annual Emissions**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT | Emissions g/sec/CT |
|---|---|---|---|---|---|---|
| **Total Hours of Operation** | 8,322.0 | | | | | |
| **Total Number of Cold Starts** | 10.0 | | | | | |
| **Cold Start Duration (hr)** | 3.0 | | $NO_X$ | 296,044.0 | 148.0 | 4.3 |
| **Total Number of Hot Starts** | 10.0 | | CO | 277,817.2 | 138.9 | 4.0 |
| **Hot Start Duration (hr)** | 1.0 | | VOC | 59,906.8 | 30.0 | 0.9 |
| **Total Number of Shutdowns** | 20.0 | | $SO_2$ | 40,045.4 | 20.0 | 0.6 |
| **Shutdown Duration (hr)** | 0.5 | | $PM_{10} = PM_{2.5}$ | 149,866.0 | 74.9 | 2.2 |
| **Duct Burner Operation (hr)** | 8,272.0 | | $NH_3$ | 134,158.6 | 67.1 | 1.9 |
| **Average Normal Operation (hr)** | 0.0 | | | | | |

**Assumptions:**
Average annual normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Parameters**

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

*Hydrogen Energy International LLC*
*HECA Project*
*7/24/2008*

**First Quarter Emissions (Jan, Feb, Mar)**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|---|
| **Total Hours of Operation** | 2,080.5 | | | | |
| **Total Number of Cold Starts** | 2.5 | | | | |
| **Cold Start Duration (hr)** | 3.0 | | $NO_X$ | 74,011.0 | 37.0 |
| **Total Number of Hot Starts** | 2.5 | | CO | 69,454.3 | 34.7 |
| **Hot Start Duration (hr)** | 1.0 | | VOC | 14,976.7 | 7.5 |
| **Total Number of Shutdowns** | 5.0 | | $SO_2$ | 10,011.4 | 5.0 |
| **Shutdown Duration (hr)** | 0.5 | | $PM_{10} = PM_{2.5}$ | 37,466.5 | 18.7 |
| **Duct Burner Operation (hr)** | 2,068.0 | | $NH_3$ | 33,539.7 | 16.8 |
| **Average Normal Operation (hr)** | 0.0 | | | | |

**Assumptions:**
Quarterly normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Second Quarter Emissions (Apr, May, Jun)**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|---|
| **Total Hours of Operation** | 2,080.5 | | | | |
| **Total Number of Cold Starts** | 2.5 | | | | |
| **Cold Start Duration (hr)** | 3.0 | | $NO_X$ | 74,011.0 | 37.0 |
| **Total Number of Hot Starts** | 2.5 | | CO | 69,454.3 | 34.7 |
| **Hot Start Duration (hr)** | 1.0 | | VOC | 14,976.7 | 7.5 |
| **Total Number of Shutdowns** | 5.0 | | $SO_2$ | 10,011.4 | 5.0 |
| **Shutdown Duration (hr)** | 0.5 | | $PM_{10} = PM_{2.5}$ | 37,466.5 | 18.7 |
| **Duct Burner Operation (hr)** | 2,068.0 | | $NH_3$ | 33,539.7 | 16.8 |
| **Average Normal Operation (hr)** | 0.0 | | | | |

**Assumptions:**
Quarterly normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Third Quarter Emissions (Jul, Aug, Sep)**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|---|
| **Total Hours of Operation** | 2,080.5 | | | | |
| **Total Number of Cold Starts** | 2.5 | | | | |
| **Cold Start Duration (hr)** | 3.0 | | $NO_X$ | 74,011.0 | 37.0 |
| **Total Number of Hot Starts** | 2.5 | | CO | 69,454.3 | 34.7 |
| **Hot Start Duration (hr)** | 1.0 | | VOC | 14,976.7 | 7.5 |
| **Total Number of Shutdowns** | 5.0 | | $SO_2$ | 10,011.4 | 5.0 |
| **Shutdown Duration (hr)** | 0.5 | | $PM_{10} = PM_{2.5}$ | 37,466.5 | 18.7 |
| **Duct Burner Operation (hr)** | 2,068.0 | | $NH_3$ | 33,539.7 | 16.8 |
| **Average Normal Operation (hr)** | 0.0 | | | | |

**Assumptions:**
Quarterly normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Fourth Quarter Emissions (Oct, Nov, Dec)**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|---|
| **Total Hours of Operation** | 2,080.5 | | | | |
| **Total Number of Cold Starts** | 2.5 | | | | |
| **Cold Start Duration (hr)** | 3.0 | | $NO_X$ | 74,011.0 | 37.0 |
| **Total Number of Hot Starts** | 2.5 | | CO | 69,454.3 | 34.7 |
| **Hot Start Duration (hr)** | 1.0 | | VOC | 14,976.7 | 7.5 |
| **Total Number of Shutdowns** | 5.0 | | $SO_2$ | 10,011.4 | 5.0 |
| **Shutdown Duration (hr)** | 0.5 | | $PM_{10} = PM_{2.5}$ | 37,466.5 | 18.7 |
| **Duct Burner Operation (hr)** | 2,068.0 | | $NH_3$ | 33,539.7 | 16.8 |
| **Average Normal Operation (hr)** | 0.0 | | | | |

**Assumptions:**
Quarterly normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Modeling Worst-Case 1 hr Emissions per Turbine**

| Pollutant | lb/hr/CT | g/sec/CT |
|---|---|---|
| NOx | 167.0 | 21.0 |
| CO | 1,679.7 | 211.6 |
| $SO_2$ | 5.1 | 0.6 |

**Assumptions:**
Startup emissions represent worst case hr for NOx and CO.
NOx emissions are from hot start
CO emissions are from cold start
Calculation assumes that startup and shutdown $SO_2$ emissions will always be lower than normal operational $SO_2$ emissions.

**Modeling Worst-Case 3 hr Emissions per Turbine**

| | hr | emission rate lb/hr | Emissions lb/CT | |
|---|---|---|---|---|
| **Total Hours of Operation** | 3.0 | | | |
| **Startup Duration** | 0.0 | | 0.0 | contribution over 3 hr from start up |
| **Shutdown Duration** | 0.0 | | 0.0 | contribution over 3 hr from shut down |
| **Hours of Normal Operation (burning natural gas)** | 3.0 | 5.1 | 15.3 | contribution over 3 hr from normal operation |
| | | | | |
| **$SO_2$ worst-case 3 hr emissions per turbine** | 15.3 | lb/3 hr | | |
| **$SO_2$ worst-case 1 hr emissions per turbine** | 5.1 | lb/hr | | |
| **$SO_2$ modeling worst-case emissions per turbine** | 0.6 | g/sec | | |

**Assumptions:**
Only $SO_2$ is considered for an average 3-hour Ambient Air Quality Standard.
Normal operation assumes max emission rate
Worst-case 3 hr emissions assumes a total start up of : 0
Worst-case 3 hr emissions assumes a total shut down of : 0
Calculation assumes that startup and shutdown $SO_2$ emissions will always be lower than normal operational $SO_2$ emissions

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*HECA Project*

*7/24/2008*

**Modeling Worst-Case 8 hr Emissions per Turbine**

| | hr | emission rate lb/hr | Emissions lb/CT | |
|---|---|---|---|---|
| **Total Hours of Operation** | 8.0 | | | |
| **Startup Duration (cold start)** | 6.0 | | 10,078.0 | contribution over 8 hr from start up |
| **Shutdown Duration** | 1.5 | | 378.0 | contribution over 8 hr from shut down |
| **Hours of Normal Operation (burning natural gas)** | 0.5 | 27.6 | 13.8 | contribution over 8 hr from normal operation |
| | | | | |
| **CO worst-case 8 hr emissions per turbine** | 10,469.8 | lb/8 hr | | |
| **CO worst-case 1 hr emissions per turbine** | 1,308.7 | lb/hr | | |
| **CO modeling worst-case emissions per turbine** | 164.9 | g/sec | | |

**Assumptions:**
Only CO is considered for an average 8-hour Ambient Air Quality Standard.
Normal operation assumes max emission rate
Worst-case 8 hr emissions assumes a total COLD start up of : 2
Worst-case 8 hr emissions assumes a total shut down of : 3

**Worst-Case Daily Emissions per Turbine and Modeling Worst-Case 24 Hour Emission Rate**

| | |
|---|---|
| **$SO_2$ (lb/day/CT)** | 122.4 |
| **$SO_2$ (g/s/CT) (burning natural gas)** | 0.6 |
| | |
| **$PM_{10}$ = $PM_{2.5}$ (lb/day/CT)** | |
| **$PM_{10}$ = $PM_{2.5}$ (g/s/CT) (burning natural gas)** | |

**Assumptions:**
Only $SO_2$ and PM are considered for an average 24-hour Ambient Air Quality Standard.
For $SO_2$ 24 hrs of normal operation at max emission rate
For PM emissions are calculated below assuming startup and shutdown contributions.

**Worst-Case Daily Emissions per Turbine and Modeling Worst-Case 24 Hour Emission Rate**

| Pollutant | Time in Startup hr | Startup Emission Rate lb/start | Time in Shut Down hr | Shutdown Emission Rate lb/shutdown | Time in Normal Operation hr | Normal Operation Emission Rate lb/start | Worst-Case Daily Emissions lb/day/CT | Modeling Worst-Case 24 Hr Emission g/s/CT |
|---|---|---|---|---|---|---|---|---|
| NOx | 12.0 | 272.0 | 2.0 | 62.0 | 10.0 | 36.3 | 1,698.5 | |
| CO | 12.0 | 5,039.0 | 2.0 | 126.0 | 10.0 | 27.6 | 20,935.8 | |
| VOC | 12.0 | 800.0 | 2.0 | 21.0 | 10.0 | 6.3 | 3,347.0 | |
| $SO_2$ | | | | | | | | |
| $PM_{10}$ = $PM_{2.5}$ | 12.0 | 64.0 | 2.0 | 5.0 | 10.0 | 18.0 | 456.0 | 2.4 |

**Assumptions:**
For NOx, CO, VOC, and PM -- emissions are calculated assuming:
Worst-case daily emissions assumes a total COLD start up of : 4
Worst-case daily emissions assumes a total shut down of : 4
Remainder of time is spent in normal operation at winter minimum - 20°F; 100% load
See above calculation for worst-case daily $SO_2$:calculated as 24 hrs of normal operation at max emissions rate

## CTG/HRSG Stack - SynGas

**Emissions Summary**

*Hydrogen Energy International LLC*
*HECA Project*

*7/24/2008*

**CTG Operating Parameters**

| Ambient Temperature | UNITS | Winter Minimum - 20°F | | | | Yearly Average- 65°F | | | | Summer Maximum - 97°F | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CTG Load Level** | Percent Load (%) | 100% | 100% | 80% | 60% | 100% | 100% | 80% | 60% | 100% | 100% | 80% | 60% |
| **Evap Cooling Status** | off / on | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **Duct Burner Status** | off / on | On | Off | Off | Off | On | Off | Off | Off | On | Off | Off | Off |

**Average Emission Rates from CTG (lbs/hr/turbine) - Normal Operation**

| | UNITS | Winter Minimum - 20°F | | | | Yearly Average- 65°F | | | | Summer Maximum - 97°F | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$NO_x$ (@ 4.0 ppm)** | lbm/hr | | 37.2 | 31.5 | 26.1 | 39.7 | 36.9 | 31.0 | 25.6 | 39.7 | 38.0 | 30.9 | 25.6 |
| **CO (@ 3.0 ppm)** | lbm/hr | | 17.0 | 14.4 | 11.9 | 18.1 | 16.8 | 14.1 | 11.7 | 18.1 | 17.4 | 14.1 | 11.7 |
| **VOC (@ 1.0 ppm)** | lbm/hr | | 3.2 | 2.7 | 2.3 | 3.5 | 3.2 | 2.7 | 2.2 | 3.5 | 3.3 | 2.7 | 2.2 |
| **$SO_2$ (@ 5.0 ppmv in fuel)** | lbm/hr | | 6.1 | 5.2 | 4.4 | 6.8 | 6.1 | 5.1 | 4.3 | 6.8 | 6.0 | 5.1 | 4.3 |
| **$PM_{10}$ = $PM_{2.5}$** | lbm/hr | | 24.0 | 24.0 | 24.0 | 24.0 | 24.0 | 24.0 | 24.0 | 24.0 | 24.0 | 24.0 | 24.0 |
| **$NH_3$ (@ 5.0 ppm slip)** | lbm/hr | | 17.2 | 14.6 | 12.0 | 18.4 | 17.0 | 14.3 | 11.8 | 18.4 | 17.6 | 14.3 | 11.8 |

All turbine operating parameters and emissions data provided by FLUOR based on expected operating parameters.

**Startup / Shutdown Emissions from Turbine (1CT)**

| Cold Startup | | | Hot Startup | | | Shutdown | | |
|---|---|---|---|---|---|---|---|---|
| 180 (min. in cold startup) | Max 1-hr. (lb/hr) | Total (lb/180min) | 60 (min. in hot startup) | Max 1-hr. (lb/hr) | Total (lb/60min) | 30 (min. in shutdown) | Max 1-hr. (lb/hr) | Total (lb/30min) |
| **$NO_X$** | 90.7 | 272.0 | **NOx** | 167.0 | 167.0 | **NOx** | 62.0 | 62.0 |
| **CO** | 1,679.7 | 5,039.0 | **CO** | 394.0 | 394.0 | **CO** | 126.0 | 126.0 |
| **VOC** | 266.7 | 800.0 | **VOC** | 98.0 | 98.0 | **VOC** | 21.0 | 21.0 |
| **$SO_2$ (@ 12.65 ppmv in fuel)** | 5.1 | 15.3 | **$SO_2$ (@ 12.65 ppmv in fuel)** | 5.1 | 5.1 | **$SO_2$ (@ 12.65 ppmv in fuel)** | 2.6 | 2.6 |
| **$PM_{10}$ = $PM_{2.5}$** | 21.3 | 64.0 | **$PM_{10}$ = $PM_{2.5}$** | 23.0 | 23.0 | **$PM_{10}$ = $PM_{2.5}$** | 5.0 | 5.0 |

All turbine operating parameters and emissions data provided by FLUOR based on expected operating parameters.
CTGs will always be started burning natural gas. Startup and shutdown emission rates above reflect natural gas.
Startup and shutdown $SO_2$ emissions will always be lower than normal operation $SO_2$ emissions. Startup and shutdown emissions are assumed equal to normal operations (burning natural gas) at the max emission rate.

**Average Annual Emissions**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT | Emissions g/sec/CT |
|---|---|---|---|---|---|---|
| **Total Hours of Operation** | 8,322.0 | | | | | |
| **Total Number of Cold Starts** | 10.0 | | | | | |
| **Cold Start Duration (hr)** | 3.0 | | $NO_X$ | 334,353.0 | 167.2 | 4.8 |
| **Total Number of Hot Starts** | 10.0 | | CO | 206,919.2 | 103.5 | 3.0 |
| **Hot Start Duration (hr)** | 1.0 | | VOC | 37,984.6 | 19.0 | 0.5 |
| **Total Number of Shutdowns** | 20.0 | | $SO_2$ | 56,713.0 | 28.4 | 0.8 |
| **Shutdown Duration (hr)** | 0.5 | | $PM_{10}$ = $PM_{2.5}$ | 199,498.0 | 99.7 | 2.9 |
| **Duct Burner Operation (hr)** | 8,272.0 | | $NH_3$ | 151,855.7 | 75.9 | 2.2 |
| **Average Normal Operation (hr)** | 0.0 | | | | | |

**Assumptions:**
Average annual normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Parameters**

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

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**First Quarter Emissions (Jan, Feb, Mar)**

| | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|
| **Total Hours of Operation** | 2,080.5 | | | |
| **Total Number of Cold Starts** | 2.5 | | | |
| **Cold Start Duration (hr)** | 3.0 | $NO_X$ | 83,588.3 | 41.8 |
| **Total Number of Hot Starts** | 2.5 | CO | 51,729.8 | 25.9 |
| **Hot Start Duration (hr)** | 1.0 | VOC | 9,496.2 | 4.7 |
| **Total Number of Shutdowns** | 5.0 | $SO_2$ | 14,178.3 | 7.1 |
| **Shutdown Duration (hr)** | 0.5 | $PM_{10} = PM_{2.5}$ | 49,874.5 | 24.9 |
| **Duct Burner Operation (hr)** | 2,068.0 | $NH_3$ | 37,963.9 | 19.0 |
| **Average Normal Operation (hr)** | 0.0 | | | |

**Assumptions:**
Quarterly normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Second Quarter Emissions (Apr, May, Jun)**

| | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|
| **Total Hours of Operation** | 2,080.5 | | | |
| **Total Number of Cold Starts** | 2.5 | | | |
| **Cold Start Duration (hr)** | 3.0 | $NO_X$ | 83,588.3 | 41.8 |
| **Total Number of Hot Starts** | 2.5 | CO | 51,729.8 | 25.9 |
| **Hot Start Duration (hr)** | 1.0 | VOC | 9,496.2 | 4.7 |
| **Total Number of Shutdowns** | 5.0 | $SO_2$ | 14,178.3 | 7.1 |
| **Shutdown Duration (hr)** | 0.5 | $PM_{10} = PM_{2.5}$ | 49,874.5 | 24.9 |
| **Duct Burner Operation (hr)** | 2,068.0 | $NH_3$ | 37,963.9 | 19.0 |
| **Average Normal Operation (hr)** | 0.0 | | | |

**Assumptions:**
Quarterly normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Third Quarter Emissions (Jul, Aug, Sep)**

| | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|
| **Total Hours of Operation** | 2,080.5 | | | |
| **Total Number of Cold Starts** | 2.5 | | | |
| **Cold Start Duration (hr)** | 3.0 | $NO_X$ | 83,588.3 | 41.8 |
| **Total Number of Hot Starts** | 2.5 | CO | 51,729.8 | 25.9 |
| **Hot Start Duration (hr)** | 1.0 | VOC | 9,496.2 | 4.7 |
| **Total Number of Shutdowns** | 5.0 | $SO_2$ | 14,178.3 | 7.1 |
| **Shutdown Duration (hr)** | 0.5 | $PM_{10} = PM_{2.5}$ | 49,874.5 | 24.9 |
| **Duct Burner Operation (hr)** | 2,068.0 | $NH_3$ | 37,963.9 | 19.0 |
| **Average Normal Operation (hr)** | 0.0 | | | |

**Assumptions:**
Quarterly normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Fourth Quarter Emissions (Oct, Nov, Dec)**

| | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|
| **Total Hours of Operation** | 2,080.5 | | | |
| **Total Number of Cold Starts** | 2.5 | | | |
| **Cold Start Duration (hr)** | 3.0 | $NO_X$ | 83,588.3 | 41.8 |
| **Total Number of Hot Starts** | 2.5 | CO | 51,729.8 | 25.9 |
| **Hot Start Duration (hr)** | 1.0 | VOC | 9,496.2 | 4.7 |
| **Total Number of Shutdowns** | 5.0 | $SO_2$ | 14,178.3 | 7.1 |
| **Shutdown Duration (hr)** | 0.5 | $PM_{10} = PM_{2.5}$ | 49,874.5 | 24.9 |
| **Duct Burner Operation (hr)** | 2,068.0 | $NH_3$ | 37,963.9 | 19.0 |
| **Average Normal Operation (hr)** | 0.0 | | | |

**Assumptions:**
Quarterly normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Modeling Worst-Case 1 hr Emissions per Turbine**

| Pollutant | lb/hr/CT | g/sec/CT |
|---|---|---|
| NOx | 167.0 | 21.0 |
| CO | 1,679.7 | 211.6 |
| $SO_2$ | 6.8 | 0.9 |

**Assumptions:**
Startup emissions represent worst case hr for NOx and CO. Startup and shutdown only burn natural gas.
NOx emissions are from hot start
CO emissions are from cold start
Normal operation burning syngas represents worst case $SO_2$.
Calculation assumes that startup and shutdown $SO_2$ emissions will always be lower than normal operational (burning natural gas) $SO_2$ emissions.

**Modeling Worst-Case 3 hr Emissions per Turbine**

| | hr | emission rate lb/hr | Emissions lb/CT | |
|---|---|---|---|---|
| **Total Hours of Operation** | 3.0 | | | |
| **Startup Duration** | 0.0 | | 0.0 | contribution over 3 hr from start up |
| **Shutdown Duration** | 0.0 | | 0.0 | contribution over 3 hr from shut down |
| **Hours of Normal Operation (burning syngas)** | 3.0 | 6.8 | 20.5 | contribution over 3 hr from normal operation |
| | | | | |
| **$SO_2$ worst-case 3 hr emissions per turbine** | 20.5 | lb/3 hr | | |
| **$SO_2$ worst-case 1 hr emissions per turbine** | 6.8 | lb/hr | | |
| **$SO_2$ modeling worst-case emissions per turbine** | 0.9 | g/sec | | |

**Assumptions:**
Only $SO_2$ is considered for an average 3-hour Ambient Air Quality Standard.
Normal operation burning syngas represents worst case $SO_2$.
Worst-case 3 hr emissions assumes a total start up of : 0
Worst-case 3 hr emissions assumes a total shut down of : 0
Calculation assumes that startup and shutdown $SO_2$ emissions will always be lower than normal operational (burning natural gas) $SO_2$ emissions.

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*HECA Project*

**Modeling Worst-Case 8 hr Emissions per Turbine**

| | hr | emission rate lb/hr | Emissions lb/CT | |
|---|---|---|---|---|
| **Total Hours of Operation** | 8.0 | | | |
| **Startup Duration** | 6.0 | | 10,078.0 | contribution over 8 hr from start up |
| **Shutdown Duration** | 1.5 | | 378.0 | contribution over 8 hr from shut down |
| **Hours of Normal Operation (burning syngas)** | 0.5 | 18.1 | 9.1 | contribution over 8 hr from normal operation |
| | | | | |
| **CO worst-case 8 hr emissions per turbine** | 10,465.1 | lb/8 hr | | |
| **CO worst-case 1 hr emissions per turbine** | 1,308.1 | lb/hr | | |
| **CO modeling worst-case emissions per turbine** | 164.8 | g/sec | | |

**Assumptions:**
Only CO is considered for an average 8-hour Ambient Air Quality Standard.
Normal operation assumes max rate.
Worst-case 8 hr emissions assumes a total COLD start up of : 2
Worst-case 8 hr emissions assumes a total shut down of : 3

**Worst-Case Daily Emissions per Turbine and Modeling Worst-Case 24 Hour Emission Rate**

| | |
|---|---|
| **$SO_2$ (lb/day/CT)** | 163.8 |
| **$SO_2$ (g/s/CT) (burning syngas)** | 0.9 |
| | |
| **$PM_{10}$ = $PM_{2.5}$ (lb/day/CT)** | 576.0 |
| **$PM_{10}$ = $PM_{2.5}$ (g/s/CT) (burning syngas)** | 3.0 |

**Assumptions:**
Only $SO_2$ and PM are considered for an average 24-hour Ambient Air Quality Standard.
For $SO_2$ 24 hrs of normal operation max emission rate
For PM 24 hrs of normal operation max emission rate

**Worst-Case Daily Emissions per Turbine and Modeling Worst-Case 24 Hour Emission Rate**

| Pollutant | Time in Startup hr | Startup Emission Rate lb/start | Time in Shut Down hr | Shutdown Emission Rate lb/shutdown | Time in Normal Operation hr | Normal Operation Emission Rate lb/start | Worst-Case Daily Emissions lb/day/CT | Modeling Worst-Case 24 Hr Emission g/s/CT |
|---|---|---|---|---|---|---|---|---|
| NOx | 12.0 | 272.0 | 2.0 | 62.0 | 10.0 | 39.7 | 1,733.4 | |
| CO | 12.0 | 5,039.0 | 2.0 | 126.0 | 10.0 | 18.1 | 20,841.4 | |
| VOC | 12.0 | 800.0 | 2.0 | 21.0 | 10.0 | 3.5 | 3,318.6 | |
| $SO_2$ | | | | | | | | |
| $PM_{10}$ = $PM_{2.5}$ | | | | | | | | |

**Assumptions:**
For NOx, CO, and VOC -- emissions are calculated assuming:
Worst-case daily emissions assumes a total start up of : 4
Worst-case daily emissions assumes a total shut down of : 4
Remainder of time is spent in normal operation at max emission rate
See above calculation for worst-case daily $SO_2$ and PM: calculated as 24 hrs of normal operationat max emissions rate

## CTG/HRSG Stack - Co Firing

**Emissions Summary**

*Hydrogen Energy International LLC*
*HECA Project*

*7/24/2008*

**CTG Operating Parameters**

| Ambient Temperature | UNITS | Winter Minimum - 20°F | | | | Yearly Average- 65°F | | | | Summer Maximum - 97°F | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CTG Load Level** | Percent Load (%) | 100% | 100% | 80% | 60% | 100% | 100% | 80% | 60% | 100% | 100% | 80% | 60% |
| **Evap Cooling Status** | off / on | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **Duct Burner Status** | off / on | On | Off | Off | Off | On | Off | Off | Off | On | Off | Off | Off |

**Average Emission Rates from CTG (lbs/hr/turbine) - Normal Operation**

| | UNITS | Winter Minimum - 20°F | | | | Yearly Average- 65°F | | | | Summer Maximum - 97°F | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$NO_x$ (@ 4.0 ppm)** | lbm/hr | 41.3 | 34.0 | | | 38.7 | 31.7 | | | | | | |
| **CO (@ 5.0 ppm)** | lbm/hr | 31.4 | 25.9 | | | 29.4 | 24.1 | | | | | | |
| **VOC (@ 2.0 ppm)** | lbm/hr | 7.2 | 5.9 | | | 6.7 | 5.5 | | | | | | |
| **$SO_2$ (@ 6.7 ppmv, average in fuel) (12.65 ppm duct firing in fuel)** | lbm/hr | 7.4 | 5.2 | | | 7.0 | 4.8 | | | | | | |
| **$PM_{10}$ = $PM_{2.5}$** | lbm/hr | 24.0 | 24.0 | | | 24.0 | 24.0 | | | | | | |
| **$NH_3$ (@ 5.0 ppm slip)** | lbm/hr | 19.1 | 15.7 | | | 17.9 | 14.6 | | | | | | |

All turbine operating parameters and emissions data provided by FLUOR based on expected operating parameters. 5.0659
Co-firing emissions are controlled at the same amount as natural gas.

**Startup / Shutdown Emissions from Turbine (1CT)**

| Cold Startup | | | Hot Startup | | | Shutdown | | |
|---|---|---|---|---|---|---|---|---|
| 180 (min. in cold startup) | Max 1-hr. (lb/hr) | Total (lb/180min) | 60 (min. in hot startup) | Max 1-hr. (lb/hr) | Total (lb/60min) | 30 (min. in shutdown) | Max 1-hr. (lb/hr) | Total (lb/30min) |
| **$NO_X$** | 90.7 | 272.0 | **NOx** | 167.0 | 167.0 | **NOx** | 62.0 | 62.0 |
| **CO** | 1,679.7 | 5,039.0 | **CO** | 394.0 | 394.0 | **CO** | 126.0 | 126.0 |
| **VOC** | 266.7 | 800.0 | **VOC** | 98.0 | 98.0 | **VOC** | 21.0 | 21.0 |
| **$SO_2$ (@ 12.65 ppmv in fuel)** | 5.1 | 15.3 | **$SO_2$ (@ 12.65 ppmv in fuel)** | 5.1 | 5.1 | **$SO_2$ (@ 12.65 ppmv in fuel)** | 2.6 | 2.6 |
| **$PM_{10}$ = $PM_{2.5}$** | 21.3 | 64.0 | **$PM_{10}$ = $PM_{2.5}$** | 23.0 | 23.0 | **$PM_{10}$ = $PM_{2.5}$** | 5.0 | 5.0 |

All turbine operating parameters and emissions data provided by FLUOR based on expected operating parameters.
CTGs will always be started burning natural gas. Startup and shutdown emission rates above reflect natural gas.
Startup and shutdown $SO_2$ emissions will always be lower than normal operation $SO_2$ emissions. Startup and shutdown emissions are assumed equal to normal operations (burning natural gas) at the max emission rate.

**Average Annual Emissions**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT | Emissions g/sec/CT |
|---|---|---|---|---|---|---|
| **Total Hours of Operation** | 8,322.0 | | | | | |
| **Total Number of Cold Starts** | 10.0 | | | | | |
| **Cold Start Duration (hr)** | 3.0 | | $NO_X$ | 325,712.3 | 162.9 | 4.7 |
| **Total Number of Hot Starts** | 10.0 | | CO | 300,390.9 | 150.2 | 4.3 |
| **Hot Start Duration (hr)** | 1.0 | | VOC | 65,066.5 | 32.5 | 0.9 |
| **Total Number of Shutdowns** | 20.0 | | $SO_2$ | 58,357.9 | 29.2 | 0.8 |
| **Shutdown Duration (hr)** | 0.5 | | $PM_{10}$ = $PM_{2.5}$ | 199,498.0 | 99.7 | 2.9 |
| **Duct Burner Operation (hr)** | 8,272.0 | | $NH_3$ | 147,864.1 | 73.9 | 2.1 |
| **Average Normal Operation (hr)** | 0.0 | | | | | |

**Assumptions:**
Average annual normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Parameters**

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

*Hydrogen Energy International LLC*
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*7/24/2008*

**First Quarter Emissions (Jan, Feb, Mar)**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|---|
| **Total Hours of Operation** | 2,080.5 | | | | |
| **Total Number of Cold Starts** | 2.5 | | | | |
| **Cold Start Duration (hr)** | 3.0 | | $NO_X$ | 81,428.1 | 40.7 |
| **Total Number of Hot Starts** | 2.5 | | CO | 75,097.7 | 37.5 |
| **Hot Start Duration (hr)** | 1.0 | | VOC | 16,266.6 | 8.1 |
| **Total Number of Shutdowns** | 5.0 | | $SO_2$ | 14,589.5 | 7.3 |
| **Shutdown Duration (hr)** | 0.5 | | $PM_{10} = PM_{2.5}$ | 49,874.5 | 24.9 |
| **Duct Burner Operation (hr)** | 2,068.0 | | $NH_3$ | 36,966.0 | 18.5 |
| **Average Normal Operation (hr)** | 0.0 | | | | |

**Assumptions:**
Quarterly normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Second Quarter Emissions (Apr, May, Jun)**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|---|
| **Total Hours of Operation** | 2,080.5 | | | | |
| **Total Number of Cold Starts** | 2.5 | | | | |
| **Cold Start Duration (hr)** | 3.0 | | $NO_X$ | 81,428.1 | 40.7 |
| **Total Number of Hot Starts** | 2.5 | | CO | 75,097.7 | 37.5 |
| **Hot Start Duration (hr)** | 1.0 | | VOC | 16,266.6 | 8.1 |
| **Total Number of Shutdowns** | 5.0 | | $SO_2$ | 14,589.5 | 7.3 |
| **Shutdown Duration (hr)** | 0.5 | | $PM_{10} = PM_{2.5}$ | 49,874.5 | 24.9 |
| **Duct Burner Operation (hr)** | 2,068.0 | | $NH_3$ | 36,966.0 | 18.5 |
| **Average Normal Operation (hr)** | 0.0 | | | | |

**Assumptions:**
Quarterly normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Third Quarter Emissions (Jul, Aug, Sep)**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|---|
| **Total Hours of Operation** | 2,080.5 | | | | |
| **Total Number of Cold Starts** | 2.5 | | | | |
| **Cold Start Duration (hr)** | 3.0 | | $NO_X$ | 81,428.1 | 40.7 |
| **Total Number of Hot Starts** | 2.5 | | CO | 75,097.7 | 37.5 |
| **Hot Start Duration (hr)** | 1.0 | | VOC | 16,266.6 | 8.1 |
| **Total Number of Shutdowns** | 5.0 | | $SO_2$ | 14,589.5 | 7.3 |
| **Shutdown Duration (hr)** | 0.5 | | $PM_{10} = PM_{2.5}$ | 49,874.5 | 24.9 |
| **Duct Burner Operation (hr)** | 2,068.0 | | $NH_3$ | 36,966.0 | 18.5 |
| **Average Normal Operation (hr)** | 0.0 | | | | |

**Assumptions:**
Quarterly normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Fourth Quarter Emissions (Oct, Nov, Dec)**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|---|
| **Total Hours of Operation** | 2,080.5 | | | | |
| **Total Number of Cold Starts** | 2.5 | | | | |
| **Cold Start Duration (hr)** | 3.0 | | $NO_X$ | 81,428.1 | 40.7 |
| **Total Number of Hot Starts** | 2.5 | | CO | 75,097.7 | 37.5 |
| **Hot Start Duration (hr)** | 1.0 | | VOC | 16,266.6 | 8.1 |
| **Total Number of Shutdowns** | 5.0 | | $SO_2$ | 14,589.5 | 7.3 |
| **Shutdown Duration (hr)** | 0.5 | | $PM_{10} = PM_{2.5}$ | 49,874.5 | 24.9 |
| **Duct Burner Operation (hr)** | 2,068.0 | | $NH_3$ | 36,966.0 | 18.5 |
| **Average Normal Operation (hr)** | 0.0 | | | | |

**Assumptions:**
Quarterly normal operational emissions are calculated using yearly average- 65°F, at 100 % load.
Duct burner emissions are calculated using yearly average- 65°F, at 100 % load with duct burners.

**Modeling Worst-Case 1 hr Emissions per Turbine**

| Pollutant | lb/hr/CT | g/sec/CT |
|---|---|---|
| NOx | 167.0 | 21.0 |
| CO | 1,679.7 | 211.6 |
| $SO_2$ | 7.4 | 0.93 |

**Assumptions:**
Startup emissions represent worst case hr for NOx and CO. Startup and shutdown only burn natural gas.
NOx emissions are from hot start
CO emissions are from cold start
Normal operation co firing represents worst case $SO_2$.
Calculation assumes that startup and shutdown $SO_2$ emissions will always be lower than normal operational (burning natural gas) $SO_2$ emissions.

**Modeling Worst-Case 3 hr Emissions per Turbine**

| | hr | emission rate lb/hr | Emissions lb/CT | |
|---|---|---|---|---|
| **Total Hours of Operation** | 3.0 | | | |
| **Startup Duration** | 0.0 | | 0.0 | contribution over 3 hr from start up |
| **Shutdown Duration** | 0.0 | | 0.0 | contribution over 3 hr from shut down |
| **Hours of Normal Operation (co firing)** | 3.0 | 7.4 | 22.1 | contribution over 3 hr from normal operation |
| | | | | |
| **$SO_2$ worst-case 3 hr emissions per turbine** | 22.1 | lb/3 hr | | |
| **$SO_2$ worst-case 1 hr emissions per turbine** | 7.4 | lb/hr | | |
| **$SO_2$ modeling worst-case emissions per turbine** | 0.9 | g/sec | | |

**Assumptions:**
Only $SO_2$ is considered for an average 3-hour Ambient Air Quality Standard.
Normal operation co firing represents worst case $SO_2$.
Worst-case 3 hr emissions assumes a total start up of : 0
Worst-case 3 hr emissions assumes a total shut down of : 0
Calculation assumes that startup and shutdown $SO_2$ emissions will always be lower than normal operational (burning natural gas) $SO_2$ emissions.

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**Modeling Worst-Case 8 hr Emissions per Turbine**

| | hr | emission rate lb/hr | Emissions lb/CT | |
|---|---|---|---|---|
| **Total Hours of Operation** | 8.0 | | | |
| **Startup Duration** | 6.0 | | 10,078.0 | contribution over 8 hr from start up |
| **Shutdown Duration** | 1.5 | | 378.0 | contribution over 8 hr from shut down |
| **Hours of Normal Operation (co firing)** | 0.5 | 31.4 | 15.7 | contribution over 8 hr from normal operation |
| | | | | |
| **CO worst-case 8 hr emissions per turbine** | 10,471.7 | lb/8 hr | | |
| **CO worst-case 1 hr emissions per turbine** | 1,309.0 | lb/hr | | |
| **CO modeling worst-case emissions per turbine** | 164.9 | g/sec | | |

**Assumptions:**
Only CO is considered for an average 8-hour Ambient Air Quality Standard.
Normal operation assumes max rate.
Worst-case 8 hr emissions assumes a total COLD start up of : 2
Worst-case 8 hr emissions assumes a total shut down of : 3

**Worst-Case Daily Emissions per Turbine and Modeling Worst-Case 24 Hour Emission Rate**

| | |
|---|---|
| **$SO_2$ (lb/day/CT)** | 177.2 |
| **SO2 (g/s/CT) (co firing)** | 0.9 |
| | |
| **$PM_{10}$ = $PM_{2.5}$ (lb/day/CT)** | 576.0 |
| **$PM_{10}$ = $PM_{2.5}$ (g/s/CT) (cofiring)** | 3.0 |

**Assumptions:**
Only $SO_2$ and PM are considered for an average 24-hour Ambient Air Quality Standard.
For $SO_2$ 24 hrs of normal operation max emission rate
For PM 24 hrs of normal operation max emission rate

**Worst-Case Daily Emissions per Turbine and Modeling Worst-Case 24 Hour Emission Rate**

| Pollutant | Time in Startup hr | Startup Emission Rate lb/start | Time in Shut Down hr | Shutdown Emission Rate lb/shutdown | Time in Normal Operation hr | Normal Operation Emission Rate lb/start | Worst-Case Daily Emissions lb/day/CT | Modeling Worst-Case 24 Hr Emission g/s/CT |
|---|---|---|---|---|---|---|---|---|
| NOx | 12.0 | 272.0 | 2.0 | 62.0 | 10.0 | 41.3 | 1,748.8 | |
| CO | 12.0 | 5,039.0 | 2.0 | 126.0 | 10.0 | 31.4 | 20,974.1 | |
| VOC | 12.0 | 800.0 | 2.0 | 21.0 | 10.0 | 7.2 | 3,355.8 | |
| $SO_2$ | | | | | | | | |
| $PM_{10}$ = $PM_{2.5}$ | | | | | | | | |

**Assumptions:**
For NOx, CO, and VOC -- emissions are calculated assuming:
Worst-case daily emissions assumes a total start up of : 4
Worst-case daily emissions assumes a total shut down of : 4
Remainder of time is spent in normal operation at max emission rate
See above calculation for worst-case daily $SO_2$ and PM: calculated as 24 hrs of normal operationat max emissions rate

## Auxiliary CTG — Emissions Summary

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**CTG Operating Parameters**

| Ambient Temperature | UNITS | Winter Minimum - 20°F | | | | Yearly Average- 65°F | | | | Summer Maximum - 97°F | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CTG Load Level** | Percent Load (%) | 100% | 100% | 75% | 50% | 100% | 100% | 75% | 50% | 100% | 100% | 75% | 50% |
| **Evap Cooling Status** | off / on | Off | Off | Off | Off | On | Off | Off | Off | On | Off | Off | Off |

**Average Emission Rates from CTG (lbs/hr/turbine) - Normal Operation**

| | UNITS | Winter Minimum - 20°F | | | | Yearly Average- 65°F | | | | Summer Maximum - 97°F | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$NO_x$ (@ 2.5 ppm)** | lbm/hr | | 7.9 | 6.4 | 4.7 | 8.1 | | 6.5 | 4.7 | 7.9 | | 6.2 | 4.6 |
| **CO (@ 6.0 ppm)** | lbm/hr | | 11.5 | 9.3 | 6.9 | 11.9 | | 9.4 | 6.9 | 11.5 | | 9.1 | 6.8 |
| **VOC (@ 2.0 ppm)** | lbm/hr | | 2.2 | 1.8 | 1.3 | 2.3 | | 1.8 | 1.3 | 2.2 | | 1.7 | 1.3 |
| **$SO_2$ (@ 12.65 ppmv in fuel)** | lbm/hr | | 1.8 | 1.4 | 1.1 | 1.9 | | 1.5 | 1.1 | 1.8 | | 1.4 | 1.0 |
| **$PM_{10}$ = $PM_{2.5}$** | lbm/hr | | 10.0 | 10.0 | 10.0 | 10.0 | | 10.0 | 10.0 | 10.0 | | 10.0 | 10.0 |
| **$NH_3$ (@ 10.0 ppm slip)** | lbm/hr | | 11.6 | 9.5 | 7.0 | 12.0 | | 9.5 | 7.0 | 11.7 | | 9.2 | 6.8 |

All turbine operating parameters and emissions data provided by FLUOR based on expected operating parameters.

**Startup / Shutdown Emissions from Turbine (1CT)**

| Cold Startup | | | Hot Startup | | | Shutdown | | |
|---|---|---|---|---|---|---|---|---|
| 10.0 (min. in cold startup) | Max 1-hr. (lb/hr) | Total (lb/10min) | 0 (min. in hot startup) | Max 1-hr. (lb/hr) | Total (lb/60min) | 10.3 (min. in shutdown) | Max 1-hr. (lb/hr) | Total (lb/10.3min) |
| **$NO_X$** | 9.0 | 3.0 | **NOx** | | | **NOx** | 12.0 | 4.0 |
| **CO** | 30.6 | 10.2 | **CO** | | | **CO** | 39.6 | 13.2 |
| **VOC** | 0.5 | 0.2 | **VOC** | | | **VOC** | 0.6 | 0.2 |
| **$SO_2$ (@ 12.65 ppmv in fuel)** | 1.9 | 0.3 | **$SO_2$ (@ 12.65 ppmv in fuel)** | | | **$SO_2$ (@ 12.65 ppmv in fuel)** | 1.9 | 0.3 |
| **$PM_{10}$ = $PM_{2.5}$** | 10.0 | 1.7 | **$PM_{10}$ = $PM_{2.5}$** | | | **$PM_{10}$ = $PM_{2.5}$** | 10.0 | 1.7 |

All turbine operating parameters and emissions data provided by FLUOR based on expected operating parameters.
NOx, CO, and VOC startup and shutdown emissions (max 1-hr) assume 3 startup and 3 shut down
Startup and shutdown SO2 and PM10 emissions will always be lower than normal operational emissions. Startup and shutdown emissions are assumed equal to normal operations max emission rate, with evap cooling.

**Average Annual Emissions and Modeling Rates**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT | Emissions g/sec/CT |
|---|---|---|---|---|---|---|
| **Total Hours of Operation** | 4,110 | | | | | |
| **Total Number of Cold Starts** | 325.0 | | | | | |
| **Cold Start Duration (hr)** | 0.2 | | $NO_X$ | 34,840.6 | 17.4 | 0.5 |
| **Total Number of Hot Starts** | 0.0 | | CO | 55,179.1 | 27.6 | 0.8 |
| **Hot Start Duration (hr)** | 0.0 | | VOC | 9,182.0 | 4.6 | 0.1 |
| **Total Number of Shutdowns** | 325.0 | | $SO_2$ | 7,644.4 | 3.8 | 0.1 |
| **Shutdown Duration (hr)** | 0.2 | | $PM_{10}$ = $PM_{2.5}$ | 41,100.0 | 20.6 | 0.6 |
| **Evaporative Cooling Operation (hr)** | 4,000 | | $NH_3$ | 48,140.5 | 24.1 | 0.7 |
| **Average Normal Operation (hr)** | 0.0 | | | | | |

**Assumptions:**
Average annual operational emissions are calculated using yearly average- 65°F, at 100 % load, with evaporative cooling.

**Parameters**

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

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**First Quarter Emissions (Jan, Feb, Mar)**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|---|
| **Total Hours of Operation** | 1,027.5 | | | | |
| **Total Number of Cold Starts** | 81.3 | | | | |
| **Cold Start Duration (hr)** | 0.2 | | $NO_X$ | 8,710.2 | 4.4 |
| **Total Number of Hot Starts** | 0.0 | | CO | 13,794.8 | 6.9 |
| **Hot Start Duration (hr)** | 0.0 | | VOC | 2,295.5 | 1.1 |
| **Total Number of Shutdowns** | 81.3 | | $SO_2$ | 1,911.1 | 1.0 |
| **Shutdown Duration (hr)** | 0.2 | | $PM_{10} = PM_{2.5}$ | 10,275.0 | 5.1 |
| **Evaporative Cooling Operation (hr)** | 1,000.0 | | $NH_3$ | 12,035.1 | 6.0 |
| **Average Normal Operation (hr)** | 0.0 | | | | |

**Assumptions:**
Quarterly operational emissions are calculated using yearly average- 65°F, at 100 % load, with evaporative cooling.

**Second Quarter Emissions (Apr, May, Jun)**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|---|
| **Total Hours of Operation** | 1,027.5 | | | | |
| **Total Number of Cold Starts** | 81.3 | | | | |
| **Cold Start Duration (hr)** | 0.2 | | $NO_X$ | 8,710.2 | 4.4 |
| **Total Number of Hot Starts** | 0.0 | | CO | 13,794.8 | 6.9 |
| **Hot Start Duration (hr)** | 0.0 | | VOC | 2,295.5 | 1.1 |
| **Total Number of Shutdowns** | 81.3 | | $SO_2$ | 1,911.1 | 1.0 |
| **Shutdown Duration (hr)** | 0.2 | | $PM_{10} = PM_{2.5}$ | 10,275.0 | 5.1 |
| **Evaporative Cooling Operation (hr)** | 1,000.0 | | $NH_3$ | 12,035.1 | 6.0 |
| **Average Normal Operation (hr)** | 0.0 | | | | |

**Assumptions:**
Quarterly operational emissions are calculated using yearly average- 65°F, at 100 % load, with evaporative cooling.

**Third Quarter Emissions (Jul, Aug, Sep)**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|---|
| **Total Hours of Operation** | 1,027.5 | | | | |
| **Total Number of Cold Starts** | 81.3 | | | | |
| **Cold Start Duration (hr)** | 0.2 | | $NO_X$ | 8,710.2 | 4.4 |
| **Total Number of Hot Starts** | 0.0 | | CO | 13,794.8 | 6.9 |
| **Hot Start Duration (hr)** | 0.0 | | VOC | 2,295.5 | 1.1 |
| **Total Number of Shutdowns** | 81.3 | | $SO_2$ | 1,911.1 | 1.0 |
| **Shutdown Duration (hr)** | 0.2 | | $PM_{10} = PM_{2.5}$ | 10,275.0 | 5.1 |
| **Evaporative Cooling Operation (hr)** | 1,000.0 | | $NH_3$ | 12,035.1 | 6.0 |
| **Average Normal Operation (hr)** | 0.0 | | | | |

**Assumptions:**
Quarterly operational emissions are calculated using yearly average- 65°F, at 100 % load, with evaporative cooling.

**Fourth Quarter Emissions (Oct, Nov, Dec)**

| | | | Pollutant | Turbine Emissions lb/yr/CT | Emissions ton/yr/CT |
|---|---|---|---|---|---|
| **Total Hours of Operation** | 1,027.5 | | | | |
| **Total Number of Cold Starts** | 81.3 | | | | |
| **Cold Start Duration (hr)** | 0.2 | | $NO_X$ | 8,710.2 | 4.4 |
| **Total Number of Hot Starts** | 0.0 | | CO | 13,794.8 | 6.9 |
| **Hot Start Duration (hr)** | 0.0 | | VOC | 2,295.5 | 1.1 |
| **Total Number of Shutdowns** | 81.3 | | $SO_2$ | 1,911.1 | 1.0 |
| **Shutdown Duration (hr)** | 0.2 | | $PM_{10} = PM_{2.5}$ | 10,275.0 | 5.1 |
| **Evaporative Cooling Operation (hr)** | 1,000.0 | | $NH_3$ | 12,035.1 | 6.0 |
| **Average Normal Operation (hr)** | 0.0 | | | | |

**Assumptions:**
Quarterly operational emissions are calculated using yearly average- 65°F, at 100 % load, with evaporative cooling.

**Modeling Worst-Case 1 hr Emissions per Turbine**

| Pollutant | lb/hr/CT | g/sec/CT |
|---|---|---|
| NOx | 20.7 | 2.6 |
| CO | 69.0 | 8.7 |
| $SO_2$ | 1.9 | 0.2 |

**Assumptions:**
Startup emissions represent worst case hr for NOx and CO.
NOx, and CO worst case 1 hr assume the contribution over 1 hr from 3 startup and 3 shut down
Calculation assumes that startup and shutdown $SO_2$ emissions will always be lower than normal operational $SO_2$ emissions.

**Modeling Worst-Case 3 hr Emissions per Turbine**

| | hr | emission rate lb/hr | Emissions lb/CT | |
|---|---|---|---|---|
| **Total Hours of Operation** | 3.0 | | | |
| **Startup Duration** | 0.0 | | 0.0 | contribution over 3 hr from start up |
| **Shutdown Duration** | 0.0 | | 0.0 | contribution over 3 hr from shut down |
| **Hours of Normal Operation** | 3.0 | 1.9 | 5.6 | contribution over 3 hr from normal operation |
| | | | | |
| **$SO_2$ worst-case 3 hr emissions per turbine** | 5.6 | lb/3 hr | | |
| **$SO_2$ worst-case 1 hr emissions per turbine** | 1.9 | lb/hr | | |
| **$SO_2$ modeling worst-case emissions per turbine** | 0.2 | g/sec | | |

**Assumptions:**
Only $SO_2$ is considered for an average 3-hour Ambient Air Quality Standard.
Normal operation assumes max emission rate
Worst-case 3 hr emissions assumes a total start up of : 0
Worst-case 3 hr emissions assumes a total shut down of : 0
Calculation assumes that startup and shutdown $SO_2$ emissions will always be lower than normal operational $SO_2$ emissions

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**Modeling Worst-Case 8 hr Emissions per Turbine**

| | hr | emission rate lb/hr | Emissions lb/CT | |
|---|---|---|---|---|
| **Total Hours of Operation** | 8.0 | | | |
| **Startup Duration** | 0.7 | | 40.8 | contribution over 8 hr from start up |
| **Shutdown Duration** | 0.7 | | 52.8 | contribution over 8 hr from shut down |
| **Hours of Normal Operation** | 6.6 | 11.9 | 79.0 | contribution over 8 hr from normal operation |
| | | | | |
| **CO worst-case 8 hr emissions per turbine** | 172.6 | lb/8 hr | | |
| **CO worst-case 1 hr emissions per turbine** | 21.6 | lb/hr | | |
| **CO modeling worst-case emissions per turbine** | 2.7 | g/sec | | |

**Assumptions:**
Only CO is considered for an average 8-hour Ambient Air Quality Standard.
Normal operation assumes annual average - 65°F; 100% load, with evap cooling.
Worst-case 8 hr emissions assumes a total start up of : 4
Worst-case 8 hr emissions assumes a total shut down of : 4

**Worst-Case Daily Emissions per Turbine and Modeling Worst-Case 24 Hour Emission Rate**

| | |
|---|---|
| **$SO_2$ (lb/day/CT)** | 44.6 |
| **$SO_2$ (g/s/CT)** | 0.2 |
| | |
| **$PM_{10}$ = $PM_{2.5}$ (lb/day/CT)** | 240.0 |
| **$PM_{10}$ = $PM_{2.5}$ (g/s/CT)** | 1.3 |

**Assumptions:**
Only $SO_2$ and PM are considered for an average 24-hour Ambient Air Quality Standard.
For $SO_2$ 24 hrs of normal operation at maximum emission rate
For PM 24 hrs of normal operation at maximum emission rate

**Worst-Case Daily Emissions per Turbine and Modeling Worst-Case 24 Hour Emission Rate**

| Pollutant | Time in Startup hr | Startup Emission Rate lb/start | Time in Shut Down hr | Shutdown Emission Rate lb/shutdown | Time in Normal Operation hr | Normal Operation Emission Rate lb/start | Worst-Case Daily Emissions lb/day/CT | Modeling Worst-Case 24 Hr Emission g/s/CT |
|---|---|---|---|---|---|---|---|---|
| NOx | 0.7 | 3.0 | 0.7 | 4.0 | 22.6 | 8.1 | 212.4 | |
| CO | 0.7 | 10.2 | 0.7 | 13.2 | 22.6 | 11.9 | 362.9 | |
| VOC | 0.7 | 0.2 | 0.7 | 0.2 | 22.6 | 2.3 | 52.8 | |
| $SO_2$ | | | | | | | | |
| $PM_{10}$ = $PM_{2.5}$ | | | | | | | | |

**Assumptions:**
For NOx, CO, and VOC -- emissions are calculated assuming:
Worst-case daily emissions assumes a total start up of : 4
Worst-case daily emissions assumes a total shut down of : 4
Remainder of time is spent in normal operation at max emission rate
See above calculation for worst-case daily $SO_2$ and PM: calculated as 24 hrs of normal operationat max emission rate

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**Cooling Towers - Annual Operating Emissions**

| | | |
|---|---|---|
| **Total Hours of Operation** | 8,322 | hr/yr |

| Hours per Qtr | | | |
|---|---|---|---|
| **Q1** | **Q2** | **Q3** | **Q4** |
| 2080.5 | 2080.5 | 2080.5 | 2080.5 |

Assuming equal operation in each quarter

**Cooling Tower Operating Parameters**

| | Power Block | Process Area | ASU | Basis |
|---|---|---|---|---|
| Cooling water (CW) circulation rate, gpm | 175,000 | 42,300 | 40,200 | Typical plant performance |
| CW circulation rate (million lb/hr) | 88 | 21 | 20 | |
| CW dissolved solids (ppmw) | 9,000 | 9,000 | 9,000 | (See note) |
| Drift, fraction of circulating CW | 0.0005% | 0.0005% | 0.0005% | Expected BACT |

Note: Assumed 9,000 ppm TDS in circulating cooling water. Circulating water could range from 1200 to 90,000 ppm TDS depending on makeup water quality and tower operation. PM10 emissions would vary proportionately.

**Cooling Tower $PM_{10}$ Emissions**

| | Cooling Tower $PM_{10}$ Emissions | | | | |
|---|---|---|---|---|---|
| | **lb/hr** | **lb/day** | **lb/yr** | **ton/qtr** | **ton/yr** |
| **Power Block Cooling Tower $PM_{10}$ Emissions** | 3.94 | 94.50 | 32,767.88 | 4.10 | 16.38 |
| **Process Area Cooling Tower $PM_{10}$ Emissions** | 0.95 | 22.84 | 7,920.46 | 0.99 | 3.96 |
| **ASU Cooling Tower $PM_{10}$ Emissions** | 0.90 | 21.71 | 7,527.25 | 0.94 | 3.76 |

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**Total Cooling Tower $PM_{10}$ Emissions**

| | (ton/yr) |
|---|---|
| $PM_{10}$ | 24.11 |
| $PM_{2.5}$ | 14.46 |

$PM_{2.5}$ emission factors were determined by multiplying $PM_{10}$ numbers by a "$PM_{2.5}$ fraction of $PM_{10}$" value. Fractional values for $PM_{2.5}$ were taken from the SCAQMD guidance: Final - Methodology to Calculate $PM_{2.5}$ and $PM_{2.5}$ Significance Thresholds, October 2006: Appendix A - Updated CEIDARS Table with $PM_{2.5}$ Fractions.

**Parameters**

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

| Modeling Worst-Case 24 Hour Emissions | Power Block | Process Area | ASU |
|---|---|---|---|
| Cells per Cooling Tower | 13 | 4 | 4 |
| $PM_{10}$ (lb/24-hr) | 94.50 | 22.84 | 21.71 |
| $PM_{10}$ (g/sec/cell) | 0.038 | 0.030 | 0.028 |
| $PM_{2.5}$ (lb/24-hr) | 56.70 | 13.71 | 13.02 |
| $PM_{2.5}$ (g/sec/cell) | 0.023 | 0.018 | 0.017 |

PM is considered for an average 24-hour Ambient Air Quality Standard.

Pounds per 24-hr assumes 24 hours of continual operation.

| Modeling Worst-Case Annual Emissions | Power Block | Process Area | ASU |
|---|---|---|---|
| Cells per Cooling Tower | 13 | 4 | 4 |
| $PM_{10}$ (ton/yr) | 16.38 | 3.96 | 3.76 |
| $PM_{10}$ (g/sec/cell) | 0.036 | 0.028 | 0.027 |
| $PM_{2.5}$ (lb/24-hr) | 9.830 | 2.376 | 2.258 |
| $PM_{2.5}$ (g/sec/cell) | 0.022 | 0.017 | 0.016 |

PM is considered for an annual average Ambient Air Quality Standard.

Assumes continual annual operation.

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**Auxiliary Boiler - Annual Operating Emissions**

| | | |
|---|---|---|
| **Total Hours of Operation** | 2,190 | hr/yr |
| **Firing Rate** | 142 | MMBtu/hr |

| Hours per Qtr | | | |
|---|---|---|---|
| **Q1** | **Q2** | **Q3** | **Q4** |
| 547.5 | 547.5 | 547.5 | 547.5 |

Assuming equal operation in each quarter

**Auxiliary Boiler Emission Factors**

| | | |
|---|---|---|
| NOx (low NOx burner and flue gas recirculation, 9 ppmvd (3% O2)) | 0.011 | lb/MMBtu |
| CO (50 ppmvd (3% O2)) | 0.037 | lb/MMBtu |
| VOC | 0.004 | lb/MMBtu |
| $SO_2$ (12.65 ppmv in fuel) | 0.00204 | lb/MMBtu |
| $PM_{10}$ = $PM_{2.5}$ | 0.005 | lb/MMBtu |

**Auxiliary Boiler Pollutant Emission Rates**

| | Auxiliary Boiler Emissions | | | | |
|---|---|---|---|---|---|
| **Pollutant** | **lb/hr** | **lb/day** | **lb/yr** | **ton/qtr** | **ton/yr** |
| NOx | 1.56 | 37.49 | 3,420.78 | 0.43 | 1.7 |
| CO | 5.25 | 126.10 | 11,506.26 | 1.44 | 5.8 |
| VOC | 0.57 | 13.63 | 1,243.92 | 0.16 | 0.6 |
| $SO_2$ | 0.29 | 6.96 | 635.09 | 0.08 | 0.3 |
| $PM_{10}$ = $PM_{2.5}$ | 0.71 | 17.04 | 1,554.90 | 0.19 | 0.8 |

## Auxiliary Boiler — Emissions Summary

*Hydrogen Energy International LLC*
*HECA Project*

*7/24/2008*

### Modeling Worst-Case 1 hr Emissions

| | |
|---|---|
| NOx (g/sec) | 0.2 |
| CO (g/sec) | 0.7 |
| $SO_2$ (g/sec) | 0.04 |

Only NOx, CO, and $SO_2$ are considered for an average 1-hour Ambient Air Quality Standard.

### Parameters

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

### Modeling Worst-Case 3 hr Emissions

| | |
|---|---|
| $SO_2$ (lb/3-hr) | 0.87 |
| $SO_2$ (g/sec) | 0.04 |

Only $SO_2$ is considered for an average 3-hour Ambient Air Quality Standard.

### Modeling Worst-Case 8 hr Emissions

| | |
|---|---|
| CO (lb/8-hr) | 42.03 |
| CO (g/sec) | 0.7 |

Only CO is considered for an average 8-hour Ambient Air Quality Standard.

### Modeling Worst-Case 24 Hour Emissions

| | |
|---|---|
| $SO_2$ (lb/24-hr) | 6.96 |
| $SO_2$ (g/sec) | 0.04 |
| $PM_{10}$ = $PM_{2.5}$ (lb/24-hr) | 17.04 |
| $PM_{10}$ = $PM_{2.5}$ (g/sec) | 0.09 |

Only $SO_2$ and PM are considered for an average 24-hour Ambient Air Quality Standard.

### Modeling Annual Average Emissions

| | |
|---|---|
| NOx (g/sec) | 0.05 |
| CO (g/sec) | 0.2 |
| VOC (g/sec) | 0.02 |
| $SO_2$ (g/sec) | 0.01 |
| $PM_{10}$ = $PM_{2.5}$ (g/sec) | 0.02 |

## Emergency Diesel Generators — Emissions Summary

*Hydrogen Energy International LLC* — *7/24/2008*
*HECA Project*

**Emergency Generator - Expected Emergency Operation and Maintenance**

| | | |
|---|---|---|
| **Total Hours of Operation** | 50 | hr/yr |
| **Generator Specification** | 2,800 | Bhp |

| Hours per Qtr | | | |
|---|---|---|---|
| **Q1** | **Q2** | **Q3** | **Q4** |
| 12.5 | 12.5 | 12.5 | 12.5 |

Assuming equal operation in each quarter

**Generator Pollutant Emission Factors (per generator)**

| | |
|---|---|
| NOx (g/Bhp/hr) | 0.50 |
| CO (g/Bhp/hr) | 0.29 |
| VOC (g/Bhp/hr) | 0.11 |
| $SO_2$ (g/Bhp/hr) | N/A |
| $PM_{10} = PM_{2.5}$ (g/Bhp/hr) | 0.03 |

**Generator Pollutant Emission Rates (per generator)**

| | Generator Emissions | | | | |
|---|---|---|---|---|---|
| **Pollutant** | **lb/hr** | **lb/day** | **lb/yr** | **ton/qtr** | **ton/yr** |
| NOx | 3.09 | 6.17 | 154.32 | 0.02 | 0.1 |
| CO | 1.79 | 3.58 | 89.51 | 0.01 | 0.04 |
| VOC | 0.68 | 1.36 | 33.95 | 0.00 | 0.02 |
| $SO_2$ | 0.03 | 0.06 | 1.40 | 0.00 | 0.001 |
| $PM_{10} = PM_{2.5}$ | 0.16 | 0.32 | 8.02 | 0.00 | 0.00 |

| | | |
|---|---|---|
| Fuel sulfur content = | 15 | ppmw in fuel |
| $SO_2$ emissions = | 0.20 | lb $SO_2$/1000 gal |
| Fuel flow | 140.00 | gal/hr |

Pounds per day assumes two (2) hours of operation for maintenance and testing.

***Please note that there are two generators; all emissions are shown for individual generators***

**Modeling Worst-Case 1 hr Emissions (per generator)**

| | |
|---|---|
| NOx (g/sec) | 0.4 |
| CO (g/sec) | 0.2 |
| $SO_2$ (g/sec) | 0.004 |

Only NOx, CO, and $SO_2$ are considered for an average 1-hour Ambient Air Quality Standard.

**Parameters**

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

**Modeling Worst-Case 3 hr Emissions (per generator)**

| | |
|---|---|
| $SO_2$ (lb/3-hr) | 0.06 |
| $SO_2$ (g/sec) | 0.002 |

Only $SO_2$ is considered for an average 3-hour Ambient Air Quality Standard.
Pounds per 3-hr assumes two (2) hours of operation.

**Modeling Worst-Case 8 hr Emissions (per generator)**

| | |
|---|---|
| CO (lb/8-hr) | 3.58 |
| CO (g/sec) | 0.06 |

Only CO is considered for an average 8-hour Ambient Air Quality Standard.
Pounds per 8-hr assumes two (2) hours of operation.

**Modeling Worst-Case 24 Hour Emissions (per generator)**

| | |
|---|---|
| $SO_2$ (lb/24-hr) | 0.06 |
| $SO_2$ (g/sec) | 0.0003 |
| $PM_{10} = PM_{2.5}$ (lb/24-hr) | 0.32 |
| $PM_{10} = PM_{2.5}$ (g/sec) | 0.002 |

Only $SO_2$ and PM are considered for an average 24-hour Ambient Air Quality Standard.
Pounds per 24-hr assumes two (2) hours of operation.

**Modeling Annual Average Emissions (per generator)**

| | |
|---|---|
| NOx (g/sec) | 0.002 |
| CO (g/sec) | 0.001 |
| VOC (g/sec) | 0.000 |
| $SO_2$ (g/sec) | 0.00002 |
| $PM_{10} = PM_{2.5}$ (g/sec) | 0.0001 |

Pounds per year assumes 50 hours of operation.

## Emergency Diesel Firewater Pump — Emissions Summary

*Hydrogen Energy International LLC* — *7/24/2008*
*HECA Project*

**Fire Water Pump - Expected Emergency Operation and Maintenance**

| | | |
|---|---|---|
| **Total Hours of Operation** | 100 | hr/yr |
| **Fire Water Pump Specification** | 556 | Bhp |

| Hours per Qtr | | | |
|---|---|---|---|
| **Q1** | **Q2** | **Q3** | **Q4** |
| 25 | 25 | 25 | 25 |

Assuming equal operation in each quarter

**Fire Water Pump Pollutant Emission Factors**

| | |
|---|---|
| NOx (g/Bhp/hr) | 1.50 |
| CO (g/Bhp/hr) | 2.60 |
| VOC (g/Bhp/hr) | 0.14 |
| $SO_2$ (g/Bhp/hr) | N/A |
| $PM_{10} = PM_{2.5}$ (g/Bhp/hr) | 0.015 |

**Fire Water Pump Pollutant Emission Rates**

| | Fire Water Pump Emissions | | | | |
|---|---|---|---|---|---|
| **Pollutant** | **lb/hr** | **lb/day** | **lb/yr** | **ton/qtr** | **ton/yr** |
| NOx | 1.84 | 3.68 | 183.86 | 0.02 | 0.1 |
| CO | 3.19 | 6.37 | 318.69 | 0.04 | 0.2 |
| VOC | 0.17 | 0.34 | 17.16 | 0.00 | 0.01 |
| $SO_2$ | 0.01 | 0.01 | 0.56 | 0.0001 | 0.0003 |
| $PM_{10} = PM_{2.5}$ | 0.02 | 0.04 | 1.84 | 0.00 | 0.00 |

| | | |
|---|---|---|
| Fuel sulfur content = | 15 | ppmw in fuel |
| $SO_2$ emissions = | 0.20 | lb $SO_2$/1000 gal |
| Fuel flow | 28.00 | gal/hr |

Pounds per day assumes two (2) hours of operation for maintenance and testing.

## Emergency Diesel Firewater Pump — Emissions Summary

*Hydrogen Energy International LLC* — *7/24/2008*

*HECA Project*

### Modeling Worst-Case 1 hr Emissions

| | |
|---|---|
| NOx (g/sec) | 0.2 |
| CO (g/sec) | 0.4 |
| $SO_2$ (g/sec) | 0.0007 |

Only NOx, CO, and $SO_2$ are considered for an average 1-hour Ambient Air Quality Standard

### Parameters

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

### Modeling Worst-Case 3 hr Emissions

| | |
|---|---|
| $SO_2$ (lb/3-hr) | 0.01 |
| $SO_2$ (g/sec) | 0.0005 |

Only $SO_2$ is considered for an average 3-hour Ambient Air Quality Standard.

Pounds per 3-hr assumes two (2) hours of operation.

### Modeling Worst-Case 8 hr Emissions

| | |
|---|---|
| CO (lb/8-hr) | 6.37 |
| CO (g/sec) | 0.1 |

Only CO is considered for an average 8-hour Ambient Air Quality Standard.

Pounds per 8-hr assumes two (2) hours of operation.

## Emergency Diesel Firewater Pump — Emissions Summary

*Hydrogen Energy International LLC* — *7/24/2008*

*HECA Project*

**Modeling Worst-Case 24 Hour Emissions**

| | |
|---|---|
| $SO_2$ (lb/24-hr) | 0.01 |
| $SO_2$ (g/sec) | 0.0001 |
| $PM_{10}$ = $PM_{2.5}$ (lb/24-hr) | 0.04 |
| $PM_{10}$ = $PM_{2.5}$ (g/sec) | 0.0002 |

Only $SO_2$ and PM are considered for an average 24-hour Ambient Air Quality Standard.

Pounds per 24-hr assumes two (2) hours of operation.

**Modeling Annual Average Emissions**

| | |
|---|---|
| NOx (g/sec) | 0.003 |
| CO (g/sec) | 0.005 |
| VOC (g/sec) | 0.0002 |
| $SO_2$ (g/sec) | 0.00001 |
| $PM_{10}$ = $PM_{2.5}$ (g/sec) | 0.00003 |

Pounds per year assumes 100 hours of operation.

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

**Ground Flare - Normal Operating Emissions From Pilot**

| | | |
|---|---|---|
| **Total Hours of Operation** | 8,760 | hr/yr |
| **Ground Flare Pilot Fuel Use =** | 0.5 | MMBtu/hr |

| **Hours per Qtr** | | | |
|---|---|---|---|
| **Q1** | **Q2** | **Q3** | **Q4** |
| 2190 | 2190 | 2190 | 2190 |

Assuming equal operation in each quarter

**Pilot Pollutant Emission Factors**

| | |
|---|---|
| NOx (lb/MMBtu, HHV) | 0.12 |
| CO (lb/MMBtu, HHV) | 0.08 |
| VOC (lb/MMBtu, HHV) | 0.0013 |
| $SO_2$ (lb/MMBtu, HHV) (12.65 ppm in fuel) | 0.002 |
| VOC (lb/MMBtu, HHV) | 0.0013 |
| $PM_{10}$ = $PM_{2.5}$ (lb/MMBtu, HHV) | 0.003 |

**Pilot Pollutant Emission Rates**

| | **Pilot Emissions** | | | | |
|---|---|---|---|---|---|
| **Pollutant** | **lb/hr** | **lb/day** | **lb/yr** | **ton/qtr** | **ton/yr** |
| NOx | 0.060 | 1.44 | 525.60 | 0.07 | 0.26 |
| CO | 0.040 | 0.96 | 350.40 | 0.04 | 0.18 |
| VOC | 0.001 | 0.02 | 5.69 | 0.0007 | 0.003 |
| $SO_2$ | 0.001 | 0.02 | 8.94 | 0.0011 | 0.004 |
| $PM_{10}$ = $PM_{2.5}$ | 0.002 | 0.04 | 13.14 | 0.00 | 0.007 |

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

**Ground Flare - Operating Emissions During Gasifier Startup and Shutdown**

| | | |
|---|---|---|
| **Total Flare SU/SD Operation** | 115,500 | MMBtu/yr |
| **Wet Unshifted Gas Heat Rate** | 900 | MMBtu/hr |
| **Dry Shifted Gas Heat Rate** | 768 | MMBtu/hr |
| **Approximate Operating Hours (wet)** | 96 | hr/yr |
| **Approximate Operating Hours (dry)** | 38 | hr/yr |

**Startup and shutdown flared gas scenario**

| | | | |
|---|---|---|---|
| Cold plant startup = | 30,000 | MMBtu/yr (1 event) | (assume 20% unshifted) |
| Plant shutdown = | 500 | MMBtu/yr (1 event) | (assume 100% unshifted) |
| Gasifier outages = | 60,000 | MMBtu/yr (24 events) | (assume 100% unshifted) |
| Gasifier hot restarts = | 25,000 | MMBtu/yr (12 events) | (assume 100% unshifted) |
| **Total** | **115,500** | **MMBtu/yr** | (approx 75% unshifted) |

**SU/SD Flare Pollutant Emission Factors**

| | |
|---|---|
| NOx (lb/MMBtu, HHV) | 0.07 |
| CO (lb/MMBtu, HHV) (wet) | 1.00 |
| CO (lb/MMBtu, HHV) (dry) | 0.10 |
| VOC (lb/MMBtu, HHV) | 0 |
| $SO_2$ (lb/MMBtu, HHV) | 0 |
| $PM_{10}$ = $PM_{2.5}$ (lb/MMBtu, HHV) | 0 |

**SU/SD Flare Pollutant Emission Rates**

| | SU/SD Flare Emissions | | | | | | |
|---|---|---|---|---|---|---|---|
| **Pollutant** | **lb/hr (wet)** | **lb/hr (dry)** | **% Wet** | **% Dry** | **lb/hr (wet/dry)** | **ton/qtr (wet/dry)** | **ton/yr (wet/dry)** |
| NOx | 63.0 | 53.8 | 75.0% | 25.0% | 60.70 | 1.01 | 4.04 |
| CO | 900.0 | 76.8 | 75.0% | 25.0% | 694.21 | 11.19 | 44.76 |
| VOC | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $SO_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $PM_{10}$ = $PM_{2.5}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Total emissions are determined based on the fractional amount of wet and dry gas burned.

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

**Total Ground Flare Emissions**

| Pollutant | Emissions Pilot (ton/yr) | SU/SD (ton/yr) | Total (ton/qtr) | Total (ton/yr) |
|---|---|---|---|---|
| NOx | 0.26 | 4.04 | 1.08 | 4.3 |
| CO | 0.18 | 44.76 | 11.23 | 44.9 |
| VOC | 0.003 | 0.00 | 0.001 | 0.003 |
| $SO_2$ | 0.004 | 0.00 | 0.001 | 0.004 |
| $PM_{10} = PM_{2.5}$ | 0.01 | 0.00 | 0.002 | 0.01 |

**Modeling Worst-Case 1 hr Emissions**

| | |
|---|---|
| NOx (g/sec) | 7.9 |
| CO (g/sec) | 113.4 |
| $SO_2$ (g/sec) | 0.0001 |

Only NOx, CO, and $SO_2$ are considered for an average 1-hour Ambient Air Quality Standard.
NOx and CO rates are taken from the SU/SD flaring events
$SO_2$ rate is from pilot operation

**Parameters**

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

**Modeling Worst-Case 3 hr Emissions**

| | |
|---|---|
| $SO_2$ (lb/3-hr) | 0.003 |
| $SO_2$ (g/sec) | 0.0001 |

Only $SO_2$ is considered for an average 3-hour Ambient Air Quality Standard.
$SO_2$ pounds per 3-hr assumes three (3) hours of pilot operation.

**Modeling Worst-Case 8 hr Emissions**

| | |
|---|---|
| CO (lb/8-hr) | 7,200.00 |
| CO (g/sec) | 113.4 |

Only CO is considered for an average 8-hour Ambient Air Quality Standard.
Pounds per 8-hr assumes eight (8) hours of SU/SD flaring events.

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

**Modeling Worst-Case 24 Hour Emissions**

| | |
|---|---|
| $SO_2$ (lb/24-hr) | 0.02 |
| $SO_2$ (g/sec) | 0.0001 |
| $PM_{10}$ = $PM_{2.5}$ (lb/24-hr) | 0.04 |
| $PM_{10}$ = $PM_{2.5}$ (g/sec) | 0.0002 |

Only $SO_2$ and PM are considered for an average 24-hour Ambient Air Quality Standard.
Pounds per 24-hr assumes 24 hours of pilot operation.

**Modeling Annual Average Emissions**

| | |
|---|---|
| NOx (g/sec) | 0.1 |
| CO (g/sec) | 1.3 |
| VOC (g/sec) | 0.0001 |
| $SO_2$ (g/sec) | 0.0001 |
| $PM_{10}$ = $PM_{2.5}$ (g/sec) | 0.0002 |

Pounds per year assumes contributions from both pilot operation and SU/SD flaring

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

**Elevated Flare - Normal Operating Emissions from Pilot**

| | | |
|---|---|---|
| **Total Hours of Operation** | 8,760 | hr/yr |
| **Elevated Flare Pilot Firing Rate** | 0.3 | MMBtu/hr |

| Hours per Qtr | | | |
|---|---|---|---|
| **Q1** | **Q2** | **Q3** | **Q4** |
| 2190 | 2190 | 2190 | 2190 |

Assuming equal operation in each quarter

**Pilot Pollutant Emission Factors**

| | |
|---|---|
| NOx (lb/MMBtu, HHV) | 0.12 |
| CO (lb/MMBtu, HHV) | 0.08 |
| VOC (lb/MMBtu, HHV) | 0.0013 |
| $SO_2$ (lb/MMBtu, HHV) (12.65 ppm in fuel) | 0.002 |
| $PM_{10}$ = $PM_{2.5}$ (lb/MMBtu, HHV) | 0.003 |

**Pilot Pollutant Emission Rates**

| | Pilot Emissions | | | | |
|---|---|---|---|---|---|
| **Pollutant** | **lb/hr** | **lb/day** | **lb/yr** | **ton/qtr** | **ton/yr** |
| NOx | 0.036 | 0.86 | 315.36 | 0.04 | 0.2 |
| CO | 0.024 | 0.58 | 210.24 | 0.03 | 0.1 |
| VOC | 0.0004 | 0.01 | 3.42 | 0.0004 | 0.002 |
| $SO_2$ | 0.0006 | 0.01 | 5.37 | 0.0007 | 0.003 |
| $PM_{10}$ = $PM_{2.5}$ | 0.0009 | 0.02 | 7.88 | 0.00 | 0.004 |

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

**Elevated Flare - Operating Emissions During Gasifier Startup and Shutdown**

| | | | | | |
|---|---|---|---|---|---|
| **Natural Gas Heat Rate (assist gas)** | 36.0 | MMBtu/hr | | | |
| **Approximate Operating Hours** | 6.0 | hr/yr | approximately | 2 | events |

Control efficiency of scrubber = 99.62%
Acid gas lb/hr SO2 = 4,600 lb/hr scrubbed SO2= 17.3

**SU/SD Flare Pollutant Emission Factors**

| | |
|---|---|
| NOx (lb/hr) | 4.32 |
| CO (lb/hr) | 2.88 |
| VOC (lb/hr) | 0.05 |
| $SO_2$ (lb/hr) from natural gas | 0.07 |
| $SO_2$ (lb/hr) from sour flaring | 17.33 |
| $PM_{10} = PM_{2.5}$(lb/hr) | 0.11 |

Natural gas emissions are the same as those listed for the pilot multiplied by the heat rate of the assist gas

**SU/SD Flare Pollutant Emission Rates**

| | SU/SD Flare Emissions | | | | |
|---|---|---|---|---|---|
| **Pollutant** | **lb/hr** | **lb/day** | **lb/yr** | **ton/qtr** | **ton/yr** |
| NOx | 4.32 | 13.0 | 25.9 | 0.00324 | 0.0130 |
| CO | 2.88 | 8.6 | 17.3 | 0.00216 | 0.0086 |
| VOC | 0.05 | 0.1 | 0.3 | 0 | 0.0001 |
| $SO_2$ | 17.41 | 52.2 | 104.4 | 0.01 | 0.0522 |
| $PM_{10} = PM_{2.5}$ | 0.11 | 0.3 | 0.6 | 0 | 0.0003 |

**Elevated Flare - Total Annual Emissions**

| | Emissions | | | |
|---|---|---|---|---|
| **Pollutant** | **Pilot (ton/yr)** | **SU/SD (ton/yr)** | **Total (ton/qtr)** | **Total (ton/yr)** |
| NOx | 0.16 | 0.0130 | 0.04 | 0.2 |
| CO | 0.11 | 0.0086 | 0.03 | 0.1 |
| VOC | 0.002 | 0.0001 | 0.000 | 0.002 |
| $SO_2$ | 0.003 | 0.05 | 0.014 | 0.1 |
| $PM_{10} = PM_{2.5}$ | 0.004 | 0.0003 | 0.001 | 0.004 |

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

**Modeling Worst-Case 1 hr Emissions**

| | |
|---|---|
| NOx (g/sec) | 0.544 |
| CO (g/sec) | 0.363 |
| $SO_2$ (g/sec) | 2.19 |

Only NOx, CO, and SO2 are considered for an average 1-hour Ambient Air Quality Standard.

NOx, CO, and SO2 one (1) hr rates are from taken from the SU/SD flaring events

**Parameters**

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

**Modeling Worst-Case 3 hr Emissions**

| | |
|---|---|
| $SO_2$ (lb/3-hr) | 52.22 |
| $SO_2$ (g/sec) | 2.19 |

Only $SO_2$ is considered for an average 3-hour Ambient Air Quality Standard.

Pounds per 3-hr assumes aproximately 3 hours (1 event) from SU/SD flaring.

**Modeling Worst-Case 8 hr Emissions**

| | |
|---|---|
| CO (lb/8-hr) | 8.76 |
| CO (g/sec) | 0.138 |

Only CO is considered for an average 8-hour Ambient Air Quality Standard.

Pounds per 8-hr assumes aproximately 3 hours (1 event) from SU/SD flaring and the remainder in pilot operation.

**Modeling Worst-Case 24 Hour Emissions**

| | |
|---|---|
| $SO_2$ (lb/24-hr) | 52.23 |
| $SO_2$ (g/sec) | 0.27 |
| $PM_{10}$ = $PM_{2.5}$ (lb/24-hr) | 0.34 |
| $PM_{10}$ = $PM_{2.5}$ (g/sec) | 0.0018 |

Only $SO_2$ and PM are considered for an average 24-hour Ambient Air Quality Standard.

$SO_2$ and PM pounds per 24-hr assume aproximately 3 hours (1 event) from SU/SD flaring and the remainder in pilot operation.

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

**Modeling Annual Average Emissions**

| | |
|---|---|
| NOx (g/sec) | 0.005 |
| CO (g/sec) | 0.003 |
| VOC (g/sec) | 0.00005 |
| $SO_2$ (g/sec) | 0.002 |
| $PM_{10}$ = $PM_{2.5}$ (g/sec) | 0.0001 |

Pounds per year assumes contributions from both pilot operation and SU/SD flaring

## Tail Gas Thermal Oxidizer — Emissions Summary

*Hydrogen Energy International LLC* — *7/24/2008*
*HECA Project*

**Thermal Oxidizer - Process Vent Disposal Emissions**

| | | |
|---|---|---|
| **Total Hours of Operation** | 8,760 | hr/yr |
| **Thermal Oxidizer Firing Rate** | 10 | MMBtu/hr |

| Hours per Qtr | | | |
|---|---|---|---|
| **Q1** | **Q2** | **Q3** | **Q4** |
| 2190 | 2190 | 2190 | 2190 |

Assuming equal operation in each quarter

**Process Vent Gas Pollutant Emission Factors**

| | |
|---|---|
| NOx (lb/MMBtu, HHV) | 0.13 |
| CO (lb/MMBtu, HHV) | 0.04 |
| VOC (lb/MMBtu, HHV) | 0.0070 |
| $SO_2$ (lb/MMBtu, HHV) | See Below |
| $PM_{10} = PM_{2.5}$ (lb/MMBtu, HHV) | 0.008 |

Assume an allowance of 2 lb/hr $SO_2$ emission to account for sulfur in the various vent streams plus fuel.

**Process Vent Gas Pollutant Emission Rates**

| | Process Vent Gas Emissions | | | | |
|---|---|---|---|---|---|
| **Pollutant** | **lb/hr** | **lb/day** | **lb/yr** | **ton/qtr** | **ton/yr** |
| NOx | 1.30 | 31.20 | 11,388.00 | 1.42 | 5.7 |
| CO | 0.35 | 8.40 | 3,066.00 | 0.38 | 1.5 |
| VOC | 0.07 | 1.68 | 613.20 | 0.0767 | 0.3 |
| $SO_2$ | 2.00 | 48.00 | 17,520.00 | 2.1900 | 8.8 |
| $PM_{10} = PM_{2.5}$ | 0.08 | 1.92 | 700.80 | 0.09 | 0.4 |

Assume an allowance of 2 lb/hr $SO_2$ emission to account for sulfur in the various vent streams plus fuel.

## Tail Gas Thermal Oxidizer — Emissions Summary

*Hydrogen Energy International LLC* — *7/24/2008*
*HECA Project*

**Thermal Oxidizer - SRU Startup Waste Gas Disposal**

| | | |
|---|---|---|
| **Total Hours of Operation** | 300 | hr/yr |
| **Thermal Oxidizer Firing Rate** | 10 | MMBtu/hr |

| Hours per Qtr | | | |
|---|---|---|---|
| **Q1** | **Q2** | **Q3** | **Q4** |
| 75 | 75 | 75 | 75 |

Assuming equal operation in each quarter

**SRU Startup Waste Gas Disposal Emission Factors**

| | |
|---|---|
| NOx (lb/MMBtu, HHV) | 0.13 |
| CO (lb/MMBtu, HHV) | 0.04 |
| VOC (lb/MMBtu, HHV) | 0.007 |
| $SO_2$ (lb/MMBtu, HHV) (12.65 ppm in fuel) | 0.002 |
| $PM_{10} = PM_{2.5}$ (lb/MMBtu, HHV) | 0.008 |

**SRU Startup Waste Gas Disposal Pollutant Emission Rates**

| | SRU Startup Waste Gas Disposal Emissions | | | | |
|---|---|---|---|---|---|
| **Pollutant** | **lb/hr** | **lb/day** | **lb/yr** | **ton/qtr** | **ton/yr** |
| NOx | 1.30 | 31.20 | 390.00 | 0.05 | 0.20 |
| CO | 0.35 | 8.40 | 105.00 | 0.01 | 0.05 |
| VOC | 0.07 | 1.68 | 21.00 | 0.003 | 0.011 |
| $SO_2$ | 0.02 | 0.49 | 6.17 | 0.001 | 0.003 |
| $PM_{10} = PM_{2.5}$ | 0.08 | 1.92 | 24.00 | 0.003 | 0.012 |

**Thermal Oxidizer - Total Annual Emissions**

| | Emissions | | | |
|---|---|---|---|---|
| **Pollutant** | **Vent (ton/yr)** | **SU/SD (ton/yr)** | **Total (ton/qtr)** | **Total (ton/yr)** |
| NOx | 5.69 | 0.20 | 1.47 | 5.9 |
| CO | 1.53 | 0.05 | 0.40 | 1.6 |
| VOC | 0.31 | 0.011 | 0.08 | 0.3 |
| $SO_2$ | 8.76 | 0.003 | 2.19 | 8.8 |
| $PM_{10} = PM_{2.5}$ | 0.35 | 0.012 | 0.09 | 0.4 |

## Tail Gas Thermal Oxidizer — Emissions Summary

*Hydrogen Energy International LLC*
*HECA Project*

*7/24/2008*

### Modeling Worst-Case 1 hr Emissions

| | |
|---|---|
| NOx (g/sec) | 0.3 |
| CO (g/sec) | 0.09 |
| $SO_2$ (g/sec) | 0.25 |

Only NOx, CO, and $SO_2$ are considered for an average 1-hour Ambient Air Quality Standard.

NOx, CO, and $SO_2$ one (1) hr rates include contributions from both process venting and SRU startup.

### Parameters

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

### Modeling Worst-Case 3 hr Emissions

| | |
|---|---|
| $SO_2$ (lb/3-hr) | 6.06 |
| $SO_2$ (g/sec) | 0.3 |

Only $SO_2$ is considered for an average 3-hour Ambient Air Quality Standard.

$SO_2$ pounds per 3-hr assumes three (3) hours of oxidation from both process venting and SRU startup.

### Modeling Worst-Case 8 hr Emissions

| | |
|---|---|
| CO (lb/8-hr) | 5.60 |
| CO (g/sec) | 0.1 |

Only CO is considered for an average 8-hour Ambient Air Quality Standard.

Pounds per 8-hr assumes eight (8) hours of oxidation from both process venting and SRU startup.

### Modeling Worst-Case 24 Hour Emissions

| | |
|---|---|
| $SO_2$ (lb/24-hr) | 48.49 |
| $SO_2$ (g/sec) | 0.3 |
| $PM_{10} = PM_{2.5}$ (lb/24-hr) | 3.84 |
| $PM_{10} = PM_{2.5}$ (g/sec) | 0.02 |

Only $SO_2$ and PM are considered for an average 24-hour Ambient Air Quality Standard.

Pounds per 24-hr assumes 24 hours of oxidation from both process venting and SRU startup.

### Modeling Annual Average Emissions

| | |
|---|---|
| NOx (g/sec) | 0.2 |
| CO (g/sec) | 0.05 |
| VOC (g/sec) | 0.01 |
| $SO_2$ (g/sec) | 0.3 |
| $PM_{10} = PM_{2.5}$ (g/sec) | 0.01 |

Pounds per year assumes all contributions from annual waste gas oxidation and periodic SRU startup.

## Intermittent $CO_2$ Vent — Emissions Summary

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

**Intermittent $CO_2$ Vent - Venting Operation**

| | | |
|---|---|---|
| **Total Days of Operation** | 21 | day/yr |
| **Total Hours of Operation** | 504 | hr/yr |
| **Total Flow** | 656,000 | lb/hr |
| **Total Flow** | 15,150 | lbmol/hr |

| Hours per Qtr | | | |
|---|---|---|---|
| **Q1** | **Q2** | **Q3** | **Q4** |
| 5.25 | 5.25 | 5.25 | 5.25 |

Assuming equal operation in each quarter

**Vent Gas Pollutant Emission Factors**

| | |
|---|---|
| CO (ppmv) | 1000 |
| VOC (ppmv) | 40 |
| $H_2S$ (ppmv) | 10 |

Molecular weight

| | | |
|---|---|---|
| $H_2S$ | 34 | lb/lbmol |
| CO | 28 | lb/lbmol |
| VOC | 16 | lb/lbmol |

**Vent Gas Pollutant Emission Rates**

| | Vent Gas Emissions | | | | |
|---|---|---|---|---|---|
| **Pollutant** | **lb/hr** | **lb/day** | **lb/yr** | **ton/qtr** | **ton/yr** |
| CO | 424.20 | 10,180.88 | 213,798.43 | 26.72 | 106.9 |
| VOC | 9.70 | 232.71 | 4,886.82 | 0.61 | 2.4 |
| $H_2S$ | 5.15 | 123.62 | 2,596.12 | 0.32 | 1.3 |

## Intermittent $CO_2$ Vent

**Emissions Summary**

*Hydrogen Energy International LLC*
*HECA Project*

*7/24/2008*

### Modeling Worst-Case 1 hr Emissions

| | |
|---|---|
| CO (g/sec) | 53.4 |
| $H_2S$ (g/sec) | 0.6 |

Only $H_2S$ and CO are considered for an average 1-hour Ambient Air Quality Standard.
$H_2S$ and CO one (1) hr rates assume normal venting operation.

### Parameters

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

### Modeling Worst-Case 8 hr Emissions

| | |
|---|---|
| CO (lb/8-hr) | 3,393.63 |
| CO (g/sec) | 53.4 |

Only CO is considered for an average 8-hour Ambient Air Quality Standard.
Pounds per 8-hr assumes eight (8) continuous hours of venting.

### Modeling Annual Average Emissions

| | |
|---|---|
| CO | 3.1 |
| VOC | 0.1 |
| H2S | 0.0 |

Pounds per year assumes normal venting averaged over the entire year.

## Gasifier Refractory Heaters — Emissions Summary

*Hydrogen Energy International LLC* — *7/24/2008*

*HECA Project*

**Gasifier Warming Emissions - Normal Operation**

| | | |
|---|---|---|
| **Total Hours of Operation** | 1,800 | hr/yr |
| **Gasifier Firing Rate** | 18 | MMBtu/hr |

| Hours per Qtr | | | |
|---|---|---|---|
| **Q1** | **Q2** | **Q3** | **Q4** |
| 450 | 450 | 450 | 450 |

Assuming equal operation in each quarter

**Gasifier Pollutant Emission Factors**

| | |
|---|---|
| NOx (lb/MMBtu, HHV) | 0.13 |
| CO (lb/MMBtu, HHV) | 0.04 |
| VOC (lb/MMBtu, HHV) | 0.007 |
| $SO_2$ (lb/MMBtu, HHV) (12.65 ppm in fuel) | 0.020 |
| $PM_{10}$ = $PM_{2.5}$ (lb/MMBtu, HHV) | 0.008 |

**Gasifier Pollutant Emission Rates**

| | Gasifier Emissions | | | | |
|---|---|---|---|---|---|
| **Pollutant** | **lb/hr** | **lb/day** | **lb/yr** | **ton/qtr** | **ton/yr** |
| NOx | 2.34 | 56.16 | 4,212.00 | 0.53 | 2.1 |
| CO | 0.63 | 15.12 | 1,134.00 | 0.14 | 0.6 |
| VOC | 0.13 | 3.02 | 226.80 | 0.03 | 0.1 |
| $SO_2$ | 0.36 | 8.64 | 648.00 | 0.08 | 0.3 |
| $PM_{10}$ = $PM_{2.5}$ | 0.14 | 3.46 | 259.20 | 0.03 | 0.1 |

***Please Note That There Are Three Gassifiers; However, Under Normal Operations, Only One Operates At A Time.***

## Gasifier Refractory Heaters — Emissions Summary

*Hydrogen Energy International LLC* — *7/24/2008*
*HECA Project*

### Modeling Worst-Case 1 hr Emissions

| | |
|---|---|
| NOx (g/sec) | 0.3 |
| CO (g/sec) | 0.1 |
| $SO_2$ (g/sec) | 0.05 |

Only NOx, CO, and $SO_2$ are considered for an average 1-hour Ambient Air Quality Standard.

NOx, CO, and $SO_2$ one (1) hr rates assume normal operation.

### Parameters

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

### Modeling Worst-Case 3 hr Emissions

| | |
|---|---|
| $SO_2$ (lb/3-hr) | 1.08 |
| $SO_2$ (g/sec) | 0.05 |

Only $SO_2$ is considered for an average 3-hour Ambient Air Quality Standard.

$SO_2$ pounds per 3-hr assumes three (3) hours of normal operation.

### Modeling Worst-Case 8 hr Emissions

| | |
|---|---|
| CO (lb/8-hr) | 5.04 |
| CO (g/sec) | 0.1 |

Only CO is considered for an average 8-hour Ambient Air Quality Standard.

Pounds per 8-hr assumes eight (8) hours of normal operation.

### Modeling Worst-Case 24 Hour Emissions

| | |
|---|---|
| $SO_2$ (lb/24-hr) | 8.64 |
| $SO_2$ (g/sec) | 0.05 |
| $PM_{10}$ = $PM_{2.5}$ (lb/24-hr) | 3.46 |
| $PM_{10}$ = $PM_{2.5}$ (g/sec) | 0.02 |

Only $SO_2$ and PM are considered for an average 24-hour Ambient Air Quality Standard.

Pounds per 24-hr assumes 24 hours of normal operation.

## Gasifier Refractory Heaters — Emissions Summary

*Hydrogen Energy International LLC* — *7/24/2008*
*HECA Project*

**Modeling Annual Average Emissions**

| | |
|---|---|
| NOx (g/sec) | 0.1 |
| CO (g/sec) | 0.0 |
| VOC (g/sec) | 0.00 |
| $SO_2$ (g/sec) | 0.01 |
| $PM_{10}$ = $PM_{2.5}$ (g/sec) | 0.00 |

Pounds per year assumes 1,800 hours of annual normal operation.

## Feedstock - Dust Collection

**Emissions Summary**

*Hydrogen Energy International LLC*
*HECA Project*

*7/24/2008*

**Operation**

| | | |
|---|---|---|
| **Total Hours of Operation** | 8,760 | hr/yr |

| Hours per Qtr | | | |
|---|---|---|---|
| **Q1** | **Q2** | **Q3** | **Q4** |
| 2190 | 2190 | 2190 | 2190 |

Assuming equal operation in each quarter

| Description | Dust Collector No. | Max Feed Handling Rate (ton/hr) | Air Flow to Collector (acfm) | Max Collector PM Emission Rate (lb/hr) | Emission Factor (lb/ton) | Max 24-hr Average | | Annual Average | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Feed Rate (ton/hr) | PM Emission (lb/hr) | Feed Rate (ton/hr) | PM Emission (lb/hr) |
| Truck Unloading | DC-1 | 900 | 20,266 | 0.52 | 0.00058 | 700 | 0.41 | 150 | 0.09 |
| Coke/coal Silos (filling) | DC-2 | 450 | 30,132 | 0.77 | 0.00172 | 350 | 0.60 | 75 | 0.13 |
| Coke/coal Silos (filling) | DC-3 | 450 | 30,132 | 0.77 | 0.00172 | 350 | 0.60 | 75 | 0.13 |
| Coke/coal Silos (loadout) | DC-4 | 660 | 1316 | 0.03 | 0.00005 | 190 | 0.01 | 150 | 0.01 |
| Crusher Inlet | DC-5 | 660 | 15,164 | 0.39 | 0.00059 | 190 | 0.11 | 150 | 0.09 |
| Crusher Outlet | DC-6 | 660 | 13,492 | 0.35 | 0.00053 | 190 | 0.10 | 150 | 0.08 |
| Feed Bin Inlet Conveyor | DC-7 | 660 | 11,206 | 0.29 | 0.00044 | 190 | 0.08 | 150 | 0.07 |
| Grinding Mill Feed Bins | DC-8 | 660 | 13,878 | 0.36 | 0.00054 | 190 | 0.10 | 150 | 0.08 |
| Fluxant Bins (filling) | DC-9 | 100 | 1553 | 0.04 | 0.00040 | 6 | 0.002 | 6 | 0.002 |

Maximum dust collector PM emission rate based on expected supplier guarantee of 0.003 grain/scf outlet dust loading.

The maximum 24-hr feed rate to the gasifiers is limited by the grinding mill capacity.

**Duct Collector Emission Rates**

| Pollutant | Collector Emissions | | | | |
|---|---|---|---|---|---|
| | lb/hr | lb/day | lb/yr | ton/qtr | ton/yr |
| Dust Collecter 1 (DC-1) | 0.41 | 9.73 | 760.84 | 0.10 | 0.4 |
| Dust Collecter 2 (DC-2) | 0.60 | 14.46 | 1,131.24 | 0.14 | 0.6 |
| Dust Collecter 3 (DC-3) | 0.60 | 14.46 | 1,131.24 | 0.14 | 0.6 |
| Dust Collecter 4 (DC-4) | 0.01 | 0.23 | 67.37 | 0.01 | 0.0 |
| Dust Collecter 5 (DC-5) | 0.11 | 2.69 | 776.32 | 0.10 | 0.4 |
| Dust Collecter 6 (DC-6) | 0.10 | 2.40 | 690.72 | 0.09 | 0.3 |
| Dust Collecter 7 (DC-7) | 0.08 | 1.99 | 573.69 | 0.07 | 0.3 |
| Dust Collecter 8 (DC-8) | 0.10 | 2.47 | 710.48 | 0.09 | 0.4 |
| Dust Collecter 9 (DC-9) | 0.00 | 0.06 | 20.99 | 0.00 | 0.0 |

Pounds per hour and pounds per day calculated based on the maximum 24-hr average emission rate.

Pounds per year calculated based on the annual average emission rate.

## Feedstock - Dust Collection

**Emissions Summary**

*Hydrogen Energy International LLC*
*HECA Project*

*7/24/2008*

| | lb/yr | ton/qtr | ton/yr |
|---|---|---|---|
| $PM_{10}$ | **5,862.9** | **0.7** | **2.9** |
| $PM_{2.5}$ | **1712.0** | **0.2** | **0.9** |

$PM_{2.5}$ emission factors were determined by multiplying $PM_{10}$ numbers by a "$PM_{2.5}$ fraction of $PM_{10}$" value. Fractional values for $PM_{2.5}$ were taken from the SCAQMD guidance: Final - Methodology to Calculate $PM_{2.5}$ and $PM_{2.5}$ Significance Thresholds, October 2006: Appendix A - Updated CEIDARS Table with $PM_{2.5}$ Fractions.

**Parameters**

| | |
|---|---|
| Days per year: | 365 |
| Hours per day: | 24 |
| Minutes per hour: | 60 |
| Seconds per minute: | 60 |

| **Modeling Worst-Case 24 Hour Emissions** | **DC-1** | **DC-2** | **DC-3** | **DC-4** | **DC-5** | **DC-6** | **DC-7** | **DC-8** | **DC-9** |
|---|---|---|---|---|---|---|---|---|---|
| $PM_{10}$ (lb/day) | 9.73 | 14.46 | 14.46 | 0.23 | 2.69 | 2.40 | 1.99 | 2.47 | 0.058 |
| $PM_{10}$ (g/sec) | 0.051 | 0.076 | 0.076 | 0.001 | 0.014 | 0.013 | 0.010 | 0.013 | 0.0003 |
| $PM_{2.5}$ (lb/24-hr) | 2.840 | 4.223 | 4.223 | 0.068 | 0.787 | 0.700 | 0.581 | 0.720 | 0.017 |
| $PM_{2.5}$ (g/sec) | 0.015 | 0.022 | 0.022 | 0.000 | 0.004 | 0.004 | 0.003 | 0.004 | 0.000 |

PM is considered for an average 24-hour Ambient Air Quality Standard.

Pounds per hour calculated based on the maximum 24-hr average emission rate.

| **Modeling Annual Average Emissions** | **DC-1** | **DC-2** | **DC-3** | **DC-4** | **DC-5** | **DC-6** | **DC-7** | **DC-8** | **DC-9** |
|---|---|---|---|---|---|---|---|---|---|
| $PM_{10}$ (lb/yr) | 760.84 | 1,131.24 | 1,131.24 | 67.37 | 776.32 | 690.72 | 573.69 | 710.48 | 20.989 |
| $PM_{10}$ (g/sec) | 0.011 | 0.016 | 0.016 | 0.001 | 0.011 | 0.010 | 0.008 | 0.010 | 0.0003 |
| $PM_{2.5}$ (lb/24-hr) | 222.166 | 330.322 | 330.322 | 19.673 | 226.685 | 201.690 | 167.517 | 207.461 | 6.129 |
| $PM_{2.5}$ (g/sec) | 0.003 | 0.005 | 0.005 | 0.000 | 0.003 | 0.003 | 0.002 | 0.003 | 0.0001 |

Pounds per year calculated based on the annual average emission rate.

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*HECA Project*

GHG emissions are numerically depicted as metric tons (tonne) of carbon dioxide equivalents ($CO_2e$). $CO_2e$ represents $CO_2$ plus the additional warming potential from $CH_4$ and $N_2O$. $CH_4$ and $N_2O$ have 21 and 310 times the warming potential of $CO_2$, respectively.

| Natural Gas GHG Emission Factors | | | | | | Diesel GHG Emission Factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ = | 52.78 | kg/MMBtu = | 116.36 | lb/MMBtu | | $CO_2$ = | 10.15 | kg/gal = | 22.38 | lb/gal |
| $CH_4$ = | 0.0059 | kg/MMBtu = | 0.013 | lb/MMBtu | | $CH_4$ = | 0.0003 | kg/gal = | 0.001 | lb/gal |
| $N_2O$ = | 0.0001 | kg/MMBtu = | 0.00022 | lb/MMBtu | | $N_2O$ = | 0.0001 | kg/gal = | 0.0002 | lb/gal |

$CO_2$, $CH_4$, and $N_2O$ emission factors are taken from Appendix C of the California Climate Action Registry (CCAR) General Reporting Protocol Version 2.2 (March 2007)

**HRSG Stack**

| | | | | | | |
|---|---|---|---|---|---|---|
| Operating Hours | | 876 | hr/yr | | | |
| HRSG Heat Input | | 1,998 | MMBtu/hr | | | |
| | | | | | | |
| $CO_2$ = | 364,052 | tonne/yr | | | | |
| $CH_4$ = | 10 | tonne/yr = | 217 | tonne $CO_2e$/yr | | |
| $N_2O$ = | 0.17 | tonne/yr = | 54 | tonne $CO_2e$/yr | Total tonne $CO_2e$/yr = | 364,324 |

Startup and shutdown of the HRSG will be accomplished using natural gas. The total operating hours, including startup and shutdown, are estimated at 876 hr/yr for the worst-case greenhouse gas emissions. The total startup and shutdown operating hours are estimated at 50 hr/yr for the worst-case criteria pollutant emissions.

HRSG heat input rate is assumed to be the maximum heat input rate firing natural gas, which corresponds to winter minimum (20 F).

**Auxiliary CTG**

| | | | | | | |
|---|---|---|---|---|---|---|
| Operating Hours | | 4,110 | hr/yr | | | |
| HRSG Heat Input | | 911 | MMBtu/hr | | | |
| | | | | | | |
| $CO_2$ = | 197,620 | tonne/yr | | | | |
| $CH_4$ = | 22 | tonne/yr = | 464 | tonne $CO_2e$/yr | | |
| $N_2O$ = | 0.4 | tonne/yr = | 116 | tonne $CO_2e$/yr | Total tonne $CO_2e$/yr = | 198,200 |

Average annual GHG operational emissions are calculated using yearly average (65 F) at 100 % load, with evaporative cooling.

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

GHG emissions are numerically depicted as metric tons (tonne) of carbon dioxide equivalents ($CO_2e$). $CO_2e$ represents $CO_2$ plus the additional warming potential from $CH_4$ and $N_2O$. $CH_4$ and $N_2O$ have 21 and 310 times the warming potential of $CO_2$, respectively.

**Auxiliary Boiler**

| | | | | | | |
|---|---|---|---|---|---|---|
| Operating Hours | | 2,190 | hr/yr | | | |
| HRSG Heat Input | | 142 | MMBtu/hr | | | |
| | | | | | | |
| $CO_2$ = | 16,418 | tonne/yr | | | | |
| $CH_4$ = | 2 | tonne/yr = | 39 | tonne $CO_2e$/yr | | |
| $N_2O$ = | 0.03 | tonne/yr = | 10 | tonne $CO_2e$/yr | Total tonne $CO_2e$/yr = | 16,466 |

**Emergency Generators**

| | | | | | | |
|---|---|---|---|---|---|---|
| Operating Hours | | 50 | hr/yr | | | |
| HRSG Heat Input | | 2,800 | Bhp | | | |
| | | | | | | |
| $CO_2$ = | 3,201 | lb/hr = | 73 | tonne $CO_2$/yr | | |
| $CH_4$ = | 0.09 | lb/hr = | 0.045 | tonne $CO_2e$/yr | | |
| $N_2O$ = | 0.03 | lb/hr = | 0.2218 | tonne $CO_2e$/yr | Total tonne $CO_2e$/yr* = | 146 |

The following conversions were used to convert from lb/gallon to lb/hp-hour; and then multiplying by the rated horsepower rating: 1 gallon/137,000 Btu; and 7,000 Btu/hp-hour.

* Total tonnes $CO_2e$ per year represent the contributions from both generators.

**Fire Water Pump**

| | | | | | | |
|---|---|---|---|---|---|---|
| Operating Hours | | 100 | hr/yr | | | |
| HRSG Heat Input | | 556 | Bhp | | | |
| | | | | | | |
| $CO_2$ = | 636 | lb/hr = | 29 | tonne $CO_2$/yr | | |
| $CH_4$ = | 0.02 | lb/hr = | 0.018 | tonne $CO_2e$/yr | | |
| $N_2O$ = | 0.01 | lb/hr = | 0.0881 | tonne $CO_2e$/yr | Total tonne $CO_2e$/yr = | 29 |

The following conversions were used to convert from lb/gallon to lb/hp-hour; and then multiplying by the rated horsepower rating: 1 gallon/137,000 Btu; and 7,000 Btu/hp-hour.

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*HECA Project*

GHG emissions are numerically depicted as metric tons (tonne) of carbon dioxide equivalents ($CO_2e$). $CO_2e$ represents $CO_2$ plus the additional warming potential from $CH_4$ and $N_2O$. $CH_4$ and $N_2O$ have 21 and 310 times the warming potential of $CO_2$, respectively.

**Ground Flare**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Pilot Operation** | | | | | | |
| Operating Hours | | 8,760 | hr/yr | | | |
| HRSG Heat Input | | 0.5 | MMBtu/hr | | | |
| | | | | | | |
| $CO_2$ = | 231 | tonne/yr | | | | |
| $CH_4$ = | 0.03 | tonne/yr = | 0.5 | tonne $CO_2e$/yr | | |
| $N_2O$ = | 0.0004 | tonne/yr = | 0.1 | tonne $CO_2e$/yr | Total tonne $CO_2e$/yr = | 232 |
| | | | | | | |
| **Flaring Events** | | | | | | |
| Total Operation | | 115,500 | MMBtu/yr | | | |
| | | | | | | |
| $CO_2$ = | 6,098 | tonne/yr | | | | |
| $CH_4$ = | 0.7 | tonne/yr = | 14 | tonne $CO_2e$/yr | | |
| $N_2O$ = | 0.01 | tonne/yr = | 4 | tonne $CO_2e$/yr | Total tonne $CO_2e$/yr = | 6,116 |

GHG emissions from flaring events are conservatively estimated using GHG emission factors for natural gas combustion.

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

GHG emissions are numerically depicted as metric tons (tonne) of carbon dioxide equivalents ($CO_2e$). $CO_2e$ represents $CO_2$ plus the additional warming potential from $CH_4$ and $N_2O$. $CH_4$ and $N_2O$ have 21 and 310 times the warming potential of $CO_2$, respectively.

**Elevated Flare**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Pilot Operation** | | | | | | |
| Operating Hours | | 8,760 | hr/yr | | | |
| HRSG Heat Input | | 0.3 | MMBtu/hr | | | |
| | | | | | | |
| $CO_2$ = | 139 | tonne/yr | | | | |
| $CH_4$ = | 0.02 | tonne/yr = | 0.3 | tonne $CO_2e$/yr | | |
| $N_2O$ = | 0.0003 | tonne/yr = | 0.08 | tonne $CO_2e$/yr | Total tonne $CO_2e$/yr = | 139 |
| | | | | | | |
| **Flaring Events (assist gas)** | | | | | | |
| Operating Hours | | 6 | hr/yr | | | |
| HRSG Heat Input | | 36 | MMBtu/hr | | | |
| | | | | | | |
| $CO_2$ = | 11 | tonne/yr | | | | |
| $CH_4$ = | 0.001 | tonne/yr = | 0.03 | tonne $CO_2e$/yr | | |
| $N_2O$ = | 0.00002 | tonne/yr = | 0.007 | tonne $CO_2e$/yr | Total tonne $CO_2e$/yr = | 11 |
| | | | | | | |
| **Throughput (inerts)** | | | | | | |
| $H_2S$ = | | 25 | % | | | |
| $CO_2$ (inerts) = | | 75 | % | | | |
| $H_2S$ = | | 72 | lbmol/hr | | | |
| $CO_2$ (inerts) = | | 216 | lbmol/hr | | | |
| $CO_2$ (inerts) = | | 9,488 | lb/hr | | | |
| Operating Hours | | 6 | hr/yr | | | |
| | | | | | | |
| | | | | | Total tonne $CO_2e$/yr = | 26 |

GHG emissions from flaring events are conservatively estimated using GHG emission factors for natural gas combustion.
Throughtput (inerts) amount calculated from the relationship of $CO_2$ to $H_2S$ in the elevated flare.

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

GHG emissions are numerically depicted as metric tons (tonne) of carbon dioxide equivalents ($CO_2e$). $CO_2e$ represents $CO_2$ plus the additional warming potential from $CH_4$ and $N_2O$. $CH_4$ and $N_2O$ have 21 and 310 times the warming potential of $CO_2$, respectively.

**Tail Gas Thermal Oxidizer**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Process Vent Disposal Emissions** | | | | | | |
| Operating Hours | | 8,760 | hr/yr | | | |
| HRSG Heat Input | | 10 | MMBtu/hr | | | |
| | | | | | | |
| $CO_2$ = | 4,625 | tonne/yr | | | | |
| $CH_4$ = | 0.52 | tonne/yr = | 10.9 | tonne $CO_2e$/yr | | |
| $N_2O$ = | 0.0088 | tonne/yr = | 2.7 | tonne $CO_2e$/yr | Total tonne $CO_2e$/yr = | 4,638 |
| | | | | | | |
| **SRU Startup Waste Gas Disposal** | | | | | | |
| Operating Hours | | 300 | hr/yr | | | |
| HRSG Heat Input | | 10 | MMBtu/hr | | | |
| | | | | | | |
| $CO_2$ = | 158 | tonne/yr | | | | |
| $CH_4$ = | 0.018 | tonne/yr = | 0.37 | tonne $CO_2e$/yr | | |
| $N_2O$ = | 0.00030 | tonne/yr = | 0.093 | tonne $CO_2e$/yr | Total tonne $CO_2e$/yr = | 159 |

GHG emissions from flaring events are conservatively estimated using GHG emission factors for natural gas combustion.

**Intermittent $CO_2$ Vent**

| | | | | |
|---|---|---|---|---|
| Operating Hours | 504 | hr/yr | | |
| $CO_2$ Emission Rate | 656,000 | lb/hr | | |
| | | | Total tonne $CO_2e$/yr = | 150,011 |

Assumes 21 days per year venting at full rate.

*Hydrogen Energy International LLC* *7/24/2008*
*HECA Project*

GHG emissions are numerically depicted as metric tons (tonne) of carbon dioxide equivalents ($CO_2e$). $CO_2e$ represents $CO_2$ plus the additional warming potential from $CH_4$ and $N_2O$. $CH_4$ and $N_2O$ have 21 and 310 times the warming potential of $CO_2$, respectively.

**Gasifier Warming**

| | | | | | | |
|---|---|---|---|---|---|---|
| Operating Hours | | 1,800 | hr/yr | | | |
| HRSG Heat Input | | 18 | MMBtu/hr | | | |
| | | | | | | |
| $CO_2$ = | 1,711 | tonne/yr | | | | |
| $CH_4$ = | 0 | tonne/yr = | 4 | tonne $CO_2e$/yr | | |
| $N_2O$ = | 0.00 | tonne/yr = | 1 | tonne $CO_2e$/yr | Total tonne $CO_2e$/yr = | 1,716 |

# Appendix D2

# Best Available Control Technology (BACT) Section

# APPENDIX D2

# BEST AVAILABLE CONTROL TECHNOLOGY (BACT) SECTION

# HECA POWER PROJECT
# KERN COUNTY, CALIFORNIA

*Prepared For:*

- San Joaquin Valley Air Pollution Control District

- California Energy Commission

- U.S. Environmental Protection Agency Region IX

*Prepared on behalf of*

**Hydrogen Energy International LLC**

July 14, 2008

**URS**

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## 1.0 APPLICABLE REGULATIONS

Federal requirements pertaining to control of pollutants subject to PSD review (i.e., attainment pollutants) were promulgated by U.S. EPA in 40 CFR 42.21 (j). This regulation defines Best Available Control Technology (BACT) as emission limits "based on the maximum degree of reduction for each pollutant." BACT determinations are made on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs.

Federal requirements pertaining to control of non-attainment pollutants, or Lowest Achievable Emission Rate (LAER), were promulgated by U.S. EPA under 40 CFR 51.165 (a). This regulation defines LAER as the emissions limit based on either (1) the most stringent emission rate contained in a State Implementation Plan (SIP), unless the [source] demonstrates the rate is not achievable; or (2) the most stringent emissions limitation that is achieved in practice. The federal LAER does not consider the cost impacts of control.

Best Available Control Technology (BACT) must be applied to any new or modified source resulting in an emissions increase exceeding any San Joaquin Valley Air Pollution Control District (SJVAPCD) BACT threshold. SJVAPCD Rule 2201 requires HECA to apply BACT to any source that has an increase in emissions of $NO_x$, VOC, $SO_2$, CO, and $PM_{10}$ (criteria pollutants) in excess of 2.0 pounds per highest day. BACT for the applicable pollutants was determined by reviewing the SJVAPCD BACT Guidelines Manual, the South Coast Air Quality Management District BACT Guidelines Manual, the most recent Compilation of California BACT Determinations, CAPCOA (2nd Ed., November 1993), and USEPA's BACT/LAER Clearinghouse.

BACT review is required for the proposed HECA project because the proposed project will result in a significant net emissions increase for NOx, CO, VOC, PM10, $SO_2$.

The basis for the emissions related analyses is annual average operation at a design capacity of nominally 250 megawatts (MW). The proposed HECA project as currently configured will involve the following major processes and emission units:

- One Hydrogen-rich fuel and/or Natural Gas-fired Combustion Turbine Generator (CTG) with a Heat Recovery Steam Generators (HRSG) and one Steam Turbine-Generator (STG);
- One Natural Gas -fired Simple Cycle Auxiliary CTG
- One Multi-cell, Mechanical-draft Cooling Towers for the combined cycle power block
- One Multi-cell, Mechanical-draft Cooling Tower for the Air Separation Unit
- One Multi-cell, Mechanical-draft Cooling Tower for the gasification block
- One Auxiliary Boiler
- Solid Feedstock Receiving and Handling System
- Gasification Block, including Enclosed Ground Flare
- Three Natural Gas Fired Gasifier Refractory Heaters
- Sulfur Recovery System (Tail Gas Thermal Oxidizer and Elevated Flare)

- Two Emergency, Diesel Engine-Driven Generators
- One Diesel Engine-Driven Fire Water Pump
- One $CO_2$ vent stack

Section 2 of this AFC provides a complete description of the Project indicating the layout of the major plant components within the site and general discussion of the project components.

## 2.0 BACT REVIEW PROCESS

BACT is defined in the PSD regulations as:

*"... an emission limitation based on the maximum degree of reduction for each pollutant subject to regulation under the Act which would be emitted from any proposed major stationary source ... which [is determined to be achievable], on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs" [40 CFR 52.21(b)(12)]*

In a December 1, 1987 memorandum from the EPA Assistant Administrator for Air and Radiation, the agency provided guidance on the "top-down" methodology for determining BACT. The "top-down" process involves the identification of all applicable control technologies according to control effectiveness. Evaluation begins with the "top," or most stringent, control alternative. If the most stringent option is shown to be technically or economically infeasible, or if environmental impacts are severe enough to preclude its use, then it is eliminated from consideration and then the next most stringent control technology is similarly evaluated. This process continues until the BACT level under consideration cannot be eliminated by technical or economic considerations, energy impacts, or environmental impacts. The top control alternative that is not eliminated in this process becomes the proposed BACT basis.

This top-down BACT analysis process can be considered to contain five basic steps described below (from the EPA's Draft New Source Review Workshop Manual, 1990)[1]:

Step 1. Identify all available control technologies with practical potential for application to the specific emission unit for the regulated pollutant under evaluation;

Step 2. Eliminate all technically infeasible control technologies;

Step 3. Rank remaining control technologies by control effectiveness and tabulate a control hierarchy;

Step 4. Evaluate most effective controls and document results; and

Step 5. Select BACT, which will be the most effective practical option not rejected, based on economic, environmental, and/or energy impacts.

Formal use of these steps is not always necessary. However, EPA has consistently interpreted the statutory and regulatory BACT definitions as containing two core requirements, which EPA believes must be met by any BACT determination, irrespective of whether it is conducted in a "top-down" manner. First, the BACT analysis must include consideration of the most stringent available technologies: i.e., those that provide the "maximum degree of emissions reduction."

[1] "New Source Review Workshop Manual", DRAFT October 1990, EPA Office of Air Quality Planning and Standards

Second, any decision to require a lesser degree of emissions reduction must be justified by an objective analysis of "energy, environmental, and economic impacts" contained in the record of the permit decisions.

Additionally, the minimum control efficiency to be considered in a BACT analysis must result in an emission rate no less stringent than the applicable New Source Performance Standard (NSPS) emission rate, if any NSPS standard for that pollutant is applicable to the source.

This BACT analysis was conducted in a manner consistent with this stepwise approach. Control options for potential reductions in criteria pollution emissions were identified for each source. These options were identified by researching the EPA database known as the RACT/BACT/LAER Clearinghouse (RBLC), drawing upon previous environmental permitting experience for similar units and surveying available literature. Available controls that are judged to be technically feasible are further evaluated based on an analysis of economic, environmental, and energy impacts.

Assessing the technical feasibility of emission control alternatives is discussed in EPA's draft "New Source Review Workshop Manual." Using terminology from this manual, if a control technology has been "demonstrated" successfully for the type of emission unit under review, then it would normally be considered technically feasible. For an undemonstrated technology, "availability" and "applicability" determine technical feasibility. An available technology is one that is commercially available; meaning that it has advanced through the following steps:

- Concept stage;
- Research and patenting;
- Bench scale or laboratory testing;
- Pilot scale testing;
- Licensing and commercial demonstration; and
- Commercial sales.

Suitability for consideration as a BACT measure involves not only commercial availability (as evidenced by past or expected near-term deployment on the same or similar type of emission unit), but also involves consideration of the physical and chemical characteristics of the gas stream to be controlled. A control method applicable to one emission unit may not be applicable to a similar unit, depending on differences in the gas streams' physical and chemical characteristics.

For this BACT analysis, the available control options were identified by querying the EPA RBLC and by consulting available literature on control options for IGCC. The analysis also involves review of currently permitted and operating IGCC facilities.

## 3.0 PROJECT SOURCES SUBJECT TO BACT ANALYSIS

HECA will consist of several facility blocks/systems representing sources of regulated air pollutants that are addressed in this BACT analysis. To evaluate possible emission control technologies, it is first important to understand the unique IGCC process and the supporting

ancillary plant processes. The process descriptions for the various processes that make up HECA are included in Chapter 2 of this Application. The proposed BACT controls and associated emission rates for each emission unit are summarized in Table 3-1.

**Table 3-1**
**Proposed BACT for HECA Project**

| Pollutant | Technology | Emission Limit |
|---|---|---|
| **CTG./HRSG Combustion Turbine (excluding Start up / Shutdown conditions).** | | |
| $NO_x$ | Diluent Injection, Selective Catalytic Reduction | 4 ppm $NO_x$ @ 15% $O_2$ on hydrogen-rich fuel and natural gas fuel, 3-hour average |
| CO | Good Combustion Practice (GCP), CO Catalyst | 3 ppm CO @ 15% $O_2$ on hydrogen-rich fuel, 5 ppm CO @ 15% $O_2$ on natural gas fuel |
| $PM/PM_{10}$ | GCP, Gas Cleanup, Gaseous Fuels | 24 lb/hr on hydrogen-rich fuel, 18 lb/hr on natural gas fuel |
| $SO_2$ | Hydrogen-rich Gas cleanup, pipeline quality natural gas | ≤ 5 ppmv in undiluted total sulfur (hydrogen-rich fuel) ≤ 0.75 grain / 100 SCF (13 ppm for natural gas) |
| VOC | CO Catalyst | 1 ppm VOC @ 15% $O_2$ on hydrogen-rich fuel, 2 ppm VOC @ 15% $O_2$ on natural gas fuel |
| $NH_3$ | Selective Catalytic Reduction | 5 ppm $NH_3$ slip on hydrogen-rich fuel and natural gas fuel |
| **Auxiliary CTG (excluding Start up / Shutdown conditions). Natural Gas fired.103.3 MW** | | |
| $NO_x$ | Diluent Injection | 2.5 ppm $NO_x$ @ 15% $O_2$ on natural gas fuel, 3-hour average |
| | Selective Catalytic Reduction | |
| CO | CO Catalyst | 6.0 ppm CO @ 15% $O_2$ |
| $PM/PM_{10}$ | PUC regulated natural gas | 10 lb/hr on natural gas fuel |
| $SO_2$ | | ≤ 0.75 grain / 100 SCF (13 ppm for natural gas) |
| VOC | CO Catalyst | 2 ppm VOC @ 15% $O_2$ on natural gas fuel |
| $NH_3$ | Selective Catalytic Reduction | 10 ppm $NH_3$ slip on natural gas fuel |
| **Cooling Towers** | | |
| $PM/PM_{10}$ | High Efficiency Drift Eliminators, Total Dissolved Solids (TDS) limit in circulating water, and Good Operating Practice | 0.0005% drift as percent of the circulating water |
| **Auxiliary Boiler, Natural Gas 142 MMBTU/hr** | | |
| $NO_x$ | Low $NO_x$ Combustor with FGR | 9 ppm $NO_x$ @ 3% $O_2$ on natural gas fuel |
| CO | GCP | 50 ppmvd @ 3% $O_2$ |
| $PM/PM_{10}$ | GCP, PUC grade natural gas fuel | 0.005 lb/MMBtu heat input |
| $SO_2$ | | ≤ 0.75 grain / 100 SCF (13 ppm for natural gas) |
| VOC | | 0.004 lb/MMBtu heat input |
| **Emergency Diesel Engines (2 Emergency Generators )** | | |
| $NO_x$ | Combustion controls, restricted operating hours | 0.5 g/brake horsepower (Bhp)/hr |
| CO | | 0.29 g/Bhp-hr |
| $PM/PM_{10}$ | Combustion controls, Low Sulfur Diesel fuel, restricted operating hours | 0.03 g/Bhp-hr |
| $SO_2$ | | N/A |
| VOC | | 0.11 g/bhp-hr |

**Table 3-1**
**Proposed BACT for HECA Project**

| Pollutant | Technology | Emission Limit |
|---|---|---|
| **Emergency Diesel Engines (Fire Pump)** | | |
| $NO_x$ | Combustion controls, restricted operating hours | 1.5 g/bhp-hr |
| CO | | 2.60 g/bhp-hr |
| $PM/PM_{10}$ | Combustion controls, Low Sulfur Diesel fuel, restricted operating hours | 0.015 g/bhp-hr |
| $SO_2$ | | N/A |
| VOC | | 0.14 g/bhp-hr |
| **Gasification Block Ground Flare** | | |
| $NO_x$. CO, $PM/PM_{10}$, $SO_2$, VOC | GCP, gaseous fuel only, Gas cleanup/Limit on reduced sulfur in hydrogen-rich fuel | |
| **Thermal Oxidizer (Sulfur Recovery System)** | | |
| $NO_x$ | GCP | 2.6 lb/hr 24-hour average |
| CO | | 0.70 lb/hr, 1-hour average |
| $PM/PM_{10}$ | | 0.16 lb/hr 24-hour average |
| $SO_2$ | GCP, Gas cleanup | 2.02 lb/hr, 3-hour average |
| VOC | GCP | 32.84 lb/hr, annual average |
| **Elevated Flare with natural gas assist (Sulfur Recovery System)** | | |
| $NO_x$ | GCP | |
| CO | | |
| $PM/PM_{10}$ | GCP, gaseous fuel only | |
| $SO_2$ | GCP, Caustic Scrubber | |
| VOC | GCP | |
| **$CO_2$ Vent** | | |
| CO | Gas Cleanup | 1000 ppmv |
| VOC | Gas Cleanup | 40 ppmv |
| **Gasifier Refractory heater** | | |
| $NO_x$ | GCP | 0.13 lb/MMBtu, higher heating value (HHV) |
| CO | GCP | 0.035 lb/MMBtu, HHV |
| $PM/PM_{10}$ | GCP, gaseous fuel only | 0.008 lb/MMBtu, HHV |
| $SO_2$ | GCP, PUC grade Natural gas | 0.020 lb/MMBtu, HHV (13 ppm) |
| VOC | GCP | 0.007 lb/MMBtu, HHV |
| **Feedstock** | | |
| $PM/PM_{10}$ | Dust Collector | 0.003 grain/scf outlet dust loading |

Source: HECA Project

Notes:

BACT = best available control technology
CO = carbon monoxide
CPUC = California Public Utility Commission
CTG = combustion turbine generator
FGR = flue gas recirculation
MMBTU = million British thermal units
$NO_x$ = nitrogen dioxide
$O_2$ = oxygen
$PM/PM_{10}$ = particulate matter/particulate matter less than 10 microns
ppm = parts per million
ppmvd = parts per million volumetric dry
SCF = standard cubic feet
$SO_2$ = sulfur dioxide
VOC = volatile organic compound

## 4.0 CONSIDERATION OF ALTERNATIVE GENERATING TECHNOLOGY

This section addresses recent guidance relating to the need for consideration of alternative electrical generating technologies for the proposed project, as part of the BACT analysis. Compared to Pulverized Coal (PC)-fired Boilers and Circulating Fluidized Bed (CFB) Boilers, the proposed IGCC process is the very lowest emitting solid fuel-based electricity generating technology available, and selection of a completely different solid fuel-based generating technology would not result in lower emissions. Later portions of this BACT analysis address the specific controls that are proposed to minimize the emissions from the proposed IGCC process.

The first step in a BACT determination process is to identify all available control technologies that could potentially be used to minimize the emissions of the source and pollutant under evaluation. The most common control technologies considered in a BACT analysis are add-on control measures and inherent process characteristics that minimize generation of pollutants in addition to process or work practice modifications to improve the emissions performance of a proposed project. These types of process modifications/measures, when applicable, are properly considered in a BACT analysis.

In contrast, consideration of alternatives that would involve completely "redefining the design" of the proposed process are not required to be considered (1990 Draft New Source Review Workshop Manual, Section IV.A.3). Alternative generating processes, such as natural gas-fired combined-cycle plants, represent a completely different family of power generation plant designs from IGCC. While there are certain types of components in common, such as cooling towers and steam-driven turbine generators, the technical basis for a gas-fired plant differs markedly from that of an IGCC facility.

Because CFB or PC boilers or a natural gas-fired electrical generating plant would be a completely different processes, and represent "redefining the design" compared to IGCC, it is reasonable to conclude that EPA would not require that the BACT analysis for HECA compare these different technologies. This point was recently reinforced in a December 13, 2005 letter from Stephen Page, Director of EPA's OAQPS, to E3 Consulting, LLC regarding BACT requirements for proposed coal-fired power plant projects. In that letter, EPA clarified that a BACT analysis need not consider an alternative "which would wholly replace the proposed facility with a different type of facility."

The remainder of this BACT analysis describes the various emission control options for specific IGCC facility processes, and demonstrates that as proposed HECA would achieve the lowest emissions rate technically and economically feasible for such a facility.

## 5.0 OTHER PERMITTED IGCC PROJECTS

For this BACT analysis, the available control options were identified by querying the RBLC database and by consulting available literature on control options for IGCC. Applications and/or permits from a number of other IGCC facilities that have completed the New Source Review process were also reviewed to provide additional reference material for this BACT analysis. A brief summary of the other recently permitted IGCC plants in the United States and their emissions limits is presented in this section.

Other recently permitted IGCC facilities will be used as comparison reference for this BACT analysis are the following:

- Duke Energy, Edwardsport Generating Station
- ERORA Group, Taylorville Energy Center
- ERORA Group, Cash Creek Generating Station

The air permits, BACT analyses and additional literature for each of these recently permitted IGCC facilities were reviewed. Each facility is discussed briefly below. The facilities that were subject to BACT determinations are listed as such.

***Duke Energy, Edwardsport Generating Station:*** Duke Energy Indiana, owner of Edwardsport Generating Station, obtained approval, via Indiana Department of Environmental Management Significant Modification Title V Permit, to install an IGCC facility in Knox County, Indiana. The Title V Significant Modification Permit was issued in January 2008. The 630 MW (net) IGCC plant will replace four older, less efficient generating units capable of generating approximately 160 megawatts at the Edwardsport site. The Edwardsport Generating Station is expected to use coal as feedstock and SCR as add-on control to minimize $NO_x$ emissions from the plant.

***ERORA Group - Taylorville Energy Center:*** The ERORA Group is developing the Taylorville Energy Center, a 630 MW (net) IGCC facility to be located in Christian County, southern Illinois. Taylorville Energy Center obtained a final Illinois Environmental Protection Agency air permit in June 2007. Taylorville Energy Center proposed to use GE Energy gasification technology and local coals (Illinois coal) as the feedstock. Taylorville Energy Center will use Selexol AGR systems, as well as SCR. The Taylorville Energy Center site is in an ozone attainment area, so SCR is not required for BACT purposes. ERORA is using SCR to minimize $NO_x$ emissions from the plant, but not as BACT. This will allow them to minimize the cost to acquire $NO_x$ allowances from the market. ERORA notes that in order to increase the chance that the SCR system will work in this unproven application on coal-derived syngas, higher sulfur removal, by using Selexol instead of MDEA, will be required.

***ERORA Group – Cash Creek Generating Station:*** The ERORA Group is developing the Cash Creek Generation Station IGCC facility, to be located near Owensboro, Henderson County, Kentucky. Cash Creek Generation Station obtained a final Kentucky DAQ air permit in January 2008. The 630 MW IGCC proposes to use GE Energy gasification technology and local coals (Kentucky coal) as the feedstock. Cash Creek Generation Station will use Selexol AGR systems, as well as SCR. Because the proposed facility site is in an ozone attainment area, SCR is not required for BACT purposes. ERORA is using SCR to minimize $NO_x$ emissions from the plant, but not as BACT. This will allow them to minimize the cost to acquire $NO_x$ allowances from the market. ERORA notes that in order to increase the chance that the SCR system will work in this unproven application on coal-derived syngas, higher sulfur removal, by using Selexol instead of MDEA, will be required.

## 6.0 SOURCE SPECIFIC BACT ANALYSIS

The following BACT analysis evaluates control technologies applicable to each of the criteria pollutants that would be emitted from the proposed HECA Project to determine appropriate BACT emission limits. This BACT analysis is based on the current state of IGCC technology, energy and environmental factors, current expected economics, energy, and technical feasibility

## 6.1 CTG/HRSG BACT Analysis

The following is the BACT analysis for the proposed combustion turbine. The proposed combustion turbine will be a GE 7FB model turbine with a nominal capacity of 232 MW. The GE 7FB is a new turbine model designed to optimally utilize hydrogen-rich fuel and natural gas and includes changes to the fuel system, combustion system, and hot gas path. The use of hydrogen-rich fuel requires the use of a diffusion-type combustor, because the high concentration of hydrogen precludes the use of dry low $NO_x$ (DLN) combustor technology.

The air permits, BACT analyses and additional literature for each of the recently permitted IGCC facilities discussed in the last section were reviewed. Table 6-1 summarizes the criteria pollutant emission levels permitted for the combustion turbines units at each facility.

**Table 6-1**
**Permitted Criteria Pollutant BACT Limits for Combined Cycle Combustion Turbine**

| Facility | HECA | Cash Creek Generation Station | Edwardsport Generating Station | Taylorville Energy Center |
|---|---|---|---|---|
| Location | Kern County, CA | Henderson County, KY | Knox County, IN | Christian County, IL |
| MW | 250 | 630 | 630 | 630 (net) |
| Turbine | GE 7FB | GE 7FB | GE 7FB | GE 7FB |
| $NO_x$ | 4 ppmc on hydrogen-rich fuel (0.019 lb/MMBtu), 4.0 ppmc on Natural Gas (0.016 lb/MMBtu) | 0.0331 lb/MMBtu (approx 5 ppmc) Syngas 0.0246 lb/MMBtu on Nat Gas | 0.027 lb/MMBtu Syngas 0.018 lb/MMBtu on Nat Gas | 0.034 lb/MMBtu (5.0 ppmc) Syngas 0.025 lb/MMBtu on Nat Gas |
| $SO_2$ | ≤ 5 ppmv in undiluted hydrogen-rich fuel ((0.003 lb/MMBtu) 0.75 grains/100 scf of total sulfur on Nat Gas (0.002 lb/MMBtu) | 0.0158 lb/MMBtu (3.8. ppmc) Syngas 0.0006 lb/MMBtu on Nat Gas | 0.0138 lb/MMBtu Syngas 0.0006 lb/MMBtu on Nat Gas | 0.016 lb/MMBtu Syngas (10 ppm Sulfur in Syngas) 0.001 lb/MMBtu on Nat Gas. |
| CO | 3 ppmc on Hydrogen-rich fuel (0.008 lb/MMBtu), 5 ppmc on Nat Gas (0.012 lb/MMBtu) | 0.0485 lb/MMBtu Syngas 0.0449 lb/MMBtu on Nat Gas | 0.0441 lb/MMBtu Syngas 0.0421 lb/MMBtu on Natural Gas | 0.049 lb/MMBtu (25.0 ppmvd) Syngas 0.045 lb/MMBtu (25.0 ppmvd) on Nat Gas |
| $PM_{10}$ (Scaled to HECA MW size) | 24 lb/hr on hydrogen-rich fuel and 18 lb/hr on Nat Gas | 47 lb/hr on syngas and 35 lb/hr on Nat Gas | 39.1 lb/hr on syngas and 18.1 lb/hr on Nat Gas | 48 lb/hr on syngas and 24 lb/hr on Nat Gas |

**Table 6-1**
**Permitted Criteria Pollutant BACT Limits for Combined Cycle Combustion Turbine**

| Facility | HECA | Cash Creek Generation Station | Edwardsport Generating Station | Taylorville Energy Center |
|---|---|---|---|---|
| VOC | 1 ppmc on Hydrogen-rich fuel (0.0016 lb/MMBtu), 2 ppmc on Nat Gas (0.0028 lb/MMBtu) | | 0.0016 lb/MMBtu Syngas or on Nat Gas | |

Notes:
"ppmc" means parts per million by volume, dry basis, corrected to 15% O2.
Only HECA would use duct firing. All emissions specified for HECA apply to non-duct firing and duct firing operation.
HECA $SO_2$ on Natural Gas is worst case short-term average based on limit of 0.75 gr.100 scf.
Taylorville CO vaules inconsistent in ratio of lb/MMBtu per ppmc for $NO_x$. Scaling ratio from $NO_x$ would result in CO value of 0.049 lb/MMBtu (11.8 ppmc.) on Hydrogen-rich fuel(lower CO ppmc would be more conservative).

CO = carbon monoxide
MMBtu = million British thermal units
MW = megawatt
$NO_x$ = oxides of nitrogen
$PM_{10}$ = particulate matter 10 microns in diameter
ppm = parts per million
ppmc = parts per million by volume, dry basis, corrected to 15% O2
$SO_2$ = sulfur dioxide
VOC = volatile organic compound

### 6.1.1 Nitrogen Oxides BACT Analysis for the CTG/HRSG

The criteria pollutant nitrogen oxides ($NO_x$) is primarily formed in combustion processes via the reaction of elemental nitrogen and oxygen in the combustion air (thermal $NO_x$), and the oxidation of nitrogen contained in the fuel (fuel $NO_x$). The hydrogen-rich fuel produced in the proposed project contains negligible amounts of fuel-bound nitrogen. Therefore, it is expected that essentially all $NO_x$ emissions from the CTG/HRSG will originate as thermal $NO_x$.

The rate of formation of thermal $NO_x$ in a combustion turbine is a function of residence time, oxygen radicals, and peak flame temperature. Front-end $NO_x$ control techniques are aimed at controlling one or more of these variables during combustion. Examples include dry low- $NO_x$ combustors, flue gas recirculation, and diluent injection (steam, water, or nitrogen). These technologies are considered to be commercially available pollution prevention techniques. It is necessary to recognize the fundamental differences between natural-gas fired and hydrogen-rich fuel-fired combustion turbines in evaluating these techniques. Compared to natural gas, hydrogen-rich syngas has a much higher hydrogen content (natural gas is often over 90% methane), and a much lower heating value (about 250 Btu/scf for hydrogen-rich fuel vs. 1,000 Btu/scf for natural gas).

**1. Identify Control Technologies**

The following $NO_x$ control technologies were evaluated for the proposed CTG/HRSG:

Combustion Process Controls

- Dry Low $NO_x$ Burner
- Diluent Injection

Post Combustion Controls

- $SCONO_x$ ™
- Selective Non-Catalytic Reduction (SNCR)
- Selective Catalytic Reduction (SCR)

**2. Evaluate Technical Feasibilities**

- Dry Low $NO_x$ Combustor

  Dry Low- $NO_x$ (DLN) combustor technology has successfully been demonstrated to reduce thermal $NO_x$ formation from natural gas combustion turbines. This is done by designing the combustors to control both the stoichiometry and temperature of combustion by tuning the fuel and air locally within each individual combustor's flame envelope. Combustor design includes features that regulate the aerodynamic distribution and mixing of the fuel and air. A lean, premixed combustor design mixes the fuel and air prior to combustion. This results in a homogeneous air/fuel mixture, which minimizes localized fuel-rich pockets that produce elevated combustion temperatures and higher $NO_x$ emissions. A lean fuel-to-air ratio approaching the lean flammability limit is maintained, and the excess air serves as a heat sink to lower the combustion temperature, which in turn lowers thermal $NO_x$ formation. A pilot flame is used to maintain combustion stability in this fuel-lean environment.

  Hydrogen-rich fuel is different than syngas and has a similar heating value, but with much less CO and $CO_2$. Hydrogen-rich fuel differs from natural gas in heating value, gas composition, and flammability characteristics. Available DLN combustor technologies are designed for natural gas (methane-based) fuels and will not operate on the syngas (hydrogen/CO-based) fuels utilized by an IGCC combustion turbine. DLN combustors are not technically feasible for this application due to the potential for explosion hazard in the combustion section due primarily to the high hydrogen content of the syngas. No manufacturer currently makes DLN combustors that can be used for a combustion turbine burning petroleum coke or coal-derived syngas. Research is ongoing to develop DLN for syngas-fueled combustion turbines. However, such combustors are not yet commercially available. Thus, DLN combustor is not a technically feasible control option for this unit.

- Diluent Injection

  Higher peak flame temperature during combustion may increase thermodynamic efficiency, but it also increases the formation of thermal $NO_x$. The injection of an inert diluent such as atomized water, steam, or nitrogen into the high temperature region of a combustor flame serves to inhibit thermal $NO_x$ formation by reducing the peak flame temperature.

For HECA Project's CTG/HRSG, nitrogen is used as a diluent which reduces thermal nitrogen oxide ($NO_x$) produced when hydrogen-rich gas is combusted. Steam is used as a diluent when Natural Gas is combusted. This method effectively lowers the fuel heat content and, consequently, the combustion temperature, and therefore reduces $NO_x$ emissions.

GE guarantees that diluent injection can achieve turbine exhaust emission levels of 15 ppmvd $NO_x$ (at 15 % oxygen) over a 3-hour average (excluding start up, shutdown and upset periods) when firing 100% hydrogen-rich fuel. For natural gas combustion and co-firing, GE guarantees emission levels of 25 ppmvd $NO_x$ (at 15 % oxygen) from the turbine exhaust. The higher emission is caused by the difference in combustion characteristic of natural gas compared to the hydrogen-rich syngas.

A secondary benefit of diluent injection is that it will increase the mass flow of the exhaust. Therefore, the power output per unit of fuel input also increases.

Diluent injection represents an inherently lower-emitting process for IGCC units, and is a technically feasible control technology. Diluent injection (steam for natural gas and nitrogen for hydrogen-rich fuel) is proposed as the baseline case for the CGT/HRSG combustion turbine $NO_x$ BACT analysis. This $NO_x$ control technology and emission level have also been determined as BACT for all other recent IGCC permits, and has been demonstrated to achieve $NO_x$ emission rates of 15 ppmvd (at 15% O2) when firing 100% syngas fuel. This $NO_x$ diluent injection control technology has been commercially demonstrated on syngas on the GE 7FA, but not on hydrogen-rich fuel on the GE 7FB.

- $SCONO_x$ ™

The $SCONO_x$ ™ system is an add-on control device that reduces emissions of multiple pollutants. $SCONO_x$™ utilizes a single catalyst for the reduction of CO,VOC and $NO_x$, which are converted to $CO_2$, $H_2O$ and $N_2$.

All installations of the technology have been on small natural gas facilities, and have experienced performance issues. The fact that $SCONO_x$™ has not been applied to large-scale natural gas combustion turbines creates concerns regarding the timing, feasibility, and cost-effectiveness of necessary design improvements. $SCONO_x$™ has also not been applied to syngas (or hydrogen-rich fuel) or exhaust streams containing sulfur in concentrations similar to the proposed project, which creates additional concerns regarding potential catalyst fouling.

In evaluating technical feasibility for large IGCC projects, the additional concerns are:

- $SCONO_x$™ uses a series of dampers to re-route air streams to regenerate the catalyst. The proposed HECA project is significantly larger than the much smaller facilities where $SCONO_x$™ has been used. This would require a significant redesign of the damper system, which raises feasibility concerns regarding reliable mechanical operation of the larger and more numerous dampers that would be required for application to the HECA CTG/HRSG.
- The catalyst is very susceptible to poisoning by sulfur compounds. Because of the sulfur content of the hydrogen-rich fuel, a separate catalyst to absorb $SO_2$ would be required. The vendor offers a SCOSOx™ catalyst; however, its performance is not proven, and

upon regeneration this process would create an $H_2S$ stream that would require further treatment.

- ° SCONO$_x$™ would not be expected to achieve lower guaranteed $NO_x$ levels than SCR, and, for reasons described above, it has even greater feasibility concerns with respect to application on IGCC turbines than those for SCR

For the above reasons, SCONO$_x$™ is considered technically infeasible for this unit.

- Selective Non-Catalytic Reduction (SNCR)

Selective Non-Catalytic Reduction (SNCR) is a post-combustion $NO_x$ control technology in which a reagent ($NH_3$ or urea) is injected into the exhaust gases to react chemically with $NO_x$ to form elemental nitrogen and water without the use of a catalyst. The success of this process in reducing $NO_x$ emissions is highly dependent on the ability to achieve uniform mixing of the reagent into the flue gas, which must occur within a narrow flue gas temperature zone (typically from 1,700°F to 2,000°F).

The consequences of operating outside the optimum temperature range are severe. Above the upper end of the temperature range, the reagent will be converted to $NO_x$. Below the lower end of the temperature range, the reagent will not react with the $NO_x$ resulting in very high $NH_3$ slip concentrations ($NH_3$ discharge from the stack).

This technology is occasionally used in conventional fired heaters or boilers upstream of any HRSG or heat recovery unit. SNCR has never been applied in IGCC service, primarily because there are no flue gas locations within the combustion turbine or upstream of the HRSG with the optimal requisite temperature and residence time characteristics to facilitate the SNCR flue gas reactions. Therefore, SNCR is not technically feasible for this unit.

- Selective Catalytic Reduction (SCR)

SCR is a technology that achieves post-combustion reduction of $NO_x$ from flue gas within a catalytic reactor. The SCR process involves the injection of ammonia ($NH_3$) into the exhaust gas stream upstream of a specialized catalyst module to promote the conversion of $NO_x$ to molecular nitrogen. SCR is a common control technology for use on natural gas fired combustion turbines.

In the SCR process, $NH_3$, usually diluted with air or steam, is injected through a grid system into the exhaust gas upstream of the catalyst bed. On the catalyst surface, the $NH_3$ reacts with $NO_x$ to form molecular nitrogen and water. The basic reactions are:

$$4NH_3 + 4NO + O_2 \rightarrow 4N_2 + 6H_2O$$

$$8NH_3 + 6NO_2 \rightarrow 7N_2 + 12H_2O$$

HECA project selected SCR and diluent injection technology to control $NO_x$ emissions from the CTG/HRSG unit. The SCR system reduces nitrogen oxide emissions from the HRSG stack gases by up to about 80 percent. Diluted 19 percent aqueous ammonia is injected into the stack gases upstream of a catalytic system which converts nitrogen oxide and ammonia to nitrogen and water.

It is anticipated that this combination of control processes will achieve a $NO_x$ emission limit of 4 ppmvd @ 15 % oxygen, based on a 3-hr rolling average, when firing hydrogen-rich fuel, natural gas, or combination of hydrogen-rich fuel/natural gas. This emission limitation represents a removal efficiency that is better than the approved emissions for recently permitted IGCC units. HRSG vendors confirm the feasibility of achieving the $NO_x$ levels cited in this AFC.

### 3. Rank Control Technologies

Among the control technologies considered in the previous subsection, only one was determined to be both technically feasible and commercially demonstrated at a cost level acceptable as a BACT option. Specifically, the feasible option is diluent injection upstream of the combustion zone to achieve a controlled level of 15 ppmvd $NO_x$ at 15% O2 while firing hydrogen-rich fuel, and 25 ppmvd $NO_x$ at 15% O2 while firing natural gas or combination of hydrogen-rich fuel/natural gas.

Although there is no commercial demonstration of SCR performance for an IGCC plant using a solid feedstock, SCR technology has been proposed as emission limits for recently permitted IGCC projects. HRSG vendors confirm that SCR catalyst will be able to achieve combined $NO_x$ reduction down to 4 ppmvd @ 15 % oxygen, based on a 3-hr rolling average, on all firing scenarios.

### 4. Evaluate Control Options

The next step in a BACT analysis is to evaluate the feasible control technology. Based on the evaluation in the previous step, the only technically feasible technologies suitable for establishment of BACT limits are diluent injection and SCR. The principal environmental consideration with respect to implementation of SCR is that, while it will reduce $NO_x$ emissions, it will add $NH_3$ emissions associated with use of ammonia ($NH_3$) as the reagent chemical. A portion of the unreacted $NH_3$ passes through the catalyst and is emitted from the stack. This is called ammonia slip and the magnitude of these emissions depends on the catalyst activity and the degree of $NO_x$ control desired. For this project, the concentration of ammonia slip is limited to 5 ppmvd @ 15 % oxygen.

Table 6-2 shows the typical $NO_x$ BACT determination (when firing hydrogen-rich fuel and natural gas respectively) and control technology for other recently permitted IGCC projects, in comparison with HECA's proposed $NO_x$ BACT for the CTG/HRSG.

**Table 6-2**
**$NO_x$ BACT Emission Limit Comparison**

| | | | | | Emission Limit on Hydrogen-rich fuel | | Emission Limit on Nat Gas | |
|---|---|---|---|---|---|---|---|---|
| **Facility** | **State** | **MW** | **Turbine** | **$NO_x$ BACT Technology** | **ppm** | **lb/MMBTU Hydrogen-rich fuel** | **ppm** | **lb/MMBTU NG** |
| HECA | CA | 250 | GE Model Number 7FB. | SCR | 4[a] | 0.019 | 4[a] | 0.016 |

**Table 6-2**
**$NO_x$ BACT Emission Limit Comparison**

| | | | | | Emission Limit on Hydrogen-rich fuel | | Emission Limit on Nat Gas | |
|---|---|---|---|---|---|---|---|---|
| **Facility** | **State** | **MW** | **Turbine** | **$NO_x$ BACT Technology** | **ppm** | **lb/MMBTU Hydrogen-rich fuel** | **ppm** | **lb/MMBTU NG** |
| Cash Creek Generation Station | KY | 630 | GE Model Number 7FB. | SCR | 5[a] | 0.0331 | | 0.0246 |
| Edwardsport Generating Station | IN | 630 | GE Model Number 7FB. | SCR operated in trial mode | | 0.027[b] | | 0.018[b] |
| Taylorville Energy Center | IL | 630 (net) | GE Model Number 7FB. | SCR | 5[a] | 0.034 | | 0.025 |

Notes:
[a] Parts per million by volume, dry basis, corrected to 15% O2
[b] Calculated. from mass emissions rate of 57 lb/hr on Hydrogen-rich fuel and 38 lb/hr on Natural Gas

MMBtu = million British thermal units
MW = megawatt
ppm = parts per million
SCR = selective catalytic reduction

As shown in Table 6-2, the BACT limitation for $NO_x$ emissions from HECA CTG/HRSG is more stringent than the historic BACT determination for other recently permitted IGCC projects.

NSPS 40 CFR 60 Subpart Da is considered as the BACT "floor" for this source category. As shown above, the BACT emission limit proposed for HECA is significantly lower than the applicable NSPS Subpart Da limit of 0.5 lb/MMBTU heat input for gaseous fuel. The proposed $NO_x$ reduction technology also more stringent than the NSPS Subparts Da recommended minimum reduction efficiency of 25%.

**5. Select Control Technology**

The final step in the top-down BACT analysis process is to select BACT based on the results of the previous steps. As has been explained, for this application of hydrogen-rich fuel-fired combustion turbines within an IGCC facility, diluent injection in the combustion turbine and SCR installation as post combustion $NO_x$ control are the appropriate control technique for setting BACT-based emission limits. The BACT selection described above is strongly supported by recent precedents for similar IGCC projects.

The proposed BACT limits based on this technology are 4 ppmvd $NO_x$ at 15% O2 for hydrogen-rich fuel firing, natural gas firing, and co-firing.

### 6.1.2 Carbon Monoxide BACT Analysis for the CTG/HRSG

CO is a product of incomplete combustion. Control of CO is typically accomplished by providing adequate fuel residence time and high temperature in the combustion zone to ensure complete combustion. However, these same control factors can increase $NO_x$ emissions.

Conversely, lower $NO_x$ emission rates achieved through flame temperature control (by diluent injection) can increase CO emissions for natural gas and un-shifted syngas. Thus, a compromise must be established whereby the flame temperature reduction is set to achieve the lowest $NO_x$ emission rate possible while keeping CO emissions to an acceptable level. However, CO emissions are inherently low for hydrogen-rich fuels that contain very little reduced carbon and are less affected by the conventional trade-off between CO and $NO_x$.

### 1. Identify Control Technologies

The following CO control technologies were evaluated for the proposed CTG/HRSG:

Combustion Process Controls

- Good Combustion Practices (GCPs)

Post Combustion Controls

- $SCONO_x$™
- Oxidation Catalyst

### 2. Evaluate Technical Feasibilities

Good Combustion Practices (GCPs)

Good combustion practices include the use of operational and design elements that optimize the amount and distribution of excess air in the combustion zone to ensure optimum complete combustion. GE guarantees the turbine exhaust can achieve CO emission levels of 5 ppmvd CO when firing hydrogen-rich fuel and 25 ppmvd CO when operating on natural gas.

This technology has been determined to be BACT for CO emissions in other operational or recently permitted IGCC projects.

- $SCONO_x$™

  The $SCONO_x$ system was evaluated in the $NO_x$ BACT analysis, and determined to be not technically feasible for this unit.

- Oxidation Catalysts

  Catalytic oxidation is a post-combustion control technology that utilizes a catalyst to oxidize CO into $CO_2$. Because of the catalyst fouling concerns, the use of oxidation catalysts has been previously limited to processes combusting natural gas. Oxidation catalysts have never been applied to coal-based IGCC processes. Other operational or recently permitted IGCC projects determined GCPs as the only feasible BACT for CO emissions. The project anticipated CO conversions up to 90% are attainable across the CO catalyst. HECA proposed CO emission limits of 3.0 ppmvd @15% O2 while firing hydrogen-rich fuel, and 5.0 ppmvd CO at 15% O2 while firing natural gas.

### 3. Rank Control Technologies

Oxidation catalyst is the only technically feasible CO control technology identified in addition to Good Combustion Practices.

### 4. Evaluate Control Options

GCP is considered the baseline and only feasible and commercially demonstrated CO control technology for IGCC combustion turbines. GCP has been selected as BACT for all other recent IGCC permits Oxidation catalysts have not been applied to the other coal-based IGCC processes. In comparison to other operational or recently permitted IGCC projects, this emission limitation represents a removal efficiency that is lower than the emission achieved in practice at currently operating IGCC units and the lowest proposed emission limits for proposed coal-fired units, including other proposed IGCC units.

Table 6-3 shows the typical CO BACT determination (when firing hydrogen-rich fuel and natural gas respectively) and control technology for other recently permitted IGCC projects, in comparison with HECA's proposed CO BACT for the CTG/HRSG.

**Table 6-3**
**CO BACT Emission Limit Comparison**

| | | | | | Emission Limit on Hydrogen-rich fuel | | Emission Limit on Nat Gas | |
|---|---|---|---|---|---|---|---|---|
| Facility | State | MW | Turbine | CO BACT Technology | ppm | lb/MMBTU Hydrogen-rich fuel | ppm | lb/MMBTU NG |
| HECA | CA | 250 | GE Model Number 7FB. | CO catalyst and GCP | 3[a] | 0.008 | 5[a] | 0.012 |
| Cash Creek Generation Station | KY | 630 | GE Model Number 7FB. | GCP | | 0.0485 | | 0.0449 |
| Edwardsport Generating Station | IN | 630 | GE Model Number 7FB. | GCP | | 0.0441b | | 0.0421b |
| Taylorville Energy Center | IL | 630 (net) | GE Model Number 7FB. | GCP | 25 | 0.049 | 25 | 0.045 |

Notes:
[a] Parts per million by volume, dry basis, corrected to 15% O2
[b] Calculated. from mass emissions rate of 93 lb/hr on Hydrogen-rich fuel and 88.7 lb/hr on Natural Gas
MMBtu = million British thermal units
MW = megawatt
ppm = parts per million

As shown in Table 6-3, the BACT limitation for CO emissions from HECA CTG/HRSG is more stringent than the historic BACT determination for other recently permitted IGCC units. This emission limitation represents a removal efficiency that is better than the emission achieved in

practice at currently operating IGCC units and the lowest proposed emission limits compared to recently permitted IGCC units

**5. Select Control Technology**

The final step in the top-down BACT analysis process is to select BACT based on the results of the previous steps. As explained, GCPs and oxidation catalyst are the appropriate control technique for setting BACT-based emission limits.

HECA proposed the CO BACT-based limit of 3.0 ppmvd @15% O2 while firing hydrogen-rich fuel and 5.0 ppmvd CO at 15% O2 while firing natural gas during non-startup operation, using Good Combustion Practices (GCPs) and an oxidation catalyst.

### 6.1.3 Particulate Matter Emissions BACT Analysis for the CTG/HRSG

Particulate matter emissions from natural gas-fired combustion sources consist of inert contaminants in natural gas, sulfates from fuel sulfur, ammonia compounds for the SCR reagent, dust drawn in from the ambient air that passes through the combustion turbine inlet air filters and particles of carbon and hydrocarbons resulting from incomplete combustion. Low ash content and high combustion efficiency exhibit correspondingly low particulate matter emissions for other fuel such as hydrogen-rich fuel.

**1. Identify Control Technologies**

The following particulate matter control technologies were evaluated for the proposed CTG/HRSG:

<u>Pre Combustion Controls</u>

- Gas Cleanup (for hydrogen-rich fuel)

<u>Combustion Process Controls</u>

- Good Combustion Practices (GCPs)

<u>Post Combustion Controls</u>

- Baghouse
- Electrostatic Precipitation

**2. Evaluate Technical Feasibilities**

In a typical solid fuel combustion process, fuel particulate matter is removed by post combustion processes such as fabric filters or electrostatic precipitators. However, in an IGCC plant, particulate matter could damage the turbine so particulate matter is removed prior to combustion. Post combustion controls, such as electrostatic precipitators (ESPs) or baghouses, have never been applied to commercial combustion turbines burning gaseous fuels. Therefore, the use of ESPs and baghouses is considered technically infeasible, and does not represent feasible control technology.

In the absence of add-on controls, the most effective control method demonstrated for gas-fired combustion turbines is the use of low ash fuel, such as natural gas or hydrogen-rich fuel and GCPs. Therefore, it is necessary to use pre-combustion controls such as particulate removal as an integral part of the gasification process in addition to GCPs.

The use of clean hydrogen-rich fuel and good combustion control is proposed as BACT for PM/ $PM_{10}$ control in the proposed HECA CTG/HRSG. These operational controls will limit filterable plus condensable PM/ $PM_{10}$ emissions to 24 lb/hr when operating on hydrogen-rich fuel and 18 lb/hr when operating on natural gas.

### 3. Rank Control Technologies

The use of clean fuels with low potential particulate emissions from optimum gas cleanup processes and good combustion practices were identified as the only technically feasible particulate emissions control technologies applicable to the proposed combustion turbines.

### 4. Evaluate Control Options

The EPA has indicated that particulate matter control devices are not typically installed on combustion turbines and that the cost of installing a particulate matter control device is prohibitive (EPA, September 1977pmec). When the NSPS for Stationary Gas Turbines (40 CFR 60 Subpart GG) was promulgated in 1979, the EPA acknowledged, "Particulate emissions from stationary gas turbines are minimal." Similarly, the recently revised Subpart GG NSPS (2004) did not impose a particulate emission standard. Therefore, performance standards for particulate matter control of stationary gas turbines have not been proposed or promulgated at a federal level.

Table 6-4 shows the typical PM BACT determination (when firing hydrogen-rich fuel and natural gas respectively) and control technology for other recently permitted IGCC projects, in comparison with HECA's proposed PM BACT for the CTG/HRSG.

**Table 6-4**
**PM BACT Emission Limit Comparison**

| Facility | State | MW | Turbine | $PM_{10}$ BACT Technology | Emission Limit on Hydrogen-rich fuel lb/hr | Emission Limit on Natural Gas lb/hr |
|---|---|---|---|---|---|---|
| HECA | CA | 250 | GE Model Number 7FB. | Gas Cleanup and GCP | 24 | 18 |
| Cash Creek Generation Station | KY | 630 | GE Model Number 7FB. | Gas Cleanup and GCP | 47 | 35 |
| Edwardsport Generating Station | IN | 630 | GE Model Number 7FB. | Gas Cleanup and GCP | 39.1 | 18.1 |
| Taylorville Energy Center | IL | 630 (net) | GE Model Number 7FB. | Gas Cleanup and GCP | 48 | 24 |

Notes:

MW = megawatt
$PM_{10}$ = particulate matter 10 microns in diameter

Based on the evaluation in the previous step, GCPs and optimum gas cleanup are considered as technically feasible PM/ $PM_{10}$ control technology technologies that are suitable for establishment of BACT limits. As shown in Table 6-4, HECA emission limitation represents a removal efficiency that is cleaner in comparison to other operational or recently permitted IGCC units. Therefore, the BACT limitation for PM emissions from HECA CTG/HRSG is more stringent than the historic BACT determination for other recently permitted IGCC units.

NSPS 40 CFR 60 Subpart Da is considered as the BACT "floor" for this source category. The proposed BACT emission limits proposed in Table 6-4 are equivalent to 0.011 lb/MMBTU on hydrogen-rich fuel and 0.008 lb/MMBTU on natural gas. These emission limits are significantly lower than the applicable NSPS Subpart Da limit of 0.03 lb/MMBtu heat input derived from the combustion of solid, liquid, or gaseous fuel.

**5. Select Control Technology**

The final step in the top-down BACT analysis process is to select BACT based on the results of the previous steps. As explained, GCPs and optimum gas cleanup are the appropriate control technique for setting BACT-based emission limits. The use of optimum gas cleanup to produce clean fuels with low potential particulate emissions and good combustion practices were selected as LAER for particulate emissions from the proposed combustion turbines. The following emission limit resulting from the implementation of these technologies is proposed for each combustion turbine.

HECA proposed the PM BACT-based limit of 24 lb/hr while firing hydrogen-rich fuel and 18 lb/hr while firing natural gas during non-startup operation, using Good Combustion Practices (GCPs) and optimum gas cleanup.

### 6.1.4 Sulfur Dioxide and Sulfuric Acid Mist BACT Analysis for the CTG/HRSG

Sulfur dioxide emissions from any combustion process are largely defined by the sulfur content of the fuel being combusted and the rate of the fuel usage. The combustion of hydrogen-rich fuel in the combustion turbines creates primarily $SO_2$ and small amounts of sulfite ($SO_3$) by the oxidation of the fuel sulfur. The $SO_3$ can react with the moisture in the exhaust to form sulfuric acid mist, or $H_2SO_4$. Emissions of these sulfur species can be controlled, either by limiting the sulfur content of the fuel (pre-combustion control) or by scrubbing the $SO_2$ from the exhaust gas (post combustion control).

**1. Identify Control Technologies**

The following sulfur dioxide and sulfuric acid mist control technologies were evaluated for the proposed CTG/HRSG when operating on hydrogen-rich fuel:

<u>Pre Combustion Controls</u>

- Chemical Absorption Acid Gas Removal (AGR), e.g., MDEA

- Physical Absorption Acid Gas Removal (AGR), e.g., Selexol®, Rectisol

Post Combustion Controls

- Flue Gas Desulfurization (FGD)

The Sulfur dioxide BACT for the proposed CTG/HRSG when operating on natural gas is PUC grade natural gas fuel with less than 0.75 grains/100scf sulfur content.

**2. Evaluate Technical Feasibilities**

- Acid Gas Removal (AGR)

  In the gasification process sulfur in the petcoke or coal feedstock converts primarily to hydrogen sulfide ($H_2S$). Solvent-based acid gas cleanup is commonly used for "gas sweetening" processes in petroleum refinery fuel gas or tail gas treating units, where $H_2S$ in the process gas is removed before use as a fuel. The removed $H_2S$ is recovered either as elemental sulfur in a Sulfur Recovery Unit (e.g., using a Claus process).

  In a chemical absorption process, acid gases in the sour syngas are removed by chemical reactions with a solvent that is subsequently separated from the gas and regenerated. The chemical absorption occurs in amine-based systems that use solvents such as methyldiethanol-amine (MDEA). Amine solvents chemically bond with the $H_2S$. The $H_2S$ can be easily liberated with low-level heat in a stripper to regenerate the solvent.

  Lower levels of sulfur removal are possible using physical absorption AGR systems. Physical absorption methods, including Selexol™ and Rectisol™, use solvents that dissolve acid gases under pressure. Selexol or Rectisol are normally applied when low syngas sulfur levels are required for SCR. Solubility of an acid gas is proportional to its partial pressure and is independent of the concentrations of other dissolved gases in the solvent. Consequently, increased operating pressure in an absorption column facilitates separation and removal of an acid gas like $H_2S$. The dissolved acid gas can then be removed from the solvent, which is regenerated, by depressurization in a stripper.

  To selectively remove $H_2S$ and $CO_2$, two absorption and regeneration columns or two-stage process are required. In general, $H_2S$ is selectively removed in the first column by a lean solvent that has been deeply stripped with steam, while $CO_2$is removed, from the now $H_2S$-free gas, in the second absorber. The second-stage solvent can be regenerated if very deep $CO_2$ removal is required. If only bulk $CO_2$ removal is required, then the flashed gas, containing the bulk of the $CO_2$, can be vented and the second regenerator duty can be substantially lowered or be totally eliminated.

  A detailed technology assessment was completed by the Applicant and discussed in Section 6, Alternatives.

- Flue Gas Desulfurization (FGD)

  Flue gas desulfurization (FGD) is a post-combustion $SO_2$ control technology that reacts an alkaline with $SO_2$ in the exhaust gas. Typical FGD processes operate by contacting the exhaust gas downstream of the combustion zone with an alkaline slurry or solution that absorbs and subsequently reacts with the acidic $SO_2$. FGD technologies may be wet, semi-

dry, or dry based on the state of the reagent as it is injected or pumped into the absorber vessel. Also, the reagent may be regenerable (where it is treated and reused) or non-regenerable (all waste streams are de-watered and either discarded or sold). Wet, calcium-based processes, which use lime (CaO) or limestone ($CaCO_3$) as the alkaline reagent, are the most common FGD systems in PC unit applications. After the exhaust gas has been scrubbed, it is passed through a mist eliminator and exhausted to the atmosphere through a stack

FGD systems are commonly employed in conventional PC plants, where the concentration of oxidized sulfur species in the exhaust is relatively high. If properly designed and operated, FGD technology can reliably achieve more than 95% sulfur removal. However, FGD cannot provide as high a level of control as the pre-combustion AGR systems. In addition, FGD has the environmental drawbacks of substantial water usage and the need to dispose of a solid byproduct (the scrubber sludge). The solid by-product requires the installation of a significant number of ancillary support systems to accommodate treatment, handling, and disposal. Given these disadvantages and the fact that FGD could not achieve the high removal efficiencies associated with AGR, even though FGD is not technically infeasible, it is not considered to be a reasonable technical option for IGCC. Therefore FGD will not be considered further in this BACT analysis

### 3. Rank Control Technologies

Both chemical and physical absorption methods for AGR are considered feasible for an IGCC, and can achieve control of the sulfur in syngas up to 99% or better. Both of these systems are further considered in the BACT analysis. A detailed technology assessment was completed by the Applicant and discussed in Section 6, Alternatives.

### 4. Evaluate Control Options

Physical absorption AGR systems (including Selexol™ and Rectisol™) are considered as feasible sulfur dioxide and sulfuric acid mist control technology for the proposed CGT/HRSG turbine. Selexol™ has been selected as BACT for all other recent IGCC permits. Rectisol™ has never been applied to other coal-based IGCC processes. However, Rectisol™ offers better gas cleanup in comparison to Selexol™ or MDEA.

Table 6-5 shows the typical $SO_2$ BACT determination (when firing hydrogen-rich fuel and natural gas respectively) and control technology for other recently permitted IGCC projects, in comparison with HECA's proposed $SO_2$ BACT for the CTG/HRSG.

**Table 6-5**
**$SO_2$ BACT Emission Limit Comparison**

| | | | | | Emission Limit on Hydrogen-rich fuel | | Emission Limit on Nat Gas | |
|---|---|---|---|---|---|---|---|---|
| **Facility** | **State** | **MW** | **Turbine** | **$SO_2$ BACT Technology** | **ppm** | **lb/MMBTU Hydrogen-rich fuel** | **ppm** | **lb/MMBTU NG** |
| HECA | CA | 250 | GE Model Number 7FB. | AGR, Rectisol | ≤ 5 ppm Sulfur in undiluted Hydrogen-rich fuel | 0.003 | 0.75 grains/100 scf | 0.002 |
| Cash Creek Generation Station | KY | 630 | GE Model Number 7FB. | AGR, Selexol | 3.8a | 0.0158 | | 0.0006 |
| Edwardsport Generating Station | IN | 630 | GE Model Number 7FB. | AGR, Selexol | | 0.0138b | | 0.0006b |
| Taylorville Energy Center | IL | 630 (net) | GE Model Number 7FB. | AGR, Selexol | 10 ppm Sulfur in Hydrogen-rich fuel | 0.016 | | 0.001 |

Notes:
[a] Parts per million by volume, dry basis, corrected to 15% O2
[b] Calculated. from mass emissions rate of 2.9 lb/hr on Hydrogen-rich fuel and 1.30 lb/hr on Natural Gas
MMBtu = million British thermal units
MW = megawatt
ppm = parts per million

As shown in Table 6-5, the BACT limitation for $SO_2$ emissions from HECA CTG/HRSG when firing hydrogen-rich fuel is more stringent than the historic BACT determination for other recently permitted IGCC units. This emission limitation represents a removal efficiency that is better than the emission achieved in practice at currently operating IGCC units and the lowest proposed emission limits compared to recently permitted IGCC units

NSPS 40 CFR 60 Subpart Da is considered as the BACT "floor" for this source category. The proposed $SO_2$ emission limits are significantly lower than the applicable NSPS Subpart Da limit of 180 ng/J (1.4 lb/MWh) or 95 percent reduction on a 30-day rolling average.

When firing natural gas, sulfur dioxide emission from CTG/HRSG is slightly higher than other recently permitted IGCC units. The Sulfur dioxide BACT for the proposed CTG/HRSG when operating on natural gas is PUC grade natural gas fuel with less than 0.75 grains/100 scf sulfur content.

### 5. Select Control Technology

The final step in the top-down BACT analysis process is to select BACT based on the results of the previous steps. HECA selected Rectisol as syngas cleanup control technology to remove sulfur dioxide from the hydrogen-rich fuel stream entering the CTG/HRSG. The reduction efficiency of Rectisol is above the NSPS floor requirement, and the overall performance of this technology is more stringent than the historic BACT determination for other recently permitted

IGCC units. The following emission limit resulting from the implementation of these technologies is proposed for each combustion turbine.

HECA proposed the PM BACT-based limit of ≤ 5 ppmv sulfur in undiluted $H_2$ - rich syngas and ≤0.75 grains/100 scf of natural gas sulfur content, using AGR system (Rectisol) and PUC grade natural gas.

### 6.1.5 Volatile Organic Compounds BACT Analysis for the CTG/HRSG

VOCs are a product of incomplete combustion of the organic components of the hydrogen-rich fuel. Hydrogen-rich fuel contains very low concentrations of VOC, and therefore, emissions of VOC are inherently very low. Reduction of VOC emissions is accomplished by providing adequate fuel residence time and high temperature in the combustion zone to ensure complete combustion. A survey of the RBLC database indicated that good combustion control and burning clean gas fuel are the VOC control technologies primarily determined to be BACT. The advantage of IGCC technology is the fact that the combustion turbine operates on hydrogen-rich fuel, a fuel which contains a very low organic content and, when burned, yields very low levels of uncombusted VOC emissions.

**1. Identify Control Technologies**

The following VOC control technologies were evaluated for the proposed CTG/HRSG:

<u>Combustion Process Controls</u>

- Good Combustion Practices (GCPs)

<u>Post Combustion Controls</u>

- $SCONO_x$™
- Oxidation Catalyst

**2. Evaluate Technical Feasibilities**

- Good Combustion Practices (GCPs)

  Good combustion practices include the use of operational and design elements that optimize the amount and distribution of excess air in the combustion zone to ensure optimum complete combustion.

  This technology has been determined to be BACT for VOC emissions in other operational or recently permitted IGCC projects.

- $SCONO_x$™

  The $SCONO_x$ system was evaluated in the $NO_x$ BACT analysis, and determined to be not technically feasible for this unit.

- Oxidation Catalysts

  Catalytic oxidation is a post-combustion control technology that utilizes a catalyst to oxidize VOC. The catalyst beds that functions to reduce CO emissions can also be effective in

reducing VOC emissions. Such systems typically achieve a maximum VOC removal efficiency of up to 50 percent, while providing control for CO.

Because of the catalyst fouling concerns, the use of oxidation catalysts has been previously limited to processes combusting natural gas. Oxidation catalysts have never been applied to coal-based IGCC processes. Other operational or recently permitted IGCC projects determined GCPs as the only feasible BACT for CO emissions. GE guarantees the turbine exhaust can achieve VOC emission levels of 1.0 ppmvd VOC (at 15 % oxygen) when firing hydrogen-rich fuel and 2.0 ppmvd CO (at 15 % oxygen) when operating on natural gas.

### 3. Rank Control Technologies

Oxidation catalyst is the only technically feasible VOC control technology identified in addition to Good combustion practices.

### 4. Evaluate Control Options

GCPs is considered the baseline and only feasible and commercially demonstrated VOC control technology for IGCC combustion turbines. GCP has been selected as BACT for all other recent IGCC permits Oxidation catalysts have never been applied to other coal-based IGCC processes. In comparison to other operational or recently permitted IGCC projects, this emission limitation represents a removal efficiency that is lower than the emission achieved in practice at currently operating IGCC units and the lowest proposed emission limits for proposed coal-fired units, including other proposed IGCC units.

Table 6-6 shows the typical VOC BACT determination (when firing hydrogen-rich fuel and natural gas respectively) and control technology for other recently permitted IGCC projects, in comparison with HECA's proposed VOC BACT for the CTG/HRSG.

**Table 6-6**
**VOC BACT Emission Limit Comparison**

| | | | | | Emission Limit on Hydrogen-rich fuel | | Emission Limit on Nat Gas | |
|---|---|---|---|---|---|---|---|---|
| Facility | State | MW | Turbine | VOC BACT Technology | ppm | lb/MMBTU Hydrogen-rich fuel | ppm | lb/MMBTU NG |
| HECA | CA | 250 | GE Model Number 7FB. | CO catalyst and GCP | 1[a] | 0.0016 | 2[a] | 0.0028 |
| Cash Creek Generation Station | KY | 630 | GE Model Number 7FB. | GCP | | N/A | | N/A |
| Edwardsport Generating Station | IN | 630 | GE Model Number 7FB. | GCP | | 0.0016[b] | | 0.0016[b] |
| Taylorville Energy Center | IL | 630 (net) | GE Model Number 7FB. | GCP | | N/A | | N/A |

Notes:
[a] Parts per million by volume, dry basis, corrected to 15% O2
[b] Calculated. from mass emissions rate of 3.3 lb/hr on Hydrogen-rich fuel and Natural Gas
MMBtu = million British thermal units
MW = megawatt
ppm = parts per million
VOC = volatile organic compound

As shown in Table 6-6, the BACT limitation for VOC emissions from HECA CTG/HRSG is comparable with the historic BACT determination for other recently permitted IGCC units. This emission limitation represents a removal efficiency that as good as the emission proposed in recently permitted IGCC units

**5. Select Control Technology**

The final step in the top-down BACT analysis process is to select BACT based on the results of the previous steps. As explained, GCPs and oxidation catalyst are the appropriate control technique for setting BACT-based emission limits.

HECA proposed the VOC BACT-based limit of 1.0 ppmvd @15% O2 while firing hydrogen-rich fuel and 2.0 ppmvd VOC at 15% O2 while firing natural gas during non-startup operation, using Good Combustion Practices (GCPs) and oxidation catalyst.

## 6.2 Auxiliary CTG BACT Analysis

The following is the BACT analysis for the proposed auxiliary combustion turbine (Aux CTG). The proposed Aux CTG is a 103 MW natural gas fired GE LMS100® in a simple cycle configuration, equipped with water injection for nitrogen oxide control. Post combustion emissions controls will include SCR and CO Catalyst systems natural gas.

HECA proposed to apply the SJVAPCD BACT Guidelines for Gas Turbine >= 50 MW, Uniform Load, without Heat Recovery as the BACT for the Aux CTG unit.

### 6.2.1 Nitrogen Oxides BACT Analysis for the Auxiliary CTG

The achieved in practice or contained in the SIP BACT guideline for $NO_x$ is 5.0 ppmvd @ 15% $O_2$, based on a three-hour average with high temperature SCR, or equal. The $NO_x$ emission limitation of 2.5 ppmvd @ 15% $O_2$, (3-hour average) is categorized as technically feasible control technology.

HECA proposed the application of water injection as combustion process control and SCR as post combustion control to reduce $NO_x$ emission from the Auxiliary CTG down to 2.5 ppmvd @ 15% $O_2$ As explained in the BACT analysis for the CTG/HRSG unit, water injection reduces the formation of thermal $NO_x$ in the combustion chamber by reducing the peak flame temperature, while SCR promotes the conversion of $NO_x$ to molecular nitrogen.

### 6.2.2 Carbon Monoxide BACT Analysis for the Auxiliary CTG

The achieved in practice or contained in the SIP BACT guideline for CO is 6.0 ppmvd @ 15% $O_2$, based on a three-hour average with Oxidation catalyst, or equal, technology. HECA

proposed the application of GCPs and CO catalyst as the control technology to reduce CO emission from the Auxiliary CTG down to 6.0 ppmvd @ 15% $O_2$ as recommended in the BACT guideline.

### 6.2.3 Particulate Emissions BACT Analysis for the Auxiliary CTG

The achieved in practice or contained in the SIP BACT guideline for $PM_{10}$ is Air inlet cooler/filter, lube oil vent coalescer (or equal) and either PUC regulated natural gas, LPG, or non-PUC regulated gas with < 0.75 grains Sulfur/100 dscf.

HECA auxiliary CTG is equipped with the following accessories to provide safe and reliable operation: evaporative coolers, inlet air filters, metal acoustical enclosure, duplex shell; and tube lube oil coolers for the turbine and generator, compressor water wash system, fire detection and protection system, hydraulic starting system, and compressor variable bleed valve vent. In addition, this unit exclusively combusts PUC grade natural gas with < 0.75 grains /100 dscf sulfur content. Therefore, the unit meets the recommended BACT emission limitation.

### 6.2.4 Sulfur Oxides BACT Analysis for the Auxiliary CTG

The achieved in practice or contained in the SIP BACT guideline for sulfur oxides is PUC regulated natural gas, LPG, or non-PUC regulated gas with < 0.75 grains S/100 dscf. As mentioned in the previous section, the auxiliary CTG is proposed to exclusively fueled by PUC regulated gas with < 0.75 grains S/100 dscf. Therefore, this unit meets the recommended BACT.

### 6.2.5 Volatile Organic Compounds BACT Analysis for the Auxiliary CTG

The achieved in practice or contained in the SIP BACT guideline for VOC is 2.0 ppmvd @ 15% $O_2$, based on a three-hour average with Oxidation catalyst, or equal, technology. HECA proposed the application of GCPs and CO catalyst as the control technology to reduce VOC and CO emission from the Auxiliary CTG down to 2.0 ppmvd @ 15% $O_2$ as recommended in the BACT guideline.

## 6.3 Cooling Towers Particulate Emissions BACT Analysis

There will be three cooling towers proposed for the Project. Two of the three cooling towers (Gasification cooling tower and the ASU cooling tower) are associated with the gasification process with the other cooling tower (Power block cooling tower) used by the power block. Compared to similar sized combined cycle power plants, the power block cooling duty is somewhat greater due to the heat integration with gasification resulting in the generation of additional steam for power production in the steam turbine. Each tower has a separate cooling water basin, pumps, and piping system, and operates independently. The cooling water will circulate through a mechanical draft-cooling tower, which uses electric motor-driven fans to move the air into contact with the flow of the cooling water. The heat removed in the condenser will be discharged to the atmosphere by heating the air and through evaporation of some of the cooling water.

The power block cooling tower is designed for an approximate capacity of 175,000 gallons per minute (gpm) of water with an hourly circulation rate of 88 million lb/hr. The ASU and gasification block cooling water system designs are similar to the power block cooling design,

but they have substantially lower duties. The ASU cooling tower circulation rate is approximately 40,000 gpm, and the gasification cooling tower circulation rate is about 42,000 gpm .

All cooling towers are supplied with high efficiency drift eliminators designed to reduce the maximum drift, that is, the fine mist of water droplets entrained in the warm air leaving the cooling tower, to less than 0.0005 % of the circulating water flow. Circulating water could range in TDS depending on makeup water quality and tower operation. Therefore, $PM_{10}$ emissions would vary proportionately.

Wet (evaporative) cooling towers emit aqueous aerosol "drift" particles that evaporate to leave crystallized solid particles that are considered $PM_{10}$ emissions. The proposed control technology for $PM_{10}$ is high-efficiency drift eliminators to capture drift aerosols upstream of the release point to the atmosphere.

**1. Identify Control Technologies**

The following particulate matter control technologies were evaluated for the proposed cooling towers:

Potential Cooling Tower Control Technology

- Drift Elimination System with limited TDS level

**2. Evaluate Technical Feasibilities**

High efficiency drift eliminators and limits on total dissolved solids (TDS) concentration in the circulating water are the techniques which set the basis for cooling tower BACT emission limits. The efficiency of drift eliminator designs is characterized by the percentage of the circulating water flow rate that is lost to drift. The drift eliminators to be used on the proposed cooling tower will be designed such that the drift rate is less than 0.0005% of the circulating water. Typical geometries for the drift eliminators include chevron

There is no $PM_{10}$ BACT guideline for mechanical draft cooling towers in SJVAPCD. However, the use of high-efficiency drift eliminating media to de-entrain aerosol droplets from the air flow exiting the wetted-media tower is a commercially proven technique to reduce $PM_{10}$ emissions. Compared to "conventional" drift eliminators, advanced drift eliminators reduce the $PM_{10}$ emission rate by more than 90 percent.

In addition to the use of high efficiency drift eliminators, management of the tower water balance to control the concentration of dissolved solids in the cooling water can also reduce particulate emissions. Dissolved solids accumulate in the cooling water due to increasing concentration of dissolved solids in the make-up water as the circulating water evaporates, and, secondarily, to addition of anti-corrosion, anti-biocide additives.

**3. Rank Control Technologies**

A drift elimination system is the only technically feasible control technology identified for the proposed cooling towers, and has been historically been selected as BACT for other projects.

**4. Evaluate Control Options**

The highest control efficiency to reduce the $PM_{10}$ emission from the proposed cooling towers involves the instillation of drift eliminators and adoption of TDS limit for the circulating water. Development of increasingly effective de-entrainment structures has resulted in equipment vendors claims that a cooling tower may be specified to achieve drift release no higher than 0.0005 percent of the circulating water rate for HECA project. This level of reduction has been approved in other recently permitted IGCC projects.

**5. Select Control Technology**

The final step in the top-down BACT analysis process is to select BACT based on the results of the previous steps. As has been explained, drift elimination system is selected as BACT for the proposed cooling towers. The proposed cooling tower will be designed with a high efficiency drift elimination system to minimize potential drift and particulate emissions achieving a maximum drift of 0.0005% of the circulating water. This measure, along with a limit on the circulating water TDS is considered to be the best available control option for particulate emissions from the cooling towers

## 6.4 Auxiliary Boiler BACT Analysis

The auxiliary boiler will provide steam to facilitate CTG startup and for other industrial purposes. The auxiliary boiler will be designed to burn pipeline-quality natural gas at the design maximum fuel flow rate of 142 MMBtu/hr (HHV). During normal operation, the auxiliary boiler may be kept in warm standby (steam sparged, no firing) or cold standby (no firing), and will not have emissions. The boiler will produce a maximum of about 100,000 pounds per hour of steam.

Pollutant emissions from natural gas boiler units include $NO_x$, $PM_{10}$, CO, $SO_2$, and VOCs. The auxiliary boiler emissions are based on 2,190 hours of operation per year. The applicant is proposing proper boiler design and operation, low $NO_x$ combustors with flue gas recirculation and use of natural gas to be BACT for the auxiliary boiler. This emission limitation is proposed to meet the SJVAPCD BACT Guidelines for greater than 20.0 MMBtu/hr natural gas fired boiler (base-loaded or with small load swings)

**1. Identify Control Technologies**

The following criteria pollutant emissions control technologies were evaluated for the proposed auxiliary boilers:

<u>Potential Auxiliary Boiler Control Technology</u>

- Good Combustion Practices (GCP)
- Low $NO_x$ combustor (LNB)
- CO Oxidation Catalysts
- Low $NO_x$ combustor (LNB) with Flue Gas Recirculation (FGR)
- Selective Catalytic Reduction (SCR)
- Selective Non-Catalytic Reduction (SNCR)

### 6.4.1 Nitrogen Oxides BACT Analysis for the Auxiliary Boiler

**2. Evaluate Technical Feasibilities**

- Low $NO_x$ Combustors

  Low $NO_x$ combustor reduces thermal $NO_x$ formation of by regulating the distribution and mixing of fuel and air to control the stoichiometry and temperature of combustion. Historically, low $NO_x$ combustors have been selected as BACT for natural gas-fired auxiliary boilers. Therefore, low $NO_x$ combustor technology is technically feasible for the proposed auxiliary boiler.

- Low $NO_x$ Combustors with Flue Gas Recirculation

  Flue gas recirculation (FGR) reduces boiler $NO_x$ emissions by recirculating a portion of the flue gas into the main combustion chamber. The increase in gas flow within the combustion chamber reduces the peak combustion temperature and oxygen in the combustion air/flue gas mixture, hence reduces the formation of thermal $NO_x$ $NO_x$ $NO_x$ $NO_x$. The application of FGR is typically in combination with low $NO_x$ combustor technology and has been selected as BACT for some auxiliary boiler processes. Therefore, FGR is considered technically feasible for the proposed auxiliary boiler.

- Selective Catalytic Reduction (SCR)

  SCR is a technology that achieves post-combustion reduction of $NO_x$ from flue gas within a catalytic reactor. The SCR process involves the injection of ammonia ($NH_3$) into the exhaust gas stream upstream of a specialized catalyst module to promote the conversion of $NO_x$ to molecular nitrogen. SCR technology has been most commonly applied pulverized coal generating units and to natural gas fired combustions turbines. However, there is no examples have been identified where an SCR has been applied to an auxiliary boiler. The auxiliary boiler will provide steam to facilitate CTG startup and kept in warm standby (steam sparged, no firing) or cold standby during normal operation. This operation results in varying flue gas characteristics that may not suitable for continuous SCR operation. Therefore, SCR is not technically feasible for the intended operation of the auxiliary boiler.

- Selective Non-Catalytic Reduction (SNCR)

  Selective Non-Catalytic Reduction (SNCR) is a post-combustion $NO_x$ control technology in which a reagent ($NH_3$ or urea) is injected into the exhaust gases to react chemically with $NO_x$ to form elemental nitrogen and water without the use of a catalyst. The success of this process in reducing $NO_x$ emissions is highly dependent on the ability to achieve uniform mixing of the reagent into the flue gas, which must occur within a narrow flue gas temperature zone (typically from 1,700°F to 2,000°F).

  The consequences of operating outside the optimum temperature range are severe. Above the upper end of the temperature range, the reagent will be converted to $NO_x$. Below the lower end of the temperature range, the reagent will not react with the $NO_x$ resulting in very high $NH_3$ slip concentrations ($NH_3$ discharge from the stack).

SNCR has never been applied in auxiliary boiler unit, primarily because there are no flue gas locations within the process with the optimal requisite temperature and residence time characteristics to facilitate the SNCR flue gas reactions. Therefore, SNCR is not technically feasible for this unit.

**3. Rank Control Technologies**

The use of low $NO_x$ combustor and flue gas recirculation is the only technically feasible control option identified for reducing $NO_x$ emissions. These control technologies are commonly used in combination and has been historically been selected as BACT for other projects.

**4. Select Control Technology**

Low $NO_x$ combustor technology and flue gas recirculation have historically been selected as BACT for natural gas fired auxiliary boilers. These technologies are commonly used in combination to reduce $NO_x$ emissions in other recently permitted IGCC projects.

The proposed auxiliary boiler will be designed with a Low $NO_x$ combustor technology and flue gas recirculation achieving a maximum $NO_x$ emission concentration of 9 ppm $NO_x$ @ 3% O2 on natural gas fuel.

### 6.4.2 Carbon Monoxide BACT Analysis for the Auxiliary Boiler

Poor fuel mixing degree, lack of available oxygen, or low temperatures in the combustion zone is common cause of incomplete combustion that resulted in CO emissions. Fuel quality and good combustion practices can limit CO emissions. Good combustion practice has commonly been determined as BACT for natural gas fired auxiliary boilers. Post-combustion control technologies utilizing catalytic reduction have also been utilized in some processes to reduce CO and VOC emissions.

**2. Evaluate Technical Feasibilities**

<u>Good Combustion Practices</u>

Good combustion practices include the use of operational and design elements that optimize the amount and distribution of excess air in the combustion zone to ensure complete combustion. Good combustion practice has historically been determined as BACT for CO and VOC emissions from auxiliary boilers and is a technically feasible control strategy for the proposed auxiliary boiler.

<u>Oxidation Catalyst</u>

Catalytic oxidation is a post-combustion control technology that utilizes a catalyst to oxidize CO and VOC into $CO_2$ or $H_2O$. The technology has most commonly been applied to natural gas fired combustion turbines. No examples were identified where oxidation catalyst technology has been applied to an auxiliary boiler. Because of the low potential CO and VOC emission without an oxidation catalyst and the limited use of the proposed auxiliary boiler, the use of catalytic oxidation technology is determined to be not feasible.

**3. Rank Control Technologies**

Good combustion practice is the only feasible control strategy identified, and has historically been selected as BACT for CO emissions from the auxiliary boiler.

**4. Select Control Technology**

The use of good combustion practices has been selected as BACT for potential CO emission from the proposed auxiliary boiler. Boiler vendor information indicates that a CO worst case hourly emission for the proposed auxiliary boiler is 50 ppmvd @ 3% O2.

### 6.4.3 Particulate Emissions, Sulfur Oxides, Volatile Organic Compounds BACT Analysis for the Auxiliary Boiler

For these pollutants, the commercially available control measures that are identified in the most stringent BACT determinations are use of low-sulfur, PUC natural gas, and GCP. Based on SJVAPCD BACT Guidelines for > 20.0 MMBtu/hr Natural gas fired Boiler (base-loaded or with small load swings), add-on controls were not implemented to achieve BACT limits for these pollutants.

Boiler vendor information indicates that the worst case hourly emissions for this unit with these technologies will be 0.005 lb $SO_2$/MMBtu, 0.004 lb VOC /MMBtu and 0.005 lb $PM_{10}$/MMBtu.These rates, or corresponding lb/hour emission rates, are proposed as BACT limits for the auxiliary boiler emission unit

## 6.5 Diesel Engines BACT Analysis

HECA project will include two 2,800HP standby diesel generators and one 556 HP, standby firewater pump. HECA proposed to apply the SJVAPCD BACT Guidelines for Emergency Diesel I.C. Engine = or > 400 hp as the BACT for the standby diesel generator engines and SJVAPCD BACT Guidelines for Emergency Diesel I.C. Engine Driving a Fire Pump as the BACT for the standby firewater pump engine The BACT emission limits will be achieved by the following control effort.

- Low Sulfur Fuel Selection

  The diesel engines will exclusively combust ultra-low sulfur diesel fuel. $SO_2$ emissions were estimated using ultra-low sulfur diesel fuel containing 15 ppm sulfur.

- Clean Combustion Process Selection

  The engines will meet EPA Tier 4 emissions standards for 2011 model equipment.

  Standby diesel generator engine: 0.3 g/bhp-hr NMHC; 0.5 g/bhp-hr $NO_x$; 2.6 g/bhp-hr CO; 0.07 g/bhp-hr PM

  Standby firewater pump engine: 0.14 g/bhp-hr NMHC; 1.5 g/bhp-hr $NO_x$; 2.6 g/bhp-hr CO; 0.015 g/bhp-hr PM

- Restricted Operating Hours

The standby diesel generators will operate less than fifty hours per year per engine for non-emergency purposes such as: routine testing, maintenance, and inspection purposes. The fire pump will operate than fifty hours per year per engine for non-emergency purposes.

### 6.5.1 BACT Analysis for the Standby Diesel Generators

The achieved in practice or contained in the SIP BACT guideline for $NO_x$ is certified emissions of 6.9 g/bhp-hr or less. The proposed control of using engines that meet EPA Tier 4 emissions standards for 2011 model equipment will meet this BACT limit with 0.5 g/bhp-hr $NO_x$. Although it is technically feasible to install add on $NO_x$ control, this option is cost prohibitive due to the emergency nature of the engine operations.

The achieved in practice or contained in the SIP BACT guideline for CO is 2.0 g/bhp-hr. The vendor emission factor for the diesel engines guaranteed 0.29 g/bhp-hr of CO emission. This emission limit is substantially below the required BACT limit. Although it is feasible to install CO oxidation catalyst to further reduce CO emissions from the engines, the cost for oxidation catalyst for CO control will be prohibitive, given the low number of routine operating hours per year of the engines.

The achieved in practice or contained in the SIP BACT guideline for $PM_{10}$ is 0.1 grams/bhp-hr (if TBACT is triggered) or 0.4 g/bhp-hr (if TBACT is not triggered). The proposed control of using engines that meet EPA Tier 4 emissions standards for 2011 model equipment will meet this BACT limit with 0.07 g/bhp-hr PM.

The achieved in practice or contained in the SIP BACT guideline for sulfur oxides is low-sulfur diesel fuel (500 ppmw sulfur or less) or Very Low-sulfur diesel fuel (15 ppmw sulfur or less). The standby diesel generator engines will exclusively combust ultra-low sulfur diesel fuel. $SO_2$ emissions were estimated using ultra-low sulfur diesel fuel containing 15 ppm sulfur.

There is no numerical emission limit achieved in practice or contained in the SIP BACT guideline for VOC. The proposed control of using engines that meet EPA Tier 4 emissions standards for 2011 model equipment proposed a BACT limit with 0.3 g/bhp-hr VOC for this unit.

### 6.5.2 BACT Analysis for the Firewater Pump Diesel Engine

The achieved in practice or contained in the SIP BACT guideline for $NO_x$ is certified emissions of 6.9 g/bhp-hr or less. The proposed control of using engines that meet EPA Tier 4 emissions standards for 2011 model equipment will meet this BACT limit with 1.5 g/bhp-hr $NO_x$. Although it is technically feasible to install add on $NO_x$ control, this option is cost prohibitive due to the emergency nature of the fire water pump engine operations.

There is no numerical emission limit achieved in practice or contained in the SIP BACT guideline for CO. The proposed control of using engines that meet EPA Tier 4 emissions standards for 2011 model equipment proposed a BACT limit with 2.6 g/bhp-hr CO for this unit. Although it is feasible to install CO oxidation catalyst to further reduce CO emissions from the engines, the cost for oxidation catalyst for CO control will be prohibitive, given the low number of routine operating hours per year of the fire water pump.

The achieved in practice or contained in the SIP BACT guideline for $PM_{10}$ is 0.1 grams/bhp-hr (if TBACT is triggered)or 0.4 grams/bhp-hr (if TBACT is not triggered). The proposed control of using engines that meet EPA Tier 4 emissions standards for 2011 model equipment will meet this BACT limit with 0.015 g/bhp-hr PM.

The achieved in practice or contained in the SIP BACT guideline for sulfur oxides is low-sulfur diesel fuel (500 ppmw sulfur or less) or ultra-low sulfur diesel fuel (15 ppmw sulfur or less). The firewater pump diesel engine will exclusively combust ultra-low sulfur diesel fuel. $SO_2$ emissions were estimated using ultra-low sulfur diesel fuel containing 15 ppm sulfur.

There is no numerical emission limit achieved in practice or contained in the SIP BACT guideline for VOC. The proposed control of using engines that meet EPA Tier 4 emissions standards for 2011 model equipment proposed a BACT limit with 0.14 g/bhp-hr VOC for this unit

## 6.6 Ground Flare BACT Analysis

Two flare control technologies were evaluated for the proposed facility: an elevated flare and an enclosed ground flare. Elevated flare technology utilizes a stack to vent combustible process gases to a combustor located at the top resulting in an open flame at the stack discharge. Elevated flares provide for greater dispersion of heat and combustion products than ground flares. Elevated flares are the most common technology used by refinery, steel, and chemical industries, and are used by operational and recently permitted IGCC projects.

Reduced noise, reduced visual impact, and better CO destruction resulted in the selection of the enclosed ground flare for the gasification block. The gasification block will be provided with a totally enclosed ground flare to safely dispose of gasifier startup gases, hydrogen-rich fuel during AGR startup, hydrogen-rich gas during short-term emergency combustion turbine outages, or other various streams within the Project during other unplanned upsets or equipment failures. The low pressure sour syngas sent to the flare from the gasification and shift units during shutdown depressurizing operations are first scrubbed in the Gasification Amine Absorber to remove essentially all the sour sulfur compounds. Flaring of untreated syngas or other streams within the plant would only occur as an emergency safety measure during unplanned plant upsets or equipment failures. The ground flare is designed with multiple combustor tiers and sufficient residence time at about 1,600$^{o}$F to ensure complete combustion.

The gasification process flare will emit criteria pollutants that are products of combustion. However, the chemical compositions of the predominant gaseous fuels that would be flared, i.e., syngas and natural gas, results in very low emissions of $PM_{10}$, $SO_2$ and VOC. For the syngas case, there is very little unoxidized carbon in the fuel, which limits the formation of particulate matter during combustion even below the rate for natural gas. Formation of $SO_2$ is limited by the pre-treatment of the syngas flare stream, and the inherently low sulfur content of pipeline natural gas.

**1. Identify Control Technologies**

The following control technologies were evaluated for the proposed gasification block enclosed ground flare:

- Clean pilot fuel (Natural gas) and Good Combustion Practices
- Low $NO_x$ Combustor
- Add-On Controls

**2. Evaluate Technical Feasibilities**

- Clean pilot fuel (Natural Gas) and Good Combustion Practices

  A certain level of flame temperature control can be exercised for the enclosed flare by implementing fuel/air ratio control. In its most sophisticated form, this control utilizes feedback control from oxygen monitors to modulate fuel and air rates in order to maintain the load demand, while reducing pollutant formation. Flare BACT options that have been achieved in practice in California (e.g., California Air Pollution Control Officers Association [CAPCOA] BACT Clearinghouse) indicate the incorporation of natural gas pilot and "proper burner management and monitoring" are used to control the emissions of CO, VOCs and $NO_x$ . The ground flare is also designed with multiple combustor tiers and sufficient residence time at about 1,600$^o$F to ensure complete combustion.

- Low $NO_x$ Combustor

  Low- $NO_x$ combustors (LNB) and ultralow $NO_x$ combustors (ULNB) technology alter air to fuel ratio in the combustion zone by staging the introduction of the air to promote a "lean-premixed" flame. This results in lower combustion temperatures and reduced $NO_x$ formation. Such designs are not available for enclosed, ground-level flares, which do not have a confined combustion zone that would allow staged introduction of fuel and air streams. Therefore this control technology is not feasible for the proposed ground flare.

- Add-On Controls

  The gasification block flare is not a candidate for add-on abatement systems. It is generally recognized in the chemical process industries that adoption of add-on control can impede the ability of a flare to respond to unexpected upset conditions. Therefore this control technology is not feasible for the proposed ground flare.

For plant safety, the flare must provide a "fail-safe" that is available regardless of the functioning of pollution control devices.

**3. Rank Control Technologies**

The use of natural gas as pilot fuel and good combustion practices were identified as the only technically feasible criteria pollutant emissions control technologies applicable to the proposed enclosed ground flare.

**4. Evaluate Control Options**

As determined in the last section, the use of natural gas as pilot fuel and good combustion practices are the only feasible control strategy identified. Based on review of SJVAPCD BACT guideline, there is no BACT determination source category for flare that supports gasification process.

**5. Select Control Technology**

The final step in the top-down BACT analysis process is to select BACT based on the results of the previous steps. As has been explained, use of natural gas as pilot fuel and good combustion practices are selected as BACT for the proposed enclosed ground flare. The proposed enclosed ground flare will be designed with multiple combustor tiers and sufficient residence time at about 1,600°F to ensure complete combustion. This measure, along with natural gas pilot and processes flare gas for non-emergency operation are considered to be the best available control option for criteria pollutant emissions from the ground flare. The proposed control and criteria pollutant emissions for the enclosed ground flare are summarized as follows.

**Table 6-7**
**Ground Flare Total Criteria Pollutant Emissions**

| Pollutant | Emissions | | | |
|---|---|---|---|---|
| | Pilot (ton/yr) | Start-Up/ Shut-Down (ton/yr) | Total (ton/qtr) | Total (ton/yr) |
| $NO_x$ | 0.26 | 4.04 | 1.08 | 4.3 |
| CO | 0.18 | 44.76 | 11.23 | 44.9 |
| VOC | 0.003 | 0.00 | 0.001 | 0.003 |
| $SO_2$ | 0.004 | 0.00 | 0.001 | 0.004 |
| $PM_{10} = PM_{2.5}$ | 0.01 | 0.00 | 0.002 | 0.01 |

Notes:
CO = carbon monoxide
$NO_x$ = oxides of nitrogen
$PM_{10} = PM_{2.5}$ = particulate matter 10 microns in diameter and is assumed to equal $PM_{2.5}$ = particulate matter 10 microns in diameter
$SO_2$ = sulfur dioxide
VOC = volatile organic compound

## 6.7 Sulfur Recovery System BACT Analysis

The sulfur recovery system is designed to process acid gas streams from the acid gas removal (AGR) system and IGCC process into an elemental sulfur by-product. Sulfur is removed from the processing facility through a sulfur complex which consists of a Claus unit (thermal stage) plus catalytic converters otherwise known as the Sulfur Recovery Unit (SRU), and a Tail Gas Treating Unit (TGTU). The SRU is a totally enclosed process with no discharges to the atmosphere. The tail gas from the SRU is composed mostly of carbon dioxide, water vapor, and sulfur vapor with trace amounts of hydrogen sulfide and sulfur dioxide. The tail gas is routed to the TGTU where the majority of the sulfur is recovered. The overhead of the TGT Unit is the only emission source in this system that mainly emits a gas stream with $H_2S$ and reduced sulfur concentrations.

The proposed sulfur process facility consists of 2 by 50 percent SRUs, 1 by 100 percent and TGTU. The SRU and TGTU give an overall sulfur recovery efficiency of 99.9 percent. Associated with the operation of the sulfur recovery system, HECA proposed the integral use of

a flare, caustic scrubber, and thermal oxidizer as control devices to provide for the safe and efficient destruction of combustible gas streams. These control devices are primarily utilized intermittently during short-term periods of startup, shutdown, and malfunction operations.

**1. Identify Control Technologies**

The following control technologies were evaluated for the proposed Sulfur Recovery System:

- Thermal Oxidizer
- Flare
- Caustic Scrubber

**2. Evaluate Control Technologies**

- Thermal Oxidizer

  In the thermal oxidizer, the TGTU tail gas and other oxidizing streams are subjected to a high temperature and a sufficient residence time to cause an essentially complete destruction of reduced sulfur compounds such as hydrogen sulfide. The thermal oxidizer uses natural gas to reach the necessary operating temperature for optimal thermal destruction. The thermal oxidizer also controls emissions from various systems during normal operations, including the sulfur pit vent. A continuous natural gas pilot will be in service on both controls. The flare and thermal oxidizer are the only control technologies identified that are capable of controlling the variable potential gas streams associated with the sulfur recovery process and the startup, shutdown, and malfunction of the integrated IGCC systems.

  Good thermal oxidizer design includes optimization of parameters that maintain efficiency, such as temperature, residence time, and the mixing of gas streams in the combustion zone. The proposed thermal oxidizer will use natural gas for preheating and to facilitate the combustion of process gases in the thermal oxidizer. Implementation of these elements into the design and operation of the thermal oxidizer, in combination with the use of a natural gas pilot flame, will support a thermal oxidizer control technology that minimizes incomplete combustion, which directly correlates to potential criteria pollutant emissions.

- Flare

  Emissions from the IGCC gas cleanup process cannot be directed to certain control systems and/or the combustion turbines during startup and shutdown operations, or during operational malfunctions. Directly venting these emissions to the atmosphere could result in very high concentrations of $SO_2$, CO, VOC, $NO_x$, and/or $H2_SO_4$ being released. In this case, a flare is selected to accommodate the variability inherent in these operations.

  Acid gas derived from the AGR, gasification unit is normally routed to the SRU for recovery as elemental sulfur. To reduce the emissions of sulfur compounds to the environment, the acid gas is routed to the Emergency Caustic Scrubber, which will be discussed in the next subsection, prior to being directed to the elevated flare Enclosed ground flares have the potential to minimize flame appearance and provide a setting for monitoring post-combustion gas streams. However, they are not technically feasible for the proposed facility because of

safety and reliability concerns. Therefore, the elevated flare design was selected for this project.

- Caustic Scrubber

  During cold plant startup of the gasification block, acid-gas streams will be diverted to a caustic scrubber prior to being directed to the elevated flare for a short time. The caustic scrubber removes $H_2S$ from the acid gas stream with an anticipated scrubbing efficiency of at least 99.6% sulfur removal.

### 3. Select Control Technology

The final step in the top-down BACT analysis process is to select BACT based on the results of the previous steps. As discussed, the use of flare, thermal oxidizer, and caustic scrubber are the proposed technologies designed to control criteria pollutant emissions from the sulfur recovery system in addition to an efficient IGCC process design. These technologies complement one another and may operate in combination with each other.

Including the proposed control system to provide for the safe and efficient destruction of combustible sulfur rich acid gas streams, the emissions from the sulfur recovery system are categorized into two emission sources of tail gas thermal oxidizer and elevated flare. Each emission source has its own emission control measure to reduce its criteria pollutant emissions. The proposed control and criteria pollutant emissions for the sulfur recovery system are summarized as follows.

**Table 6-8**
**Sulfur Recovery System Emissions**

| Pollutant | Thermal Oxidizer Emissions (lb/MMBtu, HHV) | Elevated Flare Emissions | | | |
|---|---|---|---|---|---|
| | | Pilot (ton/yr) | Start-Up/ Shut-Down (ton/yr) | Total (ton/qtr) | Total (ton/yr) |
| $NO_x$ | 0.13 | 0.16 | 0.0130 | 0.04 | 0.2 |
| CO | 0.04 | 0.11 | 0.0086 | 0.03 | 0.1 |
| VOC | 0.0070 | 0.002 | 0.0001 | 0.000 | 0.002 |
| $SO_2$ | See Below | 0.003 | 0.05 | 0.014 | 0.1 |
| $PM_{10} = PM_{2.5}$ | 0.008 | 0.004 | 0.0003 | 0.001 | 0.004 |

Assume an allowance of 2 lb/hr $SO_2$ emission to account for sulfur in the various vent streams plus fuel

Notes:

CO = carbon monoxide
$NO_x$ = oxides of nitrogen
$PM_{10} = PM_{2.5}$ = particulate matter 10 microns in diameter and is assumed to equal $PM_{2.5}$ = particulate matter 10 microns in diameter
$SO_2$ = sulfur dioxide
VOC = volatile organic compound

## 6.8 $CO_2$ Vent BACT Analysis

The Project will produce electricity while substantially reducing greenhouse gas emissions by capturing carbon dioxide ($CO_2$). At least 90 percent of the carbon in the raw syngas will be captured in a high-purity carbon dioxide stream during steady-state operation, which will be compressed and transported by pipeline off site for injection into deep underground oil reservoirs for enhanced oil recovery and sequestration.

A $CO_2$ vent stack will allow for infrequent venting of produced $CO_2$ from the AGR and TGTU when the $CO_2$ injection system is unavailable, unable to export, or other upset condition. The $CO_2$ vent will enable HECA to operate, rather than be disabled, by brief periods of gasifier shutdown and subsequent gasifier restart. The $CO_2$ vent exhaust stream will be nearly all $CO_2$, with small amounts of CO, VOC, and $H_2S$.

Due to the infrequent nature of the venting event, the option of adding add-on control technology is cost prohibitive for this emission point. In order to reduce the impact of this infrequent venting event, good engineering practice stack height, limited venting duration, and vent gas concentration limits are selected as BACT for this source.

HECA proposed a maximum of 504 hours of venting duration for this unit. The pollutant concentrations in the vent gas are limited to 1000 ppm for CO, 40 ppm for VOC, and 10 ppm for $H_2S$ to reduce the overall impact of the venting event.

**Good Engineering Practice Stack Height**

The U.S. EPA provides specific guidance for determining the Good Engineering Practice (GEP) stack height and for determining whether building downwash will occur in the Guidance for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations). GEP is defined as "the height necessary to ensure that emissions from the stack do not result in excessive concentrations of any air pollutant in the immediate vicinity of the source as a result of atmospheric downwash, eddies, and wakes that may be created by the source itself, nearby structures, or nearby terrain "obstacles".

The GEP definition is based on the observed phenomenon of atmospheric flow in the immediate vicinity of a structure. It identifies the minimum stack height at which significant adverse aerodynamics (downwash) are avoided. The U.S. EPA GEP stack height regulations specify that the GEP stack height is calculated in the following manner:

$$H_{GEP} = H_B + 1.5L$$

where:

$H_B$ = the height of adjacent or nearby structures, and

L = the lesser dimension (height or projected width) of the adjacent or nearby structures.

The regulations also specify that the creditable stack height for modeling purposes is either the GEP stack height as calculated or a de-minimus height of 65 meters.

A 288-foot stack height was chosen to satisfy HEI's inherently safe design practices to minimize ground-level $CO_2$ concentrations in the event of a $CO_2$ vent under very low wind speeds.

## 6.9 Gasifier Refractory Heaters BACT Analysis

HECA proposed to install three natural gas-fired gasification refractory heaters, each rated at 18 MMBtu/hr. Each of the three gasification trains will have one natural-gas fired combustor used to warm the gasification refractory to facilitate startup. The heaters are restricted to operate for gasifier startup with maximum total gasifier warming duration of 1800 hours per year during mature operations.

No examples were found regarding the application of LAER for the case specific emissions associated with natural gas combustion. To control criteria pollutant emissions from the heaters' natural gas combustion, HECA selected GCPs, natural gas fuel, and restricted operating hours as BACT for the heaters. The total of potential PM and VOC emissions from the gasifiers are negligible (less than 0.2 tons/year). Therefore, the use of natural gas was determined to be LAER for the heaters. Good combustion practices will optimize the performance of the combustor; hence minimize the emission of $NO_x$ and CO. Since the heaters will only combust natural gas, the potential of $SO_2$, VOC, and PM emissions is minimized. The following are the proposed BACT/LAER emission rates for each gasifier refractory heater:

**Table 6-9**
**Gasifier Refractory Heater Emissions**

| Pollutant | Emission Limit |
|---|---|
| $NO_x$ | 0.13 lb/MMBtu, HHV |
| CO | 0.035 lb/MMBtu, HHV |
| PM/ $PM_{10}$ | 0.008 lb/MMBtu, HHV |
| $SO_2$ | 0.020 lb/MMBtu, HHV (13 ppm) |
| VOC | 0.007 lb/MMBtu, HHV |

Notes:
CO = carbon monoxide
$NO_x$ = oxides of nitrogen
PM/ $PM_{10}$ = particulate matter/ particulate matter 10 microns in diameter
$SO_2$ = sulfur dioxide
VOC = volatile organic compound

## 6.10 Feedstock Handling System BACT Analysis

Two major IGCC feedstock with particulate emission potential are petcoke and fluxant. Petcoke will be delivered to the plant via truck from refineries in the Los Angeles, Santa Maria, or Bakersfield areas, and/or other regional sources. Fluxant will be delivered to the Project Site via truck from regional sources. The transportation and preparation processes related to the feedstock have a potential to emit particulate matter emission to the atmosphere. The following is the BACT analysis for the proposed feedstock handling system in HECA.

### 6.10.1 Particulate Matter BACT Analysis for the Feedstock Handling System

Because the feedstock preparation processes will be within an enclosed conveyor system, forced air dust collection system is the most appropriate and commonly control technology to control particulate matter emission from the emission points.

- Truck Unloading
- Coke/coal Silos (filling)
- Coke/coal Silos (filling)
- Coke/coal Silos (loadout)
- Crusher Inlet
- Crusher Outlet
- Feed Bin Inlet Conveyor
- Grinding Mill Feed Bins
- Fluxant Bins (filling)

HECA selected dust collection systems consisting of hoods and baghouses as BACT to control particulate emissions from the aforementioned emission points. HECA will have nine bag houses with maximum dust collector PM emission rate based on expected supplier guarantee of 0.003 grain/scf outlet dust loading.

Dust collection system using baghouses has been proposed as BACT in other operating and recently permitted IGCC projects. The proposed emission limitation represents a removal efficiency that is comparable with the emission achieved in practice at currently operating IGCC units and the lowest recently permitted IGCC units.

## 7.0 REFERENCE

Korens, Nick, et al. ”Process Screening Analysis of Alternative Gas Treating and Sulfur Removal for Gasification”. U.S. Department of Energy. National Energy Technology Laboratory. December 2002.SFA Pacific, Inc. Mountain View, California. Available online at <http://www.netl.doe.gov/technologies/coalpower/gasification/pubs/pdf/SFA%20Pacific_Process%20Screening%20Analysis_Dec%202002.pdf>

IGCC Permits and applications for Cash Creek Generating Station, Edwardsport Generating Station, and Taylorville Energy Center