

U.S. Greenhouse Gas Emissions and Sinks (MMT CO₂ Equivalents)

Change from 1990 to 2009

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Absolute	Percent
CO₂	5,099.7	5,055.0	5,158.2	5,270.8	5,354.3	5,422.8	5,602.5	5,681.2	5,713.9	5,796.6	5,975.0	5,873.3	5,912.6	5,966.0	6,076.7	6,113.8	6,021.1	6,120.0	5,921.4	5,505.2	405.5	8 %
Fossil Fuel Combustion	4,738.4	4,698.2	4,799.1	4,909.8	4,977.4	5,031.5	5,215.9	5,284.0	5,316.2	5,391.1	5,594.8	5,521.9	5,557.6	5,621.1	5,708.0	5,753.2	5,653.1	5,756.7	5,565.9	5,209.0	470.6	10 %
Non-Energy Use of Fuels	118.6	124.4	123.5	124.7	133.5	139.2	136.8	144.3	158.7	167.9	144.9	133.9	136.0	131.4	151.3	143.4	145.6	137.2	141.0	123.4	4.7	4 %
Iron and Steel Production & Metallurgical Coke Production	99.5	90.6	91.0	87.1	89.7	93.3	91.3	92.7	86.5	84.3	85.9	75.6	71.9	69.5	68.0	65.9	68.8	71.0	66.0	41.9	(57.7)	(58)%
Natural Gas Systems	37.6	37.8	37.5	40.9	41.0	42.5	40.0	39.6	29.6	30.7	29.9	29.4	30.2	29.0	28.7	29.9	30.8	31.1	32.8	32.2	(5.4)	(14)%
Cement Production	33.3	32.5	32.8	34.6	36.1	36.2	36.4	37.6	38.5	39.3	40.4	40.6	42.2	42.3	44.8	45.2	45.8	44.5	40.5	29.0	(4.3)	(13)%
Incineration of Waste	8.0	8.0	9.5	9.8	10.9	11.3	11.9	11.9	10.8	11.0	11.1	11.4	11.8	12.1	12.4	12.5	12.5	12.7	12.2	12.3	4.3	54 %
Ammonia Production and Urea Consumption	16.8	16.8	17.5	17.8	18.4	17.8	17.7	18.0	19.0	17.6	16.4	13.3	14.2	12.4	13.2	12.8	12.3	14.0	11.9	11.8	(5.0)	(30)%
Lime Production	11.5	11.4	11.8	12.1	12.6	13.3	14.1	14.3	14.6	14.3	14.1	13.6	13.1	13.8	14.5	14.4	15.1	14.6	14.3	11.2	(0.3)	(3)%
Cropland Remaining Cropland	7.1	7.3	6.9	6.4	6.8	7.0	7.0	7.0	7.7	7.5	7.5	7.8	8.5	8.3	7.6	7.9	7.9	8.2	8.7	7.8	0.7	11 %
Limestone and Dolomite Use	5.1	4.5	4.6	4.3	4.8	6.7	7.2	6.7	6.9	7.6	5.1	4.8	5.6	4.1	5.9	6.8	8.0	7.7	6.3	7.6	2.5	49 %
Soda Ash Production and Consumption	4.1	4.0	4.1	4.0	4.0	4.3	4.2	4.4	4.3	4.2	4.2	4.1	4.1	4.1	4.2	4.2	4.2	4.1	4.1	4.3	0.1	3 %
Aluminum Production	6.8	6.9	6.8	6.2	5.5	5.7	6.0	6.0	6.2	6.3	6.1	4.4	4.5	4.5	4.2	4.1	3.8	4.3	4.5	3.0	(3.8)	(56)%
Petrochemical Production	3.3	3.4	3.6	3.8	4.0	4.1	4.1	4.4	4.5	4.6	4.5	4.2	4.3	4.1	4.3	4.2	3.8	3.9	3.4	2.7	(0.6)	(17)%
Carbon Dioxide Consumption	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	0.8	1.0	1.3	1.2	1.3	1.7	1.9	1.8	1.8	0.3	24 %
Titanium Dioxide Production	1.2	1.2	1.4	1.4	1.5	1.5	1.5	1.7	1.7	1.8	1.7	1.8	1.8	1.8	2.1	1.8	1.8	1.9	1.8	1.5	0.3	29 %
Ferroalloy Production	2.2	1.9	2.0	1.9	2.0	2.0	2.1	2.2	2.2	2.2	1.9	1.5	1.3	1.3	1.4	1.4	1.5	1.6	1.6	1.5	(0.7)	(32)%
Wetlands Remaining Wetlands	1.0	1.0	0.9	1.0	0.9	1.0	0.9	1.0	1.1	1.2	1.2	1.1	1.0	1.0	1.1	1.1	0.9	1.0	1.0	1.1	0.1	5 %
Phosphoric Acid Production	1.5	1.4	1.5	1.3	1.5	1.5	1.6	1.5	1.6	1.5	1.4	1.3	1.3	1.4	1.4	1.4	1.2	1.2	1.2	1.0	(0.5)	(32)%
Zinc Production	0.7	0.9	0.9	1.0	1.0	0.9	1.0	1.0	0.9	0.9	1.0	0.8	0.8	1.2	1.1	1.1	1.1	1.1	1.2	1.0	0.3	45 %
Lead Production	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.5	+	2 %
Petroleum Systems	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	(0.1)	(17)%
Silicon Carbide Production and Consumption	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	(0.2)	(61)%
Land Use, Land-Use Change, and Forestry (Sink) ^a	(861.5)	(833.1)	(821.0)	(772.0)	(873.2)	(812.6)	(711.1)	(741.4)	(617.7)	(534.1)	(576.6)	(661.7)	(864.8)	(1,005.9)	(1,052.5)	(1,056.5)	(1,064.3)	(1,060.9)	(1,040.5)	(1,015.1)	(153.5)	18 %
Wood Biomass and Ethanol Consumption ^b	219.4	220.2	230.6	225.8	232.3	236.9	241.3	235.6	218.2	221.5	227.4	203.3	204.6	209.8	225.2	229.8	234.8	242.3	253.1	245.0	25.6	12 %
International Bunker Fuels ^c	111.8	120.7	113.3	102.2	104.7	99.8	107.5	110.2	119.5	101.8	98.5	96.6	104.2	99.8	114.7	109.7	128.4	127.6	133.7	123.1	11.3	10 %
CH₄	674.9	676.4	680.8	671.6	685.4	678.0	684.3	662.6	656.7	650.2	659.9	655.9	658.0	649.7	636.7	631.4	672.1	664.6	676.7	686.3	11.4	2 %
Natural Gas Systems	189.8	191.5	191.9	194.8	197.7	198.4	202.2	201.7	201.2	195.4	209.3	215.5	217.2	214.1	204.8	190.4	217.7	205.2	211.8	221.2	31.4	17 %
Enteric Fermentation	132.1	132.3	136.4	138.0	140.3	143.5	142.5	139.7	138.1	138.1	136.5	135.7	136.1	134.3	134.4	136.5	138.8	141.0	140.6	139.8	7.7	6 %
Landfills	147.4	148.4	149.0	148.4	146.7	139.4	136.0	127.0	119.7	114.7	111.7	108.2	108.5	113.7	109.7	112.5	111.7	111.3	115.9	117.5	(29.9)	(20)%
Coal Mining	84.1	81.1	79.0	67.7	68.1	67.1	66.8	66.4	66.8	62.9	60.4	60.4	56.8	56.8	58.1	56.9	58.2	57.9	67.1	71.0	(13.0)	(16)%
Manure Management	31.7	33.2	32.0	33.5	35.7	36.8	36.2	38.0	41.4	41.9	42.4	44.2	45.4	42.1	44.3	46.6	46.7	50.7	49.4	49.5	17.7	56 %
Petroleum Systems	35.4	35.6	34.7	33.8	33.7	33.4	33.3	33.2	32.9	31.9	31.5	31.5	31.1	30.4	29.9	29.4	29.4	30.0	30.2	30.9	(4.4)	(13)%
Wastewater Treatment	23.5	23.9	24.3	24.4	24.7	24.8	24.9	25.2	25.2	25.3	25.2	24.7	24.7	24.5	24.6	24.3	24.5	24.4	24.5	24.5	1.0	4 %
Forest Land Remaining Forest Land	3.2	2.8	4.2	2.6	7.7	4.3	12.2	2.4	3.2	11.3	14.3	8.3	12.6	8.0	4.6	9.8	21.6	20.0	11.9	7.8	4.6	144 %
Rice Cultivation	7.1	7.0	7.9	7.0	8.2	7.6	7.0	7.5	7.9	8.3	7.5	7.6	6.8	6.9	7.6	6.8	5.9	6.2	7.2	7.3	0.2	3 %
Stationary Combustion	7.4	7.6	7.8	7.3	7.2	7.1	7.4	6.7	6.2	6.3	6.6	6.2	6.2	6.4	6.5	6.6	6.2	6.5	6.5	6.2	(1.3)	(17)%
Abandoned Underground Coal Mines	6.0	6.2	6.7	6.9	8.1	8.2	8.5	7.6	6.9	7.0	7.4	6.7	6.2	6.0	5.8	5.5	5.5	5.6	5.9	5.5	(0.5)	(9)%
Mobile Combustion	4.7	4.6	4.5	4.5	4.4	4.3	4.1	4.0	3.8	3.5	3.4	3.3	2.9	2.7	2.6	2.5	2.3	2.2	2.0	2.0	(2.7)	(58)%
Composting	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.3	1.3	1.3	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.3	421 %
Petrochemical Production	0.9	0.9	0.9	1.0	1.1	1.1	1.1	1.2	1.2	1.3	1.2	1.1	1.2	1.1	1.2	1.1	1.0	1.0	0.9	0.8	(+)	(2)%
Iron and Steel Production & Metallurgical Coke Production	1.0	0.8	0.9	0.9	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.6	0.4	(0.6)	(62)%
Field Burning of Agricultural Residues	0.3	0.2	0.3	0.2	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	(+)	(8)%
Ferroalloy Production	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	(+)	(40)%
Silicon Carbide Production and Consumption	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	(+)	(67)%
Incineration of Waste	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	(+)	(23)%
International Bunker Fuels ^c	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	(+)	(14)%
N₂O	315.2	326.5	317.3	336.9	336.2	342.8	362.9	339.7	343.4	334.2	341.0	342.2	331.7	317.6	320.0	322.9	326.4	325.1	310.8	295.6	(19.6)	(6)%
Agricultural Soil Management	197.8	207.7	195.4	212.0	203.5	207.6	219.3	209.7	217.6	203.2	206.8	220.4	208.8	202.4	211.8	211.3	208.9	209.4	210.7	204.6	6.8	3 %
Mobile Combustion	43.9	46.0	49.0	51.1	52.8	54.0	54.7	55.3	55.2	54.1	53.2	50.3	46.3	42.8	40.1	36.9	33.6	30.3	26.1	23.9	(20.0)	(46)%
Manure Management	14.5	14.7	14.8	14.5	15.3	15.7	15.6	15.8	16.0	16.7	17.1	17.0	17.4	16.9	16.9	17.3	18.0	18.1	17.9	17.9	3.4	23 %
Nitric Acid Production	17.7	17.7	18.1	18.4	19.4	19.7	20.5	21.0	20.7	19.9	19.4	15.8	17.1	16.0	15.9	16.5	16.2	19.2	16.4	14.6	(3.1)	(18)%
Stationary Combustion	12.8	12.8	13.0	13.2	13.3	13.3	13.9	14.1	14.0	14.0	14.6	14.1	14.0	14.3	14.5	14.7	14.4	14.6	14.2	12.8	(+)	(+)%
Forest Land Remaining Forest Land	2.7	2.3	3.5	2.2	6.4	3.7	10.2	2.2	2.9	9.7	12.1	7.2	10.7	7.0	4.1	8.4	18.0	16.7	10.1	6.7	4.1	152 %
Wastewater Treatment	3.7	3.8	3.9	4.0	4.0	4.0	4.1	4.1	4.2	4.4	4.5	4.6	4.5	4.6	4.7	4.8	4.8	4.9	5.0	5.0	1.3	36 %
N ₂ O from Product Uses	4.4	4.3	4.0	4.6	4.6	4.6	4.6	4.9	4.9	4.9	4.9	4.9	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	(+)	(+)%
Adipic Acid Production	15.8	15.4	13.5	14.6	14.2	17.6	17.4	9.8	5.4	4.9	5.5	4.7	5.2	5.7								

Conversions and Units

Global Warming Potentials (100 Year Time Horizon)

Gas	GWP	
	SAR ^a	AR4 ^b
Carbon dioxide (CO ₂)	1	1
Methane (CH ₄) [*]	21	25
Nitrous oxide (N ₂ O)	310	298
HFC-23	11,700	14,800
HFC-125	2,800	3,500
HFC-134a	1,300	1,430
HFC-143a	3,800	4,470
HFC-152a	140	124
HFC-227ea	2,900	3,220
HFC-236fa	6,300	9,810
HFC-4310mee	1,300	1,640
CF ₄	6,500	7,390
C ₂ F ₆	9,200	12,200
C ₃ F ₈	7,000	8,860
C ₄ F ₁₀	7,400	9,300
SF ₆	23,900	22,800

^a IPCC Second Assessment Report (1996)

^b IPCC Fourth Assessment Report (2007)

* The methane GWP includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO₂ is not included.

Note: GWP values from the IPCC Second Assessment Report are used in accordance with UNFCCC guidelines.

Global Warming Potential (GWP) is defined as the cumulative radiative forcing effects of a gas over a specified time horizon resulting from the emission of a unit mass of gas relative to a reference gas. The GWP-weighted emissions of direct greenhouse gases in the U.S. Inventory are presented in terms of equivalent emissions of carbon dioxide (CO₂), using units of million metric tons of carbon dioxide equivalents (MMT CO₂ Eq.).

Conversion:

1 million metric tons = 10⁶ metric tons = 10⁹ kg

The molecular weight of carbon is 12, and the molecular weight of oxygen is 16; therefore, the molecular weight of CO₂ is 44 (i.e., 12 + [16 × 2]), as compared to 12 for carbon alone. Thus, the weight ratio of carbon to carbon dioxide is 12/44.

Conversion from gigagrams of gas to million metric tons of carbon dioxide equivalents:

$$\text{MMT CO}_2 \text{ Eq.} = \left(\frac{\text{Gg}}{\text{of gas}} \right) \times (\text{GWP}) \times \left(\frac{\text{MMT}}{1,000 \text{ Gg}} \right)$$

Energy Conversions

The common energy unit used in international reports of greenhouse gas emissions is the joule. A joule is the energy required to move an object one meter with the force of one Newton. A terajoule (TJ) is one trillion (10¹²) joules. A British thermal unit (Btu, the customary U.S. energy unit) is the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit at or near 39.2 Fahrenheit.

$$1 \text{ TJ} = \begin{aligned} &2.388 \times 10^{11} \text{ calories} \\ &23.88 \text{ metric tons of crude oil equivalent} \\ &9.478 \times 10^8 \text{ Btu} \\ &277,800 \text{ kilowatt-hours} \end{aligned}$$

Energy Units

Btu	British thermal unit	1 Btu
MBtu	Thousand Btu	1 × 10 ³ Btu
MMBtu	Million Btu	1 × 10 ⁶ Btu
BBtu	Billion Btu	1 × 10 ⁹ Btu
TBtu	Trillion Btu	1 × 10 ¹² Btu
QBtu	Quadrillion Btu	1 × 10 ¹⁵ Btu

Unit Conversions

1 pound	= 0.454 kilograms	= 16 ounces
1 kilogram	= 2.205 pounds	= 35.27 ounces
1 short ton	= 0.9072 metric tons	= 2,000 pounds
1 metric ton	= 1.1023 short tons	= 1,000 kilograms
1 cubic foot	= 0.02832 cubic meters	= 28.3168 liters
1 cubic meter	= 35.315 cubic feet	= 1,000 liters
1 U.S. gallon	= 3.78541 liters	= 0.03175 barrels = 0.02381 barrels petroleum
1 liter	= 0.2642 U.S. gallons	= 0.0084 barrels = 0.0063 barrels petroleum
1 barrel	= 31.5 U.S. gallons	= 119 liters = 0.75 barrels petroleum
1 barrel petroleum	= 42 U.S. gallons	= 159 liters
1 foot	= 0.3048 meters	= 12 inches
1 meter	= 3.28 feet	= 39.37 inches
1 mile	= 1.609 kilometers	= 5,280 feet
1 kilometer	= 0.6214 miles	= 3,280.84 feet
1 square mile	= 2.590 square kilometers	= 640 acres
1 square kilometer	= 0.386 square miles	= 100 hectares
1 acre	= 43,560 square feet	= 0.4047 hectares = 4,047 square meters

Prefix/Symbol	Factor
Tera (T)	10 ¹² 1,000,000,000,000
Giga (G)	10 ⁹ 1,000,000,000
Mega (M)	10 ⁶ 1,000,000
Kilo (k)	10 ³ 1,000
Hecto (h)	10 ² 100
Deca (da)	10 ¹ 10
—	10 ⁰ 1
Deci (d)	10 ⁻¹ .1
Centi (c)	10 ⁻² .01
Milli (m)	10 ⁻³ .001
Micro (μ)	10 ⁻⁶ .000001
Nano (n)	10 ⁻⁹ .000000001
Pico (p)	10 ⁻¹² .000000000001

Guide to Metric Unit Prefixes

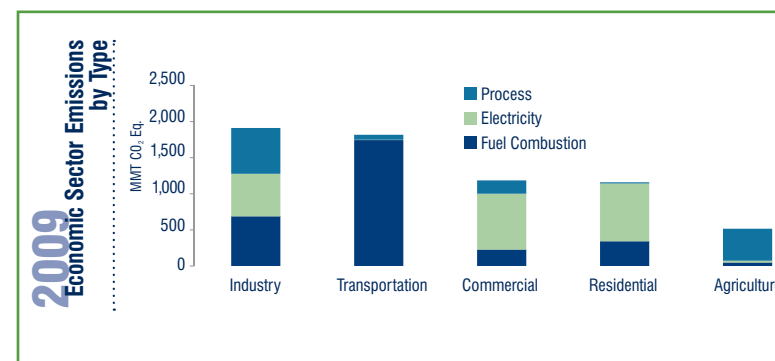
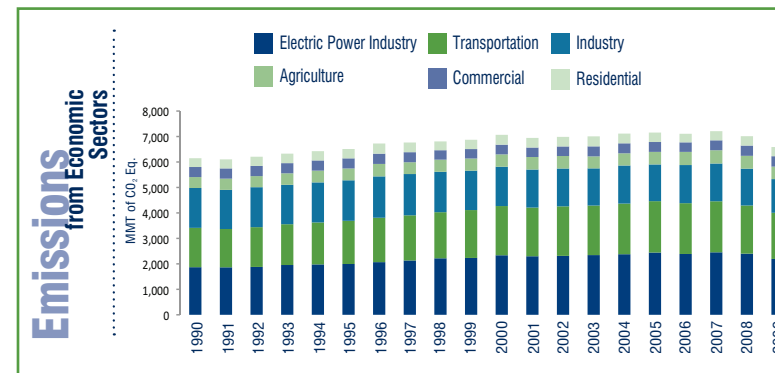
Economic Sectors

U.S. Greenhouse Gas Emissions Allocated to Economic Sectors (MMT CO₂ Eq.)

Implied Sectors	1990	2000	2005	2006	2007	2008	2009
Electric Power Industry	1,868.9	2,337.6	2,444.6	2,388.2	2,454.0	2,400.7	2,193.0
Transportation	1,545.2	1,932.3	2,017.4	1,994.4	2,003.8	1,890.7	1,812.4
Industry	1,564.4	1,544.0	1,441.9	1,497.3	1,483.0	1,446.9	1,322.7
Agriculture	429.0	485.1	493.2	516.7	520.7	503.9	490.0
Commercial	395.5	381.4	387.2	375.2	389.6	403.5	409.5
Residential	345.1	386.2	371.0	335.8	358.9	367.1	360.1
U.S. Territories	33.7	46.0	58.2	59.3	53.5	48.4	45.5
Total Emissions	6,181.8	7,112.7	7,213.5	7,166.9	7,263.4	7,061.1	6,633.2

U.S. Greenhouse Gas Emissions Allocated to Economic Sectors with Electricity Distributed (MMT CO₂ Eq.)

Implied Sectors	1990	2000	2005	2006	2007	2008	2009
Industry	2,238.3	2,314.4	2,162.5	2,194.6	2,192.9	2,146.5	1,910.9
Transportation	1,548.3	1,935.8	2,022.2	1,999.0	2,008.9	1,895.5	1,816.9
Commercial	947.7	1,135.8	1,205.1	1,188.5	1,225.3	1,224.5	1,184.9
Residential	953.8	1,162.2	1,242.9	1,181.5	1,229.6	1,215.1	1,158.9
Agriculture	460.0	518.4	522.7	544.1	553.2	531.1	516.0
U.S. Territories	33.7	46.0	58.2	59.3	53.5	48.4	45.5
Total Emissions	6,181.8	7,112.7	7,213.5	7,166.9	7,263.4	7,061.1	6,633.2



Carbon Information

Conversion Factors to Energy Units (Heat Equivalents) Heat Contents and Carbon Content Coefficients of Various Fuel Types

Converting Various Physical Units to Energy Units—The values in the following table provide conversion factors from physical units to energy equivalent units and from energy units to carbon contents. These factors can be used as default factors, if local data are not available.

Fuel Type	Heat Content	Carbon (C) Content Coefficients	Carbon Dioxide (CO ₂) per Physical Unit
Solid Fuels	Million Btu/Metric Ton	kg C/Million Btu	kg CO₂/Metric Ton
Anthracite Coal	24.88	28.28	2,579.9
Bituminous Coal	26.33	25.44	2,456.6
Sub-bituminous Coal	18.89	26.50	1,835.9
Lignite	14.18	26.65	1,385.6
Coke	27.56	31.00	3,131.9
Unspecified Coal	27.56	25.34	2,560.0
Gas Fuels	Btu/Cubic Foot	kg C/Million Btu	kg CO₂/Cubic Foot
Natural Gas	1,026	14.46	0.0544
Liquid Fuels	Million Btu/Petroleum Barrel	kg C/Million Btu	kg CO₂/Petroleum Barrel
Motor Gasoline	5.22	19.46	372.2
Distillate Fuel Oil	5.83	20.17	430.8
Residual Fuel Oil	6.29	20.48	472.1
Jet Fuel	5.67	19.70	409.5
Aviation Gasoline	5.05	18.86	349.0
LPG	3.55	16.83	219.3
Kerosene	5.67	19.96	415.1
Still Gas	6.00	18.20	400.3
Petroleum Coke	6.02	27.85	615.1
Pentanes Plus	4.62	19.10	323.6
Unfinished Oils	5.83	20.31	433.8

Note: For fuels with variable heat contents and carbon content coefficients, 2009 U.S. average values are presented. All factors are presented in gross calorific values (GCV) (i.e., higher heating values). LRG = Liquid Refinery Gas. Miscellaneous products includes all finished products not otherwise classified, (e.g., aromatic extracts and tars, absorption oils, ram-jet fuel, synthetic natural gas, naphtha-type jet fuel, and specialty oils).

$$\text{CO}_2 \text{ Emissions from Fossil Fuel Combustion} = \text{Fuel Combusted} \times \text{Carbon Content Coefficient} \times \text{Fraction Oxidized} \times (44/12)$$

May include adjustments for carbon stored in fossil fuel-based products, emissions from international bunker fuels, or emissions from territories.

Carbon Intensity of Different Fuel Types

The amount of carbon in fossil fuels per unit of energy content varies significantly by fuel type. For example, coal contains the highest amount of carbon per unit of energy, while petroleum has about 25 percent less carbon than coal, and natural gas about 45 percent less.

For more information on calculating CO₂ emissions per kWh, download eGRID at:

<http://www.epa.gov/cleanenergy/egrid>

For other related information, see:
<http://www.epa.gov/climatechange> and
<http://unfccc.int>

Download the Inventory at: <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>

Source for all data: Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2009 (EPA 2011)