Greenhouse Gas Inventory Guidance

Direct Emissions from Mobile Combustion Source

EPA
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Environmental Protection
Agency

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The U.S. EPA Center for Corporate Climate Leadership's (The Center) GHG guidance is based on The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (GHG Protocol) developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). The Center's GHG guidance is meant to extend upon the GHG Protocol to align more closely with EPA-specific GHG calculation methodologies and emission factors, and to support the Center's GHG management tools.

For more information regarding the Center for Corporate Climate Leadership, visit www.epa.gov/climateleadership.

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Section 1: Introduction

Greenhouse gas (GHG) emissions are produced by mobile sources as fuels are burned. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are emitted directly through the combustion of fuels in different types of mobile equipment. A list of mobile sources that could potentially be included in an organization's GHG inventory is provided in Table 1. GHG emissions from mobile sources also include hydrofluorocarbon (HFC) and perfluorocarbon (PFC) emissions from mobile air conditioning and transport refrigeration leaks. The calculation of fugitive HFC and PFC emissions from mobile sources is described in the Center's guidance for Direct Fugitive Emissions from Refrigeration, Air Conditioning, Fire Suppression, and Industrial Gases.

Table 1: Categories of Mobile Sources

Category	**Primary Fuels Used**
Onroad Vehicles	
—Passenger Cars	Gasoline
—Vans, Pickup Trucks & SUVs	Diesel Fuel
—Heavy-Duty Vehicles	
—Combination Trucks	
—Buses	
Nonroad Vehicles	
—Construction Equipment	Diesel Fuel
—Agricultural Equipment	
—Forklifts	
—Other Nonroad Equipment	
Waterborne	
—Ships	Diesel Fuel
—Boats	Residual Fuel Oil
	Gasoline
Rail	
—Freight Trains	Diesel Fuel
—Commuter Rail	Electric
—Amtrak	
Air	
—Commercial Aircraft	Kerosene Jet Fuel
—Executive Jets	

1.1 Scope 1 versus Scope 3 Mobile Source Emissions

This document presents the guidance for calculating scope 1 direct GHG emissions resulting from the operation of owned or leased mobile sources that are within an organization's inventory boundary. This guidance applies to all sectors whose operations include owned or leased mobile sources.

All other organization-related mobile source emissions, including employee commuting, employee travel, and upstream/downstream third-party transportation emissions, such as those associated with transporting material inputs or product distribution, are considered scope 3 indirect emissions. This guidance document focuses on scope 1 emissions. While some of the approaches in this document can also apply to scope 3 sources, organizations should refer to the separate scope 3 guidance document for specific approaches to calculate scope 3 mobile source emissions.

Furthermore, this guidance focuses on accounting for emissions resulting directly from an organization's activities, not on the full life cycle greenhouse gas emissions associated with those activities. For example, a fleet owner would use this guidance to account for emissions resulting from fleet fuel usage, but not for the emissions associated with producing the fuel.

Users of this guidance should be aware, however, that the choice of transportation modes and fuels can greatly influence GHG emissions from a life cycle perspective. A transportation mode may have relatively few GHG emissions from the vehicle itself, but emissions could be higher from the production of the fuel.

1.2 Greenhouse Gases Included

The greenhouse gases CO_2, CH_4, and N_2O are emitted during the combustion of fuels in mobile sources. For most transportation modes, CH_4 and N_2O emissions comprise a relatively small proportion of overall transportation-related GHG emissions (approximately one percent combined)[1]. For onroad vehicles less than 15 years old, CH_4, and N_2O emissions typically account for one percent of emissions or less. However, for older gasoline fueled onroad vehicles, CH_4, and N_2O could be a more significant (approximately five percent) portion of total GHG emissions. CH_4 and N_2O emissions are typically an even higher percentage of total GHG emissions from nonroad or alternative fuel vehicles.

Organizations should account for all CO_2, CH_4, and N_2O emissions associated with mobile combustion. Given the relative emissions contributions of each gas, CH_4 and N_2O emissions are sometimes excluded by assuming that they are not material. However, as outlined in Chapter 1 of the GHG Protocol, the materiality of a source can only be established after it has been assessed. This assessment does not necessarily require a rigorous quantification of all sources, but at a minimum, an estimate based on available data should be developed for all sources and categories of GHGs, and included in an organization's GHG inventory.

Information on methods used to calculate CO_2 emissions is found in Section 2. Information on an approach for determining CH_4 and N_2O emissions is found in Section 3. The approach to calculating CO_2 emissions from mobile combustion sources varies significantly from the approach to calculating CH_4 and N_2O emissions. While CO_2 can be reasonably calculated by applying emission factors based on the fuel quantity consumed, CH_4 and N_2O emissions depend largely on the emissions control equipment used (e.g., type of catalytic converter) and vehicle miles traveled. Emissions of these gases also vary with the efficiency and vintage of the combustion technology, as well as maintenance and

[1] See Table 3-7 of U.S. EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018, EPA 430-R-20-002, April 2020.

operational practices. Due to this complexity, a much higher level of uncertainty exists in the calculation of CH_4 and N_2O emissions from mobile combustion sources, compared to the calculation of CO_2 emissions.

1.3 Biofuels

Not all mobile combustion sources burn fossil fuels. Biomass (non-fossil) fuels (e.g., ethanol, biodiesel) may be combusted in mobile sources independently or co-fired with fossil fuels. The emission calculation methods discussed in this document can be used to calculate CO_2, CH_4, and N_2O emissions from combustion of these fuels. The GHG Protocol requires that CO_2 emissions from biomass combustion for mobile sources are reported as biomass CO_2 emissions (in terms of total amount of biogenic CO_2) and are tracked separately from fossil CO_2 emissions. Biomass CO_2 emissions are not included in the overall CO_2-equivalent emissions inventory for organizations following this guidance. CH_4 and N_2O emissions from biofuels are included in the overall CO_2-equivalent emissions inventory.

There are several transportation fuels that are actually blends of fossil and non-fossil fuels. For example, E85 is an ethanol (biomass fuel) and gasoline (fossil fuel) blend containing 51 percent to 83 percent ethanol, and B20 is a blend of 20 percent biodiesel (biomass fuel) and 80 percent diesel fuel (fossil fuel). The majority of motor gasoline used in the United States is made up of a blend of gasoline and ethanol. Typically, the blend is E10 (10 percent ethanol and 90 percent gasoline), but the content of ethanol in gasoline varies by location and by year. Combustion of these blended fuels results in emissions of both fossil CO_2 and biomass CO_2. Organizations should report both types of CO_2 emissions if blended fuels are used.

The blend percentage can be used to estimate the quantity of fossil fuel and biofuel. For example, if the organization consumes 1,000 gallons of E10, that can be treated as 100 gallons of ethanol and 900 gallons of gasoline. Separate fossil and biomass emission factors can then be applied to this mix of fuels. If an organization lacks specific biofuel content data, the organization may assume 10 percent ethanol for gasoline and may use the national average ethanol content for E85.This is reported in the U.S. EIA's Annual Energy Outlook, and is currently 74 percent[2].

An organization may operate "flex-fuel" vehicles, which can use either fossil fuels or a biofuel blend. If the organization is uncertain which fuel is used in these vehicles, fossil fuel should be assumed.

Recently, there has been increased scientific inquiry into accounting for biomass in energy production. The EPA's Science Advisory Board recently found that "there are circumstances in which biomass is grown, harvested and combusted in a carbon neutral fashion but carbon neutrality is not an appropriate a prior assumption; it is a conclusion that should be reached only after considering a particular feedstock's production and consumption cycle. There is considerable heterogeneity in feedstock types, sources and production methods and thus net biogenic carbon emissions will vary considerably."[3] According to the GHG Protocol Corporate Standard, "consensus methods have yet to be developed under the GHG Protocol Corporate Standard for accounting of sequestered atmospheric carbon as it moves through the value chain of biomass based industries," though some general considerations for accounting for sequestered atmospheric carbon are discussed in Chapter 9 and Appendix B of the GHG Protocol Corporate Standard.

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[2] U.S. Energy Information Administration, Annual Energy Outlook 2020, Table A2: Energy Consumption by Sector and Source. Available 11/24/2020 here: https://www.eia.gov/outlooks/aeo/.

[3] EPA Science Advisory Board Review of the 2011 Draft Accounting Framework for CO2 Emissions for Biogenic Sources Study. 2012. https://yosemite.epa.gov/sab/sabproduct.nsf/0/2F9B572C712AC52E8525783100704886?OpenDocument.

Section 2: Calculating CO_2 Emissions

The CO_2 emissions associated with fuel combustion are a function of the volume of fuel combusted, the density of the fuel, the carbon content of the fuel, and the fraction of carbon that is oxidized to CO_2. One of three equations can be used to calculate CO_2 emissions for each type of fuel combusted. The appropriate equation to use depends on what is known about the characteristics of the fuel being consumed.

Equation 1:
Emissions = Fuel x EF_1
Where:

Emissions = Mass of CO_2 emitted Fuel = Mass or volume of fuel combusted

EF_1 = CO_2 emission factor per mass or volume unit

Equation 1 is recommended when fuel consumption is known only in mass or volume units, and no information is available about the fuel heat content or carbon content. This equation is the least preferred.

It has the most uncertainty because its emission factors are based on default fuel heat content, rather than actual heat content.

Equation 2:
Emissions = Fuel x HHV x EF_2
Where:
Emissions = Mass of CO_2 emitted

Fuel = Mass or volume of fuel combusted

HHV = Fuel heat content (higher heating value), in units of energy per mass or volume of fuel

EF_2 = CO_2 emission factor per energy unit

Equation 2 is recommended when the actual fuel heat content is provided by the fuel supplier or is otherwise known. In such cases, the fuel use in energy units can be multiplied directly by the emission factor (EF2). Equation 2 is a preferable approach over Equation 1 because it uses emission factors that are based on energy units as opposed to mass or volume units. Emission factors based on energy units are less variable than factors per mass or volume units because the carbon content of a fuel is more closely related to the heat content of the fuel than to the total physical quantity of fuel.

Equation 3 is recommended to calculate CO_2emissions when the actual carbon content of the fuel is known. Carbon content is typically expressed as a percentage by mass, which requires fuel use data in mass units. This equation is most preferred for CO_2 calculations because CO_2 emissions are directly related to the fuel's carbon content. Follow the steps below to calculate emissions.

Equation 3:
Emissions = Fuel x CC x 44/12
Where:
Emissions = Mass of CO_2 emitted

Fuel = Mass or volume of fuel combusted

CC = Fuel carbon content, in units of mass of carbon per mass or volume of fuel
44/12 = ratio of molecular weights of CO_2 and carbon

Step 1: Select the appropriate equation.
Based on the information available on the characteristics of the fuel being consumed, select the appropriate equation to use in calculating emissions. See the discussion above on the three possible equations.

Step 2: Determine the amount of fuel combusted.
Each fuel type should be quantified separately. This can be based on fuel receipts or purchase records. Methods for determining fuel use are discussed in Section 4.1.

Step 3: Determine equation inputs.

The selected equation specifies which inputs are needed to calculate emissions. As appropriate, determine the fuel carbon content, fuel heat content, and/or emission factors associated with each fuel consumed. Further guidance is given in Section 4, and emission factors are provided in Appendix A.

Step 4: Calculate emissions.

Use the appropriate equation with the fuel consumption and other equation inputs to calculate the emissions of CO_2. The EPA SmartWay Transport Partnership (SmartWay) has various tools on its website that allow an organization to calculate CO_2 emissions for their mobile source fleet. If the organization has more detailed information on the vehicle models and fuel type, it may elect to use the tools available on the SmartWay website (https://www.epa.gov/smartway) instead of using the default values for CO_2 emission factors in this document. Organizations that choose to use EPA's SmartWay tools should include the specific data and factors used in their Inventory Management Plan (IMP).

Section 3: Calculating CH_4 and N_2O Emissions

One of two equations can be used to calculate CH_4 **and** N_2O emissions for each type of fuel combusted. Equation 4 is applicable to onroad vehicles such as cars, trucks, and buses. Equation 5 is applicable to nonroad vehicles such as construction or agricultural equipment, forklifts, ships, boats, rail vehicles, or aircraft.

Equation 4:

Emissions = Distance x EF_4

Where:

Emissions = Mass of CH_4 **or** N_2O emitted

Distance = Vehicle distance traveled

EF_1 = CH_4 **or** N_2O emission factor per distance unit

Equation 5:

Emissions = Fuel x EF_5

Where:

Emissions = Mass of CH_4 **or** N_2O emitted

Fuel = Volume of fuel combusted

EF_5 = CH_4 **or** N_2O emission factor per volume unit

Follow the steps below to calculate emissions.

Step 1: Select appropriate equation.

As discussed further above, Equation 4 is applicable to onroad vehicles and Equation 5 is applicable to nonroad vehicles.

Step 2: Determine the distance traveled or the amount of fuel combusted.

For road vehicles, gather data on the distance traveled, which is typically obtained from odometer readings. For nonroad vehicles, gather data on the volume of fuel combusted, which is typically obtained from fuel purchase records. Methods for determining distance and fuel use are discussed in Section 4.1.

Step 3: Determine emission factors.

The selected equation specifies the appropriate emission factors to be used. Further guidance is given in Section 4.3, and emission factors are provided in Appendix B.

Step 4: Calculate emissions.

Use the appropriate equation with the distance or fuel consumption and the appropriate emission factors to calculate the emissions of CH_4 and N_2O. Multiply the emissions of CH_4 and N_2O by the respective global warming potential (GWP) to calculate CO_2-equivalent emissions. The GWPs are 25 for CH_4 and 298 for N_2O, from the Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment Report (AR4), 2007. Sum the CO_2 equivalent emissions from CH_4 and N_2O with the emissions of CO_2 to calculate the total CO_2-equivalent (CO_2e) emissions.

Section 4: Choice of Activity Data and Emission Factors

4.1 Activity Data

To maximize the accuracy of emissions calculations, it is useful to have as much information as possible about the organization's vehicles. Ideally, a list of vehicles would be created with the following information provided for each vehicle:

- Fuel type
- Fuel use
- Distance traveled (for onroad vehicles)
- Fuel economy (if either fuel use or distance traveled is unavailable)
- Vehicle type
- Emissions control technology and/or model year

If vehicle-specific information is not available, the calculation methods can be applied to subtotaled fuel use data by fuel type, and to subtotaled distance data by vehicle type and model year.

This section provides guidance on fuel use data, distance data, and fuel economy. When calculating CO_2 emissions, and when calculating CH_4 and N_2O emissions from nonroad vehicles, the activity data that need to be gathered is the quantity of fuel combusted for each fuel type. When calculating CH_4 and N_2O emissions from onroad vehicles, the activity data needed is the distance traveled. These emissions also depend on vehicle type and control technology or model year, which are discussed in Appendix B.

The most accurate method of determining the amount of fuel combusted, and therefore the preferred method, is to gather data from fuel receipts or purchase records. If fuel is purchased at commercial fueling stations, fuel receipts can typically be obtained from the vehicle operators, or through records from centralized fuel card services. If fuel is delivered to the organization's facilities either to fill on-site fuel storage or to fill vehicles directly, fuel use can be determined through delivery records or fuel invoices. If natural gas vehicles are fueled on-site, fuel purchase data can be obtained from monthly natural gas bills. If a particular fuel type is used for both stationary and mobile sources, care should be taken to avoid double counting the fuel use.

If purchase records are used, several factors could lead to differences between the amount of fuel purchased and the amount of fuel actually combusted during a reporting period. These factors can include changes in fuel storage inventory, fugitive releases, or fuel spills.

For changes in fuel storage inventory, Equation 6 can be used to calculate actual fuel use.

Equation 6: Accounting for Changes in Fuel Inventory

Fuel B = Fuel P + (Fuel S_T- Fuel S_E)

Where:

Fuel B = Fuel burned in reporting period

Fuel P = Fuel purchased in reporting period Fuel

S_T = Fuel stock at start of reporting period Fuel S_E

= Fuel stock at end of reporting period

Fuel purchase data are usually reported as the amount of fuel provided by a supplier as it crosses the gate of the facility. However, once fuel enters the facility there could be some losses before it actually is combusted. Before calculating emissions, organizations should subtract the amount of fuel lost in fugitive releases or spills from the amount of fuel purchased. These losses are particularly important for natural gas, which could be lost due to fugitive releases from facility valves and piping, as these fugitive emissions could be significant. These fugitive natural gas releases (essentially methane emissions) should be accounted for separately from combustion emissions.

It is possible that organizations may only know the dollar amount spent on a type of fuel. This is the least accurate method of determining fuel use and is not recommended for GHG reporting. If the amount spent on fuel is the only information initially available, it is recommended that organizations contact their fuel supplier to request data in physical or energy units. If absolutely no other information is available, organizations should use fuel prices to convert the amount spent to physical or energy units, and should document the prices used. Price varies widely for specific fuels, especially over the geographic area and timeframe typically established for reporting GHG emissions.

For onroad vehicles, distance traveled data are also required in addition to fuel use. This distance should be tracked in units of vehicle-miles or vehicle-kilometers, as opposed to passenger-miles or passenger-kilometers, which are often used for scope 3 mobile source emissions. Distance data are best obtained from vehicle odometer readings. These could be provided from the vehicle operators or from vehicle maintenance records. If a centralized fuel card service is used, odometer readings may be required to be entered when fuel is purchased, in which case the odometer readings are typically available from fuel card records. In the absence of distance data for a specific year, a reasonable approximation of annual distance traveled can be made by dividing a vehicle's current odometer reading by the number of years it has been operating.

CO_2 emissions, and CH_4, and N_2O emissions for nonroad vehicles should be calculated using actual fuel use data. CH_4 and N_2O emissions for onroad vehicles should be calculated using actual distance traveled data. These approaches are especially recommended if emissions from mobile sources are a significant component of an organization's total GHG inventory. If accurate records of either fuel use or distance traveled are not available, the missing data can be estimated using fuel economy factors. For example, if fuel use in gallons is known, this can be multiplied by fuel economy in miles per gallon to obtain miles traveled. If distance traveled in miles is known, this can be divided by fuel economy in miles per gallon to obtain gallons of fuel use. Estimating fuel use with fuel economy factors is not as preferable as directly obtaining fuel use data, with the exception of fuel data based on the dollar amount spent on fuel. If accurate data are known on distance traveled and fuel economy for specific vehicle types, this method is preferred overusing fuel price data.

The preferred method for determining fuel economy for onroad vehicles is to use organization records by specific vehicle. This includes the miles per gallon (mpg) values listed on the sticker when the vehicle was purchased, or other organization fleet records. If sticker fuel economy values are not available, the recommended approach is to use fuel economy factors from the website www.fueleconomy.gov. This website, operated by the U.S. Department of Energy and the U.S. Environmental Protection Agency, lists city, highway, and combined fuel economies by make, model, model year, and specific engine type. Current year and historic model year data are both available.

Organizations should consider the following notes on the use of the fueleconomy.gov website to determine fuel economy values and fuel use:

- The default recommended approach is to use the combined city and highway mpg value for organization specific vehicle or closest representative vehicle type.
- The fuel economy values listed for older vehicles were calculated when the vehicle was new. The fuel economy could decline over time, but the decline is not considered to be significant given other uncertainties around use of the data.

- The website also lists estimated GHG emissions, but these are projected emissions based on an average vehicle miles traveled per year. These are not likely to be accurate estimates for fleet vehicles, and are not recommended for use in GHG inventories.

For heavy-duty, onroad vehicles, and nonroad vehicles, activity data could come in different forms. For some types of vehicles, activity data could be represented in terms of hours or horsepower-hours of operation, or, for some, it could be by ton-miles shipped. This activity data should be available from organization records. Specific information on fuel consumed per unit of activity data may be available from vehicle suppliers, manufacturers, or in organization records.

For freight transport, organizations should be particularly aware of any long duration idling. Idling can generate significant carbon emissions, and anti-idling strategies can be a cost-effective strategy to reduce emissions. If fuel use is tracked directly, the fuel related to idling is accounted for in the calculation. If fuel use is estimated based on distance data, organizations should be aware of and document the time spent (i.e., hours) idling and make sure it is included in their calculations of GHG emissions.

4.2 Fuel Carbon Content and Heat Content

Emissions of CO_2 from fuel combustion are dependent on the amount of carbon in the fuel, which is specific to the fuel type and grade of the fuel. It is recommended that organizations determine the actual carbon content of the fuels consumed, if possible. The most accurate method to determine a fuel's carbon content data is through chemical analysis of the fuel. This data may be obtained directly from the fuel supplier.

Carbon content can also be determined by fuel sampling and analysis. Fuel sampling and analysis should be performed periodically with the frequency dependent on the type of fuel. The sampling and analysis methodologies used should be detailed in the organization's IMP. Refer to 40 CFR Part 75, Appendix G or 40 CFR Part 98, Subpart C for recommended sampling rates and methods.

If actual fuel carbon content is available, either from the supplier or from sampling and analysis, Equation 3 in Section 2 may be used to calculate CO_2 emissions. It is also good practice to track the carbon content values used and to indicate if they vary over time.

If carbon content is not available, it is recommended that organizations determine the actual heat content of the fuel, if possible. The heat content of purchased fuel is often known and provided by the fuel supplier because it is directly related to the useful output or value of the fuel. Heat content can also be determined by fuel sampling and analysis, using methods discussed above. It is recommended that organizations use heat contents determined by one of these methods rather than default heat content, as these should better represent the characteristics of the specific fuel consumed. If actual fuel heat content is available, either from the supplier or from sampling and analysis, then Equation 2 in Section 2 may be used to calculate CO_2 emissions. It is also good practice to track the heat content values used and to indicate if they vary over time.

When determining fuel heat content or tracking fuel use data in energy units, it is important to distinguish between lower heating values (LHV) and higher heating values (HHV), also called net calorific value and gross calorific value, respectively. Heating values describe the amount of energy released when a fuel is burned completely, and LHV and HHV are different methods to measure the amount of energy released. A given fuel, therefore, always has both a LHV and a HHV. The LHV assumes that the steam released during combustion remains as a gas. The HHV assumes that the steam is condensed to a liquid, thus releasing more energy. HHV is typically used in the U.S. and in Canada, while other countries typically use LHV.

All emission factors and default heat content values in this guidance are based on HHV. Therefore, if fuel consumption is measured in LHV units, it must be converted to HHV before calculating emissions. To convert from LHV to HHV, a simplified convention used by the International Energy Agency can be used. For coal and petroleum, divide energy in LHV by 0.95. For natural gas, divide by 0.90.

4.3 Emission Factors

If actual fuel carbon content is not available, calculating CO_2 emissions relies on default emission factors. These factors approximate the carbon content of fuel to quantify the amount of CO_2 that will be released when the fuel is combusted. Appendix A provides two main types of default emission factors: factors defined per unit of fuel mass or volume (Table A-1 and A-2), and factors defined by per unit of fuel energy content (Table A-3 and A-4). As discussed in Section 2, using the emission factors per energy unit, along with Equation 2, is preferable to using emission factors per mass or volume. CH_4 and N_2O emissions depend not only on the fuel characteristics but also on the combustion technology type and control technologies. N_2O is influenced by catalytic converter design, while CH_4 is a byproduct of combustion, but can also be affected by catalytic converter design. CH_4 and N_2O emissions are often calculated as a function of vehicle miles traveled. Table B-1 in Appendix B provides emission factors by vehicle type and control technology. Information on the control technology type of each vehicle is posted on an under-the-hood label. To calculate emissions, organizations can multiply the appropriate emission factor by the distance traveled for each vehicle type.

Determining the specific control technologies of vehicles in your fleet gives the most accurate calculation of CH_4 and N_2O emissions. Organizations should be aware that in order to account for reductions obtained from certain emission savings strategies, it is necessary to use this approach and determine the particular emission control technologies for the vehicles in question.

If determining the specific technologies of the vehicle in a fleet is not possible, or is too labor intensive for a particular fleet, organizations can calculate CH_4 and N_2O emissions using emission factors by vehicle type and model year, provided in Table B-2. These emission factors are based on a weighted average of available control technologies for each model year.

Emission factors for alternative fuel onroad vehicles and for nonroad vehicles are given in Tables B-7 and B-8 of Appendix B.

Section 5: Completeness

In order for an organization's GHG inventory to be complete, it must include all emission sources within the organization's chosen inventory boundaries. See Chapter 3 of the GHG Protocol for detailed guidance on setting organizational boundaries and Chapter 4 of the GHG Protocol for detailed guidance on setting operational boundaries of the inventory.

On an organizational level, the inventory should include emissions from all applicable facilities and fleets of vehicles. Completeness of organization-wide emissions can be checked by comparing the list of sources included in the GHG emissions inventory with those included in other emissions inventories/environmental reporting, financial reporting, etc.

At the operational level, an organization should include all GHG emissions from the sources included in their inventory. Possible GHG emission sources are stationary fuel combustion, combustion of fuels from mobile sources, purchases of electricity, emissions from air conditioning equipment, and process or fugitive emissions. Organizations may refer to this guidance document for calculating emissions from mobile source fuel combustion, and to The Center's GHG Guidance documents for calculating emissions from other sources. For example, the calculation of HFC and PFC emissions from mobile source air conditioning equipment is described in the Center's guidance "Direct Fugitive Emissions from Refrigeration, Air Conditioning, Fire Suppression, and Industrial Gases."

As described in Chapter 1 of the GHG Protocol, there is no materiality threshold set for reporting emissions. The materiality of a source can only be established after it has been assessed. This does not necessarily require a rigorous quantification of all sources, but at a minimum, an estimate based on available data should be developed for all sources.

Section 6: Uncertainty Assessment

There is uncertainty associated with all methods of calculating emissions from mobile combustion sources. EPA does not recommend that organizations quantify uncertainty as +/- percentage of emissions or in terms of data quality indicators.

It is recommended that organizations attempt to identify the areas of uncertainty in their emissions and make an effort to use the most accurate data possible. The accuracy of calculating emissions from fuel combustion in mobile sources is partially determined by the availability of data on the amount of fuel consumed or purchased. If the amount of fuel combusted is directly measured or metered, then the resulting uncertainty should be fairly low. Data on the quantity of fuel purchased should also be a fairly accurate representation of fuel combusted, given that any necessary adjustments are made for changes in fuel inventory, fuel used as feedstock, etc. However, uncertainty may arise if only dollar value of fuels purchased is used to estimate fuel consumption. If fuel economy factors are used to estimate fuel use, uncertainty may arise if distance traveled and/or fuel economy is roughly estimated.

The accuracy of calculating emissions from mobile combustion sources is also determined by the factors used to convert fuel use into emissions. Uncertainty in the factors is primarily due to the variability in which they are measured, and the variability of the supply source.

Section 7: Documentation

Organizations should report data for the appropriate types of mobile sources listed in Table 2. In order to ensure that emissions calculations are transparent and verifiable, the documentation sources listed should be maintained. These documentation sources should be collected to ensure the accuracy and transparency of the data, and should also be included in the organization's IMP.

Table 2: Documentation Sources for Mobile Combustion

Data	Documentation Source
Fuel consumption data	Purchase receipts or utility bills; delivery receipts; contract purchase or firm purchase records; stock inventory documentation; metered fuel documentation
Distance traveled data	Official odometer logs or other records of vehicle distance traveled
Fuel economy data	Company fleet records, showing data on fuel economy; vehicle manufacturer documentation showing fuel economy
Heat contents and carbon contents used other than defaults provided	Purchase receipts or utility bills; delivery receipts; contract purchase or firm purchase records; other documentation from suppliers; EIA, EPA, or industry reports
Prices used to convert dollars of purchased to amount or energy content of fuel consumed	Purchase receipts; delivery receipts; contract purchase or fuel firm purchase records; EIA, EPA, or industry reports
All assumptions made in calculating fuel consumption, heat contents, and emission factors	All applicable sources

Section 8: Inventory Quality Assurance and Quality Control (QA/QC)

Chapter 7 of the GHG Protocol provides general guidelines for implementing a QA/QC process for all emissions calculations. For mobile combustion sources, activity data and emission factors can be verified using a variety of approaches:

- Fuel energy use data can be compared with data provided to Department of Energy or other EPA reports or surveys.
- If any emission factors were calculated or obtained from the fuel supplier, these factors can be compared to U.S. average emission factors.
- If actual data are available for both fuel use and distance traveled, distance can be divided by fuel use to calculate fuel economy. This can be compared to expected fuel economy for that vehicle type as a way to check the accuracy of the actual data.

Appendix A: Default CO_2 Emission Factors

This appendix contains default factors for use in calculating CO_2 emissions for different types of transportation fuels, using the method described in Section 2.

The emission factors in Table A-1 and A-2 can be used in Equation 1 from Section 2 to calculate GHG emissions if fuel use is known only in mass or volume units, and no information is available about the fuel heat content or carbon content. These emission factors are developed by multiplying the emission factors in Table A-3 and A-4 by the default heat content of the fuels, which is also shown in Table A-1 and A-2.

The emission factors in Table A-3 and A-4 can be used in Equation 2 from Section 2 to calculate GHG emissions when the actual fuel heat content is known or when the fuel use is provided in energy units.

All CO_2 emission factors assume that 100 percent of the carbon content of the fuel is oxidized to CO_2, as is recommended by the Intergovernmental Panel on Climate Change (IPCC).

Table A-1: Emission Factors for Equation 1 (EF_1) - Emissions per Mass or Volume Unit for Fossil Fuel Combustion

Fuel	Heat Content (HHV)	Emission Factors
Liquid Fuels	(mmBtu/gal)	(kg CO_2/gal)
Aviation Gasoline	0.120	8.31
Diesel Fuel	0.138	10.21
Kerosene-type Jet Fuel	0.135	9.75
Liquefied Natural Gas (LNG)	0.085	4.50
Liquefied Petroleum Gases (LPG)	0.092	5.68
Motor Gasoline	0.125	8.78
Residual Fuel Oil	0.150	11.27
Gaseous Fuels	(mmBtu/scf)	(kg CO_2/scf)
Compressed Natural gas	0.001026	0.05444

Table A-2: Emission Factors for Equation 1 (EF_1) - Emissions per Mass or Volume Unit for Biomass Fuel Combustion

Fuel	Heat Content (HHV)	Emission Factors
Liquid Fuels	(mmBtu/gal)	(kg CO_2/gal)
Biodiesel (100%)	0.128	9.45
Ethanol (100%)	0.084	5.75

Table A-3: Emission Factors for Equation 2 (EF_2) - Emissions per Energy Unit for Fossil Fuel Combustion

Fuel	Emission Factors
Liquid Fuels	(kg CO_2/gal)
Aviation Gasoline	69.25
Diesel Fuel	73.96
Kerosene-type Jet Fuel	72.22
Liquefied Natural Gas (LNG)	53.06
Liquefied Petroleum Gases (LPG)	61.71
Motor Gasoline	70.22
Residual Fuel Oil	75.10
Gaseous Fuels	
Compressed Natural Gas	53.06

Table A-4: Emission Factors for Equation 2 (EF_2) - Emissions per Energy Unit for Biomass Fuel Combustion

Fuel	**Emission Factors**
Liquid Fuels	(kg CO_2/mmBtul)
Biodiesel (100%)	73.84
Ethanol (100%)	68.44

Source for the emission factors in this appendix: Federal Register (2017) EPA; 40 CFR Part 98; June 13, 2017. Table C-1, Table C-2, Table AA-1: https://www.ecfr.gov/cgi-bin/text-idx?SID=ae265d7d6f98ec86fcd8640b9793a3f6&mc=true&node=pt40.23.98&rgn=div5#ap40.23.98_19.1.

LNG sourced from: GREET™ Software, GREET1_2019 Model, Argonne National Laboratory. The GREET model provides carbon content and fuel density, which are used to develop the CO_2 emission factor.

Appendix B: Default CH_4 and N_2O Emission Factors

The U.S. EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks ("EPA Inventory") provides a summary of tests that have been performed to determine CH_4 and N_2O emissions from mobile sources[4]. Annex 3, Table A-111 of the EPA Inventory lists CH_4 and N_2O emission factors by different types of onroad vehicles and control technologies (see Table B-1). Also listed is the percent of the different control technologies installed by model year of vehicle (see Tables B-3 through B-6). These two sources can be combined to determine CH_4 and N_2O emission factors by model year of vehicle as shown in Table B-2. The methodologies and sources used to derive the factors in these tables are documented in the EPA Inventory.

Table B-1: CH_4 and N_2O Emission Factors for Onroad Vehicles

	Emission Factor	
Vehicle Type/Control Technology	(g CH_4/mile)	(g N_2O/mile)
Gasoline Passenger Cars		
EPA Tier 2	0.0072	0.0048
Low Emission Vehicles	0.0100	0.0205
EPA Tier 1	0.0271	0.0429
EPA Tier 0	0.0704	0.0647
Oxidation Catalyst	0.1355	0.0504
Non-Catalyst	0.1696	0.0197
Uncontrolled	0.1780	0.0197
Gasoline Light-Duty Trucks		
EPA Tier 2	0.0100	0.0025
Low Emission Vehicles	0.0148	0.0223
EPA Tier 1	0.0452	0.0871
EPA Tier 0	0.0776	0.1056
Oxidation Catalyst	0.1516	0.0639
Non-Catalyst	0.1908	0.0218
Uncontrolled	0.2024	0.0220
Gasoline Heavy-Duty Vehicles		
EPA Tier 2	0.0297	0.0015
Low Emission Vehicles	0.0300	0.0466
EPA Tier 1	0.0655	0.1750
EPA Tier 0	0.2630	0.2135
Oxidation Catalyst	0.2356	0.1317
Non-Catalyst	0.4181	0.0473
Uncontrolled	0.4604	0.0497
Diesel Passenger Cars		
Aftertreatment	0.0302	0.0192
Advanced	0.0005	0.0010
Moderate	0.0005	0.0010
Uncontrolled	0.0006	0.0012
Diesel Light Trucks		
Aftertreatment	0.0290	0.2140
Advanced	0.0010	0.0015

[4] U.S. EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018, EPA 430-R-20-002, April 2020.

Table B-1: CH_4 and N_2O Emission Factors for Onroad Vehicles

Vehicle Type/Control Technology	Emission Factor (g CH_4/mile)	Emission Factor (g N_2O/mile)
Moderate	0.0009	0.0014
Uncontrolled	0.0011	0.0017
Diesel Medium-and Heavy-Duty Trucks and Buses		
Aftertreatment	0.0095	0.0431
Advanced	0.0051	0.0048
Moderate	0.0051	0.0048
Uncontrolled	0.0051	0.0048
Motorcycles		
Non-catalyst Control	0.0672	0.0069
Uncontrolled	0.0899	0.0087

Table B-2: Weighted Average Model Year CH_4 and N_2O Emission Factors for Onroad Vehicles

Vehicle Type/Model Year	Emission Factor (g CH_4/mile)	Emission Factor (g N_2O/mile)
Gasoline Fueled Vehicles		
Passenger Cars		
1973-1974	0.1696	0.0197
1975	0.1423	0.0443
1976-1977	0.1406	0.0458
1978-1979	0.1389	0.0473
1980	0.1326	0.0499
1981	0.0802	0.0626
1982	0.0795	0.0627
1983	0.0782	0.0630
1984-1993	0.0704	0.0647
1994	0.0617	0.0603
1995	0.0531	0.0560
1996	0.0434	0.0503
1997	0.0337	0.0446
1998	0.0240	0.0389
1999	0.0215	0.0355
2000	0.0175	0.0304
2001	0.0105	0.0212
2002	0.0102	0.0207
2003	0.0095	0.0181
2004	0.0078	0.0085
2005	0.0075	0.0067
2006	0.0076	0.0075
2007	0.0072	0.0052
2008	0.0072	0.0049
2009	0.0071	0.0046
2010	0.0071	0.0046

Vehicle Type/Model Year	Emission Factor (g CH_4/mile)	Emission Factor (g N_2O/mile)
Gasoline Fueled Vehicles		
Vans, Pickup Trucks, & SUVs		
1973-1974	0.1908	0.0218
1975	0.1634	0.0513
1976-1977	0.1594	0.0555
1978-1979	0.1614	0.0534
1980	0.1594	0.0555
1981	0.1479	0.0660
1982	0.1442	0.0681
1983	0.1368	0.0722
1984-1993	0.1294	0.0764
1994	0.1220	0.0806
1995	0.1146	0.0848
1996	0.0813	0.1035
1997	0.0646	0.0982
1998	0.0517	0.0908
1999	0.0452	0.0871
2000	0.0452	0.0871
2001	0.0412	0.0787
2002	0.0333	0.0618
2003	0.0340	0.0631
2004	0.0221	0.0379
2005	0.0242	0.0424
2006	0.0221	0.0373
2007	0.0115	0.0088
2008	0.0105	0.0064
2009	0.0108	0.0080
2010	0.0103	0.0061

Table B-2: Weighted Average Model Year CH_4 and N_2O Emission Factors for Onroad Vehicles

	Emission Factor	
Vehicle Type/Model Year	(g CH_4/mile)	(g N_2O/mile)
Gasoline Fueled Vehicles		
2011	0.0071	0.0046
2012	0.0071	0.0046
2013	0.0071	0.0046
2014	0.0071	0.0046
2015	0.0068	0.0042
2016	0.0065	0.0038
2017	0.0054	0.0018
2018	0.0052	0.0016
≤1980	0.4604	0.0497
1981-1984	0.4492	0.0538
1985-1986	0.4090	0.0515
1987	0.3675	0.0849
1988-1989	0.3492	0.0933
1990-1995	0.3246	0.1142
1996	0.1278	0.1680
1997	0.0924	0.1726
1998	0.0655	0.1750
1999	0.0648	0.1724
2000	0.0630	0.1660
2001	0.0577	0.1468
2002	0.0634	0.1673
2003	0.0602	0.1553
2004	0.0298	0.0164
2005	0.0297	0.0083
2006	0.0299	0.0241
2007	0.0322	0.0015
2008	0.0340	0.0015
2009	0.0339	0.0015
2010	0.0320	0.0015
2011	0.0304	0.0015
2012	0.0313	0.0015
2013	0.0313	0.0015
2014	0.0315	0.0015
2015	0.0332	0.0021
2016	0.0321	0.0061
2017	0.0329	0.0084
2018	0.0326	0.0082

	Emission Factor	
Vehicle Type/Model Year	(g CH_4/mile)	(g N_2O/mile)
Gasoline Fueled Vehicles		
2011	0.0095	0.0036
2012	0.0095	0.0036
2013	0.0095	0.0035
2014	0.0096	0.0034
2015	0.0096	0.0033
2016	0.0095	0.0035
2017	0.0095	0.0033
2018	0.0094	0.0031
1996-2018	0.0672	00069
1960-1995	0.0899	0.0087
Diesel Fueled Vehicles		
Passenger Cars		
2007-2018	0.0302	0.0192
1996-2006	0.0005	0.0010
1983-1995	0.0005	0.0010
1960-1982	0.0006	0.0012
Light Trucks		
2007-2018	0.0290	0.0214
1996-2006	0.0010	0.0015
1983-1995	0.0009	0.0014
1960-1982	0.0011	0.0017
Medium- and Heavy-Duty Vehicles		
2007-2018	0.0095	0.0431
1996-2006	0.0051	0.0048
1983-1995	0.0051	0.0048
1960-1982	0.0051	0.0048

Table B-3: Control Technology Assignments for Gasoline Passenger Cars

Model Years	Non-catalyst	Oxidation	EPA Tier 0	EPA Tier 1	CARB LEV	CARB LEV 2	EPA Tier 2	CARB LEV 3	EPA Tier 3
1973-1974	100%	-	-	-	-	-	-	-	-
1975	20%	80%	-	-	-	-	-	-	-
1976-1977	15%	85%	-	-	-	-	-	-	-
1978-1979	10%	90%	-	-	-	-	-	-	-
1980	5%	88%	7%	-	-	-	-	-	-
1981	-	15%	85%	-	-	-	-	-	-
1982	-	14%	86%	-	-	-	-	-	-
1983	-	12%	88%	-	-	-	-	-	-
1984-1993	-	-	100%	-	-	-	-	-	-
1994	-	-	80%	20%	-	-	-	-	-
1995	-	-	60%	40%	-	-	-	-	-
1996	-	-	40%	54%	6%	-	-	-	-
1997	-	-	20%	68%	12%	-	-	-	-
1998	-	-	<1%	82%	18%	-	-	-	-
1999	-	-	<1%	67%	33%	-	-	-	-
2000	-	-	-	44%	56%	-	-	-	-
2001	-	-	-	3%	97%	-	-	-	-
2002	-	-	-	1%	99%	-	-	-	-
2003	-	-	-	<1%	85%	2%	12%	-	-
2004	-	-	-	<1%	24%	16%	60%	-	-
2005	-	-	-	-	13%	27%	60%	-	-
2006	-	-	-	-	18%	35%	47%	-	-
2007	-	-	-	-	4%	43%	53%	-	-
2008	-	-	-	-	2%	42%	56%	-	-
2009	-	-	-	-	<1%	43%	57%	-	-
2010	-	-	-	-	-	44%	56%	-	-
2011	-	-	-	-	-	42%	58%	-	-
2012	-	-	-	-	-	41%	59%	-	-
2013	-	-	-	-	-	40%	60%	-	-
2014	-	-	-	-	-	37%	62%	1%	
2015	-	-	-	-	-	33%	56%	11%	<1%
2016	-	-	-	-	-	25%	50%	18%	6%
2017	-	-	-	-	-	14%	1%	29%	56%
2018	-	-	-	-	-	7%	-	42%	52%

Table B-4: Control Technology Assignments for Gasoline Light-Duty Trucks

Model Years	Non-catalyst	Oxidation	EPA Tier 0	EPA Tier 1	CARB LEV	CARB LEV 2	EPA Tier 2	CARB LEV 3	EPA Tier 3
1973-1974	100%	-	-	-	-	-	-	-	-
1975	30%	70%	-	-	-	-	-	-	-
1976	20%	80%	-	-	-	-	-	-	-
1977-1978	25%	75%	-	-	-	-	-	-	-
1979-1980	20%	80%	-	-	-	-	-	-	-
1981	-	95%	5%	-	-	-	-	-	-
1982	-	90%	10%	-	-	-	-	-	-
1983	-	80%	20%	-	-	-	-	-	-
1984	-	70%	30%	-	-	-	-	-	-
1985	-	60%	40%	-	-	-	-	-	-
1986	-	50%	50%	-	-	-	-	-	-
1987-1993	-	5%	95%	-	-	-	-	-	-
1994	-	-	60%	40%	-	-	-	-	-
1995	-	-	20%	80%	-	-	-	-	-
1996	-	-	-	100%	-	-	-	-	-
1997	-	-	-	100%	-	-	-	-	-
1998	-	-	-	87%	13%	-	-	-	-
1999	-	-	-	61%	39%	-	-	-	-
2000	-	-	-	63%	37%	-	-	-	-
2001	-	-	-	24%	76%	-	-	-	-
2002	-	-	-	31%	69%	-	-	-	-
2003	-	-	-	25%	69%	-	6%	-	-
2004	-	-	-	1%	26%	8%	65%	-	-
2005	-	-	-	-	17%	17%	66%	-	-
2006	-	-	-	-	24%	22%	54%	-	-
2007	-	-	-	-	14%	25%	61%	-	-
2008	-	-	-	-	<1%	34%	66%	-	-
2009	-	-	-	-	-	34%	66%	-	-
2010	-	-	-	-	-	30%	70%	-	-
2011	-	-	-	-	-	27%	73%	-	-
2012	-	-	-	-	-	24%	76%	-	-
2013	-	-	-	-	-	31%	69%	-	-
2014	-	-	-	-	-	26%	73%	1%	-
2015	-	-	-	-	-	22%	72%	6%	-
2016	-	-	-	-	-	20%	62%	16%	2%
2017	-	-	-	-	-	9%	14%	28%	48%
2018	-	-	-	-	-	7%	-	38%	55%

Table B-5: Control Technology Assignments for Gasoline Heavy-Duty Vehicles

Model Years	Uncontrolled	Non-catalyst	Oxidation	EPA Tier 0	EPA Tier 1	CARB LEV	CARB LEV 2	EPA Tier 2	CARB LEV 3	EPA Tier 3
≤1980	100%	-	-	-	-	-	-	-	-	-
1981-1984	95%	-	5%	-	-	-	-	-	-	-
1985-1986	-	95%	5%	-	-	-	-	-	-	-
1987	-	70%	15%	15%	-	-	-	-	-	-
1988-1989	-	60%	25%	15%	-	-	-	-	-	-
1990-1995	-	45%	30%	25%	-	-	-	-	-	-
1996	-	-	25%	10%	65%	-	-	-	-	-
1997	-	-	10%	5%	85%	-	-	-	-	-
1998	-	-	-	-	100%	-	-	-	-	-
1999	-	-	-	-	98%	2%	-	-	-	-
2000	-	-	-	-	93%	7%	-	-	-	-
2001	-	-	-	-	78%	22%	-	-	-	-
2002	-	-	-	-	94%	6%	-	-	-	-
2003	-	-	-	-	85%	14%	-	1%	-	-
2004	-	-	-	-	-	33%	-	67%	-	-
2005	-	-	-	-	-	15%	-	85%	-	-
2006	-	-	-	-	-	50%	-	50%	-	-
2007	-	-	-	-	-	-	27%	73%	-	-
2008	-	-	-	-	-	-	46%	54%	-	-
2009	-	-	-	-		-	45%	55%	-	-
2010	-	-	-	-	-	-	24%	76%	-	-
2011	-	-	-	-	-	-	7%	93%	-	-
2012	-	-	-	-	-	-	17%	83%	-	-
2013	-	-	-	-	-	-	17%	83%	-	-
2014	-	-	-	-	-	-	19%	81%	-	-
2015	-	-	-	-	-	-	31%	64%	5%	-
2016	-	-	-	-	-	-	24%	10%	21%	44%
2017	-	-	-	-	-	-	8%	8%	39%	45%
2018	-	-	-	-	-	-	13%	-	35%	52%

Table B-6: Control Technology Assignments for Diesel Onroad Vehicles and Motorcycles

Vehicle Type/Control Technology	Model Years
Diesel Passenger Cars and Light-Duty Trucks	
Uncontrolled	1960-82
Moderate control	1983-95
Advanced control	1996-2006
Aftertreatment	2007-2018
Diesel Medium- and Heavy-Duty Trucks and Buses	
Uncontrolled	1960-90
Moderate control	1991-2003
Advanced control	2004-2006
Aftertreatment	2007-2018
Motorcycles	
Uncontrolled	1960-95
Non-catalyst controls	1996-2018

Table B-7 shows the default CH_4 and N_2O emission factors for alternative fuel vehicles by vehicle and fuel type.

Table B-7: CH_4 and N_2O Emission Factors for Alternative Fuel Onroad Vehicles

Vehicle Type/Fuel Type	Emission Factor ($g\ CH_4$/mile)	($g\ N_2O$/mile)
Light Duty Cars		
Methanol (Flex Fuel ICE)	0.008	0.006
Ethanol (Flex Fuel ICE)	0.008	0.006
CNG (ICE)	0.082	0.006
CNG (Bi-Fuels)	0.082	0.006
LPG (ICE)	0.008	0.006
LPG (Bi-Fuels)	0.008	0.006
Biodiesel (BD100)	0.03	0.019
Light Duty Trucks		
Ethanol (Flex Fuel ICE)	0.012	0.011
CNG (ICE)	0.123	0.011
CNG (Bi-Fuels)	0.123	0.011
LPG (ICE)	0.012	0.013
LPG (Bi-Fuels)	0.012	0.013
LNG	0.123	0.011
Biodiesel (BD100)	0.029	0.021
Medium Duty Trucks		
CNG (ICE)	4.2	0.001
CNG (Bi-Fuels)	4.2	0.034
LPG (ICE)	0.014	0.034
LPG (Bi-Fuels)	0.014	0.001

Table B-7: CH_4 and N_2O Emission Factors for Alternative Fuel Onroad Vehicles

Vehicle Type/Fuel Type	Emission Factor (g CH_4/mile)	(g N_2O/mile)
LNG	4.2	0.043
Biodiesel (BD100)	0.009	0.001
Heavy Duty Trucks		
Neat Methanol (ICE)	0.075	0.028
Neat Ethanol (ICE)	0.075	0.028
CNG (ICE)	3.7	0.001
LPG (ICE)	0.013	0.026
LPG (Bi-Fuels)	0.013	0.026
LNG	3.7	0.001
Biodiesel (BD100)	0.009	0.043
Buses		
Neat Methanol (ICE)	0.022	0.032
Neat Ethanol (ICE)	0.022	0.032
CNG (ICE)	10	0.001
LPG (ICE)	0.034	0.017
LNG	10	0.001
Biodiesel (BD100)	0.009	0.043

Table B-8 shows the default CH_4 and N_2O emission factors for nonroad vehicles by vehicle and fuel type. These emission factors are based on emission factors in Table A-114 and A-115 of the EPA Inventory, which are given in terms of mass of emissions per mass of fuel combusted. The emission factors are converted to emissions per gallon of fuel using the fuel density conversions in Annex 6.5 of the EPA Inventory. Emission factors for LPG and biodiesel vehicles are assumed to be equal to gasoline and diesel vehicles, respectively.

Table B-8: CH_4 and N_2O Emission Factors for Nonroad Vehicles

Vehicle Type/Fuel Type		Emission Factor (g CH_4/gal fuel)	Emission Factor (g N_2O/gal fuel)
Ships and Boats	Residual Fuel Oil	0.55	0.55
	Gasoline (2 stroke)	9.54	0.06
	Gasoline (4 stroke)	4.88	0.23
	Diesel	0.31	0.50
Locomotives	Diesel	0.80	0.26
Aircraft	Jet Fuel	-	0.30
	Aviation Gasoline	7.06	0.11
Agricultural Equipment	Gasoline (2 stroke)	12.96	0.06
	Gasoline (4 stroke)	7.24	0.21
	Diesel	0.28	0.49
	LPG	2.19	0.39
Agricultural Offroad Trucks	Gasoline	7.24	0.21
	Diesel	0.13	0.49
Construction/Mining Equipment	Gasoline (2 stroke)	12.42	0.07
	Gasoline (4 stroke)	5.58	0.20
	Diesel	0.20	0.47
	LPG	1.05	0.41
Construction/Mining Offroad Trucks	Gasoline	5.58	0.20
	Diesel	0.13	0.49
Lawn and Garden Equipment	Gasoline (2 stroke)	15.57	0.06
	Gasoline (4 stroke)	5.84	0.18
	Diesel	0.33	0.47
	LPG	0.35	0.41
Airport Equip.	Gasoline	2.58	0.25
	Diesel	0.17	0.49
	LPG	0.33	0.41
Industrial/Commercial Equipment	Gasoline (2 stroke)	15.14	0.06
	Gasoline (4 stroke)	5.48	0.20
	Diesel	0.23	0.47
	LPG	0.44	0.41
Logging Equipment	Gasoline (2 stroke)	12.03	0.08
	Gasoline (4 stroke)	6.71	0.18
	Diesel	0.10	0.49
Railroad Equipment	Gasoline	5.78	0.19
	Diesel	0.44	0.42
	LPG	1.20	0.41
Recreational Equipment	Gasoline (2 stroke)	7.81	0.03
	Gasoline (4 stroke)	8.45	0.19
	Diesel	0.41	0.41
	LPG	2.98	0.38

Source for the emission factors in Appendix B: U.S. EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990- 2018, EPA 430-R-15-003, April 2020, Tables A-107 through A-115.