# Appendix D

# Air Quality Emissions and Calculations

# Appendix D1

# Emissions Calculations

# Appendix D1.1

# Construction Emissions

*Hydrogen Energy, Inc* *5/21/2009*
*HECA Project*

| Estimated Daily Maximum Construction Emissions of Criteria Pollutants (lbs/day) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Activity** | **$PM_{10}$** | **$PM_{2.5}$** | **CO** | **ROC** | **$NO_x$** | **$SO_x$** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2e$** |
| **On-Site Construction Emissions** | | | | | | | | | | |
| **On-Site Combustion Emissions** | | | | | | | | | | |
| Construction Equipment | 600.33 | 552.31 | 4931 | 1484 | 11208 | 10.81 | 996392 | 133.86 | 26.95 | 1007558 |
| Construction Trucks (Concrete, Dump Trucks, Flatbed Trucks, …) | 56.37 | 50.77 | 451.64 | 148.69 | 917.54 | 0.92 | 97909 | 1.41 | 1.70 | 98465 |
| Worker Vehicles | 0.46 | 0.08 | 30.58 | 2.36 | 2.35 | 0.06 | 6062 | 0.28 | 0.23 | 6155 |
| Delivery Trucks | 1.00 | 0.92 | 7.48 | 4.26 | 17.52 | 0.01 | 1422 | 0.02 | 0.02 | 1429 |
| **Subtotal of On-site Combustion Emissions** | **658.16** | **604.08** | **5421** | **1639** | **12146** | **11.81** | **1101785** | **135.58** | **28.90** | **1113607** |
| **On-Site Fugitive Dust Emissions** | | | | | | | | | | |
| Construction Equipment | 16.08 | 3.41 | | | | | | | | |
| Construction Trucks (Concrete, Dump Trucks, Flatbed Trucks, …) | 5.96 | 1.01 | | | | | | | | |
| Worker Vehicles | 8.23 | 1.39 | | | | | | | | |
| Delivery Trucks | 2.09 | 0.35 | | | | | | | | |
| **Subtotal of On-Site Fugitive Dust** | **32.36** | **6.16** | | | | | | | | |
| **Subtotal of On-Site Emissions** | **690.52** | **610.24** | **5421.10** | **1639** | **12146** | **11.81** | **1101785** | **135.58** | **28.90** | **1113607** |
| **Off-Site On-Highway Emissions** | | | | | | | | | | |
| **Off-Site Combustion Emissions** | | | | | | | | | | |
| Construction Equipment and Trucks | 116.17 | 106.18 | 932.76 | 327.11 | 1591 | 1.65 | 150118 | 21.89 | 3.17 | 151561 |
| Worker Vehicles | 5.89 | 5.42 | 392.44 | 30.27 | 30.13 | 0.73 | 77800 | 3.64 | 2.91 | 78989 |
| Delivery Trucks | 1.00 | 0.92 | 7.48 | 4.26 | 17.52 | 0.01 | 1422 | 0.02 | 0.02 | 1429 |
| **Subtotal of Off-Site Combustion Emissions** | **123.06** | **112.52** | **1333** | **361.65** | **1639** | **2.39** | **229340** | **25.55** | **6.11** | **231979** |
| **Off-Site Paved Road Fugitive Dust Emissions** | | | | | | | | | | |
| Construction Equipment and Trucks | 113.31 | 19.15 | | | | | | | | |
| Worker Vehicles | 211.25 | 35.70 | | | | | | | | |
| Delivery Trucks | 39.66 | 6.70 | | | | | | | | |
| **Subtotal of Off-Site Fugitive Dust** | **364.22** | **61.55** | | | | | | | | |
| **Subtotal of Off-Site Emissions** | **487.28** | **174.08** | **1333** | **361.65** | **1639** | **2.39** | **229340** | **25.55** | **6.11** | **231979** |
| **Total Maximum Daily Emissions** | **1177.80** | **784.31** | **6754** | **2001** | **13785** | **14.19** | **1331125** | **161.13** | **35.00** | **1345586** |

## Total Annual Construction Emissions — Summary

*Hydrogen Energy, Inc*
*HECA Project*

*5/21/2009*

| Estimated Maximum Annual Construction Emissions of Criteria Pollutants (tons/year) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Activity [1]** | **$PM_{10}$** | **$PM_{2.5}$** | **CO** | **ROC** | **$NO_x$** | **$SO_x$** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$CO_2e$** |
| **On-Site Construction Emissions** | | | | | | | | | | |
| **On-Site Combustion Emissions** | | | | | | | | | | |
| Construction Equipment | 2.00 | 1.84 | 16.20 | 4.99 | 36.01 | 0.04 | 3179 | 0.45 | 0.09 | 3215 |
| Construction Trucks (Concrete, Dump Trucks, Flatbed Trucks, …) | 0.20 | 0.18 | 1.65 | 0.52 | 3.33 | 3.36E-03 | 357.32 | 0.00 | 0.01 | 359.36 |
| Worker Vehicles | 0.06 | 0.01 | 4.04 | 0.31 | 0.31 | 0.01 | 800.23 | 0.04 | 0.03 | 812.46 |
| Delivery Trucks | 0.01 | 0.01 | 0.05 | 0.03 | 0.12 | 9.49E-05 | 9.88 | 0.00 | 0.00 | 9.93 |
| **Subtotal of On-site Combustion Emissions** | **2.27** | **2.04** | **21.94** | **5.85** | **39.77** | **0.05** | **4347** | **0.49** | **0.12** | **4397** |
| **On-Site Fugitive Dust Emissions** | | | | | | | | | | |
| Construction Equipment | 0.03 | 0.01 | | | | | | | | |
| Construction Trucks (Concrete, Dump Trucks, Flatbed Trucks, …) | 0.07 | 0.02 | | | | | | | | |
| Worker Vehicles | 1.09 | 0.18 | | | | | | | | |
| Delivery Trucks | 0.28 | 0.05 | | | | | | | | |
| **Subtotal of On-Site Fugitive Dust** | **1.46** | **0.25** | | | | | | | | |
| **Subtotal of On-Site Emissions (tpy)** | **3.73** | **2.29** | **21.94** | **5.85** | **39.77** | **0.05** | **4347** | **0.49** | **0.12** | **4397** |
| **Off-Site On-Highway Emissions** | | | | | | | | | | |
| **Off-Site Combustion Emissions** | | | | | | | | | | |
| Construction Trucks (Concrete, Dump Trucks, Flatbed Trucks, …) | 0.13 | 0.12 | 1.03 | 0.41 | 2.16 | 2.11E-03 | 223.34 | 0.01 | 0.00 | 224.80 |
| Worker Vehicles | 0.78 | 0.72 | 51.80 | 4.00 | 3.98 | 0.10 | 10270 | 0.48 | 0.38 | 10427 |
| Delivery Trucks | 0.13 | 0.12 | 0.99 | 0.56 | 2.31 | 1.80E-03 | 187.64 | 0.00 | 0.00 | 188.63 |
| **Subtotal of Off-Site Combustion Emissions** | **1.04** | **0.96** | **53.81** | **4.97** | **8.45** | **0.10** | **10681** | **0.49** | **0.39** | **10840** |
| **Off-Site Paved Road Fugitive Dust Emissions** | | | | | | | | | | |
| Construction Trucks (Concrete, Dump Trucks, Flatbed Trucks, …) | 14.96 | 2.53 | | | | | | | | |
| Worker Vehicles | 27.88 | 4.71 | | | | | | | | |
| Delivery Trucks | 5.24 | 0.88 | | | | | | | | |
| **Subtotal of Off-Site Fugitive Dust** | **48.08** | **8.13** | | | | | | | | |
| **Subtotal of Off-Site Emissions** | **49.12** | **9.08** | **53.81** | **4.97** | **8.45** | **0.10** | **10681** | **0.49** | **0.39** | **10840** |
| **Total Maximum Annual Emissions** | **52.85** | **11.37** | **75.75** | **10.82** | **48.22** | **0.15** | **15027** | **0.98** | **0.51** | **15237** |

(1) Onsite and offsite construction equipment totals incorporates a 66% annual average load operating factor.

## On-Site Construction Equipment Emission Factors

*Hydrogen Energy, Inc*
*HECA Project*

*4/30/2009*

| Emission Factors (lbs/hr) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Equipment Description*** | **EMFAC designation** | **Horsepower** | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_x$** | **ROG (1)** | **$CO_2e$** |
| **On-Road Vehicles** | | | | | | | | | | | | |
| Concrete Pumper Truck | HHD-DSL | | 0.320 | 69.786 | 0.0013 | 0.001 | 0.694 | 0.043 | 0.039 | 0.001 | 0.151 | 70.16 |
| Dump Truck | HHD-DSL | | 0.320 | 69.786 | 0.0013 | 0.001 | 0.694 | 0.043 | 0.039 | 0.001 | 0.151 | 70.16 |
| Service Truck - 1 ton | HHD-DSL | | 0.320 | 69.786 | 0.0013 | 0.001 | 0.694 | 0.043 | 0.039 | 0.001 | 0.151 | 70.16 |
| Pile Driver Truck | HHD-DSL | | 0.320 | 69.786 | 0.0013 | 0.001 | 0.694 | 0.043 | 0.039 | 0.001 | 0.151 | 70.16 |
| Truck - Fuel/Lube | MHD-DSL | | 0.155 | 33.180 | 0.0002 | 0.001 | 0.279 | 0.017 | 0.015 | 3.09E-04 | 0.014 | 33.39 |
| Tractor Truck 5th Wheel | HHD-DSL | | 0.320 | 69.786 | 0.0013 | 0.001 | 0.694 | 0.043 | 0.039 | 0.001 | 0.151 | 70.16 |
| Trucks - Pickup 3/4 ton | MHD-DSL | | 0.155 | 33.180 | 0.0002 | 0.001 | 0.279 | 0.017 | 0.015 | 3.09E-04 | 0.014 | 33.39 |
| Trucks - 3 ton | HHD-DSL | | 0.320 | 69.786 | 0.0013 | 0.001 | 0.694 | 0.043 | 0.039 | 0.001 | 0.151 | 70.16 |
| Truck - Water | HHD-DSL | | 0.320 | 69.786 | 0.0013 | 0.001 | 0.694 | 0.043 | 0.039 | 0.001 | 0.151 | 70.16 |
| **Off Road Vehicles** | **Fuel Type** | | | | | | | | | | | |
| Air Compressor 185 CFM | D | 50 | 0.287 | 22.271 | 0.011 | 0.0006 | 0.242 | 0.027 | 0.0253 | 0.0003 | 0.1220 | 22.68 |
| Air Compressor 750 CFM | D | 120 | 0.338 | 46.950 | 0.010 | 0.0014 | 0.625 | 0.056 | 0.0518 | 0.0006 | 0.1066 | 47.57 |
| Articulating Boom Platform | D | 120 | 0.252 | 38.072 | 0.007 | 0.0014 | 0.472 | 0.037 | 0.0345 | 0.000 | 0.074 | 38.63 |
| Bulldozer D10R | D | 250 | 0.810 | 183.487 | 0.026 | 0.0028 | 2.561 | 0.112 | 0.1034 | 0.002 | 0.289 | 184.91 |
| Bulldozer D4C | D | 120 | 0.508 | 65.811 | 0.015 | 0.0014 | 0.952 | 0.086 | 0.0792 | 0.001 | 0.164 | 66.54 |
| Concrete Trowel Machine | D | 50 | 0.156 | 14.108 | 0.006 | 0.0006 | 0.147 | 0.015 | 0.0138 | 0.000 | 0.063 | 14.40 |
| Concrete Vibrators | D | 50 | 0.156 | 14.108 | 0.006 | 0.0006 | 0.147 | 0.015 | 0.0138 | 0.000 | 0.063 | 14.40 |
| Cranes - Mobile 35 ton | D | 120 | 0.376 | 50.148 | 0.011 | 0.0014 | 0.690 | 0.063 | 0.0583 | 0.001 | 0.119 | 50.79 |
| Cranes - Mobile 45 ton | D | 175 | 0.491 | 80.345 | 0.012 | 0.0020 | 0.985 | 0.056 | 0.0519 | 0.001 | 0.128 | 81.20 |
| Crane - Mobile 65 ton | D | 175 | 0.491 | 80.345 | 0.012 | 0.0020 | 0.985 | 0.056 | 0.0519 | 0.001 | 0.128 | 81.20 |
| Cranes 100 / 150 ton cap | D | 250 | 0.366 | 112.159 | 0.012 | 0.0028 | 1.310 | 0.050 | 0.0461 | 0.001 | 0.131 | 113.28 |
| Diesel Powered Welder | D | 25 | 0.0685 | 11.2861 | 0.0024 | 0.0003 | 0.111 | 0.008 | 0.0074 | 0.0001 | 0.0268 | 11.42 |
| Backhoe/loader | D | 120 | 0.366 | 51.728 | 0.009 | 0.0014 | 0.607 | 0.055 | 0.0510 | 0.001 | 0.099 | 52.34 |
| Earth Scraper | D | 250 | 0.775 | 209.470 | 0.025 | 0.0028 | 2.616 | 0.106 | 0.0980 | 0.002 | 0.275 | 210.86 |
| Loader | D | 120 | 0.431 | 58.914 | 0.012 | 0.0014 | 0.766 | 0.070 | 0.0643 | 0.001 | 0.129 | 59.58 |
| Motor Grader | D | 120 | 0.552 | 74.965 | 0.015 | 0.0014 | 0.982 | 0.090 | 0.0827 | 0.001 | 0.166 | 75.70 |
| Excavator - Trencher | D | 120 | 0.490 | 64.895 | 0.014 | 0.0014 | 0.951 | 0.081 | 0.0742 | 0.001 | 0.159 | 65.62 |
| Fired Heaters | D | 25 | 0.055 | 13.217 | 0.002 | 0.0003 | 0.107 | 0.006 | 0.0055 | 0.0002 | 0.0167 | 13.34 |
| Forklift | D | 50 | 0.192 | 14.672 | 0.007 | 0.0006 | 0.157 | 0.018 | 0.0163 | 0.000 | 0.076 | 14.99 |
| Fusion Welder | D | 50 | 0.303 | 27.990 | 0.010 | 0.0006 | 0.283 | 0.028 | 0.0260 | 0.0004 | 0.1136 | 28.38 |
| Heavy Haul / Cranes | D | 750 | 1.200 | 303.045 | 0.029 | 0.0084 | 3.235 | 0.124 | 0.1136 | 0.003 | 0.324 | 306.28 |
| Light Plants | D | 25 | 0.055 | 13.217 | 0.002 | 0.0003 | 0.107 | 0.006 | 0.0055 | 0.000 | 0.017 | 13.34 |
| Portable Compaction Roller | D | 120 | 0.422 | 58.989 | 0.012 | 0.0014 | 0.778 | 0.067 | 0.0618 | 0.001 | 0.128 | 59.65 |
| Portable Compaction - Vibratory Plate | D | 15 | 0.026 | 4.314 | 0.000 | 0.0002 | 0.032 | 0.002 | 0.0016 | 0.000 | 0.005 | 4.38 |
| Portable Compaction - Vibratory Ram | D | 50 | 0.156 | 14.108 | 0.006 | 0.0006 | 0.147 | 0.015 | 0.0138 | 0.000 | 0.063 | 14.40 |
| Pumps | D | 25 | 0.055 | 13.2173 | 0.0015 | 0.0003 | 0.107 | 0.006 | 0.0055 | 0.0002 | 0.017 | 13.34 |

## On-Site Construction Equipment Emission Factors

*Hydrogen Energy, Inc*
*HECA Project*

*4/30/2009*

**Emission Factors (lbs/hr)**

| *Equipment Description* | EMFAC designation | Horsepower | CO | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | $SO_x$ | ROG [1] | $CO_2e$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Portable Power Generators | D | 50 | 0.297 | 30.6230 | 0.0107 | 0.0006 | 0.311 | 0.030 | 0.0273 | 0.0004 | 0.118 | 31.02 |
| Truck Crane - Greater than 300 ton | D | 500 | 0.716 | 180.101 | 0.017 | 0.0056 | 1.877 | 0.073 | 0.0668 | 0.002 | 0.191 | 182.21 |
| Truck Crane - Greater than 200 ton | D | 250 | 0.366 | 112.159 | 0.012 | 0.0028 | 1.310 | 0.050 | 0.0461 | 0.001 | 0.131 | 113.28 |
| Vibratory Roller 20 ton | D | 175 | 0.630 | 108.146 | 0.014 | 0.0020 | 1.271 | 0.069 | 0.0632 | 0.001 | 0.156 | 109.05 |

**Notes:**

(1) Assuming ROGs are equivalent to VOCs

(2) 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.

(3) 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.

(4) $PM_{2.5}$ 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

trucks in the San Joaquin Valley Air Basin (MHD =HHD). These emissions are in g/mile. On-road vehicles are limited to 10 mph, which is used to convert to lb/hr. (See GHG Reference Info tab)

(6) $N_2O$ factors for off-road vehicles are derived from California Climate Action Registry General Reporting Protocol Version 3.0 (April 2008), Table C.5 (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 lb/kg. $CH_4$ factors are from the SCAQMD data.

| | |
|---|---|
| $CO_2$ GWP (SAR, 1996) = | 1 |
| $CH_4$ GWP (SAR, 1996) = | 21 |
| $N_2O$ GWP (SAR, 1996) = | 310 |

## On-Site Construction Equipment Schedule

*Hydrogen Energy, Inc*
*HECA Project*

*5/21/2009*

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 | # units in months 17-28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **On Road Vehicles** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Concrete Pumper Truck | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 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 | 6 |
| Dump Truck | 32 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 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 |
| Service Truck - 1 ton | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| Pile Driver Truck | 12 | 0 | 0 | 0 | 1 | 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 | 0 |
| Truck - Fuel/Lube | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| Tractor Truck 5th Wheel | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| Trucks - Pickup 3/4 ton | 220 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 60 |
| Trucks - 3 ton | 67 | 0 | 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 | 24 |
| Truck - Water | 58 | 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 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| **Off Road Vehicles** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| Air Compressor 185 CFM | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| Air Compressor 750 CFM | 94 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 48 |
| Articulating Boom Platform | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| 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 | 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 | 0 |
| Concrete Trowel Machine | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 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 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| Concrete Vibrators | 36 | | | | | | | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | 9 |
| Cranes - Mobile 35 ton | 163 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 4 | 4 | 4 | 4 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 80 |
| Cranes - Mobile 45 ton | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| Crane - Mobile 65 ton | 116 | | | | | | | | | | | | | 1 | 2 | 4 | 4 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 4 | 4 | 3 | 2 | 2 | | | | | | | | 70 |
| Cranes 100 / 150 ton cap | 79 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 4 | 4 | 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 | 48 |
| Diesel Powered Welder | 101 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 41 |
| Backhoe/loader | 54 | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 2 | 2 | 2 | 2 | 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 | 6 |
| Earth Scraper | 26 | 8 | 8 | 5 | 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 | 0 |
| 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 | 0 |
| Motor Grader | 14 | 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 | 0 | 0 | 0 | 0 | 0 | 0 |
| Excavator - Trencher | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| Fired Heaters | 113 | 0 | 0 | 0 | 0 | 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 | 53 |
| Forklift | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 36 |
| Fusion Welder | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| Heavy Haul / Cranes | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 |
| Light Plants | 217 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 84 |
| 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 | 10 |
| Portable Compaction - Vibratory Plate | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| Portable Compaction - Vibratory Ram | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| Pumps | 93 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 24 |
| Portable Power Generators | 131 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 60 |
| Truck Crane - Greater than 200 ton | 72 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 42 |
| Truck Crane - Greater than 300 ton | 38 | | | | | | | | | | | | | | | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | | | | | | | | | | | | 27 |
| Vibratory Roller 20 ton | 31 | 3 | 3 | 3 | 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 |
| Misc equip for off plot construction (2) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| on road total | 409 | 12 | 13 | 13 | 14 | 14 | 14 | 14 | 13 | 13 | 13 | 12 | 12 | 11 | 11 | 11 | 10 | 10 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 7 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 5 | |
| off road total | 1679 | 27 | 27 | 28 | 30 | 26 | 27 | 29 | 34 | 35 | 37 | 41 | 42 | 46 | 51 | 52 | 52 | 55 | 54 | 56 | 60 | 63 | 58 | 59 | 60 | 61 | 61 | 58 | 55 | 49 | 47 | 47 | 45 | 40 | 34 | 28 | 26 | 16 | 11 | 10 | 9 | 9 | 9 | 8 | 7 | |
| **Project Total** | **2088** | **39** | **40** | **41** | **44** | **40** | **41** | **43** | **47** | **48** | **50** | **53** | **54** | **57** | **62** | **63** | **62** | **65** | **63** | **65** | **69** | **72** | **66** | **67** | **68** | **69** | **69** | **66** | **63** | **57** | **55** | **55** | **53** | **48** | **42** | **36** | **33** | **22** | **17** | **16** | **15** | **14** | **14** | **13** | **12** | |
| Schedule | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Site Mobilization | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Site Prep/Piling | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Construction | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Commissioning & Start-up | | | | | | | | | | | | | max | 72 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Notes: Preliminary and Confidential**
(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.
(3).Month with most onsite equipment is represented by

## Maximum Monthly On-Site Construction Exhaust Emissions — Emissions Summary

*Hydrogen Energy, Inc* *4/30/2009*
*HECA Project*

| Emissions Per Month (lbs/month) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Equipment Description** | | **# of Eq** | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_2$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_2$** | **ROG[1]** | **$CO_2e$** |
| | | | | | | | | | | | | |
| **On-Road Vehicles** | | | | | | | | | | | | |
| Concrete Pumper Truck | | 1 | 70 | 15353 | 0 | 0 | 153 | 9 | 9 | 0 | 33 | 15434 |
| Dump Truck | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Service Truck - 1 ton | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pile Driver Truck | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Truck - Fuel/Lube | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tractor Truck 5th Wheel | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Trucks - Pickup 3/4 ton | | 5 | 170 | 36498 | 0 | 1 | 307 | 18 | 17 | 0 | 16 | 36728 |
| Trucks - 3 ton | | 2 | 141 | 30706 | 1 | 0 | 305 | 19 | 17 | 0 | 66 | 30868 |
| Truck - Water | | 1 | 70 | 15353 | 0 | 0 | 153 | 9 | 9 | 0 | 33 | 15434 |
| **Off Road Vehicles** | | 0 | | | | | | | | | | |
| Air Compressor 185 CFM | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Air Compressor 750 CFM | | 4 | 297 | 41316 | 8 | 1 | 550 | 50 | 46 | 0 | 94 | 41863 |
| Articulating Boom Platform | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bulldozer D10R | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bulldozer D4C | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Concrete Trowel Machine | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Concrete Vibrators | | 1 | 34 | 3104 | 1 | 0 | 32 | 3 | 3 | 0 | 14 | 3168 |
| Cranes - Mobile 35 ton | | 7 | 580 | 77228 | 17 | 2 | 1063 | 98 | 90 | 1 | 183 | 78220 |
| Cranes - Mobile 45 ton | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crane - Mobile 65 ton | | 6 | 647 | 106055 | 15 | 3 | 1300 | 74 | 68 | 1 | 168 | 107181 |
| Cranes 100 / 150 ton cap | | 4 | 322 | 98700 | 10 | 2 | 1153 | 44 | 41 | 1 | 116 | 99687 |
| Diesel Powered Welder | | 3 | 45 | 7449 | 2 | 0 | 73 | 5 | 5 | 0 | 18 | 7540 |
| Backhoe/loader | | 1 | 81 | 11380 | 2 | 0 | 134 | 12 | 11 | 0 | 22 | 11514 |
| Earth Scraper | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Loader | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Motor Grader | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Excavator - Trencher | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fired Heaters | | 5 | 60 | 14539 | 2 | 0 | 118 | 7 | 6 | 0 | 18 | 14670 |
| Forklift | | 3 | 127 | 9683 | 5 | 0 | 103 | 12 | 11 | 0 | 50 | 9893 |
| Fusion Welder | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Heavy Haul / Cranes | | 5 | 1320 | 333349 | 32 | 9 | 3558 | 136 | 125 | 3 | 356 | 336905 |
| Light Plants | | 6 | 72 | 17447 | 2 | 0 | 141 | 8 | 7 | 0 | 22 | 17604 |
| Portable Compaction Roller | | 2 | 186 | 25955 | 5 | 1 | 342 | 30 | 27 | 0 | 56 | 26246 |
| Portable Compaction - Vibratory Plate | | 3 | 17 | 2847 | 0 | 0 | 21 | 1 | 1 | 0 | 3 | 2888 |
| Pumps | | 2 | 24 | 5816 | 1 | 0 | 47 | 3 | 2 | 0 | 7 | 5868 |
| Portable Power Generators | | 5 | 327 | 33685 | 12 | 1 | 343 | 33 | 30 | 0 | 130 | 34124 |
| Truck Crane - Greater than 300 ton | | 4 | 630 | 158489 | 15 | 5 | 1652 | 64 | 59 | 2 | 168 | 160345 |
| Truck Crane - Greater than 200 ton | | 2 | 161 | 49350 | 5 | 1 | 577 | 22 | 20 | 1 | 58 | 49844 |
| Vibratory Roller 20 ton | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Misc equip for off plot construction | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0 | 0 |
| On Road Total | | 9 | 451.6 | 97909.3 | 1.4 | 1.7 | 917.5 | 56.4 | 50.8 | 0.92 | 148.7 | 98465 |
| Off Road Total | | 63 | 4931.4 | 996392.1 | 133.9 | 27.0 | 11208.5 | 600.3 | 552.3 | 10.81 | 1483.6 | 1007558 |
| **Project Total** | | 72 | **5383.0** | **1094301** | **135.27** | **28.65** | **12126.0** | **656.70** | **603.1** | **11.74** | **1632.3** | **1106023** |

*Hydrogen Energy, Inc* *4/30/2009*
*HECA Project*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| max month 1-30 | | 5383 | 1094301 | 135.27 | 28.65 | 12126 | 656.70 | 603.08 | 11.74 | 1632.28 | 1106023 |
| max month 31-44 | | 3212 | 616428 | 80.18 | 15.65 | 6825 | 402.02 | 368.96 | 6.74 | 991.66 | 622965 |

$CH_4$ and $N_2O$ emission factors for the onroad vehicles are from reference source 2: Table C.5, California Climate Action Registry General Reporting Protocol Version 3.0, April 2007

| | |
|---|---|
| $CO_2$ GWP (SAR, 1996) = | 1 |
| $CH_4$ GWP (SAR, 1996) = | 21 |
| $N_2O$ GWP (SAR, 1996) = | 310 |

| **MODEL INPUTS** | CO | $NO_2$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ | construction |
|---|---|---|---|---|---|---|
| Max monthly value | 5383 | 12126 | 656.70 | 603.08 | 11.74 | days per month |
| (lb/month) | | | | | | 22 |
| Max daily value | 244.7 | 551.2 | 29.9 | 27.4 | 0.5 | construction |
| (lb/day) | | | | | | hours per day |
| Max 1-hour, 3-hour, 8-hour emission rate | **0.34** | **0.77** | 2.99 | 2.74 | **7.41E-04** | 10 |
| (lb/hour) | | | | | | pieces of equipment |
| Max 24-hour emission rate | | | **0.017** | **0.016** | **3.09E-04** | 72 |
| (lb/hour) | | | | | | |

## Maximum Rolling 12 Monthly On-Site Construction Exhaust Emissions — Emissions Summary

*Hydrogen Energy, Inc* — *5/21/2009*
*HECA Project*

| Month | CO Monthly Emissions (tons) | CO 12-Month Total (tons) | $CO_2$ Monthly Emissions (tons) | $CO_2$ 12-Month Total (tons) | $CH_4$ Monthly Emissions (tons) | $CH_4$ 12-Month Total (tons) | $N_2O$ Monthly Emissions (tons) | $N_2O$ 12-Month Total (tons) | $NO_2$ Monthly Emissions (tons) | $NO_2$ 12-Month Total (tons) | $PM_{10}$ Monthly Emissions (tons) | $PM_{10}$ 12-Month Total (tons) | $PM_{2.5}$ Monthly Emissions (tons) | $PM_{2.5}$ 12-Month Total (tons) | $SO_2$ Monthly Emissions (tons) | $SO_2$ 12-Month Total (tons) | ROG (1) Monthly Emissions (tons) | ROG (1) 12-Month Total (tons) | $CO_2e$ Monthly Emissions (tons) | $CO_2e$ 12-Month Total (tons) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.01 | NA | 424.63 | NA | 0.0505 | NA | 0.0069 | NA | 5.19 | NA | 0.280 | NA | 0.257 | NA | 0.0047 | NA | 0.671 | NA | 427.82 | NA |
| 2 | 2.04 | NA | 432.31 | NA | 0.0506 | NA | 0.0070 | NA | 5.27 | NA | 0.284 | NA | 0.261 | NA | 0.0048 | NA | 0.688 | NA | 435.54 | NA |
| 3 | 1.95 | NA | 385.22 | NA | 0.0472 | NA | 0.0066 | NA | 4.68 | NA | 0.273 | NA | 0.251 | NA | 0.0042 | NA | 0.649 | NA | 388.24 | NA |
| 4 | 1.98 | NA | 390.40 | NA | 0.0474 | NA | 0.0067 | NA | 4.72 | NA | 0.279 | NA | 0.256 | NA | 0.0043 | NA | 0.666 | NA | 393.46 | NA |
| 5 | 1.46 | NA | 256.15 | NA | 0.0306 | NA | 0.0049 | NA | 2.99 | NA | 0.207 | NA | 0.189 | NA | 0.0028 | NA | 0.481 | NA | 258.31 | NA |
| 6 | 1.47 | NA | 257.61 | NA | 0.0308 | NA | 0.0049 | NA | 3.00 | NA | 0.207 | NA | 0.190 | NA | 0.0028 | NA | 0.483 | NA | 259.77 | NA |
| 7 | 1.53 | NA | 264.67 | NA | 0.0326 | NA | 0.0051 | NA | 3.09 | NA | 0.216 | NA | 0.198 | NA | 0.0029 | NA | 0.503 | NA | 266.94 | NA |
| 8 | 1.45 | NA | 249.92 | NA | 0.0320 | NA | 0.0050 | NA | 2.89 | NA | 0.199 | NA | 0.183 | NA | 0.0027 | NA | 0.482 | NA | 252.13 | NA |
| 9 | 1.40 | NA | 240.27 | NA | 0.0311 | NA | 0.0049 | NA | 2.75 | NA | 0.188 | NA | 0.172 | NA | 0.0026 | NA | 0.472 | NA | 242.43 | NA |
| 10 | 1.44 | NA | 236.64 | NA | 0.0318 | NA | 0.0050 | NA | 2.70 | NA | 0.197 | NA | 0.180 | NA | 0.0026 | NA | 0.479 | NA | 238.85 | NA |
| 11 | 1.45 | NA | 232.98 | NA | 0.0335 | NA | 0.0050 | NA | 2.62 | NA | 0.193 | NA | 0.176 | NA | 0.0026 | NA | 0.482 | NA | 235.22 | NA |
| 12 | 1.52 | 19.70 | 257.43 | 3,628.23 | 0.0355 | 0.454 | 0.0059 | 0.0676 | 2.86 | 42.75 | 0.201 | 2.725 | 0.184 | 2.496 | 0.0028 | 0.0399 | 0.505 | 6.562 | 259.99 | 3,658.70 |
| 13 | 1.50 | 19.19 | 268.88 | 3,472.47 | 0.0357 | 0.439 | 0.0063 | 0.0670 | 2.96 | 40.52 | 0.191 | 2.637 | 0.175 | 2.415 | 0.0030 | 0.0382 | 0.492 | 6.383 | 271.57 | 3,502.45 |
| 14 | 1.69 | 18.84 | 295.88 | 3,336.04 | 0.0413 | 0.430 | 0.0070 | 0.0670 | 3.31 | 38.56 | 0.220 | 2.573 | 0.202 | 2.356 | 0.0033 | 0.0367 | 0.554 | 6.249 | 298.91 | 3,365.82 |
| 15 | 1.70 | 18.59 | 302.10 | 3,252.92 | 0.0420 | 0.424 | 0.0073 | 0.0677 | 3.39 | 37.28 | 0.223 | 2.523 | 0.205 | 2.310 | 0.0034 | 0.0359 | 0.562 | 6.162 | 305.24 | 3,282.82 |
| 16 | 1.68 | 18.29 | 297.73 | 3,160.24 | 0.0419 | 0.419 | 0.0072 | 0.0683 | 3.36 | 35.92 | 0.222 | 2.466 | 0.204 | 2.258 | 0.0033 | 0.0349 | 0.546 | 6.041 | 300.85 | 3,190.21 |
| 17 | 1.84 | 18.67 | 329.22 | 3,233.31 | 0.0463 | 0.435 | 0.0081 | 0.0715 | 3.71 | 36.65 | 0.240 | 2.499 | 0.220 | 2.289 | 0.0037 | 0.0358 | 0.595 | 6.155 | 332.71 | 3,264.61 |
| 18 | 1.79 | 19.00 | 319.99 | 3,295.69 | 0.0456 | 0.449 | 0.0079 | 0.0746 | 3.62 | 37.27 | 0.233 | 2.525 | 0.214 | 2.314 | 0.0036 | 0.0365 | 0.571 | 6.244 | 323.41 | 3,328.25 |
| 19 | 1.92 | 19.39 | 348.64 | 3,379.65 | 0.0487 | 0.465 | 0.0088 | 0.0782 | 3.94 | 38.12 | 0.248 | 2.557 | 0.227 | 2.343 | 0.0039 | 0.0375 | 0.607 | 6.347 | 352.38 | 3,413.69 |
| 20 | 2.47 | 20.41 | 492.76 | 3,622.50 | 0.0623 | 0.496 | 0.0127 | 0.0860 | 5.49 | 40.72 | 0.306 | 2.6633 | 0.281 | 2.442 | 0.0053 | 0.0401 | 0.757 | 6.622 | 498.02 | 3,659.58 |
| 21 max short-term | 2.69 | 21.70 | 547.15 | 3,929.38 | 0.0676 | 0.532 | 0.0143 | 0.0955 | 6.06 | 44.03 | 0.328 | 2.803 | 0.302 | 2.571 | 0.0059 | 0.0433 | 0.816 | 6.967 | 553.01 | 3,970.16 |
| 22 | 2.41 | 22.67 | 490.16 | 4,182.90 | 0.0609 | 0.561 | 0.0129 | 0.1034 | 5.43 | 46.77 | 0.293 | 2.899 | 0.269 | 2.660 | 0.0053 | 0.0460 | 0.727 | 7.214 | 495.43 | 4,226.74 |
| 23 | 2.45 | 23.67 | 501.39 | 4,451.31 | 0.0627 | 0.591 | 0.0132 | 0.1116 | 5.55 | 49.70 | 0.296 | 3.003 | 0.272 | 2.755 | 0.0054 | 0.0488 | 0.746 | 7.478 | 506.79 | 4,498.31 |
| 24 | 2.45 | 24.60 | 502.63 | 4,696.52 | 0.0630 | 0.618 | 0.0132 | 0.1189 | 5.57 | 52.40 | 0.297 | 3.099 | 0.273 | 2.844 | 0.0054 | 0.0513 | 0.749 | 7.722 | 508.05 | 4,746.37 |
| 25 | 2.46 | 25.57 | 503.87 | 4,931.51 | 0.0632 | 0.645 | 0.0132 | 0.1259 | 5.58 | 55.02 | 0.298 | 3.206 | 0.274 | 2.943 | 0.0054 | 0.0538 | 0.752 | 7.982 | 509.31 | 4,984.10 |
| 26 | 2.46 | 26.33 | 503.87 | 5,139.51 | 0.0632 | 0.667 | 0.0132 | 0.1322 | 5.58 | 57.29 | 0.298 | 3.284 | 0.274 | 3.014 | 0.0054 | 0.0559 | 0.752 | 8.181 | 509.31 | 5,194.50 |
| 27 | 2.25 | 26.87 | 459.51 | 5,296.92 | 0.0577 | 0.683 | 0.0120 | 0.1369 | 5.07 | 58.97 | 0.271 | 3.331 | 0.249 | 3.058 | 0.0050 | 0.0575 | 0.691 | 8.310 | 464.44 | 5,353.70 |
| 28 max 12 month perio | 1.85 | 27.04 | 359.50 | 5,358.70 | 0.0480 | 0.689 | 0.0092 | 0.1389 | 4.00 | 59.61 | 0.230 | 3.339 | 0.211 | 3.065 | 0.0040 | 0.0581 | 0.584 | 8.347 | 363.37 | 5,416.22 |
| 29 | 1.68 | 26.88 | 323.92 | 5,353.40 | 0.0426 | 0.685 | 0.0082 | 0.1390 | 3.59 | 59.49 | 0.210 | 3.308 | 0.193 | 3.038 | 0.0036 | 0.0580 | 0.523 | 8.275 | 327.36 | 5,410.87 |
| 30 | 1.61 | 26.70 | 308.21 | 5,341.62 | 0.0401 | 0.680 | 0.0078 | 0.1388 | 3.41 | 59.28 | 0.201 | 3.276 | 0.184 | 3.008 | 0.0034 | 0.0578 | 0.496 | 8.200 | 311.48 | 5,398.94 |
| 31 | 1.61 | 26.38 | 308.21 | 5,301.20 | 0.0401 | 0.671 | 0.0078 | 0.1379 | 3.41 | 58.75 | 0.201 | 3.229 | 0.184 | 2.965 | 0.0034 | 0.0573 | 0.496 | 8.089 | 311.48 | 5,358.04 |
| 32 | 1.49 | 25.40 | 276.07 | 5,084.50 | 0.0369 | 0.646 | 0.0069 | 0.1320 | 3.06 | 56.33 | 0.188 | 3.111 | 0.172 | 2.857 | 0.0030 | 0.0550 | 0.460 | 7.793 | 278.98 | 5,139.00 |
| 33 | 1.38 | 24.09 | 259.50 | 4,796.85 | 0.0339 | 0.612 | 0.0065 | 0.1242 | 2.88 | 53.15 | 0.176 | 2.959 | 0.162 | 2.717 | 0.0028 | 0.0520 | 0.428 | 7.404 | 262.23 | 4,848.22 |
| 34 | 1.16 | 22.83 | 206.99 | 4,513.68 | 0.0274 | 0.579 | 0.0050 | 0.1164 | 2.29 | 50.01 | 0.148 | 2.814 | 0.136 | 2.583 | 0.0023 | 0.0490 | 0.355 | 7.032 | 209.13 | 4,561.92 |
| 35 | 0.89 | 21.27 | 168.63 | 4,180.92 | 0.020 | 0.536 | 0.0041 | 0.1073 | 1.78 | 46.24 | 0.106 | 2.624 | 0.097 | 2.408 | 0.0018 | 0.0454 | 0.273 | 6.559 | 170.31 | 4,225.45 |
| 36 | 0.76 | 19.59 | 148.74 | 3,827.03 | 0.017 | 0.491 | 0.0037 | 0.0978 | 1.56 | 42.23 | 0.092 | 2.418 | 0.084 | 2.220 | 0.0016 | 0.0416 | 0.230 | 6.040 | 150.25 | 3,867.65 |
| 37 | 0.56 | 17.68 | 97.71 | 3,420.87 | 0.013 | 0.440 | 0.0024 | 0.0869 | 1.04 | 37.70 | 0.068 | 2.188 | 0.062 | 2.008 | 0.0011 | 0.0373 | 0.161 | 5.449 | 98.72 | 3,457.06 |
| 38 | 0.30 | 15.52 | 51.34 | 2,968.34 | 0.006 | 0.382 | 0.0011 | 0.0748 | 0.51 | 32.63 | 0.037 | 1.927 | 0.034 | 1.768 | 0.0006 | 0.0324 | 0.086 | 4.782 | 51.81 | 2,999.57 |
| 39 | 0.29 | 13.56 | 50.10 | 2,558.93 | 0.006 | 0.330 | 0.0011 | 0.0639 | 0.50 | 28.06 | 0.037 | 1.693 | 0.033 | 1.553 | 0.0005 | 0.0280 | 0.083 | 4.174 | 50.55 | 2,585.68 |
| 40 | 0.28 | 12.00 | 48.65 | 2,248.07 | 0.005 | 0.288 | 0.0011 | 0.0558 | 0.49 | 24.54 | 0.036 | 1.499 | 0.033 | 1.375 | 0.0005 | 0.0245 | 0.081 | 3.671 | 49.09 | 2,271.40 |
| 41 | 0.25 | 10.57 | 40.97 | 1,965.12 | 0.005 | 0.250 | 0.0009 | 0.0485 | 0.41 | 21.36 | 0.031 | 1.321 | 0.028 | 1.211 | 0.0004 | 0.0214 | 0.064 | 3.212 | 41.37 | 1,985.41 |
| 42 | 0.25 | 9.21 | 40.97 | 1,697.88 | 0.005 | 0.215 | 0.0009 | 0.0416 | 0.41 | 18.35 | 0.031 | 1.151 | 0.028 | 1.055 | 0.0004 | 0.0185 | 0.064 | 2.781 | 41.37 | 1,715.30 |
| 43 | 0.24 | 7.85 | 39.52 | 1,429.18 | 0.005 | 0.180 | 0.0009 | 0.0347 | 0.40 | 15.34 | 0.030 | 0.980 | 0.028 | 0.898 | 0.0004 | 0.0156 | 0.062 | 2.347 | 39.90 | 1,443.72 |
| 44 | 0.21 | 6.57 | 36.15 | 1,189.26 | 0.004 | 0.147 | 0.0008 | 0.0286 | 0.36 | 12.64 | 0.027 | 0.820 | 0.025 | 0.751 | 0.0004 | 0.0129 | 0.049 | 1.936 | 36.49 | 1,201.23 |
| Maximum (100 % load) | **2.69** | **27.04** | **547.15** | **5,358.70** | **0.0676** | **0.689** | **0.0143** | **0.1390** | **6.06** | **59.61** | **0.328** | **3.339** | **0.302** | **3.065** | **0.0059** | **0.0581** | **0.816** | **8.347** | **553.01** | **5,416.22** |
| Average (66 % load) | **1.78** | **17.85** | **361.12** | **3,536.74** | **0.04** | **0.455** | **0.0095** | **0.0917** | **4.00** | **39.34** | **0.217** | **2.203** | **0.199** | **2.023** | **0.0039** | **0.04** | **0.539** | **5.509** | **364.99** | **3,574.71** |
| | **66.27** | | **12,557.18** | | **1.61** | | **0.29** | | **141.50** | | **8.54** | | **7.83** | | **0.14** | | **20.98** | | **12,682.02** | |

**Note:**
(1) Assuming ROGs are equivalent to VOCs
(2) Assuming 66% operational average load

| MODEL INPUTS | NO2 | PM10 | PM2.5 | SO2 | |
|---|---|---|---|---|---|
| Max annual value (tons) | 39.34 | 2.203 | 2.023 | 0.04 | hours per year 8760 |
| Max annual value (pounds) | 78686.6 | 4406.9 | 4046.4 | 76.7 | |
| Max annual emission rate (lb/hr) | 8.98 | 0.50 | 0.46 | 0.0088 | |

## Off-Site Construction Equipment Emission Factors

*Hydrogen Energy, Inc* *4/30/2009*
*HECA Project*

| Emission Factors (lbs/hr) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Equipment Description*** | **EMFAC designation** | **Horsepower** | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_x$** | **ROG [(1)]** | **$CO_2e$** |
| **On-Road Vehicles** | | | | | | | | | | | | |
| Dump Truck | HHD-DSL | | 0.320 | 69.786 | 0.0018 | 0.001 | 0.694 | 0.043 | 0.039 | 0.001 | 0.151 | 70.165 |
| Service Truck | HHD-DSL | | 0.320 | 69.786 | 0.0018 | 0.001 | 0.694 | 0.043 | 0.039 | 0.001 | 0.151 | 70.165 |
| Pipe Haul Truck and Trailer (HHDT-DSL) | HHD-DSL | | 0.320 | 69.786 | 0.0018 | 0.001 | 0.694 | 0.043 | 0.039 | 0.001 | 0.151 | 70.165 |
| Trucks - Pickup 3/4 ton | MHD-DSL | | 0.155 | 33.180 | 0.0018 | 0.001 | 0.279 | 0.017 | 0.015 | 0.000 | 0.014 | 33.558 |
| Truck - Water | HHD-DSL | | 0.320 | 69.786 | 0.0018 | 0.001 | 0.694 | 0.043 | 0.039 | 0.001 | 0.151 | 70.165 |
| **Off Road Vehicles** | **Fuel Type** | | | | | | | | | | | |
| Air Compressor | D | 50 | 0.287 | 22.271 | 0.011 | 0.0006 | 0.242 | 0.027 | 0.0253 | 0.000 | 0.122 | 22.677 |
| Bore Machine (Hydraulic) | D | 50 | 0.261 | 31.037 | 0.006 | 0.0006 | 0.286 | 0.022 | 0.0204 | 0.000 | 0.067 | 31.338 |
| Crane | D | 250 | 0.366 | 112.159 | 0.012 | 0.0028 | 1.310 | 0.050 | 0.0461 | 0.001 | 0.131 | 113.281 |
| Backhoe | D | 120 | 0.366 | 51.728 | 0.009 | 0.0014 | 0.607 | 0.055 | 0.0510 | 0.001 | 0.099 | 52.335 |
| Excavator | D | 120 | 0.537 | 73.623 | 0.014 | 0.0014 | 0.900 | 0.084 | 0.0774 | 0.001 | 0.152 | 74.330 |
| Forklift | D | 50 | 0.227 | 31.225 | 0.006 | 0.0006 | 0.376 | 0.037 | 0.0343 | 0.000 | 0.066 | 31.525 |
| Generator (Welding) | D | 50 | 0.297 | 30.623 | 0.011 | 0.0006 | 0.311 | 0.030 | 0.0273 | 0.000 | 0.118 | 31.021 |
| Roller | D | 50 | 0.326 | 25.983 | 0.012 | 0.0006 | 0.279 | 0.031 | 0.0283 | 0.000 | 0.135 | 26.414 |
| Pipe Bending Machine | D | 50 | 0.303 | 27.990 | 0.010 | 0.0006 | 0.283 | 0.028 | 0.0260 | 0.000 | 0.114 | 28.379 |

**Notes:**

(1) Assuming ROGs are equivalent to VOCs

(2) Emission factors for on-road vehicles are based on results from Emfac Emissions Model 2010 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 2010.

(3) 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.

(4) $PM_{2.5}$ 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

(5) $CH_4$ and $N_2O$ factors are derived from California Climate Action Registry General Reporting Protocol Version 3.0 (April 2008), Table C.3 for LDT, MHD, and HHD diesel fueled trucks in the San Joaquin Valley Air Basin (MHD =HHD). These emissions are in g/mile. On-road vehicles are limited to 10 mph, which is used to convert to lb/hr. (See GHG Reference Info tab)

(6) $N_2O$ factors for off-road vehicles are derived from California Climate Action Registry General Reporting Protocol Version 3.0 (April 2008), Table C.5 (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 lb/kg. $CH_4$ factors are from the SCAQMD data.

| | |
|---|---|
| $CO_2$ GWP (SAR, 1996) = | 1 |
| $CH_4$ GWP (SAR, 1996) = | 21 |
| $N_2O$ GWP (SAR, 1996) = | 310 |

## Construction Schedule for Off-Site Construction Equipment

*Hydrogen Energy, Inc* *5/21/2009*
*HECA Project*

| Miscellaneous equipment for off plot construction (2) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Service Truck (MHD-DSL) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pipe Haul Truck and Trailer (HHDT-DSL | 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Truck (Pickup 3/4 Ton) - MHD-DSL | 17 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Truck - water | 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **OFF ROAD** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Air Compressor | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bore Machine (Hydraulic) | 5 | | | | | | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Crane | 5 | | | | | | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Backhoe | 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Excavator | 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Forklift | 4 | | | | | | | | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Welding Generator | 4 | | | | | | | | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Roller | 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pipe Bending Machine | 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **TOTAL** | **129** | **8** | **8** | **9** | **9** | **9** | **12** | **12** | **12** | **14** | **14** | **11** | **11** | **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** |

**Notes: Preliminary and Confidential**

(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.)

(3) Construction Equipment Assumptions - Water and Natural Gas line work begins in month 1 and ends in month 4. Process Water line work begins in month 5 and ends in month 8. CO2 line work begins in month 9 and ends in month 12. Transmission line work begins in month 6 and ends in month 10.

*Hydrogen Energy, Inc* *4/30/2009*
*HECA Project*

| Emissions Per Month (lbs/month) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Equipment Description** | | **# of Eq** | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_x$** | **ROG[1]** | **$CO_2$e** |
| | | | | | | | | | | | | |
| **ON ROAD** | | | | | | | | | | | | |
| Dump Truck | | 1 | 70 | 15353 | 0 | 0 | 153 | 9 | 9 | 0 | 33 | 15436 |
| Service Truck (MHD-DSL) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pipe Haul Truck and Trailer (HHDT-DSL) | | 1 | 70 | 15353 | 0 | 0 | 153 | 9 | 9 | 0 | 33 | 15436 |
| 3/4 Ton Pickup (MHD-DSL) | | 2 | 68 | 14599 | 1 | 0 | 123 | 7 | 7 | 0 | 6 | 14766 |
| Truck - water | | 1 | 70 | 15353 | 0 | 0 | 153 | 9 | 9 | 0 | 33 | 15436 |
| **OFF ROAD** | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Air Compressor (185 CFM) | | 1 | 63 | 4900 | 2 | 0 | 53 | 6 | 6 | 0 | 27 | 4989 |
| Bore Machine (Hydraulic) | | 1 | 57 | 6828 | 1 | 0 | 63 | 5 | 4 | 0 | 15 | 6894 |
| 12 Ton Hydra Crane | | 1 | 81 | 24675 | 3 | 1 | 288 | 11 | 10 | 0 | 29 | 24922 |
| Backhoe/loader | | 1 | 81 | 11380 | 2 | 0 | 134 | 12 | 11 | 0 | 22 | 11514 |
| Excavator - Trencher | | 1 | 118 | 16197 | 3 | 0 | 198 | 19 | 17 | 0 | 33 | 16353 |
| Forklift | | 1 | 50 | 6869 | 1 | 0 | 83 | 8 | 8 | 0 | 15 | 6935 |
| Welding Generator | | 1 | 65 | 6737 | 2 | 0 | 69 | 7 | 6 | 0 | 26 | 6825 |
| 3 to 5 Ton AC Roller | | 1 | 72 | 5716 | 3 | 0 | 61 | 7 | 6 | 0 | 30 | 5811 |
| Pipe Bending Machine | | 1 | 67 | 6158 | 2 | 0 | 62 | 6 | 6 | 0 | 25 | 6243 |
| On Road Total | | 5 | 279.1 | 60658 | 1.9 | 1.2 | 580.6 | 35.8 | 32.3 | 0.6 | 106.0 | 61075 |
| Off Road Total | | 9 | 653.7 | 89461 | 19.9 | 2.0 | 1011 | 80.4 | 73.9 | 1.1 | 221.1 | 90486 |
| **Project Total** | | **14** | **932.8** | **150118** | **21.9** | **3.2** | **1591** | **116.2** | **106.2** | **1.6** | **327.1** | **151561** |
| **ON ROAD** | | | | | | | | | | | | |
| Dump Truck | | 1 | 70 | 15353 | 0 | 0 | 153 | 9 | 9 | 0 | 33 | 15436 |
| Service Truck (MHD-DSL) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pipe Haul Truck and Trailer (HHDT-DSL) | | 1 | 70 | 15353 | 0 | 0 | 153 | 9 | 9 | 0 | 33 | 15436 |
| 3/4 Ton Pickup (MHD-DSL) | | 2 | 68 | 14599 | 1 | 0 | 123 | 7 | 7 | 0 | 6 | 14766 |
| Truck - water | | 1 | 70 | 15353 | 0 | 0 | 153 | 9 | 9 | 0 | 33 | 15436 |
| **OFF ROAD** | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Air Compressor (185 CFM) | | 1 | 63 | 4900 | 2 | 0 | 53 | 6 | 6 | 0 | 27 | 4989 |
| Bore Machine (Hydraulic) | | 1 | 57 | 6828 | 1 | 0 | 63 | 5 | 4 | 0 | 15 | 6894 |
| 12 Ton Hydra Crane | | 1 | 81 | 24675 | 3 | 1 | 288 | 11 | 10 | 0 | 29 | 24922 |
| Backhoe/loader | | 1 | 81 | 11380 | 2 | 0 | 134 | 12 | 11 | 0 | 22 | 11514 |
| Excavator - Trencher | | 1 | 118 | 16197 | 3 | 0 | 198 | 19 | 17 | 0 | 33 | 16353 |
| Forklift | | 1 | 50 | 6869 | 1 | 0 | 83 | 8 | 8 | 0 | 15 | 6935 |
| Welding Generator | | 1 | 65 | 6737 | 2 | 0 | 69 | 7 | 6 | 0 | 26 | 6825 |
| 3 to 5 Ton AC Roller | | 1 | 72 | 5716 | 3 | 0 | 61 | 7 | 6 | 0 | 30 | 5811 |
| Pipe Bending Machine | | 1 | 67 | 6158 | 2 | 0 | 62 | 6 | 6 | 0 | 25 | 6243 |
| On Road Total | | 5 | 279.1 | 60658 | 1.9 | 1.2 | 580.6 | 35.8 | 32.3 | 0.6 | 106.0 | 61075 |
| Off Road Total | | 9 | 653.7 | 89461 | 19.9 | 2.0 | 1011 | 80.4 | 73.9 | 1.1 | 221.1 | 90486 |
| **Project Total** | | **14** | **932.8** | **150118** | **21.9** | **3.2** | **1591** | **116.2** | **106.2** | **1.6** | **327.1** | **151561** |

## Maximum Rolling 12 Monthly Off-Site Construction Exhaust Emissions — Emissions Summary

*Hydrogen Energy, Inc* — *5/21/2009 5/21/2009*
*HECA Project*

| Month | CO Monthly Emissions (tons) | CO 12-Month Total (tons) | $CO_2$ Monthly Emissions (tons) | $CO_2$ 12-Month Total (tons) | $CH_4$ Monthly Emissions (tons) | $CH_4$ 12-Month Total (tons) | $N_2O$ Monthly Emissions (tons) | $N_2O$ 12-Month Total (tons) | $NO_x$ Monthly Emissions (tons) | $NO_x$ 12-Month Total (tons) | $PM_{10}$ Monthly Emissions (tons) | $PM_{10}$ 12-Month Total (tons) | $PM_{2.5}$ Monthly Emissions (tons) | $PM_{2.5}$ 12-Month Total (tons) | $SO_x$ Monthly Emissions (tons) | $SO_x$ 12-Month Total (tons) | ROG [(1)] Monthly Emissions (tons) | ROG [(1)] 12-Month Total (tons) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.29 | NA | 46.40 | NA | 0.01 | NA | 0.0009 | NA | 0.49 | NA | 0.038 | NA | 0.035 | NA | 0.0005 | NA | 0.11 | NA |
| 2 | 0.29 | NA | 46.40 | NA | 0.01 | NA | 0.0009 | NA | 0.49 | NA | 0.038 | NA | 0.035 | NA | 0.0005 | NA | 0.11 | NA |
| 3 | 0.32 | NA | 48.85 | NA | 0.01 | NA | 0.0010 | NA | 0.51 | NA | 0.041 | NA | 0.037 | NA | 0.0005 | NA | 0.12 | NA |
| 4 | 0.32 | NA | 48.85 | NA | 0.01 | NA | 0.000968 | NA | 0.51 | NA | 0.041 | NA | 0.037 | NA | 0.0005 | NA | 0.120 | NA |
| 5 | 0.32 | NA | 48.85 | NA | 0.01 | NA | 0.0010 | NA | 0.51 | NA | 0.041 | NA | 0.037 | NA | 0.0005 | NA | 0.12 | NA |
| 6 | 0.41 | NA | 68.26 | NA | 0.01 | NA | 0.0015 | NA | 0.72 | NA | 0.051 | NA | 0.046 | NA | 0.0007 | NA | 0.14 | NA |
| 7 | 0.41 | NA | 68.26 | NA | 0.01 | NA | 0.0015 | NA | 0.72 | NA | 0.051 | NA | 0.046 | NA | 0.0007 | NA | 0.14 | NA |
| 8 | 0.41 | NA | 68.26 | NA | 0.01 | NA | 0.0015 | NA | 0.72 | NA | 0.051 | NA | 0.046 | NA | 0.0007 | NA | 0.14 | NA |
| 9 | 0.47 | NA | 75.06 | NA | 0.01 | NA | 0.0016 | NA | 0.80 | NA | 0.058 | NA | 0.053 | NA | 0.0008 | NA | 0.16 | NA |
| 10 max short term | 0.47 | NA | 75.06 | NA | 0.01 | NA | 0.001585 | NA | 0.80 | NA | 0.058 | NA | 0.053 | NA | 0.0008 | NA | 0.164 | NA |
| 11 | 0.38 | NA | 55.66 | NA | 0.01 | NA | 0.001092 | NA | 0.59 | NA | 0.048 | NA | 0.044 | NA | 0.0006 | NA | 0.140 | NA |
| 12 max 12 month perioc | 0.38 | 4.47 | 55.66 | 705.58 | 0.01 | 0.099 | 0.001092 | 0.0145 | 0.59 | 7.45 | 0.048 | 0.563 | 0.044 | 0.514 | 0.0006 | 0.0076 | 0.140 | 1.610 |
| 13 | 0.00 | 4.18 | 0.00 | 659.17 | 0.00 | 0.093 | 0.000000 | 0.0135 | 0.00 | 6.96 | 0.000 | 0.526 | 0.000 | 0.480 | 0.0000 | 0.0071 | 0.000 | 1.503 |
| 14 | 0.00 | 3.89 | 0.00 | 612.77 | 0.00 | 0.0877 | 0.00 | 0.01264 | 0.00 | 6.47 | 0.00 | 0.488 | 0.00 | 0.445 | 0.00 | 0.0066 | 0.00 | 1.397 |
| 15 | 0.00 | 3.56 | 0.00 | 563.91 | 0.00 | 0.0807 | 0.00 | 0.01167 | 0.00 | 5.96 | 0.00 | 0.447 | 0.00 | 0.408 | 0.00 | 0.0061 | 0.00 | 1.277 |
| 16 | 0.00 | 3.24 | 0.00 | 515.06 | 0.00 | 0.0737 | 0.00 | 0.0107 | 0.00 | 5.44 | 0.00 | 0.406 | 0.00 | 0.371 | 0.00 | 0.0056 | 0.00 | 1.157 |
| 17 | 0.00 | 2.92 | 0.00 | 466.20 | 0.00 | 0.067 | 0.00 | 0.0097 | 0.00 | 4.93 | 0.00 | 0.365 | 0.00 | 0.333 | 0.00 | 0.005 | 0.00 | 1.037 |
| 18 | 0.00 | 2.51 | 0.00 | 397.95 | 0.00 | 0.058 | 0.00 | 0.0083 | 0.00 | 4.21 | 0.00 | 0.314 | 0.00 | 0.287 | 0.00 | 0.004 | 0.00 | 0.894 |
| 19 | 0.00 | 2.10 | 0.00 | 329.69 | 0.00 | 0.049 | 0.00 | 0.0068 | 0.00 | 3.49 | 0.00 | 0.263 | 0.00 | 0.241 | 0.00 | 0.004 | 0.00 | 0.751 |
| 20 | 0.00 | 1.69 | 0.00 | 261.43 | 0.00 | 0.039 | 0.00 | 0.0054 | 0.00 | 2.77 | 0.00 | 0.213 | 0.00 | 0.194 | 0.00 | 0.003 | 0.00 | 0.607 |
| 21 | 0.00 | 1.23 | 0.00 | 186.38 | 0.00 | 0.029 | 0.00 | 0.0038 | 0.00 | 1.97 | 0.00 | 0.155 | 0.00 | 0.141 | 0.00 | 0.002 | 0.00 | 0.444 |
| 22 | 0.00 | 0.76 | 0.00 | 111.32 | 0.00 | 0.018 | 0.00 | 0.0022 | 0.00 | 1.18 | 0.00 | 0.097 | 0.00 | 0.088 | 0.00 | 0.001 | 0.00 | 0.280 |
| 23 | 0.00 | 0.38 | 0.00 | 55.66 | 0.00 | 0.009 | 0.00 | 0.0011 | 0.00 | 0.59 | 0.00 | 0.048 | 0.00 | 0.044 | 0.00 | 0.001 | 0.00 | 0.140 |
| 24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 37 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 39 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 41 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| 44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| Maximum (100 % load) | **0.47** | **4.47** | # **75.06** | **705.58** | # **0.01** | **0.0991** | # **0.001585** | **0.0145** | # **0.80** | **7.45** | # **0.058** | **0.563** | # **0.053** | **0.514** | # **0.0008** | **0.0076** | # **0.164** | **1.610** |
| Average (66 % load) | **0.31** | **2.95** | # **49.54** | **465.68** | # **0.01** | **0.07** | # **0.0010** | **0.0095** | # **0.53** | **4.91** | # **0.038** | **0.372** | # **0.035** | **0.340** | # **0.0005** | **0.01** | # **0.11** | **1.06** |

**Note:**
(1) Assuming ROGs are equivalent to VOCs
(2) Assuming 66% operational average load

| | 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 | 2.30 | NA | 471.04 | NA | 0.0562 | NA | 0.0078 | NA | 5.68 | NA | 0.318 | NA | 0.291 | NA | 0.00518 | NA | 0.78 | NA |
| 2 | 2.33 | NA | 478.72 | NA | 0.0564 | NA | 0.0079 | NA | 5.75 | NA | 0.322 | NA | 0.295 | NA | 0.00525 | NA | 0.79 | NA |
| 3 | 2.28 | NA | 434.08 | NA | 0.0541 | NA | 0.0075 | NA | 5.19 | NA | 0.314 | NA | 0.288 | NA | 0.00477 | NA | 0.77 | NA |
| 4 | 2.30 | NA | 439.25 | NA | 0.0543 | NA | 0.0076 | NA | 5.24 | NA | 0.320 | NA | 0.293 | NA | 0.00482 | NA | 0.79 | NA |
| 5 | 1.78 | NA | 305.01 | NA | 0.0376 | NA | 0.0058 | NA | 3.50 | NA | 0.248 | NA | 0.226 | NA | 0.00331 | NA | 0.60 | NA |
| 6 | 1.88 | NA | 325.86 | NA | 0.0399 | NA | 0.0064 | NA | 3.72 | NA | 0.258 | NA | 0.236 | NA | 0.00355 | NA | 0.63 | NA |
| 7 | 1.93 | NA | 332.93 | NA | 0.0417 | NA | 0.0066 | NA | 3.81 | NA | 0.267 | NA | 0.244 | NA | 0.00363 | NA | 0.65 | NA |
| 8 | 1.86 | NA | 318.17 | NA | 0.0411 | NA | 0.0064 | NA | 3.61 | NA | 0.250 | NA | 0.229 | NA | 0.00349 | NA | 0.62 | NA |
| 9 | 1.87 | NA | 315.33 | NA | 0.0421 | NA | 0.0064 | NA | 3.55 | NA | 0.247 | NA | 0.226 | NA | 0.00347 | NA | 0.64 | NA |
| 10 | 1.91 | NA | 311.70 | NA | 0.0428 | NA | 0.0066 | NA | 3.49 | NA | 0.255 | NA | 0.233 | NA | 0.00343 | NA | 0.64 | NA |
| 11 | 1.83 | NA | 288.64 | NA | 0.0422 | NA | 0.0061 | NA | 3.21 | NA | 0.241 | NA | 0.220 | NA | 0.00320 | NA | 0.62 | NA |
| 12 | 1.90 | 24.17 | 313.08 | 4,334 | 0.0443 | 0.553 | 0.00696 | 0.0820 | 3.45 | 50.20 | 0.249 | 3.289 | 0.228 | 3.011 | 0.00345 | 0.048 | 0.65 | 8.172 |
| 13 | 1.50 | 23.37 | 268.88 | 4,132 | 0.0357 | 0.532 | 0.00626 | 0.0805 | 2.957 | 47.48 | 0.191 | 3.163 | 0.175 | 2.895 | 0.00298 | 0.045 | 0.49 | 7.887 |
| 14 | 1.69 | 22.73 | 295.88 | 3,949 | 0.0413 | 0.517 | 0.00698 | 0.0796 | 3.310 | 45.03 | 0.220 | 3.061 | 0.202 | 2.802 | 0.00330 | 0.043 | 0.55 | 7.646 |
| 15 | 1.70 | 22.16 | 302.10 | 3,817 | 0.0420 | 0.505 | 0.0073 | 0.0794 | 3.39 | 43.24 | 0.223 | 2.969 | 0.205 | 2.718 | 0.00337 | 0.042 | 0.56 | 7.439 |
| 16 | 1.68 | 21.53 | 297.73 | 3,675 | 0.0419 | 0.493 | 0.0072 | 0.0790 | 3.36 | 41.36 | 0.222 | 2.871 | 0.204 | 2.629 | 0.00333 | 0.041 | 0.55 | 7.199 |
| 17 | 1.84 | 21.59 | 329.22 | 3,700 | 0.0463 | 0.501 | 0.0081 | 0.0813 | 3.71 | 41.58 | 0.240 | 2.864 | 0.220 | 2.623 | 0.00366 | 0.041 | 0.60 | 7.193 |
| 18 | 1.79 | 21.51 | 319.99 | 3,694 | 0.0456 | 0.507 | 0.0079 | 0.0829 | 3.62 | 41.48 | 0.233 | 2.839 | 0.214 | 2.601 | 0.00357 | 0.041 | 0.57 | 7.138 |
| 19 | 1.92 | 21.49 | 348.64 | 3,709 | 0.0487 | 0.514 | 0.0088 | 0.0851 | 3.94 | 41.61 | 0.248 | 2.820 | 0.227 | 2.584 | 0.00386 | 0.041 | 0.61 | 7.098 |
| 20 | 2.47 | 22.11 | 492.76 | 3,884 | 0.0623 | 0.535 | 0.0127 | 0.0914 | 5.49 | 43.49 | 0.306 | 2.876 | 0.281 | 2.636 | 0.00532 | 0.043 | 0.76 | 7.230 |
| 21 | 2.69 | 22.93 | 547.15 | 4,116 | 0.0676 | 0.561 | 0.0143 | 0.0993 | 6.06 | 46.00 | 0.328 | 2.958 | 0.302 | 2.712 | 0.00587 | 0.045 | 0.816 | 7.410 |
| 22 | 2.41 | 23.43 | 490.16 | 4,294 | 0.0609 | 0.579 | 0.0129 | 0.1056 | 5.43 | 47.94 | 0.293 | 2.996 | 0.269 | 2.748 | 0.00527 | 0.047 | 0.73 | 7.495 |
| 23 | 2.45 | 24.05 | 501.39 | 4,507 | 0.0627 | 0.599 | 0.0132 | 0.1127 | 5.55 | 50.29 | 0.296 | 3.051 | 0.272 | 2.800 | 0.00540 | 0.049 | 0.75 | 7.618 |
| 24 | 2.45 | 24.60 | 502.63 | 4,697 | 0.0630 | 0.618 | 0.0132 | 0.1189 | 5.57 | 52.40 | 0.297 | 3.099 | 0.273 | 2.844 | 0.00541 | 0.051 | 0.75 | 7.722 |
| 25 | 2.46 | 25.57 | 503.87 | 4,932 | 0.0632 | 0.645 | 0.0132 | 0.1259 | 5.58 | 55.02 | 0.298 | 3.206 | 0.274 | 2.943 | 0.00543 | 0.054 | 0.75 | 7.982 |
| 26 | 2.46 | 26.33 | 503.87 | 5,140 | 0.0632 | 0.667 | 0.0132 | 0.1322 | 5.58 | 57.29 | 0.298 | 3.284 | 0.274 | 3.014 | 0.00543 | 0.056 | 0.75 | 8.181 |
| 27 | 2.25 | 26.87 | 459.51 | 5,297 | 0.0577 | 0.683 | 0.0120 | 0.1369 | 5.07 | 58.97 | 0.271 | 3.331 | 0.249 | 3.058 | 0.00496 | 0.058 | 0.69 | 8.310 |
| 28 | 1.85 | 27.04 | 359.50 | 5,359 | 0.0480 | 0.689 | 0.0092 | 0.1389 | 4.00 | 59.61 | 0.230 | 3.339 | 0.211 | 3.065 | 0.00396 | 0.058 | 0.58 | 8.347 |
| 29 | 1.68 | 26.88 | 323.92 | 5,353 | 0.0426 | 0.685 | 0.0082 | 0.1390 | 3.59 | 59.49 | 0.210 | 3.308 | 0.193 | 3.038 | 0.00355 | 0.058 | 0.52 | 8.275 |
| 30 | 1.61 | 26.70 | 308.21 | 5,342 | 0.0401 | 0.680 | 0.0078 | 0.1388 | 3.41 | 59.28 | 0.201 | 3.276 | 0.184 | 3.008 | 0.00337 | 0.058 | 0.50 | 8.200 |
| 31 | 1.61 | 26.38 | 308.21 | 5,301 | 0.0401 | 0.671 | 0.0078 | 0.1379 | 3.41 | 58.75 | 0.201 | 3.229 | 0.184 | 2.965 | 0.00337 | 0.057 | 0.50 | 8.089 |
| 32 | 1.49 | 25.40 | 276.07 | 5,085 | 0.0369 | 0.646 | 0.0069 | 0.1320 | 3.06 | 56.33 | 0.188 | 3.111 | 0.172 | 2.857 | 0.00303 | 0.055 | 0.46 | 7.793 |
| 33 | 1.38 | 24.09 | 259.50 | 4,797 | 0.0339 | 0.612 | 0.0065 | 0.1242 | 2.88 | 53.15 | 0.176 | 2.959 | 0.162 | 2.717 | 0.00284 | 0.052 | 0.43 | 7.404 |
| 34 | 1.16 | 22.83 | 206.99 | 4,514 | 0.0274 | 0.579 | 0.0050 | 0.1164 | 2.29 | 50.01 | 0.148 | 2.814 | 0.136 | 2.583 | 0.00227 | 0.049 | 0.35 | 7.032 |
| 35 | 0.89 | 21.27 | 168.63 | 4,181 | 0.0200 | 0.536 | 0.0041 | 0.1073 | 1.78 | 46.24 | 0.106 | 2.624 | 0.097 | 2.408 | 0.00182 | 0.045 | 0.27 | 6.559 |
| 36 | 0.76 | 19.59 | 148.74 | 3,827 | 0.0174 | 0.491 | 0.0037 | 0.0978 | 1.56 | 42.23 | 0.092 | 2.418 | 0.084 | 2.220 | 0.00161 | 0.042 | 0.23 | 6.040 |
| 37 | 0.56 | 17.68 | 97.71 | 3,421 | 0.0126 | 0.440 | 0.0024 | 0.0869 | 1.04 | 37.70 | 0.068 | 2.188 | 0.062 | 2.008 | 0.00106 | 0.037 | 0.16 | 5.449 |
| 38 | 0.30 | 15.52 | 51.34 | 2,968 | 0.0058 | 0.382 | 0.0011 | 0.0748 | 0.51 | 32.63 | 0.037 | 1.927 | 0.034 | 1.768 | 0.00056 | 0.032 | 0.09 | 4.782 |
| 39 | 0.29 | 13.56 | 50.10 | 2,559 | 0.0055 | 0.330 | 0.0011 | 0.0639 | 0.50 | 28.06 | 0.037 | 1.693 | 0.033 | 1.553 | 0.00054 | 0.028 | 0.08 | 4.174 |
| 40 | 0.28 | 12.00 | 48.65 | 2,248 | 0.0054 | 0.288 | 0.0011 | 0.0558 | 0.49 | 24.54 | 0.036 | 1.499 | 0.033 | 1.375 | 0.00052 | 0.025 | 0.08 | 3.671 |
| 41 | 0.25 | 10.57 | 40.97 | 1,965 | 0.0052 | 0.250 | 0.0009 | 0.0485 | 0.41 | 21.36 | 0.031 | 1.321 | 0.028 | 1.211 | 0.00045 | 0.021 | 0.06 | 3.212 |
| 42 | 0.25 | 9.21 | 40.97 | 1,698 | 0.0052 | 0.215 | 0.0009 | 0.0416 | 0.41 | 18.35 | 0.031 | 1.151 | 0.028 | 1.055 | 0.00045 | 0.019 | 0.06 | 2.781 |
| 43 | 0.24 | 7.85 | 39.52 | 1,429 | 0.0050 | 0.180 | 0.0009 | 0.0347 | 0.40 | 15.34 | 0.030 | 0.980 | 0.028 | 0.898 | 0.00043 | 0.016 | 0.06 | 2.347 |
| 44 | 0.21 | 6.57 | 36.15 | 1,189 | 0.0039 | 0.147 | 0.0008 | 0.0286 | 0.36 | 12.64 | 0.027 | 0.820 | 0.025 | 0.751 | 0.00039 | 0.013 | 0.05 | 1.936 |
| Maximum (100 % load) | **2.69** | **27.04** | # **547.15** | **5,359** | # **0.0676** | **0.689** | # **0.0143** | **0.1390** | # **6.063** | **59.61** | # **0.328** | **3.339** | # **0.302** | **3.065** | # **0.00587** | **0.058** | # **0.816** | **8.347** |
| Average (66 % load) | **1.78** | **17.85** | # **361.12** | **3,537** | # **0.045** | **0.45** | # **0.0095** | **0.0917** | # **4.00** | **39.34** | # **0.217** | **2.203** | # **0.199** | **2.023** | # **0.004** | **0.04** | # **0.54** | **5.51** |

**Note:**
(1) Assuming ROGs are equivalent to VOCs
(2) Assuming 66% operational average load

*Hydrogen Energy, Inc*
*HECA Project*
*5/21/2009*

**Short term fugitive Dust Emissions**
Maximum construction activity occurs in month 21.

1 month of dirt moving
22 construction days per month
10 construction hours per day

**Dirt Piling or Material Handling**
$E = 0.00112 * (G/5)^{1.3} / (H/2)^{1.4}$

$PM_{10}$ Emissions from Dirt Piling or Material Handling (lb/hr) from SCAQMD Table A9-9-G

12 G = Mean Wind speed (mph) default
15 H = Moisture content of surface material (%) (from Table A9-9-G-1 for moist dirt)
0.00021 lb/ton of $PM_{10}$

| Equipment | Quantity | Hours/Day | Material Handled (ton/day) | Material Handled (ton) | Watering Control Efficiency | $PM_{10}$ Emissions (lb/hr) | $PM_{10}$ Emissions (lb/day) | $PM_{2.5}$ Emissions (lb/hr) | $PM_{2.5}$ Emissions (lb/day) |
|---|---|---|---|---|---|---|---|---|---|
| Backhoe | 1 | 10 | 34851 | 766,729 | 67% | 0.2394 | 2.3941 | 0.0498 | 0.4980 |
| | | | | | **Total** | **0.2394** | **2.3941** | **0.0498** | **0.4980** |

Water efficiency from CEQA Table 11-4 watering 3 times daily or using chemical suppressants

29535 yd$^3$/day    34851 ton/day
649,770 yd$^3$    766,729 tons    2360 density of soil (lb/yd$^3$)
(USDA NRCS Physical Soil Properties from Kern County
for Lockern-Buttonwillow clay)
134.25 acres =    649,770 cubic yds, assume depth of soils moved is    1 yd
(assume 25% of entire site in month 21)

**Cover Storage Pile**
SCAQMD Table A9-9-E
E = 1.7 * G/1.5 * (365-H)/235 * I/15 * J
$PM_{10}$ Emission factor from wind erosion of storage piles per day per acre

15 G = Silt content (%) (from Table A9-9-E-1 for blended ore and dirt)
37 H = Mean number of days per year with at least 0.01 inches of precipitation (from WRCC for Bakersfield Airport Station)
0.3 I = Percentage of time that the unobstructed wind speed exceeds 12 mph at mean pile height
0.5 J = Fraction of TSP that is PM10 = 0.5
0.237 lb/acre/day

wind speed percentage based on 2000-04 (5 yrs) of wind speed data as recorded at Bakersfield Airport station

| Source | Quantity | Size of Pile (acre) | Hours/Day | Watering Control Efficiency | $PM_{10}$ Emissions (lb/hr) | $PM_{10}$ Emissions (lb/day) | $PM_{2.5}$ Emissions (lb/hr) | $PM_{2.5}$ Emissions (lb/day) |
|---|---|---|---|---|---|---|---|---|
| Cover Storage Pile | 25 | 0.25 | 24 | 67% | 0.02 | 0.49 | 0.004 | 0.102 |

Water efficiency from CEQA Table 11-4 watering 3 times daily or using chemical suppressants
pile size and number are assumed

## Monthly On-Site Fugitive Dust Emissions — Emissions Summary

*Hydrogen Energy, Inc*
*HECA Project*

*5/21/2009*

**Travel on unpaved road**

$F = 2.1 * G/12 * H/30 * (J/3)^{0.7} * (I/4)^{0.5} * (365-K)/365$ SCAQMD Table A9-9-D

Emission factor for vehicle travel on unpaved roads (lb/VMT)

4 G = Surface silt loading (%) (value for gravel road)
5 H = Mean vehicle speed (mph)
value listed in table I = Mean number of wheels on vehicle
value listed in table J = Mean vehicle weight (ton)
37 K = Mean number of days per year with at least 0.01 inches of precipitation (from WRCC for Bakersfield Airport Station)

| Vehicle Type | No. Of Unit | Round Trips /Day/ Unit | Round Trip Distance (mile) | Daily VMT (all units) | Mean Vehicle Weight (tons) | Number of Wheels on Vehicle | PM10 EF (lbs/VMT) | Watering Control Efficiency | $PM_{10}$ Emissions (lb/hr) | $PM_{10}$ Emissions (lb/day) | $PM_{2.5}$ Emissions (lb/hr) | $PM_{2.5}$ Emissions (lb/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Concrete Pumper Truck | 1 | 2 | 1 | 2.0 | 30 | 10 | 0.83 | 67% | 0.05 | 0.55 | 0.01 | 0.12 |
| Dump Truck | 0 | | | 0.0 | 15 | 10 | 0.51 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Service Truck - 1 ton | 0 | | | 0.0 | 15 | 10 | 0.51 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Pile Driver Truck | 0 | | | 0.0 | 15 | 10 | 0.51 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Truck - Fuel/Lube | 0 | | | 0.0 | 15 | 10 | 0.51 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Tractor Truck 5th Wheel | 0 | | | 0.0 | 11 | 10 | 0.41 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Trucks - Pickup 3/4 ton | 5 | 10 | 0.5 | 25.0 | 3 | 4 | 0.10 | 67% | 0.09 | 0.86 | 0.02 | 0.18 |
| Trucks - 3 ton | 2 | 2 | 1 | 4.0 | 11 | 10 | 0.41 | 67% | 0.05 | 0.54 | 0.01 | 0.12 |
| Truck - Water | 1 | 4 | 10 | 40.0 | 25 | 10 | 0.73 | 67% | 0.97 | 9.65 | 0.20 | 2.05 |
| Air Compressor 185 CFM | 0 | | | 0.0 | 0.5 | 2 | 0.02 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Air Compressor 750 CFM | 4 | 1 | 0.1 | 0.4 | 0.5 | 2 | 0.02 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Articulating Boom Platform | 0 | | | 0.0 | 5 | 10 | 0.24 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Bulldozer D10R | 0 | | | 0.0 | 35 | 2 | 0.41 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Bulldozer D4C | 0 | | | 0.0 | 15 | 2 | 0.23 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Concrete Trowel Machine | 0 | | | 0.0 | 15 | 8 | 0.46 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Concrete Vibrators | 1 | 0 | 0 | 0.0 | 0.25 | 0 | 0.00 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Cranes - Mobile 35 ton | 7 | 1 | 0.5 | 3.5 | 25 | 12 | 0.80 | 67% | 0.09 | 0.93 | 0.02 | 0.20 |
| Cranes - Mobile 45 ton | 0 | | | 0.0 | 35 | 2 | 0.41 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Crane - Mobile 65 ton | 6 | 1 | 0.5 | 3.0 | 45 | 2 | 0.49 | 67% | 0.05 | 0.49 | 0.01 | 0.10 |
| Cranes 100 / 150 ton cap | 4 | 1 | 0.5 | 2.0 | 50 | 12 | 1.30 | 67% | 0.09 | 0.86 | 0.02 | 0.18 |
| Diesel Powered Welder | 3 | 0 | 0 | 0.0 | 0.5 | 2 | 0.02 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Backhoe/loader | 1 | 5 | 0.5 | 2.5 | 11 | 4 | 0.26 | 67% | 0.02 | 0.21 | 0.00 | 0.05 |
| Earth Scraper | 0 | | | 0.0 | 40 | 4 | 0.64 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Loader | 0 | | | 0.0 | 25 | 4 | 0.46 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Motor Grader | 0 | | | 0.0 | 20 | 6 | 0.48 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Excavator - Trencher | 0 | | | 0.0 | 17 | 4 | 0.35 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Fired Heaters | 5 | 0 | 0 | 0.0 | 0.25 | 0 | 0.00 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Forklift | 3 | 5 | 0.5 | 7.5 | 10 | 4 | 0.24 | 67% | 0.06 | 0.60 | 0.01 | 0.13 |
| Fusion Welder | 0 | | | 0.0 | 0.25 | 2 | 0.01 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Heavy Haul / Cranes | 5 | 1 | 0 | 0.0 | 75 | 2 | 0.71 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Light Plants | 6 | 1 | 0 | 0.0 | 0.5 | 4 | 0.03 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Portable Compaction Roller | 2 | 1 | 0.5 | 1.0 | 3 | 3 | 0.09 | 67% | 0.00 | 0.03 | 0.00 | 0.01 |
| Portable Compaction - Vibratory Plate | 3 | 1 | 0.1 | 0.3 | 0.1 | 0 | 0.00 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Portable Compaction - Vibratory Ram | 0 | | | 0.0 | 0.25 | 0 | 0.00 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Pumps | 2 | 1 | 0 | 0.0 | 0.1 | 0 | 0.00 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Portable Power Generators | 5 | 0 | 0 | 0.0 | 0.5 | 4 | 0.03 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| Truck Crane - Greater than 200 ton | 4 | 1 | 0.5 | 2.0 | 50 | 12 | 1.30 | 67% | 0.09 | 0.86 | 0.02 | 0.18 |
| Truck Crane - Greater than 300 ton | 2 | 1 | 0.5 | 1.0 | 60 | 12 | 1.48 | 67% | 0.05 | 0.49 | 0.01 | 0.10 |
| Vibratory Roller 20 ton | 0 | | | 0.0 | 20 | 3 | 0.34 | 67% | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | | | **Total** | **1.61** | **16.08** | **0.34** | **3.41** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| worker personal vehicles | 857 | 1 | 0.5 | 428.7 | 3 | 4 | 0.10 | 85% | 0.67 | 6.74 | 0.14 | 1.43 |

Assumed maximum travel speed is 5 mph
Equipment weight from SCAQMD Table A9-9-D-3 and various websites
Water efficiency from CEQA Table 11-4 watering 3 times daily or using chemical suppressants. Parking area will be graveled and main onsite road will be paved.
$PM_{2.5}$ emission factors from updated CEIDARS List with PM2.5 fractions.
$PM_{2.5}$ numbers obtained by multiplying the $PM_{10}$ values by fraction in CEIDARS list for appropriate fugitive dust sources.
Water trucks operate at least 4 times per day.
10 Maximum number of construction work hours per day

## Monthly On-Site Fugitive Dust Emissions — Emissions Summary

*Hydrogen Energy, Inc*
*HECA Project*

*5/21/2009*

**Model Input:**

**LAY123**

| Total MODEL EMISSION RATE (lb/hr) | |
|---|---|
| **$PM_{10}$** | **$PM_{2.5}$** |
| **24hr** | **24hr** |
| 1.168 | 0.247 |

**Main**

| MODEL EMISSION RATE (lb/hr) | |
|---|---|
| **$PM_{10}$** | **$PM_{2.5}$** |
| **24hr** | **24hr** |
| 0.496 | 0.105 |

**Parking**

| MODEL EMISSION RATE (lb/hr) | |
|---|---|
| **$PM_{10}$** | **$PM_{2.5}$** |
| **24hr** | **24hr** |
| 0.203 | 0.043 |

**Roads** (18 road segments)

| MODEL EMISSION RATE (lb/hr) | |
|---|---|
| **$PM_{10}$** | **$PM_{2.5}$** |
| **24hr** | **24hr** |
| 3.7E-02 | 7.9E-03 |

| **Location** | **X (m)** | **Y (m)** | **AREA ($m^2$)** | **percent of total area** |
|---|---|---|---|---|
| LAY123 | 1400 | 450 | 630000 | 0.626 |
| main | 575 | 465 | 267375 | 0.266 |
| parking | 215 | 510 | 109650 | 0.109 |
| Total Construction Area | | | 1007025 | 1.000 |

**MODEL EMISSION RATE per Source (g/s-m2)**

| **$PM_{10}$** | **$PM_{2.5}$** |
|---|---|
| **24hr** | **24hr** |
| 2.34E-07 | 4.95E-08 |
| 2.34E-07 | 4.95E-08 |
| 2.34E-07 | 4.95E-08 |

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*5/21/2009*

**Annual Fugitive Dust Emissions**
Maximum annual fugitive dust activity occurs in months 17-28.

12 months of soil disturbance
10 total construction hours per work day
22 construction days per month

**Dirt Piling or Material Handling**
E = 0.00112 * $(G/5)^{1.3}$ / $(H/2)^{1.4}$

$PM_{10}$ Emissions from Dirt Piling or Material Handling (lb/hr) from SCAQMD Table A9-9-G
12 G = Mean Wind speed (mph) default
15 H = Moisture content of surface material (%) (from Table A9-9-G-1 for moist dirt)
0.00021 lb/ton of PM10

| Equipment | Quantity/ year | Hours/ Day | Annual Material Handled (ton) | Watering Control Efficiency | $PM_{10}$ Emissions (tons/yr) | $PM_{2.5}$ Emissions (tons/yr) |
|---|---|---|---|---|---|---|
| Backhoe | 1 | 10 | 383,364 | 67% | 0.0132 | 0.0027 |
| | | | | **Total** | **0.0132** | **0.0027** |

Water efficiency from CEQA Table 11-4 watering 3 times daily or using chemical suppressants

2461 $yd^3$/day 2904 ton/day
649,770 $yd^3$ 766,729 tons 2360 density of soil (lb/$yd^3$)
(USDA NRCS Physical Soil Properties from Kern County
Lockern-Buttonwillow clay soil)
134.25 acres = 649,770 cubic yds, assume depth of soils moved is 1 yd
(assume 25% of entire site in 12 month period)

**Cover Storage Pile**
SCAQMD Table A9-9-E
E = 1.7 * G/1.5 * (365-H)/235 * I/15 * J
PM10 Emission factor from wind erosion of storage piles per day per acre
15 G = Silt content (%) (from Table A9-9-E-1 for blended ore and dirt)
37 H = Mean number of days per year with at least 0.01 inches of precipitation (from WRCC for Bakersfield Airport Station)
0.3 I = Percentage of time that the unobstructed wind speed exceeds 12 mph at mean pile height
0.5 J = Fraction of TSP that is PM10 = 0.5
0.237 lb/acre/day

wind speed percentage based on 2000-04 (5 yrs) of wind speed data as recorded at Bakersfield Airport station

| Source | Quantity | Size of Pile (acre) | Days / year | Watering Control Efficiency | $PM_{10}$ Emissions (tons/yr) | $PM_{2.5}$ Emissions (tons/yr) |
|---|---|---|---|---|---|---|
| Cover Storage Pile | 40 | 0.25 | 365 | 67% | 0.14 | 0.030 |

Water efficiency from CEQA Table 11-4 watering 3 times daily or using chemical suppressants
pile size and number are assumed
Days per year accounts for weekend days also, not just work days

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**Travel on unpaved road**

$F = 2.1 * G/12 * H/30 * (J/3)^{0.7} * (I/4)^{0.5} * (365-K)/365$ SCAQMD Table A9-9-D

Emission factor for vehicle travel on unpaved roads (lb/VMT)

4 G = Surface silt loading (%) (value for gravel road)
5 H = Mean vehicle speed (mph)
value listed in table I = Mean number of wheels on vehicle
value listed in table J = Mean vehicle weight (ton)
37 K = Mean number of days per year with at least 0.01 inches of precipitation (from WRCC for Bakersfield Airport Station)

| Vehicle Type | Quantity per year | Round Trips /Day/ Unit | Round Trip Distance (mile) | Annual VMT (all units) | Mean Vehicle Weight (tons) | Number of Wheels on Vehicle | $PM_{10}$ EF (lbs/VMT) | Watering Control Efficiency | $PM_{10}$ Emissions (tons/yr) | $PM_{2.5}$ Emissions (tons/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| Concrete Pumper Truck | 6 | 2 | 1 | 12.0 | 30 | 10 | 0.83 | 67% | 0.002 | 0.000 |
| Dump Truck | 0 | | | 0.0 | 15 | 10 | 0.51 | 67% | 0.000 | 0.000 |
| Service Truck - 1 ton | 0 | | | 0.0 | 15 | 10 | 0.51 | 67% | 0.000 | 0.000 |
| Pile Driver Truck | 0 | | | 0.0 | 15 | 10 | 0.51 | 67% | 0.000 | 0.000 |
| Truck - Fuel/Lube | 0 | | | 0.0 | 15 | 10 | 0.51 | 67% | 0.000 | 0.000 |
| Tractor Truck 5th Wheel | 0 | | | 0.0 | 11 | 10 | 0.41 | 67% | 0.000 | 0.000 |
| Trucks - Pickup 3/4 ton | 60 | 10 | 0.5 | 300.0 | 3 | 4 | 0.10 | 67% | 0.005 | 0.001 |
| Trucks - 3 ton | 24 | 4 | 1 | 96.0 | 11 | 10 | 0.41 | 67% | 0.007 | 0.001 |
| Truck - Water | 12 | 4 | 10 | 480.0 | 25 | 10 | 0.73 | 67% | 0.058 | 0.012 |
| Air Compressor 185 CFM | 0 | | | 0.0 | 0.5 | 2 | 0.02 | 67% | 0.000 | 0.000 |
| Air Compressor 750 CFM | 48 | 1 | 0.1 | 4.8 | 0.5 | 2 | 0.02 | 67% | 0.000 | 0.000 |
| Articulating Boom Platform | 0 | | | 0.0 | 5 | 10 | 0.24 | 67% | 0.000 | 0.000 |
| Bulldozer D10R | 0 | | | 0.0 | 35 | 2 | 0.41 | 67% | 0.000 | 0.000 |
| Bulldozer D4C | 0 | | | 0.0 | 15 | 2 | 0.23 | 67% | 0.000 | 0.000 |
| Concrete Trowel Machine | 12 | 2 | 0.5 | 12.0 | 15 | 8 | 0.46 | 67% | 0.001 | 0.000 |
| Concrete Vibrators | 9 | 1 | 0.1 | 0.9 | 0.25 | 0 | 0.00 | 67% | 0.000 | 0.000 |
| Cranes - Mobile 35 ton | 80 | 1 | 0.5 | 40.0 | 25 | 12 | 0.80 | 67% | 0.005 | 0.001 |
| Cranes - Mobile 45 ton | 0 | | | 0.0 | 35 | 2 | 0.41 | 67% | 0.000 | 0.000 |
| Crane - Mobile 65 ton | 70 | 1 | 0.5 | 35.0 | 45 | 2 | 0.49 | 67% | 0.003 | 0.001 |
| Cranes 100 / 150 ton cap | 48 | 1 | 0.5 | 24.0 | 50 | 12 | 1.30 | 67% | 0.005 | 0.001 |
| Diesel Powered Welder | 41 | 1 | 0.1 | 4.1 | 0.5 | 2 | 0.02 | 67% | 0.000 | 0.000 |
| Backhoe/loader | 6 | 5 | 0.5 | 15.0 | 11 | 4 | 0.26 | 67% | 0.001 | 0.000 |
| Earth Scraper | 0 | | | 0.0 | 40 | 4 | 0.64 | 67% | 0.000 | 0.000 |
| Loader | 0 | | | 0.0 | 25 | 4 | 0.46 | 67% | 0.000 | 0.000 |
| Motor Grader | 0 | | | 0.0 | 20 | 6 | 0.48 | 67% | 0.000 | 0.000 |
| Excavator - Trencher | 0 | | | 0.0 | 17 | 4 | 0.35 | 67% | 0.000 | 0.000 |
| Fired Heaters | 53 | 1 | 0.1 | 5.3 | 0.25 | 0 | 0.00 | 67% | 0.000 | 0.000 |
| Forklift | 36 | 5 | 0.5 | 90.0 | 10 | 4 | 0.24 | 67% | 0.004 | 0.001 |
| Fusion Welder | 0 | | | 0.0 | 0.25 | 2 | 0.01 | 67% | 0.000 | 0.000 |
| Heavy Haul / Cranes | 32 | 1 | 0.25 | 8.0 | 75 | 2 | 0.71 | 67% | 0.001 | 0.000 |
| Light Plants | 84 | 1 | 0.1 | 8.4 | 0.5 | 4 | 0.03 | 67% | 0.000 | 0.000 |
| Portable Compaction Roller | 10 | 1 | 0.5 | 5.0 | 3 | 3 | 0.09 | 67% | 0.000 | 0.000 |
| Portable Compaction - Vibratory Plate | 18 | 1 | 0.1 | 1.8 | 0.1 | 0 | 0.00 | 67% | 0.000 | 0.000 |
| Portable Compaction - Vibratory Ram | 0 | | | 0.0 | 0.25 | 0 | 0.00 | 67% | 0.000 | 0.000 |
| Pumps | 24 | 1 | 0 | 0.0 | 0.1 | 0 | 0.00 | 67% | 0.000 | 0.000 |
| Portable Power Generators | 60 | 1 | 0.1 | 6.0 | 0.5 | 4 | 0.03 | 67% | 0.000 | 0.000 |
| Truck Crane - Greater than 200 ton | 42 | 1 | 0.5 | 21.0 | 50 | 12 | 1.30 | 67% | 0.005 | 0.001 |
| Truck Crane - Greater than 300 ton | 27 | 1 | 0.5 | 13.5 | 60 | 12 | 1.48 | 67% | 0.003 | 0.001 |
| Vibratory Roller 20 ton | 0 | | | 0.0 | 20 | 3 | 0.34 | 67% | 0.000 | 0.000 |
| | | | | | | | | **Total** | **0.099** | **0.021** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| worker personal vehicles | 946 | 1 | 0.5 | 473.0 | 3 | 4 | 0.10 | 85% | 0.004 | 0.001 |

worker personal vehicle data from Table 2-26, Estimated Monthly Construction Workforce from AFC, average for months 17-28 divided by 1.25 employees per vehicle

Assumed maximum travel speed is 5 mph
Equipment weight from SCAQMD Table A9-9-D-3 and various websites
Water efficiency from CEQA Table 11-4 watering 3 times daily or using chemical suppressants
except for worker vehicles - parking area will be graveled and main road onsite will be paved
$PM_{2.5}$ emission factors from updated CEIDARS List with PM2.5 fractions.
$PM_{2.5}$ numbers obtained by multiplying the $PM_{10}$ values by fraction in CEIDARS list for appropriate fugitive dust sources.
Water trucks operate at least 4 times per day.
Truck quantity based on monthly maximums

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*HECA Project*

**Model Inputs:**

| | Main | | Parking | | Lay123 | |
|---|---|---|---|---|---|---|
| | Total MODEL EMISSION RATE (lb/hr) | | Total MODEL EMISSION RATE (lb/hr) | | Total MODEL EMISSION RATE (lb/hr) | |
| | $PM_{10}$ | $PM_{2.5}$ | $PM_{10}$ | $PM_{2.5}$ | $PM_{10}$ | $PM_{2.5}$ |
| **Emission location** | **Annual** | **Annual** | **Annual** | **Annual** | **Annual** | **Annual** |
| Various | 0.0371 | 0.0078 | 0.0152 | 0.0032 | 0.0873 | 0.0183 |

| Location | X (m) | Y (m) | AREA ($m^2$) | percent of total area |
|---|---|---|---|---|
| LAY123 | 1400 | 450 | 630000 | 0.626 |
| main | 575 | 465 | 267375 | 0.266 |
| parking | 215 | 510 | 109650 | 0.109 |
| Total Construction Area | | | 1007025 | 1.000 |

**MODEL EMISSION RATE per Source (g/s-m2)**

| $PM_{10}$ Annual | $PM_{2.5}$ Annual |
|---|---|
| 1.75E-08 | 3.66E-09 |
| 1.75E-08 | 3.66E-09 |
| 1.75E-08 | 3.66E-09 |

**Roads** (per 18 road segments)

| Total MODEL EMISSION RATE (lb/hr) | |
|---|---|
| $PM_{10}$ | $PM_{2.5}$ |
| **Annual** | **Annual** |
| 1.13E-04 | 2.40E-05 |

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**Emission Factor for On-Site On Road Vehicles**

| Onroad Vehicle | Fuel Type | Vehicle Count | Weight (lbs) | Vehicle Type | EF (lbs/mile) TOC | CO | NOx | $PM_{10}$ | $SO_2$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| Passenger Vehicles | G/D | 857.333333 | 4000 | LDA | 0.0009 | 0.0119 | 0.0009 | 0.0002 | 2.20E-05 | 2.36E+00 | 8.82E-05 | 1.10E-04 | 2.393 |

Emission factors from EMFAC2007 (version 2.3) for 2010

**Emission Calculation for On Road Vehicles**

| | Total Op. Hours / Project | Trips or Hours/Day/ Unit | Round Trip Distance (miles) | Daily Total VMT | Daily Emissions (lbs) TOC | CO | $NO_x$ | $PM_{10}$ | $SO_2$ | $PM_{2.5}$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Highway Vehicles** | **Total Days** | | | | | | | | | | | | | |
| Passenger Vehicles | 264 | 2 | 1.5 | 2572 | 2.4 | 30.6 | 2.3 | 0.5 | 0.06 | 0.1 | 6062.35 | 0.23 | 0.28 | 6155 |
| | | | | | **Annual Emission Rate (tons/year)** | | | | | | | | | |
| | | | | | **TOC** | **CO** | **$NO_x$** | **$PM_{10}$** | **$SO_2$** | **$PM_{2.5}$** | **$CO_2$** | **$N_2O$** | **$CH_4$** | **$CO_2e$** |
| | | | | | 0.31 | 4.04 | 0.31 | 0.06 | 0.01 | 0.01 | 800.23 | 0.03 | 0.04 | 812.46 |

grams to pounds conversion = 0.0022046

**Passenger vehicle travel on paved roads**

| Equipment | Monthly Average Number of Employee Vehicles | Hours/Day | Days/year (mos 1-12) | Miles traveled per trip | Total miles traveled per year | $PM_{10}$ Emissions (lb/hr) | $PM_{10}$ Emissions (lb/day) | $PM_{10}$ Emissions (tons/yr) | $PM_{2.5}$ Emissions (lb/hr) | $PM_{2.5}$ Emissions (lb/day) | $PM_{2.5}$ Emissions (tons/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All Employee Vehicles | 857 | 2 | 264 | 1.5 | 339504 | 4.12 | 8.23 | 1.09 | 0.70 | 1.39 | 0.18 |

0.0064 $PM_{10}$ lb/VMT (from Table A9-9-B-1 for major streets/highways) CEQA Table A9-9-B

Employee numbers based on total employees on site during Month 21 (1286)
Assumed 1.5 employees per vehicle
onsite distance measured from draft plot plan for worker vehicles

*Hydrogen Energy, Inc*
*HECA Project*

*5/21/2009*

**Emission Calculations for On Road Vehicles**

| | Total Days / Year | Daily VMT / Vehicle | Annual VMT | Daily Emissions (lbs/day) $PM_{10}$ | $PM_{2.5}$ | CO | VOC | NOx | $SO_2$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heavy Truck (concrete, water, dump trucks) | 264 | 2 | 10,560 | 0.25 | 0.23 | 1.74 | 1.08 | 4.04 | 0.00 | 339.10 | 0.00 | 0.01 | 340.83 |
| Light Truck (service truck) | 264 | 2 | 1,584 | 0.01 | 0.01 | 0.13 | 0.01 | 0.20 | 0.00 | 19.91 | 0.00 | 0.00 | 19.96 |
| Personal Commuting Vehicles | 264 | 1.5 | 339,504 | 0.23 | 0.21 | 15.29 | 1.18 | 1.17 | 0.03 | 3031.18 | 0.11 | 0.14 | 3077.50 |
| Light delivery truck (e.g. Fed-Ex) | 264 | 2 | 1,584 | 0.00 | 0.00 | 0.05 | 0.01 | 0.11 | 0.00 | 7.00 | 0.00 | 0.00 | 7.05 |
| Heavy delivery truck (e.g. flat beds carrying construction eqp) | 264 | 2 | 2,112 | 0.05 | 0.05 | 0.35 | 0.22 | 0.81 | 0.00 | 67.82 | 0.00 | 0.00 | 68.17 |
| | | | **Total** | 0.55 | 0.50 | 17.55 | 2.50 | 6.34 | 0.03 | 3465.00 | 0.12 | 0.15 | 3513.50 |
| **Onroad Vehicle Combustion** | | | | **Annual Emission Rate (tons/year)** | | | | | | | | | |
| | | | | **$PM_{10}$** | **$PM_{2.5}$** | **CO** | **VOC** | **NOx** | **$SO_2$** | **$CO_2$** | **$N_2O$** | **$CH_4$** | **$CO_2e$** |
| Heavy Truck (concrete, water, dump trucks) | | | | 0.03 | 0.03 | 0.23 | 0.14 | 0.53 | 0.00 | 44.76 | 0.00 | 0.00 | 44.99 |
| Light Truck (service truck) | | | | 0.00 | 0.00 | 0.02 | 0.00 | 0.03 | 0.00 | 2.63 | 0.00 | 0.00 | 2.63 |
| Personal Commuting Vehicles | | | | 0.03 | 0.03 | 2.02 | 0.16 | 0.15 | 0.00 | 400.12 | 0.01 | 0.02 | 406.23 |
| Light delivery truck (e.g. Fed-Ex) | | | | 0.00 | 0.00 | 0.01 | 0.00 | 0.02 | 0.00 | 0.92 | 0.00 | 0.00 | 0.93 |
| Heavy delivery truck (e.g. flat beds carrying construction eqp) | | | | 0.01 | 0.01 | 0.05 | 0.03 | 0.11 | 0.00 | 8.95 | 0.00 | 0.00 | 9.00 |
| | | | **Total** | **0.07** | **0.06** | **2.27** | **0.30** | **0.71** | **0.00** | **447.50** | **0.02** | **0.02** | **453.85** |

| Onroad Vehicle Fugitive | Daily $PM_{10}$ Emissions (lb/day) | Annual $PM_{10}$ Emissions (tons/yr) | Daily $PM_{2.5}$ Emissions (lb/day) | Annual $PM_{2.5}$ Emissions (tons/yr) |
|---|---|---|---|---|
| Heavy Truck (concrete, fuel, water, dump trucks) | 6.0 | 0.79 | 1.01 | 0.13 |
| Light Truck (service truck) | 0.9 | 0.12 | 0.15 | 0.02 |
| Personal Commuting Vehicles | 8.2 | 1.09 | 1.39 | 0.18 |
| Light delivery truck (e.g. Fed-Ex) | 0.9 | 0.12 | 0.15 | 0.02 |
| Heavy delivery truck (e.g. flat beds carrying construction eqp) | 1.2 | 0.16 | 0.20 | 0.03 |
| **Total** | **17.18** | **2.27** | **2.90** | **0.38** |

**Combustion Emission Factor for Off-Site On Road Vehicles**

| Onroad Vehicle Combustion | Fuel Type | Daily Vehicle | Vehicle Type | EF (lbs/mile)[1] $PM_{10}$ | $PM_{2.5}$ | CO | VOC | NOx | $SO_2$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heavy Truck (concrete, water, dump trucks) | Diesel | 20 | HHD | 0.0063 | 0.0058 | 0.0434 | 0.0271 | 0.1010 | 0.0001 | 8.4774 | 0.000110229 | 0.000132 | 8.521 |
| Light Truck (service truck) | Diesel | 3 | MHD | 0.0021 | 0.0020 | 0.0225 | 0.0018 | 0.0337 | 0.0000 | 3.3179 | 6.61376E-05 | 2.2E-05 | 3.326 |
| Personal Commuting Vehicles | Gasoline | 857 | Passenger | 0.0002 | 0.0002 | 0.0119 | 0.0009 | 0.0009 | 0.0000 | 2.3571 | 8.81834E-05 | 0.00011 | 2.393 |
| Light delivery truck (e.g. Fed-Ex) | Diesel | 3 | LHD2 | 0.0004 | 0.0003 | 0.0078 | 0.0013 | 0.0190 | 0.0000 | 1.1661 | 6.61376E-05 | 2.2E-05 | 1.174 |
| Heavy delivery truck (e.g. flat beds carrying construction eqp) | Diesel | 4 | HHD | 0.0063 | 0.0058 | 0.0434 | 0.0271 | 0.1010 | 0.0001 | 8.4774 | 0.000110229 | 0.000132 | 8.521 |
| | | | **Total** | 0.0152 | 0.0140 | 0.1289 | 0.0582 | 0.2556 | 0.0002 | 23.7959 | 0.0004 | 0.0004 | 23.935 |

Daily vehicle count based on 40 truck trips per day during construction (data from client).

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| Emission Calculation for On Road Vehicles | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Days / Year | Daily VMT / Vehicle | Annual VMT | Daily Emissions (lbs/day) | | | | | | | | | |
| | | | | $PM_{10}$ | $PM_{2.5}$ | CO | VOC | NOx | $SO_2$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$ |
| Heavy Truck (concrete, water, dump trucks) | 264 | 38 | 200,640 | 4.78 | 4.39 | 32.97 | 20.57 | 76.77 | 0.06 | 6442.84 | 0.08 | 0.10 | 6475.77 |
| Light Truck (service truck) | 264 | 38 | 30,096 | 0.24 | 0.22 | 2.56 | 0.21 | 3.84 | 0.00 | 378.24 | 0.01 | 0.00 | 379.18 |
| Personal Commuting Vehicles | 264 | 38.5 | 8,713,936 | 5.89 | 5.42 | 392.44 | 30.27 | 30.13 | 0.73 | 77800.16 | 2.91 | 3.64 | 78989.18 |
| Light delivery truck (e.g. Fed-Ex) | 264 | 38 | 30,096 | 0.04 | 0.04 | 0.88 | 0.15 | 2.16 | 0.00 | 132.94 | 0.01 | 0.00 | 133.88 |
| Heavy delivery truck (e.g. flat beds carrying construction eqp) | 264 | 38 | 40,128 | 0.96 | 0.88 | 6.59 | 4.11 | 15.35 | 0.01 | 1288.57 | 0.02 | 0.02 | 1295.15 |
| | | | **Total** | 11.91 | 10.96 | 435.44 | 55.32 | 128.25 | 0.81 | 86042.76 | 3.03 | 3.76 | 87273.16 |
| | | | | Annual Emission Rate (tons/year) | | | | | | | | | |
| **Onroad Vehicle Combustion** | | | | $PM_{10}$ | $PM_{2.5}$ | CO | VOC | NOx | $SO_2$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$ |
| Heavy Truck (concrete, water, dump trucks) | | | | 0.63 | 0.58 | 4.35 | 2.72 | 10.13 | 0.01 | 850.46 | 0.01 | 0.01 | 854.80 |
| Light Truck (service truck) | | | | 0.03 | 0.03 | 0.34 | 0.03 | 0.51 | 0.00 | 49.93 | 0.00 | 0.00 | 50.05 |
| Personal Commuting Vehicles | | | | 0.78 | 0.72 | 51.80 | 4.00 | 3.98 | 0.10 | 10269.62 | 0.38 | 0.48 | 10426.57 |
| Light delivery truck (e.g. Fed-Ex) | | | | 0.01 | 0.00 | 0.12 | 0.02 | 0.29 | 0.00 | 17.55 | 0.00 | 0.00 | 17.67 |
| Heavy delivery truck (e.g. flat beds carrying construction eqp) | | | | 0.13 | 0.12 | 0.87 | 0.54 | 2.03 | 0.00 | 170.09 | 0.00 | 0.00 | 170.96 |
| | | | **Total** | **1.44** | **1.33** | **56.49** | **6.74** | **14.62** | **0.10** | **11170.00** | **0.40** | **0.49** | **11331.43** |

**Note 1:** SCAQMD Prepared - Highest (Most Conservative) Emfac 2007 (version 2.3)
Emission Factors for On-Road Personal Commuting Vehicles and Trucks
Scenario Year: 2010
All model years in the range 1965 to 2010

| Fugitive Emission Factor for On Road Vehicles | | | | |
|---|---|---|---|---|
| **Onroad Vehicle Fugitive** | **Daily $PM_{10}$ Emissions (lb/day)** | **Annual $PM_{10}$ Emissions (tons/yr)** | **Daily $PM_{2.5}$ Emissions (lb/day)** | **Annual $PM_{2.5}$ Emissions (tons/yr)** |
| Heavy Truck (concrete, fuel, water, dump trucks) | 113.3 | 14.96 | 19.15 | 2.53 |
| Light Truck (service truck) | 17.0 | 2.24 | 2.87 | 0.38 |
| Personal Commuting Vehicles | 211.2 | 27.88 | 35.70 | 4.71 |
| Light delivery truck (e.g. Fed-Ex) | 17.0 | 2.24 | 2.87 | 0.38 |
| Heavy delivery truck (e.g. flat beds carrying construction eqp) | 22.7 | 2.99 | 3.83 | 0.51 |
| **Total** | **381.22** | **50.32** | **64.43** | **8.50** |

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)

**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 traveling 12 month period per the equip. schedule

Assumed average distance traveled 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 21 1286 data from Table 2-26, Estimated Monthly Construction Workforce from AFC
Average daily vehicles 857
Number of workers per commuter vehicle = 1.5

$CO_2$ GWP (SAR, 1996) = 1
$CH_4$ GWP (SAR, 1996) = 21
$N_2O$ GWP (SAR, 1996) = 310

# Appendix D1.2

## Operating Emissions
## Stationary Sources

## Modeling Parameters for Emission Sources — Summary

*Hydrogen Energy, Inc*
*HECA Project*
*5/21/2009*

| Parameter | | CTG/HRSG , H2-rich Fuel 100% Load [2] | CTG/HRSG , H2-rich Fuel 80% Load | CTG/HRSG , H2-rich Fuel 60% Load | CTG/HRSG , Natural Gas Fuel 100% Load[3] | CTG/HRSG , Natural Gas Fuel 80% Load | CTG/HRSG , Natural Gas Fuel 60% Load | CTG/HRSG Co-Firing ** 100% Load | Auxiliary CTG 100% Load | Auxiliary CTG 75% Load | Auxiliary CTG 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 | $^{o}$F | 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 | Gasification Flare(4) | SRU Flare(6) | Rectisol 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 | 250 | 250 | 250 | 165 | 210 | 55 | 20 | 20 | 260 |
| Stack diameter | ft | 4.5 | 9.8 | 2 | 1.3 | 2.5 | 1.0 | 30 | 1.2 | 0.7 | 3.5 |
| Stack outlet temperature | $^{o}$F | 300 | (NA) | (NA) | (NA) | 1200 | 150 | 75 | 760 | 850 | 65 |
| Stack exit flow, act | $ft^3/s$ | 480 | 0.5/900 | 0.3/36 | 0.3 | 120 | 68 | 18,500 | 250 | 60 | 1,765 |
| **Metric Units** | | | | | | | | | | | |
| Stack height above grade[1] | m | 24.4 | 76.2 | 76.2 | 76.2 | 50.3 | 64.0 | 16.8 | 6.1 | 6.1 | 79.2 |
| Stack diameter | m | 1.4 | 3.0 | 0.6 | 0.4 | 0.8 | 0.3 | 9.1 | 0.4 | 0.2 | 1.1 |
| Stack outlet temperature | K | 422.0 | (NA) | (NA) | (NA) | 922.0 | 338.7 | 297.0 | 677.6 | 727.6 | 291.5 |
| Stack exit flow, act | $m^3/s$ | 13.6 | 0.01/25.49 | 0.01/1.02 | 0.01 | 3.4 | 1.9 | 523.9 | 7.1 | 1.7 | 50.0 |
| Stack Area | $m^2$ | 1.5 | 7.0 | 0.3 | 0.1 | 0.5 | 0.1 | 65.7 | 0.1 | 0.0 | 0.9 |
| Stack exit velocity, act | m/s | 9.2 | 0.001/3.64 | 0.03/3.4 | 0.1 | 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. First exit flow value is normal pilot gas, the second value is the maximum startup heat release (Rectisol Flare has no planned operation than standby with pilot on)
(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

| Parameter | | Feed Stock - Dust Collection Units | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | DC-1 | DC-2 | DC-3 | DC-4 | DC-5 | DC-6 | | | |
| **English Units** | | | | | | | | | | |
| Ground elevation | ft | 289 | 289 | 289 | 289 | 289 | 289 | | | |
| Stack elevation | ft | 314 | 459 | 428 | 314 | 368 | 428 | | | |
| Stack height above grade | ft | 25 | 170 | 139 | 25 | 79 | 139 | | | |
| Stack diameter | ft | 1.7 | 2.7 | 1.8 | 1.4 | 1.4 | 0.8 | | | |
| Stack outlet temperature (1) | $^{o}$F | Ambient | Ambient | Ambient | Ambient | Ambient | Ambient | | | |
| Stack exit flow, act | $ft^3/s$ | 108 | 273 | 127 | 81 | 78 | 21 | | | |
| **Metric Units** | | | | | | | | | | |
| Stack height above grade | m | 7.6 | 51.8 | 42.4 | 7.6 | 24.1 | 42.4 | | | |
| Stack diameter | m | 0.5 | 0.8 | 0.6 | 0.4 | 0.4 | 0.2 | | | |
| Stack outlet temperature (1) | K | Ambient | Ambient | Ambient | Ambient | Ambient | Ambient | | | |
| Stack exit flow, act | $m^3/s$ | 3.1 | 7.7 | 3.6 | 2.3 | 2.2 | 0.6 | | | |
| Stack Area | $m^2$ | 0.2 | 0.5 | 0.2 | 0.1 | 0.1 | 0.0 | | | |
| Stack exit velocity, act | m/s | 15.0 | 14.9 | 14.7 | 15.7 | 15.1 | 14.2 | | | |

(1) Assume ambient temperature

## Total Project Modeling Emission Rates — Summary

*Hydrogen Energy, Inc* — *5/21/2009*
*HECA Project*

### Modeling Worst-Case 1 hr Emissions

| | CTG/HRSG Maximum (1) | Auxiliary CTG | Cooling Towers (2) | | | Auxiliary Boiler | Emergency Generators (3) | Fire Water Pump | Gasification Flare | SRU Flare | Rectisol 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 |
| | (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) |
| NOx | 21.0 | 2.6 | -- | -- | -- | 0.2 | 0.4 | 0.2 | 7.9 | 0.544 | 0.005 | 0.6 | -- | 0.2 | -- | -- | -- | -- | -- | -- |
| CO | 211.6 | 8.7 | -- | -- | -- | 0.7 | 0.2 | 0.4 | 113.4 | 0.363 | 0.003 | 0.5 | 53.4 | 0.2 | -- | -- | -- | -- | -- | -- |
| $SO_2$ | 0.9 | 0.2 | -- | -- | -- | 0.04 | 0.004 | 0.0007 | 0.0001 | 2.19 | 0.0001 | 0.3 | -- | 0.00 | -- | -- | -- | -- | -- | -- |
| $H_2S$ | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.6 | -- | -- | -- | -- | -- | -- | -- |

(1) HRSG modeling emission rates represents the maximum emissions rate from a composite firing scenario (all three 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

| | CTG/HRSG Maximum (1) | Auxiliary CTG | Cooling Towers (2) | | | Auxiliary Boiler | Emergency Generators (3) | Fire Water Pump | Gasification Flare | SRU Flare | Rectisol 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 |
| | (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) |
| $SO_2$ | 0.9 | 0.2 | -- | -- | -- | 0.04 | 0.002 | 0.0005 | 0.0001 | 2.19 | 0.00 | 0.3 | -- | 0.00 | -- | -- | -- | -- | -- | -- |

(1) HRSG modeling emission rates represents the maximum emissions rate from a composite firing scenario (all three 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

| | CTG/HRSG Maximum (1) | Auxiliary CTG | Cooling Towers (2) | | | Auxiliary Boiler | Emergency Generators (3) | Fire Water Pump | Gasification Flare | SRU Flare | Rectisol 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 |
| | (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) |
| CO | 164.9 | 2.7 | -- | -- | -- | 0.7 | 0.06 | 0.1 | 113.4 | 0.138 | 0.003 | 0.5 | 53.4 | 0.2 | -- | -- | -- | -- | -- | -- |

(1) HRSG modeling emission rates represents the maximum emissions rate from a composite firing scenario (all three 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, Inc*
*HECA Project*

*5/21/2009*

### Modeling Worst-Case 24 Hour Emission Rate

| | CTG/HRSG Maximum (1) | Auxiliary CTG | Cooling Towers (2) | | | Auxiliary Boiler | Emergency Generators (3) | Fire Water Pump | Gasification Flare | SRU Flare | Rectisol 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 |
| | (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) |
| $SO_2$ | 0.9 | 0.2 | -- | -- | -- | 0.04 | 0.0003 | 0.0001 | 0.0001 | 0.2742 | 0.0001 | 0.3 | -- | 0.00 | -- | -- | -- | -- | -- | -- |
| $PM_{10}$ | 3.0 | 0.8 | 0.038 | 0.030 | 0.028 | 0.09 | 0.002 | 0.0002 | 0.0002 | 0.0018 | 0.0001 | 0.02 | -- | 0.02 | 0.030 | 0.076 | 0.041 | 0.026 | 0.025 | 0.003 |
| $PM_{2.5}$ (5) | 3.0 | 0.8 | 0.023 | 0.018 | 0.017 | 0.09 | 0.002 | 0.0002 | 0.0002 | 0.0018 | 0.0001 | 0.02 | -- | 0.02 | 0.009 | 0.022 | 0.012 | 0.008 | 0.007 | 0.001 |

(1) HRSG modeling emission rates represents the maximum emissions rate from a composite firing scenario (all three 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 | Gasification Flare | SRU Flare | Rectisol 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 |
| | (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) |
| $NO_X$ | 4.8 | 0.5 | -- | -- | -- | 0.05 | 0.002 | 0.003 | 0.1 | 0.005 | 0.005 | 0.3 | -- | 0.05 | -- | -- | -- | -- | -- | -- |
| CO | 4.3 | 0.8 | -- | -- | -- | 0.2 | 0.001 | 0.005 | 1.4 | 0.003 | 0.003 | 0.26 | 3.1 | 0.04194 | -- | -- | -- | -- | -- | -- |
| VOC | 0.9 | 0.1 | -- | -- | -- | 0.02 | 0.0005 | 0.0002 | 0.0001 | 0.00005 | 0.00005 | 0.01 | 0.1 | 0.00326 | -- | -- | -- | -- | -- | -- |
| $SO_2$ | 0.8 | 0.1 | -- | -- | -- | 0.01 | 0.00002 | 0.00001 | 0.0001 | 0.0016 | 0.0001 | 0.3 | -- | 0.00095 | -- | -- | -- | -- | -- | -- |
| $PM_{10}$ | 2.9 | 0.4 | 0.036 | 0.028 | 0.027 | 0.02 | 0.0001 | 0.00003 | 0.0002 | 0.0001 | 0.0001 | 0.01 | -- | 0.004 | 0.006 | 0.015 | 0.036 | 0.023 | 0.022 | 0.0004 |
| $PM_{2.5}$ (5) | 2.9 | 0.4 | 0.022 | 0.017 | 0.016 | 0.02 | 0.0001 | 0.00003 | 0.0002 | 0.0001 | 0.0001 | 0.01 | -- | 0.004 | 0.002 | 0.004 | 0.011 | 0.0068 | 0.007 | 0.0001 |
| $H_2S$ | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.0 | -- | -- | -- | -- | -- | -- | -- |

(1) HRSG modeling emission rates represents the maximum emissions rate from a composite firing scenario (all three 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, Inc*
*HECA Project*

*5/21/2009*

| 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) | Gasification Flare (ton/yr) | SRU Flare (ton/yr) | Rectisol Flare (ton/yr) | Tg Thermal Oxidizer (ton/yr) | $CO_2$ Vent (ton/yr) | Gasifier Warming (ton/yr) | Feedstock (4) (ton/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $NO_X$ | 203.8 | 167.2 | 17.4 | -- | 1.7 | 0.2 | 0.1 | 4.3 | 0.2 | 0.2 | 10.9 | -- | 1.8 | -- |
| CO | 350.3 | 150.2 | 27.6 | -- | 5.8 | 0.1 | 0.2 | 48.8 | 0.1 | 0.1 | 9.1 | 106.9 | 1.5 | -- |
| VOC | 40.7 | 32.5 | 4.6 | -- | 0.6 | 0.03 | 0.01 | 0.003 | 0.002 | 0.002 | 0.3 | 2.4 | 0.1 | -- |
| $SO_2$ | 42.2 | 29.2 | 3.8 | -- | 0.3 | 0.001 | 0.0003 | 0.004 | 0.055 | 0.003 | 8.8 | -- | 0.03 | -- |
| $PM_{10}$ | 141.1 | 99.7 | 12.3 | 24.1 | 0.8 | 0.01 | 0.001 | 0.007 | 0.004 | 0.004 | 0.4 | -- | 0.1 | 3.6 |
| $PM_{2.5}$ (5) | 128.9 | 99.7 | 12.3 | 14.5 | 0.8 | 0.01 | 0.001 | 0.007 | 0.004 | 0.004 | 0.4 | -- | 0.1 | 1.0 |
| $NH_3$ | 100.0 | 75.9 | 24.1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| $H_2S$ | 1.3 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1.3 | -- | -- |
| $CO_2e$ (6) | 383,317 | 5,290 | 198,200 | -- | 16,466 | 146 | 29 | 6,348 | 176 | 139 | 4,797 | 150,011 | 1,716 | -- |

(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% $PM_{2.5}$
(6) $CO_2e$ emission rates are shown as metric tons (tonnes)

*Hydrogen Energy, Inc*
*HECA Project*
*5/21/2009*

**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, Inc* — *5/21/2009*
*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, Inc* *5/21/2009*
*HECA Project*

**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) | 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) | 5.1 | 15.3 | $SO_2$ | 5.1 | 5.1 | $SO_2$ | 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**

| | | | | | | |
|---|---|---|---|---|---|---|
| Total Hours of Operation | 8,322.0 | | Pollutant | Turbine Emissions | Emissions | Emissions |
| Total Number of Cold Starts | 10.0 | | | lb/yr/CT | ton/yr/CT | g/sec/CT |
| 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 |

## CTG/HRSG Stack - Natural Gas — Emissions Summary

*Hydrogen Energy, Inc* — *5/21/2009*
*HECA Project*

### 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.

### 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.

### 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.

### 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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**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 ( 1 COLD start up and I shut down) | 3.0 | 272.0 | 0.5 | 62.0 | 17.5 | 36.3 | 1,426.4 | 7.5 |
| Nox ( 2 HOT start ups and 2 shut downs) | 2.0 | 167.0 | 1.0 | 62.0 | | | | |
| 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 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

For CALPUFF modeling purposes, NOx emissions are calculated assuming:
Worst-case daily emissions assumes a total COLD start up of : 1 and a total HOT start up of: 2
Worst-case daily emissions assumes a total shut down of : 3
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, Inc*
*HECA Project*
*5/21/2009*

**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)** | 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)** | 5.1 | 15.3 | **SO2** | 5.1 | 5.1 | **SO2** | 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 |

*Hydrogen Energy, Inc* *5/21/2009*
*HECA Project*

**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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**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, Inc* *5/21/2009*
*HECA Project*

### 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) (12.65 ppm duct firing)** | 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)** | 5.1 | 15.3 | **SO2** | 5.1 | 5.1 | **SO2** | 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 |

## CTG/HRSG Stack - Co Firing — Emissions Summary

*Hydrogen Energy, Inc*
*HECA Project*
*5/21/2009*

### 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

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*5/21/2009*

**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)** | 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 | | 6.0 | 6.0 | 6.0 | 6.0 | | 6.0 | 6.0 | 6.0 | | 6.0 | 6.0 |
| **$NH_3$ (@ 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)** | 1.9 | 0.3 | **$SO_2$** | | | **$SO_2$** | 1.9 | 0.3 |
| **$PM_{10}$ = $PM_{2.5}$** | 6.0 | 1.0 | **$PM_{10}$ = $PM_{2.5}$** | | | **$PM_{10}$ = $PM_{2.5}$** | 6.0 | 1.0 |

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 | | $PM_{10}$ = $PM_{2.5}$ | 24,660.0 | 12.3 | 0.4 |
| **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 |

**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 | | $PM_{10} = PM_{2.5}$ | 6,165.0 | 3.1 |
| **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 | | $PM_{10} = PM_{2.5}$ | 6,165.0 | 3.1 |
| **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 | | $PM_{10} = PM_{2.5}$ | 6,165.0 | 3.1 |
| **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 | | $PM_{10} = PM_{2.5}$ | 6,165.0 | 3.1 |
| **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

**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)** | 144.0 |
| **$PM_{10} = PM_{2.5}$ (g/s/CT)** | 0.8 |

**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

## Auxiliary Boiler — Emissions Summary

*Hydrogen Energy, Inc*
*HECA Project*

*5/21/2009*

**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 total sulfur in pipeline natural gas) | 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, Inc*
*HECA Project*

*5/21/2009*

### 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 |

## Gasification Flare — Emissions Summary

*Hydrogen Energy, Inc*
*HECA Project*

*5/21/2009*

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

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

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### Gasification 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) | 0.37 |
| 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 | 284.3 | 75.0% | 25.0% | 746.08 | 12.16 | 48.65 |
| 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, Inc*
*HECA Project*
*5/21/2009*

**Total Gasification 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 | 48.65 | 12.21 | 48.8 |
| 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, Inc* *5/21/2009*
*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) | 1.4 |
| 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

## SRU Flare — Emissions Summary

*Hydrogen Energy, Inc* — *5/21/2009*
*HECA Project*

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

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

### SRU - 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 |

### SRU 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 |

## SRU Flare — Emissions Summary

*Hydrogen Energy, Inc*
*HECA Project*

*5/21/2009*

**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, Inc* *5/21/2009*
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**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

## Rectisol Flare — Emissions Summary

*Hydrogen Energy, Inc*
*HECA Project*
*5/21/2009*

### Rectisol - Normal Operating Emissions from Pilot

| | | |
|---|---|---|
| **Total Hours of Operation** | 8,760 | hr/yr |
| **Rectisol 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) | 0.002 |
| $PM_{10}$ = $PM_{2.5}$ (lb/MMBtu, HHV) | 0.003 |

**Pilot Pollutant Emission Rates**

| Pollutant | Pilot Emissions 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 |

### Rectisol Flare - Total Annual Emissions

| Pollutant | Emissions Pilot (ton/yr) | Total (ton/qtr) | Total (ton/yr) |
|---|---|---|---|
| NOx | 0.16 | 0.04 | 0.2 |
| CO | 0.11 | 0.03 | 0.1 |
| VOC | 0.002 | 0.000 | 0.002 |
| $SO_2$ | 0.003 | 0.001 | 0.003 |
| $PM_{10}$ = $PM_{2.5}$ | 0.004 | 0.001 | 0.004 |

**Modeling Worst-Case 1 hr Emissions**

| | |
|---|---|
| NOx (g/sec) | 0.005 |
| CO (g/sec) | 0.003 |
| $SO_2$ (g/sec) | 0.0001 |

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 natural gas pilot emissions

**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) | 0.0018 |
| $SO_2$ (g/sec) | 0.0001 |

Only $SO_2$ is considered for an average 3-hour Ambient Air Quality Standard.
Pounds per 3-hr assumes aproximately 3 hours the natural gas pilot emissions.

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*5/21/2009*

**Modeling Worst-Case 8 hr Emissions**

| | |
|---|---|
| CO (lb/8-hr) | 0.19 |
| CO (g/sec) | 0.003 |

Only CO is considered for an average 8-hour Ambient Air Quality Standard.
Pounds per 8-hr assumes aproximately 8 hours of pilot operation.

**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) | 0.02 |
| $PM_{10} = PM_{2.5}$ (g/sec) | 0.0001 |

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 32 hoursof pilot operation.

**Modeling Annual Average Emissions**

| | |
|---|---|
| NOx (g/sec) | 0.005 |
| CO (g/sec) | 0.003 |
| VOC (g/sec) | 0.00005 |
| $SO_2$ (g/sec) | 0.0001 |
| $PM_{10} = PM_{2.5}$ (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, Inc* — *5/21/2009*
*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) | 0.24 |
| CO (lb/MMBtu, HHV) | 0.20 |
| 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 | 2.40 | 57.60 | 21,024.00 | 2.63 | 10.5 |
| CO | 2.00 | 48.00 | 17,520.00 | 2.19 | 8.8 |
| 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, Inc*
*HECA Project*

*5/21/2009*

**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) | 0.24 |
| CO (lb/MMBtu, HHV) | 0.20 |
| VOC (lb/MMBtu, HHV) | 0.007 |
| $SO_2$ (lb/MMBtu, HHV) (12.65 ppm) | 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 | 2.40 | 57.60 | 720.00 | 0.09 | 0.36 |
| CO | 2.00 | 48.00 | 600.00 | 0.08 | 0.30 |
| 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 | 10.51 | 0.36 | 2.72 | 10.9 |
| CO | 8.76 | 0.30 | 2.27 | 9.1 |
| 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 |

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*5/21/2009*

**Modeling Worst-Case 1 hr Emissions**

| | |
|---|---|
| NOx (g/sec) | 0.6 |
| CO (g/sec) | 0.50 |
| $SO_2$ (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) | 32.00 |
| CO (g/sec) | 0.5 |

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) | 0.3 |
| CO (g/sec) | 0.26 |
| 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.

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*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) | 0.11 |
| CO (lb/MMBtu, HHV) | 0.09 |
| VOC (lb/MMBtu, HHV) | 0.007 |
| $SO_2$ (lb/MMBtu, HHV) (12.65 ppm) | 0.002 |
| $PM_{10} = PM_{2.5}$ (lb/MMBtu, HHV) | 0.008 |

**Gasifier Pollutant Emission Rates**

| | Gasifier Emissions | | | | |
|---|---|---|---|---|---|
| **Pollutant** | **lb/hr** | **lb/day** | **lb/yr** | **ton/qtr** | **ton/yr** |
| NOx | 1.98 | 47.52 | 3,564.00 | 0.45 | 1.8 |
| CO | 1.62 | 38.88 | 2,916.00 | 0.36 | 1.5 |
| VOC | 0.13 | 3.02 | 226.80 | 0.03 | 0.1 |
| $SO_2$ | 0.04 | 0.88 | 66.10 | 0.01 | 0.0 |
| $PM_{10} = PM_{2.5}$ | 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 Warming — Emissions Summary

*Hydrogen Energy, Inc* — *5/21/2009*
*HECA Project*

**Modeling Worst-Case 1 hr Emissions**

| | |
|---|---|
| NOx (g/sec) | 0.2 |
| CO (g/sec) | 0.2 |
| $SO_2$ (g/sec) | 0.0046 |

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) | 0.11 |
| $SO_2$ (g/sec) | 0.0046 |

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) | 12.96 |
| CO (g/sec) | 0.2 |

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) | 0.88 |
| $SO_2$ (g/sec) | 0.0046 |
| $PM_{10} = PM_{2.5}$ (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 Warming — Emissions Summary

*Hydrogen Energy, Inc* — *5/21/2009*
*HECA Project*

**Modeling Annual Average Emissions**

| | |
|---|---|
| NOx (g/sec) | 0.1 |
| CO (g/sec) | 0.0419 |
| VOC (g/sec) | 0.0033 |
| $SO_2$ (g/sec) | 0.0010 |
| $PM_{10} = PM_{2.5}$ (g/sec) | 0.0037 |

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

*Hydrogen Energy, Inc* *5/21/2009*
*HECA Project*

**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.

| 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.

**Parameters**

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

| 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.

## Emergency Diesel Generators — Emissions Summary

*Hydrogen Energy, Inc* *5/21/2009*
*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 |
| $SO_2$ 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 |

## Emergency Diesel Generators — Emissions Summary

*Hydrogen Energy, Inc*
*HECA Project*

*5/21/2009*

**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, Inc* — *5/21/2009*
*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 |
| $SO_2$ 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, Inc*
*HECA Project*

*5/21/2009*

**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, Inc* — *5/21/2009*
*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.

## Intermittent $CO_2$ Vent — Emissions Summary

*Hydrogen Energy, Inc*
*HECA Project*

*5/21/2009*

**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 |

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*HECA Project*

*5/21/2009*

**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.

*Hydrogen Energy, Inc*
*HECA Project*
*5/21/2009*

### 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 Feed Rate (ton/hr) | Max 24-hr Average PM Emission (lb/hr) | Annual Average Feed Rate (ton/hr) | Annual Average PM Emission (lb/hr) |
|---|---|---|---|---|---|---|---|---|---|
| Truck Unloading | DC-1 | 900 | 6,463 | 0.277 | 0.00031 | 775 | 0.239 | 150 | 0.046 |
| Coke/coal Silos (filling) | DC-2 | 900 | 16,376 | 0.702 | 0.00078 | 775 | 0.604 | 150 | 0.117 |
| Mass Flow Bins (in/out) | DC-3 | 170 | 7,620 | 0.327 | 0.00192 | 170 | 0.327 | 150 | 0.288 |
| Coke/coal Silos (loadout) | DC-4 | 170 | 4,872 | 0.209 | 0.00123 | 170 | 0.209 | 150 | 0.184 |
| Crusher Inlet/Outlet | DC-5 | 170 | 4,673 | 0.200 | 0.00118 | 170 | 0.200 | 150 | 0.177 |
| Fluxant Bins (filling) | DC-6 | 100 | 1,234 | 0.053 | 0.00053 | 40 | 0.021 | 6 | 0.003 |

Maximum dust collector PM emission rate based on expected supplier guarantee of 0.005 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) | 0.24 | 5.72 | 404.40 | 0.05 | 0.2 |
| Dust Collecter 2 (DC-2) | 0.60 | 14.50 | 1,024.67 | 0.13 | 0.5 |
| Dust Collecter 3 (DC-3) | 0.33 | 7.84 | 2,524.21 | 0.32 | 1.3 |
| Dust Collecter 4 (DC-4) | 0.21 | 5.01 | 1,613.90 | 0.20 | 0.8 |
| Dust Collecter 5 (DC-5) | 0.20 | 4.81 | 1,547.98 | 0.19 | 0.8 |
| Dust Collecter 6 (DC-6) | 0.02 | 0.51 | 27.80 | 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.

| | lb/yr | ton/qtr | ton/yr |
|---|---|---|---|
| $PM_{10}$ | **7,143.0** | **0.9** | **3.6** |
| $PM_{2.5}$ | **2085.7** | **0.3** | **1.0** |

$PM_{2.5}$ 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.

*Hydrogen Energy, Inc* *5/21/2009*
*HECA Project*

**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 |
|---|---|---|---|---|---|---|
| $PM_{10}$ (lb/day) | 5.72 | 14.50 | 7.84 | 5.01 | 4.81 | 0.51 |
| $PM_{10}$ (g/sec) | 0.030 | 0.076 | 0.041 | 0.026 | 0.025 | 0.003 |
| $PM_{2.5}$ (lb/24-hr) | 1.672 | 4.235 | 2.289 | 1.463 | 1.404 | 0.148 |
| $PM_{2.5}$ (g/sec) | 0.009 | 0.022 | 0.012 | 0.008 | 0.007 | 0.001 |

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 |
|---|---|---|---|---|---|---|
| $PM_{10}$ (lb/yr) | 404.40 | 1,024.67 | 2,524.21 | 1,613.90 | 1,547.98 | 27.80 |
| $PM_{10}$ (g/sec) | 0.006 | 0.015 | 0.036 | 0.023 | 0.022 | 0.000 |
| $PM_{2.5}$ (lb/24-hr) | 118.085 | 299.204 | 737.068 | 471.259 | 452.010 | 8.117 |
| $PM_{2.5}$ (g/sec) | 0.002 | 0.004 | 0.011 | 0.007 | 0.007 | 0.000 |

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

*Hydrogen Energy, Inc* *5/21/2009*
*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**

| | | | | |
|---|---|---|---|---|
| $CO_2$ = | 52.78 | kg/MMBtu = | 116.36 | lb/MMBtu |
| $CH_4$ = | 0.0059 | kg/MMBtu = | 0.013 | lb/MMBtu |
| $N_2O$ = | 0.0001 | kg/MMBtu = | 0.00022 | lb/MMBtu |

**Diesel GHG Emission Factors**

| | | | | |
|---|---|---|---|---|
| $CO_2$ = | 10.15 | kg/gal = | 22.38 | lb/gal |
| $CH_4$ = | 0.0003 | kg/gal = | 0.001 | lb/gal |
| $N_2O$ = | 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 | | 50 | hr/yr | | | |
| HRSG Heat Input | | 1,998 | MMBtu/hr | | | |
| $CO_2$ = | 5,274 | tonne/yr | | | | |
| $CH_4$ = | 1 | tonne/yr = | 12 | tonne $CO_2e$/yr | | |
| $N_2O$ = | 0.01 | tonne/yr = | 3 | tonne $CO_2e$/yr | Total tonne $CO_2e$/yr = | 5,290 |

During mature operation of the HRSG, the unit will fire only syngas, except during periods of startup and shutdown.
Startup and shutdown of the HRSG will be accomplished using natural gas. The total startup and shutdown operating hours are estimated at 50 hr/yr.
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.

## GHG Emissions Summary by Source — Emissions Summary

*Hydrogen Energy, Inc* — *5/21/2009*
*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 $CO_2$e/yr | | |
| $N_2O$ = | 0.03 | tonne/yr = | 10 | tonne $CO_2$e/yr | Total tonne $CO_2$e/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 $CO_2$e/yr | | |
| $N_2O$ = | 0.03 | lb/hr = | 0.2218 | tonne $CO_2$e/yr | Total tonne $CO_2$e/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 $CO_2$e 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 $CO_2$e/yr | | |
| $N_2O$ = | 0.01 | lb/hr = | 0.0881 | tonne $CO_2$e/yr | Total tonne $CO_2$e/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.

**Gasification 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.

**SRU 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 |

*Hydrogen Energy, Inc* *5/21/2009*
*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.

**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 CO2 to H2S in the SRU Flare.

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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.

**Rectisol 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 |

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

**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 | | | | |

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*5/21/2009*

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.

| | | | | | | |
|---|---|---|---|---|---|---|
| $CO_2$ = | 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.

**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 |

| | |
|---|---|
| **Total tonne $CO_2e$/yr =** | **383,317** |

**Calculations for Trucks Operation Modeling**

| Data Supplied By Client | | | | |
|---|---|---|---|---|
| **Parameter** | **Coke and Coal Trucks (@ 10 mph)** | | **Onsite Gasifier Solids Handling (@ 5 mph)** | |
| | **Running Emissions** | **Idling Emissions** | **Running Emissions** | **Idling Emissions** |
| Distance Traveled (mi) | 0.9659 | | 0.568 | |
| Per Truck Idle Time (hr) | | 0.117 | | 0.083 |
| **Maximum number of trucks or loads:** | | | | |
| 1-hr | 18 | 18 | 2 | 2 |
| 3-hr | 54 | 54 | 7 | 7 |
| 8-hr | 144 | 144 | 13 | 13 |
| 24-hr | 180 | 180 | 38 | 37.5 |
| Annual average trucks or loads | 35,500 | 35500 | 2,900 | 2900 |

**Emission Factor based on equation from AP-42, Chapter 13 (Paved Roads)**

$$E = k\left(\frac{sL}{2}\right)^{0.65} \times \left(\frac{W}{3}\right)^{1.5} - C$$

**E =** particulate emission factor
**k =** particle size multiplier for particle size range and units of interest
**sL =** road surface silt loading
**W =** average weight (tons) of the vehicles traveling the road
**C =** emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear.

| Parameter | Value | Unit | |
|---|---|---|---|
| k = | 0.016 | lb/VMT | AP 42, Table 13.2-1.1: default k value for $PM_{10}$ |
| **C =** | 0.00047 | lb/VMT | AP 42, Table 13.2-1.2: default C value for $PM_{10}$ |
| sL= | 0.031 | g/m$^2$ | Default value from URBEMIS 9.2 for Kern County |
| W = | 2.65 | ton | Default value from URBEMIS 9.2 for Kern County |
| E = | 4.1E-04 | lb/VMT | Default value from URBEMIS 9.2 for Kern County |
| | 0.19 | g/VMT | Default value from URBEMIS 9.2 for Kern County |

## Summary of Truck Emissions - HECA — Emissions Summary

*Hydrogen Energy International LLC*
*HECA Project*

*5/21/2009*

**EMFAC2007 Emission Factors (g/mi or g/idle-hour)**

| Pollutant | Coke and Coal Trucks (@ 10 mph) | | Onsite Gasifier Solids Handling (@ 5 mph) | |
|---|---|---|---|---|
| | Running Emissions | Idling Emissions | Running Emissions | Idling Emissions |
| CO | 8.289 | 47.47 | 12.05 | 47.47 |
| NOx | 16.59 | 115.98 | 23.645 | 115.98 |
| SOx | 0.03 | 0.062 | 0.04 | 0.062 |
| PM10 * | 1.09 | 1.115 | 1.47 | 1.115 |
| PM2.5 | 0.794 | 1.026 | 1.142 | 1.026 |

** PM10 iincludes entrained road dust factor for paved roads obtained from AP-42 Ch. 13, using defaults from URBEMIS 9.2*

**1-hr Emission Rates for AERMOD (g/s)**

| Pollutant | Coke and Coal Trucks (@ 10 mph) | | Onsite Gasifier Solids Handling (@ 5 mph) | |
|---|---|---|---|---|
| | Running Emissions ( 0.84 mile route) | Idling Emissions (at each Idle Point) | Running Emissions ( 0.568 mile route) | Idling Emissions (at each Idle Point) |
| CO | 0.040 | 0.028 | 0.004 | 0.002 |
| NOx | 0.080 | 0.068 | 0.007 | 0.005 |
| SOx | 1.4E-04 | 3.6E-05 | 1.2E-05 | 2.9E-06 |
| PM10 | 0.005 | 0.001 | 0.000 | 5.2E-05 |
| PM2.5 | 0.004 | 0.001 | 3.60E-04 | 4.8E-05 |

**3-hr Emission Rates for AERMOD (g/s)**

| Pollutant | Coke and Coal Trucks (@ 10 mph) | | Onsite Gasifier Solids Handling (@ 5 mph) | |
|---|---|---|---|---|
| | Running Emissions ( 0.84 mile route) | Idling Emissions (at each Idle Point) | Running Emissions ( 0.568 mile route) | Idling Emissions (at each Idle Point) |
| CO | 0.040 | 0.028 | 0.004 | 0.003 |
| NOx | 0.080 | 0.068 | 0.009 | 0.006 |
| SOx | 1.4E-04 | 3.6E-05 | 1.4E-05 | 3.3E-06 |
| PM10 | 0.005 | 0.001 | 0.001 | 6.0E-05 |
| PM2.5 | 0.004 | 0.001 | 4.20E-04 | 5.5E-05 |

## Summary of Truck Emissions - HECA — Emissions Summary

*Hydrogen Energy International LLC* — *5/21/2009*
*HECA Project*

**8-hour Emission Rates for AERMOD (g/s)**

| Pollutant | Coke and Coal Trucks (@ 10 mph) | | Onsite Gasifier Solids Handling (@ 5 mph) | |
|---|---|---|---|---|
| | Running Emissions ( 0.84 mile route) | Idling Emissions (at each Idle Point) | Running Emissions ( 0.568 mile route) | Idling Emissions (at each Idle Point) |
| CO | 0.040 | 0.028 | 0.003 | 0.002 |
| NOx | 0.080 | 0.068 | 0.006 | 0.004 |
| SOx | 1.4E-04 | 3.6E-05 | 9.5E-06 | 2.3E-06 |
| PM10 | 0.005 | 0.001 | 3.8E-04 | 4.2E-05 |
| PM2.5 | 0.004 | 0.001 | 2.9E-04 | 3.9E-05 |

**24-hour Emission Rates for AERMOD (g/s)**

| Pollutant | Coke and Coal Trucks (@ 10 mph) | | Onsite Gasifier Solids Handling (@ 5 mph) | |
|---|---|---|---|---|
| | Running Emissions ( 0.84 mile route) | Idling Emissions (at each Idle Point) | Running Emissions ( 0.568 mile route) | Idling Emissions (at each Idle Point) |
| CO | 0.017 | 0.012 | 0.003 | 0.002 |
| NOx | 0.033 | 0.028 | 0.006 | 0.004 |
| SOx | 6.0E-05 | 1.5E-05 | 9.1E-06 | 2.2E-06 |
| PM10 | 0.002 | 2.7E-04 | 3.6E-04 | 4.0E-05 |
| PM2.5 | 0.002 | 2.5E-04 | 2.8E-04 | 3.7E-05 |

**Annual Emission Rates for AERMOD (g/s)**

| Pollutant | Coke and Coal Trucks (@ 10 mph) | | Onsite Gasifier Solids Handling (@ 5 mph) | |
|---|---|---|---|---|
| | Running Emissions ( 0.84 mile route) | Idling Emissions (at each Idle Point) | Running Emissions ( 0.568 mile route) | Idling Emissions (at each Idle Point) |
| CO | 0.009 | 0.006 | 0.001 | 0.000 |
| NOx | 0.018 | 0.015 | 0.001 | 0.001 |
| SOx | 3.3E-05 | 8.1E-06 | 1.9E-06 | 4.8E-07 |
| PM10 | 0.001 | 1.5E-04 | 7.7E-05 | 8.5E-06 |
| PM2.5 | 0.001 | 1.3E-04 | 6.0E-05 | 7.9E-06 |

Appendix D1.3

Operating Emissions
Mobile Sources

## Trip Parameters under Current Practice — Summary

*Hydrogen Energy International LLC* *5/21/2009*
*HECA Project*

**Annual Mobile Operational Summary (Current Practice)**

| | Mobile Operational Activity | Average Annual Trips (deliveries) | Route | Percentage | Distance per Route (round trip miles) | Miles (miles per year) |
|---|---|---|---|---|---|---|
| Outbound Mobile Sources | **Feedstock Material** | | | | | |
| | **Overall Feedstock Delivery** | 35,500 | | | | |
| | **Pet. Coke** | | | | | |
| | Route 2 | 15,975 | Truck from Carson to Port of Long Beach | 45% | 20 | 319,500 |
| | Route 3 | 1,775 | Truck from Bakersfield to Port of Long Beach via Highway 99, then along I-99 | 5% | 274 | 486,350 |
| | Route 4 | 1,775 | Truck from Bakersfield to SJV Basin | 5% | 468 | 830,700 |

**Annual Mobile Operational Summary for Rail (Current Practice)**

| | Mobile Operational Activity | Average Cars Per Year (round trip) | Route | Percentage | Distance per Route (round trip miles) |
|---|---|---|---|---|---|
| Outbound Mobile Sources | **Feedstock Material** | | | | |
| | **Pet. Coke** | | | | |
| | Route 1 | 4087 | Rail from Santa Maria to Long Beach via Costal Railway | 45% | 486 |

*Hydrogen Energy International LLC* *5/21/2009*
*HECA Project*

| **Emission Factors from EMFAC2007** [1] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Equipment Description** | **VMT** [2] | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$** [3] | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_x$** | **ROG** |
| | | tons/day | tons/day | tons/day | tons/day | tons/day | tons/day | tons/day | tons/day | tons/day |
| Heavy-Heavy Duty Diesel Truck - South Coast Air Basin | 9798000 | 36.05 | 20590 | 0.4 | -- | 98.61 | 5.11 | 4.29 | 0.20 | 8.68 |
| Heavy-Heavy Duty Diesel Truck - San Joaquin Air Basin | 13341000 | 48.4 | 27780 | 0.54 | -- | 142.36 | 6.10 | 5.05 | 0.27 | 11.54 |

(1) Emission factors for on-road, heavy-heavy-duty vehicles are based on results from Emfac Emissions Model 2007 Version 2.3. The values are the projected values for the HHDT vehicles within either the South Coast Air Basin or the San Joaquin Valley Air Basin in the respective year. Emission factors are based on fleet from 1971- 2015. PM10 and PM2.5 values include break wear and tire wear.

(2) Vehicle Miles Traveled per Day represents the vehicle miles traveled within either South Coast Air Basin pr San Joaquin Valley Air Basin on average and is based on the output from Emfac Emissions Model 2007 Version 2.3 (BURDEN output).

(3) $N_2O$ factors are derived from California Climate Action Registry General Reporting Protocol Version 3.1 (Janaury 2009), 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 diesel fueled heavy-heavy duty trucks in either South Coast Air Basin or San Joaquin Air Basin.

| **Calcualtion of Emisison Factors** [1] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Equipment Description** | | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_x$** | **ROG** |
| | | lb/day | lb/day | lb/day | lb/day | lb/day | lb/day | lb/day | lb/day | lb/day |
| Heavy-Heavy Duty Diesel Truck - South Coast Air Basin | | 7.36E-03 | 4.20 | 8.16E-05 | 1.06E-05 | 0.02 | 1.04E-03 | 8.76E-04 | 4.08E-05 | 1.77E-03 |
| Heavy-Heavy Duty Diesel Truck - San Joaquin Air Basin | | 7.26E-03 | 4.16 | 8.10E-05 | 1.06E-05 | 0.02 | 9.14E-04 | 7.57E-04 | 4.05E-05 | 1.73E-03 |

(1) The following equation was used to obtain the emission factors:

$$\boxed{EF = ER / VMT * 2000}$$

Where: EF= emission factor in pounds per mile
ER = Emission Rate in tons per day
VMT = Average vehicle miles traveled per day by heavy-heavy duty trucks

| **Feedstock Truck Emissions: 2015** [2] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Equipment Description** | **VMT** | | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_x$** | **ROG** [2] |
| | | | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year |
| Route 2 | 319,500 | | 1.18 | 671.41 | 0.01 | 1.69E-03 | 3.22 | 0.17 | 0.14 | 0.01 | 0.28 |
| Route 3 (South Coast Air Basin) [3] | 335,582 | | 1.23 | 705.21 | 0.01 | 1.78E-03 | 3.38 | 0.18 | 0.15 | 0.01 | 0.30 |
| Route 3 (San Joaquin Valley Air Basin) | 150,769 | | 0.55 | 313.95 | 0.01 | 7.98E-04 | 1.61 | 0.07 | 0.06 | 3.05E-03 | 0.13 |
| Route 4 | 830,700 | | 3.01 | 1,729.77 | 0.03 | 4.40E-03 | 8.86 | 0.38 | 0.31 | 0.02 | 0.72 |

(1) The following equation was used to obtain the emission factors:

$$\boxed{M = EF * D / 2000}$$

Where: M = Mass emissions rate from refinery related activities in tons per year
EF= emission factor in pounds per mile
D = Distance traveled by trucks to the refinery in miles per year.

(2) Assuming ROGs are equivalent to VOCs
(3) Assuming that 69% of the Route 3 trip is in South Coast Air Basin and 31 % of the Route 3 trip is in San Joaquin Valley Air Basin

## Summary of Rail Emissions - Current Practice — Emissions Summary

*Hydrogen Energy International LLC* — *5/21/2009*
*HECA Project*

**Calculations for Locomotives in Motion**

| Data Supplied By Client | | | |
|---|---|---|---|
| **Parameter** | | **Value** | **Unit** |
| # of Rail-Cars (Incremental) = | | 4,087 | per year |
| Capacity of Rail Car = | | 100 | ton |
| Average Tons Hauled per Day | | 1,120 | ton |
| Days per Year | | 365 | day/year |

| Assumptions | | | |
|---|---|---|---|
| **Parameter** | | **Value** | **Unit** |
| Average Round Trip Distance Traveled per Locomotive = | | 486 | miles/locomotive |
| Rail-cars per Locomotive [1] = | | 62 | rail-cars |
| Average Miles Traveled Per Locomotive = | | 69,900 | miles/yr |
| Average Fuel Consumed Per Locomotive = | | 176,600 | gallon/yr |
| Locomotive Fuel Efficiency = | | 0.13 | mile/gal |

(1) Reference: National Transportation Statistics for Locomotives, Table 4.17: Class I Rail Freight Fuel Consumption and Travel, 2008 (http://www.bts.gov/publications/national_transportation_statistics)

| Emission Factors For Locomotives in Motion [1] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Year** | **CO** | **$CO_2$ [5]** | **$CH_4$ [6]** | **$N_2O$ [6]** | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$ [2], [3]** | **SOx [4]** | **ROG** |
| | g/gal | g/gal | g/gal | g/gal | g/gal | g/gal | g/gal | ppm | g/gal |
| 2015 | 27.4 | 10084.0 | 0.30 | 0.10 | 151.0 | 5.3 | 4.9 | 15.0 | 8.5 |

(1) Reference: EPA's Technical Highlights: Emission Factors for Locomotives , 1997 (www.epa.gov/OMS/regs/nonroad/locomotv/frm/42097051.pdf)

(2) $PM_{2.5}$ 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.

(3) $PM_{2.5}$ Fraction of $PM_{10}$, Train: 0.92

(4) California state regulation requires intrastate diesel-electric locomotives that operate 90 percent of the time in the state to use only California ultra low sulfur (15 parts per million) diesel fuel.

(5) Per EPA's Emission Facts <http://www.epa.gov/otaq/climate/420f05001.pdf>, $CO_2$ emissions from a gallon of diesel fuel are 10,084 g/gal diesel.

(6) $CH_4$ and $N_2O$ factors are derived from California Climate Action Registry General Reporting Protocol Version 3.1 (January 2009), Table C.6 (Methane and Nitrous Oxide Emission Factors for Stationary Combustion by Sector and Fuel Type).

| Calculations | | | |
|---|---|---|---|
| **Parameter** | | **Value** | **Units** |
| # of Locomotives (Incremental) = | | 66 | per year |
| Locomotive Fuel Efficiency = | | 0.13 | mile/gal |
| Total Locomotive Distance Traveled (South Coast Air Basin) [1] = | | 16,017 | mile/year |
| Total Locomotive Distance Traveled (South Central Coast Air Basin) = | | 16,017 | mile/year |
| Locomotive Fuel Consumption (South Coast Air Basin)= | | 123,205 | gal/year |
| Locomotive Fuel Consumption (South Central Coast Air Basin)= | | 123,205 | gal/year |
| Average Density of Locomotive Diesel (taken from msds) = | | 7.32 | lb/gallon |
| Total Weight of Locomotive Fuel = | | 901,404.41 | lb/yr |

(1) Assuming that 50% of the trip is in the South Coast Air Basin and 50 % of the trip is in South Central Coast Air Basin

| Mobile Mass Emissions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Year** | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_x$** | **ROG** |
| | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year |
| 2015 (South Coast Air Basin) | 3.72 | 1369.51 | 4.07E-02 | 1.36E-02 | 20.51 | 0.72 | 0.66 | 1.35E-02 | 1.15 |
| 2015 (South Central Coast Air Basin) | 3.72 | 1369.51 | 0.04 | 0.01 | 20.51 | 0.72 | 0.66 | 2.04 | 1.15 |

**Calculations For Locomotives in Idle Mode**

| Emission Factors for Locomotives in Idle Mode | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Year** | **CO (1)** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_x$ (1)** | **$PM_{10}$ (1)** | **$PM_{2.5}$ (2), (3)** | **$SO_x$ (4)** | **ROG (1)** |
| | g/hr | g/hr | g/hr | g/hr | g/hr | g/hr | g/hr | ppm | g/hr |
| NA | 492 | 40336 | 1.20E+00 | 4.00E-01 | 620 | 32 | 29 | 15 | 478 |

NO

(1) References: $NO_X$ and $PM_{10}$ Emission Factors from EPA's Technical Highlights: Guidance for Quantifying and Using Long Duration Switch Yard Locomotive Idling Emission Reductions in State Yard Locomotive Idling Emission Reductions in State Implementation Plans, January 2004. ROG and CO Emission Factors from Sierra Research Group: Development of Railroad Emissions Methodology Development, June 2004

(2) $PM_{2.5}$ 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 - to Calculate PM2.5 and PM2.5 Significance Thresholds, October 2006: Appendix A - Updated CEIDARS Table with PM2.5 Fractions.

(3) $PM_{2.5}$ Fraction of $PM_{10}$, Train: 0.92

(4) California state regulation requires intrastate diesel-electric locomotives that operate 90 percent of the time in the state to use only California ultra low sulfur (15 parts per million) diesel fuel.

(5) Per EPA's Emission Facts <http://www.epa.gov/otaq/climate/420f05001.pdf>, $CO_2$ emissions from a gallon of diesel fuel are 10,084 g/gal diesel. This factor was multiplied by fuel consumed per idle hour to get a factor in units of gal/hr

(6) $CH_4$ and $N_2O$ factors are derived from California Climate Action Registry General Reporting Protocol Version 2.2 (March 2007), Table C.6 (Methane and Nitrous Oxide Emission Factors for Stationary Combustion by Sector and Fuel Type). The CH4 and N2O emission factors are multiplied by the fuel consumed per idle hours to get emission factors in units of gal/hr

| Calculations | | | |
|---|---|---|---|
| **Parameter** | | **Value** | **Unit** |
| # of idling events per year = | | 66 | per year |
| Idling time per event= | | 60 | min |
| Total idling time per year = | | 66 | hr |
| Fuel consumed per idle hour (1) = | | 4 | gal/hr |
| Average Density of Locomotive Diesel (taken from msds) = | | 7.32 | lb/gallon |
| Total Weight of Locomotive Fuel (idle) = | | 1,928.93 | lb/yr |

(1) Based on switcher idling information on EPAs web page: http://www.epa.gov/smartway/idlingimpacts.htm

| Idle Mass Emissions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Year** | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_x$** | **ROG** |
| | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year |
| NA | 3.57E-02 | 2.93 | 8.72E-05 | 2.91E-05 | 4.50E-02 | 2.32E-03 | 2.14E-03 | 2.89E-05 | 3.47E-02 |

## Summary of Rail Emissions - Current Practice — Emissions Summary

*Hydrogen Energy International LLC* — *5/21/2009*
*HECA Project*

| Total Mass Emissions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | CO | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | $SO_x$ | ROG [(1)] |
| | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year |
| 2015 (South Coast Air Basin) | 3.76 | 1,372.44 | 0.04 | 0.01 | 20.55 | 0.72 | 0.66 | 0.01 | 1.19 |
| 2015 (South Central Coast Air Basin) | 3.76 | 1,372.44 | 0.04 | 0.01 | 20.55 | 0.72 | 0.66 | 2.04 | 1.19 |

(1) Assuming ROGs are equivalent to VOCs

*Hydrogen Energy International LLC*
*HECA Project*

*5/21/2009*

**Annual Mobile Operational Summary for Trucks [1]**

| | Mobile Operational Activity | Average Trips Per Day (deliveries) | Average Annual Trips (deliveries) | Route | Percentage | Distance per Route (round trip miles) | Tucks miles (miles per year) |
|---|---|---|---|---|---|---|---|
| Inbound Mobile Sources | **Feedstock Material** | | | | | | |
| | **Overall Feedstock Delivery** | 115 | 35,500 | | | | |
| | **Scenario 1:**<br>**Delivery Expected** | **100%**<br>**80%** | **Pet. Coke**<br>**of the time** | | | | |
| | **Pet. Coke** | | | | | | |
| | Truck Route 1 | 41 | 12,780 | Highway 46 (Santa Maria Pet. Coke) | 45% | 312 | 3,987,360 |
| | Truck Route 2 | 41 | 12,780 | I-5 South (Carson Pet. Coke) | 45% | 274 | 3,501,720 |
| | Truck Route 3 | 5 | 1,420 | Highway 58 (Bakersfield Pet. Coke) | 5% | 50 | 71,000 |
| | Truck Route 4 | 5 | 1,420 | Highway 58 (Bakersfield Pet. Coke) | 5% | 50 | 71,000 |
| | **Scenario 2:**<br>**Delivery Expected** | **75%**<br>**25%**<br>**20%** | **Coal**<br>**Pet. Coke**<br>**of the time** | | | | |
| | **Coal** | | | | | | |
| | Truck | 17 | 5,325 | From Wasco to Plant | 100% | 58 | 308,850 |
| | **Pet. Coke** | | | | | | |
| | Truck Route 1 | 3 | 799 | Highway 46 (Santa Maria Pet. Coke) | 45% | 312 | 249,210 |
| | Truck Route 2 | 3 | 799 | I-5 South (Carson Pet. Coke) | 45% | 274 | 218,858 |
| | Truck Route 3 | 0 | 89 | Highway 58 (Bakersfield Pet. Coke) | 5% | 50 | 4,438 |
| | Truck Route 4 | 0 | 89 | Highway 58 (Bakersfield Pet. Coke) | 5% | 50 | 4,438 |
| | **Fluxant** | | | | | | |
| | **Fluxant** | | | | | | |
| | Truck | 3 | 790 | Kern County | 100% | 50 | 39,500 |
| | **Other Materials** | | | | | | |
| | **Chemical Shipments** | | | | | | |
| | Truck | 3 | 920 | Los Angeles Region | 100% | 274 | 252,080 |
| Outbound Mobile Sources | **Plant Waste** | | | | | | |
| | **Gasification Solids** | | | | | | |
| | Truck | 10 | 2,860 | ? Kern County | 100% | 50 | 143,000 |
| | **Export By-Products** | | | | | | |
| | **Sulfur** | | | | | | |
| | Truck | 5 | 1,470 | ? Kern County | 100% | 50 | 73,500 |
| | **ZLD Filter Cake** | | | | | | |
| | Truck | 2 | 630 | ? Kern County | 100% | 50 | 31,500 |

(1) Source: HECA Project - Onsite Operations Truck Traffic Spreadsheet

*Hydrogen Energy International LLC*
*HECA Project*

*5/21/2009*

**Annual Mobile Operational Summary for Rail**

| | Mobile Operational Activity | Average Cars Per Day (round trip) | Average Cars Per Year (round trip) | Route | Percentage | Distance per Route (round trip miles) |
|---|---|---|---|---|---|---|
| Inbound Mobile Sources | **Feedstock Material** | | | | | |
| | **Coal** | | | | | |
| | Rail | -- | 1697 | From Utah to Wasco via BNSF Rail | 100% | 606 |

## Summary of Truck Emissions - HECA

**Emissions Summary**

*Hydrogen Energy International LLC*
*HECA Project*

*5/21/2009*

| Emission Factors from EMFAC2007 (1) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Equipment Description** | **VMT (2)** | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$ (3)** | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_x$** | **ROG** |
| | | tons/day | tons/day | tons/day | tons/day | tons/day | tons/day | tons/day | tons/day | tons/day |
| Heavy-Heavy Duty Diesel Truck - South Coast Air Basin | 688000 | 1.22 | 1430 | 0.01 | -- | 2.50 | 0.14 | 0.10 | 0.01 | 0.23 |
| Heavy-Heavy Duty Diesel Truck - South Central Air Basin | 46000 | 0.08 | 90 | 0.00 | -- | 0.16 | 0.01 | 0.01 | 0.00 | 0.02 |
| Heavy-Heavy Duty Diesel Truck - San Joaquin Valley Air Basir | 906000 | 1.50 | 1870 | 0.01 | -- | 3.17 | 0.16 | 0.11 | 0.02 | 0.32 |

(1) Emission factors for on-road, heavy-heavy-duty vehicles are based on results from Emfac Emissions Model 2007 Version 2.3. The values are the projected values for the HHDT vehicles within either South Coast Air Basin, South Central Coast Air Basin or San Joaquin Valley Air Basin in the respective year. Emission factors are based on fleet from 2010 only. PM10 and PM2.5 values include break wear and tire wear.

(2) Vehicle Miles Traveled per Day represents the vehicle miles traveled in either South Coast Air Basin, South Central Coast Air Basin or San Joaquin Valley Air Basin on average and is based on the output from Emfac Emissions Model 2007 Version 2.3 (BURDEN output).

(3) $N_2O$ factors are derived from California Climate Action Registry General Reporting Protocol Version 3.1 (Janaury 2009), 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 diesel fueled heavy-heavy duty trucks in either South Coast Air Basin, South Central Coast Air Basin or San Joaquin Valley Air Basin.

| Calcualtion of Emisison Factors (1) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Equipment Description** | | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_x$** | **ROG** |
| | | lb/day | lb/day | lb/day | lb/day | lb/day | lb/day | lb/day | lb/day | lb/day |
| Heavy-Heavy Duty Diesel Truck - South Coast Air Basin | | 3.55E-03 | 4.16 | 2.91E-05 | 1.06E-05 | 7.27E-03 | 4.07E-04 | 2.91E-04 | 2.91E-05 | 6.69E-04 |
| Heavy-Heavy Duty Diesel Truck - South Central Air Basin | | 3.48E-03 | 3.91 | 0.00E+00 | 1.06E-05 | 6.96E-03 | 4.35E-04 | 4.35E-04 | 0.00E+00 | 8.70E-04 |
| Heavy-Heavy Duty Diesel Truck - San Joaquin Valley Air Basir | | 3.31E-03 | 4.13 | 2.21E-05 | 1.06E-05 | 0.01 | 3.53E-04 | 2.43E-04 | 4.42E-05 | 7.06E-04 |

(1) The following equation was used to obtain the emission factors:

$$\boxed{EF = ER / VMT * 2000}$$

Where: EF= emission factor in pounds per mile
ER = Emission Rate in tons per day
VMT = Average vehicle miles traveled per day by heavy-heavy duty trucks

*Hydrogen Energy International LLC* *5/21/2009*
*HECA Project*

| Feedstock and Miscellaneous Truck Emissions: 2015 [2] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Equipment Description** | **VMT** | **CO** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_x$** | **$PM_{10}$** | **$PM_{2.5}$** | **$SO_x$** | **ROG [2]** |
| | | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year |
| **Delivery Scenario 1 [5]** | | | | | | | | | | |
| Pet Coke Route 1 - South Central Coast Air Basin [3] | 2,392,416 | 4.16 | 4,680.81 | - | 0.01 | 8.32 | 0.52 | 0.52 | - | 1.04 |
| Pet Coke Route 1 - San Joaquin Valley Air Basin | 1,594,944 | 2.64 | 3,291.99 | 0.02 | 0.01 | 5.58 | 0.28 | 0.19 | 0.04 | 0.56 |
| Pet Coke Route 2 - South Coast Air Basin [4] | 2,171,066 | 3.85 | 4,512.54 | 0.03 | 0.01 | 7.89 | 0.44 | 0.32 | 0.03 | 0.73 |
| Pet Coke Route 2 - San Joaquin Valley Air Basin | 1,330,654 | 2.20 | 2,746.49 | 0.01 | 0.01 | 4.66 | 0.23 | 0.16 | 0.03 | 0.47 |
| Pet Coke Route 3 | 71,000 | 0.12 | 146.55 | 7.84E-04 | 3.76E-04 | 0.25 | 0.01 | 0.01 | 1.57E-03 | 0.03 |
| Pet Coke Route 4 | 71,000 | 0.12 | 146.55 | 7.84E-04 | 3.76E-04 | 0.25 | 0.01 | 0.01 | 1.57E-03 | 0.03 |
| Fluxant Truck Route | 39,500 | 0.07 | 81.53 | 4.36E-04 | 2.09E-04 | 0.14 | 6.98E-03 | 4.80E-03 | 8.72E-04 | 0.01 |
| **Delivery Scenario 2 [5]** | | | | | | | | | | |
| Coal Truck | 308,850 | 0.51 | 637.47 | 3.41E-03 | 1.63E-03 | 1.08 | 0.05 | 0.04 | 0.01 | 0.11 |
| Pet Coke Route 1 - South Central Coast Air Basin [3] | 149,526 | 0.26 | 292.55 | - | 7.91E-04 | 0.52 | 0.03 | 0.03 | - | 0.07 |
| Pet Coke Route 1 - San Joaquin Valley Air Basin | 99,684 | 0.17 | 205.75 | 1.10E-03 | 5.27E-04 | 0.35 | 0.02 | 0.01 | 2.20E-03 | 0.04 |
| Pet Coke Route 2 - South Coast Air Basin [4] | 135,692 | 0.24 | 282.03 | 1.97E-03 | 7.18E-04 | 0.49 | 0.03 | 0.02 | 1.97E-03 | 0.05 |
| Pet Coke Route 2 - San Joaquin Valley Air Basin | 83,166 | 0.14 | 171.66 | 9.18E-04 | 4.40E-04 | 0.29 | 0.01 | 0.01 | 1.84E-03 | 0.03 |
| Pet Coke Route 3 | 4,438 | 0.01 | 9.16 | 4.90E-05 | 2.35E-05 | 0.02 | 7.84E-04 | 5.39E-04 | 9.80E-05 | 1.57E-03 |
| Pet Coke Route 4 | 4,438 | 0.01 | 9.16 | 4.90E-05 | 2.35E-05 | 0.02 | 7.84E-04 | 5.39E-04 | 9.80E-05 | 1.57E-03 |
| **Other Deliveries** | | | | | | | | | | |
| Chemical Shipments | 252,080 | 0.42 | 520.30 | 2.78E-03 | 1.33E-03 | 0.88 | 4.45E-02 | 3.06E-02 | 5.56E-03 | 8.90E-02 |
| Gasification Solids Truck | 143,000 | 0.24 | 295.15 | 1.58E-03 | 7.57E-04 | 0.50 | 2.53E-02 | 1.74E-02 | 3.16E-03 | 5.05E-02 |
| Sulfur Truck | 73,500 | 0.12 | 151.71 | 8.11E-04 | 3.89E-04 | 0.26 | 1.30E-02 | 8.92E-03 | 1.62E-03 | 2.60E-02 |
| ZLD Filter Cake | 31,500 | 0.05 | 65.02 | 3.48E-04 | 1.67E-04 | 0.11 | 5.56E-03 | 3.82E-03 | 6.95E-04 | 1.11E-02 |

(1) The following equation was used to obtain the emission factors:

$$\boxed{M = EF * D / 2000}$$

Where: M = Mass emissions rate from refinery related activities in tons per year
EF= emission factor in pounds per mile
D = Distance traveled by trucks to the refinery in miles per year.

(2) Assuming ROGs are equivalent to VOCs

(3) Assuming that 60% of the Pet. Coke Route 1 trip is in South Central Coast Air Basin and 40 % of the Pet. Coke Route 1 trip is in San Joaquin Valley Air Basin

(4) Assuming that 62% of the Pet. Coke Route 2 trip is in South Coast Air Basin and 38 % of the Pet. Coke Route 2 trip is in San Joaquin Valley Air Basin

(5) Feed Deliveries Scenario 1 occurs 80% of the time, while Feed Deliveries Scenario 2 occurs 20% of the time

*Hydrogen Energy International LLC* *5/21/2009*
*HECA Project*

**Calculations for Locomotives in Motion**

| Data Supplied By Client | | |
|---|---|---|
| **Parameter** | **Value** | **Unit** |
| # of Rail-Cars (Incremental) = | 1,697 | per year |
| Capacity of Rail Car = | 100 | ton |
| Average Tons Hauled per Day | 465 | ton |
| Days per Year | 365 | day/year |

(1) Assuming 100 ton capacity for rail cars and 1,860 tons per day delivery = 19 rail cars per day multiplied by 365 days per year

| Assumptions | | |
|---|---|---|
| **Parameter** | **Value** | **Unit** |
| Average Round Trip Distance Traveled per Locomotive = | 606 | miles/locomotive |
| Rail-cars per Locomotive = | 62 | rail-cars |
| Average Miles Traveled Per Locomotive = | 69,900 | miles/yr |
| Average Fuel Consumed Per Locomotive = | 176,600 | gallon/yr |
| Locomotive Fuel Efficiency = | 0.13 | mile/gal |

(http://www.bts.gov/publications/national_transportation_statistics)

**Emission Factors For Locomotives in Motion** [1]

| Year | CO | $CO_2$ [5] | $CH_4$ [6] | $N_2O$ [6] | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ [2], [3] | SOx [4] | ROG |
|---|---|---|---|---|---|---|---|---|---|
| | g/gal | g/gal | g/gal | g/gal | g/gal | g/gal | g/gal | ppm | g/gal |
| 2015 | 27.4 | 10084.0 | 0.30 | 0.10 | 151.0 | 5.3 | 4.9 | 15.0 | 8.5 |

(1) Reference: EPA's Technical Highlights: Emission Factors for Locomotives , 1997 (www.epa.gov/OMS/regs/nonroad/locomotv/frm/42097051.pdf)
(2) $PM_{2.5}$ 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.
(3) $PM_{2.5}$ Fraction of $PM_{10}$, Train: 0.92
(4) California state regulation requires intrastate diesel-electric locomotives that operate 90 percent of the time in the state to use only California ultra low sulfur (15 parts per million) diesel fuel.
(5) Per EPA's Emission Facts <http://www.epa.gov/otaq/climate/420f05001.pdf>, $CO_2$ emissions from a gallon of diesel fuel are 10,084 g/gal diesel.
(6) $CH_4$ and $N_2O$ factors are derived from California Climate Action Registry General Reporting Protocol Version 3.1 (January 2009), Table C.6
(Methane and Nitrous Oxide Emission Factors for Stationary Combustion by Sector and Fuel Type).

| Calculations | | |
|---|---|---|
| **Parameter** | **Value** | **Units** |
| # of Locomotives (Incremental) = | 27 | per year |
| Locomotive Fuel Efficiency = | 0.13 | mile/gal |
| Total Locomotive Distance Traveled (San Joaquin Valley Air Basin) [1] = | 14,433 | mile/year |
| Total Locomotive Distance Traveled (Mojave Desert Air Basin) = | 2,157 | mile/year |
| Locomotive Fuel Consumption (Mojave Desert Air Basin) = | 111,020 | gal/year |
| Locomotive Fuel Consumption (San Joaquin Valley Air Basin) = | 16,589 | gal/year |
| Average Density of Locomotive Diesel (taken from msds) = | 7.32 | lb/gallon |
| Total Weight of Locomotive Fuel = | 812,260.52 | lb/yr |

(1) Assuming that 87% of the trip is in the Mojave Desert Air Basin and 13 % of the trip is in San Joaquin Valley Coast Air Basin

## Summary of Rail Emissions - HECA — Emissions Summary

*Hydrogen Energy International LLC* — *5/21/2009*
*HECA Project*

**Mobile Mass Emissions**

| Year | CO | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | $SO_x$ | ROG |
|---|---|---|---|---|---|---|---|---|---|
| | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year |
| 2015 (Mojave Desert Air Basin) | 3.35 | 1234.07 | 3.67E-02 | 1.22E-02 | 18.48 | 0.65 | 0.60 | 1.22E-02 | 1.04 |
| 2015 (San Joaquin Valley Air Basin) | 0.50 | 184.40 | 0.01 | 0.00 | 2.76 | 0.10 | 0.09 | 0.27 | 0.16 |

**Calculations For Locomotives in Idle Mode**

**Emission Factors for Locomotives in Idle Mode**

| Year | CO (1) | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ (1) | $PM_{10}$ (1) | $PM_{2.5}$ (2), (3) | $SO_x$ (4) | ROG (1) |
|---|---|---|---|---|---|---|---|---|---|
| | g/hr | g/hr | g/hr | g/hr | g/hr | g/hr | g/hr | ppm | g/hr |
| NA | 492 | 40336 | 1.20E+00 | 4.00E-01 | 620 | 32 | 29 | 15 | 478 |

(1) References: $NO_X$ and $PM_{10}$ Emission Factors from EPA's Technical Highlights: Guidance for Quantifying and Using Long Duration Switch Yard Locomotive Idling Emission Reductions in State Yard Locomotive Idling Emission Reductions in State Implementation Plans, January 2004. ROG and CO Emission Factors from Sierra Research Group: Development of Railroad Emissions Methodology Development, June 2004

(2) $PM_{2.5}$ 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 - to Calculate PM2.5 and PM2.5 Significance Thresholds, October 2006: Appendix A - Updated CEIDARS Table with PM2.5 Fractions.

(3) $PM_{2.5}$ Fraction of $PM_{10}$, Train: 0.92

(4) California state regulation requires intrastate diesel-electric locomotives that operate 90 percent of the time in the state to use only California ultra low sulfur (15 parts per million) diesel fuel.

(5) Per EPA's Emission Facts <http://www.epa.gov/otaq/climate/420f05001.pdf>, $CO_2$ emissions from a gallon of diesel fuel are 10,084 g/gal diesel. This factor was multiplied by fuel consumed per idle hour to get a factor in units of gal/hr

(6) $CH_4$ and $N_2O$ factors are derived from California Climate Action Registry General Reporting Protocol Version 2.2 (March 2007), Table C.6 (Methane and Nitrous Oxide Emission Factors for Stationary Combustion by Sector and Fuel Type). The CH4 and N2O emission factors are multiplied by the fuel consumed per idle hours to get emission factors in units of gal/hr

**Calculations**

| Parameter | | Value | Unit |
|---|---|---|---|
| # of idling events per year = | | 27 | per year |
| Idling time per event= | | 60 | min |
| Total idling time per year = | | 27 | hr |
| Fuel consumed per idle hour (1) = | | 4 | gal/hr |
| Average Density of Locomotive Diesel (taken from msds) = | | 7.32 | lb/gallon |
| Total Weight of Locomotive Fuel (idle) = | | 801.14 | lb/yr |

(1) Based on switcher idling information on EPAs web page: http://www.epa.gov/smartway/idlingimpacts.htm

**Idle Mass Emissions**

| Year | CO | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | $SO_x$ | ROG |
|---|---|---|---|---|---|---|---|---|---|
| | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year |
| NA | 1.48E-02 | 1.22 | 3.62E-05 | 1.21E-05 | 1.87E-02 | 9.66E-04 | 8.88E-04 | 1.20E-05 | 1.44E-02 |

**Total Mass Emissions**

| Year | CO | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | $SO_x$ | ROG (1) |
|---|---|---|---|---|---|---|---|---|---|
| | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year | tons/year |
| 2015 (Mojave Desert Air Basin) | 3.37 | 1235.29 | 0.04 | 0.01 | 18.50 | 0.65 | 0.60 | 0.01 | 1.05 |
| 2015 (San Joaquin Valley Air Basin) | 0.52 | 185.62 | 0.01 | 0.00 | 2.78 | 0.10 | 0.09 | 0.27 | 0.17 |

(1) Assuming ROGs are equivalent to VOCs

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**

May 2009

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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 Code of Federal Regulations (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 USEPA 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.

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 oxides of nitrogen ($NO_{x)}$, volatile organic compounds (VOC), sulfur dioxide ($SO_2$), carbon monoxide (CO), and particulate matter equal to or less than 10 microns in diameter ($PM_{10)}$ (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 Project because the proposed Project will result in a significant net emissions increase for $NO_x$, CO, VOC, $PM_{10}$, and $SO_2$.

The basis for the emissions-related analyses is annual average operation at a design capacity of nominally 250 megawatts. The proposed 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 Heat Recovery Steam Generator (HRSG) and one Steam Turbine-Generator (STG);
- One Natural-Gas – fired Simple-Cycle Auxiliary CTG
- One Multi-cell, Mechanical-draft Cooling Tower 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 an Elevated Gasification Flare
- Three Natural-Gas – Fired Gasifier Warming (Refractory Heaters)

- Sulfur Recovery System (Tail Gas Thermal Oxidizer and two elevated flares with natural gas assist)
- Two Emergency, Diesel-Engine — Driven Generators
- One Diesel-Engine – Driven Fire – Water Pump
- One carbon dioxide ($CO_2$) 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 USEPA 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 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 USEPA'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.

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

Formal use of these steps is not always necessary. However, the USEPA has consistently interpreted the statutory and regulatory BACT definitions as containing two core requirements, which USEPA 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."

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 USEPA 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 USEPA'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 USEPA RBLC and by consulting available literature on control options for integrated gasification combined cycle (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.

HECA includes one type of source unique to power generation facilities operating at this time – the CTG/HRSG equipped to combust syngas. It is important to emphasize that BACT for this source is based on the "best of class" in current diffusion combustor based syngas fired gas turbine technology. The emissions profile contained in this application for this source is as good as or better than other syngas IGCC permitted to date, as discussed later in this section. However, the IGCC BACT level emissions should not be compared to the natural gas combined cycle (NGCC) gas turbine technology using dry low NOx burner technology emission levels.

**Table 3-1**
**Proposed BACT for 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 percent $O_2$ on hydrogen-rich fuel and natural gas fuel, 3-hour average |
| CO | Good Combustion Practice (GCP), CO Catalyst | 3 ppm CO @ 15 percent $O_2$ on hydrogen-rich fuel, 5 ppm CO @ 15 percent $O_2$ 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 (12.65 ppm for natural gas) |
| VOC | CO Catalyst | 1 ppm VOC @ 15 percent $O_2$ on hydrogen-rich fuel, 2 ppm VOC @ 15 percent $O_2$ 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** | | |
| $NO_x$ | Selective Catalytic Reduction | 2.5 ppm $NO_x$ @ 15 percent $O_2$ on natural gas fuel, 3-hour average |
| CO | CO Catalyst | 6.0 ppm CO @ 15 percent $O_2$ |
| $PM/PM_{10}$ | PUC regulated natural gas | 6 lb/hr on natural gas fuel |
| $SO_2$ | | ≤ 0.75 grain / 100 SCF (12.65 ppm for natural gas) |
| VOC | CO Catalyst | 2 ppm VOC @ 15 percent $O_2$ on natural gas fuel |

**Table 3-1**
**Proposed BACT for Project (Continued)**

| Pollutant | Technology | Emission Limit |
|---|---|---|
| $NH_3$ | 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 percent 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 percent $O_2$ on natural gas fuel |
| CO | GCP | 50 ppmvd @ 3 percent $O_2$ |
| $PM/PM_{10}$ | GCP, PUC grade natural gas fuel | 0.005 lb/MMBtu heat input |
| $SO_2$ | | ≤ 0.75 grain / 100 SCF (12.65 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 |
| **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 Flare (an elevated 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 | 4.8 lb/hr 24-hour average |
| CO | | 4.0 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 |

**Table 3-1**
**Proposed BACT for Project (Continued)**

| Pollutant | Technology | Emission Limit |
|---|---|---|
| **SRU Flare (an elevated flare with natural gas assist)** | | |
| $NO_x$ | GCP | |
| CO | GCP | |
| $PM/PM_{10}$ | GCP, gaseous fuel only | |
| $SO_2$ | GCP, Caustic Scrubber | |
| VOC | GCP | |
| **$CO_2$ Vent** | | |
| CO | Gas Cleanup | 1000 ppmv |
| $H_2S$ | Acid Gas Removal | 10 ppmv |
| VOC | Gas Cleanup | 40 ppmv |
| **Gasifier Warming (refractory heater)** | | |
| $NO_x$ | GCP | 0.11 lb/MMBtu, higher heating value (HHV) |
| CO | GCP | 0.09 lb/MMBtu, HHV |
| $PM/PM_{10}$ | GCP, gaseous fuel only | 0.008 lb/MMBtu, HHV |
| $SO_2$ | GCP, PUC grade Natural gas | 0.002 lb/MMBtu, HHV (12.65 ppm) |
| VOC | GCP | 0.007 lb/MMBtu, HHV |
| **Feedstock** | | |
| $PM/PM_{10}$ | Dust Collector | 0.005 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
$NH_3$ = ammonia
$O_2$ = 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
HHV = higher heating value

## 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 coalpc (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. Although 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 the USEPA 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 the USEPA's OAQPS, to E3 Consulting, LLC regarding BACT requirements for proposed coal-fired power plant projects. In that letter, the USEPA 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 that will be used as comparison reference for this BACT analysis are:

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

- ERORA Group, Cash Creek Generating Station

The air permits, BACT analyses, and additional literature were reviewed for each of these recently permitted IGCC facilities. 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–megawatt (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 megawatt (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 megawatt 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 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 megawatt. The GE 7FB is a new turbine model designed to optimally uses 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 turbine units at each facility.

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

The criteria pollutant $NO_x$ 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 and syngas, hydrogen-rich fuel has a much higher hydrogen content (natural gas is often over 90 percent methane), and a much lower heating value (about 250 Btu/scf for hydrogen-rich fuel vs. 1,000 Btu/scf for natural gas). HECA will be fired on hydrogen-rich fuel. The other power plants used for comparison in this Appendix are fired on syngas.

#### *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)

**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 |
| 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:
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 values 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 or less in diameter
ppm = parts per million
ppmc = parts per million by volume, dry basis, corrected to 15 percent O2
$SO_2$ = sulfur dioxide
VOC = volatile organic compound

### *2. Evaluate Technical Feasibilities*

- Dry Low-$NO_x$ Combustor

DLN combustor technology has been successfully 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, pre-mixed 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 carbon dioxide. 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 used 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 fueled by petroleum coke (petcoke) 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 the Project's CTG/HRSG, nitrogen is used as a diluent that reduces thermal $NO_x$ 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, thereby reducing $NO_x$ emissions.

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

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 percent $O_2$) when firing 100 percent 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. $SCONO_x$™ uses a single catalyst for the reduction of CO, VOC, and $NO_x$, which are converted to $CO_2$, water ($H_2O$), and nitrogen ($N_2$).

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).

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 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.

– $SCONO_x$™ 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

Selective non-catalytic reduction 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 to 2,000 degrees Fahrenheit [°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 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 $NH_3$ 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:

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

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

The 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 that 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 at 15 percent oxygen, based on a 3-hour rolling average, when firing hydrogen-rich fuel, natural gas, or a combination of hydrogen-rich fuel and 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 percent $O_2$ while firing hydrogen-rich fuel, and 25 ppmvd $NO_x$ at 15 percent $O_2$ while firing natural gas or a combination of hydrogen-rich fuel and natural gas.

Although there is no commercial demonstration of SCR performance for an IGCC plant using coal or petcoke 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 at 15 percent oxygen, based on a 3-hour 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 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 $NH_3$ 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 at 15 percent 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.

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 is also more stringent than the NSPS Subparts Da recommended minimum reduction efficiency of 25 percent.

### *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 techniques 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 percent $O_2$ for hydrogen-rich–fuel firing, natural-gas firing, and co-firing.

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

| Facility | State | MW | Turbine | $NO_x$ BACT Technology | Emission Limit on Hydrogen-Rich or Syngas Fuels | | Emission Limit on Natural Gas | |
|---|---|---|---|---|---|---|---|---|
| | | | | | 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 |
| 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 percent $O_2$.
[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

### 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*

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 uses 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 percent are attainable across the CO catalyst. HECA proposed CO emission limits of 3.0 ppmvd at 15 percent $O_2$ while firing hydrogen-rich fuel, and 5.0 ppmvd CO at 15 percent $O_2$ 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**

| Facility | State | MW | Turbine | CO BACT Technology | Emission Limit on Hydrogen-Rich Fuel | | Emission Limit on Nat Gas | |
|---|---|---|---|---|---|---|---|---|
| | | | | | ppm | lb/MMBTU Hydrogen-Rich Fuel or Syngas Fuels | 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 percent $O_2$.
[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 at 15 percent $O_2$ while firing hydrogen-rich fuel, and 5.0 ppmvd CO at 15 percent $O_2$ while firing natural gas during non-startup operation, using 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:

*Pre-Combustion Controls*

- Gas Cleanup (for hydrogen-rich fuel)

*Combustion Process Controls*

- Good Combustion Practices

*Post-Combustion Controls*

- 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 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 GCPs were identified as the only technically feasible particulate emissions control technologies applicable to the proposed combustion turbines.

### *4. Evaluate Control Options*

The USEPA 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. When the NSPS for Stationary Gas Turbines (40 CFR 60 Subpart GG) was promulgated in 1979, the USEPA 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.

Based on the evaluation in the previous step, GCPs and optimum gas cleanup are considered as technically feasible PM/ $PM_{10}$ control 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 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 GCPs 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 GCPs and optimum gas cleanup.

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

| Facility | State | MW | Turbine | PM10 BACT Technology | Emission Limit on Hydrogen-Rich Fuel or Syngas Fuels | Emission Limit on Natural Gas |
|---|---|---|---|---|---|---|
| | | | | | lb/hr | 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

## 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:

*Pre-Combustion Controls*

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

*Post-Combustion Controls*

- Flue Gas Desulfurization

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

### 2. Evaluate Technical Feasibilities

- Acid Gas Removal

  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 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. However, amine-based systems such as MDEA are not effective at removing COS and have not demonstrated the deep total sulfur removal levels required by the Project.

  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, can be vented, and the second regenerator duty can be substantially lowered or totally eliminated.

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

- Flue Gas Desulfurization

  Flue gas desulfurization 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 that 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 percent 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 percent 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 CTG/HRSG turbine. Selexol® has been selected as BACT for all other recent IGCC permits. Rectisol has not yet been applied to other coal-based IGCC processes but has been widely used in gasification projects in the chemical industry where both deep sulfur removal and $CO_2$ removal are required. Both Rectisol and Selexol® are considered viable alternatives or MDEA. However, the Project selected Rectisol because there are more units operating at similar capacities and similar conditions to those required for the Project, making Rectisol the more proven alternative.

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**

| Facility | State | MW | Turbine | $SO_2$ BACT Technology | Emission Limit on Hydrogen-Rich Fuel | | Emission Limit on Nat Gas | |
|---|---|---|---|---|---|---|---|---|
| | | | | | ppm | lb/MMBTU Hydrogen-Rich Fuel or Syngas Fuels | 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 percent $O_2$.
[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 nanograms per joule (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 sulfurs dioxide BACT for the proposed CTG/HRSG when operating on natural gas is PUC-grade natural gas fuel with less than 0.75 grain/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 an 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 in the hydrogen-rich fuel. Hydrogen-rich fuel contains very low concentrations of VOC; therefore, emissions of VOC are inherently very low. Reduction of VOC emissions is accomplished by providing adequate fuel residence time and a 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, which contains a very low organic content, and yields very low levels of uncombusted VOC emissions.

*1. Identify Control Technologies*

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

*Combustion Process Controls*

- Good Combustion Practices

*Post-Combustion Controls*

- $SCONO_x$™
- Oxidation Catalyst

### *2. Evaluate Technical Feasibilities*

- Good Combustion Practices

  GCPs 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 uses 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 percent oxygen) when firing hydrogen-rich fuel, and 2.0 ppmvd CO (at 15 percent oxygen) when operating on natural gas.

### *3. Rank Control Technologies*

Oxidation catalyst is the only technically feasible VOC control technology identified in addition to GCPs.

### *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.

As shown in Table 6-6, the BACT limitation for VOC emissions from HECA CTG/HRSG is comparable to the historic BACT determination for other recently permitted IGCC units. This emission limitation represents a removal efficiency that is as good as the emissions 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 at 15 percent $O_2$ while firing hydrogen-rich fuel, and 2.0 ppmvd VOC at 15 percent $O_2$ while firing natural gas during non-startup operation, using GCPs and oxidation catalyst.

**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 or Syngas Fuels** | **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 percent $O_2$.
[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

## 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 megawatt natural-gas – fired GE LMS100® in a simple-cycle configuration, equipped with water injection for nitrogen oxide control. Post-combustion emission 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 at 15 percent $O_2$, based on a 3-hour average with high-temperature SCR, or equal. The $NO_x$ emission limitation of 2.5 ppmvd at 15 percent $O_2$, (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 at 15 percent $O_2$. 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 at 15 percent $O_2$, based on a 3-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 at 15 percent $O_2$ 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 grain/100 dscf sulfur content. Therefore, the unit meets the recommended BACT emission limitation.

In addition to the recommendation from the BACT guideline, HECA proposed a $PM_{10}$ emission limit of 6 lbs/hour. This emission limit is proposed based on the lowest $PM_{10}$ BACT determination for a similar source from recently permitted power plants in California[2].

### 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 grain S/100 dscf. As mentioned in the previous section, the auxiliary CTG is proposed to be exclusively fueled by PUC-regulated gas with < 0.75 grain 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 VOCs is 2.0 ppmvd at 15 percent $O_2$, based on a 3-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 at 15 percent $O_2$ 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 cooling towers (gasification cooling tower and the ASU cooling tower) are associated with the gasification process, and the third cooling tower (power block cooling tower) is 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 that 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 systems are similar in design 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 percent 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.

[2] Final Decision Panoche Energy Center (2007)

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 TDS concentrations in the circulating water are the techniques that 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 percent of the circulating water. Typical geometries for the drift eliminators include chevron-type.

There is no $PM_{10}$ BACT guideline for mechanical draft cooling towers in the 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 concentrations of dissolved solids in the make-up water as the circulating water evaporates;; and secondarily, to the 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 historically has 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 the 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 percent of the circulating water. This measure, along with a limit on the circulating water TDS, is considered to be the BACT 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 FGR, and use of natural gas to be the 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:

*Potential Auxiliary Boiler Control Technology*

- Good Combustion Practices
- Low $NO_x$ combustor
- CO Oxidation Catalysts
- Low $NO_x$ combustor with Flue Gas Recirculation
- Selective Catalytic Reduction
- Selective Non-Catalytic Reduction

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

#### *2. Evaluate Technical Feasibilities*

- Low $NO_x$ Combustors

  Low $NO_x$ combustors reduce thermal $NO_x$ formation 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

  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, thereby reducing the formation of thermal $NO_x$. 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 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 $NH_3$ 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 to pulverized-coal–generating units and to natural-gas–fired combustions turbines. However, 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 will be 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 be suitable for continuous SCR operation. Therefore, SCR is not technically feasible for the intended operation of the auxiliary boiler.

- Selective Non-Catalytic Reduction

  Selective non-catalytic reduction 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 an 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 historically have 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 $NO_x$ at 3 percent $O_2$ on natural gas fuel.

## 6.4.2 Carbon Monoxide BACT Analysis for the Auxiliary Boiler

An inadequate degree of fuel mixing, lack of available oxygen, or low temperatures in the combustion zone are common causes of incomplete combustion that results 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 using catalytic reduction have also been employed in some processes to reduce CO and VOC emissions.

### *2. Evaluate Technical Feasibilities*

*Good Combustion Practices*

GCPs 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.

*Oxidation Catalyst*

Catalytic oxidation is a post-combustion control technology that uses 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 infeasible.

#### *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 at 3 percent $O_2$.

### 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 would 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

The Project will include two 2,800 HP 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 USEPA 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 50 hours per year per engine for non-emergency purposes such as: routine testing, maintenance, and inspection purposes. The fire pump will operate than less than 50 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 USEPA 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 a 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 gram/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 USEPA 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 USEPA 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 USEPA 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 USEPA 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 an 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 USEPA 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.

No numerical emission limit is achieved in practice or contained in the SIP BACT guideline for VOC. The proposed control of using engines that meet USEPA Tier 4 emissions standards for 2011 model equipment proposed a BACT limit with 0.14 g/bhp-hr VOC for this unit.

## 6.6 Gasification Flare BACT Analysis

The gasification block will be provided with a relief system and associated gasification flare to safely dispose of gasifier streams during startup, shutdown, and unplanned upsets or emergency events, syngas 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. Note that sulfur compounds will be treated upstream of the gasification flare header by the Gasification Amine Absorber.

Two flare-control technologies were evaluated for the proposed facility: an elevated flare, and an enclosed ground flare. Elevated flare technology uses 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.

Compared to an elevated flare, an enclosed ground flare offers reduced noise, reduced visual impact, potentially, and better CO destruction. However, an enclosed ground flare poses potentially decreased dispersion of combustion gases and increased reliability concerns and have never been installed on any IGCC plants and so are considered unproven technology in this application with an associated risk. Elevated flares are used extensively with IGCC applications and therefore, the gasification block will be designed with an elevated 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 is first scrubbed in the Gasification Amine Absorber to remove essentially all of the sulfur bearing 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 gasification 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, result 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 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 gasification flare by implementing fuel/air ratio control. Flare BACT options that have been achieved in practice in California (e.g., CAPCOA BACT Clearinghouse) indicate a natural gas pilot and "proper burner management and monitoring" are used to control the emissions of CO, VOCs and $NO_x$.

- Low-$NO_x$ Combustor

  Low-$NO_x$ combustor and ultralow $NO_x$ combustor 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 elevated flares, that do not have a confined combustion zone, which would allow staged introduction of fuel and air streams. Therefore, this control technology is not feasible for the proposed gasification 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 gasification 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 gasification 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 the 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 GCPs are selected as BACT for the proposed gasification flare. The 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 gasification flare. The proposed control and criteria pollutant emissions for the gasification flare are summarized in Table 6-7.

## 6.7 Sulfur Recovery System BACT Analysis

The sulfur recovery system is designed to process acid gas streams from the 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 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 $H_2S$ and $SO_2$. The tail gas is routed to the TGTU where the majority of the sulfur is recovered. The overhead of the TGT Unit is combined with the much larger product $CO_2$ stream and exported offsite for oil reservoir injection.

**Table 6-7**
**Gasification 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 | 48.65 | 12.21 | 48.8 |
| 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 or smaller and is assumed to equal $PM_{2.5}$ = particulate matter 10 microns in diameter
$SO_2$ = sulfur dioxide
VOC = volatile organic compound

The proposed sulfur process facility consists of 2 by 50 percent SRUs, and 1 by 100 percent 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 two elevated flares, a caustic scrubber, and a thermal oxidizer as control devices to provide for the safe and efficient destruction of combustible gas streams. These control devices are primarily used 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 $H_2S$. 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, VOCs, $NO_x$, and/or $H2_SO_4$ being released. In this case, two elevated flares are selected to accommodate the variability inherent in these operations: Sulfur Recovery Unit Flare, and Rectisol Flare.

An SRU Flare will be used to safely dispose of gas streams containing sulfur during startup and shutdown, and gas streams containing sulfur during unplanned upsets or emergency events. Acid gas derived from the AGR, gasification unit, and SWS overhead is normally routed to the SRU for recovery as elemental sulfur. During cold plant startup of the gasifiers, AGR, and Shift units, these acid-gas streams will be diverted to the SRU Flare Header for a short time. To reduce the emissions of sulfur compounds to the environment during SRU or TGTU shutdown, the acid gas is routed to the Emergency Caustic Scrubber, where the sulfur compounds are absorbed with caustic solution. After scrubbing, the gas is then routed to the elevated SRU Flare Stack.

Enclosed ground flares have the potential to minimize flame appearance and provide a setting for monitoring post-combustion gas streams. However, they have not been proven for the proposed facility because of reliability concerns.

Elevated flares are used extensively with IGCC applications and therefore, are considered proven technology. The gasification block will be designed with an elevated flare.

- 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 percent 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 flares, 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 three emission sources of tail gas thermal oxidizer, SRU flare and Rectisol flare (elevated flares with natural gas assist). 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 in Table 6-8.

**Table 6-8**
**Sulfur Recovery System Emissions**

| Pollutant | Thermal Oxidizer Emissions (lb/MMBtu, HHV) | SRU Flare Emissions | | | | Rectisol Flare Emissions* | | |
|---|---|---|---|---|---|---|---|---|
| | | Pilot (ton/yr) | Start-Up/ Shut-Down (ton/yr) | Total (ton/qtr) | Total (ton/yr) | Pilot (ton/yr) | Total (ton/qtr) | Total (ton/yr) |
| $NO_x$ | 0.13 | 0.16 | 0.0130 | 0.04 | 0.2 | 0.16 | 0.04 | 0.2 |
| CO | 0.04 | 0.11 | 0.0086 | 0.03 | 0.1 | 0.11 | 0.03 | 0.1 |
| VOC | 0.0070 | 0.002 | 0.0001 | 0.000 | 0.002 | 0.002 | 0.000 | 0.002 |
| $SO_2$ | See Below | 0.003 | 0.05 | 0.014 | 0.1 | 0.003 | 0.001 | 0.003 |
| $PM_{10}$ = $PM_{2.5}$ | 0.008 | 0.004 | 0.0003 | 0.001 | 0.004 | 0.004 | 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 or smaller and is assumed to equal $PM_{2.5}$ = particulate matter 10 microns in diameter
$SO_2$ = sulfur dioxide
VOC = volatile organic compound
* = Rectisol Flare will be used exclusively for emergency events. During normal plant operation, Rectisol Flare will have a natural-gas–fired pilot light (there is no planned operation expected for this source).

## 6.8 $CO_2$ Vent BACT Analysis

The Project will produce electricity while substantially reducing greenhouse gas emissions by capturing $CO_2$. 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 using 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 1,000 ppm for CO, 40 ppm for VOCs, and 10 ppm for $H_2S$ to reduce the overall impact of the venting event.

### *Good Engineering Practice Stack Height*

The USEPA 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 minimis height of 65 meters.

A 260-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 Warming (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 1,800 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, thereby minimizing the emission of $NO_x$ and CO. Because the heaters will only combust natural gas, the potential for $SO_2$, VOC, and PM emissions is minimized. The proposed BACT/LAER emission rates for each gasifier refractory heater are presented in Table 6-9.

**Table 6-9**
**Gasifier Warming (Refractory Heater) Emissions**

| Pollutant | Emission Limit |
|---|---|
| $NO_x$ | 0.11 lb/MMBtu, HHV |
| CO | 0.09 lb/MMBtu, HHV |
| PM/ $PM_{10}$ | 0.008 lb/MMBtu, HHV |
| $SO_2$ | 0.002 lb/MMBtu, HHV (12.65 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 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, a forced air dust collection system is the most appropriate and common control technology for particulate matter emission control from the emission points.

- Truck Unloading
- Petcoke/coal Silos (filling)
- Mass Flow Bins (in/out)
- Petcoke/coal Silos (loadout)
- Crusher Inlet/Outlet
- 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 six bag houses, with the maximum dust collector PM emission rate based on expected supplier guarantee of 0.005 grain/scf outlet dust loading.

AA 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

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