# California Climate Action Registry General Reporting Protocol

## Reporting Entity-Wide Greenhouse Gas Emissions

**Version 3.1 | January 2009**

## Table C.8 Methane and Nitrous Oxide Emission Factors for Stationary Combustion by Fuel Type and Sector

| Fuel Type/End-Use Sector | $CH_4$ (kg/MMBtu) | $N_2O$ (kg/MMBtu) |
|---|---|---|
| **Coal** | | |
| **Residential** | 0.316 | 0.0016 |
| **Commercial/Institutional** | 0.011 | 0.0016 |
| **Manufacturing/Construction** | 0.011 | 0.0016 |
| **Electric Power** | 0.001 | 0.0016 |
| **Petroleum Products** | | |
| **Residential** | 0.011 | 0.0006 |
| **Commercial/Institutional** | 0.011 | 0.0006 |
| **Manufacturing/Construction** | 0.003 | 0.0006 |
| **Electric Power** | 0.003 | 0.0006 |
| **Natural Gas** | | |
| **Residential** | 0.005 | 0.0001 |
| **Commercial/Institutional** | 0.005 | 0.0001 |
| **Manufacturing/Construction** | 0.001 | 0.0001 |
| **Electric Power** | 0.001 | 0.0001 |
| **Wood** | | |
| **Residential** | 0.316 | 0.0042 |
| **Commercial/Institutional** | 0.316 | 0.0042 |
| **Manufacturing/Construction** | 0.032 | 0.0042 |
| **Electric Power** | 0.032 | 0.0042 |
| **Pulping Liquors** | | |
| **Manufacturing** | 0.0025 | 0.0020 |

Source: EPA Climate Leaders, Stationary Combustion Guidance (2007), Table A-1, based on U.S. EPA, Inventory of Greenhouse Gas Emissions and Sinks: 1990-2005 (2007), Annex 3.1.

## Emission Factors for Stationary Combustion

### Table C.7 Carbon Dioxide Emission Factors for Stationary Combustion

| Fuel Type | Carbon Content | Heat Content | Fraction Oxidized | $CO_2$ Emission Factor | $CO_2$ Emission Factor |
|---|---|---|---|---|---|
| **Coal and Coke** | kg C/ MMBtu | MMBtu/ short ton | | kg $CO_2$/ metric ton | kg $CO_2$/MMBtu |
| Anthracite | 28.26 | 25.09 | 1.00 | 2,865.77 | 103.62 |
| Bituminous | 25.49 | 24.93 | 1.00 | 2,568.39 | 93.46 |
| Sub-bituminous | 26.48 | 17.25 | 1.00 | 1,846.19 | 97.09 |
| Lignite | 26.30 | 14.21 | 1.00 | 1,510.49 | 96.43 |
| Residential/Commercial | 26.00 | 22.05 | 1.00 | 2,317.13 | 95.33 |
| Industrial Coking | 25.56 | 26.27 | 1.00 | 2,713.87 | 93.72 |
| Other Industrial | 25.63 | 22.05 | 1.00 | 2,284.16 | 93.98 |
| Electric Power | 25.76 | 19.95 | 1.00 | 2,077.10 | 94.45 |
| Coke | 31.00 | 24.80 | 1.00 | 3,107.29 | 113.67 |
| **Petroleum Products (Gaseous)** | kg C/ MMBtu | Btu/ standard cubic foot | | kg $CO_2$/ standard cubic foot | kg $CO_2$/MMBtu |
| Natural Gas (weighted U.S. average) | 14.47 | 1,029 | 1.00 | 0.0546 | 53.06 |
| Acetylene ($C_2H_2$) | 19.48 | 1,476 | 1.00 | .1043 | 71.42 |
| **Petroleum Products (Liquid)** | kg C/ MMBtu | MMBtu/ barrel | | kg $CO_2$/gallon | kg $CO_2$/MMBtu |
| Asphalt & Road Oil | 20.62 | 6.636 | 1.00 | 11.95 | 75.61 |
| Aviation Gasoline | 18.87 | 5.048 | 1.00 | 8.32 | 69.19 |
| Distillate Fuel Oil (#1,2&4) | 19.95 | 5.825 | 1.00 | 10.15 | 73.15 |
| Jet Fuel | 19.33 | 5.670 | 1.00 | 9.57 | 70.88 |
| Kerosene | 19.72 | 5.670 | 1.00 | 9.76 | 72.31 |
| LPG (average for fuel use) | 17.23 | 3.849 | 1.00 | 5.79 | 63.16 |
| Propane | 17.20 | 3.824 | 1.00 | 5.74 | 63.07 |
| Ethane | 16.25 | 2.916 | 1.00 | 4.14 | 59.58 |
| Isobutane | 17.75 | 4.162 | 1.00 | 6.45 | 65.08 |
| n-Butane | 17.72 | 4.328 | 1.00 | 6.70 | 64.97 |
| Lubricants | 20.24 | 6.065 | 1.00 | 10.72 | 74.21 |
| Motor Gasoline | 19.33 | 5.218 | 1.00 | 8.81 | 70.88 |
| Residual Fuel Oil (#5 & 6) | 21.49 | 6.287 | 1.00 | 11.80 | 78.80 |
| Crude Oil | 20.33 | 5.800 | 1.00 | 10.29 | 74.54 |
| Naphtha (<401 deg. F) | 18.14 | 5.248 | 1.00 | 8.31 | 66.51 |
| Natural Gasoline | 18.24 | 4.620 | 1.00 | 7.36 | 66.88 |
| Other Oil (>401 deg. F) | 19.95 | 5.825 | 1.00 | 10.15 | 73.15 |

## Table C.6 Methane and Nitrous Oxide Emission Factors for Non-Highway Vehicles

| Vehicle Type/Fuel Type | $N_2O$ (g/gallon) | $CH_4$ (g/gallon) |
|---|---|---|
| **Ships & Boats** | | |
| Residual Fuel Oil | 0.30 | 0.86 |
| Diesel Fuel | 0.26 | 0.74 |
| Gasoline | 0.22 | 0.64 |
| **Locomotives** | | |
| Diesel Fuel | 0.26 | 0.80 |
| **Agricultural Equipment** | | |
| Gasoline | 0.22 | 1.26 |
| Diesel Fuel | 0.26 | 1.44 |
| **Construction** | | |
| Gasoline | 0.22 | 0.50 |
| Diesel Fuel | 0.26 | 0.58 |
| **Other Non-Highway** | | |
| Snowmobiles (Gasoline) | 0.22 | 0.50 |
| Other Recreational (Gasoline) | 0.22 | 0.50 |
| Other Small Utility (Gasoline) | 0.22 | 0.50 |
| Other Large Utility (Gasoline) | 0.22 | 0.50 |
| Other Large Utility (Diesel) | 0.26 | 0.58 |
| **Aircraft** | | |
| Jet Fuel | 0.31 | 0.27 |
| Aviation Gasoline | 0.11 | 7.04 |
| **All Non-Highway/Construction Vehicles** | | |
| Butane* | 0.41 | 0.09 |
| Propane* | 0.41 | 0.09 |

Source: U.S. EPA, Climate Leaders, Mobile Combustion Guidance (2008) based on U.S. EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005 (2007), Annex 3.2, Table A-101, except butane and propane.

* Butane and propane emission factors based on stationary combustion emission factors for these fuels from U.S. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000 (2002).

# Appendix C Calculation References

## Converting to $CO_2$ Equivalent

To incorporate and evaluate non-$CO_2$ gases in your GHG emissions inventory, the mass estimates of these gases will need to be converted to $CO_2$ equivalent ($CO_2e$). To do this, multiply the emissions in units of mass by the GHGs global warming potential (GWP).

Global warming potentials were developed by the Intergovernmental Panel on Climate Change (IPCC) to quantify the globally averaged relative radiative forcing effects of a given GHG, using carbon dioxide as the reference gas. In 1996, the IPCC published a set of GWPs for the most commonly measured greenhouse gases in its Second Assessment Report (SAR). In 2001, the IPCC published its Third Assessment Report (TAR), which adjusted the GWPs to reflect new information on atmospheric lifetimes and an improved calculation of the radiative forcing of carbon dioxide. However, SAR GWPs are still used by international convention and the U.S. to maintain the value of the carbon dioxide "currency". To maintain consistency with international practice, the California Registry requires participants to use GWPs from the SAR for calculating their emissions inventory.

Table C.1 lists the 100-year GWPs from SAR and TAR. The equation above provides the basic calculation required to determine $CO_2e$ from the total mass of a given GHG using the GWPs published by the IPCC.

**Converting Mass Estimates to Carbon Dioxide Equivalent**

$$\text{Metric Tons of } CO_2e = \text{Metric Tons of GHG} \times \text{GWP}$$

### Table C.1 Comparison of GWPs from the IPCC's Second and Third Assessment Reports

| Greenhouse Gas | GWP (SAR, 1996) | GWP (TAR, 2001) |
|---|---|---|
| $CO_2$ | 1 | 1 |
| $CH_4$ | 21 | 23 |
| $N_2O$ | 310 | 296 |
| HFC-23 | 11,700 | 12,000 |
| HFC-32 | 650 | 550 |
| HFC-125 | 2,800 | 3,400 |
| HFC-134a | 1,300 | 1,300 |
| HFC-143a | 3,800 | 4,300 |
| HFC-152a | 140 | 120 |
| HFC-227ea | 2,900 | 3,500 |
| HFC-236fa | 6,300 | 9,400 |
| HFC-4310mee | 1,300 | 1,500 |
| $CF_4$ | 6,500 | 5,700 |
| $C_2F_6$ | 9,200 | 11,900 |
| $C_3F_8$ | 7,000 | 8,600 |
| $C_4F_{10}$ | 7,000 | 8,600 |
| $C_6F_{14}$ | 7,400 | 9,000 |
| $SF_6$ | 23,900 | 22,000 |

Source: U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003 (April 2005).

## Emission Factors for Electricity Use

### Table C.2 Carbon Dioxide, Methane and Nitrous Oxide Electricity Emission Factors by eGRID Subregion

| eGRID Subregion Acronym | eGRID Subregion Name | $CO_2$ (lbs/MWh) | $CH_4$ (lbs/MWh) | $N_2O$ (lbs/MWh) |
|---|---|---|---|---|
| **AKGD** | ASCC Alaska Grid | 1,232.36 | 0.0256 | 0.0065 |
| **AKMS** | ASCC Miscellaneous | 498.86 | 0.0208 | 0.0041 |
| **AZNM** | WECC Southwest | 1,311.05 | 0.0175 | 0.0179 |
| **CAMX** | WECC California | 724.12 | 0.0302 | 0.0081 |
| **ERCT** | ERCOT All | 1,324.35 | 0.0187 | 0.0151 |
| **FRCC** | FRCC All | 1,318.57 | 0.0459 | 0.0169 |
| **HIMS** | HICC Miscellaneous | 1,514.92 | 0.3147 | 0.0469 |
| **HIOA** | HICC Oahu | 1,811.98 | 0.1095 | 0.0236 |
| **MROE** | MRO East | 1,834.72 | 0.0276 | 0.0304 |
| **MROW** | MRO West | 1,821.84 | 0.0280 | 0.0307 |
| **NEWE** | NPCC New England | 927.68 | 0.0865 | 0.0170 |
| **NWPP** | WECC Northwest | 902.24 | 0.0191 | 0.0149 |
| **NYCW** | NPCC NYC/Westchester | 815.45 | 0.0360 | 0.0055 |
| **NYLI** | NPCC Long Island | 1,536.80 | 0.1154 | 0.0181 |
| **NYUP** | NPCC Upstate NY | 720.80 | 0.0248 | 0.0112 |
| **RFCE** | RFC East | 1,139.07 | 0.0303 | 0.0187 |
| **RFCM** | RFC Michigan | 1,563.28 | 0.0339 | 0.0272 |
| **RFCW** | RFC West | 1,537.82 | 0.0182 | 0.0257 |
| **RMPA** | WECC Rockies | 1,883.08 | 0.0229 | 0.0288 |
| **SPNO** | SPP North | 1,960.94 | 0.0238 | 0.0321 |
| **SPSO** | SPP South | 1,658.14 | 0.0250 | 0.0226 |
| **SRMV** | SERC Mississippi Valley | 1,019.74 | 0.0243 | 0.0117 |
| **SRMW** | SERC Midwest | 1,830.51 | 0.0212 | 0.0305 |
| **SRSO** | SERC South | 1,489.54 | 0.0263 | 0.0255 |
| **SRTV** | SERC Tennessee Valley | 1,510.44 | 0.0201 | 0.0256 |
| **SRVC** | SERC Virginia/Carolina | 1,134.88 | 0.0238 | 0.0198 |

Source: eGRID2007 Version 1.1, December 2008 (Year 2005 data).
Note: Reporters calculating historical data for calendar years 1990-2007 should use the electricity emission factors in Appendix E.

## III.7.6 Example: Carbon Dioxide Emissions from Biodiesel

### BioClean Drycleaning Service

BioClean is an environmentally-friendly dry cleaning service with a delivery fleet of 10 biodiesel vans. Last year, the company purchased 12,000 gallons of B20 to fuel their vans.

**Step 1: Identify the biodiesel blend being used.**

BioClean is using B20, which is made up of 20% biodiesel and 80% petroleum-based diesel.

**Step 2: Identify total annual biodiesel consumption.**

BioClean purchased 12,000 gallons of B20 – they do not store fuel on-site, so no additional mass balance calculation is needed.

**Step 3: Based on the blend, calculate the annual consumption of diesel and biodiesel.**

**Annual consumption of B20 = 12,000 gallons**

12,000 gallons x 80% = 9,600 gallons diesel consumed

12,000 gallons x 20% = 2,400 gallons biodiesel consumed

**Step 4: Select the appropriate emission factor for the petroleum-based diesel from Appendix C, Table C.3 to calculate the anthropogenic $CO_2$ emissions.**

The $CO_2$ emission factor for diesel is 10.15 kilograms per gallon, and the biogenic $CO_2$ emission factor for biodiesel is 9.46 kilograms per gallon.

**Carbon Dioxide Emission Factors for Transport Fuels**

| Fuel | kg $CO_2$/gallon |
|---|---|
| **Diesel** | 10.15 |
| **Biodiesel (B100)** | 9.46* |

* Note that the $CO_2$ emissions from burning biodiesel are biogenic, and should not be included as direct mobile emissions in your inventory. These emissions may be reported optionally.

**Step 5: Multiply fuel consumed by the emission factor to calculate total $CO_2$ emissions and convert to metric tons.**

| Equation III.7c | $CO_2$ Emissions Contribution of Each Fuel | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $CO_2$ from diesel | = | 10.15 kg/gallon | x | 9,600 gallons | x | 0.001 metric tons/kg | = | 97.44 metric tons $CO_2$ |
| Biogenic $CO_2$ from biodiesel | = | 9.46 kg/gallon | x | 2,400 gallons | x | 0.001 metric tons/kg | = | 22.70 metric tons biogenic $CO_2$ |

## III.6.3 Example: Indirect Emissions from Electricity Use

### Costlo Clothing Distributors

Costlo is a discount retail clothing chain with two outlets in Los Angeles, California, one in Portland, Oregon, and one in Tucson, Arizona. The company only purchases electricity and has no other GHG emissions.

**Step 1: Determine annual electricity consumption.**

**Step 2: Select electricity emission factors that apply to the electricity purchased.**

Because emission factors for electricity vary from region-to-region, Costlo tracks its electricity purchases by utility providing the electricity.

**Annual Electricity Emissions and Emissions Factors**

| Region/ State | Power Generator | Annual Electricity Purchases (MWh) | $CO_2$ lbs/MWh | $CH_4$ lbs/MWh | $N_2O$ lbs/MWh |
|---|---|---|---|---|---|
| **CAMX/ California** | Los Angeles | 1,600 | 724.12 | 0.0302 | 0.0081 |
| **NWPP/Oregon** | Portland | 600 | 902.24 | 0.0191 | 0.0149 |
| **AZNM/Arizona** | Tucson | 800 | 1,311.05 | 0.0175 | 0.0179 |

**Step 3: Determine total annual emissions and convert to metric tons.**

| Equation III.6b | Total Carbon Dioxide, Methane, and Nitrous Oxide Emissions for Electricity Use from Each Utility | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Los Angeles, CA | = | 1,600 MWh | x | 724.12 (lbs/MWh) | ÷ | 2,204.62 lbs/mt | = | 525.53 mt $CO_2$ |
| Portland, OR | = | 600 MWh | x | 902.24 (lbs/MWh) | ÷ | 2,204.62 lbs/mt | = | 245.55 mt $CO_2$ |
| Tucson, AZ | = | 800 MWh | x | 1,311.05 (lbs/MWh) | ÷ | 2,204.62 lbs/mt | = | 475.75 mt $CO_2$ |
| | | | | | | Subtotal | = | 1,246.83 mt $CO_2$ |
| Los Angeles, CA | = | 1,600 MWh | x | 0.0081 (lbs/MWh) | ÷ | 2,204.62 lbs/mt | = | 0.00588 mt $N_2O$ |
| Portland, OR | = | 600 MWh | x | 0.0149 (lbs/MWh) | ÷ | 2,204.62 lbs/mt | = | 0.00406 mt $N_2O$ |
| Tucson, AZ | = | 800 MWh | x | 0.0179 (lbs/MWh) | ÷ | 2,204.62 lbs/mt | = | 0.00650 mt $N_2O$ |
| | | | | | | Subtotal | = | 0.01644 mt $N_2O$ |
| Los Angeles, CA | = | 1,600 MWh | x | 0.0302 (lbs/MWh) | ÷ | 2,204.62 lbs/mt | = | 0.02192 mt $CH_4$ |
| Portland, OR | = | 600 MWh | x | 0.0191 (lbs/MWh) | ÷ | 2,204.62 lbs/mt | = | 0.00520 mt $CH_4$ |
| Tucson, AZ | = | 800 MWh | x | 0.0175 (lbs/MWh) | ÷ | 2,204.62 lbs/mt | = | 0.00635 mt $CH_4$ |
| | | | | | | Subtotal | = | 0.03347 mt $CH_4$ |

**Step 4: Convert Non-$CO_2$ emissions to $CO_2e$ and sum the total. Use Equation III.6c and III.6d.**

| Equation III.6c | Convert Non-$CO_2$ GHGs to Carbon Dioxide Equivalent and Sum Total | | | | | |
|---|---|---|---|---|---|---|
| Metric Tons of $CO_2e$ | = | Metric Tons of GHG | x | GWP (SAR, 1996) | | |
| Metric Tons of $CO_2$ | | | | | = | 1,246.83 metric tons $CO_2$ |
| $CH_4$ Tons of $CO_2e$ | = | 0.03347 metric tons $CH_4$ | x | 21 (GWP) | = | 0.70287 metric tons $CO_2e$ |
| $N_2O$ Tons of $CO_2e$ | = | 0.01644 metric tons $N_2O$ | x | 310 (GWP) | = | 5.0964 metric tons $CO_2e$ |
| | | | | Total | = | 1,252.63 metric tons $CO_2e$ |