Clean Energy

Calculations and References

This page describes the calculations used to convert greenhouse gas emission numbers into different types of equivalent units. Go to the equivalency calculator page for more information.

Electricity Reductions (kilowatt-hours)

The Greenhouse Gas Equivalencies Calculator uses the Emissions & Generation Resource Integrated Database (eGRID) U.S. annual non-baseload CO_2 output emission rate to convert reductions of kilowatt-hours into avoided units of carbon dioxide emissions. Most users of the Equivalencies Calculator who seek equivalencies for electricity-related emissions want to know equivalencies for emissions **reductions** from energy efficiency or renewable energy programs. These programs are not generally assumed to affect baseload emissions (the emissions from power plants that run all the time), but rather non-baseload generation (power plants that are brought online as necessary to meet demand).

Emission Factor

6.8956×10^{-4} metric tons CO_2 / kWh
(eGRID2010 Version 1.1, U.S. annual non-baseload CO_2 output emission rate, year 2007 data)

Notes:

This calculation does not include any greenhouse gases other than CO_2.
This calculation does not include line losses.
Individual subregion non-baseload emissions rates are also available on the eGRID Web site.
To estimate indirect greenhouse gas emissions from electricity use, please use Power Profiler or use eGRID subregion annual output emission rates as a default emission factor (see eGRID2010 Version 1.1 Year 2007 GHG Annual Output Emission Rates (PDF) (1 p, 278K, About PDF).

Sources

(EPA 2011) eGRID2010 Version 1.1, U.S. annual non-baseload CO_2 output emission rate, year 2007 data U.S. Environmental Protection Agency, Washington, DC.

Passenger vehicles per year

Passenger vehicles are defined as 2-axle 4-tire vehicles, including passenger cars, vans, pickup trucks, and sport/utility vehicles.

In 2007, the weighted average combined fuel economy of cars and light trucks combined was 20.4 miles per gallon (FHWA 2008). The average vehicle miles traveled in 2007 was 11,720 miles per year.

In 2007, the ratio of carbon dioxide emissions to total emissions (including carbon dioxide, methane, and nitrous oxide, all expressed as carbon dioxide equivalents) for passenger vehicles was 0.977 (EPA 2009).

The amount of carbon dioxide emitted per gallon of motor gasoline burned is $8.92*10^{-3}$ metric tons, as calculated in the "Gallons of gasoline consumed" section.

To determine annual greenhouse gas emissions per passenger vehicle, the following methodology was used: vehicle miles traveled (VMT) was divided by average gas mileage to determine gallons of gasoline consumed per vehicle per year. Gallons of gasoline consumed was multiplied by carbon dioxide per gallon of gasoline to determine carbon dioxide emitted per vehicle per year. Carbon dioxide emissions were then divided by the ratio of carbon dioxide emissions to total vehicle greenhouse gas emissions to account for vehicle methane and nitrous oxide emissions.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

$8.92*10^{-3}$ metric tons CO_2/gallon gasoline * 11,720 VMT $_{\text{car/truck average}}$ * 1/20.4 miles per gallon $_{\text{car/truck average}}$ * 1 CO_2, CH_4, and N_2O/0.977 CO_2 = **5.1 metric tons CO_2E /vehicle/year**

Sources

EPA (2009). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007. Chapter 3 (Energy), Tables 3-12, 3-13, and 3-14. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-09-004 (PDF) (410 pp, 35MB, About PDF)
FHWA (2008). Highway Statistics 2007. Office of Highway Policy Information, Federal Highway Administration. Table VM-1.

Gallons of gasoline consumed

To obtain the number of grams of CO_2 emitted per gallon of gasoline combusted, the heat content of the fuel per gallon is multiplied by the kg CO_2 per heat content of the fuel. The average heat content per gallon of gasoline is 0.125 mmbtu/gallon and the average emissions per heat content of gasoline is 71.35 kg CO_2/mmbtu. (EPA 2010)

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

0.125 mmbtu/gallon * 71.35 kg CO_2/mmbtu * 1 metric ton/1,000 kg = **$8.92*10^{-3}$ metric tons CO_2/gallon of gasoline**

Sources

EPA (2010). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008. Annex 2 (Methodology for estimating CO_2 emissions from fossil fuel combustion), Table A-33 and P. A-61. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-10-006 (PDF) (407 pp, 19MB, About PDF)
IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Therms of natural gas

Average heat content of natural gas is 0.1 mmbtu per therm (EPA 2010). Average carbon coefficient of natural gas is 14.47 kg carbon per mmbtu (EPA 2010). Fraction oxidized to CO_2 is 100 percent (IPCC 2006).

Carbon dioxide emissions per therm were determined by multiplying heat content times the carbon coefficient times the fraction oxidized times the ratio of the molecular weight ratio of carbon dioxide to carbon (44/12).

Note: When using this equivalency, please keep in mind that it represents the CO_2 equivalency for natural gas **burned** as a fuel, not natural gas released to the atmosphere. Direct methane emissions released to the atmosphere (without burning) are about 21 times more powerful than CO_2 in terms of their warming effect on the atmosphere.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

0.1 mmbtu/1 therm * 14.47 kg C/mmbtu * 44 g CO_2/12 g C * 1 metric ton/1000 kg = **0.005 metric tons CO_2/therm**

Sources

EPA (2010). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008, Annex 2 (Methodology for estimating CO_2 emissions from fossil fuel combustion), P. A-75. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-10-006 (PDF) (407 pp, 19MB, About PDF).
IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Barrels of oil consumed

Average heat content of crude oil is 5.81 mmbtu per barrel (EPA 2010). Average carbon coefficient of crude oil is 20.17 kg carbon per mmbtu (EPA 2010). Fraction oxidized is 100 percent (IPCC 2006).

Carbon dioxide emissions per barrel of crude oil were determined by multiplying heat content times the carbon coefficient times the fraction oxidized times the ratio of the molecular weight of carbon dioxide to that of carbon (44/12).

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

5.81 mmbtu/barrel * 20.17 kg C/mmbtu * 44 g CO_2/12 g C * 1 metric ton/1000 kg = **0.43 metric tons CO_2/barrel**

Sources

EPA (2007). Inventory of U.S. Greenhouse Gas Emissions and Sinks: Fast Facts 1990-2005. Conversion Factors to Energy Units (Heat Equivalents) Heat Contents and Carbon Content Coefficients of Various Fuel Types. U.S. Environmental Protection Agency, Washington, DC. USEPA #430-F-07-004 (PDF) (2 pp, 216K, About PDF).

EPA (2010). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008. Annex 2 (Methodology for estimating CO_2 emissions from fossil fuel combustion). P. A-58. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-10-006 (PDF) (407 pp, 19MB, About PDF).
IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Tanker trucks filled with gasoline

Average heat content of conventional motor gasoline is 0.125 mmbtu/gallon or 5.25 mmbtu/barrel (EPA 2010). Average carbon coefficient of motor gasoline is 19.46 kg CO_2/mmbtu (EPA 2010). Fraction oxidized to CO_2 is 100 percent (IPCC 2006).

Carbon dioxide emissions per barrel of gasoline were determined by multiplying heat content times the carbon dioxide coefficient times the fraction oxidized times the ratio of the molecular weight ratio of carbon dioxide to carbon (44/12). A barrel equals 42 gallons. A typical gasoline tanker trunk contains 8,500 gallons.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

5.25 mmbtu/barrel * 19.46 kg C/mmbtu * 1 barrel/42 gallons * 44 g CO_2/12 g C * 1 metric ton/1000 kg = $8.92*10^{-3}$ metric tons CO_2/gallon

$8.92*10^{-3}$ metric tons CO_2/gallon * 8,500 gallons/tanker truck = **75.82 metric tons CO_2/tanker truck**

Sources

EPA (2008). Inventory of U.S. Greenhouse Gas Emissions and Sinks: Fast Facts 1990-2006. Conversion Factors to Energy Units (Heat Equivalents) Heat Contents and Carbon Content Coefficients of Various Fuel Types. U.S. Environmental Protection Agency, Washington, DC. USEPA #430-F-08-005 (PDF) (2 pp, 430K, About PDF).
EPA (2010). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008. Annex 2 (Methodology for estimating CO_2 emissions from fossil fuel combustion), Table A-33 and P. A-61. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-10-006 (PDF) (407 pp, 19MB, About PDF)
IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Home electricity use

In 2005, there were 111.1 million homes in the United States; of those, 72.1 million were single-family detached homes and 7.6 million were single-family attached homes for a total 79.7 million single-family homes* nationally (EIA 2008). On average, each single-family home consumed 12,773 kWh of delivered electricity (EIA 2008). The national average carbon dioxide output rate for electricity generated in 2007 was 1,293 lbs CO_2 per megawatt-hour (EPA 2011), which translates to about 1,384 lbs CO_2 per megawatt-hour for delivered electricity (assuming 7 percent in transmission and distribution losses).

Annual single-family home electricity consumption was multiplied by the carbon dioxide emission rate (per unit of electricity delivered) to determine annual carbon dioxide emissions per home.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

12,773 kWh per home * 1,383.56 lbs CO_2 per megawatt-hour delivered * 1 mWh/1000 kWh * 1 metric ton/2204.6 lb = **8.02 metric tons CO_2/home.**

*A single-family home is defined in the U.S. Department of Energy's Residential Energy Consumption Survey as follows: A housing unit, detached or attached, that provides living space for one home or family. Attached houses are considered single-family houses as long as they are not divided into more than one housing unit and they have independent outside entrance. A single-family house is contained within walls extending from the basement (or the ground floor, if there is no basement) to the roof. A mobile home with one or more rooms added is classified as a single-family home. Townhouses, rowhouses, and duplexes are considered single-family attached housing units, as long as there is no home living above another one within the walls extending from the basement to the roof to separate the units.

Sources

EIA (2008). 2005 Residential Energy Consumption Survey. Table US-3, Total Consumption by Fuels Used, 2005, Physical Units (PDF) (4 pp, 50K, About PDF).
EPA (2011). eGRID2010 Version 1.1. U.S. Environmental Protection Agency, Washington, DC.

Home energy use

In 2005, there were 111.1 million homes in the United States; of those, 72.1 million were single-family detached homes and 7.6 million were single-family attached homes for a total 79.7 million single-family homes* nationally (EIA 2008). On average, each single-family home consumed 12,773 kWh of delivered electricity, 47,453 cubic feet of natural gas, 59.1 gallons of liquid petroleum gas, 58.0 gallons of fuel oil, and 0.85 gallons of kerosene. (EIA 2008).

The national average carbon dioxide output rate for generated electricity in 2007 was 1,293 lbs CO_2 per megawatt-hour (EPA 2011), which translates to about 1,384 lbs CO_2 per megawatt-hour for delivered electricity (assuming 7 percent in transmission and distribution losses).

The average carbon dioxide coefficient of natural gas is 0.0545 kg CO_2 per cubic foot (EPA 2010a). Fraction oxidized to CO_2 is 100 percent (IPCC 2006).

The average carbon dioxide coefficient of distillate fuel oil is 429.61 kg CO_2 per 42-gallon barrel (EPA 2010b). Fraction oxidized to CO_2 is 100 percent (IPCC 2006).

The average carbon dioxide coefficient of liquefied petroleum gases is 238.45 kg CO_2 per 42-gallon barrel (EPA 2010b). Fraction oxidized is 100 percent (IPCC 2006).

The average carbon dioxide coefficient of kerosene is 426.31 kg CO_2 per 42-gallon barrel (EPA 2010b). Fraction oxidized to CO_2 is 100 percent (IPCC 2006).

Total single-family home electricity, natural gas, distillate fuel oil, and liquefied petroleum gas consumption figures were converted from their various units to metric tons of CO_2 and added together to obtain total CO_2 emissions per home.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

1. Delivered electricity: 12,773 kWh per home * 1,383.56 lbs CO_2 per megawatt-hour delivered * 1 mWh/1000 kWh * 1 metric ton/2204.6 lb = 8.02 metric tons CO_2/home.

2. Natural gas: 47,453 cubic feet per home * 0.0545 kg CO_2/cubic foot * 1/1000 kg/metric ton = 2.59 metric tons CO_2/home

3. Liquid petroleum gas: 59.1 gallons per home * 1/42 barrels/gallon * 238.45 kg CO_2/barrel * 1/1000 kg/metric ton = 0.34 metric tons CO_2/home

4. Fuel oil: 58.0 gallons per home * 1/42 barrels/gallon * 429.61 kg CO_2/barrel * 1/1000 kg/metric ton = 0.59 metric tons CO_2/home

5. Kerosene: 0.85 gallons per home * 1/42 barrels/gallon * 426.31 kg CO_2/barrel *1/1000 kg/metric ton = 0.01 metric tons CO_2/home

Total CO_2 emissions for energy use per single-family home: 8.02 metric tons CO_2 for electricity + 2.59 metric tons CO_2 for natural gas + 0.34 metric tons CO_2 for liquid petroleum gas + 0.59 metric tons CO_2 for fuel oil + 0.01 metric tons CO_2 for kerosene = **11.55 metric tons CO_2 per home per year**.

*A single-family home is defined in the U.S. Department of Energy's Residential Energy Consumption Survey as follows: A housing unit, detached or attached, that provides living space for one home or family. Attached houses are considered single-family houses as long as they are not divided into more than one housing unit and they have independent outside entrance. A single-family house is contained within walls extending from the basement (or the ground floor, if there is no basement) to the roof. A mobile home with one or more rooms added is classified as a single-family home. Townhouses, rowhouses, and duplexes are considered single-family attached housing units, as long as there is no home living above another one within the walls extending from the basement to the roof to separate the units.

Sources

EIA (2008). 2005 Residential Energy Consumption Survey. Table US-3. Total Consumption by Fuels Used, 2005, Physical Units (PDF) (4 pp, 50K, About PDF). Per-home averages were obtained by dividing the physical units of total consumption for each fuel used by the total number of single-family homes.

EPA (2010a). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008. Annex 2 (Methodology for estimating CO_2 emissions from fossil fuel combustion), P. A-75. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-10-006 (PDF) (407 pp, 19MB, About PDF).

EPA (2010b). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008. Annex 2 (Methodology for estimating CO_2 emissions from fossil fuel combustion), P. A-58. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-10-006 (PDF) (407 pp, 19MB, About PDF).

EPA (2008). Inventory of U.S. Greenhouse Gas Emissions and Sinks: Fast Facts 1990-2006. Conversion Factors to Energy Units (Heat Equivalents) Heat Contents and Carbon Content Coefficients of Various Fuel Types. U.S. Environmental Protection Agency, Washington, DC. USEPA #430-F-08-005 (PDF) (2 pp, 430K, About PDF).

IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

EPA (2011). eGRID2010 Version 1.1. U.S. Environmental Protection Agency, Washington, DC.

Number of tree seedlings grown for 10 years

A medium growth coniferous tree, planted in an urban setting and allowed to grow for 10 years, sequesters 23.2 lbs of carbon. This estimate is based on the following assumptions:

The medium growth coniferous trees are raised in a nursery for one year until they become 1 inch in diameter at 4.5 feet above the ground (the size of tree purchased in a 15-gallon container).
The nursery-grown trees are then planted in a suburban/urban setting; the trees are not densely planted.
The calculation takes into account "survival factors" developed by U.S. DOE (1998). For example, after 5 years (one year in the nursery and 4 in the urban setting), the probability of survival is 68 percent; after 10 years, the probability declines to 59 percent. For each year, the sequestration rate (in lb per tree) is multiplied by the survival factor to yield a probability-weighted sequestration rate. These values are summed for the 10-year period, beginning from the time of planting, to derive the estimate of 23.2 lbs of carbon per tree.

Please note the following caveats to these assumptions:

While most trees take 1 year in a nursery to reach the seedling stage, trees grown under different conditions and trees of certain species may take longer – up to 6 years.
Average survival rates in urban areas are based on broad assumptions, and the rates will vary significantly depending upon site conditions.
Carbon sequestration is dependent on growth rate, which varies by location and other conditions.
This method estimates only direct sequestration of carbon, and does not include the energy savings that result from buildings being shaded by urban tree cover.

To convert to units of metric tons CO_2 per tree, we multiplied by the ratio of the molecular weight of carbon dioxide to that of carbon (44/12) and the ratio of metric tons per pound (1/2204.6).

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

23.2 lbs C/tree * (44 units CO_2 / 12 units C) * 1 metric ton / 2204.6 lbs = **0.039 metric ton CO_2 per urban tree planted**

Sources

U.S. DOE (1998). Method for Calculating Carbon Sequestration by Trees in Urban and Suburban Settings. Voluntary Reporting of Greenhouse Gases, U.S. Department of Energy, Energy Information Administration (16 pp, 111K, About PDF)

Acres of pine or fir forests storing carbon for one year

Growing forests store carbon. Through the process of photosynthesis, trees remove CO_2 from the atmosphere and store it as cellulose, lignin, and other compounds. The rate of accumulation is equal to growth minus removals (i.e., harvest for the production of paper and wood) minus decomposition. In most U.S. forests, growth exceeds removals and decomposition, so there has been an overall increase in the amount of carbon stored nationally.

The estimate of the annual average rate of carbon accumulation is based on two studies, one on Douglas fir in the Pacific Northwest (Nabuurs and Mohren, 1995), and the other on slash pine in Florida (Shan et al., 2001). These two studies represent commercially important species from different regions and with different rotation periods (i.e., time between planting and harvesting). The calculations below include both above-ground and below-ground carbon stored in these two species of plantation trees. They do not include litter or soil carbon.

Calculation for Slash Pine

The calculation uses the Gain Loss method, as outlined in the 2006 IPCC Guidelines, in order to estimate carbon stored annually per hectare in the slash pine plantation system described in the Shan et al. paper. The general equation for this method is shown below. Here, carbon losses due to harvested wood products, firewood foraging, and other sources of wood removals are assumed to be zero.

$$\Delta CB = \Delta CG - \Delta CL$$

Where:
ΔCB = annual change in carbon stocks in biomass for each land sub-category, considering the total area, metric tons of carbon per year
ΔCG = annual increase in carbon stocks due to biomass growth for each land sub-category, considering the total area, metric tons of carbon per year
ΔCL = annual decrease in carbon stocks due to biomass loss for each land sub-category, considering the total area, metric tons of carbon per year (Here assumed to be 0).

Gains:

$$\Delta CG = \Sigma(A_{i,j} * Gtotal_{i,j} * CF_{i,j})$$

Where:
$Gtotal = \Sigma (Gw*(1+R)$
A = area of land remaining in the same land-use category, here assumed to be 1
Gtotal= mean annual biomass growth
i = ecological zone
j = climate domain
CF = carbon fraction of dry matter

Gw = average annual above-ground biomass growth for a specific woody vegetation type
R = ratio of below-ground biomass to above ground biomass for a specific vegetation type.

Since this paper measured growth in a plantation of trees harvested at age 17, the value is for relatively young trees that are growing more quickly than older trees would. The paper included several options in terms of management. The value used in the calculations below is the "control" – meaning that there was no fertilization (which had a big impact on growth) and no trimming of the understory for these trees. The calculation below uses the IPCC assumption that the carbon fraction is 47 percent of dry biomass.

The final result (3.052 MT C/ha/yr) * 0.4048 hectares/acre = **1.24 MT C/acre/year**

	Reference	**Aboveground biomass growth rate (MT/ha/yr) (averaged over 17 years)**	**Root:Shoot ratio (R)**	**Total Biomass Growth Rate (MT/ha/yr)**	**Carbon Fraction (MT C per MT dry matter)**	**Net Sequestration Rate (MT C/ha/yr)**
Slash Pine, age 17	Shan et al 2001	5.209	0.2912	6.493	0.47	3.052

Calculation for Douglas Fir

This calculation is based on results found in a 1995 paper by Nabuurs et al. The paper uses a model to calculate the amount of carbon sequestered in plots of various tree types across the world. The model uses turnover rates in order to calculate carbon stored in forests over time during different types of logging intervals. Parameters included in the model include basic wood density, allocation of net primary production, turnover rates of tree organs, resident times of litter and humus, current volume increment, and allocation of harvested wood. The parameters are specific for each of the six sites chosen for the study. Within each site, three areas of fertility and production are measured, although the study uses sample data from the "moderate" site during the discussion and results sections. The numbers presented below are also from the "moderate" site.

Since this paper is concerned with carbon sequestered in forests undergoing selective logging, the designers of this calculator had to choose at what point during the harvesting cycle to measure the carbon sequestered. We decided to use the total carbon stock stored (including biomass and forest products, not including soil carbon) after 100 years of accumulation. The model in this paper assumes that the carbon fraction is 50 percent.

		Total C Stock After 100 Years (Mg C per ha)	**Net Sequestration Rate (MT C/ha/yr)**
Douglas-Fir, age 100	**Nabuurs et al 1995**	327	3.27

The final result (3.27 MT C/ha/yr) * 0.4048 hectares/acre = **1.32 MT C/acre/year.**
One reason why this value is higher than the slash pine plantation number is because the Douglas fir trees had 100 years to accumulate biomass – including more years at a relatively fast-growing maturity than the slash-pine trees.

The average of these two values is 1.28 metric tons of C per acre per year, which corresponds to **4.69 metric tons of CO_2 per acre of pine or fir forests.**

Sources

Nabuurs, G.J., and G.M.J. Mohren. 1995. Modelling analysis of potential carbon sequestration in selected forest types. Canadian Journal of Forest Research 25(7):1157-1172.
Shan, J.P., L.A. Morris, and R.L. Hendrick. 2001. The effects of management on soil and plant carbon sequestration in slash pine plantations. Journal of Applied Ecology 38(5):932-941.
IPCC 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. Volume 4. Available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

Acres of forest carbon preserved from avoided deforestation

According to the 2010 U.S. Greenhouse Gas Inventory, the average carbon density of U.S. forests in 2008 was 73 metric tons per hectare, or 29.55 metric tons per acre (EPA 2010).

For crop or pasture land, IPCC guidance on characterizing land use change suggests that an average value of aboveground cropland dry biomass is 10 metric tons per hectare (IPCC 2006). We assumed that the carbon content of dry biomass is 50 percent. Therefore, the carbon content of cropland was calculated to be 5.0 metric tons of carbon per hectare, or 2.02 metric tons per acre.

The change in carbon density from converting forested land to crop or pasture land would thus be 29.55 MT carbon/acre minus 2.02 MT carbon/acre, or 27.53 MT carbon/acre. To convert to a carbon dioxide basis, we multiplied by the ratio of the molecular weight of carbon dioxide to that of carbon (44/12), yielding a value of 100.94 MT CO_2/acre.

This method assumes that all of the forest biomass is oxidized during burning (i.e. none of the burned biomass remains as charcoal or ash).

Note: The conversion provided may be an underestimate due to the omission of soil C in the calculation. Forest soil C stocks will likely decline with conversion. If the forests exist on organic soils, conversion would cause C stocks to decline, unless they are converting to wetland agriculture. However, most forests in the contiguous United States are growing on mineral soils. In the case of mineral soils forests, soil C stocks could be replenished or even increased, depending on the starting stocks, how the agricultural lands are managed, and the time frame over which lands are managed.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

5.0 metric tons C biomass/ hectare * 1 hectare/ 2.47 acres = 2.02 metric tons C/acre of cropland

29.55 metric tons C/acre forest – 2.02 metric ton C/acre of cropland = 27.53 metric tons C/acre converted * 44 units CO_2/12 units C = **100.94 metric tons CO_2/acre converted**

Sources

EPA (2010). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008. Chapter 7 (Land Use, Land-Use Change, and Forestry), U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-10-006. (PDF) (407 pp, 19MB, About PDF).
IPCC 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. Volume 4.

Propane cylinders used for home barbeques

Propane is 81.7 percent carbon (EPA 2009). Fraction oxidized is 100 percent (IPCC 2006).

Carbon dioxide emissions per pound of propane were determined by multiplying the weight of propane in a cylinder times the carbon content percentage times the fraction oxidized times the ratio of the molecular weight of carbon dioxide to that of carbon (44/12). Propane cylinders vary with respect to size - for the purpose of this equivalency calculation, a typical cylinder for home use was assumed to contain 18 pounds of propane.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

18 pounds propane/1 cylinder * 0.817 pound C/pound propane * 0.4536 kilograms/pound * 44 kg CO_2/12 kg C * 1 metric ton/1000 kg = **0.024 metric tons CO_2/cylinder**

Sources

EPA (2009). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007. Annex 2. Table A -41. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-09-004 (PDF) (410 pp, 35MB, About PDF).
EPA (2010). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008. Annex 2 (Methodology for estimating CO_2 emissions from fossil fuel combustion), P. A-65. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-10-006 (PDF) (407 pp, 19MB, About PDF).
IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Railcars of coal burned

Average heat content of coal in 2008 was 21.92 mmbtu per metric ton (EIA 2010b). Average carbon coefficient of coal in 2008 was 25.14 kilograms carbon per mmbtu (EPA 2010a). Fraction oxidized is 100 percent (IPCC 2006).

Carbon dioxide emissions per ton of coal were determined by multiplying heat content times the carbon coefficient times the fraction oxidized times the ratio of the molecular weight of carbon dioxide to that of carbon (44/12). The amount of coal in an average railcar was assumed to be 100.19 short tons, or 90.89 metric tons (Hancock 2001).

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

21.92 mmbtu/metric ton coal * 25.14 kg C/mmbtu * 44g CO_2/12g C * 90.89 metric tons coal/railcar * 1 metric ton/1000 kg = **183.65 metric tons CO_2/railcar**

Sources

EPA (2008). Inventory of U.S. Greenhouse Gas Emissions and Sinks: Fast Facts 1990-2006. Conversion Factors to Energy Units (Heat Equivalents) Heat Contents and Carbon Content Coefficients of Various Fuel Types. U.S. Environmental Protection Agency, Washington, DC. USEPA #430-F-08-005 (PDF) (2 pp, 430K, About PDF).
EPA (2010a). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008. Annex 2 (Methodology for estimating CO_2 emissions from fossil fuel combustion), P. A-23-A-24. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA #430-R-10-006 (PDF) (407 pp, 19MB, About PDF).
EIA (2010b). Table 4.1. Receipts, Average Cost, and Quality of Fossil Fuels: Total (All Sectors), 2008.
Hancock (2001). Hancock, Kathleen and Sreekanth, Ande. *Conversion of Weight of Freight to Number of Railcars*. *Transportation Research Board*, Paper 01-2056, 2001.
IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Tons of waste recycled instead of landfilled

To develop the conversion factor for recycling rather than landfilling waste, emission factors from EPA's WAste Reduction Model (WARM) were used (EPA 2009). These emission factors were developed following a life-cycle assessment methodology using estimation techniques developed for national inventories of greenhouse gas (GHG) emissions. According to WARM, the net emission reduction from recycling mixed recyclables (e.g., paper, metals, plastics), compared to a baseline in which the materials are landfilled, is 0.78 metric tons of carbon equivalent (MTCE) per short ton. This factor was then converted to metric tons of carbon dioxide equivalent ($MTCO_2E$) by multiplying by 44/12, the molecular weight ratio of carbon dioxide to carbon.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

0.78 MTCE/ton * 44 g CO_2/12 g C = **2.87 metric tons CO_2E/ton of waste recycled instead of landfilled**

Sources

EPA (2010). WAste Reduction Model (WARM). U.S. Environmental Protection Agency.

Coal-fired power plant emissions for one year

In 2007, a total of 464 power plants used coal to generate at least 95% of their electricity (EPA 2011). These plants emitted 1,866,813,072.1 metric tons of CO_2 in 2007.

Carbon dioxide emissions per power plant were calculated by dividing the number of power plants by the total emissions from power plants whose primary source of fuel was coal.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

1,866,813,072.1 metric tons of CO_2 * 1/464 power plants = **4,023,304 metric tons CO_2/power plant**

Sources

EPA (2011). eGRID2010 Version 1.1, year 2007 data.