United States Environmental Protection Agency

Office of Transportation and Air Quality

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Emission Facts

Greenhouse Gas Emissions from a Typical Passenger Vehicle

The U.S. Environmental Protection Agency (EPA) developed this series of four fact sheets to facilitate consistency of assumptions and practices in the calculation of emissions of greenhouse gases from transportation and mobile sources. They are intended as a reference for anyone estimating emissions benefits of mobile sources air pollution control programs.

Issue

Each EPA voluntary climate change program has used slightly different assumptions to translate the greenhouse gas (GHG) reductions associated with the program to the equivalent GHG emissions of a number of cars on the road. The result is that different numbers for the greenhouse gas emissions associated with a passenger vehicle have been used for different programs. The purpose of this fact sheet is to determine consistent assumptions and produce a number that is accepted for the annual GHG emissions associated with a passenger vehicle. The estimate calculated here is for vehicle emissions only, and does not include lifecycle emissions such as emissions associated with the production and distribution of fuel.

Recommendation

To translate GHG reductions into an equivalent number of cars off the road, annual emissions from a typical passenger vehicle should be equated to 5.5 metric tons of carbon dioxide equivalent or 1.5 metric tons of carbon equivalent.

Key steps to the calculation

There are six key steps to estimate the annual greenhouse gas emissions associated with a passenger vehicle:

1. Determining the carbon dioxide (CO_2) produced per gallon of gasoline
2. Estimating the fuel economy of passenger cars and light trucks (in miles per gallon [mpg])
3. Determining the number of miles driven
4. Determining the emissions of greenhouse gases other than CO_2 (methane [CH_4], nitrous oxide [N_2O], and hydrofluorocarbons [HFCs])
5. Estimating the relative percentages of passenger cars and light trucks
6. Calculating the resulting annual greenhouse gas emissions

Note that for the purposes of this fact sheet, representative values were chosen for each of these variables, despite the fact that in practice variation does occur in these numbers.

Step 1: Determining the CO_2 produced per gallon of gasoline

A gallon of gasoline is assumed to produce 8.8 kilograms (or 19.4 pounds) of CO_2. This number is calculated from values in the Code of Federal Regulations at 40 CFR 600.113-78, which EPA uses to calculate the fuel economy of vehicles, and relies on assumptions consistent with the Intergovernmental Panel on Climate Change (IPCC) guidelines.

In particular, 40 CFR 600.113-78 gives a carbon content value of 2,421 grams (g) of carbon per gallon of gasoline, which produces 8,877 g of CO_2. (The carbon content is multiplied by the ratio of the molecular weight of CO_2 to the molecular weight of carbon: 44/12).

This number is then multiplied by an oxidation factor of 0.99, which assumes that 1 percent of the carbon remains un-oxidized.[1] This produces a value of 8,788 g or 8.8 kg (19.4 lbs) of CO_2.

Step 2: Estimating the fuel economy of passenger cars and light trucks (MPG estimate)

There are two sources of data which EPA has used for the average fuel economy of passenger cars and light trucks. MOBILE6.2 (EPA's computer model for estimating emissions for highway vehicles) can calculate an average fuel economy across the fleet, based on the EPA annual Fuel Economy Trends reports. For 2003, MOBILE calculates values of 23.9 miles per gallon (mpg) for passenger cars and 17.4 mpg for light trucks. These values are weighted averages (based on vehicle age data for the fleet, including vehicles up to 25 years old) of the Fuel Economy Trends sales-weighted average fuel economy of passenger cars and light trucks for each model year. MOBILE6.2 calculates an overall average fuel economy for passenger vehicles of 20.3 mpg (weighted by vehicle miles traveled [VMT] for passenger cars and light trucks).

The Federal Highway Administration's (FHWA) "Highway Statistics 2001" gives average values of 22.1 mpg for passenger cars and 17.6 mpg for light trucks as a fleet wide average in for the year 2001 (includes all vehicles on the road in 2001). These values are obtained by dividing vehicle miles traveled by fuel use.[2] These values are used in the development of the "Inventory of U.S. Greenhouse Gas Emissions and Sinks."

Recommendation: Values were calculated using both sets of fuel economy numbers. Depending on the circumstances, use of one set of numbers or the other may be more appropriate. Generally EPA staff should use the MOBILE6 estimates. However, EPA uses the FHWA numbers in developing the National Inventory for Greenhouse Gas Emissions because they are consistent with the methodology used to develop the inventory. (Note that a small variation in the fuel economy number will not change the rough estimate of greenhouse gases derived here.)

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[1] The International Panel on Climate Change Guidelines (IPCC) recommends a fraction of carbon oxidized factor of 0.99 for all oil and oil-based products. Based on the fundamentals of internal combustion engine design and combustion, EPA is currently examining whether this fraction is higher (closer to 100 percent) for gasoline vehicles in the US.

[2] U.S. Department of Transportation, Federal Highway Administration, "Highway Statistics 2000," Washington, DC, 2001. Vehicle travel and fuel use data are kept separately for passenger cars and light trucks.

Step 3: Determining the number of miles driven

The number of miles driven per year is assumed to be 12,000 miles for all passenger vehicles.

This number is based on several sources. Calculations from EPA's MOBILE6 model show an average annual milage of roughly 10,500 miles per year for passenger cars and over 12,400 miles per year for light trucks across all vehicles in the fleet. However, these numbers include the oldest vehicles in the fleet (vehicles 25 years of age and older), which are likely not used as primary vehicles and are driven substantially less than newer vehicles. Since this calculation is for a typical vehicle, including the oldest vehicles may not be appropriate. For all vehicles up to 10 years old, MOBILE6 shows an annual average milage of close to 12,000 miles per year for passenger cars, and over 15,000 miles per year for light trucks.

FHWA's National Highway Statistics contains values of 11,766 miles for passenger cars and 11,140 miles for light trucks across the fleet. However, as with the MOBILE6 fleet-wide estimates, these numbers include the oldest vehicles in the fleet. EPA's Commuter Model uses 1997 data from Oak Ridge Laboratories for the number of cars nationally and number of miles driven which produces a value of just over 12,000 miles per year. Due to the wide range of estimates, 12,000 miles per vehicle is used as a rough estimate for calculating the greenhouse gas emissions from a typical passenger vehicle.)

Step 4: Determining the emissions of greenhouse gases other than CO_2 (N_2O, CH_4, and HFCs)

In addition to carbon dioxide, automobiles produce methane (CH_4) and nitrous oxide (N_2O) from the tailpipe, as well as HFC emissions from leaking air conditioners.

The emissions of CH_4 and N_2O are related to vehicle miles traveled rather than fuel consumption, and the emissions of CH_4, N_2O, and HFCs are not as easily estimated from a vehicle as for CO_2.[3] On average, CH_4, N_2O, and HFC emissions represent roughly 5 - 6 percent of the GHG emissions from passenger vehicles, while CO_2 emissions account for 94-95 percent, accounting for the global warming potential of each greenhouse gas. (These percentages are estimated from the EPA "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 2001.") To simplify this estimate, it is assumed that CH_4, N_2O, and HFCs account for 5 percent of emissions, and the CO_2 estimate was multiplied by 100/95 to incorporate the contribution of the other greenhouse gases.

[3] EPA is currently examining ways to better disaggregate the HFC emissions from vehicles.

Step 5: Estimating the relative percentages of passenger cars and light trucks

Because FHWA calculates fuel economy for passenger cars and light trucks separately, it is necessary to determine the relative percentage of cars and light trucks in order to derive the greenhouse gas emissions for an average passenger vehicle. (This step is not necessary when using the MOBILE6 fuel economy data because MOBILE6 already calculates a weighted average fuel economy for all passenger vehicles.) Passenger cars are assumed to make up 63.4 percent and light trucks make up 36.6 percent of the passenger vehicle fleet. These values are derived from table 6.4 (2000 data) of the "Transportation Energy Data Book: Edition 22" (published by the Center for Transportation Analysis, Oak Ridge National Laboratory), which states there are 127,721,000 passenger cars on the road and 73,775,000 light trucks (less than 8500 lbs[4]). Note that this percentage is changing over time, as light trucks now represent roughly 50 percent of annual new vehicle sales.

Step 6: Calculating the resulting annual greenhouse gases from a typical passenger vehicle

A: Using EPA MOBILE6.2 fuel economy numbers

Metric tons of CO_2e for the average passenger vehicle =

(VMT/passenger vehicle avg. MPG) x CO_2 per gallon x (100/95) /1000 =

(12,000/20.3) x 8.8 x (100/95)/1000 =

5.48 metric tons CO_2e for the average passenger vehicle (1.49 metric tons CE)

B: Using DOT fuel economy numbers

[%LDV x (LDVVMT/LDVMPG) x CO_2 per gallon x (100/95) /1000] + [%LDT x (LDTVMT/LDTMPG) x CO_2 per gallon x (100/95) /1000] =

[0.634 x (12,000/22.1) x 8.8 x (100/95)/1000] + [0.366 x (12,000/17.6)] x 8.8 x (100/95)/1000] =

5.03 metric tons CO_2e for passenger cars and 6.32 metric tons CO_2e for light trucks (= 1.37 metric tons CE for cars and 1.72 metric tons CE for trucks) =

5.50 metric tons CO_2e for the average passenger vehicle (1.50 metric tons CE)

[4] Vehicles over 8500 lbs are often not included in the light truck category. These vehicles are not required to meet CAFE standards. Examples of these vehicles include the Hummer and the Ford Excursion.

Recommendation: To calculate rough translations of GHG reductions into an equivalent number of cars off the road, use 5.5 metric tons of CO_2, or 1.5 metric tons of carbon equivalent. This number is rounded to the nearest tenth of a ton (using either DOT or EPA fuel economy estimates). This rough estimate will also allow for some variability in the underlying variables.

CO_2 only numbers

A: Using EPA MOBILE6.2 fuel economy numbers

Average passengerr vehicle = 5.20 metric tons CO_2e (1.42 metric tons CE)

B: Using DOT fuel economy numbers

Passenger Cars = 4.78 metric tons CO_2e (1.30 metric tons CE)
Light Trucks = 6.00 metric tons CO_2e (1.64 metric tons CE)
All passenger vehicles = 5.23 metric tons CO_2e (1.43 metric tons CE)

Recommendation: For CO_2 only estimate, use 5.2 metric tons CO_2e, or 1.4 metric tons CE

Note: These calculations and the supporting data have associated variation and uncertainty. EPA may use other values in certain circumstances, and in some cases it may be appropriate to use a range of values.

For More Information

You can access documents on greenhouse gas emissions on the Office of Transportation and Air Quality Web site at:

www.epa.gov/otaq/greenhousegases.htm

For further information on calculating emissions of greenhouse gases, please contact Ed Coe at:

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