Voluntary Reporting of Greenhouse Gases Program (Voluntary Reporting of Greenhouse Gases Program Fuel Carbon Dioxide Emission Coefficients)

Voluntary Reporting of Greenhouse Gases Program
Fuel Emission Coefficients

1. Carbon Dioxide Emission Factors for Stationary Combustion[1]		
Fuel	Emission Factor	Units
Coal by Rank[2]		
Anthracite	103.69	kg CO_2 / MMBtu
Bituminous	93.28	kg CO_2 / MMBtu
Sub-bituminous	97.17	kg CO_2 / MMBtu
Lignite	97.72	kg CO_2 / MMBtu
Coal by Sector[2]		
Electric Power Sector	95.52	kg CO_2 / MMBtu
Industrial Coking	93.71	kg CO_2 / MMBtu
Other Industrial	93.98	kg CO_2 / MMBtu
Residential/Commercial	95.35	kg CO_2 / MMBtu
Natural Gas[3]		
Pipeline Natural Gas		
HHV of 975 - 1000 Btu/scf	54.01	kg CO_2 / MMBtu
	5.401	kg CO_2 / therm
HHV of 1000 - 1025 Btu/scf	52.91	kg CO_2 / MMBtu
	5.291	kg CO_2 / therm
HHV of 1025 - 1050 Btu/scf	53.06	kg CO_2 / MMBtu
	5.306	kg CO_2 / therm
HHV of 1050 - 1075 Btu/scf	53.46	kg CO_2 / MMBtu
	5.346	kg CO_2 / therm
HHV of 1075 - 1100 Btu/scf	53.72	kg CO_2 / MMBtu
	5.372	kg CO_2 / therm
Weighted National Average (1029Â Btu/scf)	53.06	kg CO_2 / MMBtu
	5.306	kg CO_2 / therm
Flared Natural Gas	54.71	kg CO_2 / MMBtu
	5.471	kg CO_2 / therm
Petroleum Fuels[3]		
Middle Distillate Fuels (No. 1, No. 2, No. 4 fuel oil, diesel, home heating oil)	73.15	kg CO_2 / MMBtu
	10.15	kg CO_2 / gallon
Jet Fuel (Jet A, JP-8)	70.88	kg CO_2 / MMBtu
	9.57	kg CO_2 / gallon

Kerosene	72.31	kg CO_2 / MMBtu
	9.76	kg CO_2 / gallon
Heavy Fuel Oil (No. 5, 6 fuel oil), bunker fuel	78.80	kg CO_2 / MMBtu
	11.80	kg CO_2 / gallon
Ethane	59.59	kg CO_2 / MMBtu
	4.14	kg CO_2 / gallon
Propane	63.07	kg CO_2 / MMBtu
	5.74	kg CO_2 / gallon
Isobutane	65.07	kg CO_2 / MMBtu
	6.45	kg CO_2 / gallon
n-Butane	64.95	kg CO_2 / MMBtu
	6.69	kg CO_2 / gallon
Unspecified LPG	62.28	kg CO_2 / MMBtu
	-	kg CO_2 / gallon
Refinery (Still) Gas	64.20	kg CO_2 / MMBtu
	9.17	kg CO_2 / gallon
Crude Oil	74.54	kg CO_2 / MMBtu
	10.29	kg CO_2 / gallon
Petroleum Coke	102.12	kg CO_2 / MMBtu
	14.65	kg CO_2 / gallon
Other Fuels		
Tires/Tire Derived Fuel [4]	85.97	kg CO_2 / MMBtu
Waste Oil[5,6]	9.98	kg CO_2 / gallon
Waste Oil Blended with Residual Fuel Oil[5]	66.53	kg CO_2 / MMBtu
Waste Oil Blended with Distillate Fuel Oil[5]	71.28	kg CO_2 / MMBtu
Municipal Solid Waste (MSW)[7,8]	417.04	kg CO_2 / short ton MSW
Municipal Solid Waste (MSW)[7,8]	41.70	kg CO_2 / MMBtu MSW
Plastics Portion of MSW[7]	2,539.80	kg CO_2 / short ton plastics

[1]All factors assume 100 percent combustion except those for MSW, which assume 98 percent combustion.

[2]U. S. Energy Information Administration, Documentation for Emissions of Greenhouse Gases in the United States 2008, DOE/EIA-0638 (2006), October 2008, Table 6-2, p. 183.

[3]Energy Information Administration, Documentation for Emissions of Greenhouse Gases in the United States 2005, DOE/EIA-0638 (2005), October 2007, Tables 6-1, 6-2, 6-4, and 6-5.

[4]U.S. Department of Energy, Technical Guidelines Voluntary Reporting of Greenhouse Gases (1605(b)) Program, Chapter 1, Part C, Stationary Source Combustion, January 2007.

[5]U.S. EPA, AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s11.pdf.

[6]To convert to an energy basis (kg/MMBtu), divide by the heating value of the oil in units of MMBtu/gal, if known. If the heating value is not known, use the default values below depending on whether the waste oil is blended with residual or distillate fuel oil.

[7]Emissions factors for components of MSW calculated from 2006 data in U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006, Public Review Draft, February 22, 2008, Section 3.9 and Annex 3.6. Weighted emission factor based on MSW composition for 2006 reported in U.S. Environmental Protection Agency, 2006 MSW Characterization Data Tables, http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/06data.pdf.

[8]Emissions from other components of municipal solid waste are excluded because they are considered to be biogenic.

2. Carbon Dioxide Emission Factors for Transportation Fuels[1]

Transportation Fuel	**Emission Factors**		
	Kilograms CO_2 Per Unit of Volume		**Kilograms CO_2 Per Million Btu**
Aviation Gasoline	8.32	per gallon	69.19
Biodiesel			
-B100	0.00	per gallon	0.00
-B20	8.12	per gallon	59.44
-B10	9.13	per gallon	66.35
-B5	9.64	per gallon	69.76
-B2	9.94	per gallon	71.80
Diesel Fuel (No. 1 and No. 2)	10.15	per gallon	73.15
Ethanol/Ethanol Blends			
-E100	0.00	per gallon	0.00
-E85	1.34	per gallon	14.79

-E10 (Gasohol)	8.02	per gallon	66.30
Methanol/Methanol Blends			
-M100	4.11	per gallon	63.62
-M85	4.83	per gallon	65.56
Motor Gasoline	8.91	per gallon	71.26
Jet Fuel, Kerosene	9.57	per gallon	70.88
Natural Gas	54.60	per Mcf	53.06
Propane	5.74	per gallon	63.07
Residual Fuel (No. 5 and No. 6 Fuel Oil)	11.79	per gallon	78.80

[1]Emissions factors calculated from data in: (1) Energy Information Administration, Documentation for Emissions of Greenhouse Gases in the U.S. 2005, DOE/EIA-0638 (2005), October 2007, Tables 6-1, 6-4, and 6-5.Â (Non-biogenic carbon content and gross heat of combustion for motor gasoline and diesel (distillate fuel)). (2) U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Alternative Fuels & Advanced Vehicles Data Center, Fuel Properties web page (http://www.eere.energy.gov/afdc/fuels/properties.html). (Biodiesel gross heat of combustion). (3) Energy Information Administration, Annual Energy Review 2006, DOE/EIA-0384(2006), June 2007, Table A3, p. 361. (Gross heat of combustion for ethanol). (4) Stacy C. Davis and Susan W. Diegel, Transportation Energy Data Book, Edition 26, Oak Ridge National Laboratory, ORNL-6978, 2007, Table B.7 TablesÂ 6.7 and B.4. (Density and gross heat of combustion of methanol.)

3. Generic Methane and Nitrous Oxide Emission Factors for Stationary Fuel Combustion

Source	Methane	Nitrous Oxide
	(g /MMBtu)	(g/MMBtu)
Coal		
Residential	301	1.5
Commercial	10	1.5
Industry	10	1.5
Electricity Generation	1	1.5
Petroleum		
Residential	10	0.6
Commercial	10	0.6
Industry	3	0.6
Electricity Generation	3	0.6
Natural Gas		
Residential	5	0.1
Commercial	5	0.1
Industry	1	0.1
Electricity Generation	1	0.1
Wood		
Residential	253	3.2
Commercial	253	3.2
Industry	25	3.2
Electricity Generation	25	3.2

Source: Intergovernmental Panel on Climate Change (IPCC), 2006 IPCC Guidelines for National Greenhouse Gas Inventories, pp. 2.16 - 2.23, Tables 2.2, 2.3, 2.4 and 2.5Â (Revised April 2007).
Note: Energy units are in higher heating value (HHV). Lower heating value (LHV) assumed to be 5 percent lower than HHV for coal and petroleum, 10 percent lower for natural gas, and 20 percent lower for wood.

4. Specific Methane and Nitrous Oxide Emission Factors for Biogenic Fuel Sources

Source	Methane	Nitrous Oxide
Wood residue (industrial)[1]	0.0953 kg / MMBtu residue	0.0059 kg / MMBtu
Conventional wood stove (non-catalytic)[1]	15 kg / metric ton wood	NA
Wood stove (non-catalytic)[1]	8 kg / metric ton wood	NA
Wood stove (catalytic)[1]	5.8 kg / metric ton wood	NA
Residential fireplace[1]	NA	0.15 kg / metric ton
Charcoal manufacture[1]	55 kg / metric ton charcoal	NA
Municipal solid waste (MSW)[2]	NA	0.044 kg / metric ton

Sources:
[1]Environmental Protection Agency, Compilation of Air Pollutant Emission Factors (AP-42), Fifth Edition, Volume I: Stationary Point and Area Sources.
[2] U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006, EPA 430-R-08-005, April 15, 2008, Section 3.9.NA=not available.

5. Methane and Nitrous Oxide Emissions Factors for Highway Vehicles

Vehicle Type/ Control Technology	Model Year	N_2O	CH_4	N_2O	CH_4
		(g/mi)	(g/mi)	(g/km)	(g/km)
Gasoline Passenger Cars					

EPA Tier 2	2004 and Later	0.0036	0.0173	0.0022	0.0108
Low Emission Vehicles	2000-2003	0.0150	0.0105	0.0093	0.0065
EPA Tier 1	1995-1999	0.0429	0.0271	0.0267	0.0168
EPA Tier 0	1981-1994	0.0647	0.0704	0.0402	0.0437
Oxidation Catalyst	1975-1980	0.0504	0.1355	0.0313	0.0842
Non-Catalyst	1973-1974	0.0197	0.1696	0.0122	0.1054
Uncontrolled	1972 and Earlier	0.0197	0.1780	0.0122	0.1106
Gasoline Light-Duty Trucks					
EPA Tier 2	2005 and Later	0.0066	0.0163	0.0041	0.0101
Low Emission Vehicles	2001-2004	0.0157	0.0148	0.0098	0.0092
EPA Tier 1	1995-2000	0.0871	0.0452	0.0541	0.0281
EPA Tier 0	1986-1994	0.1056	0.0776	0.0656	0.0482
Oxidation Catalyst	1975-1985	0.0639	0.1516	0.0397	0.0942
Non-Catalyst	1973-1974	0.0218	0.1908	0.0135	0.1186
Uncontrolled	1972 and Earlier	0.0220	0.2024	0.0137	0.1258
Gasoline Heavy-Duty Vehicles					
EPA Tier 2	2004 and Later	0.0134	0.0333	0.0083	0.0207
Low Emission Vehicles	1998-2003	0.0320	0.0303	0.0199	0.0188
EPA Tier 1	1996-2003	0.1750	0.0655	0.1087	0.0407
EPA Tier 0	1996 and Later	0.2135	0.2630	0.1327	0.1634
Oxidation Catalyst	1996 and Later	0.1317	0.2356	0.0818	0.1464
Non-Catalyst Control	1985-1995	0.0473	0.4181	0.0294	0.2598
Uncontrolled	1984 and Earlier	0.0497	0.4604	0.0309	0.2861
Diesel Passenger Cars					
Advanced	1996 and Later	0.0010	0.0005	0.0006	0.0003
Moderate	1983-1995	0.0010	0.0005	0.0006	0.0003
Uncontrolled	1982 and Earlier	0.0012	0.0006	0.0008	0.0004
Diesel Light-Duty Trucks					
Advanced	1996 and Later	0.0015	0.0010	0.0009	0.0006
Moderate	1983-1995	0.0014	0.0009	0.0009	0.0006
Uncontrolled	1982 and Earlier	0.0017	0.0011	0.0011	0.0007
Diesel Heavy-Duty Vehicles					
Advanced	1996 and Later	0.048	0.0051	0.030	0.0032
Moderate	1983-1995	0.048	0.0051	0.030	0.0032
Uncontrolled	1982 and Earlier	0.048	0.0051	0.030	0.0032
Motorcycles					
Non-Catalyst Control	1996 and Later	0.0069	0.0672	0.0043	0.0418
Uncontrolled	1995 and Earlier	0.0087	0.0899	0.0054	0.0559

Source: U.S. Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005, EPA 430-R-07-002, Annex 3.2, (April 2007), web site: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

6. Methane and Nitrous Oxide Emission Factors for Alternative Fuel Vehicles

Vehicle Type/Control Technology	N_2O (g/mi)	CH_4 (g/mi)	N_2O (g/km)	CH_4 (g/km)
Light Duty Vehicles				
Methanol	0.067	0.018	0.0416	0.0112
CNG	0.050	0.737	0.0311	0.4580
LPG	0.067	0.037	0.0416	0.0230
Ethanol	0.067	0.055	0.0416	0.0342
Heavy Duty Vehicles				
Methanol	0.175	0.066	0.1087	0.0410
CNG	0.175	1.966	0.1087	1.2216
LNG	0.175	1.966	0.1087	1.2216
LPG	0.175	0.066	0.1087	0.0410
Ethanol	0.175	0.197	0.1087	0.1224
Buses				
Methanol	0.175	0.066	0.1087	0.0410
CNG	0.175	1.966	0.1087	1.2216
Ethanol	0.175	0.197	0.1087	0.1224

Source: U.S. Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005, EPA 430-R-07-002, Annex 3.2, (April 2007), web site: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

7. Methane and Nitrous Oxide Emission Factors for Non-Highway Mobile Combustion

Vehicle Type/Fuel Type	N_2O (g/kg fuel)	CH_4 (g/kg fuel)	N_2O (g/gal fuel)	CH_4 (g/gal fuel)
Ships and Boats				
Residual	0.08	0.23	0.30	0.86
Distillate	0.08	0.23	0.26	0.74
Gasoline	0.08	0.23	0.22	0.65
Locomotives				
Diesel	0.08	0.25	0.26	0.80
Agricultural Equipment				
Gas	0.08	0.45	0.22	1.26
Diesel	0.08	0.45	0.26	1.44
Construction				
Gas	0.08	0.18	0.22	0.51
Diesel	0.08	0.18	0.26	0.58
Other Non-Highway				
All "Other" Categories[1]	0.08	0.18	0.22	0.51
Aircraft				
Jet Fuel	0.10	0.09	0.31	0.27
Aviation Gasoline	0.04	2.64	0.11	7.05

[1]"Other" includes snowmobiles and other recreational equipment, logging equipment, lawn and garden equipment, railroad equipment, airport equipment, commercial equipment, and industrial equipment. (Assumes gasoline fuel.)
Source: U.S. Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005, EPA 430-R-07-002, Annex 3.2, (April 2007), web site: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

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