

Greenhouse Gas Emissions from a Typical Passenger Vehicle

The U.S. Environmental Protection Agency (EPA) developed this fact sheet to answer common questions about greenhouse gas emissions from passenger vehicles. This fact sheet provides emission rates and calculations consistent with EPA's regulatory work.

How much tailpipe carbon dioxide (CO₂) is created from burning one gallon of fuel?

The amount of CO₂ created from burning one gallon of fuel depends on the amount of carbon in the fuel. After combustion, a majority of the carbon is emitted as CO₂ and very small amounts as hydrocarbons and carbon monoxide. Carbon content varies by fuel, and some variation within each type of fuel is normal. The EPA and other agencies use the following average carbon content values to estimate CO₂ emissions:

| | | |
|--|--------|---|
| CO ₂ Emissions from a gallon of gasoline: | 8,887 | grams CO ₂ / gallon ¹ |
| CO ₂ Emissions from a gallon of diesel: | 10,180 | grams CO ₂ / gallon ² |

Vehicles that use diesel fuel generally have higher fuel economy than comparable gasoline vehicles. However, when comparing carbon dioxide emissions, the higher CO₂ emissions from diesel fuel partially offset the fuel economy benefit.

¹ This gasoline factor is from a recent regulation establishing GHG standards for model year 2012-2016 vehicles (75 FR 25324, May 7, 2010).

² This diesel factor is from the calculations that vehicle manufacturers use to measure fuel economy (40 C.F.R. 600.113).

How much tailpipe carbon dioxide (CO₂) is emitted from driving a mile?

The average passenger vehicle emits about 423 grams of CO₂ per mile. This number can vary based on two factors: the fuel economy of the vehicle and the amount of carbon in the vehicle's fuel. The average gasoline vehicle on the road today has a fuel economy of about 21 miles per gallon.³ Most vehicles on the road in the US today are gasoline vehicles, and every gallon of gasoline creates about 8887 grams of CO₂ when burned. Therefore, the average vehicle when driving one mile has tailpipe CO₂ emissions of about:

$$\text{CO}_2 \text{ emissions per mile} = \frac{\text{CO}_2 \text{ per gallon}}{\text{MPG}} = \frac{8887}{21} = 423 \text{ grams}$$

What are the average annual carbon dioxide (CO₂) emissions of a typical passenger vehicle?

A typical passenger vehicle emits about 5.1 metric tons of carbon dioxide per year. This number can vary based on a vehicle's fuel, fuel economy, and the number of miles driven per year. The average gasoline vehicle on the road today has a fuel economy of about 21 miles per gallon and drives around 12,000 miles per year. Every gallon of gasoline burned by that vehicle creates about 8887 grams of CO₂, and there are one million grams per metric ton. Therefore, the average vehicle over a year of driving has tailpipe CO₂ emissions of about⁴:

$$\text{Annual CO}_2 \text{ emissions} = \frac{\text{CO}_2 \text{ per gallon}}{\text{MPG}} \times \text{miles} = \frac{8887}{21} \times 12000 = 5.1 \text{ metric tons}$$

EPA uses this to compare CO₂ emissions from other sources to emissions from passenger vehicles. For example, an energy efficiency program that reduces greenhouse gas emissions by 5,100 metric tons of CO₂ per year has the same impact as removing 1000 vehicles from the road.

Are there other sources of greenhouse gas emissions from a vehicle?

In addition to carbon dioxide (CO₂), automobiles produce methane (CH₄) and nitrous oxide (N₂O) from the tailpipe, as well as hydro fluorocarbon (HFC) emissions from leaking air conditioners. The emissions of these gases are small in comparison to CO₂; however, these gases are more potent greenhouse gases (they have a higher global warming potential) than CO₂.

³ This is representative of the light duty passenger vehicle fleet as a whole, including both new and existing vehicles. EPA expects the average passenger vehicle fuel economy to increase over time as a result of new greenhouse gas and fuel economy standards developed in coordination between EPA, DOT and California.

⁴ This calculation provides a simple way to determine the average annual CO₂ emissions from a passenger vehicle. Anyone that needs a more detailed approach should use the EPA's [Motor Vehicle Emission Simulator \(MOVES\)](http://www.epa.gov/otaq/models/moves/index.htm) model (www.epa.gov/otaq/models/moves/index.htm). This model contains detailed data about the light duty fleet and driving patterns in the United States. Although simplified, the calculated annual CO₂ emissions above are consistent with analyses performed by the EPA using MOVES.

Emissions of greenhouse gases are typically expressed in a common metric so that their impacts can be directly compared. The international standard is to express greenhouse gases in units of carbon dioxide equivalent, commonly written as CO₂e. For a given amount of a greenhouse gas, multiplying the amount of gas times the global warming potential (GWP) for that gas results in the amount of greenhouse gas in terms of CO₂e. For automotive-related gases, these global warming potentials are:

| Greenhouse Gas | Abbreviation | GWP ⁵ |
|------------------------------|------------------|------------------|
| Carbon Dioxide | CO ₂ | 1 |
| Methane | CH ₄ | 25 |
| Nitrous Oxide | N ₂ O | 298 |
| Air Conditioning Refrigerant | HFC-134a | 1,430 |

It is more difficult to estimate vehicle emissions of CH₄, N₂O, and HFCs than of CO₂. Emissions of CH₄ and N₂O are dependent on vehicle miles traveled rather than fuel consumption per mile. The amount of HFC leakage from air conditioners is dependent on many factors, including system design, amount of use, and maintenance. On average, CO₂ emissions represent 95-99% of the total greenhouse gas emissions from a passenger vehicle. CH₄, N₂O, and HFC emissions represent roughly 1-5% of the total greenhouse gas emissions from passenger vehicles, after accounting for the global warming potential of each greenhouse gas.

What are the tailpipe emissions from a plug-in hybrid or an electric vehicle? What about hydrogen fuel cell vehicles?

A vehicle that can only operate on electricity will not emit any tailpipe emissions. A fuel cell vehicle operating on hydrogen will emit only water vapor.

Plug-in hybrid vehicles (PHEVs) can operate on either electricity or gasoline. When a PHEV is operating on electricity, it does not create any tailpipe emissions. However, when it is operating on gasoline, it creates tailpipe greenhouse gas emissions based on the PHEV's gasoline fuel economy. These emissions can be calculated as shown in the second question. The overall tailpipe emissions for a PHEV depend on the percentage of miles the vehicle drives on electricity versus gasoline. This can vary significantly based on the PHEV's battery capacity, how it is driven, and how often it is charged.

Are there any greenhouse gas emissions associated with the use of my vehicle other than the tailpipe emissions?

Driving most vehicles creates tailpipe greenhouse gas emissions. Producing and distributing the fuel used to power your vehicle also creates greenhouse gasses. Gasoline, for example, requires

⁵ These 100-year time horizon GWP values are from the 2007 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

extracting oil from the ground, transporting it to a refinery, refining the oil into gasoline, and transporting the gasoline to service stations. Each of these steps can produce additional greenhouse gas emissions.

Electric vehicles have no tailpipe emissions; however, greenhouse gas emissions are created during both the production and distribution of the electricity used to fuel the vehicle. Calculators on Fueleconomy.gov allow you to estimate grams of greenhouse gas emissions per mile for an electric vehicle in your region of the country.

I thought my gasoline was blended with ethanol. Does that change the tailpipe CO₂ emissions?

It is common in the U.S. to blend gasoline with a small percentage of ethanol. Most of the gasoline sold in the U.S. is really a mixture of gasoline and up to 10% ethanol (this mixture is often referred to as E10)⁶. The exact formulation of the gasoline in your vehicle will vary depending on season, region in the U.S., and other factors. While your fuel economy when using an ethanol blend in your vehicle will be slightly lower than when using pure gasoline, the CO₂ tailpipe emissions per mile will be similar. This is because ethanol has less carbon per gallon than gasoline.

How does the EPA measure CO₂ emissions from motor vehicles?

The EPA and automobile manufacturers test vehicles using a set of standardized laboratory tests. These tests were designed by the EPA to mimic typical driving patterns. The EPA and the Department of Transportation use these values to ensure that the vehicle meets federal corporate average fuel economy (CAFE) standards. The test results are then adjusted to reflect different driving conditions and estimate fuel economy and greenhouse gas emissions for an average driver. These adjusted results are used on the Fuel Economy and Environment Label seen on all new vehicles and on Fueleconomy.gov. Detailed information on the test cycles is available on the EPA's [National Vehicle and Fuel Emissions Laboratory](http://www.epa.gov/nvfel/) website (www.epa.gov/nvfel/).

How can I find and compare CO₂ emission rates for specific vehicle models?

You can find and compare vehicle CO₂ emissions at Fueleconomy.gov. Beginning with model year 2013, vehicle manufacturers will include tailpipe CO₂ emission rates on the vehicle Fuel Economy and Environment labels. These new labels also feature a convenient 1-to 10 Fuel Economy and Greenhouse Gas Rating to enable easy comparison shopping. A Smartphone QR Code[®] on the label will direct consumers to the website Fueleconomy.gov for more information.⁷

⁶ The amount of ethanol in gasoline has historically been limited to 10%; however, the E15 waiver increases that amount to 15% for some vehicles. For more information see: www.epa.gov/otaq/regs/fuels/additive/e15/

⁷ QR (or "quick response") Codes are simply two-dimensional bar codes used to store information. In this case, the information is a web site URL. The term QR Code[®] is a registered trademark of Denso Wave Incorporated.

The EPA publishes additional data in the report “[Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends](http://www.epa.gov/otaq/fetrends.htm)” (www.epa.gov/otaq/fetrends.htm). The Trends Report analyzes trends in fuel economy and CO₂ emissions for new light duty vehicles from 1975 to the present.

**Where can I find information on the emissions of the transportation sector as a whole?
How can I compare this to other sectors?**

You can find documents on greenhouse gas emissions on the EPA’s [Transportation and Climate](http://www.epa.gov/otaq/climate) (www.epa.gov/otaq/climate) website. This website is maintained by the Office of Transportation and Air Quality (OTAQ).

- [U.S. Greenhouse Gas Inventory Report](http://www.epa.gov/climatechange/emissions/usinventoryreport.html) (EPA-430-R-11-005, April 2011): www.epa.gov/climatechange/emissions/usinventoryreport.html
- [Light-Duty Greenhouse Gas Standards](http://www.epa.gov/otaq/climate/regulations.htm): www.epa.gov/otaq/climate/regulations.htm
- [Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends](http://www.epa.gov/otaq/fetrends.htm): www.epa.gov/otaq/fetrends.htm
- [Fueleconomy.gov](http://www.fueleconomy.gov)

For additional information on calculating emissions of greenhouse gases, please contact:

OTAQ@epa.gov

Or you can contact the OTAQ library for document information at:

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