Greenhouse Gas Inventory Guidance

Direct Emissions from Mobile Combustion Source

EPA
United States
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. This includes on-road vehicles such as cars, trucks and buses, and non-road vehicles such as aircraft, ships and boats, locomotives, forklifts, and construction or agricultural equipment.

This guidance does not include GHG emissions from leakage of refrigerants from mobile air conditioning and refrigerated transport. The calculation of these fugitive emissions from mobile sources is described in the Center's guidance for Direct Fugitive Emissions from Refrigeration, Air Conditioning, Fire Suppression, and Industrial Gases.

This guidance also does not include indirect GHG emissions from fully or partially operating on-road and non-road vehicles with electricity. Because the electricity that the organization purchases to charge those vehicles will contribute to its scope 2 emissions, the methods in this document do not apply to electricity use. Refer to the Center's Indirect Emissions from Purchased Electricity guidance document for additional guidance on quantifying emissions from electricity use associated with electric vehicles (EVs), hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs). If an organization operates partially electric vehicles, such as HEVs and PHEVs, they also combust fuel, and this document can be used to quantify the emissions from their fuel consumption.

<table>
<tr><th></th><th>Included in this Guidance</th><th>Not Included in this Guidance</th></tr>
<tr><td>On-Road Vehicles</td><td>Cars, trucks, buses that consume fuel</td><td rowspan="2">Vehicles that do not consume fuel. Refer to Indirect Emissions from Purchased Electricity guidance document for guidance on quantifying emissions associated with EVs and PHEVs.</td></tr>
<tr><td>Non-Road Vehicles</td><td>Aircraft, ships, boats, locomotives, forklifts, construction and agricultural equipment that consume fuel</td></tr>
<tr><td>Refrigerants</td><td>Leakage of refrigerants from mobile air conditioning and refrigerated transport</td><td>Fugitive emissions due to leakage of refrigerants from mobile air conditioning and refrigerated transport. Calculation of these emissions are described in Direct Fugitive Emissions from Refrigeration, Air Conditioning, Fire Suppression, and Industrial Gases guidance.</td></tr>
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1.1 Scope 1 versus Scope 3 Mobile Source Emissions

This document presents 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 mobile sources.

This document covers the direct emissions from combustion of fuels and does not address the upstream emissions associated with the extraction, production, and transportation of these fuels, which are included in Scope 3, Category 3, Fuel- and energy-related activities. Other transportation-related emissions, including employee commuting, business travel, and upstream or downstream third-party transportation emissions are also considered scope 3 indirect emissions. For more information on calculating scope 3 emissions, see the EPA's Scope 3 Inventory Guidance page.

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 on-road vehicles less than 20 years old, CH_4, and N_2O emissions typically account for less than one percent of total GHG emissions. However, for older on-road vehicles, and for non-road or alternative fuel vehicles (such as a bus or trash truck using compressed natural gas), CH_4, and N_2O could be five percent or more of total GHG emissions.

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 quantifying 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 (for on-road vehicles). Emissions of these gases also vary with the efficiency and vintage of the combustion technology, as well as maintenance and 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., sustainable aviation fuel, ethanol, biodiesel) may be combusted in mobile sources independently or blended 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 be reported as biomass CO_2 emissions (in terms of total amount of biogenic CO_2) and be 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 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. Sustainable aviation fuel (SAF) is a biomass-based jet fuel that is blended with fossil jet fuel for use in aircraft. SAF ranges from 10 to 50 percent of the blend, depending on the feedstock and how the fuel is produced.[1] 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

[1] https://afdc.energy.gov/fuels/sustainable_aviation_fuel.html

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. 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 GHG 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."[2] According to the GHG Protocol, "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.

Section 2: Calculating CO_2 Emissions

Calculating CO_2 emissions involves determining the carbon content of fuel combusted using either fuel-specific information or default emission factors and applying that carbon content to the amount of fuel burned during the reporting year. 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. 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 physical quantity of fuel.

[2] 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.

Equation 3 is recommended to calculate CO_2 emissions 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.

Step 4: Calculate emissions.

Use the appropriate equation with the fuel consumption and other equation inputs to calculate the emissions of CO_2.[3]

[3] If an organization's mobile combustion emissions are significant and it has more detailed information on the vehicle models and fuel types, the organization may elect to use the tools to calculate CO_2 emissions provided by EPA's SmartWay transportation program (https://www.epa.gov/smartway).

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:

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.

Equation 4 is applicable to on-road vehicles such as cars, trucks, and buses. Equation 5 is applicable to non-road vehicles such as aircraft, ships and boats, locomotives, forklifts, and construction or agricultural equipment.

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

For on-road vehicles, gather data on the distance traveled during the reporting year, which is typically obtained from odometer readings. For non-road vehicles, gather data on the volume of fuel combusted during the reporting year, 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.

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. For GWP values, see the latest release of the EPA's GHG Emission Factors Hub. 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 on-road vehicles)
- Fuel economy (for on-road vehicles, if either fuel use or distance traveled is unavailable)
- Vehicle type
- Vehicle 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 non-road vehicles, the activity data that need to be gathered is the quantity of fuel combusted for each fuel type during the reporting year. When calculating CH_4 and N_2O emissions from on-road vehicles, the activity data needed is the distance traveled. These emissions also depend on vehicle type and model year.

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 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

$$\text{Fuel B} = \text{Fuel P} + (\text{Fuel } S_T - \text{Fuel } S_E)$$

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 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 represent fugitive methane emissions that should be accounted for separately from combustion emissions.

It is possible that organizations may only know the cost of fuels purchased. 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 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 on-road vehicles, distance traveled during the reporting year is 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 transportation 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 non-road vehicles should be calculated using actual fuel use data. CH_4 and N_2O emissions for on-road 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, but it is preferable to estimating fuel data based on the cost of fuels purchased.

The preferred method for determining fuel economy for on-road 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, on-road vehicles, and non-road 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 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 Inventory Management Plan (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 the EPA GHG Emission Factors Hub 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[4], divide energy in LHV by 0.95. For natural gas[5], 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. Table 2 of EPA's GHG Emission Factors Hub provides emission factors per unit of fuel mass or volume, which can be used with Equation 1. Table 1 of EPA's GHG Emission Factors Hub provides emission factors per unit of fuel energy content, which can be used with Equation 2 if actual heat content is known. 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.

Tables 3 through 5 of EPA's GHG Emission Factors Hub provide CH_4 and N_2O emission factors by fuel type, vehicle type and model year. These can be used with Equation 4 and Equation 5 to calculate CH_4 and N_2O emissions. If an organization has vehicles newer than the most recent model year available in the GHG Emission Factors Hub, use the most recent model year available.

It is recommended that organizations use the newest emission factors available at the time they calculate emissions for a reporting year.[6] Emission factors are based on fuel characteristics and emission control technologies for a given vehicle model year. At times, there may be changes in the methodology used to develop emission factors. These changes are noted in the GHG Emission Factors Hub. Applying these updated factors is an example of a methodology change in the organization's GHG inventory, and in such cases, prior years' emissions should be adjusted in a manner consistent with the organization's base year adjustment policy. The addition of emission factors for more recent model years and applying those to a new GHG inventory does not represent a methodology change.

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[4] Oil Information, Database documentation, page 103. 2023 Edition. International Energy Administration (IEA).

[5] Natural Gas Information, Database documentation, page 63. 2023 Edition. International Energy Administration (IEA).

[6] This applies whether an organization uses a calendar year period or other period for their GHG Inventory. For example, if an organization is calculating a GHG Inventory in August for a July through June reporting year, the inventory should use the newest factors available in August.

Section 5: Completeness

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 in 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 combustion sources, and to the Center's GHG Guidance documents for calculating emissions from other sources. Operational completeness of mobile combustion sources can be checked by comparing the sources included in the GHG inventory with those included in fleet or insurance records. Examples of types of vehicles that should be included are as follows:

- Passenger cars, vans, pickup trucks and SUVs
- Heavy-duty on-road vehicles
- Combination trucks
- Buses
- Aircraft
- Ships and boats
- Locomotives
- Forklifts
- Construction equipment
- Agricultural equipment

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 some level of uncertainty associated with all methods of calculating GHG emissions. It is recommended that organizations attempt to identify the areas of highest uncertainty in their emissions calculations and consider options for improving the quality of this data in the future.

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 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, fugitive releases, or spills. However, uncertainty may arise if only prices of fuels purchased are used to estimate fuel consumption. Uncertainty will be higher if fuel economy factors are used to estimate fuel use or distance traveled.

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 arises primarily because they are national averages and do not reflect the variability in fuel sources.

Section 7: Documentation

To ensure that emissions calculations are transparent and verifiable, the documentation sources listed in Table 1 should be maintained. These documentation sources should be collected to ensure accuracy and transparency, and should also be included in the organization's Inventory Management Plan (IMP).

Table 1: 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 cost of fuels 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 to check the accuracy of the actual data.