**APPENDIX C**

**OPERATIONAL EMISSIONS CALCULATIONS**

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**TESORO RELIABILITY IMPROVEMENT AND REGULATORY COMPLIANCE PROJECT**

**APPENDIX C**
**OPERATIONAL EMISSIONS CALCULATIONS**

# TABLE C-1

## Tesoro Reliability Improvement and Regulatory Compliance Project
## REFINERY OPERATIONAL EMISSIONS SUMMARY

| Source | Emissions (lbs/day) CO | VOC | NOx | SOx | PM10 | PM2.5 |
|---|---|---|---|---|---|---|
| **STATIONARY SOURCES** | | | | | | |
| Fugitives | | | | | | |
| Cogeneration Unit | | 34.92 | | | | |
| Boilers | | 15.68 | | | | |
| LPG/HCU | | 8.24 | | | | |
| LPG/FCCU | | 3.25 | | | | |
| LPG/DCU | | 7.08 | | | | |
| Fuel Gas HDT | | 68.81 | | | | |
| Amine Flash | | 9.85 | | | | |
| Coker Blowdown | | 5.02 | | | | |
| DCU Modifications | | 6.12 | | | | |
| Sour Gas Treatment | | 8.43 | | | | |
| HTU-2 | | 3.45 | | | | |
| H-101 | | 5.58 | | | | |
| ~~Ammonia Storage~~ *PRD Connections to Flare* | | 6.78 | | | | |
| Generator | | 3.17 | | | | |
| Boiler 11 | ~~312.17~~ *321.60* | 38.72 | ~~92.40~~ *111.21* | 40.8 | 91.20 | 89.38 |
| Boiler 12 | ~~312.17~~ *321.60* | 38.72 | ~~92.40~~ *111.21* | 40.8 | 91.20 | 89.38 |
| Retired Boilers | -1233.39 | -80.76 | -1468.32 | -494.59 | -308.35 | -302.18 |
| Cogen | ~~57.36~~ *111.36* | 36.00 | ~~134.40~~ *155.00* | 102.96 | 159.36 | 159.04 |
| Replaced Cogens | -1542.91 | -39.51 | -602.11 | -528.73 | -264.00 | -263.47 |
| Tank | | 16.09 | | | | |
| Backup Generator | 181.89 | 66.87 | 836.32 | 12.66 | 59.74 | 58.54 |
| **Total Stationary Source Emissions** | **~~-1912.7~~ *-1839.9*** | **262.5** | **~~-914.9~~ *-856.7*** | **-826.1** | **-170.9** | **-169.3** |
| **OFFSITE MOBILE SOURCES** | | | | | | |
| Delivery Trucks | 0.67 | 0.17 | 2.07 | 0.00 | 0.10 | 0.09 |
| Fugitive Road Dust | | | | | 1.21 | 0.20 |
| **Total Mobile Source Emissions** | **0.67** | **0.17** | **2.07** | **0.00** | **1.31** | **0.30** |

# TABLE C-2

## Tesoro Reliability Improvement and Regulatory Compliance Project
## Refinery Fugitive VOC Emission Calculations

| | Component Counts[1] | | | | | | | | | Total Emissions (lb/yr)[2] | Total Emissions (lb/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pumps | | Valves | | | | | | | |
| Project | Comp. | Light Liquid | Heavy Liquid | Gas | Light Liquid | Heavy Liquid | Flanges | Sample Conn. | Drains | | |
| Cogeneration Unit | | 0 | 10 | 328 | 0 | 136 | 1168 | 3 | 25 | 12744 | 34.92 |
| Boilers | | 0 | 6 | 100 | 0 | 102 | 584 | 3 | 19 | 5722 | 15.68 |
| LPG/HCU | | 2 | | 30 | 70 | 0 | 200 | 3 | 3 | 3008 | 8.24 |
| LPG/FCCU | | 0 | | 20 | 20 | 0 | 70 | 0 | 3 | 1185 | 3.25 |
| LPG/DCU | | 1 | | 60 | 20 | 0 | 160 | 3 | 3 | 2584 | 7.08 |
| Fuel Gas HDT | 3 | 2 | 2 | 680 | 100 | 70 | 2090 | 10 | 19 | 25115 | 68.81 |
| Amine Flash | | 3 | | 40 | 100 | 0 | 310 | | | 3597 | 9.85 |
| Coker Blowdown | | 1 | 1 | 10 | 40 | 80 | 280 | | | 1834 | 5.02 |
| DCU Modifications | | 1 | | 30 | 60 | 0 | 200 | | | 2234 | 6.12 |
| Sour Gas Treatment | | 2 | | 50 | 70 | 0 | 260 | | | 3078 | 8.43 |
| HTU-2 | | 0 | | 20 | 20 | 50 | 180 | | | 1260 | 3.45 |
| H-101 | | 0 | | 60 | 10 | 0 | 150 | | 3 | 2035 | 5.58 |
| ~~Ammonia Storage~~ *PRD Connections to Flare* | | | | | 111 | 0 | 244 | | | 2475 | 6.78 |
| Generator | | | 4 | | | 42 | 154 | 2 | 4 | 1157 | 3.17 |

(1) Includes all valves irrespective of BACT requirements, which will be required during permitting and, thus, lower emissions.

(2) Annual Emission Rate = Σ (Emission Factor * Component Count). Emission Factors listed below from Jay Chen Memo. (SCAQMD, ~~July 1993~~ *April 1999* )

| | | Pumps | | Valves | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Component Type | Comp. | Light Liquid | Heavy Liquid | Gas | Light Liquid | Heavy Liquid | Flanges | Sample Connections | Drains |
| Emission Factors (lb/yr) | 514 | 104 | 80 | 23 | 19 | 3 | 1.5 | 80 | 80 |

# TABLE C-3

## Tesoro Reliability Improvement and Regulatory Compliance Project
## Refinery Boiler Criteria Pollutant Emission Calculations
**(lbs/day)**

| Source[1] | CO[2] | VOC[3] | NOx[4] | NOx[5] | SOx[6] | PM10[7] | PM2.5[8] |
|---|---|---|---|---|---|---|---|
| Boiler 11 | ~~312.17~~ *321.60* | 38.72 | ~~92.40~~ *111.21* | 71.87 | 40.8 | 91.20 | 89.38 |
| Boiler 12 | ~~312.17~~ *321.60* | 38.72 | ~~92.40~~ *111.21* | 71.87 | 40.8 | 91.20 | 89.38 |
| Retired Boilers[9] | -1233.39 | -80.76 | -1468.32 | -- | -494.59 | -308.35 | -302.18 |
| Emissions Change | ~~-609.05~~ *-590.19* | -3.32 | ~~-1283.52~~ *-1245.90* | 143.73 | -412.99 | -125.95 | -123.43 |

(1) Firing rate of 352 mmBTU/hr. Heating value of 1200 BTU/scf for refinery fuel gas.

(2) Based on ~~50 ppm @ 3% Oxygen.~~ *13.4 lbs/hr.*

(3) Based on 5.5 lbs/mmscf.

(4) Based on 9 ppm @ 3% Oxygen for hourly maximums *for controlled emissions and 29.22 lbs/hr during startup and shutdown periods*.

(5) Based on 7 ppm @ 3% Oxygen for annual maximums.

(6) Based on 1.7 lbs/hr as provided by manufacturer.

(7) Based on 3.8 lb/hr as provided by manufacturer.

(8) Methodology to Calculate PM2.5 and PM2.5 Significance Thresholds Appendix A.

(9) Based on total firing rate of 734.16 mmBTU/hr, SCAQMD Annual Emissions Reporting General Instructions, Appendix A, Table 2 emission factors of 84 lbs/mmscf for CO, 5.5 lbs/mmscf for VOC, 100 lbs/mmscf for NOx, .

# TABLE C-4

## Tesoro Reliability Improvement and Regulatory Compliance Project
## Refinery Cogen Criteria Pollutant Emission Calculations
## (lbs/day)

| Source[1] | CO[2] | VOC[3] | NOx[4] | SOx[5] | PM10[6] | PM2.5[7] |
|---|---|---|---|---|---|---|
| New Cogen C | ~~57.36~~ *111.36* | 36.00 | ~~134.40~~ *155.00* | 102.96 | 159.36 | 159.04 |
| Removal of Cogens A and B[8] | -1542.91 | -39.51 | -602.11 | -528.73 | -264.00 | -263.47 |
| Emissions Change | ~~-1485.55~~ *-1431.55* | -3.51 | ~~-467.71~~ *-447.11* | -425.77 | -104.64 | -104.43 |

(1) Firing rates of 534 mmBTU/hr for the turbine and 96 mmBTU/hr for the duct burner.
Heating value of 1200 BTU/scf for refinery fuel gas.
Based on 8736 hours of normal operation, 61 hours of startup, and 24 hours of shutdown per year.

(2) Based on ~~2.39~~ *4.64* lbs/hr provided by manufacturer.

(3) Based on 1.5 lbs/hr provide by manufacturer.

(4) Based on 5.6*2* lbs/hr *for controlled emissions* provided by manufacturer *and 92 lbs/hr uncontrolled emissions during startup and shutdown periods*.

(5) Based on 3.64 lbs/hr for the turbine and 0.65 lbs/hr for the duct burner provide by manufacturer.

(6) Based on 6.64 lbs/hr provided by manufacturer.

(7) Methodology to Calculate PM2.5 and PM2.5 Significance Thresholds Appendix A.

(8) Firing rates of 392 mmBTU/hr each and EPA AP-42 emission factors, section 3.1of 0.082 lb/mmBTU for CO, 0.0021 lb/ mmBTU for VOC, and 0.032 lb/mmBTU for NOx; 0.0056 for SOx based on sulfur content of 200 ppmv in fuel; and, 11 lbs/hr limit for PM10 from SCAQMD Rule 476.

**TABLE C-5**



## TANKS 4.0.9d
## Emissions Report - Detail Format
## Tank Indentification and Physical Characteristics

**Identification**

| | |
|---|---|
| User Identification: | 500001 |
| City: | Long Beach |
| State: | California |
| Company: | Tesoro |
| Type of Tank: | Domed External Floating Roof Tank |
| Description: | |

**Tank Dimensions**

| | |
|---|---|
| Diameter (ft): | 300.00 |
| Volume (gallons): | 12,600,000.00 |
| Turnovers: | 100.00 |

**Paint Characteristics**

| | |
|---|---|
| Internal Shell Condition: | Light Rust |
| Shell Color/Shade: | White/White |
| Shell Condition | Good |

**Roof Characteristics**

| | |
|---|---|
| Type: | Pontoon |
| Fitting Category | Detail |

**Tank Construction and Rim-Seal System**

| | |
|---|---|
| Construction: | Welded |
| Primary Seal: | Mechanical Shoe |
| Secondary Seal | Rim-mounted |

| Deck Fitting/Status | Quantity |
|---|---|
| Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed | 4 |
| Automatic Gauge Float Well/Bolted Cover, Gasketed | 1 |
| Slotted Guide-Pole/Sample Well/Gask. Sliding Cover, w. Pole Sleeve | 2 |
| Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Sock | 60 |
| Roof Leg (3-in. Diameter)/Adjustable, Center Area, Sock | 170 |
| Roof Drain (3-in. Diameter)/90% Closed | 1 |

Meterological Data used in Emissions Calculations: Long Beach, California (Avg Atmospheric Pressure = 14.7 psia)

**TABLE C-5 - Continued**



## TANKS 4.0.9d
## Emissions Report - Detail Format
## Liquid Contents of Storage Tank

**500001 - Domed External Floating Roof Tank**
**Long Beach, California**

| Mixture/Component | Month | Daily Liquid Surf. Temperature (deg F) Avg. | Min. | Max. | Liquid Bulk Temp (deg F) | Vapor Pressure (psia) Avg. | Min. | Max. | Vapor Mol. Weight | Liquid Mass Fract. | Vapor Mass Fract. | Mol. Weight | Basis for Vapor Pressure Calculations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crude Oil (Tesoro TVP 7.6) | All | 66.43 | 60.99 | 71.87 | 64.33 | 8.7249 | N/A | N/A | 50.0000 | | | 207.00 | Option 4: RVP=10.4 |

**TABLE C-5 - Continued**



## TANKS 4.0.9d
## Emissions Report - Detail Format
## Detail Calculations (AP-42)

### 500001 - Domed External Floating Roof Tank
### Long Beach, California

Annual Emission Calcaulations

| | |
|---|---|
| Rim Seal Losses (lb): | 796.5552 |
| Seal Factor A (lb-mole/ft-yr): | 0.6000 |
| Seal Factor B (lb-mole/ft-yr (mph)^n): | 0.4000 |
| Average Wind Speed (mph): | 0.0000 |
| Seal-related Wind Speed Exponent: | 1.0000 |
| Value of Vapor Pressure Function: | 0.2213 |
| Vapor Pressure at Daily Average Liquid Surface Temperature (psia): | 8.7249 |
| Tank Diameter (ft): | 300.0000 |
| Vapor Molecular Weight (lb/lb-mole): | 50.0000 |
| Product Factor: | 0.4000 |
| Withdrawal Losses (lb): | 4,243.5000 |
| Annual Net Throughput (gal/yr.): | 1,260,000,000.0000 |
| Shell Clingage Factor (bbl/1000 sqft): | 0.0060 |
| Average Organic Liquid Density (lb/gal): | 7.5000 |
| Tank Diameter (ft): | 300.0000 |
| Roof Fitting Losses (lb): | 833.2853 |
| Value of Vapor Pressure Function: | 0.2213 |
| Vapor Molecular Weight (lb/lb-mole): | 50.0000 |
| Product Factor: | 0.4000 |
| Tot. Roof Fitting Loss Fact.(lb-mole/yr): | 188.3000 |
| Average Wind Speed (mph): | 0.0000 |
| Total Losses (lb): | 5,873.3405 |

| Roof Fitting/Status | Quantity | Roof Fitting Loss Factors KFa(lb-mole/yr) | KFb(lb-mole/(yr mph^n)) | m | Losses(lb) |
|---|---|---|---|---|---|
| Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed | 4 | 1.60 | 0.00 | 0.00 | 28.3220 |
| Automatic Gauge Float Well/Bolted Cover, Gasketed | 1 | 2.80 | 0.00 | 0.00 | 12.3909 |
| Slotted Guide-Pole/Sample Well/Gask. Sliding Cover, w. Pole Sleeve | 2 | 11.00 | 46.00 | 1.40 | 97.3567 |
| Roof Leg (3-in. Diameter)/Adjustable, Pontoon Area, Sock | 60 | 1.20 | 0.14 | 0.65 | 318.6221 |
| Roof Leg (3-in. Diameter)/Adjustable, Center Area, Sock | 170 | 0.49 | 0.16 | 0.14 | 368.6280 |
| Roof Drain (3-in. Diameter)/90% Closed | 1 | 1.80 | 0.14 | 1.10 | 7.9656 |

**TABLE C-5 - Concluded**



**TANKS 4.0.9d**
**Emissions Report - Detail Format**
**Individual Tank Emission Totals**

**Emissions Report for: Annual**

**500001 - Domed External Floating Roof Tank**
**Long Beach, California**

| | Losses(lbs) | | | | |
|---|---|---|---|---|---|
| Components | Rim Seal Loss | Withdrawl Loss | Deck Fitting Loss | Deck Seam Loss | Total Emissions |
| Crude Oil (Tesoro TVP 7.6) | 796.56 | 4,243.50 | 833.29 | 0.00 | 5,873.34 |

## TABLE C-6

## Tesoro Reliability Improvement and Regulatory Compliance Project
## Refinery Backup Generator Criteria Pollutant Emission Calculations
## (lbs/day)

| Source | Fuel Use (max. per day) | Operating Hours (max. per day) | CO | VOC | NOx | SOx | PM10 | PM2.5[1] |
|---|---|---|---|---|---|---|---|---|
| Emission Facotr (lb/1000gallons)[2] | | | 102 | 37.5 | 469 | 7.1 | 33.5 | 32.83 |
| Backup Generator[3] | 1783.2 | 24 | 181.89 | 66.87 | 836.32 | 12.66 | 59.74 | 58.54 |

(1) Methodology to Calculate PM2.5 and PM2.5 Significance Thresholds Appendix A.
(2) Emission factors from SCAQMD General Instruction Book for the 2006-2007 Annual Emissions Reporting Program, Table 2.
(3) Based on a fuel rate use of 74.3 gal/hr for 200 hours per year.

**TABLE C- 7**

**Tesoro Reliability Improvement and Regulatory Compliance Project**
**Refinery Off-site Vehicle Emissions**
**(Operational Emissions)**

On Road Mobile Emission Factors from California ARB EMFAC2007 Scenario Year 2011 (Model Years 1965 to 2011)

| Vehicle Type | CO Emissions Factor (lb/mile) | VOC Emission Factor (lb/mile) | NOx Emissions Factor (lb/mile) | SOx Emissions Factor (lb/mile) | PM10 Exhaust Emissions Factor (lb/mile) | PM10 Fugitive Emission Factor (g/mile) |
|---|---|---|---|---|---|---|
| Heavy Duty Trucks | 0.011125 | 0.002795 | 0.034558 | 0.000040 | 0.001661 | 0.02011945 |

| Source | Parameters | | | | Peak Day Emissions, lbs/day | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number of Vehicles per Day | Trips per Day per Vehicle | Distance Traveled per Trip | Distance Traveled per Day | CO | VOC | NOx | SOx | PM10 | PM2.5[1] |
| Heavy Duty Trucks[2] | 1 | 2 | 30 | 60 | 0.67 | 0.17 | 2.07 | 0.002 | 0.10 | 0.09 |
| | | | | | | | | | 1.21 | 0.20 |
| Totals | | | | | 0.67 | 0.17 | 2.07 | 0.002 | 1.31 | 0.30 |

Based on 2011 SCAQMD on-road emission rates. (http://www.aqmd.gov/ceqa/handbook/onroad/onroad.html)

Peak Day Emissions = Emission Factor x Distance Travelled per Day

(1) PM2.5 calculated using 0.928 for exhaust emissions and 0.169 for fugitive trip emissions from SCAQMD Methodology to Calculate PM2.5 and PM2.5 Significance Thresholds, Appendix A (October 2006).
(2) The proposed project will result in a maximum increase of one truck per day and 52 trucks per year.

## TABLE C-8

## Tesoro Reliability Improvement and Regulatory Compliance Project
## Refinery Comparitive $CO_2$ Emissions
## New Cogen vs Utility-Supplied Power and Existing Cogens

### New Cogen

| GHG | Fuel Input MMBTUH | Fuel Input MMSCFD | Emission Factor | | Emissions (lbs/day) | $CO_2e$ Emissions (metric tons/yr) |
|---|---|---|---|---|---|---|
| **$CO_2$** | | | | | | |
| CGT | 534 | 10.68 | 110 | lb/mm/Btu | 1,409,760 | 233,402 |
| Duct Burners | 95.3 | 1.91 | 120000 | lb/MMSCF | 228,720 | 37,867 |
| Total Fuel Input | 629.3 | | | | | |
| **$N_2O$** | | | | | | |
| CGT | 534 | 10.68 | 0.003 | lb/mm/Btu | 38 | 1,884 |
| Duct Burners | 95.3 | 1.91 | 0.64 | lb/MMSCF | 1 | 60 |
| **Methane ($CH_4$)** | | | | | | |
| CGT | 534 | 10.68 | 0.0086 | lb/mm/Btu | 110 | 420 |
| Duct Burners | 95.3 | 1.91 | 2.3 | lb/MMSCF | 4 | 17 |
| Total $CO_2e$ Emissions (metric tons/yr) | | | | | | 273,649 |

### Currently Supplied ~~SCE~~ *LADWP* Power

| GHG | Fuel Input MMBTUH | Fuel Input MMSCFD | Emission Factor | | Emissions (lbs/day) | $CO_2e$ Emissions (tonnes/yr) |
|---|---|---|---|---|---|---|
| **$CO_2$** | 50.0 | 1.14 | 120000 | lb/MMSCF | 137,143 | 22,707 |
| **$N_2O$** | 50.0 | 1.14 | 0.64 | lb/MMSCF | 1 | 36 |
| **Methane ($CH_4$)** | 50.0 | 1.14 | 2.3 | lb/MMSCF | 3 | 10 |
| Total $CO_2e$ Emissions (metric tons/yr) | | | | | | 22,752 |

### Existing Cogen Emissions

| GHG | Fuel Input MMBTUH | Fuel Input MMSCFD | Emission Factor | | Emissions (lbs/day) | $CO_2e$ Emissions (metric tons/yr) |
|---|---|---|---|---|---|---|
| **$CO_2$** | 784.0 | 15.68 | 110 | lb/mm/Btu | 2,069,760 | 342,672 |
| **$N_2O$** | 784.0 | 15.68 | 0.003 | lb/mm/Btu | 56 | 2766 |
| **Methane ($CH_4$)** | 784.0 | 15.68 | 0.0086 | lb/mm/Btu | 162 | 616 |
| Total $CO_2e$ Emissions (metric tons/yr) | | | | | | 346,055 |

### Existing GHG Emissions versus Proposed GHG Emissions from Cogen

| GHG | Existing GHG Emissions (metric tons/yr) | Proposed Project GHG Emissions (metric tons/yr) | Change from Baseline |
|---|---|---|---|
| | | | |
| **$CO_2$** | 365379.0 | 271269.1 | -94109.9 |
| **$N_2O$** | 2802.1 | 1944.0 | -858.2 |
| **Methane ($CH_4$)** | 626.2 | 436.4 | -189.8 |
| Total CO2e Emissions (metric tons/yr) | | | -95157.9 |

ASSUMPTIONS:
1. Refinery fuel gas heating value is 1200 Btu/hr.
2. Natural gas heating value is 1050 Btu/hr.
3. New Cogen is 61 MW.
4. Purchased power (that the project will offset) is 1 MW.
5. Existing Cogen is 60 MW with no duct burner.

## TABLE C-9

## Tesoro Reliability Improvement and Regulatory Compliance Project
## Refinery Comparitive $CO_2$ Emissions
## New Boilers vs Existing Boilers

### Existing Boilers

| GHG | Fuel Input MMBTUH | Fuel Input MMSCFD | Emission Factor | | Emissions (lbs/day) | $CO_2e$ Emissions (metric tons/yr) |
|---|---|---|---|---|---|---|
| **$CO_2$** | 734.16 | 14.68 | 120,000 | lb/MMSCF | 1,761,984 | 291,718 |
| $N_2O$ | 734.16 | 14.68 | 0.64 | lb/MMSCF | 9.40 | 461 |
| **Methane ($CH_4$)** | 734.16 | 14.68 | 2.3 | lb/MMSCF | 33.771 | 129 |
| Total $CO_2e$ Emissions (metric tons/yr) | | | | | | 292,308 |

### New Fired Boilers

| GHG | Fuel Input MMBTUH | Fuel Input MMSCFD | Emission Factor | | Emissions (lbs/day) | $CO_2e$ Emissions (metric tons/yr) |
|---|---|---|---|---|---|---|
| **$CO_2$** | 704 | 14.08 | 120,000 | lb/MMSCF | 1,689,600 | 279,734 |
| $N_2O$ | 704 | 14.08 | 0.64 | lb/MMSCF | 9.01 | 442 |
| **Methane ($CH_4$)** | 704 | 14.08 | 2.3 | lb/MMSCF | 32.384 | 123 |
| Total $CO_2e$ Emissions (metric tons/yr) | | | | | | 280,299 |

### Existing GHG Emissions versus Proposed GHG Emissions from Boilers

| GHG | Existing GHG Emissions (metric tons/yr) | Proposed Project GHG Emissions (metric tons/yr) | Change from Baseline |
|---|---|---|---|
| | | | |
| **$CO_2$** | 291717.6 | 279733.6 | -11984.0 |
| **$N_2O$** | 460.5 | 441.6 | -18.9 |
| **Methane ($CH_4$)** | 128.6 | 123.3 | -5.3 |
| Total CO2e Emissions (metric tons/yr) | | | -12008.2 |

Notes

Edison heat input based on 10,000 BTU/kWH
Assumed refinery fuel at 1200 BTU/SCF HHV
$CO_2$ factor is from EPA AP-42

# TABLE C-10

## Tesoro Reliability Improvement and Regulatory Compliance Project
## Cogen C Greenhouse Gas Intensity
## Compared to CEC Standard

### Cogen $CO_2e$ Emissions

| GHG | Fuel Input MMBTUH | Fuel Input MMSCFH | Emission Factor | | Emissions (lbs/hr) | $CO_2e$ Emissions (lbs/hr) |
|---|---|---|---|---|---|---|
| **$CO_2$** | | | | | | |
| CGT | 534 | 0.45 | 110 | lb/mm/Btu | 58,740 | 58,740 |
| Duct Burners | 95.3 | 0.08 | 120000 | lb/MMSCF | 10,891 | 10,891 |
| Total Fuel Input | 629.3 | | | | | |
| **$N_2O$** | | | | | | |
| CGT | 534 | 0.45 | 0.003 | lb/mm/Btu | 2 | 474.19 |
| Duct Burners | 95.3 | 0.08 | 0.64 | lb/MMSCF | 0.06 | 17.19 |
| **Methane ($CH_4$)** | | | | | | |
| CGT | 534 | 0.45 | 0.0086 | lb/mm/Btu | 5 | 105.63 |
| Duct Burners | 95.3 | 0.08 | 2.3 | lb/MMSCF | 0.21 | 4.80 |
| | | | | | **$CO_2e$ Emissions Total** | 70,233 |

### Electrical Output

| | Electrical Output MW-hr |
|---|---|
| Gas Turbine | 42.62 |
| Steam Turbine | 18.4 |
| **Total Electrical** | **61.02** |

### Thermal Output

| | Flow lb | Energy Content over datum BTU/lb | Thermal Output BTU | Thermal Output MW-hr |
|---|---|---|---|---|
| 925 psig Steam | 15,000 | 1361.1 | 20,416,500 | **5.98** |
| 225 psig Steam | 445,900 | 1250.4 | 557,553,360 | **163.41** |
| 15 psig Steam Import | 31,500 | 1155.4 | -36,395,100 | **-10.67** |
| Stm. Cond. Import | 302,200 | 148 | -44,725,600 | **-13.11** |
| MU from Water Treat. | 316,700 | 29.8 | -9,437,660 | **-2.77** |
| Bolier Feed Export | 133,600 | 213.1 | 28,470,160 | **8.34** |
| NOx Inj. Steam | 31,310 | 1285.6 | -40,252,136 | **-11.80** |
| Boiler BD | 3,300 | 206.0 | -679,800 | **-0.20** |
| | **Total** | | **474,949,724** | **139.20** |

### Energy Efficiency

| Efficiency | lb $CO_2$(e)/MW-hr |
|---|---|
| Cogen | **351** |

**Notes**

CEC STANDARD: 1100 lb $CO_2$ per MW-hr

Basis: One hour of operation

CO2, N2O, and CH4 factors for CGT is from EPA AP-42 for stationary gas turbines burning natural gas

CO2, N2O, and CH4 factors for duct burners is from EPA AP-42 for external combustion sources burning natural gas

Fuel quantities and factors based on HHV

Thermal datum is liquid water at 60o F.

Steam Generator steam throughput based on 70% overall turbine/generator efficiency

Methodology per Jim Ross of RCS, Inc.

Energy Efficiency = CO2e Emissions /(Electrical Output + Thermal Output)