# Emissions of Greenhouse Gases per Household and per Capita, 1998

Compiled by Rick Heede 11-Apr-2002 Rocky Mountain Institute www.rmi.org

| Carbon dioxide | Total emissions | Total per household | | Total per capita | | |
|---|---|---|---|---|---|---|
| | Million tons CO2-e/yr | Tons CO2-e/yr | Pounds CO2-e/yr | Tons CO2-e/yr | Pounds CO2-e/yr | Kg carbon/yr |
| **Transportation** | | | | | | |
| **Household vehicles & equipment** | | | | | | |
| Passenger cars | 645.2 | 6.29 | 12,586 | 2.39 | 4,775 | 1,181 |
| Light trucks | 452.6 | 4.41 | 8,830 | 1.67 | 3,350 | 829 |
| Motorcycles | 2.1 | 0.02 | 40 | 0.01 | 15 | 4 |
| Motorhomes | - | - | - | - | - | - |
| ATVs, snowmobiles, off-road veh. | 17.1 | 0.17 | 333 | 0.06 | 126 | 31 |
| Personal boats & watercraft | 15.1 | 0.15 | 294 | 0.06 | 112 | 28 |
| Lawn & garden equipment | 8.7 | 0.09 | 170 | 0.03 | 65 | 16 |
| Personal aviation | 1.7 | 0.02 | 33 | 0.01 | 13 | 3 |
| **Total household vehicles & equip** | 1,142.5 | 11.14 | 22,287 | 4.23 | 8,455 | 2,092 |
| **Non-household highway vehicles** | | | | | | |
| Other passenger cars | 59.7 | 0.58 | 1,165 | 0.22 | 442 | 109 |
| Other light trucks | 41.8 | 0.41 | 816 | 0.15 | 309 | 77 |
| Medium trucks | 109.0 | 1.06 | 2,127 | 0.40 | 807 | 200 |
| Combination (heavy) trucks | 236.2 | 2.30 | 4,607 | 0.87 | 1,748 | 432 |
| Non-transit buses | 11.7 | 0.11 | 228 | 0.04 | 87 | 21 |
| **Total non-household vehicles** | 458.4 | 4.47 | 8,943 | 1.70 | 3,393 | 839 |
| **Non-highway fuel uses** | | | | | | |
| Agriculture | 9.8 | 0.10 | 192 | 0.04 | 73 | 18 |
| Aviation | | | | | | |
| Marine | 9.4 | 0.09 | 183 | 0.03 | 69 | 17 |
| Construction and miscellaneous | 27.3 | 0.27 | 533 | 0.10 | 202 | 50 |
| **Total non-highway fuel** | 46.5 | 0.45 | 907 | 0.17 | 344 | 85 |
| **Aviation** | | | | | | |
| Commercial aviation | 149.4 | 1.46 | 2,914 | 0.55 | 1,106 | 274 |
| Other (non-defense) jet fuel | 8.8 | 0.09 | 171 | 0.03 | 65 | 16 |
| General aviation: avgas | 1.1 | 0.01 | 22 | 0.00 | 8 | 2 |
| **Total aviation** | 159.3 | 1.55 | 3,107 | 0.59 | 1,179 | 292 |
| **Transit** (buses, light rail) | 12.5 | 0.12 | 243 | 0.05 | 92 | 23 |
| **Amtrak** (diesel and electricity) | 1.0 | 0.01 | 20 | 0.00 | 8 | 2 |
| **Freight rail** (Class 1, all fuels) | 40.1 | 0.39 | 782 | 0.15 | 297 | 73 |
| **Waterborne commerce** (all fuels) | 111.6 | 1.09 | 2,176 | 0.41 | 826 | 204 |
| **Pipeline** (natural gas consumed) | 38.3 | 0.37 | 748 | 0.14 | 284 | 70 |
| **Lubricants** | 7.3 | 0.07 | 142 | 0.03 | 54 | 13 |
| **Miscellaneous Transport CO 2** | 22.8 | 0.22 | 445 | 0.08 | 169 | 42 |
| **Total Transportation (CO 2 only)** | 2,040.3 | 19.90 | 39,800 | 7.55 | 15,100 | 3,736 |
| **Commercial sector CO 2 emissions** | 1,012.2 | 9.87 | 19,745 | 3.75 | 7,491 | 1,853 |
| **Industrial sector CO 2 emissions** | 1,897.8 | 18.51 | 37,020 | 7.02 | 14,045 | 3,475 |
| **Residential sector CO 2 emissions** | | | | | | |
| Space heating | 402.7 | 3.93 | 7,855 | 1.49 | 2,980 | 737 |
| Air conditioning | 85.8 | 0.84 | 1,674 | 0.32 | 635 | 157 |
| Water heating | 162.3 | 1.58 | 3,166 | 0.60 | 1,201 | 297 |
| Refrigerators & freezers | 119.0 | 1.16 | 2,320 | 0.44 | 880 | 218 |
| Cooking | 37.6 | 0.37 | 734 | 0.14 | 279 | 69 |
| Other appliances | 282.0 | 2.75 | 5,500 | 1.04 | 2,087 | 516 |
| Lighting | 97.8 | 0.95 | 1,908 | 0.36 | 724 | 179 |
| **Total residential sector CO 2** | 1,187.2 | 11.58 | 23,159 | 4.39 | 8,786 | 2,174 |
| **Other CO 2 emissions** | | | | | | |
| Gas flaring | 15.8 | 0.15 | 307 | 0.06 | 117 | 29 |
| CO2 in natural gas | 19.8 | 0.19 | 386 | 0.07 | 147 | 36 |
| Cement manufacturing | 43.3 | 0.42 | 844 | 0.16 | 320 | 79 |
| Other industrial | 32.7 | 0.32 | 639 | 0.12 | 242 | 60 |
| Waste combustion | 28.7 | 0.28 | 560 | 0.11 | 212 | 53 |
| **Total other CO 2 emissions** | 140.3 | 1.37 | 2,736 | 0.52 | 1,038 | 257 |
| **Total CO 2 emissions** | 6,277.8 | 61.23 | 122,460 | 23.23 | 46,459 | 11,494 |
| **Methane** | | | | | | |
| Coal mining | 81.1 | 0.79 | 1,583 | 0.30 | 600 | 149 |
| Natural gas and petroleum systems | 178.5 | 1.74 | 3,482 | 0.66 | 1,321 | 327 |
| Stationary combustion sources | 10.0 | 0.10 | 195 | 0.04 | 74 | 18 |
| Mobile sources | 6.1 | 0.06 | 118 | 0.02 | 45 | 11 |
| Landfills | 220.6 | 2.15 | 4,303 | 0.82 | 1,632 | 404 |
| Wastewater treatment | 4.1 | 0.04 | 79 | 0.02 | 30 | 7 |
| Domestic animals (eructation, flatulence) | 137.2 | 1.34 | 2,676 | 0.51 | 1,015 | 251 |
| Domesticated animals (solid waste) | 78.2 | 0.76 | 1,526 | 0.29 | 579 | 143 |
| Riced paddies and crop residue burning | 12.7 | 0.12 | 247 | 0.05 | 94 | 23 |
| Industrial processes | 3.4 | 0.03 | 66 | 0.01 | 25 | 6 |
| **Total methane** | 731.8 | 7.14 | 14,275 | 2.71 | 5,416 | 1,340 |
| **Nitrous oxide** | | | | | | |
| Mobile sources | 72.8 | 0.71 | 1,419 | 0.27 | 538 | 133 |
| Stationary sources | 15.7 | 0.15 | 305 | 0.06 | 116 | 29 |
| Nitrogen fertilization of agricultural soils | 208.8 | 2.04 | 4,073 | 0.77 | 1,545 | 382 |
| Domestic animals (solid waste) | 76.0 | 0.74 | 1,483 | 0.28 | 563 | 139 |
| Wastewater treatment plants | 5.9 | 0.06 | 115 | 0.02 | 43 | 11 |
| Industrial processes | 18.9 | 0.18 | 369 | 0.07 | 140 | 35 |
| **Total nitrous oxide** | 398.1 | 3.88 | 7,765 | 1.47 | 2,946 | 729 |
| **Other gases** | | | | | | |
| Hydrofluorocarbons | 106.2 | 1.04 | 2,071 | 0.39 | 786 | 194 |
| Perfluorocarbons | 36.3 | 0.35 | 708 | 0.13 | 269 | 66 |
| Other HFCs, PFCs, and PFPEs | 14.3 | 0.14 | 279 | 0.05 | 106 | 26 |
| Sulfur hexafluoride | 28.0 | 0.27 | 546 | 0.10 | 207 | 51 |
| "Excluded" emissions (CFC leakage, etc) | 652.3 | 6.36 | 12,724 | 2.41 | 4,827 | 1,194 |
| **Total other gases** | 837.1 | 8.16 | 16,329 | 3.10 | 6,195 | 1,533 |
| **Total GHG emissions** | 8,245 | 80.4 | 160,828 | 30.5 | 61,016 | 15,095 |

**Cell:** E5
**Comment:** Rick Heede:
According to the 2000 census, there were 102.528 million households in the U.S. in 1998. U.S. Department of Commerce, Bureau of the Census (2000), Statistical Abstract of the United States 2000.

Note: Based on 2000 data from the 2000 Census, in which year there were 105.480 million households and 273.643 million people "living in households" (of a total population of 281.422 million), the average U.S. household has 2.594 resident humans (down from 2.632 per hh in 1990 (in which year total population = 248.710 million, of which 242.012 lived in households, and there were 91.947 million occupied housing units)). See www.census.gov for details.

**Cell:** G5
**Comment:** Rick Heede:
According to the 2000 census, there were 270.248 million people ("resident population") in the U.S. in 1998. U.S. Department of Commerce, Bureau of the Census (2000), Statistical Abstract of the United States 2000.

Note: This appears to conflict with other census data that states total U.S. population in 2000 as 281.422 million (of which 273.643 million lived in households): we could not have added 11.174 million people in two years: must be due to (a) differing definitions of "population" or (b) different method or lack of updating 1998 estimates. In any case, we use the 270.248 million figure to divide total U.S. greenhouse gas emissions into a per capita figure in this column.

Note: in both this and the per household ccolumn there are uncertainties about the data: are homeless included? military personnel living on bases? folk living temporary housing such as hotels and motels? population living in prisons? Presumably, all GHG emissions from such facilities are included, but it is not clear if the "residents" are included.

**Cell:** C7
**Comment:** Rick Heede:
Note: By adding in ATVs, watercraft, and lawn/garden equipment we may be overstating "transportation"-related fuel consumption and GHG emissions. Fuel purchased for such vehicles are most likely counted elsewhere in EIA's Emissions of GHG 2000 estimates (but not line-itemed). For this reason, and because we built transportation emissions from the bottom up (BTS stats on fuel by end uses detailed in this section, and not always the same year 1998), our "transportation" CO2 emissions total 2,042.2 million tons CO2 (= 505.2 MtC). The EIA "transportation" emissions of CO2, 1998 = 481.5 MtC; our 1998 estimate is 4.9 percent higher. Of course, we may, but cannot at this point determine, be including in "transportation" some emissions accounted for by EIA in other sector emissions. However, we have used EIA emissions data for 1998 for each of the other sectoral CO2 emissions below.

Our estimated total emissions of CO2 is 6,279.7 million tons CO2 (1,553.6 MtC), or 42.7 MtC higher and 2.8 percent above EIA's 1998 total of 1,510.9 MtC.

**Cell:** C9
**Comment:** Rick Heede:
We had to use disparate statistics (sources and years) to estimate per household fuel consumption and CO2 emissions.

Total miles per household: 20,895 miles/yr (1995)(FHWA, Nationwide Personal Transportation Survey).
Vehicles per household: 1.705 (2000: household vehicle ownership = 179.418 million / 105.220 million HH; Bureau of the Census).
Fuel rate per vehicle: 19.62 mpg (Heede calculation in TransportSolutns.doc).

Fuel consumption per household per year: 20,895 miles / 19.62 = 1,065.0 gallons per HH/yr. Note: this does not include other HH fuel consumption for RVs, snowmobiles, ATVs, lawnmowers, etc.)

Per household GHG emissions: 1,065 gallons x 19.594 lbs CO2 per gallon = 20,868 lbs CO2/yr.

That said:
U.S. household sector fuel consumption: 1,065 gallons/hh/yr times 105.22 million households = 112.06 billion gallons.

U.S. household sector GHG emissions: 112.06 billion gallons x 19.594 lbs CO2/gallon = 2.196 trillion lbs CO2 = 1,097.85 million tons CO2.

If we furthermore allocate this total between passenger cars and light trucks on the same basis as in the main table:
passenger cars = 704.9 million tons or 0.5877 of total 1,199.4 million tons CO2
light trucks = 0.4123.

Of total U.S. household vehicle emissions, passenger cars use 112.06 billions gallons x 0.5877 = 65.86 gallons and emit 645.21 million tons CO2 per year; light trucks use 46.20 billion gallons and emit 452.64 million tons CO2/yr.

On a per household basis: passenger cars = 1,065 x 0.5877 = 625.9 gallons and 12,264 lbs CO2, whereas light trucks comprise 439.1 gallons and 8,604 lbs CO2.

BTS (2001), NTS2000, chapter 4.

Data is listed as "passenger cars and motorcycles" total of 9,052 trillion Btu. Table 4-22 splits out 0.4456 percent to motorcycles, and is applied here. Hence motorcycles = 40.34 trillion Btu x 156.425 lbs CO2 per million Btu = 6.31 million tons CO2. Motorcycle VMT = 10.26 billion miles = 0.615 lbs CO2 per vehicle-mile. Note: this does not agree with the TEBD21 data used for our transportation intensity tables in Transport.doc.

**Cell:** C11
**Comment:** Rick Heede:
Data is listed as "passenger cars and motorcycles" total of 9,052 trillion Btu. Table 4-22 splits out 0.4456 percent to motorcycles, and is applied here. Hence motorcycles = 40.34 trillion Btu x 156.425 lbs CO2 per million Btu = 6.31 billion lbs CO2 = 3.15 million tons CO2.

Motorcycle VMT = 10.26 billion miles = 0.615 lbs CO2 per vehicle-mile. Note: this does not agree with the TEBD21 data used for our transportation intensity tables in Transport.doc, where, in 1999, motorcycles consumed 211 million gallons of fuel over 10.58 billion miles. 211 million gallons x 19.594 lbs CO2 per gallon = 4,134 million lbs CO2 = 2.07 million tons CO2. We will use this latter figure for this baseline worksheet.

BTS (2001), NTS2000, chapter 4.

**Cell:** C12
**Comment:** Rick Heede:
Motorhomes are likely categorized under light and/or medium trucks in DoT, BTS, and ORNL statistics. We have yet to find VMT or fuel consumption data for motorhomes, or vehicle specs as a fraction of fuel consumed by trucks.

**Cell:** C13
**Comment:** Rick Heede:
All-terrain and other off-road vehicles consume gasoline and emit CO2 as follows:

Year: 2000

| Equipment | Gallons/Year | CO2 ton/yr | Miles or Hrs/Yr |
|---|---|---|---|
| Snowmobiles | 395,685,678 | 3,894,067 | 89,542,354 hrs |
| ATV 2-stroke | 218,604,480 | 2,151,355 | 4,731,178,500 miles |
| ATV 4-stroke | 1,052,351,743 | 10,356,523 | 5,869,962,157 hrs |
| Off-road MotoCross 2-stroke | 48,241,280 | 474,758 | 1,932,783,900 miles |
| Off-road MotoCross 4-stroke | 21,736,897 | 213,920 | 47,598,289 hrs |
| PWC (Personal Water Craft?) | 312,169,110 | 3,072,154 | 93,672,673 hrs |
| Rec boats - Outboard Gas | 641,378,232 | 6,312,004 | 311,960,417 hrs |
| Rec boats - Inboard Gasoline | 363,430,101 | 3,576,629 | 89,228,587 hrs |
| Rec boats - Diesel | 186,208,435 | 2,108,752 | 41,183,401 hrs |
| Lawn/Garden Residential Gas | 887,280,701 | 8,732,008 | 1,955,004,235 hrs |
| Lawn/Garden Commercial Gas | 1,632,287,277 | 16,063,850 | 2,916,947,103 hrs |
| Total | 5,759,373,934 | 56,956,020 | |
| Included in Lawn/Garden above: | | | |
| Lawnmowers - residential | 195,877,578 | 1,927,693 | 880,174,989 hrs |
| Lawnmowers - commercial | 130,193,101 | 1,281,271 | 663,810,007 hrs |

Subtotal ATVs + snowmobiles + MotoCross = 17,090,623 tons CO2/yr.

Equipment Population:

| | |
|---|---|
| Snowmobiles | 1,570,919 |
| ATV 2-stroke | 675,883 |
| ATV 4-stroke | 3,253,667 |
| Off-road MotoCross 2-stroke | 805,327 |
| Off-road MotoCross 4-stroke | 396,652 |
| Personal water craft | 1,211,807 |
| Rec - Outboard Gas | 8,964,380 |
| Rec - Inboard Gasoline | 1,874,550 |
| Rec - Diesel | 206,604 |

| | | |
|---|---|---|
| Lawn/Garden Residential Gas | 88,029,880 | |
| Lawn/Garden Commercial Gas | 9,436,709 | |
| Lawnmowers - residential | 35,206,999 | (included in Lawn/Garden above) |
| Lawnmowers - commercial | 1,635,000 | (included in Lawn/Garden above) |

Source: Craig Harvey, U.S. EPA, Office of Transportation and Air Quality, 734-214-4237.

**Cell:** C14
**Comment:** Rick Heede:
See above line item for boats and watercraft:
Total gasoline/yr: 1,503,185,878 gallons
Total emissions/yr: 15,069,539 tons CO2/yr.

**Cell:** C15
**Comment:** Rick Heede:
See "ATV" entry for data:

| | Gallons/yr | Tons CO2/yr |
|---|---|---|
| Lawn/Garden - residential | 887,280,701 | 8,732,008 |

**Cell:** C16
**Comment:** Rick Heede:
We calculated (TranspEmissions2000.xls) that general aviation use of avgas (total 1998 37 trillion Btu, 311 million gallons, and 2.8 million tons CO2; BST, NTS2000) resulted in emissions of 2.8 million tons. If we allocate (based on nothing but personal hunch as an aviator) that 0.6 of such fuel consumption is from personal as opposed to corporate or fleet aircraft, then we allocate 2.8 x 0.6 = 1.7 million tons to household emissions.

**Cell:** C20
**Comment:** Rick Heede:
Total passenger car emissions (1998, based on BTS data) = 704.9 million tons CO2; subtract the amount estimated for household-owned vehicles of 645.2 = 59.7 million tons CO2.

A full and accurate account is hard to come by, but it appears that this remainder includes fleet vehicles (rental, corporate, utility, taxi companies, and Government vehicles) in this vehicle category.

**Cell:** C21
**Comment:** Rick Heede:
Total light trucks (from other worksheet) of 494.46 million tons minus the household vehicle emissions of 452.64 = 41.82 million tons CO2 per year.

**Cell:** C22
**Comment:** Rick Heede:
We allocate all medium trucks and their fuel used and GHG emissions to the commercial and industrial sectors (in this case, called "non-household highway vehicles").

"Single-unit 2-axles 6-tire or more trucks."
In view of the assumption above that both passenger cars and light trucks use gasoline (rather than specifying fractions of gasoline and diesel for each vehicle category), we compensate for this slight conservatism by assuming all medium and heavy trucks use diesel fuel. Hence 1.35 Q = 109.21 million tons CO2 (at 161.386 lbs CO2 per million Btu of diesel fuel).

**Cell:** C23
**Comment:** Rick Heede:
2.937 Q of fuel consumed in 1998 (BTS, NTS2000) by heavy trucks = 236.19 million tons CO2. We allocate all of this to "non-household highway vehicles."

**Cell:** C24
**Comment:** Rick Heede:
Based on BTS statistics (NTS2000), buses listed in the Highway category we assume to mean non-transit buses (school buses, intercity buses, etc). 145 trillion Btu (assumed all diesel fuel at 161.386 lbs CO2 per million Btu) = 11.70 million tons CO2.

**Cell:** C28
**Comment:** Rick Heede:
Agricultural fuel consumption, 1998: 907 million gallons. Here we assume 3/4 diesel and 1/4 gasoline (22.384 lbs CO2 per gallon x 3 + 19.594 lbs CO2 per gallon x 1 = 86.746 / 4 = 21.687 lbs CO2 per weighted gallon.

Hence: 907 million gallons x 21.687 lbs CO2 per weighted gallon = 19.670 billion lbs CO2 = 9.83 million tons CO2.

BTS (2001), NTS2000, table 4.7.

**Cell:** C29
**Comment:** Rick Heede:
Aviation fuel consumption is covered in the next section below. I can only assume, since the notes are sparse in NTS regarding what, precisely is included: private helicopters, medi-vac choppers, agricultural sprayers, private fixed-wing aircraft, etc. In any case, Table 4.7 lists 351 million gallons of consumption for 1998: 351 million gallons x 120.190 Btu per gallon (avgas) = 42.18 billion Btu; 351 million gallons x 18.355 lbs CO2 per gallon = 6.44 billion lbs CO2 = 3.22 million tons CO2. Note: this disagrees somewhat from the total listed under personal aviation above PLUS general aviation below (total = 2.8 million tons)).

BTS (2001), NTS2000, table 4.7.

**Cell:** C30
**Comment:** Rick Heede:
Marine fuel consumption in 1998: 956 million gallons. Again, BTS notes do not specify what is included here (personal motorboats, jetskiis, water-borne commerce may or may not be excluded, transit may or may not be excluded (it is covered under transit), etc.)

In any case, 956 million gallons, if it's all GASOLINE, as table 4.7 specifies, then 956 million gallons x 19.594 lbs CO2 per gallon = 18.732 billion lbs CO2 = 9.37 million tons CO2.

BTS (2001), NTS2000, table 4.7.

**Cell:** C31
**Comment:** Rick Heede:
"Other" non-highway uses of gasoline includes "state, county, and municipal uses, industrial and commercial, construction, and miscellaneous. Misc is unspecified.

Other totaled 1,070 million gallons in 1998: 1,070 million gallons x 19.594 lbs CO2 per gallon = 54.60 billion lbs CO2 = 27.30 million tons CO2.

BTS (2001), NTS2000, table 4.7.

**Cell:** C37
**Comment:** Rick Heede:
Here we allocate 0.4 of total avgas consumption to general, non-household account. See B18 above.

**Cell:** C38
**Comment:** Rick Heede:
"Total," that is, not including (a) personal aviation listed under household avgas consumption, or (b) Federal govt jetfuel and avgas consumption. I assume, but cannot ascertain from available statistics, that FedEx and UPS etc are included in "GA - jet fuel" above.

**Cell:** C40
**Comment:** Rick Heede:
Transit, 1998:
Electricity: 5.25 billion kWh, or 18 trillion Btu: 5.25 billion kWh x 1.43 lbs CO2 per kWh consumed = 7.508 billion lbs CO2 = 3.75 million tons CO2.

Diesel fuel: 700 million gallons, or 97 trillion Btu: 700 million gallons x 22.384 lbs CO2 per gallon = 15.99 billion lbs = 7.99 million tons CO2.

Gasoline: 50 million gallons, or 6 trillion Btu: 50 million gallons x 19.594 lbs CO2 per gallon = 0.98 billion lbs = 0.49 million tons CO2.

Compressed natural gas: 31 million gallons, or 4.3 trillion Btu (at 138,700 Btu per gallon): 4.3 trillion Btu x 117.080 lbs CO2 per million Btu = 0.50 billion lbs CO2 = 0.25 million tons CO2.

Sum of all transit fuels, 1998: 3.75 + 7.99 + 0.49 + 0.25 = 12.48 million tons CO2.

Source: Bureau of Transportation Statistics (2001), National Transportation Statistics 2000, Tables 4-5 and 4-6.

**Cell:** C50
**Comment:** Rick Heede:
Not included in the main listing is EIA's estimate of CO2 emissions from lubricants of 1.8 million tonnes carbon, or 7.28 million tons CO2 (same in 1998, 1999, and 2000).

**Cell:** C52
**Comment:** Rick Heede:

This is principally an adjustment factor to true up our estimate with the EIA's year 1998 estimated transportation CO2 total of 1,946.3 million tons CO2 (481.5 million tonnes carbon). Hence we add a "misc" of 22.8 million tons CO2 -- which must be adjusted if we get stats on missing line items, e.g., boats, RVs, ATVs, snowmobiles, etc.

Energy Information Administration (2001), Emissions of Greenhouse Gases in the United States in 2000, Nov01, www.eia.doe.gov

**Cell:** C54
**Comment:** Rick Heede:
As stated in the above comment, EIA estimates 1998 transport CO2 at 1,946.3 millions tons CO2; 1999 = 2,018.6 million tons CO2; 2000P = 2,080.9 million tons CO2. The most substantial increases were in motor gasoline, diesel, and residual fuel.

**Cell:** C56
**Comment:** Rick Heede:
Commercial sector carbon dioxide emissions totaled 1,012.2 million tons CO2 in 1998; 1999 = 1,023.1 millions tons CO2; 2000P = 1,082.5 million tons CO2.

Three-quarters (76 percent) of commercial building's CO2 emissions is from consumption of electricity, 18 percent from natural gas, and the remainder from coal and petroleum.

EIA (2001), Emissions of Greenhouse Gases in the United States 2000, DOE, p.29.

**Cell:** C58
**Comment:** Rick Heede:
U.S. carbon dioxide emissions from industrial sector energy consumption totaled 1,897.8 million tons CO2 (469.5 million tonnes carbon), 1999 = 1,882.8 million tons CO2; 2000P = 1,882.4 million tons CO2. N ote that other industrial emissions appear below (cement manufacturing, methane emissions, etc.)

EIA (2001), Emissions of Greenhouse Gases in the United States 2000, DOE, p.29.

**Cell:** C60
**Comment:** Rick Heede:
CO2 emissions from residential sector energy consumption totaled 1,187.2 million tons CO2 in 1998 (293.7 million tonnes carbon); 1999 = 1,207.8 million tons CO2; 2000P = 1,266.8 million tons CO2. The biggest jump 1998 - 2000 came from consumption of electricity (44.9 million tons CO2 increase).

EIA (2001), Emissions of Greenhouse Gases in the United States 2000, DOE, p.29.

**Cell:** C61
**Comment:** Rick Heede:
Our analysis of residential energy end-use and carbon dioxide emissions, based on EIA's Residential Energy Consumption Survey for1997 for single-family dwellings (attached and detached single-family households comprise 73.7 million of total 1997 101.5 million households), estimates the following:

CO2 per Single-Family Home, 1997

| | Cost | Energy | CO2 | Percent |
|---|---|---|---|---|
| | $/yr | million Btu/yr | lbs/yr | of CO2 |
| Space heating | $476 | 68.1 | 8,829 | 33.92% |
| Air conditioning | $105 | 13.6 | 1,882 | 7.23% |
| Water heating | $202 | 27.8 | 3,558 | 13.67% |
| Refrigerator, freezer | $146 | 18.9 | 2,607 | 10.02% |
| Cooking | $46 | 6.5 | 825 | 3.17% |
| Other Appliances | $346 | 44.7 | 6,182 | 23.75% |
| Lighting | $120 | 15.5 | 2,145 | 8.24% |

| | | | | |
|---|---|---|---|---|
| Total | $1,441 | 195.1 | 26,028 | 100.00% |

We apply these percentage carbon dioxide emissions to the total residential emissions in 1998. The per household emissions are slightly lower than in our dataset for single-family households ( lbs CO2/hh/yr vs lbs CO2/hh/yr, or % lower). This is for a "typical" American household covering an array of differences in climate, solar income, age and size of homes, carbon content of electricity supply, levels of insulation and appliance usage, occupancy, and so forth. Clearly, household energy use and CO2 emissions vary enormously, yet our end-use profile is the most detailed available and will be used to identify and specify GHG-reduction opportunities and the best bang-for-the-buck priorities.

**Cell:** C70
**Comment:** Rick Heede:

EIA (2001), Emissions of Greenhouse Gases in the United States 2000, DOE, p. 28.

**Cell:** C71
**Comment:** Rick Heede:
Gas flaring 3.9 million tonnes carbon in 1998, 4.0 in 1999, and 4.5 in 2000P. 1998 = 15.76 million tons CO2.

**Cell:** C72
**Comment:** Rick Heede:
Natural gas CO2 = 4.9 million tonnes carbon in 1998, 4.9 in 1999, 5.0 in 2000P. 1998 = 19.81 million tons CO2.

**Cell:** C73
**Comment:** Rick Heede:
Cement production (from the calcining process, not its energy inputs) = 10.7 million tonnes carbon in 1998, 1999 = 10.9, 2000P = 11.3. 1998 = 43.25 million tons CO2.

**Cell:** C74
**Comment:** Rick Heede:
"Other industrial" totaled 8.1 million tonnes carbon in 1998, 7.9 in 1999, and 8.1in 2000P. 1998 = 32.74 million tons CO2.

**Cell:** C75
**Comment:** Rick Heede:
Waste combustion totaled 6.9 million tonnes carbon in 1998; 1999 = 7.1; 2000P = 7.1. 1998 = 28.70 million tons CO2.

**Cell:** C78
**Comment:** Rick Heede:
This total for 1998 compares to EIA's estimate of 1,529.9 million tonnes carbon, or 6,184.1 million tons CO2. This does not include EIA's adjustments for U.S. territories (+12.3 million tonnes carbon), military bunker fuels (-2.6 million tonnes carbon), and international bbunker fuels (-27.3 million tonnes carbon).

**Cell:** C80
**Comment:** Rick Heede:
The global warming potential (GWP) of methane was re-estimated in the IPCC 2001 report at 23xCO2 (vs the previous value of 21x). The following estimates use this GWP factor.

Intergovernmental Panel on Climate Change (2001), Climate Change 2001: The Scientific Basis, Contribution of Working Group I, J.T. Houghton et al, Cambridge University Press, p. 388.

**Cell:** C81
**Comment:** Rick Heede:
Methane emissions from coal mining and post-mining activities totaled 3.20 million tonnes CH4 on 1998; 1999 = 3.03; 2000P = 2.89.

3.20 x 1.1023 x 23 = 81.13 million tons CO2-e.

EIA (2001), Emissions 2000, DOE, p. 41.

**Cell:** C82
**Comment:** Rick Heede:
Methane emissions from natural gas systems, 1998: 5.94 million tonnes CH4; 1999: 6.20; 2000P: 6.40.

Methane emissions from petroleum systems, 1998: 1.10 million tonnes CH4; 1999: 1.04; 2000P: 1.03.

Combined emissions, 1998: 7.04 million tonnes methane x 1.1023 x 23 (GWP) = 178.48 million tons CO2 equivalent.

EIA (2001), Emissions of Greenhouse Gases in the United States 2000. DOE, p. 42.

**Cell:** C83
**Comment:** Rick Heede:
Stationary sources, 1998: 0.395 million tonnes CH4; 1999 = 0.421; 2000P = 0.439. In 1998, nearly all such emissions came from residential wood combustion (0.350 of 0.395 or 88.6 percent).

0.395 million tonnes x 1.1023 x 23 = 10.01 million tons CO2-e.

EIA (2001), Emissions of Greenhouse Gases in the United States 2000. DOE, p. 42.

**Cell:** C84
**Comment:** Rick Heede:
Mobile sources = 0.239 million tonnes CH4 in 1998; 1999 = 0.259; 2000P = 0.249. In 1998, 43.9 percent came from passenger cars (0.105), 1.7 percent from motorcycles (0.004), and 38.1 percent from light trucks (0.091) for a total contribution of 83.7 percent (0.200 of 0.239), of which 91.56 percent (1,100.9 of 1,202.4 million tons CO2) are from household-owned vehicles.

0.239 million tonnes CH4 = 6.06 million tons CO2-e.

EIA (2001), Emissions of Greenhouse Gases in the United States 2000. DOE, p. 44.

**Cell:** C85
**Comment:** Rick Heede:
Landfills emissions in 1998 = 8.7 million tonnes CH4; 1999 = 8.4; 2000P = 7.8.

8.7 million tonnes x 1.1023 x 21 = 220.57 million tons CO2-e.

EIA (2001), Emissions 2000, p. 44.

**Cell:** C86
**Comment:** Rick Heede:
Wastewater treatment plants = 0.16 million tonnes CH4 (0.16 in 1999, 0.17 in 2000P). 0.16 million tonnes CH4 = 4.06 million tons CO2-e.

**Cell:** C87
**Comment:** Rick Heede:
Methane emissions from "enteric fermentation in domesticated animals" totaled 5.41 million tonnes CH4 in 1998; 1999 = 5.43; 2000P = 5.54.

5.41 million tonnes x 1.1023 x 23 = 137.16 million tons CO2-e.

EIA (2001), Emissions 2000, p. 45.

**Cell:** C88
**Comment:** Rick Heede:
Methane from "solid waste of domesticated animals" totaled 3.086 million tonnes CH4 in 1998; 1999 = 3.026; 2000P = 3.048.

3.086 million tonnes CH4 x 1.1023 (tonnes to tons) x 23 (GWP) = 78.24 million tons CO2-e.

EIA (2001), Emissions 2000, p. 45.

**Cell:** C89
**Comment:** Rick Heede:
Rice paddies = 0.46 million tonnes CH4 in 1998 (0.49 in 1999, 0.43 in 2000P).

Crop residue burning totaled 0.04 million tonnes in 1998 (0.04 in 1999, 0.05 in 2000P).

Total in 1998 = 0.50 million tonnes CH4 x 1.1023 x 23 = 12.68 million tons CO2-e.

**Cell:** C90

**Comment:** Rick Heede:
Industrial process (chemical production, eg ethylene, styrene, and iron and steel production, eg pig iron) emissions totaled 0.133 million tonnes CH4 (ditto 1999 and 2000P). 0.133 x 1.1023 x 23 = 3.38 million tons CO2-e.

**Cell:** C93
**Comment:** Rick Heede:
The global warming potential (GWP) of nitrous oxide was re-estimated in the IPCC 2001 report at 296xCO2 (vs the previous value of 310x). The following estimates use this GWP factor.

Intergovernmental Panel on Climate Change (2001), Climate Change 2001: The Scientific Basis, Contribution of Working Group I, J.T. Houghton et al, Cambridge University Press, p. 388.

**Cell:** C94
**Comment:** Rick Heede:
Nitrous oxide emissions from mobile sources totaled 0.223 million tonnes N2O in 1998; 1999 = 0.245; 2000P = 0.235.

0.223 million tonnes N2O = 1.1023 (tonnes to tons) x 296 (Global Warming Potential) = 72.76 million tons CO2-e.

Most of these emissions are from passenger cars (0.110 of 0.223) and light trucks (0.092 of 0.223), or a total personal cars of 90.6 percent, of which household vehicles comprise 91.56 percent. In total, of the 76.2 million tons CO2-e in 1998 from mobile sources, household vehicles emit 63.21 million tons CO2-e.

EIA (2001), Emissions 2000, DOE, p. 52.

**Cell:** C95
**Comment:** Rick Heede:
Stationary sources, principally coal-fired powerplants (0.030 of 0.048), totaled 0.48 million tonnes N2O; 1999 = 0.049; 2000P = 0.050.

0.048 million tonnes N2O x 1.1023 x 296 = 15.66 million tons CO2-e.

**Cell:** C96
**Comment:** Rick Heede:
Nitrogen conversion to nitrous oxide is a slow process, but a default value developed by IPCC and EIA estimates an annual emission rate based on the application rate of 0.640 million tonnes N2O; 1999 = 0.636; 2000P = 0.637. These processes include direct emissions (fertilizers, animal manure, crop residues, fixation in crops) and indirect emissions (soil leaching, atmospheric deposition). See p. 54 for details.

0.640 million tonnes N2O x 1.1023 x 296 = 208.82 million tons CO2-e.

EIA (2001), Emissions 2000, DOE, p. 54.

**Cell:** C97
**Comment:** Rick Heede:
Domesticated animals' solid waste generated 0.233 million tonnes N2O in 1998; 1999 = 0.232; 2000P = 0.231. 0.218 of 0.233 is from cattle, 0.006 from swine.

0.233 million tonnes N2O x 1.1023 x 296 = 76.02 million tons CO2-e.

**Cell:** C98
**Comment:** Rick Heede:
Emissions from human waste at wastewater treatment plants totaled 0.018 million tonnes N2O in 1998 (ditto 1999; 0.019 in 2000P).

0.018 million tonnes N2O x 1.1023 x 296 = 5.87 million tons CO2-e.

**Cell:** C99
**Comment:** Rick Heede:
Industrial processes (nitric acid = 0.046, adipic acid = 0.012) totaled 0.058 million tonnes N2O in 1998.

0.058 million tonnes N2O x 1.1023 x 296 = 18.92 million tons CO2-e.

**Cell:** C103

**Comment:** Rick Heede:
HFC emissions in 1998: 3,400 tonnes of HFC-23, 26,900 tonnes of HFC-134a, and 1,700 tonnes of misc (HFC-125, HFC-143a, 100 tonnes of HFC-236fa).

EIA estimates carbon-equivalent of hydrofluorocarbons to equal 26.26 million tonnes carbon equivalent, or x 1.1023 x 3.667 = 106.15 million tons CO2-e.

EIA (2001), Emissions 2000, DOE, p. 67.

**Cell:** C104
**Comment:** Rick Heede:
Perfluorocarbons emissions in 1998: 4,100 tonnes of CF4, and 800 tonnes of C2F6.

EIA estimates carbon-equivalent of perfluorocarbons to equal 8.98 million tonnes carbon equivalent, or x 1.1023 x 3.667 = 36.30 million tons CO2-e.

EIA (2001), Emissions 2000, DOE, p. 67.

**Cell:** C105
**Comment:** Rick Heede:
EIA estimates carbon-equivalent of other PFCs etc to equal 3.54 million tonnes carbon equivalent, or x 1.1023 x 3.667 = 14.31 million tons CO2-e.

EIA (2001), Emissions 2000, DOE, p. 67.

**Cell:** C106
**Comment:** Rick Heede:
EIA estimates carbon-equivalent of sulfur hexafluoride to equal 6.93 million tonnes carbon equivalent, or x 1.1023 x 3.667 = 28.01 million tons CO2-e.

EIA (2001), Emissions 2000, DOE, p. 67.

**Cell:** C107
**Comment:** Rick Heede:
EIA excludes the emission of CFCs, halons, and HCFCs on the basis that these compounds are not covered by the Kyoto Protocol and are being phased out. Insamuch as such compunds leak from insulating foams and refrigeration systems, we include them here. We base our estimates on EIA, Appendix D: "Emissions Sources Excluded," p. 153, for 1998:
CFC-11: 8,400 tonnes x 1.1023 (tonnes to tons) x 4,000 GWP = 37.04 million tons CO2-e;
CFC-12: 52,600 tonnes x 1.1023 (tonnes to tons) x 8,500 GWP = 492.80 million tons CO2-e;
Other CFCs: 1,800 tonnes x 1.1023 (tonnes to tons) x 8,350 GWP = 16.57 million tons CO2-e;
Halons: 1,800 tonnes x 1.1023 (tonnes to tons) x 0 GWP = 0.00 million tons CO2-e;
HCFC-22: 43,900 tonnes x 1.1023 (tonnes to tons) x 1,700 GWP = 82.26 million tons CO2-e;
HCFC-141b: 9,700 tonnes x 1.1023 (tonnes to tons) x 630 GWP = 6.74 million tons CO2-e;
HCFC-142b: 4,700 tonnes x 1.1023 (tonnes to tons) x 2,000 GWP = 10.36 million tons CO2-e;
Other HCFCs: 7,400 tonnes x 1.1023 (tonnes to tons) x 800 GWP = 6.53 million tons CO2-e;
Total CO2-2: 652.30 million tons CO2-e.

We have not included carbon monoxide (87.1 million tonnes), nitrogen oxides (23.4 million tonnes), or non-methane VOCs (16.9 million tonnes).

EIA (2001), Emissions 2000, DOE, p. 153.