Questions and Answers

Tailpipe 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 (CO_2) is created from burning one gallon of fuel?

The amount of CO_2 created from burning one gallon of fuel depends on the amount of carbon in the fuel. Typically, more than 99% of the carbon in a fuel is emitted as CO_2 when the fuel is burned. Very small amounts are emitted as hydrocarbons and carbon monoxide, which are converted to CO_2 relatively quickly in the atmosphere. Carbon content varies by fuel, and some variation within each type of fuel is normal. EPA and other agencies use the following average carbon content values to estimate CO_2 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]

Diesel creates about 15% more CO_2 per gallon. However, many vehicles that use diesel fuel achieve higher fuel economy than similar vehicles that use gasoline, which generally offsets the higher carbon content of diesel fuel.

How can burning one gallon of gasoline produce 8,887 grams (approximately 20 pounds) of tailpipe carbon, when one gallon of gasoline weighs only about six pounds?

Most of the weight of the CO_2 doesn't come from the gasoline itself, but the oxygen in the air. When gasoline burns, the carbon and hydrogen separate. The hydrogen combines with oxygen to form water (H_2O), and carbon combines with oxygen to form carbon dioxide (CO_2). Visit fueleconomy.gov for more details, including the calculations.

[1] This gasoline factor is from a regulation establishing GHG standards for model year 2017-2025 vehicles (77 FR 62773, October 15, 2012).

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

EPA United States Environmental Protection Agency

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How much tailpipe carbon dioxide (CO_2) is emitted from driving one mile?

The average passenger vehicle emits about 400 grams of CO_2 per mile. The average fuel economy for all vehicles on the road today is 22.2 miles per gallon.[3] The majority of vehicles run on gasoline, and every gallon of gasoline creates about 8,887 grams of CO_2 when burned. Therefore, the average vehicle when driving one mile has tailpipe CO_2 emissions of about:

$$CO_2 \text{ emissions per mile} = \frac{CO_2 \text{ per gallon}}{MPG} = \frac{8{,}887}{22.2} = \mathbf{400 \text{ grams}}$$

Electric vehicles (EVs) have zero tailpipe emissions.

What is the average *annual* carbon dioxide (CO_2) emissions of a typical passenger vehicle?

A typical passenger vehicle emits about 4.6 metric tons of CO_2 per year. This number can vary based on a vehicle's fuel, fuel economy, and the number of miles driven per year. The average vehicle on the road today has a fuel economy of about 22.2 miles per gallon (MPG) and drives around 11,500 miles per year.[4] Every gallon of gasoline burned creates about 8,887 grams of CO_2, and there are one million grams per metric ton. Therefore, the average gasoline vehicle over a year of driving has tailpipe CO_2 emissions of about[5]:

$$CO_2 \text{ emissions per mile} = \frac{CO_2 \text{ per gallon}}{MPG} \times \text{miles} = \frac{8{,}887}{22.2} \times 11{,}500 = \mathbf{4.6 \text{ metric tons}}$$

EPA uses this to compare CO_2 emissions from other sources to emissions from passenger vehicles. For example, an energy efficiency program that reduces greenhouse gas emissions by 4,600 metric tons of CO_2 per year has the same impact as removing 1,000 vehicles from the road.

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

In addition to CO_2, automobiles using gasoline produce methane (CH_4) and nitrous oxide (N_2O) from the tailpipe and all vehicles can emit hydrofluorocarbon (HFC) from leaking air conditioners. For gasoline vehicles, the emissions of HFCs are small in comparison to CO_2; however, the impact of these emissions can be important because they have a higher global warming potential (GWP) than CO_2.

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[3] Federal Highway Administration Highway Statistics 2020, data for calendar year 2019. Data for 2020 was not used due to the impacts of the COVID-19 outbreak. The average passenger vehicle fuel economy is expected to increase over time because of greenhouse gas and fuel economy standards developed in coordination between EPA, DOT, and California.

[4] Federal Highway Administration Highway Statistics 2020.

[5] This calculation provides a simple way to determine the average annual CO_2 emissions from a passenger vehicle. Anyone that needs a more detailed approach should use the EPA's Motor Vehicle Emission Simulator (MOVES) model. MOVES contains detailed data about the light duty fleet and driving patterns in the United States. Although simplified, the calculated annual CO_2 emissions above are consistent with analyses performed by EPA using MOVES.

The GWP of a gas relates the impact of that gas relative to an equivalent amount of CO_2. Using GWP, the impact of various GHGs can be directly compared using a common metric. This metric is expressed in units of carbon dioxide equivalent, written as CO_2e. Multiplying the amount of a GHG times the GWP of that GHG results in the amount of GHG in terms of CO_2e. For automotive-related gases, these GWPs are:

Greenhouse Gas	Abbreviation	Global Warming Potential[6]
Carbon Dioxide	CO_2	1
Methane	CH_4	25
Nitrous Oxide	N_2O	298
Air Conditioning Refrigerant	HFC-134a	1,430

It is more difficult to estimate vehicle emissions of CH_4, N_2O, and HFCs than CO_2. Emissions of CH_4 and N_2O are dependent on the design of the gasoline engine and emission control system, rather than fuel consumption per mile. The amount of HFC leakage from air conditioners is dependent on system design, amount of use, and maintenance. On average, CO_2 emissions are 95-99% of the total GHGs from a gasoline passenger vehicle, after accounting for the GWP of all GHGs. The remaining 1-5% is CH_4, N_2O, and HFC emissions. EVs also emit a small amount of GHGs due to air conditioner/HFC leakage.

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

Electric vehicles (EVs) have a battery instead of a gasoline tank, and an electric motor instead of an internal combustion engine. EVs do not emit any tailpipe emissions. A fuel cell electric vehicle (FCEV) operating on hydrogen will emit only water vapor. Calculating tailpipe emissions for PHEVs is more complicated because they use both gasoline and electricity as fuel sources. When operating on electricity only, a PHEV does not generate any tailpipe emissions. When a PHEV is operating on gasoline only, it creates tailpipe emissions based on its gasoline fuel economy. Tailpipe emissions for a PHEV operating on both electricity and gasoline cannot be calculated without detailed information about how the specific PHEV operates. The overall tailpipe emissions for a PHEV can vary significantly based on its battery capacity, how it is driven, and how often it is charged. For more information, see the My Plug-In Hybrid calculator.

[6] These 100-year time horizon GWP values are from the 2007 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. The IPCC released updated values in the Fifth Assessment Report (2014), however international reporting guidelines still use the values shown here.

Are there any greenhouse gas (GHG) emissions associated with the use of my vehicle other than what comes out of the tailpipe?

Driving gasoline vehicles results in tailpipe GHG emissions. Producing and distributing the gasoline used to power your vehicle also creates GHGs. For example, the production of gasoline requires 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 GHGs.

Electric vehicles (EVs) have no tailpipe emissions; however, emissions are created during both the production and distribution of the electricity used to fuel the vehicle. Visit the Beyond Tailpipe Emissions calculator to estimate GHG emissions for an EV in your region of the country.

I thought my gasoline was blended with ethanol. Does that change my tailpipe carbon dioxide (CO_2) emissions?

Most of the gasoline sold in the U.S. is a mixture of gasoline and up to 10% ethanol (often referred to as E10). 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 gasoline without ethanol, the CO_2 tailpipe emissions per mile will be similar. This is because ethanol has less carbon per gallon than gasoline.

How does the EPA measure carbon dioxide (CO_2) emissions from vehicles?

EPA measures vehicle fuel economy and CO_2 emissions using a set of standardized laboratory tests. These tests were designed by EPA to mimic typical driving patterns. Both EPA and the Department of Transportation use these values to ensure that manufacturers meet federal greenhouse gas and corporate average fuel economy (CAFE) standards.

For every new vehicle, the test results are used to determine real world fuel economy and CO_2 emissions. These adjusted results are used on the Fuel Economy and Environment Labels and on Fueleconomy.gov.

Visit Testing at the National Vehicle and Fuel Emissions Laboratory and Frequent Questions on Fuel Economy Testing and Labeling for more information.

How can I find and compare carbon dioxide (CO_2) emission rates for specific vehicle models?

Visit Fueleconomy.gov and click on "Find a Car." Select your vehicle of interest. From the vehicle search results page, click on the "Energy and Environment" tab. A vehicle's GHG emissions rate (g/mile) and GHG rating (1-10 scale) can be found on that search results page.

When shopping at a dealership, check out tailpipe carbon dioxide (CO_2) emission rates on vehicle Fuel Economy and Environment Labels. The labels also feature a 1-to 10 Fuel Economy and GHG rating to enable easy comparison shopping.

Where can I find information on the emissions of the transportation sector as a whole?

Visit EPA's Fast Facts on Transportation Greenhouse Gas Emissions and Carbon Pollution from Transportation.

Annually EPA also publishes industry-wide data in the report, "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends." This report analyzes trends in fuel economy and CO_2 emissions for new light duty vehicles from 1975 to the present.

Other useful sources include:

- Beyond Tailpipe Emissions Calculator
- Fueleconomy.gov
- Greenhouse Gas Equivalencies Calculator
- Green Vehicle Guide
- Household Carbon Footprint Calculator
- Inventory of U.S. Greenhouse Gas Emissions and Sinks

For additional information on calculating emissions of greenhouse gases, please contact greenvehicles@epa.gov, or you can contact the OTAQ library for document information at:

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