

Federal Greenhouse Gas Accounting and Reporting Guidance

Technical Support Document

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1.0 Introduction

On October 5, 2009, President Obama signed Executive Order (E.O.) 13514 (74 Federal Register 52117) to establish an integrated strategy for sustainability throughout the Federal Government and to make reduction of greenhouse gas (GHG) emissions a priority for Federal agencies. Among other provisions, E.O. 13514 requires agencies to “measure, report, and reduce their greenhouse gas emissions from direct and indirect activities.” Section 9 of E.O. 13514 directs the Department of Energy’s (DOE’s) Federal Energy Management Program (FEMP)—in coordination with the Environmental Protection Agency (EPA), Department of Defense, General Services Administration (GSA), Department of the Interior, Department of Commerce, and other agencies as appropriate—to develop recommended Federal GHG reporting and accounting procedures.

This is a technical support document (TSD) that accompanies the Federal Greenhouse Gas Accounting and Reporting Guidance (or Guidance).¹ This document provides detailed information on the inventory reporting process and accepted calculation methodologies.

The Federal Government seeks to continually improve both the quality of data and methods necessary for calculating GHG emissions. Over time, and as required by E.O. 13514, additional requirements, methodologies, and procedures will be included in revisions to this document to improve the Federal Government’s overall ability to accurately account for and report GHG emissions.

The Guidance and supporting TSD are not designed for quantifying the reductions from individual GHG mitigation projects, nor do they include strategies for reducing GHG emissions.²

While all final reporting must be accomplished through the GHG Reporting Portal, agencies are not precluded from using other agency-specific tools to assist them in better managing and maintaining data necessary to develop and submit inventories. However, agencies must ensure that any agency-specific tools are appropriately aligned with this Guidance and the TSD.

Agency-specific tools may include, but are not limited to:

- Headquarters-level, “top-down” data entry, calculation, aggregation, and analysis
- Facility-level, “bottom-up” data acquisition, entry, calculation and/or management
- Emission category/source data acquisition, calculation and/or analysis
- Project-level data capture, calculation, and analysis.

If other GHG calculation tools are used, agencies should ensure that they conform to the methods and procedures described in this section and in the TSD. Because different tools may produce dissimilar results depending on the calculation methodologies used, agencies should evaluate

¹ Federal Greenhouse Gas Accounting and Reporting Guidance revised June 2012, http://www.whitehouse.gov/sites/default/files/microsites/ceq/revised_federal_greenhouse_gas_accounting_and_reporting_guidance_060412.pdf.

² The only emission reduction strategy discussed is the use of renewable energy purchases, including renewable energy credits (RECs), because of their unique GHG accounting and reporting issues.

their calculation tools carefully prior to use and ensure that they are consistent with the methods used in the GHG Reporting Portal.

1.1. Overview of the Technical Support Document

The remaining chapters of the TSD cover the following topics:

Chapter 2: Reporting GHG Emissions

- Outlines Federal GHG reporting approach and the GHG Reporting Portal
- Describes qualitative information for reporting.
- Summarizes required and voluntary quantitative information for reporting.
- Summarizes use of emission factors as applied throughout the TSD.

Appendix A: Calculating Scope 1 Emissions

- Establishes “default” and “advanced” methodologies and data inputs for calculating Scope 1 emissions.

Appendix B: Calculating Scope 2 Emissions

- Establishes “default” and “advanced” methodologies and data inputs for calculating Scope 2 emissions.

Appendix C: Calculating Scope 3 Emissions

- Establishes “default” and “advanced” methodologies and data inputs for calculating specified Scope 3 emissions.

Appendix D: Emission and Conversion Factors

- Provides emission and conversion factors used in calculation of Scope 1, 2, and 3 emissions.

Appendix E: Acronyms and Abbreviations

2.0 Reporting GHG Emissions

This chapter summarizes the GHG reporting process, qualitative and quantitative data requirements, and use of emission factors. Supporting appendices provide methodologies and emission factors necessary to calculate GHG emissions. The reporting process is covered in detail in Chapter 5 of the main Guidance document.

2.1. Reporting Qualitative Content

The GHG inventory reporting content can be broken down into qualitative and quantitative emissions inventory data. This section includes the qualitative information that agencies must report through the GHG Reporting Portal and qualitative statement. These requirements are summarized in Table 2-1 and explained below.

Table 2-1: GHG Inventory Qualitative Reporting Requirements

Qualitative Reporting Category	Required Information
Agency Reporting Points of Contact (POCs)	<ul style="list-style-type: none"> • Agency • POC information of agency staff responsible for the GHG inventory
Reporting Period Information	<ul style="list-style-type: none"> • Fiscal year • Number of employees, on-site contractors, and/or visitors • Number of square feet for goal-subject (GS) and goal-excluded (GE) buildings³
Allowable Exclusions from the Target ⁴	<ul style="list-style-type: none"> • Emission sources excluded from the target • Justification for excluded emissions
Inventory Calculations for Current Reporting Year	<ul style="list-style-type: none"> • Emission categories inventoried • Data sources and uncertainty in data quality • Tools and calculation methodologies used, if applicable
Changes in GHG Inventory	<ul style="list-style-type: none"> • Description of changes since prior reporting period • Anticipated future changes in inventory
Verification and Validation	<ul style="list-style-type: none"> • Documentation of inventory development process, data collection procedures, and points of contact as described in Section 6.1 of the Guidance • Description of verification and validation process, including the process for identifying and correcting errors • Known or potential double-counting • Second- or third-party verifier, if applicable

³ Given the intent of combined energy and GHG reporting, this required information aligns with existing FEMP Energy Report guidance on the determination of energy GS and GE buildings. This includes leased space where the agency directly pays for the utilities. Further information on determination of GE buildings can be accessed at www1.eere.energy.gov/femp/pdfs/exclusion_criteria.pdf.

⁴ These are emissions excluded from GHG targets; they are not excluded from comprehensive inventory reporting requirements.

Qualitative Reporting Category	Required Information
Other Information	<ul style="list-style-type: none"> • Other information as necessary to explain report

Agency Reporting POC

Although each agency’s Senior Sustainability Officer is ultimately responsible for submitting the agency GHG inventory and certifying its accuracy, designated agency staff serving as POCs are responsible for addressing general and technical questions regarding the agency's GHG inventory.

Reporting Period Information

Identify the fiscal year of the data reported. Agencies will report how many employees, on-site contractors, and/or visitors they have to facilitate data analysis and normalization. These data may also be necessary, depending on which calculation methodologies an agency chooses to adopt. Facility square footage data, which is already reported for energy reporting, will likewise facilitate data normalization and analysis.

It is important to recognize that while E.O. 13514 excludes certain sources of Federal GHG emissions from agency GHG emissions reduction targets, these exclusions do not apply to agency comprehensive GHG inventories. Whereas an agency’s target may exclude, “direct emissions from excluded vehicles and equipment and from electric power produced and sold commercially to other parties in the course of regular business,” these sources are not excluded from the agency’s inventory.

Inventory Calculations for the Current Reporting Year

For each emissions category, the agency must describe the following:

- Whether the emissions category is currently excluded from agency GHG reduction targets
- Sources of data used
- Any uncertainty in data quality, including potential errors or omissions in the data⁵
- Any additional tools or methodologies utilized for advanced methodology or voluntary reporting.

Changes in GHG Inventory

Agencies must include the degree to which the following potential changes from the prior reporting year have impacted their inventory, and should explain the key reasons for these changes:⁶

⁵ Both the utility and accuracy of a GHG emissions report depend on the quality of the data available. Agencies should give particular attention to any data problems, including missing data, means used to evaluate data quality, and procedures used to ensure data accuracy.

⁶ For FY 2010 reporting, agencies should compare to their FY 2008 inventory, where applicable.

1. Changes in calculation or estimation methods: Where an agency chooses to use an advanced methodology, it must indicate which one it applied. Because any changes in methodology from year to year can affect the accuracy of the emissions estimate, the agency must indicate whenever calculation methodologies change and estimate the impact of that change. If an agency wants to employ a different methodology from that stipulated in the main Guidance document or this TSD, the agency must first discuss it with Council on Environmental Quality (CEQ) and the Office of Management and Budget (OMB). Note that estimation method changes may require base year and intervening year recalculations as stipulated in item 3 below.
2. Changes in organizational boundary: Describe how the list of exclusions and exemptions reported, as well as other factors, may have changed the agency's organizational boundary. Note that organizational boundary changes may require base year and intervening year recalculations as stipulated in item 3 below.
3. Base year and subsequent year recalculation: Summarize changes in base year and subsequent year calculations.⁷ Agencies may also describe how any adjustments to emission factors, especially Emissions and Generation Resource Integrated Database (eGRID) output emission rates, affected their past inventories, if warranted.⁸
4. Other changes in emissions: Agencies may summarize other changes in emissions that did not trigger a base year recalculation.
5. Anticipated changes for next reporting period: Indicate any known or anticipated changes in organizational boundaries in future years that may affect the inventory. For instance, long-term or temporary planned changes in an agency's mission or operations may significantly impact GHG emissions. Agencies should report such changes to the extent they consider them relevant to understanding the high-level summary and trends of emissions reported.

Verification and Validation

As part of their qualitative statement, agencies should accurately describe the steps taken to develop the inventory, document the processes used to collect the inventory data, and include points of contact. In the qualitative report, agencies must discuss their approach for verification and validation, and whether any change is foreseen in this approach for the next reporting year. Agencies must also identify and acknowledge any known or potential double-counting within their inventory. If an agency used second- or third-party verification, the verifier's contact information must be listed. See Chapter 6 of the main Guidance document for more information on verification and validation.

⁷ Agencies may consider recalculating annual or baseline inventories when significant changes within a given scope occur. Consult CEQ to determine whether a recalculation is warranted. See Section 5.3.1 in the Guidance for further detail.

⁸ Agencies should not recalculate base year or annual inventories when the emission factors that were available at the time of inventories are subsequently updated. For example, FY 2008 base year inventories should not be recalculated to adjust for updates to eGrid subregion factors released in FY 2011.

2.2. Quantitative Inventory Data Requirements

Agencies must report activity data inputs and/or GHG emissions for each emissions category through the GHG Reporting Portal. For most categories, agencies may choose between the default and an advanced methodology. In determining which methodology is most appropriate an agency should consider what data are available and how the methodology will impact tracking progress year-on-year towards meeting GHG reduction targets.

This section lists the default data elements for reporting Scope 1, 2, and 3 emissions, biogenic carbon dioxide (CO₂) emissions for Scope 1, 2, and 3 activities, and voluntary reporting.⁹ Data reported by the agency must be summed to the highest level within the agency to encompass all operating units. Agencies must maintain records of the underlying data inputs that feed into the agency-level GHG inventory. The GHG Reporting Portal will maintain records for each year reported, including the chosen GHG methodology (default or advanced) for each year and the resulting GHG emissions. The sum of carbon dioxide equivalent (CO₂e) emissions will be calculated for each emissions category and maintained over time.

Required Scope 1 Data

Agencies must report all direct GHG emissions from sources that are owned or controlled by the Federal agency within this scope. It is important to recognize that while E.O. 13514 excludes certain sources of Federal GHG emissions from agency GHG emissions reduction targets, these exclusions do not apply to agency comprehensive GHG inventories. Whereas an agency's target may exclude, "direct emissions from excluded vehicles and equipment and from electric power produced and sold commercially to other parties in the course of regular business," these sources are not excluded from the agency's inventory. Agencies must report Scope 1 emissions in four major categories: stationary combustion, mobile combustion, fugitive emissions, and process emissions. Agencies that do not have any process emissions must provide a statement that emissions in that category do not apply to them.

Stationary and Mobile Combustion

All agency Scope 1 stationary and mobile combustion emissions data must be reported in units as indicated in the "Default Data" column of Table 2-2. Agencies must report the fuel use and total of each GHG emitted if using the advanced method for mobile sources.¹⁰ Because agencies will also be using the GHG Reporting Portal for FEMP energy reporting, they must report emissions from GS energy, GE energy, non-fleet vehicles and equipment (VE), and fleet vehicles separately, according to the definitions previously established under the Energy Policy Act (EPA) of 2005, E.O. 13423, and the Energy Independence and Security Act (EISA).

⁹ It is recognized that not all required data elements will be available. In such cases, agencies must utilize proxy data to estimate values for the required elements. Agencies must detail the methodologies used for proxy data calculations in their inventory reports.

¹⁰ For each category using an advanced method, agencies will report the energy activity data and the calculated total quantity of CO₂, CH₄, N₂O, HFCs, PFCs, and SF₆ in metric tons, respectively.

Table 2-2: Data Needed for Required Reporting: Scope 1 Emissions from Stationary and Mobile Combustion

Emissions Category	Default Data	Current Reporting	Advanced Methodology Available?
Stationary Combustion (agency-owned and -controlled heat and steam)	<ul style="list-style-type: none"> GS and GE for natural gas Volume [KCUFT] or energy content [BBtu] 	<ul style="list-style-type: none"> FEMP Energy Report¹¹ 	No
	<ul style="list-style-type: none"> GS and GE for fuel oil, gasoline, and liquefied petroleum gases (LPG)/propane Volume [KGal] or energy content [BBtu] 	<ul style="list-style-type: none"> FEMP Energy Report 	No
	<ul style="list-style-type: none"> GS and GE for coal and other municipal solid waste (MSW) Mass [short tons] or energy content [BBtu] 	<ul style="list-style-type: none"> FEMP Energy Report 	No
	<ul style="list-style-type: none"> GS and GE for biofuels and biomass Volume [KCUFT or KGal], mass [short tons], and/or energy content [BBtu] 	<ul style="list-style-type: none"> FEMP Energy Report 	No
Mobile Fossil Fuel (agency-owned and -controlled vehicles, aircraft, etc.)	<ul style="list-style-type: none"> Fleet and VE for compressed natural gas (CNG), gasoline, diesel, LPG/propane, aviation gas, jet fuel, navy special, and other Gasoline Gallon Equivalent [GGE], Volume [KGal or KCUFT], and/or energy content [BBtu] 	<ul style="list-style-type: none"> Federal Automotive Statistical Tool (FAST) system FEMP Energy Report 	Yes
	<ul style="list-style-type: none"> Fleet and VE for ethanol and biodiesel blends, such as E85, biodiesel (B20), and biodiesel (B100) Biofuel content (such as % ethanol) Volume [KGal] or energy content [BBtu] 	<ul style="list-style-type: none"> FAST system FEMP Energy Report 	Yes

Required Biogenic Emissions Reporting

Biogenic CO₂ emissions are generated during the combustion of biofuels and biomass. For the fiscal year (FY) 2008 base year and annual inventories, agencies must clearly identify Scope 1, 2, and 3 activities’ CO₂ emissions associated with the biogenic portion of biofuel and biomass combustion. These biogenic emissions are not subject to agency reduction targets at this time. Agencies are required to account for and report the biogenic CO₂ emissions generated by these combustion activities, where data are available. However, it is important that biogenic CO₂ emissions from Scope 1, 2, and 3 activities’ are clearly identified and accounted for separately

¹¹ For consistency with existing FEMP Energy Report guidance, Scope 1 and 2 categories utilizing the energy-related activity data in their native energy reporting units (e.g., Thousand Cubic Feet [KCUFT], Billion Btu [BBtu], Thousand Gallons[KGal], etc.) rather than more common units (e.g., [SCF], [MMBtu], [Gal], etc.).

within agency’s inventory.¹² Agencies using advanced methodologies should ensure they calculate and report biogenic emissions in those categories, as applicable.

Beginning in FY 2013, agencies are required to report net carbon stock changes on forest land. Refer to Section A.9 for more information.

Fugitive Emissions

All agency Scope 1 fugitive emissions data must be reported in units as indicated in the “Default Data” column of Table 2-3. If advanced methodologies are used, the agency Scope 1 fugitive emissions must be reported in metric tons (MT) for each GHG emitted.

Table 2-3: Data Needed for Required Reporting: Scope 1 Fugitive Emissions

Emissions Category	Default Data	Current Reporting	Advanced Methodology Available?
Fluorinated Gases (F-gases): hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF ₆)	<ul style="list-style-type: none"> • Mixed refrigerant and/or F-gas material type • Amount charged or issued [lb] • Amount returned to the supply system, including recovered from equipment [lb] 	<ul style="list-style-type: none"> • Facility Title VI reporting materials • Procurement records • Facility hazardous material management 	Yes
On-Site Wastewater Treatment	<ul style="list-style-type: none"> • Population served (includes employees, on-site contractors, and visitors) • Type of wastewater treatment system 	<ul style="list-style-type: none"> • Facility human resource records • Facility security records 	Yes
On-Site Landfill/MSW	<ul style="list-style-type: none"> • Landfill open date • Landfill close date • Total mass of MSW disposed on-site [short tons] • Past waste disposal 	<ul style="list-style-type: none"> • Facility Title V reporting materials • E.O.s 13423 and 13514 solid waste and diversion reporting 	Yes

¹² Due to ongoing analysis, efforts to collect and synthesize data, and the development of accounting approaches that will appropriately reflect the true atmospheric impact of biogenic emissions, agencies are not required to include these emissions in their reduction targets under E.O. 13514 at this time, but agencies are required to inventory their biogenic GHG emissions. Part or all of the carbon in these fuels is derived from material that was fixed by biological sources on a relatively short timescale. Depending on the full emissions impact of biomass production and use, these emissions may or may not represent a net change in atmospheric CO₂. This contrasts with carbon from fossil fuels, which was removed from the atmosphere millions of years ago.

Emissions Category	Default Data	Current Reporting	Advanced Methodology Available?
Other Fugitive Emissions	<ul style="list-style-type: none"> Agency- and facility-specific data required 	<ul style="list-style-type: none"> Facility Title V, GHG Reporting Program (GHGRP), and/or Emergency Planning and Community Right-To-Know Act (EPCRA) reporting 	Yes

Process Emissions

All agency Scope 1 process emissions must be reported in MT for each GHG type emitted. There are no default methodologies for process emissions because they are site- and/or process-specific. Instead, Appendix A.8 lists methodology references for specific types of process emissions. If agencies have process emissions to which the list of methodology references does not apply, they may consult with CEQ and OMB to identify an appropriate methodology. Agencies are encouraged to use available data and document methodologies applied to estimate fugitive or process emissions.

Some agencies may find that supporting data on their process emissions are already used to prepare their reports under the Clean Air Act (CAA) Title V, EPA’s GHGRP, EPCRA 313 (Toxic Release Inventory), and other programs. Agencies are encouraged to leverage data directly from their existing regulatory compliance data collection and calculation efforts, as appropriate.

Agencies may voluntarily report additional Scope 1 emissions resulting from unique activities that do not currently have a methodology in the TSD. Voluntary reporting refers to the reporting of emissions that do not currently have a specified calculation methodology in the TSD, or are not otherwise identified as required for reporting purposes in the Guidance. Agencies may report emissions for these voluntary items, but must clearly identify them and provide documentation for calculation methods used in the submission of the agency’s inventory. For example, agencies may voluntarily report non-covered GHGs with high global warming potentials, such as nitrogen trifluoride.

Required Scope 2 Data

Agencies must report emissions in five major categories: purchased electricity, purchased steam, purchased hot water or chilled water, purchased combined heat and power, and waste-to-energy purchased steam. When reporting combined heat and power, agencies must use the appropriate method, which depends on whether it purchased electricity, steam, and/or hot water. All agency

Scope 2 emissions data must be reported in units as indicated in the “Default Data” column of Table 2-4.

Table 2-4: Data Needed for Required Reporting: Scope 2 Emissions

Emissions Category	Default Data	Current Reporting	Advanced Methodology Available?
Purchased Electricity	<ul style="list-style-type: none"> GS and GE electricity consumed [megawatt hour, MWh] by eGRID subregion and U.S Territory 	<ul style="list-style-type: none"> FEMP Energy Report* 	No
Purchased Steam, Hot Water, or Chilled Water	<ul style="list-style-type: none"> Steam and hot water consumed [BBtu] Cooling demand [BBtu or Ton Hours] 	<ul style="list-style-type: none"> FEMP Energy Report 	Yes
Combined Heating and Power	<ul style="list-style-type: none"> GS and GE electricity consumed [MWh] by eGRID subregion Steam or hot water consumption [BBtu] 	<ul style="list-style-type: none"> FEMP Energy Report[†] 	Yes
Purchased Steam from Waste to Energy	<ul style="list-style-type: none"> Steam consumed [BBtu] Default eGRID derived emission factors 	<ul style="list-style-type: none"> FEMP Energy Report 	Yes
Renewable Energy Purchases and RECs Purchases	<ul style="list-style-type: none"> Renewable energy, or RECs, purchased [MWh] eGRID subregions in which the renewable energy was generated Generator on- or off-agency site and whether on the agency side of meter, separately metered, or off grid 	<ul style="list-style-type: none"> FEMP Energy Report[†] 	No

* Requires new level of disaggregated data for eGRID subregion.

† Requires new source location information for eGRID subregion level.

Agencies must track and report the requisite data separately for each calculation methodology.¹³ For purchased electricity, data must be reported separately for each eGRID subregion and U.S. Territory, and emissions will be calculated by the GHG Reporting Portal using the most current eGRID subregion output emission rate factors available at the time for each reporting year. Because agencies will also be using the GHG Reporting Portal for FEMP energy reporting, they must report GS and GE energy separately according to the definitions previously established under EAct 2005, E.O. 13423, and EISA.

FEMP will use the same data classifications as existing Federal energy reporting to the extent possible. If agencies utilize the default category, the GHG Reporting Portal will use the reported activity data to automatically calculate emissions for each of the six respective types of GHGs separately and express the total in MT CO₂e. Otherwise, the data entered into the advanced

¹³ Agencies that produce power for facilities collocated with power production facilities may develop their own emission factors. This allowance recognizes that agencies in this situation would require a unique determination of transmission and distribution (T&D) losses. FEMP will work with agencies in these situations to avoid double counting.

methodology categories should consist of both the energy used and the MT for each GHG emitted.

Renewable Energy and RECs

Agencies must separately report purchased renewable energy, including RECs, that are being applied to reduce agency Scope 2 electricity use. Reporting must be consistent with existing renewable energy guidance and Chapter 4 of the Guidance document. Agencies must provide the following information related to all RECs purchased:

- Source/type
- Location or eGRID subregion of the energy generation project producing the REC
- Amount of renewable energy associated with the REC [MWh or BBTu]
- If the generator is on site, the data needed for EISA energy reporting and GHG calculation include, identifying whether the generator is on the agency side of the meter, separately metered, or off-grid.

The eGRID subregion non-baseload output emission rate factors will be used in the GHG Reporting Portal, so the total MT CO₂e of each REC purchased can be automatically calculated.

Required Scope 3 Data

Because efforts to account for Scope 3 emissions are new, and recognized methods for calculating emissions are just emerging, the Guidance utilizes a phased approach to inclusion of Scope 3 emissions in agency inventories. Initial efforts focus on accounting for Scope 3 emission categories for which reliable and accessible data are available for estimating emissions, and for which more detailed calculation methodologies have been established. The key is to continually improve Scope 3 data quality. Over time, new methodologies and procedures may be included in revisions to the TSD to improve the Federal Government's ability to account for and report GHG emissions through the inventory process. Examples of areas that may be added over time include emissions from the following:

- Operations associated with leased space,
- Vendors, contractors and supply chain,
- Production of fuels (biofuels, gasoline, hydrogen, etc.) used to operate combustion vehicles.

Beginning with the FY 2008 base year and FY 2010 reporting, agencies must also report emissions for those Scope 3 categories where the agency quantified a baseline (in terms of MT CO₂e) in their Scope 3 target.¹⁴

Scope 3 categories included in the FY 2008 base year, FY 2010, and future annual inventories include the following:

¹⁴ Base year inventories should be provided for all of emission categories reported. Refer to Chapter 5.3 of the Guidance for more information on calculating base year inventories when FY 2008 data is not available.

- Federal employee business air travel
- Federal employee business ground travel
- Federal employee commuting
- Contracted solid waste disposal (MSW that is sent to a landfill not owned or operated by the agency)
- Contracted wastewater treatment (Municipal wastewater that is sent to a wastewater treatment plant (WWTP) not owned or operated by the agency)
- T&D losses associated with purchased electricity.¹⁵

The TSD provides the calculation methodologies for each of these emission categories.

All agency Scope 3 emissions data must be reported in units as indicated in the “Default Data” column of Table 2-5. For business air travel, agencies may coordinate with GSA to report data into the GSA Travel Management Information Service (MIS) tool or with their travel agent to obtain employee air travel data through other means (see Appendix C.4 for additional detail). For ground business travel (such as rail, bus, and/or rental vehicle), agencies should coordinate with their travel agents and accounting departments to determine data availability (Table 2-5). Information on commuter travel should come from agency- or site-specific commuter surveys using the default methodology.

For contracted solid waste, the default methodology in the GHG Reporting Portal will use the tons disposed of and the default values provided in Appendix C.3.1. Agencies may alternatively coordinate with their waste contractors for site-specific emission factors. For contracted wastewater treatment, the GHG Reporting Portal will use the number of employees served and the default values provided in Appendix C for the default methodology. Agencies may alternatively coordinate with their facility-level providers for the variables necessary to calculate advanced emission estimates. T&D losses from purchased electricity will be automatically calculated in the GHG Reporting Portal because emissions are based on the emission factors for Scope 2 data already submitted.

Table 2-5: Data Needed for Scope 3 Emissions Reporting

Emissions Category	Default Data	Current Reporting	Advanced Methodology Available?
Federal Employee Business Air Travel	<ul style="list-style-type: none"> • Passenger Name Record (PNR) from Travel Agent sent to GSA 	<ul style="list-style-type: none"> • PNRs currently submitted to GSA • Agency Travel Reporting 	No
T&D Losses	<ul style="list-style-type: none"> • Purchased electricity [MWh] by eGRID subregion 	<ul style="list-style-type: none"> • FEMP Energy Report 	No

¹⁵ Emissions associated with T&D losses from purchased steam, hot water, and chilled water are categorized as Scope 2 emissions.

Emissions Category	Default Data	Current Reporting	Advanced Methodology Available?
Contracted MSW Disposal	<ul style="list-style-type: none"> MSW disposed [short tons] 	<ul style="list-style-type: none"> E.O. 13423 & E.O. 13514 Solid Waste and Diversion Reporting 	Yes
Federal Employee Business Ground Travel	<ul style="list-style-type: none"> Mode of transportation Distance-traveled data, in miles 	<ul style="list-style-type: none"> Agency Travel Reporting 	Yes
Federal Employee Commuting	<ul style="list-style-type: none"> Mode of transportation Agency average number of commuting days (by mode) Roundtrip distance (by mode) [mi] 	<ul style="list-style-type: none"> No current reporting 	No
Contracted Wastewater Treatment	<ul style="list-style-type: none"> Number of employees served 	<ul style="list-style-type: none"> No current reporting 	Yes

See Chapter 2.2.3 of the main Guidance document for more information.

Voluntary Scope 3 Reporting

Agencies may voluntarily report additional Scope 3 emissions resulting from unique activities that do not currently have a methodology in the TSD. Voluntary reporting refers to the reporting of emissions that do not currently have a specified calculation methodology in the TSD, or are not otherwise identified as required for reporting purposes in the Guidance. Agencies may report emissions for these voluntary items, but must clearly identify them and provide documentation for calculation methods used in the submission of the agency’s inventory. Some examples of such activities include emissions associated with the following:

- Fully serviced leased space
- Visitors to Federal sites (e.g., National Parks)
- Third-party oil, gas, and coal mine leasing activities
- Enteric fermentation, when releases occur from livestock not owned by an agency, but occur on Federal land
- Manure management systems, when the systems exist on Federal land, but are operated by others
- Composting process when on Federal land, but are operated by others
- Nitrous oxide (N₂O) from fertilizer application on cropland when used on Federal land, but under operation by others.

For voluntary reporting of fully serviced leased space, beginning with the FY 2012 reporting year, FEMP has provided a “Full Service Leased Space Scope 3 Emissions” Excel workbook. The procedures used in this workbook are outlined in Section C.7.

For other voluntary categories, to the extent possible, agencies should use methodologies that are commonly accepted. This approach promotes consistent calculations that may be of use for emission categories that become required reporting in future years. If an agency reports emissions in a category where no commonly accepted methodology is available, it must document and submit the calculation methodologies used as part of its annual inventory. Over time, new methodologies will be included in revisions to this document to improve the Federal Government’s ability to account for and report Scope 3 emissions. Beginning with the FY 2012 reporting year, the GHG Reporting Portal includes a tab for reporting voluntary Scope 3 categories.

2.3. Emission and Conversion Factors

To ensure accurate GHG inventories, appropriate emission and conversion factors must be applied consistently across the government. This section describes the factors used in the calculation methodologies presented in the TSD. As necessary, this document will be revised to incorporate the most accurate calculation methodologies and emission factors available.

Emission Factor and Calculation Methodology Selection

Emission factors and methodologies referenced in this document were selected because of their applicability to Federal operations, technical authority, and acceptance in other GHG reporting programs. The calculation methods and emission factors were leveraged from existing GHG regulatory and voluntary inventory protocols, with the EPA GHGRP given top priority when applicable, followed by other Federal sources. Emission factors and methodologies were selected from the following sources:

1. EPA, GHGRP, *Federal Register*, October 30, 2009, see www.epa.gov/climatechange/emissions/ghgrulemaking.html.
2. EPA, *Climate Leaders Program, Technical Guidance*, see www.epa.gov/stateply/resources/index.html.
3. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, see www.epa.gov/climatechange/emissions/usinventoryreport.html.
4. EPA, *eGRID Technical Support Document, Chapter 3*, see www.epa.gov/egrid.
5. DOE, *1605(b) Voluntary Reporting of Greenhouse Gases Program, Technical Guidelines*, see www.eia.doe.gov/oiaf/1605/gdlins.html, www.eia.doe.gov/oiaf/1605/ggrpt/index.html, and www.eia.doe.gov/oiaf/1605/emission_factors.html.
6. Energy Information Administration (EIA), *Emissions of Greenhouse Gases in the United States*, Documentation and Emission Factors, see www.eia.doe.gov/oiaf/1605/ggrpt/documentation/pdf/0638%282006%29.pdf and www.eia.doe.gov/environment.html.

7. International Panel on Climate Change (IPCC), *2006 Guidelines for National Greenhouse Gas Inventories*, see www.ipcc-nggip.iges.or.jp/public/2006gl/vol1.html.

For emission factors other than those for Scope 2 purchased electricity, agencies may develop activity-specific or local emission factors.¹⁶ This is particularly applicable where on-site operators are familiar with the operating conditions and equipment characteristics. Examples include combined heat and power facilities that generate electricity, steam, and/or hot water; and waste-to-energy plants. Agencies must fully document the justification and methodology for developing emission factors not provided in the TSD.

Agencies may also substitute emission factors in the TSD with data from their operations utilizing continuous emissions monitoring equipment.

Emission and Conversion Factor Sources

Table 2-6 summarizes emission and conversion factor sources used throughout this TSD.

Table 2-6: Emission and Conversion Factor Sources

Applicable Scope	Emissions Categories	Factor Type	Default Methodology Emission Factor Source	Emission Factor Applies to Advanced Methodology?
All scopes	All emission categories	Global warming potentials (100-year)	EPA GHGRP, Table A-1 to Subpart A of Part 98	Yes
		General conversion factors	EPA GHGRP, Table A-2 to Subpart A of Part 98	Yes
		GGE conversion factors	E.O. 13514, Guidance for Federal Agencies on E.O. 13514 Section 12 - Federal Fleet Management	Yes
Scope 1 (including biogenic)	Stationary combustion (agency-owned and -controlled heat and steam)	CO ₂ emission factors and High Heat Values (HHVs) for various types of fuel	EPA GHGRP, Table C-2 to Subpart C of Part 98	Yes
		Methane (CH ₄) and N ₂ O emission factors for various types of fuel	EPA GHGRP, Table C-1 to Subpart C of Part 98	Equipment-specific
	Mobile combustion (agency-owned)	CO ₂ emission factors and HHVs for various types of fuel	EPA GHGRP, Table C-1 to Subpart C of Part 98	Yes

¹⁶ Local emissions factors may not be used in mandatory, domestic, electricity reporting or voluntary reporting of international emissions that are included in reduction targets. Local emission factors may be used in voluntary reporting of international emissions that are not included in reduction targets. In these cases, agencies must document the source and justification for the factors used in their qualitative statement.

Applicable Scope	Emissions Categories	Factor Type	Default Methodology Emission Factor Source	Emission Factor Applies to Advanced Methodology?
	and -controlled vehicles, airplanes, etc.)	CH ₄ and N ₂ O emission factors for various types of fuel	EPA Climate Leaders, Mobile Sources Guidance, Table A-1	Vehicle-specific
	Fugitive F-Gas Emission Factors	Default F-Gas Emission Factors for Refrigeration/Air Conditioning Equipment	EPA Climate Leaders Direct HFC and PFC Emissions from Use of Refrigeration and Air Conditioning Equipment, Table 2	Yes
Scopes 1 and 3	Landfill/MSW	Emission model equation defaults	EPA GHGRP, Table HH-1 to Subpart H of Part 98 and Landfill Gas Emissions Model (LandGEM)	Yes, site-specific*
	Wastewater treatment	CH ₄ emission factors/model	EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks	Yes, site-specific*
Scope 2	Purchased electricity	CO ₂ , CH ₄ , and N ₂ O emission factors by eGRID subregion	EPA, eGRID Output Emission Rate Summary Tables and DOE 1605(b) Emission Factors	N/A
	Purchased steam or hot water	CO ₂ , CH ₄ , and N ₂ O emission factors	DOE 1605(b), Technical Guidelines, Part F: Indirect Emissions	No, plant-specific [†]
	Chilled water	CO ₂ , CH ₄ , and N ₂ O emission factors	DOE 1605(b), Technical Guidelines, Part F: Indirect Emissions and Appendix N	No, plant-specific [†]
	Combined heating and power	Electricity, steam, and hot water CO ₂ , CH ₄ , and N ₂ O emission factors	EPA, eGRID Output Emission Rate Summary Tables and DOE 1605(b), Technical Guidelines	No, plant-specific [†]
	Purchased steam from waste-to-energy	Steam CO ₂ , CH ₄ , and N ₂ O emission factors	EPA, eGRID Derived	No, plant-Specific [†]
	Renewable energy purchases	CO ₂ , CH ₄ , and N ₂ O emission factors by eGRID subregion	EPA, eGRID Emission Rate Summary Tables	Yes

Applicable Scope	Emissions Categories	Factor Type	Default Methodology Emission Factor Source	Emission Factor Applies to Advanced Methodology?
Scope 3	Business air travel	Custom air travel CO ₂ , CH ₄ , and N ₂ O emission factor model	EPA, Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport	GSA Travel MIS
	T&D losses	Loss factors	EPA eGRID and DOE 1605(b), Technical Guidelines	N/A
	Ground business travel	Vehicle CO ₂ , CH ₄ , and N ₂ O emission factors	EPA Climate Leaders, Optional Emissions Guidance	Yes
	Commuter travel	Public Transit CO ₂ , CH ₄ , and N ₂ O emission factors		Yes

* Emission factors used for this methodology are the same as those for the default methodology, in addition to site-specific variables.

† Emission factors used for this methodology are not the same as those for the default methodology, but must be generated by the user or obtained from the utility provider.

Scope 2 Output Emission Rate Factors and Reporting by eGRID Subregion

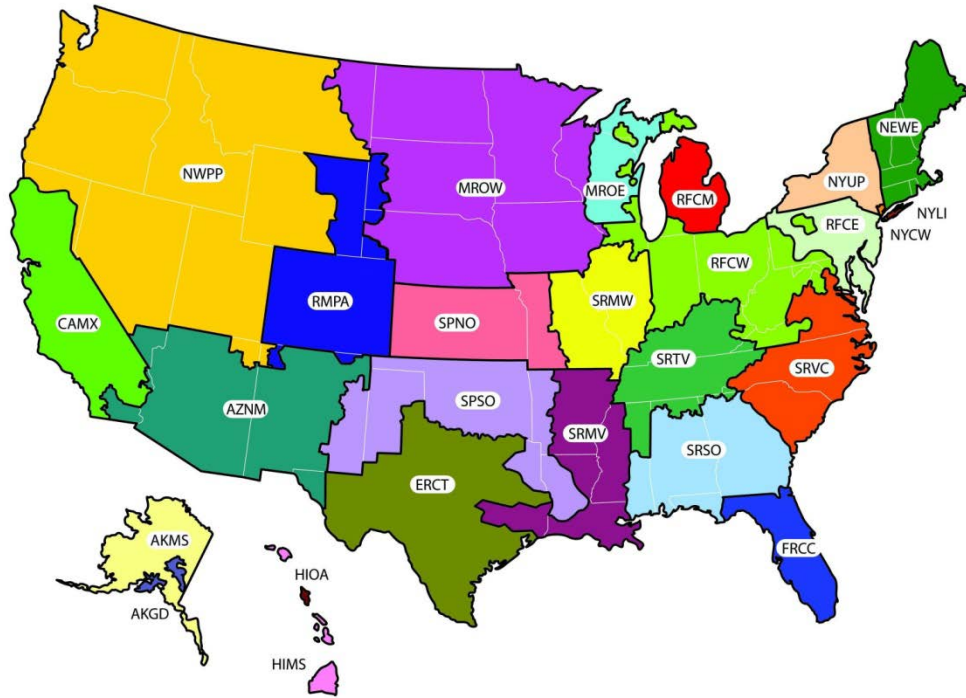
For Scope 2 purchased electricity, the GHG Reporting Portal will use the most current eGRID subregion output emission rate factors provided by the EPA eGRID database at the time of each annual inventory to calculate default category GHG emissions. This database divides the electric grid into 26 subregions with unique emission factors based on the regional electricity generation mix. Figure 2-1 shows the eGRID subregion map illustrating the approximate boundaries of the eGRID subregions, which are not all defined by clear geographic boundaries but by utility areas. EPA’s Power Profiler can be used to determine the appropriate eGRID subregion for a particular facility or building. See www.epa.gov/powerprofiler.

Agencies are responsible for reporting their electricity usage according to these subregions and for U.S. Territories, if applicable. Agencies can map a facility’s ZIP code to the corresponding eGRID subregion using the EPA Power Profiler website or the GHG Reporting Portal.¹⁷ For the base year inventory, if an agency cannot map FY 2008 electricity data by region, percentage factors determined from the FY 2010 electricity usage may be applied to the FY 2008 consumption to allocate this usage and report under the appropriate eGRID subregion. Agencies reporting facilities in U.S. Territories or choosing to report facilities in foreign nations must use emission factors from DOE 1605(b) Technical Guidelines.¹⁸

¹⁷ EPA Power Profiler. See www.epa.gov/powerprofiler.

¹⁸ DOE 1605(b) Emission Factors. See www.eia.doe.gov/oiaf/1605/emission_factors.html.

Figure 2-1: eGRID Subregions



This is a representational map; many of the boundaries shown on this map are approximate because they are based on companies, not on strictly geographical boundaries.

Appendix A—Calculating Scope 1 Emissions

This appendix describes the Scope 1 emission sources most commonly operated by Federal agencies, default and advanced calculation methodologies, required data, and recommended data sources.

This appendix provides calculation methodologies for the following:

- Stationary combustion: electricity, steam, heating
- Stationary combustion: biomass and biofuels
- Mobile combustion: fossil fuels
- Mobile combustion: biofuels
- Fugitive emissions: fluorinated gases
- Fugitive emissions: wastewater treatment
- Fugitive emissions: landfills and solid waste facilities
- Industrial process emissions.

A.1. Stationary Combustion: Electricity, Heating, and Steam

Description

Scope 1 stationary combustion emissions result from the generation of electricity, heat, or steam from sources owned and controlled by the agency. This includes emissions from use of boilers, furnaces, turbines, and emergency generators. This section only includes emissions from fossil fuel combustion. Emissions from biomass combustion are calculated in A.2.

A.1.1. Default Methodology (to be Calculated by GHG Reporting Portal)

Data Sources

The default methodology is a fuel-use method, rather than direct emissions monitoring (i.e., continuous emissions monitoring) or direct sampling, as fuel use is already tracked and reported to FEMP annually.¹⁹ If a source is not currently reported to FEMP but within an agency's operational control, these data may be available in bulk fuel or delivery receipts, contract or agency purchase records, stock inventory documentation, or maintenance records on turbines or emergency generators, furnaces, and boilers (see Table A-1).

¹⁹ In the EPA GHGRP, this approach is considered a Tier 1 method.

Table A-1: Stationary Combustion—Electricity, Heating, and Steam Default Data Sources

Data Element	Preferred Source
Electricity Generation: Total amount of natural gas, coal, fuel oil, diesel, gasoline, propane, and other fuels consumed by generators and/or turbines	<ul style="list-style-type: none"> • FEMP Energy Report
Steam Production: Total amount of fuels consumed	<ul style="list-style-type: none"> • FEMP Energy Report
Heat: Total amount of fuels consumed	<ul style="list-style-type: none"> • FEMP Energy Report
Emission Factor	<ul style="list-style-type: none"> • CO₂: see Table D-2 by fuel type • CH₄ and N₂O: see Table D-3 by fuel type

Calculation Steps²⁰

The methodology used to calculate Scope 1 emissions from stationary combustion is described below. Using the default methodology, agencies will enter the activity data from step 1 into the GHG Reporting Portal. To the greatest extent feasible, the portal will conduct steps 2 through 5.

1. Determine the amount of fuel consumed annually
2. Determine the appropriate CO₂ emission factors for each fuel
3. Determine the appropriate CH₄ and N₂O emission factors for each fuel
4. Calculate each fuel’s GHG emissions and convert to MT
5. Convert CH₄ and N₂O emissions to MT CO₂e and determine the total emissions.

Step 1: Determine the amount of fuel consumed annually

Identify all fuels combusted at the agency’s facilities. Much of these data should already be collected and reported at the agency level in the FEMP Energy Report. These data are entered into the GHG Reporting Portal. The GHG Reporting Portal will convert the fuel-use data from physical units (mass or volume) to energy units (million BTU, or MMBtu) using the HHVs available in Table D-2.²¹ When needed or applicable, the agency should input other fuel-use data in physical units and other HHVs not provided in the GHG Reporting Portal.

Equation A-1: Stationary Combustion Fuel Consumed

$\text{Fuel consumed [MMBtu]} = \text{Fuel consumed [units of fuel type]} \bullet \text{HHV [MMBtu/units of fuel type]}$
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²⁰ Primary reference: EPA, TSD for Stationary Fuel Combustion Emissions: Proposed Rule for Mandatory Reporting of Greenhouse Gases (previously the Greenhouse Gas Mandatory Reporting Rule or MRR), 40 Code of Federal Regulations (CFR) 98, Subpart C, January 30, 2009.

²¹ Also see TSD MRR Stationary Sources, 40 CFR 98, Subpart C, Tables C-1 and C-2 for emission factors.

Step 2: Determine the appropriate CO₂ emission factors for each fuel

The GHG Reporting Portal will identify the CO₂ emission factors by fuel type (see Table D-2).

Step 3: Determine the appropriate CH₄ and N₂O emission factors for each fuel

The GHG Reporting Portal will identify the CH₄ and N₂O emission factors by fuel type (see Table D-3).²²

Step 4: Calculate each fuel's GHG emissions and convert to MT

The GHG Reporting Portal will multiply the annual fuel consumed (step 1) by the emission factors for CO₂ (step 2), as well as the fuel consumed by emission factors for CH₄ and N₂O (step 3). Units are then converted into MT.

Equation A-2: Stationary Combustion GHG Emissions²³

CO₂ emissions [MT] = Fuel consumed [MMBtu] • CO ₂ emission factor [kg/MMBtu] • 0.001 [MT/kg]
CH₄ Emissions [MT] = Fuel consumed [MMBtu] • CH ₄ emission factor [kg/MMBtu] • 0.001 [MT/kg]
N₂O Emissions [MT] = Fuel consumed [MMBtu] • N ₂ O emission factor [kg/MMBtu] • 0.001 [MT/kg]

Step 5: Convert CH₄ and N₂O emissions to MT CO₂e and determine the total emissions

The GHG Reporting Portal will use the 100-year global warming potential (GWP) values (found in Table D-13) to convert CH₄ and N₂O emissions to units of CO₂e. The portal will sum emissions from all three gases to determine total MT CO₂e.

Equation A-3: Stationary Combustion MT CO₂e Emissions

CO₂e Emissions [MT CO₂e] = MT CO₂ + (MT CH₄ • CH₄ GWP) + (MT N₂O • N₂O GWP)

²² If the agency wishes to pursue a more advanced approach, it may substitute site-specific emission factors using data that consider the end-use sector (such as commercial or industrial) or other considerations, when applicable. Emission factors are also identified for specific types of combustion equipment for sites with significant stationary emissions. The Climate Registry, *Local Government Operations Protocol* (2008), Table G.4.

²³ For clarity, the symbol “•” has been used to indicate multiplication instead of symbols such as “×”.

Example A-1: Stationary Combustion

<p><i>Step 1: Determine the amount of fuel consumed annually</i></p> <p style="text-align: center;">An agency consumes 1,000 CCF (hundred cubic feet) of natural gas.</p>	
<p>Equation A-1: Stationary Combustion Fuel Consumed</p>	
<p>Fuel consumed [MMBtu]</p>	<p>= Fuel consumed [scf] • HHV [MMBtu/scf²⁴]</p> <p>= (100 [KCUFT] • 1,000 [scf/KCUFT]) • 1.028 x 10⁻³ [MMBtu/scf]</p> <p>= 102.8 [MMBtu]</p>
<p><i>Step 2: Determine the appropriate CO₂ emission factors for each fuel</i></p> <p style="text-align: center;">The CO₂ emission factor for natural gas is 53.02 kg CO₂/MMBtu.</p>	
<p><i>Step 3: Determine the appropriate CH₄ and N₂O emission factors for each fuel</i></p> <p style="text-align: center;">The natural gas emission factors for CH₄ and N₂O are 1.0 x 10⁻³ and 1.0 x 10⁻⁴ kg/MMBtu.</p>	
<p><i>Step 4: Calculate each fuel's GHG emissions and convert to MT</i></p>	
<p>Equation A-2: Stationary Combustion GHG Emissions</p>	
<p>CO₂ Emissions [MT]</p>	<p>= Fuel consumed [MMBtu] • CO₂ emission factor [kg/MMBtu] • 0.001 [MT/kg]</p> <p>= 102.8 [MMBtu] • 53.02 [kg/MMBtu] • 0.001 [MT/kg]</p> <p>= 5.450 [MT CO₂]</p>
<p>CH₄ Emissions [MT]</p>	<p>= Fuel consumed [MMBtu] • CH₄ emission factor [kg/MMBtu] • 0.001 [MT/kg]</p> <p>= 102.8 [MMBtu] • 1.0 x 10⁻³ [kg/MMBtu] • 0.001 [MT/kg]</p> <p>= 1.028 x 10⁻⁴ [MT CH₄]</p>
<p>N₂O Emissions [MT]</p>	<p>= Fuel consumed [MMBtu] • N₂O emission factor [kg/MMBtu] • 0.001 [MT/kg]</p> <p>= 102.8 [MMBtu] • 1.0 x 10⁻⁴ [kg/MMBtu] • 0.001 [MT/kg]</p> <p>= 1.028 x 10⁻⁵ [MT N₂O]</p>
<p><i>Step 5: Convert CH₄ and N₂O emissions to MT CO₂e and determine the total emissions</i></p>	
<p>Equation A-3: Stationary Combustion MT CO₂e Emissions</p>	
<p>CO₂e Emissions [MT CO₂e]</p>	<p>= MT CO₂ + (MT CH₄ • CH₄ GWP) + (MT N₂O • N₂O GWP)</p> <p>= 5.450 + (1.028 x 10⁻⁴ • 21) + (1.028 x 10⁻⁵ • 310)</p> <p>= 5.450 + 2.159 x 10⁻³ + 3.187 x 10⁻³</p> <p>= 5.455 [MT CO₂e]</p>
<p>Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.</p>	

No advanced methodologies for stationary combustion are available for reporting.

²⁴ Standard cubic feet (SCF).

A.2. Stationary Combustion: Biomass and Biofuel

Description

Biomass combustion emissions usually come from boilers, backup generators, wood stoves, and incinerators. Biomass can include wood (cords, chips, pellets, etc.), agricultural products, by-products, residues and waste, and the non-fossilized and biodegradable organic fractions of industrial and municipal wastes. Biofuels can include landfill gas and biodiesel in generators.

Emission factors may be unavailable for certain types of biomass, including certain types of waste. Such sources, including regulated medical waste and confiscated materials, should be included in an agency's GHG inventory (at least in the qualitative statement), but may be difficult to quantify in the absence of operational data and analysis.²⁵

A.2.1. Default Methodology (to be Calculated by GHG Reporting Portal)

These calculations mirror the stationary combustion method (see Appendix A.1) and are summarized here. The GHG Reporting Portal will separately calculate and clearly identify Scope 1 biogenic emissions (biomass CO₂) from Scope 1 CH₄ and N₂O emissions (see Table A-2).

²⁵ Neither AP-42 (EPA Compilation of Air Pollutant Emission Factors) nor EPA's GHGRP have GHG emission factors specifically for regulated medical waste, and the IPCC states that regulated medical waste is not a significant source of emissions, so emissions are not elaborated upon. AP-42 has emission factors for criteria pollutants, a discussion of combustion technologies, and some specific information on regulated medical waste characteristics, which is available at: <http://www.epa.gov/ttn/chief/ap42/ch02/bgdocs/b02s03.pdf> and <http://www.epa.gov/ttn/chief/ap42/ch02/final/c02s03.pdf>.

There are three options for an agency to use:

1. Use the same emission factor for regulated medical waste as for municipal solid waste.
2. Fine tune emission factors for municipal solid waste, as described below, based on an analysis of the agency's regulated medical waste stream.

The heating value given for regulated medical waste in AP42 is 19,700 kJ/kg [8,500 Btu/lb]). This value could be used in conjunction with the GHG per MMBTU in Tables D-2 and D-3 of the TSD. An agency can deconstruct the values in Tables D-2 and D-3, using the characteristics of its regulated medical waste. Specifically, the municipal solid waste in the tables assumes about 50/50 mixture of organic and inorganic waste. If an agency knows the mix of its own regulated medical waste, it could revise the emission factors accordingly and use these tailored values. As this requires more detailed and specific knowledge of the regulated medical waste composition, it may not be possible for some agencies.

3. Employ customized methods and emission factors for the agency's specific regulated medical waste stream and facilities. These methods must be detailed in an agency's inventory report.

Agencies do not have to report emissions from an incinerator if the sole purpose of the incinerator is exempt for reporting purposes. If the incinerator is also used for non-exempt activities, then the entire GHG emissions amount should be included.

Table A-2: Stationary Combustion—Biomass and Biofuel Default Data Sources

Data Element	Preferred Source
Biomass by type: Total amount [MMBtu] or tons where energy is not produced ²⁶	<ul style="list-style-type: none"> Agency records
Emission Factor	<ul style="list-style-type: none"> CO₂: see Table D-2 by fuel type CH₄ and N₂O: see Table D-3 by fuel type
Biomass fraction of MSW	<ul style="list-style-type: none"> Agency records, or default value of 60%

Calculation Steps

The default methodology includes the following steps. The GHG Reporting Portal will use the data entered by the federal manager in step 1 to complete steps 2 through 5.

1. Determine the amount of fuel consumed annually
2. Determine the appropriate CO₂ emission factors for each fuel
3. Determine the appropriate CH₄ and N₂O emission factors for each fuel
4. Calculate each fuel’s GHG emissions and convert them to MT
5. Convert CH₄ and N₂O emissions to MT CO₂e and determine the total emissions.

Example A-2: Biomass Combustion

<i>Step 1: Determine the amount of fuel consumed annually</i>	
A facility burned 134 tons of wood waste in a biomass boiler to reduce its natural gas use.	
Equation A-1: Stationary Combustion Fuel Consumed	
Fuel	= Fuel consumed [short tons] • HHV [MMBtu/ton]
consumed	= 134 [short tons] • 15.38 [MMBtu/short ton]
[MMBtu]	= 2,060.92 [MMBtu]
<i>Step 2: Determine the appropriate CO₂ emission factors for each fuel</i>	
The CO ₂ emission factor for this example is 93.80 kg/MMBtu.	
<i>Step 3: Determine the appropriate CH₄ and N₂O emission factors for each fuel</i>	
The wood waste emission factors for CH ₄ and N ₂ O are 0.032 and 0.0042 kg/MMBtu.	

²⁶ To estimate Scope 1 emissions from waste incineration where incineration is not used as a fuel for energy generation, an agency should estimate the quantity of waste incinerated and apply emissions factors for waste as a feedstock (found in Tables D-1 and D-2 of the TSD) to the mass of the waste processed by that facility. Values based on energy content should be converted to values based on mass or volume. For municipal solid waste, for example, the appropriate factor to use is 902.47 kgCO₂/short ton of MSW sent to the incinerator (from Table D-1: 9.95 MMBtu/short ton x 90.7 kgCO₂/MMBtu = 902.47 kgCO₂/short ton).

Step 4: Calculate each fuel's GHG emissions and convert them to MT

Equation A-2: Biomass Combustion GHG Emissions

$$\begin{aligned} \text{CO}_2 &= \text{Fuel consumed [MMBtu]} \bullet \text{CO}_2 \text{ emission factor [kg/MMBtu]} \bullet 0.001 \text{ [MT/kg]} \\ \text{Emissions} &= 2,060.92 \text{ [MMBtu]} \bullet 93.80 \text{ [kg/MMBtu]} \bullet 0.001 \text{ [MT/kg]} \\ \text{[MT]} &= 193.31 \text{ [MT CO}_2\text{]} \end{aligned}$$

$$\begin{aligned} \text{CH}_4 &= \text{Fuel consumed [MMBtu]} \bullet \text{CH}_4 \text{ emission factor [kg/MMBtu]} \bullet 0.001 \text{ [MT/kg]} \\ \text{Emissions} &= 2,060.92 \text{ [MMBtu]} \bullet 3.2 \times 10^{-2} \text{ [kg/MMBtu]} \bullet 0.001 \text{ [MT/kg]} \\ \text{[MT]} &= 6.59 \times 10^{-2} \text{ [MT CH}_4\text{]} \end{aligned}$$

$$\begin{aligned} \text{N}_2\text{O} &= \text{Fuel consumed [MMBtu]} \bullet \text{N}_2\text{O emission factor [kg/MMBtu]} \bullet 0.001 \text{ [MT/kg]} \\ \text{Emissions} &= 2,060.92 \text{ [MMBtu]} \bullet 4.2 \times 10^{-3} \text{ [kg/MMBtu]} \bullet 0.001 \text{ [MT/kg]} \\ \text{[MT]} &= 8.66 \times 10^{-3} \text{ [MT N}_2\text{O]} \end{aligned}$$

Step 5: Convert CH₄ and N₂O emissions to MT CO₂e and determine the total emissions

Equation A-3: Biomass Combustion MT CO₂e Emissions

➤ *Reported as Scope 1 emissions:*

$$\begin{aligned} \text{CO}_2\text{e} &= (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP}) \\ \text{Emissions} &= (0.0659 \text{ [MT CH}_4\text{]} \bullet 21) + (0.0087 \text{ [MT N}_2\text{O]} \bullet 310) \\ \text{[MT CO}_2\text{e]} &= 1.384 \text{ [MT CO}_2\text{e]} + 2.697 \text{ [MT CO}_2\text{e]} \\ &= \mathbf{4.08 \text{ [MT CO}_2\text{e]}} \end{aligned}$$

➤ *Reported as biogenic in Scope 1:*

$$\begin{aligned} \text{CO}_2\text{e} &= \text{MT CO}_2 \\ \text{Emissions} &= \mathbf{197.39 \text{ [MT CO}_2\text{]}} \\ \text{[MT CO}_2\text{e]} & \end{aligned}$$

****Note:** Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.**

A.3. Mobile Combustion: Fossil Fuels

Description

Vehicle fleets are the primary source of mobile fossil fuel emissions, but they can also come from non-highway vehicles (such as agriculture equipment), research aircraft, and waterborne vessels. Fuel types include gasoline, diesel, aviation gas, Jet-A, CNG, LPG, liquefied natural gas (LNG), and other fuels derived from fossil fuel sources.²⁷

Most CO₂ emissions, which account for the majority of emissions from mobile sources, can be calculated using fuel consumption data already reported to the FAST system for both the default and advanced methodology. CH₄ and N₂O emissions calculations vary depending on emission control technologies and distance traveled. FAST system fuel consumption data are

²⁷ The term “fossil fuels” in the Guidance is not synonymous with the definition of “petroleum and alternative fuels” used by FAST.

used for the default methodology. Agencies may utilize specific fleet composition and fuel consumption to report using the advanced methodology.

A.3.1. Default Methodology (to be Calculated by GHG Reporting Portal)

Data Sources

The default methodology uses the data already reported in FAST and potentially other analogous agency-specific systems. The GHG Reporting Portal will use default factors to automatically calculate the CH₄ and N₂O emissions to the greatest extent feasible (see Table A-3).

Table A-3: Mobile Combustion—Fossil Fuels Default Data Sources

Data Element	Preferred Source
Annual Fuel Consumption: by type [GGE]*	<ul style="list-style-type: none"> • FAST system • Other analogous agency-specific systems
Emission Factor	<ul style="list-style-type: none"> • CO₂: see Table D-2 by fuel type • CH₄ and N₂O: see Table D-4 by fuel type

* This methodology applies to highway vehicles and alternative fuel vehicles, but not to non-highway vehicles such as ships and aircraft. For those vehicles, estimation of CH₄ and N₂O emissions is also based on fuel consumption.

Calculation Steps²⁸

To calculate Scope 1 emissions from mobile combustion of fossil fuels, agencies' vehicle fuel consumption data available in the FAST system will be imported automatically into the GHG Reporting Portal (step 1). Similar import arrangements may be possible with other analogous agency-specific systems, as necessary. The portal will, to the greatest extent feasible, automatically perform steps 2 through 6.

1. Determine the total amount of energy consumed by fuel
2. Determine the appropriate CO₂ emission factors for each fuel
3. Determine the appropriate CH₄ and N₂O emission factors for each fuel using default assumptions
4. Calculate the total CO₂ (biogenic and anthropogenic), CH₄, and N₂O emitted for each fuel
5. Calculate the total CO₂e emissions for each fuel
6. Convert kg CO₂e emissions to MT CO₂e and determine the total emissions.

Step 1: Determine the total amount of energy consumed by fuel

The FAST system includes agency-level information on fuel consumption per fuel type on a GGE basis. Agencies should review this data for accuracy prior to input into the GHG

²⁸ EPA, Climate Leaders Technical Guidance, *Direct Emissions from Mobile Combustion Sources*, May 2008.

Reporting Portal. The agency can modify the data to correct inaccuracies or to include mobile emissions sources not currently included in FAST system but under the operational control of the agency. The GHG Reporting Portal will automatically convert GGEs to gallons using the conversions in Table D-16. The GHG Reporting Portal will calculate the total energy consumed [MMBtu] for each fuel by multiplying the total amount of fuel consumed [GGE] for each fuel by the default HHV [MMBtu/GGE].

Equation A-4: Amount of Energy Consumed (for Each Fuel)

<p>Amount of Energy Consumed [MMBtu] = Total annual consumption [GGE] • 0.125 [MMBtu/GGE]</p>

Step 2: Determine the appropriate CO₂ emission factors for each fuel

The GHG Reporting Portal will apply the appropriate biogenic and anthropogenic CO₂ emission factors [kg CO₂/MMBtu] for each fuel. Table D-2 shows CO₂ emission factors by fuel.

Step 3: Determine the appropriate CH₄ and N₂O emission factors for each fuel using default assumptions

The GHG Reporting Portal will apply the appropriate converted CH₄ and N₂O emission factors [kg/MMBtu] for each fuel. Default CH₄ and N₂O emission factors are developed in grams per mile. Because the FAST system does not correlate fuel use by type of vehicle or mileage, this methodology requires significant assumptions about the mobile inventory. It conservatively estimates the amount of CH₄ and N₂O emissions from mobile sources by using a high emission factor under available control technology from 2005 for the entire fleet.²⁹ Beginning with FY 2008 and FY 2010 reporting, the GHG Reporting Portal will use the emission factors [g/mile] and default fuel efficiency [MPG] for a 2005 gasoline light-duty truck with low emissions vehicle (LEV) technology or advanced controls. The default emission factors are 0.0148 g CH₄/mile and 0.0157 g N₂O/mile (see Table D-4),³⁰ and the default fuel efficiency is 16.2 MPG.³¹ The converted emission factors are calculated by dividing the product of the default emission factors and the default fuel efficiency by the HHV [gal/MMBtu].

Agencies with more detail on the vehicle fleet composition connected to fuel use can choose to use the advanced calculation methodology described after this section, either with full data or weighted averages per vehicle and fuel type.

²⁹ The GHG Reporting Portal will use values from 5 years prior to the reporting year, as GSA leases vary from 3 to 8 years, depending on type and fuel. In 2005, the majority of all vehicles were Tier 2 control technologies, so this approach uses the second largest (and more conservative) group—low emissions vehicles and advanced control mechanisms. The average model year CH₄ and N₂O emissions did not vary significantly between 2001 and 2005.

³⁰ EPA, Climate Leaders, *Mobile Combustion Sources*, May 2008, Tables A-1, A-6, and A-7.

³¹ U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 2005, Table VM-1. See www.fhwa.dot.gov/policy/ohim/hs05/pdf/vm1.pdf.

Step 4: Calculate the total CO₂ (biogenic and anthropogenic), CH₄, and N₂O emitted for each fuel

To determine CO₂, CH₄, and N₂O emissions from mobile combustion, the GHG Reporting Portal will multiply fuel use (step 1) by the biogenic and anthropogenic CO₂ emission factors (step 2), and the CH₄ and N₂O emission factors (step 3) for each fuel.

Equation A-5: Mobile Combustion CO₂, CH₄, and N₂O Emissions (Fossil Fuels)

CO₂ emissions [kg] = Amount of Energy Consumed [MMBtu] • CO ₂ emission factor [kg/MMBtu]
CH₄ emissions [kg] = Amount of Energy Consumed [MMBtu] • CH ₄ emission factor [kg/MMBtu]
N₂O emissions [kg] = Amount of Energy Consumed [MMBtu] • N ₂ O emission factor [kg/MMBtu]

Step 5: Calculate the total CO₂e emissions for each fuel

The GHG Reporting Portal will use the GWP values (found in Table D-14) to convert CO₂, CH₄, and N₂O emissions to units of CO₂e. The Portal will sum emissions from all three gases to determine total kg CO₂e for each fuel.

Equation A-6: Mobile Combustion kg CO₂e Emissions (Fossil Fuels—Default)

CO₂e emissions [kg CO₂e] = (kg CO ₂ • CO ₂ GWP) + (kg CH ₄ • CH ₄ GWP) + (kg N ₂ O • N ₂ O GWP)

Step 6: Convert kg CO₂e emissions to MT CO₂e and determine the total emissions

The GHG Reporting Portal will convert kg CO₂e to units of MT CO₂e for each fuel. The portal will then sum emissions from all fuels to determine total MT CO₂e.

Equation A-7: Mobile Combustion Total MT CO₂e Emissions (Fossil Fuels—Default)

Total CO₂e emissions [MT CO₂e] = ∑ (kg CO ₂ e • 0.001 [MT/kg])

Example A-3: Mobile Combustion (Fossil Fuels—Default Methodology)

Goal: Determine the total MT CO₂e Emissions

The agency fleet consumed 500,000 GGEs of gasoline

Step 1: Determine the total amount of energy consumed

Equation A-4: Amount of Energy Consumed (for Each Fuel)	
Amount of	= Total Consumption [GGE] • 0.125 [MMBtu/GGE]
Energy	= 500,000 [GGE] • 0.125 [MMBtu/GGE]

Consumed [MMBtu]	= 62,500 [MMBtu]
<i>Step 2: Determine the appropriate CO₂ emission factors for each fuel</i>	
The default anthropogenic emission factor for gasoline is 70.22 kg CO ₂ /MMBtu.	
<i>Step 3: Determine the appropriate CH₄ and N₂O emission factors for each fuel using default assumptions</i>	
The emission factors for CH ₄ and N ₂ O are 0.001918 kg CH ₄ /MMBtu and 0.002035 kg NO ₂ /MMBtu.	
<i>Step 4: Calculate the total CO₂ (biogenic and anthropogenic), CH₄, and N₂O emitted for each fuel</i>	
<u>Equation A-5: Mobile Combustion CO₂, CH₄, and N₂O Emissions (Fossil Fuels)</u>	
CO₂ emissions [kg]	= amount of energy consumed [MMBtu] • CO ₂ emission factor [kg/MMBtu] = 62,500 [MMBtu] • 70.22 [kg/MMBtu] = 4,388,750 [kg]
CH₄ emissions [kg]	= amount of energy consumed [MMBtu] • CH ₄ emission factor [kg/MMBtu] = 62,500 [MMBtu] • 0.002035 [kg/MMBtu] = 119.88 [kg]
N₂O emissions [kg]	= amount of energy consumed [MMBtu] • N ₂ O emission factor [kg/MMBtu] = 62,500 [MMBtu] • 0.002035 [kg/MMBtu] = 127.19 [kg]
<i>Step 5: Calculate the total CO₂e emissions for each fuel</i>	
<u>Equation A-6: Mobile Combustion kg CO₂e Emissions (Fossil Fuels-Default)</u>	
CO₂e emissions [kg CO₂]	= (kg CO ₂ • CO ₂ GWP) + (kg CH ₄ • CH ₄ GWP) + (kg N ₂ O • N ₂ O GWP) = (4,388,750 [kg] • 1) + (119.88 [kg] • 21) + (127.19 [kg] • 310) = 4,430,696.38 [kg CO ₂ e]
<i>Step 6: Convert kg CO₂e emissions to MT CO₂e and determine the total emissions</i>	
<u>Equation A-7: Mobile Combustion Total MT CO₂e Emissions (Fossil Fuels—Default)</u>	
Total CO₂e emissions [MT CO₂e]	= ∑ (kg CO ₂ e • 0.001 [MT/kg]) = 4,430,696.38 [kg CO ₂ e] • 0.001 [MT/kg] = 4,430.70 [MT CO ₂ e]
Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.	

A.3.2. Advanced Methodology (User Calculated)

Data Sources

The advanced calculation methodology uses data on annual mileage and fleet composition to find fleet-specific emissions totals for CH₄ and N₂O (Table A-4).

Table A-4: Mobile Combustion—Fossil Fuels Advanced Data Sources

Data Element	Preferred Source	Alternate Source
Annual fuel consumption data by type	<ul style="list-style-type: none"> FAST system Other agency resources, such as the operating and support management information system, when applicable Agency non-fleet VE records 	<ul style="list-style-type: none"> Dollars spent on fuel and average price per unit of volume Annual mileage and vehicle fuel economy reported Hours operated (off-road vehicles)
Annual mileage by vehicle type, emission control technology, and fuel type* (for CH ₄ and N ₂ O calculation only) [mi]	<ul style="list-style-type: none"> Agency data on miles traveled 	<ul style="list-style-type: none"> Miles traveled estimates based on hours traveled and fuel economy Weighted average percentages of vehicle type and efficiency data from vehicle population Hours operated (off-road vehicles)
Emission factor	<ul style="list-style-type: none"> CO₂: see Table D-2 by fuel type CH₄ and N₂O: see Tables D-4 through D-6 by fuel type, vehicle type, and combustion technology 	

* This applies to highway vehicles and alternative fuel vehicles, but not to non-highway vehicles such as ships and aircraft. For those vehicles, CH₄ and N₂O emissions are estimated from fuel consumption rather than distance traveled.

Calculation Steps for CO₂ Emissions

See Appendix A.3.1, steps 1, 2, and 5 of the Default Methodology, for CO₂ emissions. To convert from GGEs, use the conversions in Table D-15.

Equation A-8: Fuel Consumption GGE Conversion

$\text{Total fuel consumption [gal]} = \text{Total fuel [GGE]} \div \text{GGE factor [GGE/gal]}$
--

Calculation Steps for CH₄ and N₂O Emissions

Although not required, agencies with additional alternative activity data (i.e., fleet fuel consumption by vehicle class) can choose to utilize this advanced methodology to more accurately estimate their fleet emissions. This increased accuracy can be used to better estimate (and get credit for) reductions obtained through certain fleet management strategies (such as creating a “cleaner” mix of fleet vehicles). Alternatively, if data on specific control technologies are not available, or are too labor intensive to generate, agencies can estimate CH₄ and N₂O emissions using a weighted average of available control technologies by model year and apply the sums to the advanced calculation methodology (see Table D-4 for average emission factors).

To calculate Scope 1 CH₄ and N₂O emissions from the mobile combustion of fossil fuels, do the following:

1. Identify the vehicle type, fuel type, and technology type of all the vehicles
2. Determine the mileage by vehicle type
3. Determine the appropriate emission factors for fuel and vehicle type
4. Calculate CH₄ and N₂O emissions by vehicle type and convert them to MT
5. Determine the total annual MT CO₂e.

Step 1: Identify the vehicle type, fuel type, and technology type of all the vehicles

The agency Federal fleet manager is responsible for identifying all vehicles under operational control of the agency by vehicle type (passenger car, light-duty truck, heavy-duty truck, and/or motorcycle), fuel type (gasoline or diesel), and emission control technology (LEVs, moderate control technologies, etc.). See Table D-4 for control technologies and emission factors. See the EPA Climate Leader’s Mobile Combustion Guidance for more detail on the tiered emission control technology.³²

Step 2: Determine the mileage by vehicle type

For each vehicle type referenced in Table D-4, the agency Federal fleet manager determines distance traveled for the reporting period.

Step 3: Determine the appropriate emission factors for fuel and vehicle type

The agency Federal fleet manager selects the appropriate factors. (See Table D-4 and Table D-5 for emission factors by vehicle type and technology.) See the EPA’s Mobile Combustion guidance for weighted assumptions by year. The weighted assumptions provide the estimated emission factor by type of vehicle and year. Additional tables in Appendix A of EPA Climate Leaders Mobile Combustion guidance present the percentage of vehicles by type in each year that was designed with the EPA’s tiered designations, which can be used if the vehicle population by type of technology is not known but date of purchase is known. Agencies should establish the information available for their fleet and use the best estimates available.

Step 4: Calculate the CH₄ and N₂O emissions by vehicle type and convert them to MT

For each category of vehicle type, technology, and fuel, the agency Federal fleet manager will use Equation A-9 for CH₄ and N₂O emissions.

Equation A-9: Mobile Combustion CH₄ and N₂O Emissions (Fossil Fuels—Advanced)

<p>CH₄ emissions [MT CH₄] = Total miles traveled [mi] • CH₄ emission factor [g/mi] • 0.001 [kg/g] • 0.001 [MT/kg]</p>
<p>N₂O emissions [MT N₂O] = Total miles traveled [mi] • N₂O emission factor [g/mi] • 0.001 [kg/g] • 0.001 [MT/kg]</p>

³² EPA, Climate Leaders, *Direct Emissions from Mobile Combustion Sources*, Appendix A, May 2008. See www.epa.gov/climateleaders/documents/resources/mobilesource_guidance.pdf.

Step 5: Determine the total annual MT CO_{2e}

To determine the total CO_{2e} emissions, the agency manager will multiply by the appropriate GWP value for each gas found in Table D-13, and sums.

Equation A-10: Mobile Combustion MT CO_{2e} Emissions (Fossil Fuels—Advanced)

$$\text{CO}_2\text{e emissions [MT CO}_2\text{e]} = \text{MT CO}_2 + (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP})$$

Example A-4: Mobile Combustion (Fossil Fuels—Advanced Methodology)

➤ **CO₂ Calculation**

Step 1: Determine the total amount of fuel consumed by type

A truck owned by the agency consumed 2,350 gallons of diesel fuel (Distillate Oil No. 2).

Step 2: Determine the appropriate CO₂ emission factors for each fuel

$$\begin{aligned} \text{CO}_2 &= \text{HHV [MMBtu/gal]} \bullet \text{Diesel emission factor [kg/MMBtu]} \\ \text{emission} &= 0.138 \text{ [MMBtu/gal]} \bullet 73.96 \text{ [kg/MMBtu]} \\ \text{factor} &= 10.21 \text{ [kg/gal]} \\ \text{[kg/gal]} & \end{aligned}$$

Step 3: Calculate the total CO₂ emissions and convert them to MT

Equation A-5: Mobile Combustion CO₂ Emissions (Fossil Fuels)

$$\begin{aligned} \text{CO}_2 &= \text{Vehicle fuel consumption [gal]} \bullet \text{CO}_2 \text{ emission factor [kg/gal]} \bullet 0.001 \text{ [MT/kg]} \\ \text{emissions} &= 2,350 \text{ [gal]} \bullet 10.21 \text{ [kg/gal]} \bullet 0.001 \text{ [MT/kg]} \\ \text{[MT]} &= 23.99 \text{ [MT CO}_2\text{]} \end{aligned}$$

➤ **CH₄ and N₂O Calculation**

Step 1: Identify the vehicle type, fuel type, and technology type of all the vehicles

The 1993 truck's average mileage is 15 mpg. It uses moderate emissions control technology.

Step 2: Determine mileage by vehicle type

The truck used 2,340 gallons of diesel fuel and averaged 15 mpg, driving a total of 35,250 miles.

Step 3: Determine the appropriate emission factors for fuel and vehicle type

The CH₄ and N₂O emission factors for a diesel light truck with moderate emission control technology are 0.0009 g/mile and 0.0014 g/mile, respectively.

Step 4: Calculate CH₄ and N₂O emissions by vehicle type and convert them to MT

Equation A-9: Mobile Combustion CH₄ and N₂O Emissions (Fossil Fuels—Advanced)

$$\begin{aligned} \text{CH}_4 \text{ emissions} &= \text{Total miles traveled [mi]} \bullet \text{CH}_4 \text{ emission factor [g/mi]} \bullet 0.001 \text{ [kg/g]} \bullet 0.001 \\ \text{[MT]} &= 35,250 \text{ miles} \bullet 0.0009 \text{ [g/mi]} \bullet 0.001 \text{ [kg/g]} \bullet 0.001 \text{ [MT/kg]} \\ &= 3.17 \times 10^{-5} \text{ [MT CH}_4\text{]} \end{aligned}$$

$$\begin{aligned} \text{N}_2\text{O} \text{ emissions} &= \text{Total miles traveled [mi]} \bullet \text{N}_2\text{O emission factor [g/mi]} \bullet 0.001 \text{ [kg/g]} \bullet .001 \\ \text{[MT]} &= 35,250 \text{ miles} \bullet 0.0014 \text{ [g/mi]} \bullet 0.001 \text{ [kg/g]} \bullet 0.001 \text{ [MT/kg]} \\ &= 4.94 \times 10^{-5} \text{ [MT N}_2\text{O]} \end{aligned}$$

Step 5: Determine the total annual MT CO₂e

Equation A-10: Mobile Combustion MT CO₂e Emissions (Fossil Fuels—Advanced)

$$\begin{aligned} \text{CO}_2\text{e} \text{ emissions} &= \text{MT CO}_2 + (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP}) \\ \text{[MT CO}_2\text{e]} &= 23.99 \text{ [MT CO}_2\text{]} + (3.17 \times 10^{-5} \text{ [MT CH}_4\text{]} \bullet 21) + (4.94 \times 10^{-5} \text{ [MT N}_2\text{O]} \bullet 310) \\ &= 23.99 \text{ [MT CO}_2\text{]} + 6.66 \times 10^{-4} \text{ [MT CO}_2\text{e]} + 1.53 \times 10^{-2} \text{ [MT CO}_2\text{e]} \\ &= \mathbf{24.01 \text{ [MT CO}_2\text{e]}} \end{aligned}$$

****Note:** Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.**

Non-Highway Vehicles

A list of default emission factors for non-highway vehicles are included in Table D-6 to assist in calculating emissions for aircraft, boats and ships, agriculture equipment, and various other vehicle and fuel types. Estimating emissions from these non-highway vehicles also requires data on the quantity of fuel consumed by fuel types. The same general calculation methodology described for highway vehicles applies to non-highway vehicles. For non-highway vehicles recorded by hours traveled, agencies should use known vehicle efficiency data and report the resulting total fuel usage or mileage. Additional emission factors for non-highway vehicles are available in EPA’s Climate Leader’s guidance, Table A-6: www.epa.gov/stateply/documents/resources/mobilesource_guidance.pdf.

A.4. Mobile Combustion: Biofuels

Description

Biofuels combusted in vehicles, such as cars, trucks, airplanes, and water vessels, produce CO₂, CH₄, and N₂O emissions. Agencies should include CH₄ and N₂O emissions as Scope 1, and CO₂ emissions should be clearly identified and reported in Scope 1 as biogenic emissions. The CH₄ and N₂O calculations are the same as those outlined in Appendix A.3. Because the reporting requires separately addressing the biogenic and non-biogenic fractions of fuels separately within Scope 1, the calculation steps for the methodologies below distinguish between CO₂ emissions calculations and those from CH₄ and N₂O. To the greatest extent feasible, the GHG Reporting Portal will automatically separate these emissions in the default methodology.

A.4.1. Default Methodology (to be Calculated by GHG Reporting Portal)

Data Sources

Use the FAST system and FEMP energy reporting data for fuel consumption totals from biofuel combusted by mobile sources (Table A-5).

Table A-5: Mobile Combustion—Biofuels Default Data Sources

Data Element	Preferred Source
Annual fuel consumption data by type	<ul style="list-style-type: none"> • FAST system and other FEMP data reporting sources
CH ₄ and N ₂ O: annual fuel consumption data by type	<ul style="list-style-type: none"> • FAST system and other FEMP data reporting sources
Biobased fraction of fuel	<ul style="list-style-type: none"> • Calculated percentage of annual fuel consumption
Emission factor	<ul style="list-style-type: none"> • CO₂: see Table D-2 by fuel type • CH₄ and N₂O: see Tables D-4 through D-6 by fuel type

*Calculation Steps for CO₂ Emissions*³³

To calculate Scope 1 CO₂ emissions from mobile combustion of biofuels, agencies' vehicle fuel consumption data available in the FAST system will be imported automatically into the GHG Reporting Portal (step 1).³⁴ The agency must enter the appropriate non-fleet vehicle and equipment data as part of the FEMP energy reporting requirements. To the greatest extent feasible, the GHG Reporting Portal will automatically perform steps 2 through 4:

1. Determine the total amount of fuel consumed by type
2. Determine the biofuel and fossil fuel portions of each fuel type (blend)
3. Select the appropriate CO₂ emission factor for each fuel type
4. Calculate the CO₂ emissions by biofuel and fossil fuel type.

Step 1: Determine the total amount of fuel consumed by type

Each agency must review and approve its own data in FAST prior to final submission to FEMP. Typically, Federal fleet managers enter fuel use in FAST. This includes petroleum and alternative fuels used for fleet applications. Some alternative fuels, such as biofuel blends and ethanol blends, are indicated in terms of the fraction of renewable fuel with petroleum. For example, B20 contains 20 percent biodiesel and 80 percent diesel. Likewise with ethanol blends, E85 contains 85 percent ethanol and 15 percent gasoline. Blends lower than B20 and E85 are not considered alternative fuels under the EPAct of 1992 and will be considered standard gasoline or petrodiesel in the GHG Reporting Portal.

³³ Primary Reference: EPA, Climate Leaders Technical Guidance, *Direct Emissions from Mobile Combustion Sources*, May 2008.

³⁴ Additional agency-specific analogous data systems may potentially be linked to the GHG Reporting Portal.

When using the FAST system, agencies do not have to concern themselves with the conversion of natural gallons to GGE or distinguishing between blends (i.e., E85, B20). For example, an agency will enter the number of gallons of E85 in the corresponding field and the system, which has the conversion factors built in, will automatically convert to GGE. It also conducts separate calculations for each blend fraction (step 2). For those interested in seeing these conversion factors, refer to Table D-15.

Step 2: Determine the biofuel and fossil fuel portions of each fuel type (blend)

The fractional components of the biofuels have different carbon contents, requiring the CO₂ emissions for each fraction to be calculated separately. To the greatest extent feasible, the GHG Reporting Portal will calculate the total amount of each fraction of fuel.

Step 3: Select the appropriate CO₂ emission factor for each fuel type

To the greatest extent feasible, the GHG Reporting Portal will identify the appropriate emission factor for each type and fraction of fuel (see Table D-2 for fuel emission factors).

Step 4: Calculate the CO₂ emissions by biofuel and fossil fuel type

For each category of biofuel and fossil fuel type, the federal manager uses Equation A-11 to calculate their respective CO₂ emissions.

Equation A-11: Mobile Combustion CO₂ Emissions (Biofuels—Default)

<p>Biofuel CO₂ emissions [MT] = Total volume of biofuel in fuel consumed [gal] • CO₂ emission factor [kg/gal] • 0.001 [MT/kg]</p>
<p>Fossil fuel CO₂ emissions [MT] = Total volume of fossil fuel in fuel consumed [gal] • CO₂ emission factor [kg/gal] • 0.001 [MT/kg]</p>

The GHG Reporting Portal will report CO₂ generated from the fossil fuel fraction as Scope 1; the quantity of CO₂ from the biofuel portion is calculated separately and reported in Scope 1 as biogenic.

Calculation Steps for CH₄ and N₂O Emissions

CH₄ and N₂O emissions are considered anthropogenic (not biogenic), and all emissions are attributed to Scope 1. However, there are slight differences in CH₄ and N₂O emission factors for mobile combustion. The GHG Reporting Portal will attribute the emission factor for each fuel type to the fraction of the fuel it comprises. For example, the emissions factor for E85 is the sum of 85 percent of the emissions factor for ethanol (E100) and 15 percent of the emissions factor for gasoline.

To calculate blend-specific CH₄ and N₂O emission factors for blends not available in the GHG Reporting Portal, sum the product of the fuel percentage and fuel-specific emissions factor.

Equation A-12: CH₄ and N₂O Emission Factors for Blended Fuels

Blended CH₄ emission factor [g/mile] =

(Total fraction of biofuel [%] • CH₄ emission factor [g/mile])
+ (Total fraction of fossil fuel [%] • CH₄ emission factor [g/mile])

Blended N₂O emission factor [g/mile] =

(Total fraction of biofuel [%] • N₂O emission factor [g/mile])
+ (Total fraction of fossil fuel [%] • N₂O emission factor [g/mile])

A.4.2. Advanced Methodology (User Calculated)

Data Sources

Data sources for calculating CO₂ emissions are the same as in the default method, and sources for calculating CH₄ and N₂O are the same as in Appendix A.3 with one additional step for determining the emissions factor.

Calculation Steps for CO₂, CH₄, and N₂O Emissions

The advanced methodology for CO₂ is the same as the default. The CH₄ and N₂O advanced methodology is described in the advanced methodology for mobile combustion of fossil fuels (Appendix A.3.2). Report CH₄ and N₂O emissions for both fossil and biofuel components under Scope 1. CH₄ and N₂O emissions from either fossil or biofuel mobile combustion are considered anthropogenic (not biogenic) and are included in agency reduction targets and inventories.

To calculate blend-specific CH₄ and N₂O emission factors, sum the product of the fuel percentage and fuel-specific emissions factor.

Example A-5: Mobile Combustion (Biofuels—Advanced Methodology)

Step 1: Determine the total amount of fuel consumed by type

A light truck owned by an agency consumed 2,500 gallons of E85.

Step 2: Determine the biofuel and fossil fuel portions of each fuel type(blend)

This equates to 2,125 gallons of ethanol and 375 gallons of regular gasoline.

Step 3: Select the appropriate CO₂ emission factor for each fuel type

The ethanol emission factor is 5.75 kg CO₂/gal and the gasoline emission factor is 8.78 kg CO₂/gal.

Step 4: Calculate the CO₂ emissions by biofuel and fossil fuel type

Equation A-11: Mobile Combustion CO₂ Emissions (Biofuels—Default)

Ethanol CO₂ emissions [MT]	=	Total fraction of ethanol in fuel consumed [gal] • CO ₂ emission factor [kg/gal] • 0.001 [MT/kg]
	=	2,125 [gal] • 5.75 [kg/gal] • 0.001 [MT/kg]
	=	12.22 [MT CO ₂]
Gasoline CO₂ emissions [MT]	=	Total fraction of gasoline in fuel consumed [gal] • CO ₂ emission factor [kg/gal] • 0.001 [MT/kg]
	=	375 [gal] • 8.78 [kg/gal] • 0.001 [MT/kg]
	=	3.29 [MT CO ₂]

The Scope 1 gasoline CO₂ emissions are added to the total amount of CH₄ and N₂O emissions calculated using Equation A-5 below and reported as Scope 1 mobile emissions (see Equation A-7). The ethanol CO₂ emissions above are separately reported as biogenic in Scope 1 (see Example A-3 for more explanation). The truck has an average efficiency of 21 MPG and used 2,500 gallons; it traveled approximately 52,500 miles. The emission factors for the blend are calculated as follows, using E100 and motor gasoline:

Equation A-12: CH₄ and N₂O Emission Factors for Blended Fuels

E85 CH₄ emission factor [g/mile]	=	(Total fraction of biofuel [%] • CH ₄ emission factor [g/mile]) + (Total fraction of fossil fuel [%] • CH ₄ emission factor [g/mile])
	=	(.85 • 0.055) + (.15 • 0.0148)
	=	0.049 [g/mi]
E85 N₂O emission factor [g/mile]	=	(Total fraction of biofuel [%] • N ₂ O emission factor [g/mile]) + (Total fraction of fossil fuel [%] • N ₂ O emission factor [g/mile])
	=	(.85 • 0.067) + (.15 • 0.0157)
	=	0.059 [g/mi]

➤ *CH₄ and N₂O Emissions Calculations:*

Equation A-9: Mobile Combustion CH₄ and N₂O emissions (Fossil Fuels—Advanced)

CH₄ Emissions [MT]	=	Total miles traveled [mi] • CH ₄ emission factor [g/mi] • 0.001 [kg/g] • 0.001 [MT/kg]
	=	52,500 miles • 0.049 [g/mi] • 0.001 [kg/g] • 0.001 [MT/kg]
	=	0.0026 [MT CH ₄]
N₂O Emissions [MT]	=	Total miles traveled [mi] • N ₂ O emission factor [g/mi] • 0.001 [kg/g] • 0.001 [MT/kg]
	=	52,500 miles • 0.059 [g/mi] • 0.001 [kg/g] • 0.001 [MT/kg]
	=	0.0031 [MT N ₂ O]

➤ *Report as Scope 1:*

Equation A-10: Mobile Combustion MT CO₂e Emissions (Fossil Fuels—Advanced)

CO₂e Emissions [MT CO₂e]	=	MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP)
	=	3.29 [MT CO ₂] + (0.0026 [MT CH ₄] • 21) + (0.0031 [MT N ₂ O] • 310)
	=	3.29 [MT CO ₂] + 0.055 [MT CO ₂ e] + 0.961 [MT CO ₂ e]
	=	4.31 [MT CO₂e]

➤ **Report as biogenic and Scope 1:**

CO₂e	=	MT CO ₂
Emissions [MT CO₂e]	=	12.22 [MT CO ₂]

****Note:** Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.**

A.5. Fugitive Emissions: Fluorinated Gases

Description

This section discusses default and advanced approaches for calculating Scope 1 fugitive GHG emissions from F-gases. For purposes of inventory development, fugitive emissions are GHG emissions resulting from equipment operations or practices that do not pass through a stack, chimney, or other functionally equivalent opening (point source) and which are not captured or destroyed by an emissions control system. Agencies should note that ozone depleting substances (chlorofluorocarbons [CFCs] and hydrochlorofluorocarbons [HCFCs]) are not included GHGs in the context of E.O. 13514 and other GHG accounting systems. Thus, it is recommended that agencies carefully track both refrigerant type and quantity to avoid reporting challenges with these commingled refrigerant gases.³⁵

F-gas fugitive emissions can occur during the manufacture, installation, use, service, and disposal of heating, ventilation, and air conditioning (HVAC) and refrigeration equipment; mobile source air-conditioning equipment; and electrical equipment in which SF₆ or PFCs are used as electrical insulators. Such electrical equipment includes gas-insulated circuit breakers, switch gears, substations, gas-insulated lines, and some transformers.

For purposes of the TSD, it is generally assumed that all agency emissions of F-gases are “fugitive.” However, if an agency has F-gas emissions that are “non-fugitive” (pass through a stack or chimney, or are intentionally released during research), an agency should calculate these emissions and include them in their inventory as Scope 1 process emissions.

General Data Sources

In general, the information required to estimate F-gas emissions from HVAC, refrigeration, and electrical equipment consists of data on F-gas consumption and the net growth (or decline) of the total charge (nameplate capacity) of the equipment during the year. The net growth or decline of the total charge is tracked by the total quantities of equipment newly installed or retired. The total charge is also useful for its own sake in applying the screening analysis

³⁵ CO₂, CH₄, and N₂O are not F-gases though there are also fugitive emissions of these GHGs. Fugitive emission of these GHG could stem from their use as specialty gases, waste water treatment, and solid waste facilities. See Appendices A-6 and A-7 on wastewater treatment and solid waste facilities, respectively).

(discussed further below) or calculating emission rates (such as kg HFC emitted per kg HFC charge).³⁶

The ease and ability of obtaining the underlying activity data needed to calculate fugitive GHG emissions may be influenced by the size, mission, and maintenance capabilities of an agency. Larger organizations may operate agency-specific logistics and supply management systems at the facility level that track the requisition, purchase, receipt, storage, issue, shipment, disposition, and identification of equipment and supply materials and may maintain equipment in-house. If these systems are not centrally accessible at the agency headquarters level, formal data calls may be needed to obtain the necessary data from individual agency locations. Agencies are encouraged to use existing data, including purchase records, to estimate potential fugitive emissions.

Smaller organizations may not have the same logistics, data management, and equipment maintenance needs and/or may contract out such services. If F-gas purchase data are not available from local sources, best judgment estimates may be needed. Agencies may consider modifying facility support or service contracts to require contractors to provide these data for future inventories or utilizing existing data and documenting methodologies used for estimating fugitive emissions.

Specific data requirements will depend on the methodology applied, as described below.

Default and Advanced Methodologies³⁷

Depending on the quality of available underlying data, any of the following four methodologies may be used for calculating fugitive F-gas emissions:

1. Federal supply system transaction approach (default)
2. Material balance approach (advanced)
3. Simplified material balance approach (advanced)
4. Screening approach (advanced).

The default method is a simplified method based on the use of Federal supply system requisition and/or local purchase data. The material balance approach is generally the most accurate method of determining fugitive emissions. The simplified material balance approach is potentially more accurate than the screening approaches, and it can be used by agencies without detailed inventory information on each F-gas.

The screening approach can be used to calculate emissions or determine whether material balance methods are appropriate. This requires multiplying the quantity of F-gases by default emission factors for the specific type of equipment or emission event.

³⁶ Mixed refrigerants will need to be calculated to their constituent compounds. The GHG Reporting Portal has a calculator for this purpose that automatically populates the fugitives data entry module.

³⁷ Primary Reference: EPA, Climate Leaders Technical Guidance, *Direct HFC and PFC Emissions from Use of Refrigeration and Air Conditioning Equipment*, May 2008; EPA TSD for Emissions from Production of Fluorinated GHGs: Proposed Rule for Mandatory Reporting of Greenhouse Gases, February 2009.

A.5.1. Default Methodology (to be Calculated by GHG Reporting Portal)

The Federal supply system transaction screening approach (default) is a much simplified version of the material balance approach used by Federal agencies in conjunction with the development of inventories of ozone depleting substances. Central to this methodology is the assumption that subtracting the quantity of F-gas returned from the quantity an agency purchases or issues to maintain equipment can be used as a reasonable estimate of actual emissions. This assumption is reasonable when the total charge of a particular F-gas in the installed equipment is fairly constant from year to year. However, if the total charge is declining because more equipment containing the F-gas is being retired than installed, this assumption could lead to an underestimate of F-gas emissions.³⁸ If the agency knows that its total charge is declining significantly, it should consider using one of the other methodologies.

Furthermore, agencies with cyclical operations or events that use this default screening approach may find that a single reporting year is not representative of their Scope 1 F-gas fugitive emissions (HFCs, PFCs, and SF₆). As discussed in Chapter 5.3 of the Guidance, agencies may choose to calculate a 3-year rolling average base year value for their specific Scope 1 fluorinated fugitive emissions. The FY 2008 base year should consist of the average Scope 1 fluorinated gas fugitive emissions for FY 2006, FY 2007, and FY 2008. If an agency uses a 3-year rolling average base year for fugitive emission, it must continue to use it for subsequent reporting years. Agencies must note the use of this rolling average approach in the “Other Information” section of their qualitative statement. Agencies may not use the rolling average approach for their entire comprehensive inventory, but only for the F-gas fugitive emissions category.

Data Sources

Agencies will need to obtain purchase and supply requisition data on each F-gas from local or centralized sources (see Table A-6). Chemical compounds are often listed by chemical name or trade name, which can lead to confusion when a single compound is referred to by multiple names. The Chemical Abstract Service (CAS) number is a unique numeric identifier for chemical compounds that should be used when searching a chemical inventory database to avoid such confusion.

Table A-6: Fugitive Emissions—F-Gas Default Data Sources (Federal Supply System Transaction Screening Approach)

Data Element	Preferred Source	Alternate Source
Amount and type of each F-gas issued from procurement and	<ul style="list-style-type: none"> • GSA • Defense Logistics Agency 	<ul style="list-style-type: none"> • Local hazardous material management/

³⁸ Agencies should ensure there is no double counting or underreporting as they switch equipment (from R-22 to HFC-based refrigerants). If little or no new equipment is being installed, but significant amounts of old equipment are being retired, emissions can occur without resulting in demand for new gas. Specifically, emissions can occur between the final servicing of equipment and its retirement or during its retirement. These emissions could account for most or even all of the equipment charge. When at least some of the equipment charge is recovered and recycled, that charge can be used to service existing equipment (whose charge has leaked previously), offsetting demand for new gas that would have occurred if the gas from the retiring equipment were not available.

Data Element	Preferred Source	Alternate Source
storage [lb]	<ul style="list-style-type: none"> Agency logistics/supply organizations Chemical inventory tracking system 	distribution centers <ul style="list-style-type: none"> Purchase records Maintenance records
Amount recovered from equipment and the amount returned to the supply system [lb]	<ul style="list-style-type: none"> See above 	<ul style="list-style-type: none"> See above

Calculation Steps

To calculate Scope 1 emissions from fugitive F-gas emissions, do the following:

1. Collect transaction data
2. Find the difference in the amounts recovered and returned to estimate annual emissions
3. Convert annual emissions to MT CO₂e and sum emissions.

Step 1: Collect transaction data

The agency Federal fleet manager identifies the CAS numbers of the F-gases used and obtains supply system transactional data to determine the amount and type of each F-gas issued from storage. If F-gas purchase data are not available from local sources, the federal manager may need to make best judgment estimates. These data are entered by the agency manager into the GHG Reporting Portal (see Table D-15 for conversion factors).

Step 2: Find the difference in amount recovered and returned to estimate annual emissions

The GHG Reporting Portal will subtract from the amount issued the amount recovered from equipment and the amount returned to the supply system. In some cases, the agency manager may need to first convert gas reported in units of volume to units of mass before estimating emissions.

Total mass of gas [lb] = volume of gas [cu ft] • conversion factor [cu m/cu ft] • density of gas [lb/cu m]

Equation A-13 can be used once volume is known in pounds.

Equation A-13: Annual Fugitive Emissions (F-Gas—Default)

Annual Emissions [MT F-gas] = (I – R) • 4.536 x 10 ⁻⁴ [MT/lb]

Where:

I = Amount of F-gas issued from supply system [lb]

R = Amount of F-gas returned to supply system from equipment, which includes the amount recovered from equipment during maintenance and the unused amount originally issued from supply [lb]

Step 3: Convert annual emissions to MT CO₂e and sum emissions

The GHG Reporting Portal will multiply the F-gas annual emissions [MT F-gas] by the GWP of each F-gas to calculate the CO₂e emissions (see Equation A-14). It will sum all F-gas emissions. (See Table D-13 for GWP values.)

Equation A-14: Conversion of F-Gas Emissions to CO₂e (Default)

$\text{CO}_2\text{e [MT F-gas]} = \text{Annual Emissions [MT]} \bullet \text{F-gas GWP}$
--

In Examples A-6 and A-7, the refrigerant HFC-23 (CAS number 75-46-7) is listed under two names: trifluoromethane and fluoroform, illustrating the importance of using CAS numbers when querying supply systems. The examples provide steps for applying the supply system transaction screening approach when the supply system provides information in both mass and volume units.

Example A-6: Fugitive Emissions (F-Gas—Default Methodology) When Supply Data Are Available in Mass-Based Units

Step 1: Collect transaction data

- Amount of HFC-23 issued from supply system = 220 lb
- Amount of HFC-23 returned to supply system from equipment = 55 lb

Step 2: Find the difference in the amounts recovered and returned to estimate annual emissions

Equation A-13: Annual Fugitive Emissions (F-Gas—Default)

Annual	= (I – R) • 4.536 x 10 ⁻⁴ [MT/lb]
Emissions	= (220 [lb] – 55 [lb]) • 4.536 x 10 ⁻⁴ [MT/lb]
[MT HFC-23]	= 7.48 x 10 ⁻² [MT HFC-23]

Where:

- I = Amount of F-gas issued from supply system [lb]
- R = Amount of F-gas returned to supply system from equipment, which includes the amount recovered from equipment during maintenance and the unused amount originally issued from supply [lb]

Step 3: Convert annual emissions to MT CO₂e and sum emissions

Equation A-14: Conversion of F-Gas Emissions to CO₂e (Default)

CO₂e	= Annual Emissions [MT] • F-gas GWP
[MT F-gas]	= 7.48 x 10 ⁻² [MT] • 11,700
	= 875.16 [MT CO₂e]

****Note:** Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.**

Example A-7: Fugitive Emissions (F-Gas—Default Methodology) When Supply Data Are Available in Volume-Based Units

Step 1: Collect transaction data

Example calculation: The chemical inventory report shows that three canisters of HFC-23 have been issued and returned through the supply system over the past year. The amounts of gas are listed:

<u>Canister number</u>	<u>Gas quantity</u>	<u>CAS Number</u>	<u>Chemical Name</u>	<u>Transaction</u>
3778546	220 lb	75-46-7	Trifluoromethane	Issue
3645585	10 cu ft	75-46-7	Fluoroform	Issue
3654486	55 lb	75-46-7	Trifluoromethane	Return

Step 2: Find the difference in amount recovered and returned

To use the information to calculate emissions, convert the volumetric data to an equivalent mass by obtaining the density of the gas. See the available material safety data sheet (MSDS) information for HFC-23. The gas HFC-23 has a density of 6.59 lb/cu m. In the interest of accuracy and verifiability, always provide the gas density value used for the calculation and its source.

First, convert the volume of HFC-23 consumed to an equivalent mass-based format using recognized conversion factors and the density information from the MSDS.

$$\begin{aligned}
 \text{Total mass of HFC-23 [lb]} &= \text{volume of gas [cu ft]} \bullet \text{conversion factor [cu m/cu ft]} \bullet \text{density of gas [lb/cu m]} \\
 &= 10 \text{ [cu ft]} \bullet 2.83 \times 10^{-2} \text{ [cu m/cu ft]} \bullet 6.59 \text{ [lb/cu m]} \\
 &= 1.87 \text{ [lb HFC-23]}
 \end{aligned}$$

Step 3: Estimate annual emissions

Equation A-13: Annual Fugitive Emissions (F-Gas—Default)

$$\begin{aligned}
 \text{Annual Emissions [MT HFC-23]} &= (I - R) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]} \\
 &= ((220 \text{ [lb]} + 1.87 \text{ [lb]}) - 55 \text{ [lb]}) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]} \\
 &= 7.57 \times 10^{-2} \text{ [MT HFC-23]}
 \end{aligned}$$

Where:

I = Amount of F-gas issued from supply system [lb]

R = Amount of F-gas returned to supply system from equipment, which includes the amount recovered from equipment during maintenance and the unused amount originally issued from supply [lb]

Step 4: Convert annual emissions to MT CO₂e and sum emissions

Equation A-14: Conversion of F-Gas Emissions to CO₂e (Default)

$$\begin{aligned}
 \text{CO}_2\text{e Emissions [MT F-gas]} &= \text{Annual Emissions [MT]} \bullet \text{F-gas GWP} \\
 &= 7.57 \times 10^{-2} \text{ [MT HFC-23]} \bullet 11,700 \\
 &= 885.69 \text{ [MT CO}_2\text{e]}
 \end{aligned}$$

****Note:** Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.**

A.5.2. Advanced Methodologies (User Calculated)

There are three advanced methodologies that agencies may use to calculate fugitive emissions:

1. Material balance approach
2. Simplified material balance approach
3. Screening approach.

Agencies using an advanced methodology may also want to consider the minimum charge size of equipment that will be inventoried. Conducting equipment inventories of many small sealed refrigerant systems, each containing only small quantities of HFCs, may not be an efficient use of resources, given the minor emissions likely result from these systems. For example, an agency might consider excluding equipment that has installed charge sizes of less than 50 pounds such as household refrigeration/small appliances, stand-alone commercial-type refrigeration applications, smaller residential and commercial-type AC and heat-pumps, and small sealed electrical/electronic devices containing SF₆. This would have the advantage of harmonizing with the record keeping requirements under 40 CFR 82.166 (j) and (k).

Advanced Methodology 1: Material Balance Approach

A material balance approach is the most thorough method for determining fugitive F-gas emissions.

Data Sources

This methodology requires detailed information on the type of each F-gas used by your organization and each piece of F-gas-containing equipment operated at the facility level. It requires data on acquisitions, disbursements, inventory, and capacity (Table A-7).

Table A-7: Fugitive Emissions—F-Gas Advanced Data Sources (Material Balance Approach)

Data Element	Preferred Source
F-gas in inventory (storage not equipment) at the beginning of reporting period [lb]	<ul style="list-style-type: none"> • Purchase records • Maintenance records • Chemical inventory tracking system
F-gas acquisitions during the reporting period [lb]	
Total capacity of F-gas in equipment at the beginning of the reporting period [lb]	
F-gas in inventory (storage not equipment) at the end of reporting period [lb]	
F-gas disbursements during reporting period [lb]	
Total capacity of F-gas in equipment at the end of the reporting period [lb]	

Calculation Steps

To calculate Scope 1 emissions from fugitive F-gas emissions, do the following:

1. Determine the base inventory
2. Calculate changes to the base inventory
3. Calculate the annual emissions
4. Convert annual emissions to MT CO₂e and sum emissions for each facility.

Step 1: Determine the base inventory

For each F-gas in use at each facility, determine the quantity of F-gas in storage at the beginning of the year (does not include F-gas contained within equipment) and the quantity in storage at the end of the year.

Step 2: Calculate changes to the base inventory

For each F-gas, determine purchases and other acquisitions,³⁹ sales and other disbursements,⁴⁰ and net change of total equipment capacity for a given F-gas during the year.⁴¹

Step 3: Calculate the annual emissions

For each F-gas or refrigerant blend, use Equation A-15.

Equation A-15: Annual Fugitive Emissions (F-Gas—Material Balance Approach)

$$\text{Annual Emissions [MT F-gas]} = (I_B - I_E + P - S + C_B - C_E) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]}$$

Where:

I_B = Quantity of F-gas in storage at beginning of inventory year [lb]

I_E = Quantity of F-gas in storage at end of inventory year [lb]

P = Sum of all the F-gas acquisitions [lb]

S = Sum of all the F-gas disbursements [lb]

C_B = Total capacity of F-gas in equipment at beginning of inventory year [lb]

C_E = Total capacity of F-gas in equipment at end of inventory year [lb]

³⁹ Acquisitions are the sum of all individual F-gases purchased or otherwise acquired during the year, either in storage containers or in equipment. This includes F-gases purchased from producers or distributors, provided by manufacturers or inside equipment, added to equipment by contractors or other service personnel (unless that refrigerant is from the agency's inventory), and returned after off-site recycling or reclamation.

⁴⁰ Disbursements are the sum of all F-gases sold or otherwise dispersed during the year, either in storage containers or in equipment. This includes F-gases in containers or left in equipment that is sold, returned to suppliers, or sent off site for recycling, reclamation, or destruction.

⁴¹ The net increase in total full charge of equipment refers to the full and proper charge of the equipment rather than to the actual charge, which may reflect leakage.

Step 4: Convert annual emissions to MT CO₂e and sum emissions for each facility

Use Equation A-16 to convert them to MT CO₂e. (See Table D-13 for the GWP for each gas.)
Sum the emissions from each F-gas type.

Equation A-16: Conversion of F-Gas Emissions to MT CO₂e (Advanced)

$$\text{CO}_2\text{e [MT F-gas]} = \text{Annual Emissions [MT]} \bullet \text{F-gas GWP}$$

Example A-8: Fugitive Emissions (F-Gas—Material Balance)

Step 1: Determine the base inventory

- Beginning of year storage = 1367 lb
- End of year storage = 1323 lb
- Purchases of HFC-23 = 441 lb
- HFC-23 sold (i.e., disbursements) = 0.0 lb
- Total nameplate capacity of HFC-23 equipment retired during the inventory year = 44 lb
- Total nameplate capacity of new HFC-23 in equipment installed during the inventory year = 22 lb

Step 2: Calculate changes to the base inventory

Step 3: Calculate the annual emissions

Equation A-15: Annual Fugitive Emissions (F-Gas—Material Balance Approach)

$$\begin{aligned} \text{Annual Emissions [MT HFC]} &= (I_B - I_E + P - S + C_B - C_E) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]} \\ &= (1367 \text{ [lb]} - 1323 \text{ [lb]} + 441 \text{ [lb]} + 0.0 \text{ [lb]} + 44 \text{ [lb]} - 22 \text{ [lb]}) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]} \\ &= 0.23 \text{ [MT HFC-23]} \end{aligned}$$

Where:

- I_B = Quantity of F-gas in storage at beginning of inventory year [lb]
- I_E = Quantity of F-gas in storage at end of inventory year [lb]
- P = Sum of all the F-gas acquisitions [lb]
- S = Sum of all the F-gas disbursements [lb]
- C_B = Total capacity of F-gas in equipment at beginning of inventory year [lb]
- C_E = Total capacity of F-gas in equipment at end of inventory year [lb]

Step 4: Convert annual emissions to MT CO₂e and sum emissions for each facility

Equation A-16: Conversion of F-Gas Emissions to MT CO₂e (Advanced)

$$\begin{aligned} \text{CO}_2\text{e emissions [MT F-gas]} &= \text{Annual Emissions [MT]} \bullet \text{F-gas GWP} \\ &= 0.25 \text{ [MT]} \bullet 11,700 \\ &= 2,925 \text{ [MT]} \end{aligned}$$

****Note:** Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.**

Advanced Methodology 2: Simplified Material Balance Approach

Description

This methodology is a simplified version of the first advanced methodology.

Data Sources

Table A-8 shows the data by F-gas type agencies will need for this method.

Table A-8: Fugitive Emissions—F-Gas Advanced Data Sources (Simplified Material Balance Approach)

Data Element	Preferred Source
F-gas used to charge new equipment (omitted if the equipment has been precharged by the manufacturer) [lb]	<ul style="list-style-type: none">• Purchase records• Maintenance records• Chemical inventory tracking system
Total full capacity of the new equipment (omitted if the equipment has been precharged by the manufacturer) [lb]	
Quantity of F-gas used to service equipment [lb]	
Total full capacity of retiring equipment [lb]	
F-gas recovered from retiring equipment [lb]	

Calculation Steps

To calculate Scope 1 emissions from fugitive F-gas emissions, do the following:

1. Determine the base inventory
2. Calculate the annual emissions
3. Convert annual emissions to MT CO₂e and sum emissions.

Step 1: Determine the base inventory

Determine the types and quantities of F-gas used at each facility by determining the quantity of F-gas used to charge new equipment and service existing equipment, including types and quantities recovered from retiring equipment. Also, determine the total full capacity of new and retiring equipment.

Step 2: Calculate the annual emissions

For each type of F-gas, determine any emissions from installation, operation, and disposal of equipment. If the reporting entity did not install or dispose of equipment during the reporting year, emissions from these activities should not be included. Using Equation A-17, add emissions from each piece of equipment to get the total emissions.

Equation A-17: Annual Fugitive Emissions (F-Gas—Simplified Material Balance Approach)

$$\text{Annual Emissions [MT F-gas]} = (P_N - C_N + P_S + C_D - R_D) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]}$$

Where:

- P_N = Purchases of F-gas used to charge new equipment [lb]*
- C_N = Total full capacity of the new equipment [lb]*
- P_S = Quantity of F-gas used to service equipment [lb]
- C_D = Total full capacity of retiring equipment [lb]
- R_D = F-gas recovered from retiring equipment [lb]

* If no equipment was newly purchased or retired, variables can be omitted.

Step 3: Convert annual emissions to MT CO₂e and sum emissions

Use Equation A-16 to convert the emissions associated with each F-gas to MT CO₂e and total F-gas emissions at each facility.

Example A-9: Fugitive Emissions (F-Gas—Simplified Material Balance)

Step 1: Determine the base inventory

- Purchases of HFC-23 = 1543 lb
- Total full capacity of the new equipment = 882 lb
- Quantity of HFC-23 used to service equipment = 441 lb
- Total full capacity of retiring equipment = 794 lb
- HFC-23 recovered from retiring equipment = 220 lb

Step 2: Calculate the annual emissions

Equation A-17: Annual Fugitive Emissions (F-Gas—Simplified Material Balance Approach)

$$\begin{aligned} \text{Annual Emissions [MT HFC-23]} &= (P_N - C_N + P_S + C_D - R_D) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]} \\ &= (1543 \text{ [lb]} - 882 \text{ [lb]} + 441 \text{ [lb]} + 794 \text{ [lb]} - 220 \text{ [lb]}) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]} \\ &= 0.76 \text{ [MT HFC-23]} \end{aligned}$$

- P_N = Purchases of F-gas used to charge new equipment [lb]
- C_N = Total full capacity of the new equipment [lb]
- P_S = Quantity of F-gas used to service equipment [lb]
- C_D = Total full capacity of retiring equipment [lb]
- R_D = F-gas recovered from retiring equipment [lb]

Step 3: Convert annual emissions to MT CO₂e and sum emissions

Equation A-16: Conversion of F-Gas Emissions to MT CO₂e (Advanced)

$$\begin{aligned} \text{CO}_2\text{e emissions [MT F-gas]} &= \text{Annual Emissions [MT F-gas]} \bullet \text{F-gas GWP} \\ &= 0.76 \text{ [MT HFC-23]} \bullet 11,700 \\ &= 8,892 \text{ [MT CO}_2\text{e]} \end{aligned}$$

****Note:** Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.**

Advanced Methodology 3: Screening Approach⁴²

Data Sources

To use this screening method, an agency must have an inventory of equipment by quantity, equipment category, F-gas type, and total charge capacity (Table A-9).

Table A-9: Fugitive Emissions—F-Gas Advanced Data Sources (Screening Approach)

Data Element	Preferred Source
Inventory of equipment by number, equipment category, F-gas type, and total charge capacity [lb]	<ul style="list-style-type: none"> • Purchase records • Maintenance records • Chemical inventory tracking system
Amount of F-gas in the equipment [lb]	<ul style="list-style-type: none"> • Same as above
Emission Factor	<ul style="list-style-type: none"> • See Table D-7

Calculation Steps

To calculate Scope 1 emissions from fugitive F-gas emissions, do the following:

1. Determine the base inventory
2. Calculate the annual emissions
3. Convert annual emissions to MT CO₂e and sum emissions.

Step 1: Determine the base inventory

Determine the quantity and types of equipment by equipment category, the types of F-gas used, and the F-gas charge capacity of each piece of equipment.

Step 2: Calculate the annual emissions

For each type of F-gas, determine any emissions from installation, operation, or disposal of equipment. Equation A-18 combines these three sources, as follows:

Installation: $(C_N \bullet k)$, where the emissions from installation equal the amount of refrigerant charged into new equipment (C_N) multiplied by assembly losses (k)

Operation: $(C \bullet x \bullet T)$, where emissions from operation equal the charge capacity (C) multiplied by the annual leak rate (x) and time used (T)

⁴² Although this enhanced screening approach would enhance the fidelity of estimates over the default methodology, the fugitive emission estimates are still uncertain.

Disposal: $(C_D \bullet y \bullet (1 - z))$, where disposal equals the charge capacity being disposed of (C_D) multiplied by the percent capacity remaining (y) and the percent refrigerant removed ($1-z$).

If the reporting entity did not install or dispose of equipment during the reporting year, emissions from these activities should not be included. Use default emission factors provided in Table D-7 by equipment type. Estimate annual emissions of each F-gas type, using Equation A-18.

Equation A-18: Annual Fugitive Emissions (F-gas—Screening Approach)

Annual Emissions [MT F-gas] =

$$((C_N \bullet k) + (C \bullet x \bullet T) + (C_D \bullet y \bullet (1 - z))) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]}$$
 Where:
 C_N = Quantity of F-gas charged into the new equipment [lb]*
 C = Total full charge capacity of the equipment [lb]
 T = Time equipment was in use
 (such as 0.5 if used only during half the year and then disposed) [yrs]
 C_D = Total full charge capacity of equipment being disposed [lb]*
 k = Installation emission factor [%]
 x = Operation emission factor [%]
 y = Refrigerant remaining at disposal [%]
 z = Recovery efficiency [%]

* If no equipment was added or retired, variables can be omitted.

Step 3: Convert annual emissions to MT CO₂e and sum emissions

Use Equation A-16 to convert them to units of CO₂e and determine the total F-gas emissions. (See Table D-13 for the GWP for each gas.)

Example A-10: Fugitive Emissions (F-Gas—Screening)

Step 1: Determine the base inventory

Screening sample data for medium and large commercial refrigeration:

- Quantity of HFC-23 charged into the new equipment = 1,764 lb
- Total full charge of the new equipment = 882 lb
- Time equipment was in use = 1 yr
- Total full charge of equipment being disposed of = 441 lb
- Installation emission factor = 3% (0.03)
- Operating emission factor = 35% (0.35)
- Refrigerant remaining at disposal = 100% (1.00)
- Recovery efficiency = 70% (0.70)

Step 2: Calculate the annual emissions

Equation A-18: Annual Fugitive Emissions (F-gas—Screening Approach)

$$\begin{aligned}
 \text{HFC-23 Emissions [MT]} &= ((C_N \bullet k) + (C \bullet x \bullet T) + (C_D \bullet y \bullet (1 - z))) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]} \\
 &= ((1764 \text{ [lb]} \bullet 0.03 + (882 \text{ [lb]} \bullet 0.35 \bullet 1) + (441 \text{ [lb]} \bullet 1.00 \bullet (1-0.70))) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]} \\
 &= (52.92 \text{ [lb]} + 308.7 \text{ [lb]} + 132.3) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]} \\
 &= 0.2240 \text{ [MT HFC-23]}
 \end{aligned}$$

Where:

- C_N = Quantity of F-gas charged into the new equipment [lb]
- C = Total full charge capacity of the equipment [lb]
- T = Time equipment was in use (such as 0.5 if used only during half the year and then disposed) [yrs]
- C_D = Total full charge capacity of equipment being disposed [lb]
- k = Installation emission factor [%]
- x = Operation emission factor [%]
- y = Refrigerant remaining at disposal [%]
- z = Recovery efficiency [%]

Step 3: Convert annual emissions to MT CO₂e and sum emissions

Equation A-16: Conversion of F-Gas Emissions to MT CO₂e (Advanced)

$$\begin{aligned}
 \text{CO}_2\text{e emissions [MT F-gas]} &= \text{Annual Emissions [MT F-gas]} \bullet \text{F-gas GWP} \\
 &= 0.2153 \text{ [MT HFC-23]} \bullet 11,700 \\
 &= \mathbf{2,519.01 \text{ [MT CO}_2\text{e]}}
 \end{aligned}$$

****Note:** Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.**

A.6. Fugitive Emissions: Wastewater Treatment

Description

This category includes emissions from treatment of wastewater generated as a result of operations, with the treatment plant falling within the agency’s organizational boundary. The category includes anaerobic reactors, anaerobic lagoons, and anaerobic sludge digesters.⁴³ Wastewater from domestic (municipal sewage) and industrial sources is treated to remove soluble organic matter, suspended solids, pathogenic organisms, and chemical contaminants. WWTP processes can produce anthropogenic CH₄ and N₂O emissions.

⁴³ An *anaerobic reactor* is an enclosed vessel used for anaerobic wastewater treatment (e.g., upflow anaerobic sludge blanket, fixed film). An *anaerobic sludge digester* is an enclosed vessel in which wastewater treatment sludge is degraded anaerobically. An *anaerobic lagoon* is a lined or unlined earthen basin used for wastewater treatment, in which oxygen is absent throughout the depth of the basin, except for a shallow surface zone. Anaerobic lagoons are not equipped with surface aerators. Anaerobic lagoons are classified as deep (depth more than 2 meters) or shallow (depth less than 2 meters).

This section focuses solely on calculating the CH₄ and N₂O emissions created by on site wastewater treatment and septic systems. GHG emissions from other activities related to wastewater treatment are currently not included in the Guidance.

The default methodology requires only data on the population served by each type of agency owned or operated WWTP. Where one treatment process feeds into another, agencies should enter the population served into each process calculation. The default methodology uses national averages to determine the treatment processes and operating variables. However, this is not as accurate as the advanced methodology approach, which uses facility-specific wastewater treatment processes and operating variables.⁴⁴ Agencies can pursue the advanced method when flow data are known.

A.6.1. Default Methodology (to be Calculated by GHG Reporting Portal)

Data Sources

The default methodology (Table A-10) applies population-based calculations that use national average defaults. The population served should include the population actually served by the plant, regardless of employer (Federal, contractor, sub-contractor). For example, if construction workers bring their own outhouses, they would not be counted. If the site includes a visitors' center or a prison, those visitor or prisoner populations should be included. If the number fluctuates throughout the year, agencies should provide an annual average of the population contributing to the system. The GHG Reporting Portal will allow for customization in the number of hours the population is using the system (default is 12 hours).

Table A-10: Fugitive Emissions—Wastewater Treatment Default Data Sources

Data Element	Preferred Source	Alternate Source
Type of WWTP	<ul style="list-style-type: none"> Default provided 	<ul style="list-style-type: none"> Wastewater operations division
Population served (includes employees, on-site contractors, and visitors) ⁴⁵	<ul style="list-style-type: none"> Agency records 	<ul style="list-style-type: none"> Agency records

The default methodology divides sources of CH₄ and N₂O emissions into six categories (Table A-11). Agencies may use more than one of these processes.

⁴⁴ Both the minimum required and advanced methodologies are based on EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks* and *LGO Protocol*, Chapter 10. Agencies should be aware that there are a limited number of widely accepted methodologies for calculating emissions associated with wastewater treatment at an organizational scale and the *LGO Protocol* is not from a federal source. See www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/ for the *LGO Protocol*.

⁴⁵ Given that an agency maintains operational control over the on-site WWTP facilities and process, the number of Federal employees, on-site contractor and visitors is used as a proxy for estimating biological oxygen demand (BOD₅) input for the WWTP facility's treatment stream emission calculations. If industrial BOD₅ or significant amounts of visitors increase this treatment load, this additional BOD₅ should be converted to full time equivalent personnel served and added to the overall personnel served number. However, if BOD₅ monitoring data are available, these should be used and converted to full time equivalent population served as an advanced methodology.

Table A-11: Fugitive Emissions—Summary of Wastewater Treatment Default Emission Sources

GHG Source	GHG Type	Data Required	Equation
On-site centralized WWTP with anaerobic digestion	Stationary CH ₄ emissions	Population served	A-19
On-site centralized WWTP with nitrification/denitrification	N ₂ O emissions	Population served	A-20
On-site centralized WWTP without nitrification/denitrification	N ₂ O emissions	Population served	A-21
On-site effluent discharge to rivers and estuaries with and without nitrification/denitrification	N ₂ O emissions	Population served	A-22
On-site wastewater treatment lagoons	CH ₄ emissions	Population served	A-23
On-site septic systems	CH ₄ emissions	Population served	A-24

Calculation Steps

1. Determine which wastewater treatment processes are used and the number of personnel served by each
2. Calculate emissions from each wastewater treatment process used
3. Sum emissions from all processes

Step 1: Determine which wastewater treatment processes are used and the number of personnel served by each

The emissions from WWTPs depend on the wastewater treatment processes used. Agencies should coordinate with their wastewater operations division to determine which of the processes outlined in Table A-11 are part of the agency wastewater treatment operations.

Agency calculations of the number of personnel served by the WWTP are not performed by the GHG Reporting Portal. To calculate employee and on-site contractor population served by the system, use the equation below. Estimate the percentage of time that part-time employees/contractors (PT) spend on site compared with full-time employees/contractors (FT).

Employee and on-site contractor population served by system = the number of FT + (the number of PT x percent of time spent on site)

Methods to estimate visitor population served by the on-site wastewater treatment system are specific to facility type. For office buildings, laboratories, and other similar facilities, agencies may assume that visitor wastewater treatment inputs are netted out by off-site visits made by employees. Therefore, agencies can input only the number of employees and on-site contractors.

For national parks/federal lands, and other visitor-focused sites, where available, use visitor data.

Where data are unavailable, agencies may develop a method to estimate visitors, such as developing a factor to be applied to the number of employees at the site (e.g., 10 visitors for every employee) to estimate visitors. Alternatively, in the GHG Reporting Portal, the default number of workdays per year may be adjusted to reflect the number of visitors or that the visitors do not remain on site for the duration of a workday. It is recommended that agencies clearly document assumptions behind visitor numbers and length of stay.

The agency enters the population served by each type of process. Where treatment processes occur in series, the population served should be entered into each treatment process calculation. For example, centralized wastewater treatment and on-site effluent discharged to rivers and estuaries are not mutually exclusive since a site may have both centralized treatment and effluent discharges. “Centralized waste water treatment” refers to on-site wastewater treatment processes that generate emissions prior to discharge into a river. These emissions include CH₄ from bacterial activity in the anaerobic digesters of the treatment plant. “On-site effluent discharged to rivers and estuaries” refers to a WWTP direct discharge of treated wastewater to a river. This wastewater contains nutrients that cause additional biological activity in the river or estuary. GHG emissions are generated in the river downstream due to this increased biological activity as bacteria process these added nutrients.

Agencies are given a number of options to calculate wastewater flow to the various treatment processes or series of processes:

1. Attribute a share of personnel to each wastewater treatment system based on the amount of wastewater processed in each system when that data is available or when an estimate can be made
2. Attribute a share of personnel to each wastewater treatment system based on the capacity of each system
3. Assume all wastewater goes to the treatment system that would create highest amount of GHG
4. Assume all wastewater goes to the largest treatment system.

Agencies may need to adjust the population served for some wastewater treatment processes if there are significant industrial contributions to the system. Examples of sources of potential significant contribution of nitrogen and/or biological oxygen demand (BOD) include food processing, ethanol production, and pulp and paper processing. The contribution factor from industry is calculated by estimating the total nitrogen and BOD contribution of the industrial process and dividing units of nitrogen or BOD per day by a population equivalent, identified by process in Table A-12. This factor is added to the population served. Processes not listed do not need to adjust the population served.

Table A-12: Fugitive Emissions—Industrial Contribution Equivalents for GHG Sources

GHG Source	Industrial Contribution Equivalent	Equation
On-site centralized WWTP with and without nitrification/denitrification	= kg total nitrogen from industrial sources per day ÷ 0.026 [kg N/person/day]	A-20,21
On-site effluent discharge to rivers and estuaries with and without nitrification/denitrification	= kg total nitrogen from industrial sources per day ÷ 0.026 [kg N/person/day]	A-22
On-site wastewater treatment lagoons	= kg total BOD ₅ from industrial sources per day ÷ 0.090 [kg BOD ₅ /person/day]	A-23

Step 2: Calculate emissions from each wastewater treatment process used

The GHG Reporting Portal will automatically calculate emissions associated with each process on the basis of population information provided using the default national averages within the GHG Reporting Portal. Agencies may choose to alter certain criteria, such as the number of workdays per year and fraction of time allocated to the facility (the default is 50 percent, or 12 hours).

This step is subdivided into the six processes outlined in Table A-11. Each subsection below briefly describes the process and associated calculations that will be performed by the GHG Reporting Portal.

On-Site Centralized WWTP with Anaerobic Digestion

Many agencies use anaerobic digesters to treat excess biosolids produced by the wastewater treatment processes. The process of anaerobic digestion creates CH₄, which is then combusted as a flare. However, these combustion flares are also a source of CH₄ and N₂O emissions. Equation A-19 describes the default methodology to be used in the GHG Reporting Portal. The GHG Reporting Portal will also calculate the stationary combustion emissions from flaring. This will be calculated according to the methodology in Section A.1 and will not require any additional agency input.

Equation A-19: Fugitive CH₄ Emissions from On-Site Centralized WWTP with Anaerobic Digestion (Default)

$$\text{Annual CH}_4 \text{ emissions [MT]} = (P_{\text{total}} \bullet 230 \bullet 0.5) \bullet \text{Digester Gas} \bullet F_{\text{CH}_4} \bullet \rho(\text{CH}_4) \bullet 0.001$$

Where:

- P_{total} = Population serviced by the WWTP with anaerobic digesters
- 230.00 = Conversion factor [workdays/year]
- 0.5 = Fraction of time allocated to facility (12 hrs)
- Digester Gas = Measured standard cubic feet of digester gas produced per capita per day [cu ft/day], default value of 1.0
- F_{CH₄} = Fraction of CH₄ in biogas, default value of 0.65

$\rho(\text{CH}_4)$	=	Density of CH_4 at standard conditions [kg/cu ft], default value of 0.019
0.001	=	Conversion from kg to MT [MT/kg]

Source: EPA, *Inventory of US Greenhouse Gas Emissions and Sinks: 1990 – 2008*, Chapter 8 (2010) and *LGO Protocol*. See www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/.

On-Site Centralized WWTP with or without Nitrification/Denitrification

This section provides equations for calculating N_2O emissions from a centralized WWTP. Agencies with large Federal facilities may maintain and operate such WWTP facilities on site. At the treatment facility, the wastewater is treated to standards that allow for surface water discharge. Some centralized systems have nitrification/denitrification treatment processes, and some do not.⁴⁶

If significant industrial contributions of nitrogen are discharged to the municipal treatment system, the agency should modify the population served value. The contribution factor from industry is calculated by dividing the total nitrogen discharged by industry to the municipal treatment system [kg of total nitrogen per day] by the nitrogen population equivalent of 0.026 kg N/person/day.

This industrial contribution is adjusted for using an equivalent population proxy value that should be added to the domestic populations served by the centralized wastewater treatment system. As much as possible, this adjusted population served number (domestic plus industrial equivalent) is the value agencies should use in the GHG Reporting Portal.

Equation A-20: Fugitive N_2O Emissions from WWTP with Nitrification/Denitrification (Default)

$$\text{Annual } \text{N}_2\text{O} \text{ emissions [MT]} = (P_{\text{total}} \bullet 230.00 \bullet 0.5) \bullet \text{EF nit/denit} \bullet 10^{-6}$$

Where:

P_{total}	=	Total population served by the centralized WWTP adjusted for industrial discharge, if applicable [person]
230.00	=	Conversion factor [workdays/year]
0.5	=	Fraction of time allocated to facility (12 hrs)
EF nit/denit	=	Emission factor for a WWTP with nitrification/denitrification [g N_2O /person/day], default value of 0.019
10^{-6}	=	Conversion from g to MT [MT/g]

⁴⁶ Equations in this section are adapted for use by agencies from Section 6.3 of the 2006 IPCC Guidelines and Section 8.2 of the EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks (1990–2008)*.

Equation A-21: Fugitive N₂O Emissions from WWTP without Nitrification/Denitrification (Default)

$$\text{Annual N}_2\text{O emissions [MT]} = (P_{\text{total}} \bullet 230.00 \bullet 0.5) \bullet \text{EF w/o nitrification/denitrification} \bullet 10^{-6}$$

Where:

P_{total}	=	Total population served by the centralized WWTP adjusted for industrial discharge, if applicable [person]
230.00	=	Conversion factor [workdays/year]
0.5	=	Fraction of time allocated to facility (12 hrs)
EF w/o nit/denit	=	Emission factor for a WWTP without nitrification/denitrification [g N ₂ O/person/day], default value of 0.009
10^{-6}	=	Conversion from g to MT [MT/g]

Effluent Discharge to Rivers and Estuaries for WWTP with and without Nitrification/Denitrification

If site-specific data are not available, Equation A-18 is used to estimate fugitive N₂O emissions from effluent discharge with or without nitrification/denitrification. The only difference in either calculation is the default value of the plant nitrification/denitrification factor. The GHG Reporting Portal will automatically calculate each type per the population served. Agencies should adjust population for industrial contributions for this source. The portal will assume the system is aerobic.

Equation A-22: Fugitive N₂O Emissions from Effluent Discharge (Default)

$$\text{Annual N}_2\text{O emissions [MT]} = (P_{\text{total}} \bullet 230 \bullet 0.5) \bullet (N_{\text{Load}} - N_{\text{uptake}} \bullet \text{BOD}_5 \text{ load}) \bullet \text{EF}_{\text{effluent}} \bullet 44/28 \bullet (1 - F_{\text{plant nit/denit}}) \bullet 0.001$$

Where:

P_{total}	=	Total population served by the centralized WWTP adjusted for industrial discharge, if applicable [person]
230.00	=	Conversion factor [workdays/year]
0.5	=	Fraction of time allocated to facility (12 hrs)
N_{Load}^{47}	=	Per capita nitrogen load [kg N/person/day], default value of 0.026
N_{uptake}^{48}	=	Nitrogen uptake for cell growth in aerobic system/anaerobic system [kg N/kg BOD ₅], default values of 0.05* for aerobic and 0.005* for anaerobic

⁴⁷ The default total nitrogen load value is derived on the basis of the following default values from EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2008*, Chapter 8 and Table 8.13: Average U.S. protein intake (41.9 kg/person-year) x default fraction of N in protein (0.16 kg N/kg protein) x factor for non-consumed protein added to water (1.4)/days per year (365.25) = 0.026 kg N/person/day.

⁴⁸ Some of the influent nitrogen is required for microbial growth inherent in aerobic or anaerobic treatment processes. Nitrogen is assimilated by bacteria, which grow and are further managed as biosolids. This assimilation results in lower nitrogen levels in the discharged effluent.

BOD ₅ load	=	Per capita BOD ₅ produced per day [kg BOD ₅ /person/day], default value of 0.090
EF _{effluent}	=	Effluent emission factor [kg N ₂ O-N/kg sewage-N produced], default value of 0.005
44/28	=	Molecular weight ratio of N ₂ O to N ₂
F _{plant nit/denit}	=	Fraction of nitrogen removed for the centralized WWTP with nit/denit, default value of 0.7* or, fraction of nitrogen removed for the centralized WWTP w/o nit/denit, default value of 0.0 ¹
0.001	=	Conversion from kg to MT [MT/kg]

* C. P. L. Grady Jr., G. T. Daigger, and H. C. Lim, *Biological Wastewater Treatment*, p. 108–109, 644 2nd edition (1999).

On-Site Wastewater Treatment Lagoons

Treatment lagoons are pond-like bodies of water used to receive, hold, and treat wastewater for a predetermined period. Wastewater is treated aerobically and anaerobically, and the latter generates quantities of CH₄ emissions. Equation A-23 details the process to estimate fugitive CH₄ emissions from wastewater treatment lagoons. If significant industrial contributions of wastewater are discharged, the agency should modify the population served value. The contribution factor from industry is calculated by dividing the total BOD₅ discharged by industry to the municipal treatment system, expressed in kg of total BOD₅ per day by the BOD₅ population equivalent of 0.090 kg BOD₅/person/day.

The industrial-equivalent population is then added to the domestic population served by the centralized wastewater treatment system, and the total population (domestic plus industrial-equivalent) is the value agencies should use in the GHG Reporting Portal.

Equation A-23: Fugitive CH₄ Emissions from Wastewater Treatment Lagoons (Default)

Annual CH₄ emissions [MT] =

$$(P_{\text{total}} \bullet 230 \bullet 0.5) \bullet \text{BOD}_5 \text{ load} \bullet (1-F_p) \bullet B_o \bullet \text{MCF}_{\text{anaerobic}} \bullet F_{\text{removed}} \bullet 0.001$$

Where:

P _{total}	=	Population served by lagoons adjusted for industrial discharge, if applicable [person]
230.00	=	Conversion factor [workdays/year]
0.5	=	Fraction of time allocated to facility (12 hrs)
BOD ₅ load	=	Per capita BOD ₅ produced per day (influent to wastewater treatment process) [kg BOD ₅ /person/day], default value of 0.090
F _p	=	Fraction of BOD ₅ removed in primary treatment, if present, default value of 0.325
B _o	=	Maximum CH ₄ -producing capacity for domestic wastewater [kg CH ₄ /kg BOD ₅ removed], default value of 0.6
MCF _{anaerobic}	=	CH ₄ correction factor for anaerobic systems, default value of 0.8
F _{removed}	=	Fraction of lagoon BOD ₅ removal performance, default value of 1.0
0.001	=	Conversion from kg to metric ton [metric ton/kg]

On-Site Septic Systems

Septic tanks are usually small-scale treatment systems where wastewater is held in a tank or receptacle while it is being treated. Anaerobic bacteria treat the waste and release CH₄ in the process. If an agency has operational control of septic systems, fugitive CH₄ emissions should be estimated. If site-specific data are not available, emissions from septic systems will be calculated in the GHG Reporting Portal using Equation A-24.

Equation A-24: Fugitive CH₄ Emissions from Septic Systems (Default)

$$\text{Annual CH}_4 \text{ emissions [MT]} = (P_{\text{total}} \bullet 230 \bullet 0.5) \bullet \text{BOD}_5 \text{ load} \bullet B_o \bullet \text{MCF}_{\text{septic}} \bullet 0.001$$

Where:

P _{total}	=	Population served by septic systems [person]
230.00	=	Conversion factor [workdays/year]
0.5	=	Fraction of time allocated to facility (12 hrs)
BOD ₅ load	=	Per capita BOD ₅ produced per day [kg BOD ₅ /person/day], default value of 0.090
B _o	=	Maximum CH ₄ -producing capacity for domestic wastewater [kg CH ₄ /kg BOD ₅ removed], default value of 0.6
MCF _{septic}	=	CH ₄ correction factor for septic systems, default value of 0.5
0.001	=	Conversion from kg to MT [MT/kg]

Step 3: Sum emissions from all processes

In this final step, the GHG Reporting Portal will sum the emissions from all processes and apply the appropriate GWP values to calculate total emissions from wastewater treatment in units of CO₂e.

Equation A-25: Fugitive Wastewater Treatment MT CO₂e Emissions (Default)

$$\text{CO}_2\text{e Emissions [MT CO}_2\text{e]} = (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP})$$

Example A-11: Fugitive Emissions (Wastewater Treatment—Default)

An agency's wastewater treatment facility combusts digester gas and has a nitrification/denitrification process. The facility serves 10,000 people, and the agency does not have any site-specific data on the facility. The site has industrial contributions for N₂O, a total of 10 kg of N, which requires an increase in population of 385.

$$\begin{aligned} \text{Industrial Contribution:} &= \text{kg total nitrogen from industrial sources per day} \div 0.026 \text{ [kg N/person/day]} \\ &= 10 \text{ [N]} \div 0.026 \text{ [kg N/person/day]} \\ &= 384.62 \text{ industrial population equivalent} \end{aligned}$$

The following equations do not include the stationary process of flaring, leading to very different results, which will be addressed in one step in the GHG Reporting Portal.

Step 1: Determine which wastewater treatment processes are used

The WWTP uses incomplete combustion of digester gas and nitrification/denitrification.

Step 2: Calculate emissions from each wastewater treatment process used

Equation A-20: Fugitive CH₄ Emissions from On-Site Centralized WWTP with Anaerobic Digestion (Default)

$$\begin{aligned} \text{Annual CH}_4 \text{ emissions [MT]} &= (P \bullet 230 \bullet 0.5) \bullet \text{Digester Gas} \bullet F_{\text{CH}_4} \bullet \rho(\text{CH}_4) \bullet 0.001 \\ &= (10,000 \bullet 230 \bullet 0.5) \bullet 1.0 \bullet 0.65 \bullet 0.019 \bullet 0.001 \\ &= 14.20 \text{ [MT CH}_4\text{]} \end{aligned}$$

Where:

- P = Population serviced by the WWTP with anaerobic digesters
- 230.00 = Conversion factor [workdays/year]
- 0.5 = Fraction of time allocated to facility (12 hrs)
- Digester Gas = Measured standard cubic feet of digester gas produced per capita per day [cu ft/day], default value of 1.0
- F CH₄ = Fraction of CH₄ in biogas, default value of 0.65
- ρ(CH₄) = Density of CH₄ at standard conditions [kg/cu ft], default value of 0.019
- 0.001 = Conversion from kg to MT [MT/kg]

Equation A-21: Fugitive N₂O Emissions from WWTP with Nitrification/Denitrification (Default)

$$\begin{aligned} \text{Annual N}_2\text{O emissions [MT]} &= (P_{\text{total}} \bullet 230 \bullet 0.5) \bullet \text{EF nit/denit} \bullet 10^{-6} \\ &= (10,385 \bullet 230 \bullet 0.5) \bullet 0.019 \bullet 10^{-6} \\ &= 0.02269 \text{ [MT N}_2\text{O]} \end{aligned}$$

Where:

- P_{total} = Total population served by the centralized WWTP adjusted for industrial discharge, if applicable [person]
- 230.00 = Conversion factor [workdays/year]
- 0.5 = Fraction of time allocated to facility (12 hrs)
- EF nit/denit = Emission factor for a WWTP with nitrification/denitrification [g N₂O/person/day], default value of 0.019
- 10⁻⁶ = Conversion from g to MT [MT/g]

Step 3: Sum emissions from all processes

Equation A-26: Fugitive Wastewater Treatment MT CO₂e Emissions (Default)

$$\begin{aligned} \text{CO}_2\text{e emissions [MT CO}_2\text{e]} &= (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP}) \\ &= (14.20 \bullet 21) + (0.02185 \bullet 310) \\ &= 304.97 \text{ [MT CO}_2\text{e]} \end{aligned}$$

****Note:** Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.**

A.6.2. Advanced Methodology (User Calculated)

Data Sources

The advanced methodology requires the data shown in Table A-13 for each WWTP over which the agency has operational control.

Table A-13: Fugitive Emissions—Wastewater Treatment Advanced Data Sources

Data Element	Preferred Source
Population served	<ul style="list-style-type: none"> Agency records
Wastewater treatment processes used	<ul style="list-style-type: none"> Wastewater operations division
Digester gas [cu ft/day]	<ul style="list-style-type: none"> Wastewater operations division
Fraction of CH ₄ in biogas	<ul style="list-style-type: none"> Wastewater operations division
BOD ₅ load [kg BOD ₅ /day]	<ul style="list-style-type: none"> Wastewater operations division
Fraction of overall BOD ₅ removal performance	<ul style="list-style-type: none"> Wastewater operations division
N load	<ul style="list-style-type: none"> Wastewater operations division

As in the default methodology, sources of CH₄ and N₂O emissions are divided into six categories. Table A-14 shows the sources of CH₄ and N₂O emissions and references the detailed equations agencies should use to calculate emission from each applicable source.

Table A-14: Fugitive Emissions—Summary of Wastewater Treatment Advanced Emission Sources

GHG Source	GHG Type	Data Required	Equation
On-site centralized WWTP with anaerobic digestion	Stationary CH ₄ emissions	<ul style="list-style-type: none"> Digester gas [cu ft/day] Fraction of CH₄ in biogas 	A-26
On-site centralized WWTP with nitrification/denitrification	Fugitive N ₂ O emissions	<ul style="list-style-type: none"> Population served 	A-27
On-site centralized WWTP without nitrification/denitrification	Fugitive N ₂ O emissions	<ul style="list-style-type: none"> Population served 	A-28
On-site effluent discharge to receiving aquatic environments	Fugitive N ₂ O emissions	<ul style="list-style-type: none"> N load [kg N/day] 	A-29
On-site wastewater treatment lagoons	Fugitive CH ₄ emissions	<ul style="list-style-type: none"> BOD₅ load [kg BOD₅/day] Fraction of overall BOD₅ removal performance 	A-30
On-site septic systems	Fugitive CH ₄ emissions	<ul style="list-style-type: none"> BOD₅ load [kg BOD₅/person/day] 	A-31

Calculation Steps

To calculate Scope 1 emissions from wastewater treatment, do the following:

1. Determine which wastewater treatment processes are used *and the number of personnel served by each*

2. Calculate emissions from each wastewater treatment process used
3. Sum emissions from all processes.

Step 1: Determine which wastewater treatment processes are used and the number of personnel served by each

The emissions from WWTPs depend on the wastewater treatment processes used. Agencies should work with their wastewater operations division to determine which of the processes outlined in Table A-14 are relevant to the agency.

If the number of employees using specific types of wastewater treatment systems is unknown, and the capacities of the systems are known, attribute a share of personnel to each wastewater treatment system based on the capacity of each system.

Step 2: Calculate emissions from each wastewater treatment process used

Once an agency has identified the wastewater treatment processes it uses, it should calculate emissions associated with each process using the equations referenced in Table A-14. See the default methodology for more detail on each source.

On-Site Centralized WWTP with Anaerobic Digestion

Equation A-26 should be used by agencies that collect measurements of the volume of digester gas (biogas) produced and the fraction of CH₄ in their biogas in accordance with local, state, and Federal regulations or permits or published industry standardized sampling and testing methodologies, such as 40 CFR 136, NSPS, APHA, AWWA, WEF, ASTM, and EPA. The conversion factor from day to year can be modified to reflect the agency's usage of the facility. Equation A-26 does not include the stationary combustion from flaring (which is addressed in Appendix A.1), so the calculations below, which illustrate this methodology, will not match those produced in the GHG Reporting Portal.

Equation A-26: Fugitive CH₄ Emissions from On-Site Centralized WWTP with Anaerobic Digestion (Advanced)

$$\text{Annual CH}_4 \text{ emissions [MT]} = \text{Digester Gas} \bullet \text{FCH}_4 \bullet \rho(\text{CH}_4) \bullet 365.25 \bullet 0.001$$

Where:

Digester Gas	=	Measured standard cubic feet of digester gas produced per day [cu ft/day]
F CH ₄	=	Measured fraction of CH ₄ in biogas
P(CH ₄)	=	Density of methane at standard conditions [kg/cu ft], default value of 0.019
365.25	=	Conversion factor [day/year]
0.001	=	Conversion from kg to MT [MT/kg]

Source: EPA *Inventory of US Greenhouse Gas Emissions and Sinks: 1990 – 2008*, Chapter 8 (2010) and *LGO Protocol*. See www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/.

On-Site Centralized WWTP with or without Nitrification/Denitrification

This section provides equations for calculating N₂O emissions from a centralized WWTP. Agencies with large Federal facilities may maintain and operate such WWTP facilities on site. At the treatment facility, the wastewater is treated to standards that allow for surface water discharge. Some centralized systems have nitrification/denitrification treatment processes, and some do not.⁴⁹

Equation A-27: Fugitive N₂O Emissions from WWTP with Nitrification/Denitrification (Advanced)

$$\text{Annual N}_2\text{O emissions [MT]} = P_{\text{total}} \bullet \text{EF nit/denit} \bullet 10^{-6}$$

Where:

P_{total}	=	Total population served by the centralized WWTP adjusted for industrial discharge, if applicable [person]
EF nit/denit	=	Emission factor for a WWTP with nitrification/denitrification [g N ₂ O/person/year], default value of 7.0
10^{-6}	=	Conversion from g to MT [MT/g]

Equation A-28: Fugitive N₂O Emissions from WWTP without Nitrification/Denitrification (Advanced)

$$\text{Annual N}_2\text{O emissions [MT]} = P_{\text{total}} \bullet \text{EF w/o nit/denit} \bullet 10^{-6}$$

Where:

P_{total}	=	Total population served by the centralized WWTP adjusted for industrial discharge, if applicable [person]
EF w/o nit/denit	=	Emission factor for a WWTP without nitrification/denitrification [g N ₂ O/person/year], default value of 3.2
10^{-6}	=	Conversion from g to MT [MT/g]

Effluent Discharge to Rivers and Estuaries

If significant industrial contributions of nitrogen are discharged to the treatment system used by an agency, the agency should use Equation A-29.

Equation A-29 requires wastewater operators to collect measurements of the average total nitrogen discharged in accordance with local, state and Federal regulations or permits or published industry standardized sampling and testing methodologies (such as 40 CFR 136, NSPS, APHA, AWWA, WEF, ASTM, and EPA).

⁴⁹ Equations in this section are adapted for use by agencies from Chapter 6.3 of the 2006 IPCC Guidelines and Chapter 8.2 of the EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks (1990–2008)*.

Equation A-29: Fugitive N₂O Emissions from Effluent Discharge (Advanced)

$$\text{Annual N}_2\text{O emissions [MT]} = \text{N Load} \bullet \text{EF effluent} \bullet 44/28 \bullet 365.25 \bullet 0.001$$

Where:

N Load	=	Measured average total nitrogen discharge [kg N/day]
EF effluent	=	Emission factor [kg N ₂ O-N/kg sewage-N produced], default value of 0.005
44/28	=	Molecular weight ratio of N ₂ O to N ₂
365.25	=	Conversion factor [day/year]
0.001	=	Conversion from kg to MT [MT/kg]

On-Site Wastewater Treatment Lagoons

If significant industrial contributions of BOD₅ are discharged to the treatment lagoons, agencies should use Equation A-30. Equation A-30 requires agencies to collect measurements of the average BOD₅ load, BOD₅ removal in primary treatment upstream of the lagoon (if primary treatment is present), and the fraction of overall lagoon removal performance in accordance with local, state and Federal regulations or permits or published industry standardized sampling and testing methodologies (such as 40 CFR 136, NSPS, APHA, AWWA, WEF, ASTM, and EPA).

Equation A-30: Fugitive CH₄ Emissions from Wastewater Treatment Lagoons (Advanced)

$$\text{Annual CH}_4 \text{ emissions [MT]} = \text{BOD}_5 \text{ load} \bullet (1-F_p) \bullet B_o \bullet \text{MCF}_{\text{anaerobic}} \bullet F_{\text{removed}} \bullet 365.25 \bullet 0.001$$

Where:

BOD ₅ load	=	Amount of BOD ₅ produced per day (influent to wastewater treatment process) [kg BOD ₅ /day]
F _p	=	Fraction of BOD ₅ removed in primary treatment, if present
B _o	=	Maximum CH ₄ -producing capacity for domestic wastewater [kg CH ₄ /kg BOD ₅ removed], default value of 0.6
MCF _{anaerobic}	=	CH ₄ correction factor for anaerobic systems, default value of 0.8
F _{removed}	=	Fraction of overall lagoon BOD ₅ removal performance
0.001	=	Conversion from kg to MT [MT/kg]

On-Site Septic Systems

Equation A-31 should be used when measurements of the average BOD₅ load are collected in accordance with local, state, and Federal regulations or permits or published industry standardized sampling and testing methodologies (such as 40 CFR 136, NSPS, APHA, AWWA, WEF, ASTM, and EPA).

Equation A-31: Fugitive CH₄ Emissions from Septic Systems (Advanced)

$$\text{Annual CH}_4 \text{ emissions [MT]} = \text{BOD}_5 \text{ load} \bullet \text{Bo} \bullet \text{MCF}_{\text{septic}} \bullet 365.25 \bullet 0.001$$

Where:

BOD₅ load = Amount of BOD₅ produced per day [kg BOD₅/day]

Bo = Maximum CH₄-producing capacity for domestic wastewater [kg CH₄/kg BOD₅ removed], default value of 0.6

MCF_{septic} = CH₄ correction factor for anaerobic systems, default value of 0.5

365.25 = Conversion factor [day/year]

0.001 = Conversion from kg to MT [MT/kg]

Step 3: Sum emissions from all processes

Agencies should sum the emissions from all processes and apply the appropriate GWP values to calculate total emissions from wastewater treatment in units of CO₂e.

Equation A-32: Fugitive Wastewater Treatment MT CO₂e Emissions (Advanced)

$$\text{CO}_2\text{e Emissions [MT CO}_2\text{e]} = (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP})$$

A.7. Fugitive Emissions: Landfills and Solid Waste Facilities

Description

This category includes emissions from the disposal and treatment of MSW generated as a result of agency operations and treated at on-site landfills that accepted waste on or after January 1, 1980.⁵⁰ This category also includes any on-site industrial landfill with a design capacity greater than or equal to 300,000 MT that does not accept only inert wastes. This category does not include construction and demolition wastes or waste piles.⁵¹

There is no *de minimis* accounting and reporting threshold for small on-site or closed landfills. Small on-site or closed landfills are within the agency's Scope 1 operational boundaries and should be included in the agency's GHG inventory, with the exception of closed landfills that did not accept waste on or after January 1, 1980. In the absence of necessary data, these small or closed landfills should, at a minimum, be noted as an emissions source in the agency's qualitative statement.

Disposal of waste may result in potentially significant GHG emissions. Landfilling organic waste causes anaerobic decomposition and CH₄ generation. If this landfill gas (LFG) is subsequently combusted, the combustion constitutes disposal and releases CO₂ emissions.

⁵⁰ Landfills are defined as an area of land or an excavation in which wastes are placed for permanent disposal and that is not a land application unit, surface impoundment, injection well, or waste pile as those terms are defined under 40 CFR 257.2.

⁵¹ Waste Piles are non-containerized piles of solid, non-liquid hazardous waste that are used for temporary storage or treatment. <http://www.epa.gov/osw/hazard/tsd/td/ldu/>

The default approach for calculating solid waste emissions is based on both the EPA's LandGEM⁵² and the calculations behind the EPA's Climate Leader's Offset Project Methodology.

The agency can choose to use site-specific data from its waste operations division in the advanced method.

If an agency has an industrial landfill with a design capacity greater than or equal to 300,000 MT, and does not accept only inert wastes, it is to use a first order decay model such as that found in LandGEM or as defined in Subpart TT of the EPA GHGRP.⁵³

For some agencies, data on total waste disposal are available, but there are no data available for disposal off site versus on site. To develop separate Scope 1 and Scope 3 estimates, agencies can either monitor the amount of waste sent off site versus on site annually, or can develop a one-time estimate of the percent of wastes disposed on site versus off site and apply that percentage every year.

A.7.1. Default Methodology (User Calculated by LandGEM)

Data Sources

The EPA's LandGEM model is well established tool for regulatory reporting purposes.⁵⁴ Agencies may find that their facilities have already calculated their respective CH₄ emissions. However, if not, the Microsoft Excel-based LandGEM requires agencies to enter the requisite data and automatically estimates the emission rates for total landfill gas, CH₄, CO₂ (biogenic), non-methane organic compounds, and individual air pollutants from MSW landfills. However, this model does not consider emission reductions from LFG capture.

The GHG Reporting Portal will assume 40 percent of landfills include LFG collection systems. The user calculates the mass of CH₄ and biogenic CO₂ using LandGEM. The agency will need data on the mass of solid waste disposed of for all years of landfill operation, and landfill open year and close year for LandGEM. Table A-15 shows the data sources.

Many agencies may not have all of the required historical landfill disposal data. Landfills without this data should use one of the methods listed below to estimate historical waste quantities. These calculations are not conducted by the GHG Reporting Portal, and must be completed separately by the reporting agency. Historical waste disposal quantities should only be determined once, and the same values should be used for all subsequent annual reports, supplemented by the next year's data on new waste disposal.

⁵² See www.epa.gov/ttn/catc/dir1/landgem-v302.xls for the EPA LandGEM model. See www.epa.gov/ttn/catc1/dir1/landgem-v302-guide.pdf for the LandGEM user guide.

⁵³ Estimates resulting from application of Subpart TT of the GHGRP for GHG reporting purposes may be used for reporting in the GHG Reporting Portal.

⁵⁴ LandGEM is a first order decay model and estimates landfill methane emissions generated from the anaerobic decay of municipal solid waste. Agencies should, however, note that this approach is different from the mass-balance approaches used in the Scope 3 targeting tool and the Scope 3 Contracted Waste Disposal methodology presented in Appendix C.

1. Assume all prior years waste disposal quantities are the same as the waste quantity in the first year for which waste quantities are available.
2. Using data from the first year for which waste quantities are available, develop a per capita or per unit of activity/product amount of waste disposal. Use historical data on population or activity/production to estimate previous disposal for previous years.
3. Use a constant average waste disposal quantity calculated using Equation A-33 for each year the landfill was in operation (i.e., from the first year accepting waste until the last year for which waste disposal data is unavailable, inclusive).

Table A-15: Fugitive Emissions—Landfills/MSW Default Data Sources

Data Element		Preferred Source
Mass of solid waste disposed		<ul style="list-style-type: none"> • Reporting to Office of the Federal Environmental Executive (OFEE) under E.O. 13514, Sec. 2(e)
Landfill open year and close year		<ul style="list-style-type: none"> • Solid waste operations division
Mass of biogenic CO ₂ and CH ₄ [MT (Mg)]*		<ul style="list-style-type: none"> • Calculated by LandGEM or supplemented from Title V permit and annual emission reporting data
CH ₄ concentration rate, k		<ul style="list-style-type: none"> • Default provided by GHG Reporting Portal
Potential methane generation capacity, Lo		<ul style="list-style-type: none"> • Default provided by GHG Reporting Portal
Non-CH ₄ Organic Compounds (NMOC) concentration, ppmv		<ul style="list-style-type: none"> • Default provided by GHG Reporting Portal
CH ₄ content of LFG, % by volume		<ul style="list-style-type: none"> • Default provided by GHG Reporting Portal
Does the landfill have a LFG collection system?		<ul style="list-style-type: none"> • GHG Reporting Portal assumes 50% include LFG collection system
If LFG collection system	Efficiency of LFG collection system	<ul style="list-style-type: none"> • Default provided by GHG Reporting Portal
	Oxidation factor	<ul style="list-style-type: none"> • Default provided by GHG Reporting Portal

* 1 MT = 1 Mg (megagram)

Calculation Steps⁵⁵

Landfill fugitive emission can be calculated using the following steps:

1. Determine historical waste disposal quantity
2. Use EPA’s LandGEM to calculate the CO₂ and CH₄ generation and input into GHG Reporting Portal
3. Calculate emissions from MSW landfills.

⁵⁵ Primary Reference: EPA, Climate Leaders, *Direct Emissions from Municipal Solid Waste Landfilling*, October 2004, and EPA TSD for the Landfill Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases, February 2009.

Step 1: Determine historical waste disposal quantity

Equation A-33: Landfill Waste Quantity (Default)

$$W_x \text{ [MT]} = \text{LFC} / (\text{YrData} - \text{YrOpen} + 1)$$

Where:

W_x	=	Quantity of waste placed in the landfill in year x [MT, wet basis]
LFC	=	Landfill capacity or, for operating landfills, capacity of the landfill used (or the total quantity of waste-in-place) at the end of the year prior to the year when waste disposal data are available from design drawings or engineering estimates [MT]
YrData	=	Year in which the landfill last received waste or, for operating landfills, the year prior to the first reporting year when waste disposal data is first available from company records, or best available data
YrOpen	=	Year in which the landfill first received waste from company records or best available data. If no data are available for estimating for a closed landfill, use 30 years as the default operating life of the landfill

Step 2: Use EPA's LandGEM to calculate the CO₂ and CH₄ generation and input into GHG Reporting Portal

LandGEM calculates the annual quantity of biogenic CO₂ and anthropogenic CH₄ that a landfill will generate based upon past and current disposal of MSW. LandGEM's most accurate estimates are calculated when past and current year quantities of MSW are entered.⁵⁶ While disposed solid waste generates GHGs for several years, the limits of the agencies' Scope 1 GHG inventories only require that the facility's annual emissions be included in Scope 1 for that fiscal year's GHG inventory. This is consistent with methods used for compliance with CAA Title V reporting, which agencies also leverage to obtain, aggregate, and input the required data.

The agency should select the "Inventory Conventional" values, input the mass of solid waste disposed,⁵⁷ landfill open and close date, and then enter the mass of CH₄ and CO₂ determined by LandGEM into the GHG Reporting Portal.

Step 3: Calculate emissions from MSW landfills

The GHG Reporting Portal will apply LFG collection (defaults to 50 percent national average), LFG collection efficiency (assumes 75 percent default), and the methotropic bacteria oxidation factor (assumes 10 percent default).

⁵⁶ To the extent possible, agencies should leverage historical landfill data and LandGEM calculations from existing CAA Title V reporting. Where historic data is not available, LandGEM can be used to calculate biogenic CO₂ and anthropogenic emissions using annual municipal solid waste disposal quantities. However, this data-limited approach will result in an underestimation of landfill emissions.

⁵⁷ The LandGEM model will require an agency to input the mass of waste disposed in each past year, as well as in the current year, consistent with the use of LandGEM for CAA Title V reporting. Without inclusion of past waste data, agencies should note that LandGEM would underestimate emissions of anthropogenic CH₄ and biogenic CO₂ for the current reporting year.

Equation A-34 does not take into account emissions from landfill gas flaring, which is a stationary combustion emission source. Flaring emissions are calculated by the same methodology described in Appendix A.1 and would complete the mass balance of the global estimation approach. The GHG Reporting Portal will calculate landfill gas flaring in the same location as fugitive landfill emissions to reduce data input requirements. Equation A-34 applies national average factors based upon information in the EPA Climate Leaders “Greenhouse Gas Inventory Protocol Offset Project Methodology” and covers all operations of the approach, with the exception of flare combustion and venting (1-percent non-combustion stack loss).

Equation A-34: Fugitive Emissions from Solid Waste Facilities (Default)

$$\text{CO}_2\text{e Emissions [MT]} = \frac{((\text{CH}_{4\text{gen}} \bullet \text{CH}_{4\text{release}} \bullet (1 - \text{OX}_B)) + (\text{CH}_{4\text{gen}} \bullet (1 - \text{CH}_{4\text{release}}) \bullet (1 - \eta_{\text{LFGsystem}}) \bullet (1 - \text{OX}_B))) \bullet \text{GWP}}{\text{GWP}}$$

Where:

- $\text{CH}_{4\text{gen}}$ = CH_4 generated by landfill, calculated in LandGEM [MT]
- $\text{CH}_{4\text{release}}$ = Percentage of uncontrolled release of CH_4 , default national average value of 0.5
- OX_B = Methotropic Bacteria Oxidation Factor, default value of 0.10
- $\eta_{\text{LFGsystem}}$ = Efficiency of LFG collection system, default value of 0.75
- GWP = Global Warming Potential of CH_4 , 21

Source: EPA, Climate Leaders, Greenhouse Gas Inventory Protocol, Direct Emissions From Municipal Solid Waste Landfilling Methodology and Offset Project Methodology. See both at: www.epa.gov/climateleaders/resources/index.html.

Example A-12: Fugitive Emissions (Solid Waste Management—Default)

An agency does not know whether its solid waste facility has an LFG collection system. For brevity, this example assumes output from LandGEM, and begins at Step 2.

Step 2: Use EPA’s LandGEM to calculate the CO_2 and CH_4 generation and input into the GHG Reporting Portal

The agency inputs the mass of solid waste they dispose of annually, the facility’s open/close dates, and other known factors into LandGEM. LandGEM outputs that the waste generates 1,000 MT of CO_2 and 1,000 MT of CH_4 . As no site-specific data are available, the agency uses available default values.

➤ *Reported as biogenic emissions in Scope 1* = 1,000 MT CO_2

Step 3: Calculate emissions from landfills and solid waste facilities

Equation A-34: Fugitive Emissions from Solid Waste Facilities (Default)

➤ *Reported as Scope 1 emissions*

$$\begin{aligned}
 \text{CO}_2\text{e emissions [MT]} &= ((\text{CH}_{4\text{gen}} \bullet \text{CH}_{4\text{release}} \bullet (1 - \text{OX}_B)) + (\text{CH}_{4\text{gen}} \bullet (1 - \text{CH}_{4\text{release}}) \bullet (1 - \eta_{\text{LFGsystem}}) \bullet (1 - \text{OX}_B))) \bullet \text{GWP} \\
 &= ((1,000 \bullet 0.5 \bullet (1 - 0.10)) + (1,000 \bullet (1 - 0.5) \bullet (1 - 0.75) \bullet (1 - 0.10))) \bullet 21 \\
 &= ((1,000 \bullet 0.5 \bullet 0.9) + (1,000 \bullet 0.5 \bullet 0.25 \bullet 0.9)) \bullet 21 \\
 &= (450 + 112.5) \bullet 21 \\
 &= \mathbf{11,812.5 \text{ MT CO}_2\text{e}}
 \end{aligned}$$

Where:

- $\text{CH}_{4\text{gen}}$ = CH_4 generated by landfill, calculated in LandGEM [MT]
- $\text{CH}_{4\text{release}}$ = Percentage of uncontrolled release of CH_4 , default national average value of 0.5
- OX_B = Methotropic Bacteria Oxidation Factor, default value of 0.10
- $\eta_{\text{LFGsystem}}$ = Efficiency of LFG collection system, default value of 0.75
- GWP = Global Warming Potential of CH_4 , 21

****Note:** Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.**

A.7.2. Advanced Methodology (User Calculated by LandGEM)

Data Sources

The advanced methodology also uses LandGEM. For the advanced methodology, the agency should also have data on site-specific methane concentrations, generation capacity, and system efficiency. If the agency is already reporting under EPA’s GHGRP, use this output.

Before performing the calculations, an agency must determine whether the landfills in its operational control have LFG collection systems. If they do not, agencies need only apply the methodology approach outlined in Step 1 in the next section. However, if one or more of the agency’s landfills have an LFG collection system, they should apply both steps 1 and 2 to the respective landfills. If agencies are unsure whether their landfill has an LFG collection system, step 2 enables the agency to apply a national average factor until more detailed information is available. Table A-16 shows the data sources.

Table A-16: Fugitive Emissions—Landfills/MSW Advanced Data Sources

Data Element	Preferred Source
Does the landfill have a LFG collection system?	• Waste operations division
Mass of solid waste disposed	• Reporting to OFEE under E.O. 13514, Sec. 2(e)
Landfill open year and close year	• Waste operations division
Mass of biogenic CO ₂ and CH ₄ [MT (Mg)]*	• Calculated by LandGEM or supplemented from Title 5 permit data
CH ₄ concentration rate, k	• Waste operations division
Potential CH ₄ generation capacity, Lo	• Waste operations division
NMOC concentration, ppmv	• Waste operations division

Data Element		Preferred Source
CH ₄ content of LFG, % by volume		• Waste operations division
If LFG collection system	Efficiency of LFG collection system	• Waste operations division
	Oxidation factor	• Waste operations division

* 1 MT = 1 Mg (megagram)

Calculation Steps

Landfill fugitive emissions can be calculated using the following steps:

1. Use EPA's LandGEM or other method to calculate the CH₄ and biogenic CO₂ generation
2. Calculate emission reductions from capture and combustion of LFG.

The calculation steps for the advanced methodology are the similar to the default, except for substituting site-specific information about the landfills.

Equation A-35: Fugitive Emissions from Solid Waste Facilities (Advanced)

$$\text{CO}_2\text{e Emissions [MT]} = ((\text{CH}_{4\text{gen}} \bullet \text{CH}_{4\text{release}} \bullet (1 - \text{OX}_B)) + (\text{CH}_{4\text{gen}} \bullet (1 - \text{CH}_{4\text{release}}) \bullet (1 - \eta_{\text{LFGsystem}}) \bullet (1 - \text{OX}_B))) \bullet \text{GWP}$$

Where:

CH _{4gen}	=	CH ₄ generated by landfill, calculated in LandGEM [MT]
CH _{4release}	=	Percentage of uncontrolled release of CH ₄ (either 1.0 or 0 depending on presence of LFG-collection system)
η _{LFGsystem}	=	Efficiency of LFG collection system, default value of 0.75
OX _B	=	Methotropic Bacteria Oxidation Factor, default value of 0.10
GWP	=	Global Warming Potential of CH ₄ , 21

Source: Climate Leaders, Greenhouse Gas Inventory Protocol, Direct Emissions From Municipal Solid Waste Landfilling and Offset Project Methodology.

A.8. Industrial Process Emissions

Most agencies will not likely have applicable fugitive emissions beyond those detailed above. If the agency owns and/or operates industrial sources of GHG emissions, the following guidelines can be used to calculate associated process emissions. All references to the IPCC 2006 Guidelines are to Volume 3 of those Guidelines, *Industrial Processes and Product Use*.

- Adipic acid production (process N₂O emissions)
 - EPA GHGRP Technical Support Document: 40 CFR 98, Subpart E
 - IPCC 2006 Guidelines, Volume 3, Chapter 3, Equation 3.8

- World Resources Institute (WRI)/World Business Council for Sustainable Development (WBCSD), Calculating N₂O Emissions from the Production of Adipic Acid, 2001
- Aluminum production (process CO₂ and PFC emissions)
 - EPA GHGRP Technical Support Document: 40 CFR 98, Subpart F
 - CO₂: IPCC 2006 Guidelines, Volume 3, Chapter 4, Equations 4.21–4.24
 - PFCs: IPCC 2006 Guidelines, Volume 3, Chapter 4, Equations 4.25–4.27
- Ammonia production (process CO₂ emissions)
 - EPA GHGRP Technical Support Document: 40 CFR 98, Subpart G
 - IPCC 2006 Guidelines, Volume 3, Chapter 3, Equation 3.3
- Cement production (process CO₂ emissions)
 - EPA GHGRP Technical Support Document: 40 CFR 98, Subpart H
 - California Air Resources Board, Draft Regulation for the Mandatory Reporting of Greenhouse Gas Emissions, 2008
 - California Climate Action Registry Cement Reporting Protocol, 2005
 - Cement Sustainability Initiative, The Cement CO₂ Protocol: CO₂ Accounting and Reporting Standard for the Cement Industry (2005) Version 2.0
- HCFC-22 production (process HFC-23 emissions)
 - EPA GHGRP Technical Support Document: 40 CFR 98, Subpart O
 - IPCC 2006 Guidelines, Volume 3, Chapter 3, Equations 3.31–3.33
 - WRI/WBCSD, Calculating HFC-23 Emissions from the Production of HCFC-22, 2001
- Iron and steel production (process CO₂ emissions)
 - EPA GHGRP Technical Support Document: 40 CFR 98, Subpart Q
 - IPCC 2006 Guidelines, Volume 3, Chapter 4, Equations 4.9–4.11.
- Lime production (process CO₂ emissions)
 - EPA GHGRP Technical Support Document: 40 CFR 98, Subpart S
 - IPCC 2006 Guidelines, Volume 3, Chapter 2, Equation 2.5–2.7
- Nitric acid production (process N₂O emissions)
 - EPA GHGRP Technical Support Document: 40 CFR 98, Subpart V
 - IPCC 2006 Guidelines, Volume 3, Chapter 3, Equation 3.6
 - WRI/WBCSD, Calculating N₂O Emissions from the Production of Nitric Acid, 2001
- Particle accelerators (SF₆ emissions)

- IPCC 2006 Guidelines, Volume 3, Chapter 8, Equation 8.17
- Pulp and paper production (process CO₂ emissions)
 - EPA GHGRP Technical Support Document: 40 CFR 98, Subpart AA
 - IPCC 2006 Guidelines, Volume 3, Chapter 2, Chapter 2.5
 - International Council of Forest and Paper Associations, Calculation Tools for Estimating Greenhouse Gas Emissions from Pulp and Paper Mills, Version 1.1, 2005
- Refrigeration and air conditioning equipment manufacturing (process HFC and PFC emissions)
 - EPA Climate Leaders, Direct HFC and PFC Emissions from Manufacturing Refrigeration and Air Conditioning Units, 2003
 - WRI/WBCSD, Calculating HFC and PFC Emissions from the Manufacturing, Installation, Operation and Disposal of Refrigeration & Air-conditioning Equipment (Version 1.0) 2005
- Semiconductor manufacturing (process PFC and SF₆ emissions)
 - IPCC 2006 Guidelines, Equations 6.7–6.11

A.9. Emissions from Biological Sequestration from Land Management Techniques: Net Carbon Stock Changes on Forest Land

Description

Sequestration refers to the storage of carbon to reduce atmospheric carbon and mitigate the effects of climate change. For the purposes of Federal land managers, biological sequestration occurs when atmospheric carbon is absorbed and stored by plants or soils. Land management techniques, including changes in land use or land management strategies, can and do have a significant effect on atmospheric carbon release and biological sequestration. Within a parcel of land, carbon stocks may decrease (such as when carbon is released into the atmosphere through combustion and decay) or increase (such as when carbon is stored during tree growth or through soil absorption). Biological sequestration is the net increase of carbon stored within a parcel of land over time, while the net decrease is considered an emission. In other words, a standing forest that exists today is not, in and of itself, considered sequestration, but any additional carbon that is stored within that forest as it grows over time would be considered sequestration.

Net carbon stock changes on forest land are changes in biologically sequestered GHGs (additions or removals) on federal forest lands. The net carbon stock changes on forest land may be positive (where carbon stock gains through sequestration exceed losses) or negative (where emissions exceed additional sequestration).

Beginning with the FY 2013 annual inventory report, agencies with forest lands will work with the U.S. Forest Service (USFS) to report net carbon stock changes. The USFS will provide

agency-level net carbon stock change data at 5-year intervals, and responsible agencies will annually report the most recently provided USFS data.

Only agencies that own land defined as forest are required to report, and only forest plots larger than the minimum size designated by the USFS must be monitored. Agencies should work with the USFS to clarify any uncertainties regarding forest land definitions, agency forest boundaries, and plot sizes.

Carbon stock changes will be categorized as Scope 1 emissions in a separate “Forest Carbon Stock Change” emissions category. They will not be included in reduction targets, and will not affect progress toward meeting reduction goals. Reporting results will be used to help agencies evaluate the effectiveness of forest management efforts.

A.9.1. Default Methodology

The USFS will employ the U.S. Forest Carbon Calculation Tool to calculate net carbon stock changes at the agency level.⁵⁸ This tool is used to meet the requirements of the annual national level GHG inventory reported to the IPCC. The reporting will include the five main IPCC ecosystem pools reported in the U.S. GHG Inventory: aboveground biomass, belowground biomass, dead wood, litter, and soil. Unmanaged forest lands are will not be included in the report. Agencies should work with the USFS to clarify any uncertainties regarding forest land definitions, agency forest boundaries, and plot sizes.

Initial reporting will be completed for the FY 2013 report and will be based on the most current Forest Inventory and Analysis (FIA) data available at that time. FIA data are updated at the forest plot-level on rotating roughly 5-year basis. As such, data available to agencies from USFS will not change annually, but the most recent data from the USFS must be annually reported by agencies.

Agencies are to report agency-level aggregate estimates; however, if data are already available at a bureau/service level, disaggregating to that scale is preferred. Agency reporting should state current carbon stocks as well as an estimate of the change in those stocks from a similar calculation based on data from 5 years earlier. Reporting should be disaggregated for the five main IPCC ecosystem pools reported in the U.S. GHG Inventory: aboveground biomass, belowground biomass, dead wood, litter, and soil.

⁵⁸ See <http://nrs.fs.fed.us/pubs/2394> for further details.

Appendix B—Calculating Scope 2 Emissions

Scope 2 emissions are indirect GHG emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling. They are a consequence of activities occurring within the agency’s boundaries, but are emitted at sources owned or controlled by another entity.

This section provides calculation methodologies for the following:

- Purchased electricity
- Purchased steam or hot water
- Purchased chilled water
- Electricity, steam, or hot water purchases from a combined heat and power (CHP) facility⁵⁹
- Steam purchases from a MSW waste-to-energy (WTE) facility
- Reductions from RECs⁶⁰

B.1. Purchased Electricity

Description

Purchased electricity is defined as electricity purchased or otherwise brought into the organizational boundary of the agency. Appendix B.1.1 describes the default methodology for calculated emissions from purchased electricity to be calculated by the GHG Reporting Portal. This GHG emissions calculation methodology is the only acceptable one for purchased electricity. Appendix B.1.2 describes the alternative data estimation methods for purchased electricity if these activity data are not available.

B.1.1. Default Methodology (to be Calculated by GHG Reporting Portal)

Data Sources

The default methodology uses purchased electricity data as reported in the FEMP Energy Report and is ideally based on metered electricity consumption. Table B-1 shows the required data elements and sources.

⁵⁹ CHP methodology can be used for advanced methodology for estimating the emissions associated with the purchased electricity generated at a waste-to-energy facility.

⁶⁰ Note that this appendix also includes a calculation methodology for GHGs associated with RECs because they can be used to reduce Scope 2 emissions.

Table B-1: Purchased Electricity Default Data Sources

Data Element	Preferred Source
Purchased Electricity [MWh]	<ul style="list-style-type: none"> FEMP Energy Report or purchasing records by eGRID subregion
Emission Factor [kg/MWh] or [kg/GWh]	<ul style="list-style-type: none"> Standardized emission factors provided in Table D-8

Calculation Steps

The GHG Reporting Portal will calculate Scope 2 emissions from use of purchased electricity. Agencies must provide activity data in step 1, and the portal automatically calculates emissions using steps 2 through 4:

1. Determine annual use of purchased electricity from all facilities within the agency’s operational control by eGRID subregion
2. Select the appropriate eGRID subregion output emission rate factors that apply to the electricity used
3. Calculate total CO₂, CH₄, and N₂O emissions, and convert them to MT
4. Convert to MT CO₂e and calculate total emissions.

Step 1: Determine annual use of purchased electricity from all facilities within the agency’s operational control

Include purchased electricity data for all facilities that fit with the definition of operational control under Scope 2 provided in Chapter 2 of the main Guidance document. Agencies must report electricity use by the corresponding eGRID subregion and, if applicable, U.S. Territory.⁶¹ Agencies should refer to the Federal Energy Management Guidance⁶² for preferred sources of electricity use data (metered readings or utility bills) and alternate methods for estimating electricity use when metered data are not available (see Appendix B.1.2).

Step 2: Select the appropriate eGRID subregion output emission rate factors that apply to the electricity used

Electricity emission factors represent the amount of GHGs emitted per unit of electricity consumed. They are usually reported in GHG [lb] per MWh or gigawatt hour (GWh).

The GHG Reporting Portal will choose the appropriate eGRID subregion output emission rate factors (see Table D-8). These are included in this document to provide a consistent, verifiable basis for emissions calculations. Because emission factors vary by location, agencies should be sure to use the appropriate subregion-specific factors for each facility. Because eGRID is updated periodically, the GHG Reporting Portal will use emission rates from the eGRID edition

⁶¹ Agencies reporting facilities in U.S. Territories and/or choosing to report facilities in foreign nations must use emission factors from DOE 1605(b) Technical Guidance. See www.eia.doe.gov/oiaf/1605/emission_factors.html.

⁶² FEMP, Federal Energy Management Guidance. See www1.eere.energy.gov/femp/regulations/guidance.html.

that is closest to the year of their inventory activity data.⁶³ Agencies are not expected to retroactively update their inventories with new eGRID output emissions rate factors once the inventory has been submitted to CEQ.

Step 3: Calculate total CO₂, CH₄, and N₂O emissions, and convert them to MT

To determine annual emissions, the GHG Reporting Portal will multiply annual electricity use in MWh (Step 1) by the emission factors for CO₂, CH₄, and N₂O in kg/MWh (Step 2), and convert them to MT.

Equation B-1: Purchased Electricity GHG Emissions

<p>CO₂ Emissions [MT] = Electricity use [MWh] • CO₂ emission factor [kg CO₂/MWh] • 0.001 [MT/kg]</p>
<p>CH₄ Emissions [MT] = Electricity use [MWh] • CH₄ emission factor [kg CH₄/GWh] • 0.001 [MT/kg] • 0.001[GWh/MWh]</p>
<p>N₂O Emissions [MT] = Electricity use [MWh] • N₂O emission factor [kg N₂O/GWh] • 0.001 [MT/kg] • 0.001[GWh/MWh]</p>

Step 4: Convert to MT CO₂e and calculate total emissions

The GHG Reporting Portal will convert CH₄ and N₂O into units of CO₂e using the emissions [MT] and the GWP values provided in Table D-13. It will sum the CO₂e emissions of each of the three gases to determine total GHG emissions for Scope 2 purchased electricity.

Equation B-2: Purchased Electricity MT CO₂e Emissions

<p>CO₂e emissions [MT CO₂e] = MT CO₂ + (MT CH₄ • CH₄ GWP) + (MT N₂O • N₂O GWP)</p>
--

T&D Losses

If the agency purchases (rather than generates) electricity and transports it through a T&D system that it owns or controls, it should report the emissions associated with T&D losses under Scope 2.

End consumers of purchased electricity do not report indirect emissions associated with T&D losses in Scope 2 if they do not own or control the T&D operation where the electricity is consumed. If the agency does not own or control the T&D operation, it must estimate these emissions as Scope 3 (see Appendix C.2).

⁶³ eGRID publishes data regularly but reflects the operational data from power plants from 2–3 years prior. For example, eGRID 2007 has year 2005 operational data but is configured to company ownerships and industry structures as of year 2007.

Example B-1: Purchased Electricity (Default)

An agency with operations in the eGRID subregion SRVC has all the monthly energy statements for the reporting year. The annual electricity use is 30,000 MWh for the facility, based on monthly energy statements.

Step 1: Determine annual use of purchased electricity from all facilities within the agency's operational control

The electricity use for this facility is 30,000 MWh.

Step 2: Select the appropriate eGRID subregion output emission rate factors that apply to the electricity used

The SRVC subregion output emission rate factors from eGRID are shown below:

- CO₂ emission factor = 507.30 [kg/MWh]
- CH₄ emission factor = 10.10 [kg/GWh]
- N₂O emission factor = 8.65 [kg/GWh]

Step 3: Calculate total CO₂, CH₄, and N₂O emissions, and convert them to MT

Equation B- 1: Purchased Electricity GHG Emissions

$$\begin{aligned} \text{CO}_2 \text{ Emissions [MT]} &= \text{Electricity use [MWh]} \bullet \text{CO}_2 \text{ emission factor [kg CO}_2\text{/MWh]} \bullet 0.001 \text{ [MT/kg]} \\ &= 30,000 \text{ [MWh]} \bullet 507.30 \text{ [kg CO}_2\text{/MWh]} \bullet 0.001 \text{ [MT/kg]} \\ &= 15,219 \text{ [MT CO}_2\text{]} \end{aligned}$$

$$\begin{aligned} \text{CH}_4 \text{ Emissions [MT]} &= \text{Electricity use [MWh]} \bullet \text{CH}_4 \text{ emission factor [kg CH}_4\text{/MWh]} \bullet 0.001 \text{ [MT/kg]} \bullet 0.001 \text{ [GWh/MWh]} \\ &= 30,000 \text{ [MWh]} \bullet 10.10 \text{ [kg CH}_4\text{/GWh]} \bullet 0.001 \text{ [MT/kg]} \bullet 0.001 \text{ [GWh/MWh]} \\ &= 0.260 \text{ [MT CH}_4\text{]} \end{aligned}$$

$$\begin{aligned} \text{N}_2\text{O Emissions [MT]} &= \text{Electricity use [MWh]} \bullet \text{N}_2\text{O emission factor [kg N}_2\text{O/MWh]} \bullet 0.001 \text{ [MT/kg]} \bullet 0.001 \text{ [GWh/MWh]} \\ &= 30,000 \text{ [MWh]} \bullet 8.65 \text{ [kg CH}_4\text{/GWh]} \bullet 0.001 \text{ [MT/kg]} \bullet 0.001 \text{ [GWh/MWh]} \\ &= 0.303 \text{ [MT N}_2\text{O]} \end{aligned}$$

Step 4: Convert to MT CO₂e and calculate total emissions

Equation B-2: Purchased Electricity MT CO₂e Emissions

$$\begin{aligned} \text{Total Emissions [MT CO}_2\text{e]} &= \text{MT CO}_2 + (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP}) \\ &= 15,219 \text{ [MT CO}_2\text{]} + (0.260 \text{ [MT CH}_4\text{]} \bullet 21) + (0.303 \text{ [MT N}_2\text{O]} \bullet 310) \\ &= \mathbf{15,318.39 \text{ [MT CO}_2\text{e]}} \end{aligned}$$

****Note:** Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.**

B.1.2. Alternative Data Estimation Methods (User Calculated)⁶⁴

For Scope 2 purchased electricity, this section shows alternative methods for calculating the amount of electricity consumed by a Federal agency. The agency can use these alternative data estimation methods if it is unable to determine annual electricity use from preferred sources of electricity use data (see Appendix B.1.1, Step 1). The data values for electricity use calculated

⁶⁴ The Climate Registry, *Local Government Operations Protocol*, Version 1.0, September 2008.

through these alternative methods should be input into the GHG Reporting Portal by the user only if electricity use cannot otherwise be obtained. The GHG Reporting Portal will use these values to continue the default methodology (Appendix B.1.1, Steps 2 through 4).

These alternative ways of calculating electricity use data are based on estimates and are less accurate than the metered data requirements for FEMP energy reporting. If metered electricity data are unavailable for an agency’s buildings or facilities, there are two alternative approaches for estimating electricity use in order to calculate Scope 2 purchased electricity emissions:

1. Estimate electricity use based on proxy year data, or
2. Estimate electricity use based on known electricity use at comparable facilities.

Alternative Data Estimation Method 1: Proxy Year Data

If purchase records, electricity bills, or meter readings are not available, the agency can estimate electricity use for a facility on the basis of electricity consumed at the building or facility in another year. Typically, this approach is used when data are unavailable for one or a few minor facilities. Generally, it should not be used as a substitute for a significant group of facilities. Agencies should disclose the use of any proxy years in reporting as part of their qualitative statement disclosure (see Chapter 2.1).

Data Sources

Table B-2 shows the data elements and sources.

Table B-2: Purchased Electricity Proxy Year Alternative Data Sources

Data Element	Preferred Source
Electricity use from prior years [kWh]	<ul style="list-style-type: none"> • FEMP Energy Report • Electricity purchasing records
Heating and cooling degree days	<ul style="list-style-type: none"> • National Climate Data Center

Description

The following steps can be taken to estimate the annual electricity use at a facility using proxy year data:

1. Determine the electricity used in each facility in the proxy year
2. Normalize for heating and cooling degree days.

Step 1: Determine the electricity used in each facility in the proxy year

The proxy year can be either another calendar year or a fiscal year.

Step 2: Normalize for heating and cooling degree days

Estimate the proportion of electricity used in a year for heating as a percentage of the total electricity consumed and the proportion of annual electricity used in a year for cooling as a percentage of the electricity consumed. This should be based on the increased electricity

consumed during winter months and summer months, respectively. Where monthly data are not available, the best recommendation of the facility manager may be used. Then determine annual heating and cooling degree days in the region in the year being estimated and the proxy year. The National Climate Data Center website provides information on the heating and cooling degree days by month and by state.⁶⁵

Normalize for heating and cooling degree days using Equation B-3.

Equation B-3: Normalization for Heating and Cooling Degree Days

Estimated Energy Consumed in Inventory Year [kWh] =

$$[(EP \bullet Eh)/DHP] \bullet (DHI/1) + [(EP \bullet EC)/DCP] \bullet (DCI/1) + [(1 - Eh - EC) \bullet EP]$$

Where:

- EP = Electricity used in proxy year [kWh]
- Eh = Percentage of electricity used for heating [%]
- DHP = Heating degree days in the proxy year
- DHI = Heating degree days in inventory year
- EC = Percentage of electricity used for cooling [%]
- DCP = Cooling degree days in the proxy year
- DCI = Cooling degree days in inventory year

Source: LGO Protocol. See www.theclimateregistry.org/resources/protocols/local-government-operations-protocol.

Agencies should input the estimated electricity use calculated from Equation B-3 into the GHG Reporting Portal, which will follow the default methodology to estimate CO₂, CH₄, and N₂O Scope 2 emissions from the facility (see Appendix B.1.1).

Alternative Data Estimation Method 2: Comparable Facilities and Square Footage

If total annual electricity consumption data are not available for the current reporting year or previous years, agencies can estimate electricity use on the basis of the size and function of the facility.

Typically, this approach is used when data are unavailable for one or a few minor facilities. It should not be used as a substitute for a significant group of facilities. When reporting, agencies should note the use of any comparable facilities data to ensure full disclosure in the agency’s qualitative statement (see Chapter 2.1).

Data Sources

Table B-3 shows the data elements and sources.

⁶⁵ National Climate Data Center. See: www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp#.

Table B-3: Purchased Electricity Comparable Facilities and Square Footage Alternative Data Sources

Data Element	Preferred Source
Size of the facility [sq ft]	<ul style="list-style-type: none"> • Building Manager
Size [sq ft] and annual electricity use [MWh] of comparable facilities	<ul style="list-style-type: none"> • Buildings Manager of comparable facilities

Calculation Steps

Use the following steps to estimate the electricity use at the facility:

1. Determine the size of the facility measured in floor area [sq ft]
2. Identify comparable facilities with known annual electricity use and square footage
3. Determine the electricity used per square foot at a comparable facility and estimate the electricity used at the facility.

Step 1: Determine the size of the facility measured in floor area [sq ft]

Agencies can obtain this information from the respective building manager or from the agency’s Federal Real Property Profile database, as appropriate.

Step 2: Identify comparable facilities with known annual electricity use rates and square footage

If possible, these facilities should be owned or operated by the same agency. The determination of comparability should include consideration of the primary function of the facility (such as office or hospital) and the primary uses of electricity at each facility (such as heating or cooling). Facility age, hours of operation, number of occupants, and the type of heating and cooling systems employed should also be considered.

If electricity consumption for another comparable facility owned or operated by the same agency is not available, consult the U.S. EIA’s Commercial Building Energy Consumption Survey for average energy use by facility type and region of the country (www.eia.doe.gov/emeu/cbecs).

Step 3: Determine the electricity used per square foot at a comparable facility and estimate the electricity used at the facility

Divide the annual electricity use at the comparable facility by its square footage to obtain a kWh/sq ft coefficient. Then multiply this energy intensity by the area of the facility for which electricity use is being estimated.

Equation B-4: Estimated Annual Electricity Use (Square Footage)

<p>Energy Intensity [kWh/sq ft] = Annual electricity use at comparable facility [kWh] ÷ size of comparable facility [sq ft]</p>
<p>Estimated Electricity Use [kWh] = Coefficient [kWh/sq ft] • size of facility being estimated [sq ft]</p>

Agencies should input the estimated electricity use from Equation B-4 into the GHG Reporting Portal, which will follow the default approach to estimate CO₂, CH₄, and N₂O Scope 2 emissions and total CO₂e from the facility (see Appendix B.1.1).

B.2. Purchased Steam or Hot Water

Many agencies purchase steam or district heating to provide space heating in the buildings or process heating for industrial needs. Emissions associated with these sources are considered to be indirect. The default methodology below describes the method for calculating emissions from purchased steam or hot water using the GHG Reporting Portal. The advanced methodology, B.2.2, describes a more detailed method.

B.2.1. Default Methodology (to be Calculated by GHG Reporting Portal)

Data Sources

Scope 2 GHG emissions from purchased steam and hot water are primarily calculated from metered steam and hot water consumption data and published emission factors. Table B-4 shows the preferred and alternate data sources for calculating Scope 2 emissions from steam or hot water use.

Table B-4: Purchased Steam or Hot Water Default Data Sources

Data Element	Preferred Source	Alternate Source
Steam or hot water consumption [MMBtu]	<ul style="list-style-type: none"> FEMP Energy Report 	<ul style="list-style-type: none"> Purchasing records Maintenance records
Emission factors [kg/MMBtu]	<ul style="list-style-type: none"> Standardized emission factors provided in Table D-9 	<ul style="list-style-type: none"> N/A

Calculation Steps

To calculate Scope 2 emissions from purchased steam or hot water, do the following:

1. Determine the annual steam and hot water use from all facilities within an agency's organizational boundary
2. Calculate the appropriate emission factors that apply to the steam and hot water used
3. Determine total annual emissions in MT CO₂e.

Step 1: Determine the annual steam and hot water use from all facilities within an agency's organizational boundary

Agencies should begin by calculating the quantity of steam and hot water purchased. If steam purchases are metered and recorded by the agency, those data should be used. Steam and hot water use data should be included for all facilities within an agency's organizational boundary.

Agencies should refer to Federal Energy Management Guidance for preferred sources of steam and hot water data (metered readings or utility bills) and alternate methods for estimating steam and hot water use when metered data are not available.

Step 2: Calculate the appropriate emission factors that apply to the steam and hot water used

Steam and hot water emission factors represent the amount of GHGs emitted per unit of steam and hot water consumed by fuel type. These are usually reported in units of kg of CO₂e per MMBtu of steam or hot water (see Table D-9).

Emission factors depend on the mix of fuel burned to generate purchased steam and hot water.⁶⁶ In some cases, obtaining emission factors directly from the supplier may be possible. In cases where this is not possible, the GHG Reporting Portal will calculate emission factors on the basis of steam and hot water being produced by a natural gas boiler (see Table D-2 and Table D-3).

The GHG Reporting Portal will calculate the emission factors for steam by dividing the default emission factors for natural gas for CO₂, CH₄, and N₂O by the product of boiler efficiency (default 80 percent),⁶⁷ steam production efficiency (75 percent),⁶⁸ and distribution loss (10 percent).^{69,70}

Equation B-5: Steam Emission Factor Calculation

<p>CO₂ Emission Factor of Steam [kg/MMBtu] = Emission factor CO₂ [kg/MMBtu] ÷ (boiler efficiency [%] • steam production efficiency [%] • (1-distribution loss [%]))</p>
<p>CH₄ Emission Factor of Steam [kg/MMBtu] = Emission factor CH₄ [kg/MMBtu] ÷ (boiler efficiency [%] • steam production efficiency [%] • (1-distribution loss [%]))</p>
<p>N₂O Emission Factor of Steam [kg/MMBtu] = Emission factor N₂O [kg/MMBtu] ÷ (boiler efficiency [%] • steam production efficiency [%] • (1-distribution loss [%]))</p>

⁶⁶ Within DOE’s 1605(b) Program, *Technical Guidelines, Voluntary Reporting of Greenhouse Gases*, a default emission factor for steam and hot water is provided. However, this factor does not break out emissions by GHG gas and combines emissions from both steam and hot water. This technical guidance calculates its own emission factors for both steam and hot water separately.

⁶⁷ DOE, Industrial Technology Programs, Energy Use and Loss Footprints, Assumption and Definitions. See www1.eere.energy.gov/industry/program_areas/footprints.html.

⁶⁸ eGRID2007 TSD, EPA. See www.epa.gov/cleanenergy/documents/egridzips/eGRIDwebV1_0_UsersManual.pdf.

⁶⁹ During the transmission and distribution of steam and hot water, some portion of the energy will be absorbed by the ambient environment due to imperfect insulation. In addition, the transmission lines are relatively short as steam and hot water cannot be transported over long distances without losing significant thermal energy. Due to the short distances, a separate entity rarely owns and controls the transmission system. Therefore, this is regarded as part of Scope 2 as the transmission lines are considered to occur within a generation facility’s operational control.

⁷⁰ DOE, Office of Policy and International Affairs, 1605(b) Program, *Technical Guidelines, Voluntary Reporting of Greenhouse Gases (1605(b)) Program* (March 2006) p. 154–156. See www.eia.doe.gov/oiaf/1605/pdf/Appendix%20N.pdf.

Hot water calculations are similar to those of steam but don't consider the 75 percent steam production efficiency. The GHG Reporting Portal will calculate the emission factor for hot water by dividing the emission factor for natural gas (see Tables D-2 and D-3) by the product of boiler efficiency (default 80 percent)⁷¹ and distribution loss (10 percent).⁷²

Equation B-6: Hot Water Emission Factor Calculation

CO₂ Emission Factor of Hot Water [kg/MMBtu] = Emission factor CO ₂ [kg/MMBtu] ÷ (boiler efficiency • (1– distribution loss [%]))
CH₄ Emission Factor of Hot Water [kg/MMBtu] = Emission factor CH ₄ [kg/MMBtu] ÷ (boiler efficiency • (1– distribution loss [%]))
N₂O Emission Factor of Hot Water [kg/MMBtu] = Emission factor N ₂ O [kg/MMBtu] ÷ (boiler efficiency • (1– distribution loss [%]))

Step 3: Determine total annual emissions in MT CO₂e

To determine annual emissions, the GHG Reporting Portal will multiply annual steam and hot water in MMBtu use separately (Step 1) by the emission factors calculated for CO₂, CH₄, and N₂O in kg of CO₂e per MMBtu (Step 2).

Equation B-7: Purchased Steam GHG Emissions

CO₂ Emission [MT CO₂] = Steam use [MMBtu] • emission factor [kg CO ₂ /MMBtu] • 0.001[MT/kg]
CH₄ Emission [MT CH₄] = Steam use [MMBtu] • emission factor [kg CH ₄ /MMBtu] • 0.001[MT/kg]
N₂O Emission [MT N₂O] = Steam use [MMBtu] • emission factor [kg N ₂ O/MMBtu] • 0.001[MT/kg]

Equation B-8: Purchased Hot Water GHG Emissions

CO₂ Emission Factor [MT] = Hot water use [MMBtu] • emission factor [kg CO ₂ /MMBtu] • 0.001[MT/kg]
CH₄ Emission Factor [MT] = Hot water use [MMBtu] • emission factor [kg CH ₄ /MMBtu] • 0.001[MT/kg]
N₂O Emission Factor [MT] = Hot water use [MMBtu] • emission factor [kg N ₂ O/MMBtu] • 0.001[MT/kg]

⁷¹ DOE Energy Efficiency and Renewable Energy, Industrial Technology Programs, Energy Use and Loss Footprints, Assumption and Definitions. See www1.eere.energy.gov/industry/program_areas/footprints.html.

⁷² DOE, Office of Policy and International Affairs, 1605(b) Program, *Technical Guidelines, Voluntary Reporting of Greenhouse Gases (1605(b)) Program* (March 2006) p. 154–156. See www.eia.doe.gov/oiaf/1605/pdf/Appendix%20N.pdf.

The GHG Reporting Portal will convert the CO₂, CH₄, and N₂O emissions into units of CO₂e by multiplying the total emissions of each gas in MT by the GWP values provided in Table D-13. Then, it will sum the CO₂e emissions of each of the three gases to obtain total GHG emissions. The GHG Reporting Portal will complete this calculation for both steam and hot water separately.

Equation B-9: Conversion to CO₂e and Determination of Total Purchased Steam and Hot Water Emissions

$\text{CO}_2\text{e Emissions [MT CO}_2\text{e]} = \text{MT CO}_2 + (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP})$
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Example B-2: Purchased Steam and Hot Water

A government entity imports steam and hot water at its Nevada facility. After going through utility bills, the agency determines that it consumed 1,000 MMBtu of steam and 2,000 MMBtu of hot water for the year.

Step 1: Determine the annual steam and hot water use from all facilities within an agency’s operational control

Agency facilities used 1,000 MMBtu of steam and 2,000 MMBtu of hot water this year.

Step 2: Calculate the appropriate emission factors that apply to the steam and hot water used

Equation B-5 Steam Emission Factor Calculation	
CO₂ Emission Factor of Steam [kg CO₂/MMBtu]	$= \text{CO}_2 \text{ emission factor [kg/MMBtu]} \div (\text{boiler efficiency [\%]} \bullet \text{steam production efficiency [\%]} \bullet (1 - \text{distribution loss [\%]}))$ $= 53.02 \text{ [kg CO}_2\text{/MMBtu]} \div (0.80 \bullet 0.75 \bullet 0.90)$ $= 98.19 \text{ [kg CO}_2\text{/MMBtu]}$
CH₄ Emission Factor of Steam [kg CH₄/MMBtu]	$= \text{CH}_4 \text{ emission factor [kg/MMBtu]} \div (\text{boiler efficiency [\%]} \bullet \text{steam production efficiency [\%]} \bullet (1 - \text{distribution loss [\%]}))$ $= 1.0 \times 10^{-3} \text{ [kg CH}_4\text{/MMBtu]} \div (0.80 \bullet 0.75 \bullet 0.90)$ $= 1.85 \times 10^{-3} \text{ [kg CH}_4\text{/MMBtu]}$
N₂O Emission Factor of Steam [kg N₂O/MMBtu]	$= \text{N}_2\text{O emission factor [kg/MMBtu]} \div (\text{boiler efficiency [\%]} \bullet \text{steam production efficiency [\%]} \bullet (1 - \text{distribution loss [\%]}))$ $= 1.0 \times 10^{-4} \text{ [kg N}_2\text{O/MMBtu]} \div (0.80 \bullet 0.75 \bullet 0.90)$ $= 1.85 \times 10^{-4} \text{ [kg N}_2\text{O/MMBtu]}$
Equation B-6: Hot Water Emission Factor Calculation	
CO₂ Emission Factor of Hot Water [kg CO₂/MMBtu]	$= \text{CO}_2 \text{ emission factor [kg/MMBtu]} \div (\text{boiler efficiency [\%]} \bullet (1 - \text{distribution loss [\%]}))$ $= 53.02 \text{ [kg CO}_2\text{/MMBtu]} \div (0.80 \bullet 0.90)$ $= 73.64 \text{ [kg CO}_2\text{/MMBtu]}$
CH₄ Emission Factor of Hot Water [kg CH₄/MMBtu]	$= \text{CH}_4 \text{ emission factor [kg/MMBtu]} \div (\text{boiler efficiency [\%]} \bullet (1 - \text{distribution loss [\%]}))$ $= 1.0 \times 10^{-3} \text{ [kg CH}_4\text{/MMBtu]} \div (0.80 \bullet 0.90)$ $= 1.4 \times 10^{-3} \text{ [kg CH}_4\text{/MMBtu]}$
N₂O Emission Factor of Hot Water [kg N₂O/MMBtu]	$= \text{N}_2\text{O emission factor [kg/MMBtu]} \div (\text{boiler efficiency [\%]} \bullet (1 - \text{distribution loss [\%]}))$ $= 1.0 \times 10^{-4} \text{ [kg N}_2\text{O/MMBtu]} \div (0.80 \bullet 0.90)$

[kg N₂O/MMBtu]	= 1.4 x 10 ⁻⁴ [kg N ₂ O/MMBtu]
<i>Step 3: Determine total annual emissions in MT CO₂e</i>	
<u>Equation B-7: Purchased Steam GHG Emissions</u>	
CO₂ Emissions [MT CO₂]	= Steam use [MMBtu] • CO ₂ emission factor [kg/MMBtu] • 0.001 [MT/kg] = 1,000 [MMBtu] • 98.19 [kg CO ₂ /MMBtu] • 0.001 [MT/kg] = 98.19 [MT CO ₂]
CH₄ Emissions [MT CH₄]	= Steam use [MMBtu] • CH ₄ emission factor [kg/MMBtu] • 0.001 [MT/kg] = 1,000 [MMBtu] • 1.85 x 10 ⁻³ [kg CH ₄ /MMBtu] • 0.001 [MT/kg] = 1.85 x 10 ⁻³ [MT CH ₄]
N₂O Emissions [MT N₂O]	= Steam use [MMBtu] • N ₂ O emission factor [kg/MMBtu] • 0.001 [MT/kg] = 1,000 [MMBtu] • 1.85 x 10 ⁻⁴ [kg N ₂ O/MMBtu] • 0.001 [MT/kg] = 1.85 x 10 ⁻⁴ [MT N ₂ O]
<u>Equation B-8: Purchased Hot Water GHG Emissions</u>	
CO₂ Emissions [MT CO₂]	= Hot water [MMBtu] • CO ₂ emission factor [kg/MMBtu] • 0.001 [MT/kg] = 2,000 [MMBtu] • 73.64 [kg CO ₂ e/MMBtu] • 0.001 [MT/kg] = 147.28 [MT CO ₂]
CH₄ Emissions [MT CH₄]	= Hot water • CH ₄ emission factor [kg/MMBtu] • 0.001 [MT/kg] = 2,000 [MMBtu] • 1.4 x 10 ⁻³ [kg CH ₄ /MMBtu] • 0.001 [MT/kg] = 2.8 x 10 ⁻³ [MT CH ₄]
N₂O Emissions [MT N₂O]	= Hot water • N ₂ O emission factor [kg/MMBtu] • 0.001 [MT/kg] = 2,000 [MMBtu] • 1.4 x 10 ⁻⁴ [kg N ₂ O/MMBtu] • 0.001 [MT/kg] = 2.8 x 10 ⁻⁴ [MT N ₂ O]
<u>Equation B-9: Conversion to CO₂e and Determination of Total Purchased Steam and Hot Water Emissions</u>	
Steam CO₂ Emissions [MT CO₂e]	= MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP) = 98.19 [MT CO ₂] + (1.85 x 10 ⁻³ [MT CH ₄] • 21) + (1.85 x 10 ⁻⁴ [MT N ₂ O] • 310) = 98.29 [MT CO₂e]
Hot Water CO₂ Emissions [MT CO₂e]	= MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP) = 147.28 [MT CO ₂] + (2.8 x 10 ⁻³ [MT CH ₄] • 21) + (2.8 x 10 ⁻⁴ [MT N ₂ O] • 310) = 147.43 [MT CO₂e]
Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.	

B.2.2. Advanced Methodology (User Calculated)

The advanced method of calculating Scope 2 purchases of steam and hot water follows the same procedural steps as outlined above in the default methodology. However, in this instance, the agency is able to obtain information from the steam and hot water provider and use factors specific to the plant rather than the defaults. This methodology can be utilized if the actual boiler efficiency and distribution loss is provided by the supplier.

B.3. Purchased Chilled Water

Many agencies purchase chilled water for cooling purposes. Some agencies purchase chilled water generated by a plant or specific equipment owned and operated by another entity. As is the case with electricity and steam purchases, agencies in these circumstances may need to obtain information from their suppliers to estimate the emissions associated with these purchases. If this information is not available, agencies can use default factors to estimate the emissions associated with their purchased chilled water. Use the default methodology if agency chiller type is electric-driven, or when the chiller type is unknown.

B.3.1. Default Methodology (to be Calculated by GHG Reporting Portal)

Data Sources

Agencies can estimate emissions associated with purchased chilled water by using values for cooling demand, transmission loss adjustment, and coefficient of performance (COP) (Table B-5). Default factor COP values are provided in Table D-10.

Table B-5: Purchased Chilled Water Default Data Sources

Data Element	Preferred Source
Cooling demand [MMBtu or ton-hours]	• FEMP Energy Report
COP	• Default value
Transmission loss adjustment factor	• Default value

*Calculation Steps*⁷³

To calculate Scope 2 emissions from purchased chilled water purchases:

1. Estimate the cooling demand
2. Determine the supplier's COP
3. Calculate the cooling plant inputs from energy cooling demand
4. Determine the annual input of electrical energy from all facilities within an agency's operational control
5. Select the appropriate eGRID subregion output emission rate factors that apply to the chilled water used
6. Calculate total CO₂, CH₄, and N₂O emissions, and convert them to MT.

Step 1: Estimate the Cooling Demand

Agencies should refer to monthly cooling bills to estimate the yearly cooling demand of the relevant facility. If the supplied cooling is reported in ton-hours of cooling, convert it to MMBtu

⁷³ DOE, Office of Policy and International Affairs, 1605(b) Program, *Technical Guidelines, Voluntary Reporting of Greenhouse Gases*, January 2007.

at the rate of 0.012 MMBtu per ton-hour. Determine whether the cooling demand includes or excludes off-site transmission and distribution losses.

Step 2: Determine the Supplier's COP

COP values vary depending on the type of chiller used by the supplier. Default cooling supplier COP values are provided in Table D-10. Use the default value for electric-driven chillers when chiller type is unknown.

Step 3: Calculate the Cooling Plant Inputs from Energy Cooling Demand

If they are not billed for their suppliers' transmission losses, agencies can estimate the amount of energy input into the cooling system to meet an entity's demand by multiplying the cooling demand and transmission loss⁷⁴ adjustment factor (default percentage of loss 10 percent)⁷⁵ then dividing by the COP of the cooling plant. The cooling plant energy input is represented in Equation B-10.

Equation B-10: Energy Input of Cooling Plant Calculation

Energy Input from the Cooling Plant =

Agency cooling demand [MMBtu] • transmission loss adjustment factor ÷ COP cooling plant

Step 4: Determine the annual input of electrical energy from all facilities within an agency's operational control

Agencies determine the energy input quantity from the cooling plant and convert it to MWh. Agencies then sum energy input from all relevant facilities.

Step 5: Select the appropriate eGRID subregion output emission rate factors that apply to the chilled water used

The agency should report purchased chilled water by eGRID subregion into the GHG Reporting Portal. The portal will utilize appropriate emission factors for CO₂, CH₄, and N₂O, listed in Appendix D. This default methodology assumes an electric driven chiller.

Step 6: Calculate total CO₂, CH₄, and N₂O emissions, and convert them to MT

The GHG Reporting Portal will convert the CO₂, CH₄, and N₂O emissions into units of MT CO₂e by multiplying the total emissions of each gas (in MT) by the GWP value, included in Table

⁷⁴ During the transmission and distribution of chilled water will be absorb energy from the environment consequently raising its temperature. The transmission lines that transport chilled water are relatively short as chilled water cannot be transported over long distances. Due to the short distances, there is rarely a separate entity that owns and controls the transmission system. Therefore, this is regarded as part of Scope 2 as the transmission lines are considered to occur within a generation facility's operational control.

⁷⁵ The transmission loss factor approach and default are provided by the DOE, Office of Policy and International Affairs, 1605(b) Program, *Technical Guidelines, Voluntary Reporting of Greenhouse Gases (1605(b)) Program* (March 2006), p. 154–156. See www.eia.doe.gov/oiaf/1605/pdf/Appendix%20N.pdf. The transmission loss factor is meant to account for the thermal losses incurred while transmitting the steam, hot water, or chilled water from generation plant to end user facility.

D-13. The GHG Reporting Portal will sum the CO₂e emissions of each of the three gases to obtain total GHG emissions.

Equation B-11: Conversion to CO₂e and Determination of Total Emissions

$$\text{CO}_2\text{e Emissions [MT CO}_2\text{e]} = \text{MT CO}_2 + (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP})$$

Example B-3: Purchased Chilled Water

After going through utility bills, an agency located in eGRID subregion RFC West determines that it has consumed 320,000 ton hours of cooling (from an absorption chiller) for the entire year.

Step 1: Estimate the Cooling Demand

The agency has consumed 320,000 ton hours of chilled water

Conversion from ton hours to MMBtu = 320,000 [ton hours] • 0.012 [MMBtu/ton hour]
 = 3,840 [MMBtu]

Step 2: Estimate the Supplier's COP

Default value for absorption chiller = 0.8

Step 3: Calculate the Cooling Plant Inputs from Energy Demand

Equation B-10: Energy Input of Cooling Plant Calculation

Energy Input from Cooling Plant = Agency cooling demand [MMBtu] • Transmission loss adjustment factor [%] ÷ Cooling plant COP
 = 3,840 [MMBtu] • (1/(1 - 0.10))/0.80
 = 3,840 [MMBtu] • 1.11/0.80
 = 5,328 [MMBtu]

Step 4: Determine the annual input of electrical energy from all facilities within an agency's operational control

The agency converts the energy input from the cooling plant value from Equation B-10 to MWh

Convert to MWh = Electricity input [MMBtu] • conversion factor [MWh/MMBtu]
 = 5,328 [MMBtu] • 1/3.413 [MWh/MMBtu]
 = 5,328 [MMBtu] ÷ 3.413 [MWh]
 = 1,561.09 [MWh]

Step 5: Select the appropriate eGRID subregion output emission rate factors that apply to the chilled water

Use eGRID subregion RFC West emission factors for

- CO₂ = 703.75 [lb/MWh]
- CH₄ = 8.33 [lb/GWh] = [8.33 [lb/GWh] • 0.001] [lb/MWh] = 0.00833 [lb/MWh]
- N₂O = 11.76 [lb/GWh] = [11.76 [lb/GWh] • 0.001] [lb/MWh] = 0.01176 [lb/MWh]

Step 6: Calculate total CO₂, CH₄, and N₂O emissions, and convert them to MT

The agency multiplies the energy input in MWh by the emission factor and converts them to MT

CO₂ Emissions [MT CO₂]	= 1561.09 [MWh] • 703.75 [lb CO ₂ /MWh] • 4.53592 × 10 ⁻⁴ [MT/lb] = 498.32 [MT CO ₂]
CH₄ Emissions [MT CH₄]	= 1561.09 [MWh] • 0.00833 [lb CH ₄ /MWh] • 4.53592 × 10 ⁻⁴ [MT/lb] = 0.00590 [MT CH ₄]
N₂O Emissions [MT N₂O]	= 1561.09 [MWh] • 0.01176 [lb N ₂ O/MWh] • 4.53592 × 10 ⁻⁴ [MT/lb] = 0.00832 [MT N ₂ O]
<u>Equation B-11: Conversion to CO₂e and Determination of Total Emissions</u>	
CO₂ Emissions [MT CO₂e]	= MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP) = 498.32 [MT CO ₂] + (0.00590 [MT CH ₄] • 21) + (0.00832 [MT N ₂ O] • 310) = 498.32 + 0.12 + 2.58 = 501.02 [MT CO₂e]
Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.	

B.3.2. Advanced Calculation Methodology 1: Non-Electric Chiller, Unknown COP (User Calculated)

This advanced methodology for purchased chilled water should be used when the type of chiller is known to be either absorption or engine-driven and the COP for the chiller is not known. The methodology uses the same equations as the default method, except that it does not use eGRID subregion output emission rate factors (since electricity is not the chiller’s energy source). Instead, emissions factors for CO₂, CH₄, and N₂O are determined from Table D-2 based on the chiller’s energy source. NOTE: If an absorption chiller is powered by waste heat, which is highly likely, then emissions will have to be allocated based on the proportion of energy used for this purpose (see CHP methodology, below). This method uses default COP values from Table D-10 for the type of non-electric chiller selected.

B.3.3. Advanced Calculation Methodology 2: Non-Electric Chiller, COP Known (User Calculated)

The second advanced methodology for purchased chilled water should be used when the COP for the chiller, and its emissions factors, are known. It uses the same equations as the default method, but uses plant- and fuel-specific emission factors to reflect site-specific efficiencies and conditions instead of default emission factors in Table D-10. This advanced methodology is the most accurate of the three, provided that the agency obtains specific, accurate information about a cooling plant’s COP and emissions factors.

B.4. Purchased Electricity, Steam, or Hot Water from a CHP Facility

Emissions from CHP facilities represent a special case for estimating Scope 2 emissions. Because CHP simultaneously produces electricity and heat (steam and hot water), attributing the total GHG emissions to each product stream would result in double counting and not provide proper credit for the inherent efficiency of cogeneration. Thus, when two or more parties receive

the energy streams from CHP plants, GHG emissions must be determined and allocated separately for heat production and electricity production. Since the output from CHP results simultaneously in heat and electricity, the agency must determine what “share” of the total emissions is a result of electricity and heat by using a ratio based on the Btu content of heat and/or electricity relative to the CHP plant’s total output.

Below are both the default and advanced approaches for calculating Scope 2 emissions for heat (steam or hot water) and power purchases from a CHP facility. It is recommended that agencies use advanced methodologies when possible given the possible overestimation of emissions with the default methods.

B.4.1. Default Methodology (to be Calculated by GHG Reporting Portal)

Data Sources

The default methodology requires only the quantity of electricity, steam, and/or hot water consumed from the local CHP (Table B-6). The use of these simplified methods will likely result in overestimation of emissions.

Table B-6: CHP Default Data Sources

Data Element	Preferred Sources
Electricity consumption [MMBtu]	<ul style="list-style-type: none"> • FEMP Energy Report
Steam and/or Hot Water consumption [MMBtu]	<ul style="list-style-type: none"> • FEMP Energy Report

Because of the potential for overestimating Scope 2 emissions, the default methodology is not recommended if agencies possess sufficient data for use of the advanced methodologies. In the absence of alternative data, the default approaches are built on the assumption that an agency is purchasing electricity and heat from standard, less-efficient systems, rather than a CHP.

Default Methodology for Electricity Purchases

If purchased electricity is from a CHP facility, the default methodology for purchased electricity can be used to estimate Scope 2 emissions from this source (see Appendix B.1.1). This methodology assumes that an agency is purchasing electricity from the grid. Grid-average electricity may be produced less efficiently than electricity produced at a CHP facility, so this may result in an overestimation of Scope 2 emissions. This methodology should be used if data from the CHP facility are unavailable.

Default Methodology for Steam or Heat Purchases

If an agency purchases steam or district heating from a CHP facility, the methodology in the steam and hot water section can be used to estimate Scope 2 emissions from this source (see Appendix B.2.1). This methodology assumes that purchased steam or district heating is from a conventional boiler plant. Conventional boiler plants produce steam and heat less efficiently than CHP facilities, so this may result in an overestimation of Scope 2 emissions. This methodology should be used if the data from the CHP facility is unavailable.

B.4.2. Advanced Methodology (User Calculated)

Data Sources

The recommended advanced methodology for CHP (Advanced Calculation Methodology 1) requires only minimal utility purchase information and existing energy/emission datasets from eGRID to calculate plant-specific emissions. When a plant is not present in eGRID, advanced method 2 requires additional Federal facility and utility CHP provider coordination to obtain the same energy, emissions, and allocation data. Table B-7 shows the required data and sources for both methods.

Table B-7: CHP Advanced Data Sources

Data Element	Preferred Source
<i>Advanced Calculation Methodology 1: CHP Facilities Present in eGRID</i>	
CHP identity	<ul style="list-style-type: none"> Federal facility energy manager
Electricity use [MMBtu]	<ul style="list-style-type: none"> FEMP Energy Report
Steam or hot water [MMBtu]	<ul style="list-style-type: none"> FEMP Energy Report
Emission factors	<ul style="list-style-type: none"> eGRID plant data file
Plant energy input, CHP adjustment, and emissions	<ul style="list-style-type: none"> eGRID plant data file
<i>Advanced Calculation Methodology 2: CHP Facilities Not Present in eGRID</i>	
Emissions based on fuel [MT]	<ul style="list-style-type: none"> Fuel use data
Total electricity production from the CHP plant [MMBtu]	<ul style="list-style-type: none"> Generation and meter readings
Net heat production from the CHP plant [MMBtu]	<ul style="list-style-type: none"> Heat content values for steam at different temperature and pressure conditions
Emission factor	<ul style="list-style-type: none"> Appendix D

Advanced Calculation Methodology 1: CHP Facilities Present in eGRID

To calculate emissions from heat and power purchases from a CHP facility that is present in eGRID:

1. Determine annual CHP-provided purchased electricity, steam, and/or hot water used at all facilities within agency's operational control
2. Identify and select the appropriate emission factors that apply to the CHP electricity purchased
3. Identify, calculate, and select the appropriate emission factors that apply to the steam purchased
4. Identify, calculate, and select the appropriate emission factors that apply to the hot water purchased
5. Calculate the total annual emissions in MT of CO₂, CH₄, and N₂O

6. Determine the total annual emissions in MT CO₂e.

Step 1: Determine annual CHP-provided purchased electricity, steam, and/or hot water use from all facilities within agency's operational control

Electricity, steam, and/or hot water use data should be included for all facilities that fit with the definition of operational control provided in Chapter 2 of the main Guidance document. This should align with the agency's annual energy consumption reporting to the FEMP. Agencies should refer to Federal Energy Management Guidance⁷⁶ for preferred sources of electricity use data (metered readings or utility bills) and alternate methods for estimating electricity use when metered data are not available.

Step 2: Identify and select the appropriate emission factors that apply to the CHP electricity purchased

Agencies should use the eGRID CHP plant output emission rate factors corresponding to the year of their inventory activity data. As with standard grid provided electricity, agencies are not expected to retroactively update their inventories with new eGRID output emission rate factors once the inventory has been submitted to CEQ.

The agency should obtain CHP plant-specific data, which is available from the eGRID website, by downloading the most current version of "eGRID Plant, Boiler, and Generator Data Files." This will be an option once the "Plant and Aggregate Files" are downloaded. Find the identified CHP in the plant file using the state and county data elements to simplify the search. Once identified, the CHP specific emission factors are identified in the applicable eGRID data elements:

- Plant Annual CO₂ Output Emission Rate [lb CO₂/MWh] (PLCO₂RTA)
- Plant Annual CH₄ Output Emission Rate [lb CH₄/GWh] (PLCH₄RTA)
- Plant Annual N₂O Output Emission Rate [lb N₂O/GWh] (PLN₂ORTA).

Step 3: Identify, calculate, and select the appropriate emission factors that apply to the steam purchased

Using the eGRID plant file and the identified CHP from purchased electricity, the steam emission factors for the specific CHP can be calculated from existing eGRID data elements. The requisite CHP specific eGRID data elements include:

- Plant Unadjusted Annual CO₂ Emissions [short tons] (UNCO₂)
- Plant Unadjusted Annual CH₄ Emissions [lb] (UNCH₄)
- Plant Unadjusted Annual N₂O Emissions [lb] (UNN₂O)
- Plant Annual CO₂ Emissions [short tons] (PLCO₂AN)
- Plant Annual CH₄ Emissions [lb] (PLCH₄AN)

⁷⁶ FEMP, Energy Report guidance. See www1.eere.energy.gov/femp/regulations/guidance.html.

- Plant Annual N₂O Emissions [lb] (PLN₂OAN)
- CHP Plant Useful Thermal Output (USETHRMO) [MMBtu].

Equation B-12 should be used to calculate the steam emission factor.

Equation B-12: eGRID CHP Plant Steam Emission Factor Calculation

eGRID CHP Steam Emission Factor [lb CO₂/MMBtu] =	
[(UNCO ₂ – PLCO ₂ AN) • STLC] ÷ [(USETHRMO • SP) • (1 – DL)]	
Where:	
UNCO ₂	Plant Unadjusted Annual CO ₂ Emissions [short tons CO ₂]
PLCO ₂ AN	Plant Annual CO ₂ Emissions [short tons CO ₂]
STLC	Short-ton-to-lb conversion (2,000) [lb/short ton]
USETHRMO	CHP Plant Useful Thermal Output [MMBtu]
SP	Steam Production Efficiency (75%)
DL	Distribution Loss (10%)

Source: eGRID2010 TSD, EPA. See www.epa.gov/cleanenergy/documents/egridzips/eGRID2010TechnicalSupportDocument.pdf.

The CH₄ and N₂O emission factors are likewise derived by substituting UNCH₄ or UNN₂O for UNCO₂ and by substituting PLCH₄AN or PLN₂OAN for PLCO₂AN. However, STLC is omitted due to a change from reporting in short tons to lb.

Step 4: Identify, calculate, and select the appropriate emission factors that apply to the hot water purchased

As with steam (step 3), the hot water emission factors for the specific CHP can be calculated from existing eGRID data elements. The requisite CHP-specific eGRID data elements are the same as those listed under step 3.

Equation B-13 should be used to calculate the hot water emission factor.

Equation B-13: eGRID CHP Plant Hot Water Emission Factor Calculation

eGRID CHP Hot Water Emission Factor [lb CO₂/MMBtu] =	
[(UNCO ₂ – PLCO ₂ AN) • STLC] ÷ [USETHRMO • (1 – DL)]	
Where:	
UNCO ₂	Plant Unadjusted Annual CO ₂ Emissions [short tons CO ₂]
PLCO ₂ AN	Plant Annual CO ₂ Emissions [short tons CO ₂]
STLC	Short-ton-to-lb conversion (2,000) [lb/short ton]
USETHRMO	CHP Plant Useful Thermal Output [MMBtu]
DL	Distribution Loss [%], default value of 10%

Source: eGRID2010 Technical Support Document, EPA. See www.epa.gov/cleanenergy/documents/egridzips/eGRID2010TechnicalSupportDocument.pdf.

Similar to step 3, the CH₄ and N₂O emission factors are likewise derived by substituting UNCH₄ or UNN₂O for UNCO₂ and by substituting PLCH₄AN or PLN₂OAN for PLCO₂AN. However, STLC is omitted due to a change from reporting in short tons to lb.

Step 5: Calculate the total annual emissions in MT of CO₂, CH₄, and N₂O

To determine annual emissions, multiply annual electricity, steam, and/or hot water use (step 1) by the respective emission factors for CO₂, CH₄, and N₂O in lb per MWh (step 2) or MMBtu (step 3 and 4).

Equation B-14: Electricity Use GHG Emissions

CO₂ Emissions [MT CO₂] = Electricity use [MWh] • Emission factor [lb CO ₂ /MWh] ÷ 2,204.62 [lb/metric ton]
CH₄ Emissions [MT CH₄] = Electricity use [MWh] • Emission factor [lb CH ₄ / GWh] ÷ 1,000 [MWh/GWh] ÷ 2,204.62 [lb/metric ton]
N₂O Emissions [MT N₂O] = Electricity use [MWh] • Emission factor [lb N ₂ O/ GWh] ÷ 1,000 [MWh/GWh] ÷ 2,204.62 [lb/metric ton]

Equation B-15: Purchased Steam Use GHG Emissions

CO₂ Emissions [MT CO₂] = Steam use [MMBtu] • Emission factor [lb CO ₂ /MMBtu] ÷ 2,204.62 [lb/metric ton]
CH₄ Emissions [MT CH₄] = Steam use [MMBtu] • Emission factor [lb CH ₄ /MMBtu] ÷ 2,204.62 [lb/metric ton]
N₂O Emissions [MT N₂O] = Steam use [MMBtu] • Emission factor [lb N ₂ O/MMBtu] ÷ 2,204.62 [lb/metric ton]

Equation B-16: Purchased Hot Water Use GHG Emissions

CO₂ Emissions [MT CO₂] = Hot water use [MMBtu] • Emission factor [lb CO ₂ /MMBtu] ÷ 2,204.62 [lb/metric ton]
CH₄ Emissions [MT CH₄] = Hot water use [MMBtu] • Emission factor [lb CH ₄ /MMBtu] ÷ 2,204.62 [lb/metric ton]
N₂O Emissions [MT N₂O] = Hot water use [MMBtu] • Emission factor [lb N ₂ O/MMBtu] ÷ 2,204.62 [lb/metric ton]

Step 6: Determine the total annual emissions in MT CO₂e

The final step is to convert CH₄ and N₂O into units of CO₂e, and multiply total emissions of each gas in MT by the GWP value provided in Table D-13. Then, sum the CO₂e emissions of each of the three gases to obtain total GHG emissions.

Equation B-17: Conversion to CO₂e and Determination of Total Emissions

$$\text{CO}_2\text{e Emissions [MT CO}_2\text{e]} = \text{MT CO}_2 + (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP})$$

Example B-4: Heat and Power Purchases from a Combined Heat and Power Facility

As a notional example, a U.S. Navy facility in New York State directly purchases electric, steam, and hot water from a CHP facility named the Brooklyn Navy Yard Cogeneration Plant. This plant is owned and operated by Edison Mission Energy. For the purposes of this example, the plant is outside of the U.S. Navy's operational control; the emissions associated with the electricity, steam, and hot water used would be calculated and reported as Scope 2 emissions.

Step 1: Access U.S. Navy Facility Report Energy Use

U.S. Navy Purchases from NTC/MCRD Energy CHP:

- Electricity 750 [MWh]
- Steam 300 [MMBtu]
- Hot Water 150 [MMBtu]

Step 2: Locate NTC/MCRD Energy CHP Plant, its Electricity Emission Factors, and its Emission Values in the eGRID Plant File

- CO₂ Emission Factor [lb CO₂/MWh] = PLCO₂RTA = 758.88 [lb CO₂/MWh]
- CH₄ Emission Factor [lb CH₄/GWh] = PLCH₄RTA = 14.66 [lb CH₄/GWh]
- N₂O Emission Factor [lb N₂O/GWh] = PLN₂ORTA = 1.47 [lb N₂O/GWh]
- CHP Plant Useful Thermal Output [MMBtu] = USETHRMO = 4,733,504.80 [MMBtu]
- Plant Unadjusted Annual CO₂ Emissions [short tons CO₂] = UNCO₂ = 1,128,319.78 [short tons CO₂]
- Plant Annual CO₂ Emissions [short tons CO₂] = PLCO₂AN = 733,634.46 [short tons CO₂]
- Plant Unadjusted Annual CH₄ Emissions [lb CH₄] = UNCH₄ = 43,581.71 [lb CH₄]
- Plant Annual CH₄ Emissions [lb CH₄] = PLCH₄AN = 28,336.86 [lb CH₄]
- Plant Unadjusted N₂O Annual N₂O Emissions [lb N₂O] = UNN₂O = 4,358.17 [lb N₂O]
- Plant Annual N₂O Emissions [lb N₂O] = PLN₂OAN = 2,833.69 [lb N₂O]

Step 3: Calculate CHP Plant Steam Emission Factors from eGRID

$$\begin{aligned} \text{CO}_2 \text{ Emission Factor [lb CO}_2\text{/MMBtu]} &= [(\text{UNCO}_2 - \text{PLCO}_2\text{AN}) \bullet \text{STLC}] \div [(\text{USETHRMO} \bullet \text{SP}) \bullet (1 - \text{DL})] \\ &= [(1,128,319.78 \text{ [short tons CO}_2\text{]} - 733,634.46 \text{ [short tons CO}_2\text{]}) \bullet 2000 \text{ [lb/short ton]}] \\ &\quad \div [(4,733,504.80 \text{ [MMBtu]} \bullet 0.75) \bullet (1 - 0.10)] \\ &= [394,685.32 \text{ [short tons CO}_2\text{]} \bullet 2,000 \text{ [lb/short ton]}] \div [3,550,128.60 \text{ [MMBtu]} \bullet 0.90] \\ &= 789,370,640.00 \text{ [lb CO}_2\text{]} \div 3,195,115.74 \text{ [MMBtu]} \\ &= 247.06 \text{ [lb CO}_2\text{/MMBtu]} \end{aligned}$$

$$\begin{aligned} \text{CH}_4 \text{ Emission Factor [lb CH}_4\text{/MMBtu]} &= [(\text{UNCH}_4 - \text{PLCH}_4\text{AN})] \div [(\text{USETHRMO} \bullet \text{SP}) \bullet (1 - \text{DL})] \\ &= [(43,581.71 \text{ [lb CH}_4\text{]} - 28,336.86 \text{ [lb CH}_4\text{]})] \div [(4,733,504.80 \text{ [MMBtu]} \bullet 0.75) \bullet (1 - 0.10)] \\ &= 15,244.85 \text{ [lb CH}_4\text{]} \div [3,550,128.60 \text{ [MMBtu]} \bullet 0.90] \\ &= 15,244.85 \text{ [lb CH}_4\text{]} \div 3,195,115.74 \text{ [MMBtu]} \\ &= 0.004771 \text{ [lb CH}_4\text{/MMBtu]} \end{aligned}$$

$$\begin{aligned} \text{N}_2\text{O Emission Factor [lb N}_2\text{O/MMBtu]} &= [(\text{UNN}_2\text{O} - \text{PLN}_2\text{OAN})] \div [(\text{USETHRMO} \bullet \text{SP}) \bullet (1 - \text{DL})] \\ &= [(4,358.17 \text{ [lb N}_2\text{O]} - 2,833.69 \text{ [lb N}_2\text{O]})] \div [(4,733,504.80 \text{ [MMBtu]} \bullet 0.75) \bullet (1 - 0.10)] \end{aligned}$$

N₂O/MMBtu	$0.10]$ $= 1,524.48 \text{ [lb N}_2\text{O]} \div [3,550,128.60 \text{ [MMBtu]} \bullet 0.90]$ $= 1,524.48 \text{ [lb N}_2\text{O]} \div 3,195,115.74 \text{ [MMBtu]}$ $= 0.000477 \text{ [lb N}_2\text{O/MMBtu]}$
<i>Step 4: Locate CHP plant and electricity emission factors in eGRID</i>	
CO₂ Emission Factor [lb CO₂/MMBtu]	$= [(UNCO_2 - PLCO_2AN) \bullet STLC] \div [USETHRMO \bullet (1 - DL)]$ $= [(1,128,319.78 \text{ [short tons CO}_2\text{]} - 733,634.46 \text{ [short tons CO}_2\text{]}) \bullet 2000 \text{ [lb/short ton]}] \div [4,733,504.80 \text{ [MMBtu]} \bullet (1 - 0.10)]$ $= [394,685.32 \text{ [short tons CO}_2\text{]} \bullet 2,000 \text{ [lb/short ton]}] \div [4,733,504.80 \text{ [MMBtu]} \bullet 0.90]$ $= 789,370,640 \text{ [lb CO}_2\text{]} \div 4,260,154.32 \text{ [MMBtu]}$ $= 185.29 \text{ [lb CO}_2\text{/MMBtu]}$
CH₄ Emission Factor [lb CH₄/MMBtu]	$= [(UNCH_4 - PLCH_4AN)] \div [USETHRMO \bullet (1 - DL)]$ $= [(43,581.71 \text{ [lb CH}_4\text{]} - 28,336.86 \text{ [lb CH}_4\text{]})] \div [4,733,504.80 \text{ [MMBtu]} \bullet (1 - 0.10)]$ $= 15,244.85 \text{ [lb CH}_4\text{]} \div [4,733,504.80 \text{ [MMBtu]} \bullet 0.90]$ $= 15,244.85 \text{ [lb CH}_4\text{]} \div 4,260,154.32 \text{ [MMBtu]}$ $= 0.00358 \text{ [lb CH}_4\text{/MMBtu]}$
N₂O Emission Factor [lb N₂O/MMBtu]	$= [(UNN_2O - PLN_2OAN)] \div [USETHRMO \bullet (1 - DL)]$ $= [(4,358.17 \text{ [lb N}_2\text{O]} - 12,833.69 \text{ [lb N}_2\text{O]})] \div [4,733,504.80 \text{ [MMBtu]} \bullet (1 - 0.10)]$ $= 1,524.48 \text{ [lb N}_2\text{O]} \div [4,733,504.80 \text{ [MMBtu]} \bullet 0.90]$ $= 1,524.48 \text{ [lb N}_2\text{O]} \div 4,260,154.32 \text{ [MMBtu]}$ $= 0.000358 \text{ [lb N}_2\text{O/MMBtu]}$
<i>Step 5: Calculate annual emissions in MT of GHGs by type of energy</i>	
Equation B-14: Electricity Use GHG Emissions	
Electric CO₂ Emissions [MT CO₂]	$= \text{Electricity use [MWh]} \bullet \text{CO}_2 \text{ emission factor [lb/MWh]} \div 2,204.62 \text{ [lb/MT]}$ $= 750 \text{ [MWh]} \bullet 758.88 \text{ [lb CO}_2\text{/MWh]} \div 2,204.62 \text{ [lb/MT]}$ $= 51.63 \text{ [MT CO}_2\text{]}$
Electric CH₄ Emissions [MT CH₄]	$= \text{Electricity Use [MWh]} \bullet \text{CH}_4 \text{ emission factor [lb/ GWh]} \div 1,000 \text{ [MWh/GWh]} \div 2,204.62 \text{ [lb/MT]}$ $= 750 \text{ [MWh]} \bullet 14.66 \text{ [lb CH}_4\text{/ GWh]} \div 1,000 \text{ [MWh/GWh]} \div 2,204.62 \text{ [lb/MT]}$ $= 0.0050 \text{ [MT CH}_4\text{]}$
Electric N₂O Emissions [MT N₂O]	$= \text{Electricity use [MWh]} \bullet \text{N}_2\text{O emission factor [lb/ GWh]} \div 1,000 \text{ [MWh/GWh]} \div 2,204.62 \text{ [lb/MT]}$ $= 750 \text{ [MWh]} \bullet 1.47 \text{ [lb N}_2\text{O/ GWh]} \div 1,000 \text{ [MWh/GWh]} \div 2,204.62 \text{ [lb/MT]}$ $= 0.00050 \text{ [MT N}_2\text{O]}$
Equation B-15: Purchased Steam GHG Emissions	
Steam CO₂ Emissions [MT CO₂]	$= \text{Steam use [MMBtu]} \bullet \text{CO}_2 \text{ emission factor [lb/MMBtu]} \div 2,204.62 \text{ [lb/MT]}$ $= 300 \text{ [MMBtu]} \bullet 247.06 \text{ [lb CO}_2\text{/MMBtu]} \div 2,204.62 \text{ [lb/MT]}$ $= 33.62 \text{ [MT CO}_2\text{]}$
Steam CH₄ Emissions [MT CH₄]	$= \text{Steam use [MMBtu]} \bullet \text{CH}_4 \text{ emission factor [lb/MMBtu]} \div 2,204.62 \text{ [lb/MT]}$ $= 300 \text{ [MMBtu]} \bullet 0.004771 \text{ [lb CH}_4\text{/MMBtu]} \div 2,204.62 \text{ [lb/MT]}$ $= 0.00065 \text{ [MT CH}_4\text{]}$
Steam N₂O Emissions [MT N₂O]	$= \text{Steam use [MMBtu]} \bullet \text{N}_2\text{O emission factor [lb/MMBtu]} \div 2,204.62 \text{ [lb/MT]}$ $= 300 \text{ [MMBtu]} \bullet 0.000477 \text{ [lb N}_2\text{O/MMBtu]} \div 2,204.62 \text{ [lb/MT]}$ $= 0.000065 \text{ [MT N}_2\text{O]}$

Equation B-16: Purchased Hot Water GHG Emissions	
Hot Water CO₂ Emissions [MT CO₂]	= Hot water use [MMBtu] • CO ₂ emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT] = 150 [MMBtu] • 185.29 (lb CO ₂ /MMBtu) ÷ 2,204.62 [lb/MT] = 12.61 [MT CO ₂]
Hot Water CH₄ Emissions [MT CH₄]	= Hot water use [MMBtu] • CH ₄ emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT] = 150 [MMBtu] • 0.00358 [lb CH ₄ /MMBtu] ÷ 2,204.62 [lb/MT] = 0.00024 [MT CH ₄]
Hot Water N₂O Emissions [MT N₂O]	= Hot water use [MMBtu] • N ₂ O emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT] = 150 [MMBtu] • 0.000358 [lb N ₂ O/MMBtu] ÷ 2,204.62 [lb/MT] = 0.000024 [MT N ₂ O]
<i>Step 6: Determine Annual Emissions in MT CO₂e (such as Steam)</i>	
Equation B-17: Conversion to CO₂e and Determination of Total Emissions	
Electricity CO₂ Emissions [MT CO₂e]	= MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP) = 51.63 [MT CO ₂] + (0.0050 [MT CH ₄] • 21) + (0.00050 [MT N ₂ O] • 310) = 51.63 [MT CO ₂] + 0.105 [MT CO ₂ e] + 0.155 [MT CO ₂ e] = 51.89 [MT CO ₂ e]
Steam CO₂ Emissions [MT CO₂e]	= MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP) = 33.62 [MT CO ₂] + (0.00065 [MT CH ₄] • 21) + (0.000065 [MT N ₂ O] • 310) = 33.62 [MT CO ₂] + 0.0137 [MT CO ₂ e] + 0.0202 [MT CO ₂ e] = 33.65 [MT CO ₂ e]
Hot Water CO₂ Emissions [MT CO₂e]	= MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP) = 12.61 [MT CO ₂] + (0.00024 [MT CH ₄] • 21) + (0.000024 [MT N ₂ O] • 310) = 12.61 [MT CO ₂] + 0.00504 [MT CO ₂ e] + 0.00744 [MT CO ₂ e] = 12.62 [MT CO ₂ e]
Total Emissions [MT CO₂e]	= Electricity Emissions [MT CO ₂ e] + Steam Emissions [MT CO ₂ e] + Hot Water Emissions [MT CO ₂ e] = 51.89 [MT CO ₂ e] + 33.65 [MT CO ₂ e] + 12.62 [MT CO ₂ e] = 98.16 [MT CO ₂ e]
Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.	

Advanced Calculation Methodology 2: CHP Facilities Not Present in eGRID⁷⁷

The process for estimating Scope 2 emissions from the heat and power product streams produced at a CHP facility not present in eGRID involves the following four steps:

1. Obtain total emissions, power, and heat generation information from CHP facility
2. Determine emissions attributable to net heat production⁷⁸ and electricity production

⁷⁷ EPA, Climate Leaders, Indirect Emissions from Purchases/Sales of Electricity and Steam, June 2008.

- a. Determine the Total Scope 1 Emissions from the CHP System
 - b. Determine the Total Steam and Electricity Output for the CHP System
 - c. Determine the Efficiencies of Steam and Electricity Production
 - d. Determine the Fraction of Total Emissions Allocated to Steam and Electricity Production
3. Calculate emissions attributable to the agency's portion of heat and electricity consumed
 4. Convert to units of CO₂e and determine total emissions.

Step 1: Obtain total emissions, power, and heat generation information from the CHP facility

Obtain the following information from the CHP plant owner or operator to estimate Scope 2 GHG emissions:

- Total emissions of CO₂, CH₄, and N₂O from the CHP facility, based on fuel input information
- Total electricity production from the CHP plant, based on generation meter readings
- Net heat production from the CHP plant.

Equation B-18: Net Heat Production Calculation

Net Heat Production [MMBtu]=

Heat of steam export [MMBtu] – heat of return condensate [MMBtu]

Step 2: Determine emissions attributable to net heat production⁶⁵ and electricity production

The most consistent approach for allocating GHG emissions in CHP plants is the efficiency method, which allocates emissions of CHP plants between electric and thermal outputs on the basis of the energy input used to produce the separate steam and electricity products. To use this method, obtain the following information:

- The total emissions from the CHP plant
- The total steam (or heat) and electricity production
- The steam (or heat) and electricity efficiency of the facility.

Use the following steps to determine the share of emissions attributable to steam (or heat) and electricity production:

Step 2a: Determine the Total Scope 1 Emissions from the CHP System

Calculate total Scope 1 GHG emissions using the methods described in Appendix A.

⁷⁸ Net heat production refers to the useful heat that is produced in CHP, minus whatever heat returns to the boiler as steam condensate, as shown in the equation below.

Step 2b: Determine the Total Steam and Electricity Output for the CHP System

To determine the total energy output of the CHP plant attributable to steam production, use published tables that provide heat content values for steam at different temperature and pressure conditions (for example, the Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam published by the International Association for the Properties of Water and Steam). Energy content values multiplied by the quantity of steam produced at the temperature and pressure of the CHP plant yield energy output values in units of MMBtu.

Alternatively, determine net heat (or steam) production (in MMBtu) by subtracting the heat of return condensate [MMBtu] from the heat of steam export (MMBtu). To convert total electricity production from MWh to MMBtu, multiply by 3.413 MMBtu/MWh.

Step 2c: Determine the Efficiencies of Steam and Electricity Production

Identify steam (or heat) and electricity production efficiencies. If actual efficiencies of the CHP plant are not known, use a default value of 80 percent for steam and a default value of 35 percent for electricity. The use of default efficiency values may, in some cases, violate the energy balance constraints of some CHP systems. However, total emissions will still be allocated between the energy outputs. If the constraints are not satisfied, the efficiencies of the steam and electricity can be modified until constraints are met. Facility energy managers should be aware of the need for expert judgment when applying this approach to a specific CHP facility. It is assumed that balancing the energy allocation and thermodynamic balance is within the standard training and skill set for a Federal facility energy manager or specialist. As such, additional instruction is not provided here.

Step 2d: Determine the Fraction of Total Emissions Allocated to Steam and Electricity Production

Allocate the emissions from the CHP plant to the steam (or heat) and electricity product streams by using Equation B-19.

Equation B-19: Allocation of CHP Emissions to Steam and Electricity

Step 1:
$$E_H = \frac{H \cdot e_P \cdot E_T}{P \cdot e_H + H \cdot e_P}$$

Where:

- E_H = Emissions allocated to steam production
- H = Total steam (or heat) output (MMBtu)
- e_H = Efficiency of steam (or heat) production
- P = Total electricity output (MMBtu)
- e_P = Efficiency of electricity generation
- E_T = Total direct emissions of the CHP system
- EP = Emissions allocated to electricity production

$$\text{Step 2: } EP = E_T - E_H$$

Where:

E_H = Emissions allocated to steam production

E_T = Total direct emissions of the CHP system

EP = Emissions allocated to electricity production

Step 3: Calculate emissions attributable to the agency's portion of heat and electricity consumed

After determining total emissions attributable to heat and electricity production, calculate the agency's portion of heat or electricity consumed, and thus the agency's indirect GHG emissions associated with heat or electricity use. First, obtain electricity and heat consumption information, then use Equation B-20 to calculate the agency's share of emissions, as appropriate.

Equation B-20: Calculation of Indirect Emissions Attributable to Electricity Consumption

Indirect Emissions Attributable to Electricity Consumption [MT] =

Total CHP emissions attributable to electricity production [MT] • (agency electricity consumption [kWh] ÷ total CHP electricity production [kWh])

Equation B-21: Calculation of Indirect Emissions Attributable to Heat (or Steam) Consumption

Indirect Emissions Attributable to Heat Consumption [MT] =

Total CHP emissions attributable to heat production [MT] • (agency heat consumption [MMBtu] ÷ CHP net heat production [MMBtu])

Step 4: Convert to units of CO₂e and determine total emissions

Finally, use the GWP values provided in Table D-13 to convert CH₄ and N₂O emissions to units of CO₂e. Sum the emissions of all three gases to determine an agency's total emissions from CHP.

Equation B-22: Combined Heat and Power MT CO₂e Emissions

CO₂e Emissions [MT CO₂e] = CO₂ [MT] + (MT CH₄ • CH₄ GWP) + (MT N₂O • N₂O GWP)

B.5. Purchased Steam from an MSW WTE Facility

Description

GHG emissions from MSW WTE facilities represent a special case for estimating Scope 2 emissions. WTE plants use MSW as a primary fuel to generate steam through this dual-use energy recovery and waste management application. MSW fuel is comprised of both renewable biomass (such as wood, paper, and food) and nonrenewable materials (such as plastics and tires). All associated Scope 2 emissions must be reported through the GHG Reporting Portal. Beginning with the FY 2008 base year and FY 2010 annual inventories, agencies must clearly

identify and report Scope 2 CO₂ emissions associated with the biogenic portion of biofuel and biomass combustion. These are known as biogenic emissions. Though biogenic emissions are not subject to agency reduction targets at this time they will be reported within agency inventories under Scope 2 and identified as biogenic.⁷⁹

WTE facilities are sometimes built in proximity to Federal facilities to take mutual advantage of long-term steam purchase agreements and to provide a significant portion of the Federal facilities’ thermal energy requirements. Although MSW-fueled CHPs are accounted for in the EPA’s eGRID, WTE plants producing only thermal energy are not subject to or participants in the program. This section provides both a site-specific and a simplified approach for calculating the GHG emissions associated with the steam purchases from MSW-fueled WTE plants. Below are the default and advanced approaches for calculating Scope 2 GHG and biogenic CO₂ emissions from MSW-fueled WTE steam purchases.

B.5.1. Default Methodology (to be Calculated by GHG Reporting Portal)

Data Sources

Scope 2 GHG emissions from purchased steam generated by a MSW WTE plant can be calculated from the volume of delivered steam (which is metered) and the default or plant-specific emission factors. Table B-8 shows the recommended and alternate activity data and emission factor sources for calculating Scope 2 emissions from MSW-fueled steam purchases.

Table B-8: Steam Purchases from MSW WTE Plants Default Data Sources

Data Element	Preferred Source	Alternate Source
Steam or hot water consumption [MMBtu]	<ul style="list-style-type: none"> FEMP Energy Report 	<ul style="list-style-type: none"> Utility purchase records Maintenance records
Emission factors	<ul style="list-style-type: none"> eGRID Derived Default 	<ul style="list-style-type: none"> MSW WTE Plant-Provided

Calculation Steps

If site-specific MSW WTE plant emission factors are not available, agencies may use the default methodology, which uses default emission factors (Table B-9) derived from similar MSW WTE plants captured via eGRID (plants that generate electricity, not steam). The steps that the GHG Reporting Portal will use to calculate Scope 2 emissions from MSW-fueled, WTE-delivered steam are identical to those used for the advanced method, except for Step 2.

1. Determine annual delivered steam purchased for use by all facilities within agency’s operational control

⁷⁹ Due to ongoing analysis, efforts to collect and synthesize data, and the development of accounting approaches that will appropriately reflect the true atmospheric impact of biogenic emissions, agencies are not required to include these emissions in their reduction targets under E.O. 13514 at this time, but agencies are required to inventory their biogenic GHG emissions. Part or all of the carbon in these fuels is derived from material that was fixed by biological sources on a relatively short timescale. Depending on the full emissions impact of biomass production and use, these emissions may or may not represent a net change in atmospheric CO₂. This contrasts with carbon from fossil fuels, which was removed from the atmosphere millions of years ago.

2. Utilize the most recent eGRID derived emission factors that apply to the delivered steam
3. Determine the total annual emissions in MT for each GHG
4. Determine total annual emissions in MT CO₂e.

**Table B-9: Indirect Emission Factor Defaults
from MSW WTE Purchased Steam Use**

Emission Factor	Default Value
CO ₂ emissions	350.5 [lb CO ₂ /MMBtu]
CH ₄ emissions	0.1292 [lb CH ₄ /MMBtu]
N ₂ O emissions	0.0172 [lb N ₂ O/MMBtu]
Biogenic CO ₂ emissions	385.6 [lb CO ₂ /MMBtu]

These default emission factors were derived from a sample of similar MSW-fueled WTE plants found in the eGRID2007 Version 1.1 Plant File (Year 2005 Data). These plants were selected because their primary fuel was MSW and they produce only electricity (i.e., no CHPs with apportioned data inputs). Using a similar approach to that outlined in Appendix B.4 “Advanced Calculation Methodology 1: CHP Facilities Present in eGRID” approach, these plants’ delivered steam emission factors were calculated using the following extracted eGRID data elements:

- Plant annual heat input [MMBtu] (PLHTIAN)
- Plant unadjusted annual CO₂ emissions [short tons] (UNCO₂)
- Plant unadjusted annual CH₄ emissions [lb] (UNCH₄)
- Plant unadjusted annual N₂O emissions [lb] (UNN₂O)
- Plant total nonrenewables generation percent (resource mix) [%] (PLTNPR)
- Plant total renewables generation percent (resource mix) [%] (PLTRPR).

Each plant’s annual heat input [MMBtu] was converted to delivered steam using standard assumptions for:

- External boiler efficiency (80 percent)⁸⁰
- Steam conversion efficiency (75 percent)⁸¹
- Distribution loss (10 percent).⁸²

⁸⁰ DOE, Industrial Technology Programs, Energy Use and Loss Footprints, Assumption and Definitions. See www1.eere.energy.gov/industry/program_areas/footprints.html.

⁸¹ eGRID2007 TSD, EPA. See www.epa.gov/cleanenergy/documents/egridzips/eGRIDwebV1_0_UsersManual.pdf.

⁸² DOE, Office of Policy and International Affairs, 1605(b) Program, *Technical Guidelines, Voluntary Reporting of Greenhouse Gases (1605(b)) Program* (March 2006) p. 154–156. See www.eia.doe.gov/oiaf/1605/pdf/Appendix%20N.pdf.

Equation B-23 shows the calculation that the GHG Reporting Portal will perform to determine the delivered steam [MMBtu].

Equation B-23: eGRID MSW WTE Delivered Steam

$$\text{eGRID MSW WTE Delivered Steam [MMBtu]} = \text{DS}$$

$$\text{DS} = \text{PLHTIAN} \bullet \text{BE} \bullet \text{SP} \bullet (1 - \text{DL})$$

Where:

- PLHTIAN = Plant annual heat input [MMBtu]
- BE = Boiler efficiency (80%)
- SP = Steam production efficiency (75%)
- DL = Distribution loss (10%)
- DS = Delivered steam [MMBtu]

The eGRID plant unadjusted annual CO₂ emissions [short tons], plant unadjusted annual CH₄ emissions [lb] (UNCH₄), and plant unadjusted annual N₂O emissions [lb] (UNN₂O) quantities were used as the numerator and the delivered steam [MMBtu] as the denominators to develop plant specific emission factors for CO₂, CH₄, and N₂O, as shown in Equation B-24.

Equation B-24: eGRID MSW WTE Delivered Steam

$$\text{eGRID MSW WTE Delivered Steam Emission Factor [lb CO}_2\text{/MMBtu]} =$$

$$(\text{UNCO}_2 \bullet \text{STLC}) \div \text{DS}$$

Where:

- UNCO₂ = Plant unadjusted annual CO₂ emissions [short tons CO₂]
- STLC = Short-ton-to-lb conversion (2,000) [lb/short ton]
- DS = Delivered steam [MMBtu]

The GHG Reporting Portal will calculate emission factors for CH₄ and N₂O using the same equation but without the use of lb/ton conversion. However, as eGRID adjusts out all biogenic CO₂ from its emission factors, the biogenic CO₂ emission factor is generated by back calculating each respective plant's total CO₂ emissions and then breaking out the biogenic CO₂ emission portion using Equation B-25.

Equation B-25: eGRID MSW WTE Biogenic CO₂ Factor

$$\text{eGRID MSW WTE Delivered Steam Emission Factor [lb CO}_2\text{ (Biogenic)/MMBtu]} =$$

$$[(\text{UNCO}_2 \bullet \text{STLC}) \bullet (\text{PLTRPR}/\text{PLTNPR})] \div \text{DS}$$

Where:

- UNCO₂ = Plant unadjusted annual CO₂ emissions [short tons CO₂]
- STLC = Short-ton-to-lb conversion (2,000) [lb/short ton]
- PLTNPR = Plant total nonrenewables generation percent (resource mix) [%]
- PLTRPR = Plant total renewables generation percent (resource mix) [%]

DS = Delivered steam [MMBtu]

These emission factors were calculated for all 49 of the eGRID MSW WTE plants. The median plant value for anthropogenic CO₂ was identified, and the derived values used as the default emission factors.

B.5.2. Advanced Methodology (User Calculated)

The advanced methodology for MSW WTE steam purchases is shown below.

Calculation Steps

To calculate Scope 2 emissions from MSW-fueled, WTE-purchased steam, do the following:

1. Determine annual delivered steam purchased for use
2. Obtain the provider plant's most recent emission factors that apply to the delivered steam
3. Determine the total annual emissions in MT for each GHG
4. Determine total annual Scope 2 emissions in MT CO₂e.

Step 1: Determine annual delivered steam purchased for use

Purchased steam and hot water use data should be included for all facilities that fit with the definition of operational control provided in Chapter 2 of the main Guidance document. This should align with the agency's annual energy consumption report to the DOE and maintain consistency with the data used for calculations as outlined in both Appendix B.2 and B.3.

Step 2: Obtain the provider plant's most recent emission factors that apply to the delivered steam

From preliminary Federal GHG inventory experience, local MSW-fueled, WTE thermal plant operators already calculate and maintain records on total fuel input, GHG emission factors, useful heat production, and delivered steam and hot water emission factors. Given the recent release and stringent requirements of the EPA's GHGRP, these records and calculations are anticipated to become even more robust and available for all covered facilities by the end of calendar year 2010. The recommended source of current emission factors is the local facility's WTE account manager or environmental manager. When obtaining these factors, it is imperative that the agency's representative specifically request non-offset adjusted factors as many providers may already have incorporated offsets into their final consumer emission factors. If they have not calculated these factors, it is possible to work with the provider and use the "Advanced Calculation Methodology for CHP Facilities Not Present in eGRID" detailed in Appendix B.3 by specifying a 100-percent allocation to steam production.

If obtaining (or developing) site-specific emission factors is not possible, use the default emission factors outlined in the default methodology (see Appendix B.5.1).

Step 3: Determine total annual emissions in MT for each GHG

To determine annual emissions, multiply annual delivered steam in MMBtu (Step 1) by the emission factors for CO₂, CH₄, and N₂O in lb per MMBtu of delivered steam (Step 2). Divide this product by 2,204.62 to convert them to MT.

Equation B-26: Purchased Steam Use GHG Emissions

CO₂ Emissions [MT] = Steam use [MMBtu] • CO ₂ emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT]
CH₄ Emissions [MT] = Steam use [MMBtu] • CH ₄ emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT]
N₂O Emissions [MT] = Steam use [MMBtu] • N ₂ O emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT]
Biogenic CO₂ Emissions [MT] = Steam use [MMBtu] • Biogenic CO ₂ emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT]

Step 4: Determine total annual Scope 2 emissions in MT CO₂e

The final step is to convert the anthropogenic CO₂, CH₄, and N₂O into units of CO₂e by multiplying the total emissions of each gas in MT by the GWP value provided in Table D-13. Then, agencies should sum the CO₂e emissions of each of the three gases to obtain total Scope 2 GHG emissions.

Equation B-27: Conversion to CO₂e and Determination of Total Scope 2 Emissions

CO₂e Emissions [MT CO₂e] = MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP)

Biogenic CO₂ emissions resulting from MSW WTE-purchased steam should be clearly identified and included in Scope 2 biogenic emissions subtotals. Biogenic CO₂ emissions should always be clearly identified and reported separately from anthropogenic emissions in the appropriate scope.

Example B-5: Steam Purchases from MSW WTE Plant

A notional National Aeronautics and Space Administration (NASA) facility in Hampton, VA, purchases steam from a local MSW-fueled WTE plant close to its facility to help meet its thermal energy needs.

Step 1: Determine annual delivered steam purchased

The NASA Center's Energy Manager maintains records and bills paid for the purchased steam that are used to generate the facility energy report. For this fiscal year, the total purchased steam delivered and used at the Center is 1,500 MMBtu.

Step 2: Obtain the provider's most recent emission factors

After a request is submitted to the MSW WTE steam plant's account manager, the NASA Center is provided with the following emission factors.

Site-Specific MSW WTE Purchased Steam Emission Factors

- CO₂ Emission Factor 320.5 [lb CO₂/MMBtu]
- CH₄ Emission Factor 0.1475 [lb CH₄/MMBtu]
- N₂O Emission Factor 0.0165 [lb N₂O/MMBtu]
- Biogenic CO₂ Emission Factor 390.5 [lb CO₂/MMBtu]

Step 3: Determine total annual emissions in MT for each GHG

Equation B-26: Purchased Steam Use GHG Emissions

➤ *Reported as Scope 2:*

Purchased Steam	= 1,500 [MMBtu] • 320.5 [lb CO ₂ /MMBtu] ÷ 2,204.62 [lb/MT]
CO₂ Emissions	= 218.06 [MT CO ₂]
	[MT CO ₂]

Purchased Steam	= 1,500 [MMBtu] • 0.1475 [lb CH ₄ /MMBtu] ÷ 2,204.62 [lb/MT]
CH₄ Emissions	= 0.1004 [MT CH ₄]
	[MT CH ₄]

Purchased Steam	= 1,500 [MMBtu] • 0.0165 [lb N ₂ O/MMBtu] ÷ 2,204.62 [lb/MT]
N₂O Emissions	= 0.01123 [MT N ₂ O]
	[MT N ₂ O]

➤ *Reported as biogenic in Scope 2:*

Purchased Steam	= 1,500 [MMBtu] • 390.5 [lb CO ₂ /MMBtu] ÷ 2,204.62 [lb/MT]
Biogenic CO₂ Emissions	= 265.7 [MT Biogenic CO ₂]
	[MT CO ₂]

Step 4: Determine total annual Scope 2 emissions in MT CO₂e

Equation B-27: Conversion to CO₂e and Determination of Total Scope 2 Emissions

Steam CO₂ Emissions	= MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP)
	= 218.06 [MT CO ₂] + (0.1004 [MT CH ₄] • 21) + (0.01123 [MT N ₂ O] • 310)
	[MT CO ₂ e]
	= 218.06 [MT CO ₂] + 2.108 [MT CO ₂ e] + 3.481 [MT CO ₂ e]
	= 223.65 [MT CO₂e]

****Note:** Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.**

B.6. Quantifying Emission Reductions from RECs

B.6.1. Default Methodology (to be Calculated by GHG Reporting Portal)

Federal agencies may reduce their Scope 2 emissions from electricity by purchasing energy generated from renewable energy sources, including purchased renewable energy and environmental attributes embodied in RECs. A REC is a transferable certificate issued when one MWh of electricity is generated and delivered to the grid from a renewable energy source. RECs are generally defined by states and certification organizations as representing the “environmental attributes” of electricity generated from renewable energy sources. This allows REC owners to claim the attributes of renewable energy (such as GHG emissions benefits) when matched with conventional electricity. Buyers can purchase RECs on the basis of the generation resource (such as wind, solar, geothermal), year, and location. In addition, RECs may be associated with

energy from MSW WTE projects and matched with emissions from conventional electricity to estimate Scope 2 emission impacts like other renewable energy. Like biomass generation, MSW WTE projects must also account separately for their biogenic CO₂, CH₄, and N₂O created by combustion, and for anthropogenic CO₂ from the portion of the fuel that comes from fossil sources.

Data Sources

Table B-10 shows the data elements and their sources.

Table B-10: Preferred Data Sources for Calculating RECs

Data Element	Preferred Source
Emission factors	<ul style="list-style-type: none"> eGRID derived default
Location of renewable energy generator	<ul style="list-style-type: none"> REC Supplied by renewable energy supplier
Amount of RECs purchased [MWh]	<ul style="list-style-type: none"> REC

Calculation Steps

To calculate Scope 2 emission reductions from REC purchases, follow the steps below:

1. Determine emissions normally emitted
2. Estimate emissions reductions.

Step 1: Determine emissions normally emitted

Use the methodologies in Appendix B.1 to establish a “baseline” or actual quantity of emissions that would be emitted in the absence of the renewable energy purchases. This is the same as calculating all required Scope 2 emissions before RECs.

Step 2: Estimate emission reductions

The procedure used to estimate emission reductions is shown in Equation B-28. Initial estimates of the reductions can be made using assumptions for the amount of renewable energy purchased and the location of the renewable energy facility.

Equation B-28: Emission Reduction Calculation

Emission reduction $E_{i,sr} = RE_{sr} \bullet ERate_avoided_{i,sr}$	
Where:	
Emission reduction $E_{i,sr}$	= Quantity [lb] of avoided GHG of type <i>i</i> in each subregion <i>sr</i>
RE $_{sr}$	= Quantity of renewable energy purchased from each eGRID subregion <i>sr</i> as distinct from the agency’s electricity supplier’s system mix of energy resources
ERate_ $_{i,sr}$	= Emission factor for each GHG of type <i>i</i> (such as lb CO ₂ /MWh, lb CH ₄ /MWh, lb N ₂ O/MWh) for each eGRID subregion <i>sr</i> where the renewable energy generators are

located

These emission reductions must then be summed for each GHG and for each eGRID subregion in which the renewable energy generators are located.

Equation B-29: Sum of Emission Reductions by GHG and eGRID Subregion

$$\text{Inventory adjustment} = \sum \text{Baseline emissions}_{i, sr} - \sum \text{Emission reduction}_{i, sr}$$

Where:

Inventory adjustment = Number reported as Scope 2 emissions

\sum Baseline emissions_{i, sr} = Summation of baseline emissions

\sum Emission reduction_{i, sr} = Summation of emission reductions

For renewable energy purchased from U.S. generating facilities, the default emission rate for $E_{\text{Ratebaseline}_{i, sr}}$ is the eGRID non-baseload output emission rate for the eGRID subregions in which the renewable electricity was generated. The most current eGRID non-baseload output emission rates published should be used at the time the inventory adjustment is calculated.

For renewable energy purchased from international renewable facilities, the emission rate used for $E_{\text{Ratebaseline}_{i, sr}}$ should be a non-baseload emission rate, if available, for the country or region of origin. Otherwise, a system average emission rate should be used. Regional emission rates are preferable if available, but national average rates can also be used for non-U.S. locations. Only international Federal facilities should purchase international renewable energy.

Agencies should use the eGRID non-baseload output emission rate for the eGRID subregions in which the renewable energy was generated.⁸³ The location of the renewable energy generators from which the renewable energy is sourced should be requested from the renewable energy supplier. This information may not be available from the agency's supplier until after the year has ended. If the generators are located in multiple subregions, the calculation to determine emission reductions should be repeated for each subregion, using the amount of renewable energy purchased from each subregion.

As outlined in the Guidance, agencies may adjust their Scope 3 emissions by allowing third-party operated renewable energy projects on their land, defined as "Scope 3 percentage points". Scope 3 percentage points are created when third-party operated renewable energy is generated from a project on Federal land, but the hosting agency does not purchase associated energy and/or RECs. See Section 4.3.2 of the Guidance for further details. Calculations for Scope 3 percentage points use the non-baseload eGRID factors that are also used to estimate Scope 2 adjustments for renewable energy purchases. Scope 3 percentage points have no emission reduction value, but can be used to show progress towards achieving Scope 3 goals in units of percent progress towards target achievement. They are determined by calculating

⁸³ The reason for using the non-baseload emission factor is that non-baseload generation is most likely to be displaced by renewable energy generation, while baseload generation would generally be unaffected. The exclusion of baseload generation from the calculation of emission rates is a widely accepted approach internationally.

avoided GHG emissions from relevant agency-hosted electric and non-electric renewable projects, and converting the results to the percentage of Scope 3 emissions.

Appendix C—Calculating Scope 3 Emissions

Scope 3 emissions are indirect emissions not covered by Scope 1 or Scope 2. They occur as a consequence of agency activities, but originate from sources not controlled by the agency. Refer to Chapter 2 of the Guidance document for further information on organizational boundaries.

Scope 3 categories selected for inclusion in annual inventories are shown in Table C-1. Beginning in FY 2010, agency reporting must include emissions for all those Scope 3 categories for where the agency included in their Scope 3 target.

Table C-1: Scope 3 Emissions Categories

Required Scope 3 Emission Categories
<ul style="list-style-type: none">• Federal Employee Business Air Travel• T&D Losses from Purchased Electricity• Contracted MSW Disposal• Federal Employee Business Ground Travel• Federal Employee Commuting• Contracted Wastewater Treatment

Agencies may not have access to quality FY 2008 data for some Scope 3 emission categories. Per Chapter 5 of the Guidance document, agencies should use the earliest year for which data are available to include in the FY 2008 base year inventory. For example, if an agency's employee commuting data becomes available in 2011, those emissions should be incorporated into the FY 2008 baseline.

C.1. Federal Employee Business Air Travel

Description

Business air travel includes official business-related travel aboard third-party owned or operated aircraft. For reporting purposes, Scope 3 emissions from business air travel are limited to those from the combustion of fuels (such as the fuel consumed by an aircraft), but not the life-cycle emissions associated with fuel production or manufacturing capital equipment and infrastructure (such as the emissions associated with aircraft manufacturing) or the radiative forcing impacts of high altitude air travel GHG emissions.⁸⁴

This category excludes aircraft owned and leased by the reporting agency as they are captured under Scope 1.

Agencies are required to use one of two methodologies, described in the following sections.

⁸⁴ Given the scientific debate surrounding radiative forcing impacts of air travel and for consistency with national and international GHG accounting guidance, the air travel methodologies in this section do not incorporate radiative forcing adjustments. In addition to GHG emissions, air travel also impacts the climate through creation of contrails and changes in cirrus cloud formation.

C.1.1. Default Methodology (To Be Calculated by GSA Travel MIS)

Data Sources

This methodology calculates air travel emissions using GSA’s Travel MIS.⁸⁵ This system can calculate emissions for air travel on behalf of all government agencies and is available for agencies to use. GSA Travel MIS provides the data in a format that facilitates direct insertion into the GHG Reporting Portal.

Data required for the Travel MIS tool are the PNRs, as indicated in Table C-2. The PNR is the travel record created for each air travel trip. It provides the complete details of a passenger’s booking, including itinerary details such as airline, flight number, class of service, and miles traveled.

Table C-2: Air Travel Advanced Data Sources

Data Element	Preferred Source
Passenger Name Record (PNR)	<ul style="list-style-type: none">• Obtained from the agency’s E-Gov Travel Service (ETS) or from their Travel Agency, also called a Travel Management Center (TMC) or Commercial Travel Office

Most agencies and subagencies currently have air travel data available in GSA Travel MIS and can immediately access the associated GHG emissions for reporting and planning purposes. Agencies that currently do not have their data in GSA Travel MIS can request it within several weeks (usually two) if they use any of the TMCs or ETSs with established data feed capabilities. Federal agencies with TMCs or ETSs that do not yet have a data feed established with GSA may require up to 6 weeks before their data are available after request from GSA.

Security

Access to each Federal agency’s air travel data is restricted to that agency only. GSA only uses summary data for strategic sourcing purposes, such as to support the City Pair Program negotiations, and to validate existing or justify new government-wide policies.

A security certification and accreditation (C&A) was successfully completed for the GSA Travel MIS by GSA’s Designated Approving Authority. The C&A was completed with the same stringent government requirements adhered to by each of GSA’s outsourced ETS vendors.

Reporting Steps

GSA Travel MIS standardizes the calculation and reporting of the data. The following steps detail the calculation process utilized by the default methodology.

1. Determine whether the agency PNR data are in GSA Travel MIS
2. Obtain a user name and password for the GSA Travel MIS from GSA

⁸⁵ The GSA Travel MIS methodology for calculating air travel emission is based on the TRX Airline Carbon Emissions Calculator, a detailed and well-accepted methodology for calculating air travel emissions. For clarity, the airline travel is calculated on tickets issued versus flights taken.

3. Access the GSA Travel MIS
4. Generate the GHG emissions estimate and report
5. Enter data into the Portal and calculate additional GHGs.

Step 1: Determine whether the agency PNR data are in GSA Travel MIS

Contact GSA to determine whether the agency's PNR data are already being submitted via e-mail at Travel.programs@gsa.gov, or by telephone, 888-472-5585.

If PNR data are not already submitted, inform contracted travel vendors that they are to coordinate with GSA to transfer the data to GSA Travel MIS. Some travel vendors may require that the request originate from the contracting officer or contracting officer's technical representative. For other travel vendors, an e-mail providing direction will be sufficient. The communication to the agency's travel vendor can be done using the following:

[Travel vendor name] is to provide the [Federal agency's name] travel data (see attached for a standard list of data elements) to GSA's third-party data aggregator beginning with travel commencing on 10/1/2007 through the present. [Travel vendor name] must continue to provide the data monthly in accordance with its contractual obligations (as specified in the applicable ETS and/or TSS contracts as either an accommodated TMC or an ETS provider). GSA's data aggregator provides a software program, which will export for the data automatically each month without requiring any staff resources, or [travel vendor name] provides the data using secure FTP.

Note: The standard list of data elements can be provided by GSA.

Step 2: Obtain a user name and password for the GSA Travel MIS from GSA

Contact GSA (see contact information in step 1) to establish an account. The user name and password will allow access to the GSA Travel MIS.

Step 3: Access the GSA Travel MIS

Using a web browser, access the <https://gsa.traveltrax.com> web link and enter login information.

Figure C-1: Login Page for GSA Travel MIS



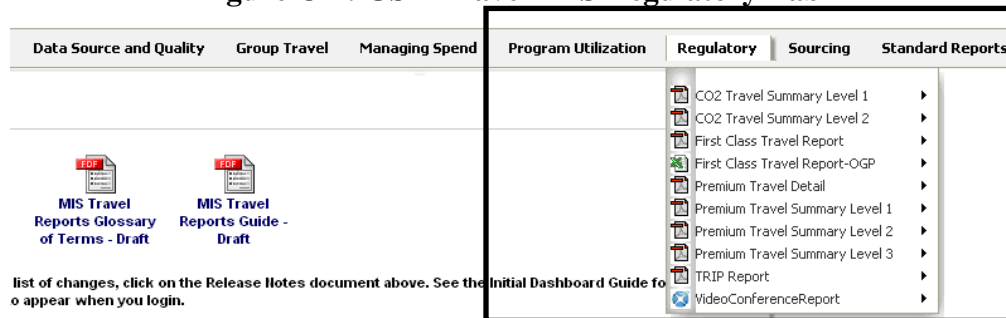
Step 4: Generate the GHG emissions estimate and report

After successfully logging in to the GSA Travel MIS, select the Regulatory tab. A menu of all available regulatory reports will appear. There are two GHG emission estimate reports available in this menu:

1. CO₂ Emissions Air Travel by Agency
2. CO₂ Emissions Air Travel by Organization

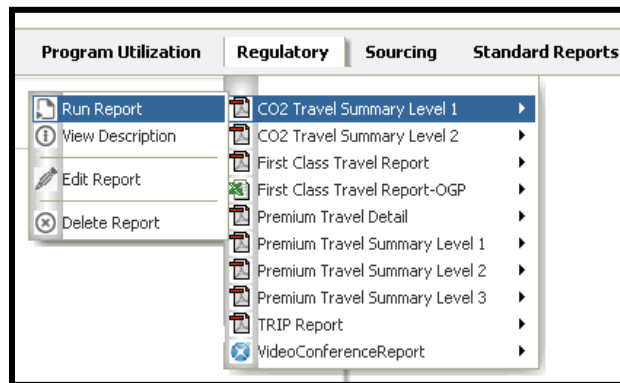
The first report (“by Agency”) provides the air travel GHG emissions estimates for the entire agency. The second report (“by Organization”) breaks down emissions data to the second level of the agency’s organizational hierarchy. The organization breakdown is determined by each agency and is reported to GSA as data are sent from each agency Travel Management center. If any agency wishes to change the hierarchy in which data are presented, they should contact GSA to help facilitate such changes with their TMCs.

Figure C-2: GSA Travel MIS Regulatory Tab



To run the report, move the cursor over the desired report and then click “Run Report”.

Figure C-3: Running the Report



Enter the dates you wish to report. The following example would generate a report that compares the FY 2008 baseline to FY 2010. After entering the dates, click Run in the lower right corner of the screen and the CO₂ air travel emissions report will generate as a PDF file.

Figure C-4: Entering Dates

Profiles Admin Multiselect Data Source and Quality Group Travel Managing Spend Program Utilization Regulatory

Edit Filters
Please enter the filters for the report(s) you are running. Red asterisks mark the required fields.

Report List

Profile Name	Report Name	Design Type	Output Format	Output Destination
Demo Data	CO2 Travel Summary Level 1	RSL	PDF	Browser

Prompts

Profile Name	Report Name	Name	Operator	Value
[ALL]	[ALL]	* CURRENT	BETWEEN	[10/01/2009] AND [09/30/2010]
[ALL]	[ALL]	* PREVIOUS	BETWEEN	[10/01/2007] AND [09/30/2008]

Corporate Structure

Name	Rollup
[None]	[None]

Select | Reset

Run | Reset

The following is an example of the “by Agency” report.

Figure C-5: Page 1 of the Emissions Report

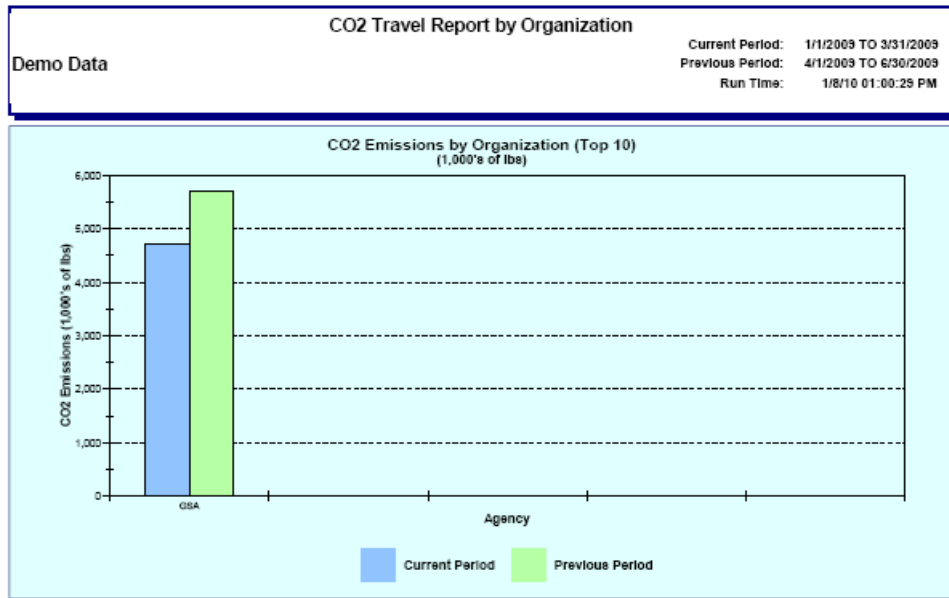


Figure C-6: Page 2 of the Emissions Report

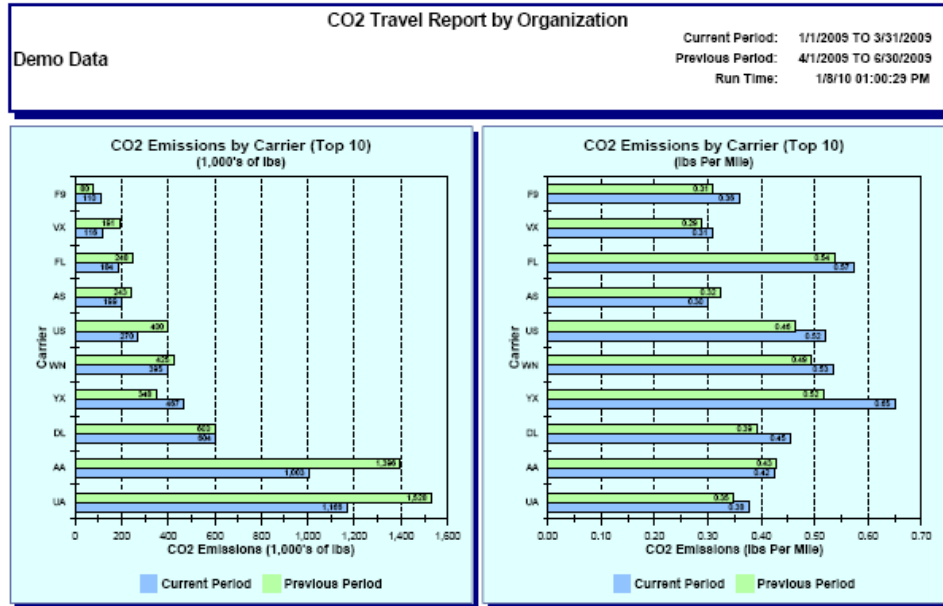


Figure C-7: Page 3 of the Emissions Report

CO2 Travel Report by Organization
 Demo Data
 Current Period: 1/1/2009 TO 3/31/2009
 Previous Period: 4/1/2009 TO 6/30/2009
 Run Time: 1/8/10 01:00:29 PM

Agency	O&D Segment Count Curr Period	O&D Segment Count Prev Period	O&D Segment Count Variance	Total CO2 Emissions Curr Period (Pounds)	Total CO2 Emissions Prev Period (Pounds)	Total CO2 Emissions Variance (Pounds)	Average CO2 Emissions Per O&D Segment Curr Period (Pounds)	Average CO2 Emissions Per O&D Segment Prev Period (Pounds)
General Services Administration	14,620	18,232	(3,612)	4,702,606	5,701,578	(998,972)	322	313
Grand Total:	14,620	18,232	(3,612)	4,702,606	5,701,578	(998,972)	322	313

Save the Emissions Report PDF file to your computer. Find the total quantity of CO₂ for the current period at the bottom of the column titled “Total CO₂ Emissions Current Period.” Note that the report displays both pounds and MT, with MT being the required unit for reporting.⁸⁶

Step 5: Enter data into Portal and calculate additional GHGs

The GHG Reporting Portal will calculate additional emissions associated with CH₄ and N₂O, making the resulting calculations consistent with the advanced methodology. The GHG Reporting portal applies a factor of 0.000014 kg CH₄/lb CO₂ and 0.000017 kg N₂O/lb CO₂. The CH₄ and N₂O emission factors were derived by the US EPA, and are based on the mass of CH₄

⁸⁶ The GSA Travel MIS has an interactive dashboard that is to be used for monitoring your GHG emissions and can be used to help plan reductions. The dashboard is also under the *Regulatory* tab. This dashboard displays the top 20 city pairs travelled by the agency during the reporting period. The levers on the right allow the user to adjust the trips taken to the most traveled city pairs, which can facilitate an assessment of emission reduction opportunities. The current methodology may be revised as more accurate methodologies become available.

and N₂O per mass of CO₂ for aircraft emissions as reported in the *Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2009*.⁸⁷

Calculation Methodology

GSA's Travel MIS tool calculates the emissions associated with business air travel. Once agencies submit their PNRs, each step in the methodology is performed automatically in the GSA Travel MIS tool using the instruction provided above. **This calculation methodology is only presented for purposes of technical background and transparency. The GSA Travel MIS tool will automatically complete the calculations.** This methodology is outlined below:

Step 1: Calculate the distance traveled for each employee trip

To accurately estimate GHG emissions associated with business air travel trip, the GSA Travel MIS tool must have data on the originating city and destination city, as well as any connecting cities if not a nonstop flight. The requisite data for this operation are found in the reporting agency's PNRs.

Step 2: Determine the fuel burn rate for the aircraft

The amount of GHG emissions is directly related to the amount of fuel burned by aircraft. Different aircraft can burn very different amounts of fuel, so it is important to have detailed information on fuel burn rates.⁸⁸ The fuel burn rate per passenger is calculated as fuel burned (by aircraft type) divided by or apportioned to the number of seats. However, the number of seats must be a weighted average or specific to the actual seat size (varying among the cabin classes) in the plane. In addition, GSA Travel MIS receives information regarding the occupancy rate of the seats in each cabin class.

An accurate fuel burn rate is obtained from the 2009 version, or the most recent version, of the EMEP/Corinair Emission Inventory Guidebook (EIG). This dataset provides fuel consumption data for different aircraft by a range of total journey lengths for each of the different fuel-consumption stages: taxi out, take off, climb-out, climb/cruise/descent, approach landing, and taxi in.

Step 3: Calculate CO₂ emissions for the flight^{89,90}

To convert from fuel burned to CO₂ emitted, a factor of 3.15 [kg CO₂/kg fuel] is used from the EIG. A conversion factor of 2.20 [lb/kg] is used.

⁸⁷ See www.epa.gov/climatechange/emissions/usinventoryreport.html.

⁸⁸ Straight line distance is not used between cities. The GSA Travel MIS makes an adjustment to the city pair mileage to take into account the excess mileage beyond the great circle route mileage that an aircraft may fly due to actual routing, detours due to weather, or holding pattern.

⁸⁹ For consistency with Scope 1 aircraft and default air travel methodologies, the GSA Travel MIS tool does not currently account for radiative forcing into its generation of CO₂e estimates. In doing so, it also does not account for CH₄ or N₂O. However, agencies should note that this tool architecture does have the capability to incorporate such provision in the future as the state of the science progresses relative to this GHG accounting topic.

⁹⁰ Future iterations of the GSA Travel MIS tool will include an expanded capability to more fully calculate emissions in terms of MT CO₂e.

Step 4: Determine the cargo and passenger allocation

Cargo and passenger data have been gathered for U.S. carriers from the U.S. Department of Transportation, Bureau of Transportation Statistics. Cargo includes freight and mail. Passenger and baggage weight is derived from the number of passengers and an industry standard assumption of 100 kg per individual and baggage. The data are provided by carrier, stage (domestic), and aircraft type for each carrier. The particular table used is Air Carrier Statistics: Form 41 Traffic (All Carriers), T-100 Segment (All Carriers). Data from calendar year 2009 is used to avoid seasonality issues, and is updated annually.

For each carrier, stage, and equipment type, CO₂ emissions are allocated between cargo and passengers by the percentage of cargo weight to actual payload and the percentage of passenger weight to actual payload.

Step 5: Determine the cabin allocations

CO₂ emissions are allocated among cabin classes to obtain a more accurate amount of the space taken by a passenger's seat. The number of seats for a flight is taken from the Schedules database, while the distribution of seats among the various cabins is taken from the Fleet database. Both databases are available from OAG Back Aviation Solutions. Data from www.SeatGuru.com is used to determine the seat pitch and width of equipment from various carriers, which are used to more accurately determine the area occupied by each seat.

Step 6: Adjust for passenger load

Typically, airline flights are not 100 percent occupied. To more accurately calculate the CO₂ emissions, the emissions are allocated among the average number of passengers for that carrier. Passenger load factor data are gathered from data supplied by the U.S. Department of Transportation, Bureau of Transportation Statistics (www.transtats.bts.gov). These values are updated annually. If a carrier is not in the list, then the overall year U.S. average load factor is used for U.S. carriers and the overall year Non-U.S. average load factor is used for Non-U.S. carriers.

More detailed information regarding the calculation process can be found at <http://carbon.trx.com>.

C.1.2. Alternative Methodology (to be Calculated by GHG Reporting Portal)⁹¹

Data Sources

Agencies are required to annually report their estimated business air travel GHG emissions via the GHG Reporting Portal. Agencies that choose to not utilize the GSA Travel MIS tool may use this methodology that is based on passenger air miles traveled by segment type. Agencies must work with their travel agents and systems to compile air travel data presented in Table C-3, which shows the data elements and their sources.

⁹¹ This methodology is based on EPA Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, *Optional Emissions from Commuting, Business Travel and Public Transport*. www.epa.gov/climateleaders/documents/resources/commute_travel_product.pdf.

Table C-3: Federal Employee Air Travel Data Sources

Data Element	Preferred Source
Passenger miles traveled by segment categorized by short, medium, long, or unspecified haul [miles]	<ul style="list-style-type: none">Agency Travel records, GSA Travel MIS, ETS, and Defense Travel System (DTS)
Emission factors [kg GHG/passenger-mile] by short, medium, long, or unspecified haul	<ul style="list-style-type: none">Table D-13

Calculation Steps

Air travel emissions are calculated using Equation C-1. These calculations use average passenger estimates to determine GHG emissions for any given flight. The following steps detail the calculation methods utilized by the GHG Reporting Portal:

1. Identify the total passenger-miles by segment class (i.e., short, medium, long, or unspecified)
2. Determine the appropriate emission factor based upon the flight characteristics
3. Calculate the GHG emissions using the appropriate emissions factor
4. Determine total annual emissions in MT CO₂e.

Step 1: Identify the total passenger-miles by segment class (i.e., short, medium, long, or unspecified) for all agency flights

ETS, DTS, travel records, or travel agencies should be able to provide mileage traveled for each segment of each passenger trip. Agencies should compile data for each flight segment and segregate by segment class. Results will be most accurate if agencies are able to collect travel distances for each segment of multi-segmented trips; however, a less accurate result can be obtained using aggregate passenger miles and the appropriate unknown segment class emission factor in Table D-13.

Step 2: Determine the appropriate emission factor based upon the flight characteristics

The Portal will use the flight mileage data compiled within segment classes to determine the appropriate emission factors for each segment class. These distance-based emission factors can be found in Table D-13 and are derived from aggregated data of typical emissions per passenger-miles.

Step 3: Calculate the GHG emissions using the appropriate emissions factor

The Portal will use the aggregated passenger-miles by segment class and Equation C-1 to determine the GHG emissions for each segment class. Emission factors will be applied automatically based upon the segment distance traveled. The Portal will also automatically convert the emissions to MT.

Equation C-1: Airline Business Travel Emissions

CO₂ emissions[MT] = Passenger-miles traveled [miles] • appropriate CO ₂ emission factor [kg/mi] • 0.001 [MT/kg]
CH₄ emissions[MT] = Passenger-miles traveled [miles] • appropriate CH ₄ emission factor [g/mi] • 0.000001 [MT/g]
N₂O emissions [MT] = Passenger-miles traveled [miles] • appropriate N ₂ O emission factor [g/mi] • 0.000001 [MT/kg]

Step 4: Determine total annual emissions in MT CO₂e

The Portal will use the GWP values found in Table Table D-13 to convert CH₄ and N₂O emissions to units of CO₂e, then sum the emissions from all three gases.

Equation C-2: Conversion of GHG MT to CO₂e Emissions

CO₂e Emissions [MT CO₂e] = MT CO₂ + (MT CH₄ • CH₄ GWP) + (MT N₂O • N₂O GWP)

Example C-1: Calculate Airline Business Travel Emissions

A Federal energy manager calculates the emissions for travel in FY 2008. The manager works in Chicago, but attended two separate work events in San Francisco and New Orleans during the year. The New Orleans trip was via a direct flight; the flight to San Francisco had a stop in Denver. To determine the emissions associated with the business trips in FY 2008, the federal manager should do the following:

Step 1: Identify the total passenger-miles for each segment of each trip

The manager's flight records are as follows:

- MDW to MSY: 831 miles
- MSY to MDW: 831 miles
- ORD to DEN: 891 miles
- DEN to SFO: 970 miles
- SFO to DEN: 970 miles
- DEN to ORD: 891 miles

Step 2: Determine the appropriate emission factor (EF) based upon the flight characteristics

Table D-13 indicates that all flight segments are long haul. The EFs for this situation are as follows:

- 0.199189 kg CO₂/passenger-mile
- 0.0060 g N₂O/passenger-mile
- 0.000800084 g CH₄/passenger-mile

Step 3: Calculate the GHG emissions associated with each trip and convert to MT

Use Equation C-1 to calculate the emissions from each segment in MT.

<u>Equation C-1: Airline Business Travel Emissions</u>	
CO₂ emissions [MT]	= Passenger-miles traveled [miles] • appropriate CO ₂ EF [kg/mi] • 0.001 [MT/kg] = (831 + 831 + 891 + 970 + 970 + 891) [miles] • 0.199189 [kg/mi] • 0.001 [MT/kg] = 5384 [miles] • 0.199189 [kg/mi] • 0.001 [MT/kg] = 1.018 [MT]
CH₄ emissions [MT]	= Passenger-miles traveled [miles] • appropriate CH ₄ EF [g/mi] • 0.000001 [MT/g] = (831 + 831 + 891 + 970 + 970 + 891) [miles] • 0.00084 [g/mi] • 0.000001 [MT/g] = 5384 [miles] • 0.00084 [g/mi] • 0.000001 [MT/g] = 4.523 x 10 ⁻⁶ [MT]
N₂O emissions [MT]	= Passenger-miles traveled [miles] • appropriate N ₂ O EF [g/mi] • 0.000001 [MT/g] = (831 + 831 + 891 + 970 + 970 + 891) [miles] • 0.00630060 [g/mi] • 0.000001 [MT/g] = 5384 [miles] • 0.0060 [g/mi] • 0.000001 [MT/g] = 3.23 x 10 ⁻⁵ [MT]
<i>Step 4: Determine total annual emissions in MT CO₂e</i>	
Using the appropriate GWP, convert all GHG gases to CO ₂ e, then sum to determine the total emissions in MT CO ₂ e.	
<u>Equation C-2: Convert GHG MT to CO₂e Emissions</u>	
CO₂e Emissions [MT CO₂e]	= MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP) = 1.018 [MT CO ₂] + (4.523 x 10 ⁻⁶ [MT CH ₄] • 21) + (3.23 x 10 ⁻⁵ [MT N ₂ O] • 310) = 1.018 [MT CO ₂] + 9.498 x 10 ⁻⁵ [MT CO ₂ e] + 1.00 x 10 ⁻² [MT CO ₂ e] = 1.028 [MT CO₂e]
Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.	

C.2. Transmission and Distribution Losses

Description

This category includes the emissions associated with the purchased electricity consumed by the T&D system.

C.2.1. Default Methodology (to be Calculated by GHG Reporting Portal)⁹²

Data Sources

The GHG Reporting Portal will utilize this default calculation methodology. It will automatically draw from the existing FEMP energy reporting data reported under Scope 2 and subsequently apply a national loss factor to calculate T&D energy losses (Table C-4). The GHG

⁹² This methodology is based on Rothschild (Pechan) and Diem (EPA), Guidance on the Use of eGRID Output Emission Rates, April 2009, p. 2. See www.epa.gov/ttn/chief/conference/ei18/session5/rothschild.pdf.

Reporting Portal will calculate the lost quantity of energy and estimate its resultant GHG emissions using the appropriate emission factors.

Table C-4: T&D Losses Default Data Sources

Data Element	Preferred Source
Total electricity purchases [MWh]	<ul style="list-style-type: none"> • FEMP Energy Report Records
National average T&D loss factor [%]	<ul style="list-style-type: none"> • Electricity: 6.18 %⁹³

Calculation Steps

Electricity T&D losses are calculated using Equation C-3. These calculations account for the eGRID output emission rate factors adjustments that exclude T&D losses. The following steps detail the calculation methods to be utilized by the GHG Reporting Portal:

1. Import the electricity purchased data by eGRID subregion from FEMP energy reporting
2. Determine the electricity T&D loss adjustment factor
3. Calculate the T&D loss quantity and the associated GHG emissions
4. Determine total annual emissions in MT CO₂e.

Step 1: Import the electricity purchased data by eGRID subregion from FEMP energy reporting

All agencies are required to report their total electricity consumption through FEMP energy reporting by eGRID subregion. These quantities will be used in the GHG Reporting Portal to account for the electricity usage under the Scope 2. To the greatest extent feasible, the GHG Reporting Portal will automatically import these data for calculation of the T&D losses.

Step 2: Determine electricity T&D loss adjustment factor

This default methodology currently uses a national average T&D loss of 0.0618 (or 6.18 percent) and Equation C-3 to determine the electricity loss adjustment factor.

Equation C-3: Distribution Loss Adjustment Factor Calculation

Distribution Loss Adjustment Factor = $T \div (1-T)$

Where:

T = T&D loss factor, 0.0618 (or 6.18%) national average.

Step 3: Calculate the T&D loss quantity and the associated GHG emissions

The GHG Reporting Portal will apply the national average default value of 0.0618 for the T&D loss to determine the total quantity of electricity lost by eGRID subregion. It will also subsequently apply the appropriate eGRID output emission rate factors as provided in Table D-8.

⁹³ Diem, A. 2010. Personal Communication. Clear Air Markets Division Emission Monitoring Branch, Office of Air and Radiation, U.S. EPA.

Equation C-4: Calculation of Electricity T&D Losses and Emissions

<p>CO₂ emissions [MT] = Electricity purchased [MWh] • T&D adjustment factor • CO₂ emission factor [kg/MWh] • 0.001 [MT/kg]</p>
<p>N₂O emissions [MT] = Electricity purchased [MWh] • T&D adjustment factor • N₂O emission factor [kg/MWh] • 0.001 [MT/kg]</p>
<p>CH₄ emissions [MT] = Electricity purchased [MWh] • T&D adjustment factor • CH₄ emission factor [kg/MWh] • 0.001 [MT/kg]</p>

Source: DOE 1605(b), Technical Guidance

Step 4: Determine total annual emissions in MT CO₂e

Use the GWP values found in Table D-14 to convert them to units of CO₂e, then sum the emissions from all three gases.

Equation C-5: Conversion of GHG MT to CO₂e Emissions

$\text{CO}_2\text{e Emissions [MT CO}_2\text{e]} = \text{MT CO}_2 + (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP})$
--

Example C-2: Determine Transmission and Loss Emissions for Purchased Electricity

A Federal energy manager for a Veterans Administration hospital in southern Texas is tasked to determine the T&D loss from electricity purchased during FY 2008. To determine the emissions associated with that T&D loss, the federal manager should do the following:

Step 1: Import the electricity purchased data by eGRID subregion from FEMP energy reporting

The FEMP energy reporting data indicate that total purchased electricity for the hospital facility is 20,000 MWh.

Step 2: Determine electricity T&D loss adjustment factor

Equation C-3 is then used to calculate the loss adjustment factor.

Equation C-3: Distribution Loss Adjustment Factor Calculation

$$0.0618 \div (1 - 0.0618) = 0.0618 \div 0.9382 = 0.0659$$

Step 3: Calculate the T&D loss quantity and the associated GHG emissions

Because the facility is in southern Texas, it is within the ERCT eGRID subregion, so the ERCT eGRID output emission rate factor must be used for the calculation.

Equation C-4: Calculate Electricity T&D Losses and Emissions

<p>CO₂ emissions [MT]</p>	<p>= Electricity purchased [MWh] • CO₂ emission factor [kg/MWh] • T&D adjustment factor • 0.001 [MT/kg]</p> <p>= 20,000 [MWh] • 568.15 [kg/MWh] • 0.0659 • 0.001 [MT/kg]</p> <p>= 748.82 [MT] CO₂</p>
---	---

<p>CH₄ emissions [MT]</p>	<p>= Electricity purchased [MWh] • CH₄ emission factor [kg/MWh] • T&D adjustment factor • 0.001 [MT/kg]</p> <p>= 20,000 [MWh] • 8.05 [kg/MWh] • 0.0659 • 0.001 [MT/kg]</p>
---	---

	= 10.61 [MT] CH ₄
N₂O emissions [MT]	= Electricity purchased [MWh] • N ₂ O emission factor [kg/MWh] • T&D adjustment factor • 0.001 [MT/kg] = 20,000 [MWh] • 6.35 [kg/MWh] • 0.0659 • 0.001 [MT/kg] = 8.37 [MT] N ₂ O
<i>Step 4: Determine total annual emissions in MT CO₂e</i>	
Using the appropriate GWP, convert all GHG gases to CO ₂ e, then sum to determine the total emissions in CO ₂ e.	
Equation C-5: Convert GHG MT to CO₂e Emissions	
CO₂e Emissions [MT CO₂e]	= MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP) = 748.82 [MT CO ₂] + (10.61 [MT CH ₄] • 21) + (8.37 [MT N ₂ O] • 310) = 748.82 [MT CO ₂] + 222.81 [MT CO ₂ e] + 2,594.70 [MT CO ₂ e] = 3,566.33 [MT CO₂e]
Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.	

C.3. Contracted MSW Disposal

Description

Contracted disposal of agency waste refers to the off-site disposal of MSW performed by an independent entity. Appendix A provides guidance on inventorying emissions from agency-controlled (Scope 1) MSW disposal. The mass balance methodology⁹⁴ for contracted landfill disposal of MSW generating CH₄ and biogenic CO₂ used in this Scope 3 methodology differs from the LandGEM-based approach used for Scope 1. Even though waste disposed of in a particular reporting year generates emissions over a period of over 50 years, the methodology used for Scope 3 emissions allocates to the current reporting year all future emissions from waste that is disposed in the current year. Emissions from any waste disposed in past years are not allocated to the current reporting year.

The rationale for this differing approach is primarily due to the lack of control over the MSW once it is released to the contractor for disposal. It also eliminates the temporal data management complexities inherent with agencies applying a multi-year first-order decomposition model like LandGEM. This approach also enables a more temporally consistent, “apples-to-apples” comparison of emissions impacts of waste disposal options.

Agencies should account for contracted solid waste disposal emissions associated with Federal employees in leased facilities. The agency maintains direct operational control over the presence of Federal employees at the facilities, so the agency should account for the employees’ contribution to solid waste disposal. The ownership status of the facility does not affect whether

⁹⁴ This method is based upon the estimate approach used in the EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2007, p. A-304, and EPA, Climate Leaders, Landfill Offset Methodology. See www.epa.gov/climatechange/emissions/downloads09/Annex3.pdf and www.epa.gov/stateply/documents/resources/draft_landfill_offset_protocol.pdf.

employees are included. Only Federal employees are required to be included in the calculation of an agency’s emissions associated with Scope 3 solid waste disposal. An agency may also voluntarily include contractor employees and visitors in its calculation of Scope 3 solid waste disposal emissions. For example, an agency for which government-owned, contractor-operated (GOCO) facilities constitute a significant portion of the agency may choose to voluntarily report the Scope 3 solid waste disposal emissions associated with contractor employees at those facilities, in an attempt to more realistically report the full impact of the solid waste disposal emissions from the agency’s activities. If an agency’s Scope 3 solid waste disposal emissions include contractor employees or visitors, the agency should explicitly note this in the qualitative statement accompanying its inventory. Section A.6.1 outlines methods for estimating visitor populations served that may be adapted for solid waste disposal.

C.3.1. Default Methodology (to be Calculated by GHG Reporting Portal)

Data Sources

Table C-5 shows the data elements and their sources.

Table C-5: Contracted Solid Waste Disposal Default Data Sources

Data Element		Preferred Source
Mass of solid waste disposed [short ton] ⁹⁵		<ul style="list-style-type: none"> Reporting to OFEE under E.O. 13514, Sec. 2(e) Waste management contractor Landlord
Mass of biogenic CO ₂ and CH ₄ [MT (Mg)]		<ul style="list-style-type: none"> Will be calculated by GHG Reporting Portal using EPA method
Does the landfill have a LFG collection system?		<ul style="list-style-type: none"> GHG Reporting Portal will assume 50% include LFG collection system Waste management contractor Landlord
Methane concentration rate, k		<ul style="list-style-type: none"> Default will be provided by GHG Reporting Portal
Potential methane generation capacity, Lo		<ul style="list-style-type: none"> Default will be provided by GHG Reporting Portal
NMOC concentration [ppmv]		<ul style="list-style-type: none"> Default will be provided by GHG Reporting Portal
Methane content of LFG [% by volume]		<ul style="list-style-type: none"> Default will be provided by GHG Reporting Portal
If LFG collection system	Efficiency of LFG collection system	<ul style="list-style-type: none"> Default will be provided by GHG Reporting Portal
	Oxidation factor	<ul style="list-style-type: none"> Default will be provided by GHG Reporting Portal

* 1 MT = 1 Mg (megagram)

⁹⁵ If only volume data are available, the conversion factor of 1.5 Mg/m³ may be used. EPA 2009 (reference).

Calculation Steps

To calculate Scope 3 emissions from contracted MSW disposal, do the following:

1. Input solid waste disposal data in GHG Reporting Portal to calculate the CH₄ and CO₂ generation
2. Calculate emissions from landfills and solid waste facilities.

Step 1: Input solid waste disposal data in GHG Reporting Portal to calculate the CH₄ and CO₂ generation

The agency must input the annual disposal of solid waste into the GHG Reporting Portal. Waste collected from a federal agency has a variety of potential fates including, landfilling, recycling, and incineration.⁹⁶ When an agency does not have data on how waste was treated, it should assume the national percentages for disposal: Landfilling (54.3 percent), Recycling or other Recovery (33.8 percent), and Incineration (11.9 percent).⁹⁷ These ratios should not be applied to known amounts of waste sent off site since that waste presumably already has the recycling removed from it. These ratios may be used if agencies are using a proxy method (such as a tons of waste per employee factor) to estimate total waste amounts, assuming the method doesn't already incorporate segregated recycling. Amounts of waste not sent to landfills and assumed to be recycled or incinerated for energy recovery are avoided emissions for agency Scope 3 inventories.

Step 2: Calculate emissions from landfills and solid waste facilities

Using this quantitative input, the GHG Reporting Portal will use the EPA's mass balance model and its national default values to calculate an estimate of MSW's anthropogenic CH₄ and biogenic CO₂ emissions over time. The Portal applies the Scope 1 methodology outlined in Appendix A.7.1 using the national default values for uncontrolled releases, fugitive CH₄ losses, flare combustion, and venting. The derived calculations are outlined in Equation C-6 and Equation C-7, respectively.

Equation C-6: CH₄ Generation per Short Ton of MSW

$$\text{CH}_4 \text{ Generation [MT]} = \text{MSW}_{\text{mass}} \bullet 0.90718 \bullet \text{DOC} \bullet \text{DOC}_f \bullet \text{MCF} \bullet \text{F} \bullet 16/12$$

Where:

CH₄_{gen} = CH₄ generated by landfill [MT]

MSW_{mass} = Municipal solid waste disposed of in landfill [short ton]

0.90718 = Conversion from short ton to MT [MT/short ton]

DOC = Degradable organic carbon [MT C/MT waste], default value of 0.203

DOC_f = Degradable organic carbon digestible under the anaerobic conditions in the landfill [%], default value of 50%

⁹⁶ For waste disposal off site of a federal agency, where the fate of the waste is gasification, agencies can report zero Scope 3 emissions from this activity at this time.

⁹⁷ EPA 2009. MSW: Facts and Figures. <http://www.epa.gov/osw/nonhaz/municipal/pubs/msw2009-fs.pdf>.

MCF	=	Methane correction factor/uncontrolled release of CO ₂ [%], default value of 100%
F	=	Fraction of CH ₄ by volume in generated landfill gas, default value of 50%
16/12	=	Molecular weight ratio CH ₄ /C

Source: EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008, p. A-293. See: www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010-Annex-3-Addtl-Source-Sink-Categories.pdf.

Equation C-7: Biogenic CO₂ Generation per Short Ton MSW

$$\text{CO}_2 \text{ Generation [MT]} = \text{MSW}_{\text{mass}} \bullet 0.90718 \bullet \text{DOC} \bullet \text{DOC}_f \bullet \text{MCF} \bullet \text{F} \bullet 44/12$$

Where:

CO _{2gen}	=	CO ₂ generated by landfill [MT]
MSW _{mass}	=	Municipal solid waste disposed of in landfill [short ton]
0.90718	=	Conversion from short ton to MT [MT/short ton]
DOC	=	Degradable organic carbon [MT C/MT waste], default value of 0.203
DOC _f	=	Degradable organic carbon digestible under the anaerobic conditions in the landfill [%], default value of 50%
MCF	=	Methane correction factor/uncontrolled release of CO ₂ [%], default value of 100%
F	=	Fraction of CH ₄ by volume in generated landfill gas, default value of 50%
44/12	=	Molecular weight ratio CO ₂ /C

Source: EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008, p. A-293. See: www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010-Annex-3-Addtl-Source-Sink-Categories.pdf.

C.3.2. Advanced Methodology (User Calculated)⁹⁸

Data Sources

Agencies can utilize the same variables listed above for the default methodology but substitute site-specific or facility-level data available from the third-party contractor.

Calculation Steps

The advanced calculation method for contracted solid waste emissions is identical to the default, except for use of the site-specific data and disposal pathways available from the third-party contractor. For example, agencies with data on contracted waste disposal sent to MSW incinerators and WTE plants could use this detail to utilize a stationary combustion emission methodology found in Appendix A.

⁹⁸ This methodology is derived from the Climate Leaders Optional Emissions from Commuting, Business Travel, and Product Transport methodology. See www.epa.gov/stateply/documents/resources/commute_travel_product.pdf.

C.4. Federal Employee Business Ground Travel

Business ground travel refers to official business travel by Federal employees aboard third-party-owned or -operated ground vehicles.⁹⁹ It does not include daily commutes to, from, or within an employee’s official station, only official business travel as defined in the Federal Travel Regulations. Scope 3 emissions from business travel include those from the combustion of fuels (such as the fuel consumed by a vehicle), but not the life-cycle emissions associated with fuel production or manufacturing capital equipment and infrastructure (such as the emissions associated with vehicle manufacturing).

Business ground travel includes the following:

- Passenger vehicle business travel: personal vehicles (POVs), rental vehicles, and taxi cabs
- Mass transit: transit rail (such as subway or tram), commuter rail, intercity rail (such as Amtrak), buses, and shuttles

Due to the current lack of data for many modes of business ground travel, the default methodology estimates emissions for only rental vehicles and mass transit.

Agencies may utilize a combination of the default and advanced methodologies to calculate total emissions from business travel if travel data are managed in multiple systems or processes. When doing so, agencies should work to avoid double counting.

C.4.1. Default Methodology (to be Calculated by GHG Reporting Portal)¹⁰⁰

Data Sources

The default calculation methodology (Table C-6) is derived from average travel statistics provided by GSA and the private sector. If agencies have their own specific data available, they may use it, provided they justify any modifications.

Table C-6: Ground Travel Default Data Sources

Data Element	Preferred Source
Number of roundtrip air flights (business trips)	<ul style="list-style-type: none"> • Agency travel data from MIS or Chief Financial Officer

⁹⁹ The current methodologies presented do not include provisions for business travel over water (ferries, water taxis, etc.). However, agencies may choose to additionally report such emissions should sufficient data and methods become available at the time of reporting.

¹⁰⁰ This methodology is based on correspondence with the GSA Office of Travel and Transportation.

Calculation Steps

The GHG Reporting Portal will use the following steps to calculate emissions:

1. Report the number of agency-wide business trips
2. Calculate rental vehicle miles traveled
3. Calculate mass transit miles traveled
4. Apply emission factors and determine total annual GHG emissions.

Step 1: Report the number of agency-wide business trips

Agencies should refer to their GSA Travel MIS Rental Car report, or work with Defense Travel Management Office (DTMO) or their travel agents to determine the number of roundtrip business flights agency employees took during the fiscal year. The GHG Reporting Portal will estimate mileage for rental vehicles and mass transit based on the number of agency business trips.

Step 2: Calculate rental vehicle miles traveled

The GHG Reporting Portal will multiply the number of agency business trips by an average factor of 210 miles traveled per trip.¹⁰¹ This factor is based on the Federal government average factor of 420 miles traveled per vehicle rental, and an assumption that 50 percent (or 1:2 ratio) of all roundtrip travelers travel in a rental vehicle.

Step 3: Calculate mass transit miles traveled

The remaining 50 percent of federal travelers are assumed to utilize mass transit instead of rental vehicles while on business travel. GSA has provided an estimate that mass transit miles traveled are equal to 10 percent of rental vehicle miles traveled.¹⁰² Accordingly, the GHG Reporting Portal will apply a factor of 21 miles per business trip to estimate emissions for mass transit.¹⁰³

Step 4: Apply emission factors and determine the total annual GHG emissions

The GHG Reporting Portal will use Equation C-8 and the distance-traveled emission factors in Table D-11 to calculate the CO₂, N₂O, and CH₄ emissions for the applicable vehicle rentals and mass transit. This default methodology assumes a gasoline passenger car achieving 22.5 mpg for rental vehicles and 21 miles per trip for the mass transit portion of business ground travel. The GHG Reporting Portal will multiply each GHG quantity by the appropriate GWP value from Table D-14 and then calculate the total emissions in CO₂e.

¹⁰¹ This factor is provided by the GSA Office of Travel and Transportation, based on correspondence with rental agencies and federal agency business travel characteristics. The factor is a national average of all government rentals with three rental companies. These agencies constitute about 40 percent of total federal rentals.

¹⁰² Based on correspondence with the GSA Office of Travel and Transportation.

¹⁰³ $21 \text{ [miles/business trip for mass transit]} = 420 \text{ [rental vehicle miles/business trip]} \times 50 \text{ percent [business travel by non-rental vehicles]} \times 10 \text{ percent [rental vehicle miles/mass transit miles]}$.

C.4.2. Advanced Methodology 1: Detailed Rental and POV Data (to be Calculated by GHG Reporting Portal)

This advanced methodology is designed to provide an alternative for agencies that have vehicle rental and/or POV data (Table C-7) beyond just the number of business trips used in the default methodology.

Data Sources

Agencies should obtain the following information:

- The mileage per vehicle by class (POV or rental)

Table C-7: Advanced Methodology 1 Data Sources

Data Element	Preferred Sources
Mileage by class of rental vehicle or POV	<ul style="list-style-type: none"> • Rental Vehicles: GSA Travel MIS, DTMO, or Agency’s Travel Agent • POVs: Travel reimbursement forms
Vehicle class-specific CO ₂ emission factors	<ul style="list-style-type: none"> • Table C-8
Vehicle class-specific N ₂ O and CH ₄ emissions factors	<ul style="list-style-type: none"> • Table D-4

Calculation Steps

Calculation steps include the following:¹⁰⁴

1. Report mileage sum for agency rentals and POVs by vehicle class
2. Use the vehicle class to determine the appropriate emissions factor
3. Determine the GHG emissions for each vehicle used
4. Sum the total annual GHG emissions for all vehicles used
5. Convert emissions to CO₂e.

Step 1: Report mileage sum for agency rentals and POVs by vehicle class

Agencies should sum temporary duty rental and POV mileage by vehicle class. For POVs and rental vehicles, use the exact mileage that was devoted to business travel. Use rental records or POV auto information to determine the auto class for each vehicle used. Auto class types should be limited to those auto types presented in Table C-8. If an auto class cannot be determined, assign the class as “unknown” in the Portal.

¹⁰⁴ Advanced calculation methodology is derived in part from the EPA Climate Leaders guidance for *Optional Emissions from Commuting, Business Travel and Product Transport*.

Step 2: Use the vehicle class to determine the appropriate CO₂, N₂O, and CH₄ emissions factor

Based upon the classification of automobile used, the Portal will select the appropriate emissions factor from Table C-8. Vehicle type N₂O and CH₄ emissions factors are presented in Table D-4. All standard passenger vehicles are considered LEVs, assuming that all rental vehicle fleets consist of vehicles less than 5 years old.

Table C-8: CO₂ Emission Factors by Auto Class

Auto Class	kg CO ₂ /mile
Economy	0.315
Compact	0.287
Midsized	0.314
Full Size	0.392
Luxury/Premium	0.445
Minivan/Wagon	0.435
Small Sport Utility Vehicle (SUV)	0.442
Medium SUV	0.528
Large SUV	0.557
12/15 Pass Vans	0.585
1/2 Ton Pickup	0.545
Unknown	0.364

Note: Using data provided by the DTMO, these emissions factors (except “unknown”) were derived for the 2006–2010 model year vehicles fleet of the federal government’s large rental car vendors. MPG ratings use an average of city and highway EPA estimates for each vehicle type. The standard EPA GHGRP CO₂ emission factor for gasoline (Table D-2) was used for all vehicle types. The emission factor for “unknown” vehicle types was derived from Climate Leaders.

Step 3: Determine the GHG emissions for each vehicle used

The Portal will use Equation C-8 to calculate the emissions for each vehicle class used.

Equation C-8: Emissions for Each Vehicle

<p>CO₂ emissions[kg] = Distance traveled for a given vehicle class [miles] • CO₂ emission factor for that vehicle’s auto class [kg/mi]</p>
<p>N₂O emissions [kg] = Distance traveled for a given vehicle class [miles] • N₂O emission factor for each vehicle control technology [g/mi] • 0.001 [kg/g]</p>
<p>CH₄ emissions[kg] = Distance traveled for a given vehicle class [miles] • CH₄ emission factor for each vehicle control technology [g/mi] • 0.001 [kg/g]</p>

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Step 4: Sum the total GHG annual emissions for all vehicles used

The Portal will use Equation C-9 to sum the emissions of CO₂, N₂O, and CH₄ for all vehicles used and convert them to MT

Equation C-9: Total Emissions Calculations

<p>Total CO₂ emission from ground travel [MT] = (CO₂ from vehicle class 1 [kg] + CO₂ from vehicle class 2 [kg] + CO₂ from vehicle class 3 [kg] ...) • 0.001MT/kg</p>
<p>Total N₂O emission from ground travel [MT] = (N₂O from vehicle class 1 [kg] + N₂O from vehicle class 2 [kg] + N₂O from vehicle class 3 [kg] ...) • 0.001MT/kg</p>
<p>Total CH₄ emission from ground travel [MT] = (CH₄ from vehicle class 1 [kg] + CH₄ from vehicle class 2 [kg] + CH₄ from vehicle class 3 [kg] ...) • 0.001MT/kg</p>

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Step 5: Convert emissions to CO₂e

The Portal will use Equation C-10, the N₂O and CH₄ emissions, and their respective GWPs to convert these gases to CO₂e, then sum all CO₂ and CO₂e emissions to generate the total emissions for business ground travel.

Equation C-10: Ground Travel MT CO₂e Emissions

<p>CO₂e Emissions [MT CO₂e] = MT CO₂ + (MT CH₄ • CH₄ GWP) + (MT N₂O • N₂O GWP)</p>
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C.4.3. Advanced Methodology 2: Distance Traveled by Mode and Fuel Type (to be Calculated by GHG Reporting Portal)

Data Sources

Agencies can use this advanced distance-traveled methodology to calculate emissions from employee business ground travel. Agencies can use distance-traveled activity data captured by mode of ground transportation to calculate their emissions (Table C-9) in conjunction with total number of temporary duty travelers. Distance-based methodologies were chosen for their alignment with agency data availability.

Table C-9: Advanced Methodology 2 Data Sources

Data Element	Preferred Sources
Distance traveled by mode of passenger car (includes POV, taxis, or rental), SUV or truck, and fuel type used [mi]	<ul style="list-style-type: none"> Rental Vehicles: GSA Travel MIS, DTMO, or Agency's Travel Agent POVs, Taxis: Travel reimbursement forms
Emission factor [kg/vehicle-mi]	<ul style="list-style-type: none"> Table D-11

Calculation Steps

Calculation steps include the following:

1. Report miles traveled by mode of passenger car (includes POV, taxi, or rental), SUV or truck, and fuel type used
2. Calculate emissions for each mode of transportation and fuel type
3. Determine the total annual GHG emissions in MT
4. Convert emissions to CO₂e.

Step 1: Report miles traveled by mode of passenger car (includes POV, taxi, or rental), SUV or truck, and fuel type used

Agencies should sum mileage of passenger vehicles and SUVs or trucks by fuel type used. Use exact mileage that was devoted to business travel. .

Step 2: Calculate emissions for each mode of transportation and fuel type

Agencies should use Equation C-11 and the distance-traveled emission factors found in Table D-11 to calculate the CO₂, N₂O, and CH₄ emissions for each mode of travel. More detailed information on multiple occupant allocations is provided in the commuter methodologies in Appendix C.5.

Equation C-11: Emissions by Transportation Mode

CO₂ emissions[kg] = Distance traveled for a given mode [miles] • CO ₂ emission factor for each mode [kg/mi]
N₂O emissions [kg] = Distance traveled for a given mode [miles] • N ₂ O emission factor for each mode [kg/mi]
CH₄ emissions[kg] = Distance traveled for a given mode [miles] • CH ₄ emission factor for each mode [kg/mi]

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Step 3: Determine the total annual GHG emissions in MT

To determine the total CO₂, N₂O, and CH₄ emissions, sum the emissions of each gas for all ground transportation modes and fuel types, and convert them to MT.

Equation C-12: Total Emissions Calculations

Total CO₂ emission from ground travel [MT] = (CO ₂ from mode 1 [kg] + CO ₂ from mode 2 [kg] + CO ₂ from mode 3 [kg] ...) • 0.001MT/kg
Total N₂O emission from ground travel [MT] = (N ₂ O from mode 1 [kg] + N ₂ O from mode 2 [kg] + N ₂ O from mode 3 [kg] ...) • 0.001MT/kg

$$\text{Total CH}_4 \text{ emission from ground travel [MT]} = (\text{CH}_4 \text{ from mode 1 [kg]} + \text{CH}_4 \text{ from mode 2 [kg]} + \text{CH}_4 \text{ from mode 3 [kg]} \dots) \bullet 0.001\text{MT/kg}$$

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Step 4: Convert emissions to CO₂e

Multiply the CO₂, N₂O, and CH₄ emissions by their respective GWP to determine the CO₂e for business ground travel.

Equation C-13: Ground Travel MT CO₂e Emissions

$$\text{CO}_2\text{e Emissions [MT CO}_2\text{e]} = \text{MT CO}_2 + (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP})$$

C.5. Federal Employee Commuting

Description

Employee commuting includes the travel of employees between their homes and primary worksites or between their homes and alternate worksites.

C.5.1. Default Methodology (to be Calculated by GHG Reporting Portal)

Data Sources

Agencies using the default methodology must use at least the eight mandatory questions listed in Table C-11 to obtain information on employee commuting habits.^{105,106} Agencies may choose to use the free survey administered through GSA’s Carbon Footprint Tool, which uses the mandatory questions. The survey component of the Carbon Footprint Tool will be completely separate from all other Tool functions; agencies do not have to sign up or agree to use any other component of the Tool to access the survey.

The default survey will use eight mandatory questions developed by the John A. Volpe National Transportation Systems Center to calculate GHG emissions from employee commuting. These questions ask respondents for information on their typical weekly commute, including:

- Modes of transportation used to commute to and from work
- Mileage traveled by each mode
- Location of their worksite
- Participation in an alternative work schedule (AWS)

¹⁰⁵ Agencies should be aware that there are privacy rights to be considered when developing and administering any voluntary survey.

¹⁰⁶ This methodology is derived from Climate Leaders, Optional Emissions from Commuting, Business Travel, and Product Transport methodology. See www.epa.gov/stateply/documents/resources/commute_travel_product.pdf.

- Number of occupants in a vehicle if carpool/vanpool are used.

Agencies may choose to use an advanced methodology through the GSA Carbon Footprint Tool by which they select additional, optional questions for inclusion in their surveys. These questions will be noted as optional in the survey, and respondents will not be required to answer them to complete the survey. The optional questions ask respondents for information on a variety of issues related to commuting, including

- Telework
- Transit subsidies
- Distance and duration of commute
- Willingness to utilize mass transit options.

Agencies may seek an exception from OMB and CEQ if they feel that they are unable to administer a survey. If an exception is granted, an agency should look to on-site data sources such as parking permits or payroll records to gather information on distance traveled, mode of transport, and frequency of commute (Table C-10). If no on-site data are available, agencies may consider using regional or national databases to estimate the necessary data sources, such as the U.S. Census Bureau at: www.census.gov/acs/www/index.html.

Table C-10: Commuter Travel Data Sources

Data Element	Preferred Source	Alternate Source
Mode	<ul style="list-style-type: none"> • Commuter questionnaire 	<ul style="list-style-type: none"> • Public transit records • Regional/national transportation surveys
Agency average number of commuting days (by mode)	<ul style="list-style-type: none"> • Commuter questionnaire 	<ul style="list-style-type: none"> • Regional/national transportation surveys (such as U.S. Census Bureau)
Roundtrip distance (by mode) [mi]	<ul style="list-style-type: none"> • Commuter questionnaire 	<ul style="list-style-type: none"> • Commuter address (payroll records, personnel records, parking permits) • Regional/national transportation surveys (such as U.S. Census Bureau)
Emission factors [g/passenger-mile]	<ul style="list-style-type: none"> • Tables D-11 and D-12 	<ul style="list-style-type: none"> • N/A

Agencies should collect employee commuting data from a statistically appropriate number of respondents and extrapolate from a representative sample of employees to estimate commuting patterns of all employees. Agencies should record their sampling and extrapolation methodologies and include them in the GHG Reporting Qualitative Content portion of their annual GHG inventory submission to FEMP. In order to issue the survey, agencies will need to submit the email addresses of individuals within a representative sample to the GSA Carbon Footprint Tool. All responses in the Carbon Footprint Tool are made anonymous, and e-mail addresses will not be present on any output generated by the tool.

The GSA Carbon Footprint Tool will administer the commuter surveys, automatically calculate emissions, and present them in the format required for entry in the GHG Reporting Portal. The GSA Carbon Footprint Tool will not be able to calculate employee commuting emissions from outside data sources or surveys.

Agencies must report commuter emissions in each annual inventory. Agencies must ensure that the commuter survey is administered frequently enough to be reflective of their employees' commuting habits so that significant changes in emissions are captured in a timely fashion.

Calculation Steps

Agencies should use the following steps to calculate commuter emissions, which are also employed by the GSA Carbon Footprint Tool.

1. Collect commuter data by frequency, distance, and mode of travel using the eight mandatory questions developed by the Volpe Center.
2. Sum mileage by transportation mode for the typical working week and working day.
3. Estimate the average number of commuting days within the agency and calculate emissions by transportation mode.
4. Sum transportation mode emissions and convert them to MT.
5. Convert emissions to CO₂e and determine total emissions.

Step 1: Collect commuter data by frequency, distance, and mode of travel using the eight mandatory questions developed by the Volpe Center

Agencies should collect activity data for commuters using the eight mandatory questions in the default methodology (Table C-11).

Table C-11: Mandatory Commuter Survey Questions

Question No.	Question
1	Please select your agency/operating administration or office
2	What is the 5-digit zip code at your primary duty station? (e.g., 20590, 02142)
3	What is your employment status? (Full-time, intern, employee, contractor, etc.)
4	<p>How did you travel TO WORK each day during the week and what was the distance?</p> <ul style="list-style-type: none"> • Monday-Friday (questions below answered for each day) <ul style="list-style-type: none"> ○ Number of miles for 1st method of transportation (POV – passenger car, POV – SUV/truck [gasoline], POV – SUV/truck [diesel], POV – motorcycle, car pool, van pool, bus, metro/transit rail, commuter rail, intercity rail, walking and/or bicycling) ○ Number of miles for 2nd method of Transportation – <i>if applicable</i> ○ Number of miles for 3rd method of Transportation – <i>if applicable</i>

Question No.	Question
5	If you selected carpool/vanpool: What was the average total number of people in your vehicle, including yourself?
6	Did you use the same method(s) of transportation indicated above to commute FROM WORK at the end of your workdays? -If yes, mandatory questions complete. -If no, questions 7 and 8
7	How did you travel FROM WORK each day during the week and what was the distance? <ul style="list-style-type: none"> • Monday-Friday (questions below answered for each day) <ul style="list-style-type: none"> ○ Number of miles for 1st method of transportation (POV – passenger car, POV – SUV/truck [gasoline], POV – SUV/truck [diesel], POV – motorcycle, car pool, van pool, bus, metro/transit rail, commuter rail, intercity rail, walking and/or bicycling) ○ Number of miles for 2nd method of transportation – <i>if applicable</i> ○ Number of miles for 3rd method of transportation – <i>if applicable</i>
8	If you selected carpool/vanpool from work: What was the average total number of people in your vehicle, including yourself?

At a minimum, agencies should allow respondents to select from the eleven transportation modes below when choosing the mode of transportation they use to commute to and/or from work. Emission factors for these modes are provided in Table D-11 and D-12.

- POV – passenger car
- POV – SUV/truck (gasoline)
- POV – SUV/truck (diesel)
- POV – motorcycle
- Car pool
- Van pool
- Bus
- Metro/transit rail
- Commuter rail
- Intercity rail
- Walking and/ or bicycling.

Step 2: Sum mileage by transportation mode for the typical working week and working day

The mandatory survey questions will allow agencies to capture miles by transportation mode during a respondent’s typical week. Respondents will indicate the days they telework, and they will indicate whether or not they participate in an AWS. The total weekly mileage by transportation mode should be divided by the 5-work days within a working week to arrive at average mileage per work day for each mode. Refer to equation C-14 for the calculation of average mileage per work day.

Equation C-14: Average Transportation Mode Mileage per Work Day

Average Transportation Mode Mileage per Work Day =

Sum of weekly commuting miles by mode [mi]/ 5 [work days/week]

Step 3: Estimate the average number of commuting days within the agency and calculate emissions by transportation mode

Respondents are assumed to have 230 commuting days; respondents that participate in an alternative work schedule are assumed to have 205 commuting days. The average number of commuting days for an agency will be calculated using equation C-15.

Equation C-15: Average Agency Number of Commuting Days

Average Agency Commuting Days =

(Number of respondents participating in AWS/total number of respondents) * 205 [commuting days/year]+ (number of respondents not participating in an AWS/total number of respondents)* 230 [commuting days/year]

The GHG Reporting Portal will use Equation C-16 to calculate GHG emissions from each mode of transportation (See Tables D-11 and D-12 for emission factors for commuting.) Note that the listed emission factors assume that commuting vehicles have two passengers per carpool and four passengers per van-pool. See Example C-2.

Equation C-16: Emissions by Transportation Mode

CO₂ emissions [kg] =

Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor [kg/mi]

N₂O emissions [kg] =

Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor [g/mi] • 0.001 [kg/g]

CH₄ emissions [kg] =

Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor [g/mi] • 0.001 [kg/g]

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Step 4: Sum transportation mode emissions and convert them to MT

Use Equation C-17 to add the respective CO₂, N₂O, and CH₄ emissions from each transportation mode.

Equation C-17: Total Emissions Calculations

<p>Total CO₂ emission from commuter travel [MT] = (CO₂ from mode 1 [kg] + CO₂ from mode 2 [kg] + CO₂ from mode 3 [kg] ...) • 0.001MT/kg</p>
<p>Total CH₄ emission from commuter travel [MT] = (CH₄ from mode 1 [kg] + CH₄ from mode 2 [kg] + CH₄ from mode 3 [kg] ...) • 0.001MT/kg</p>
<p>Total N₂O emission from commuter travel [MT] = (N₂O from mode 1 [kg] + N₂O from mode 2 [kg] + N₂O from mode 3 [kg] ...) • 0.001MT/kg</p>

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Step 5: Convert emissions to CO₂e and determine total emissions

Use Equation C-18 to multiply the N₂O and CH₄ emissions by their respective GWPs (see Table D-14) to determine the total CO₂e emissions.

Equation C-18: Commuter Travel MT CO₂e Emissions

$\text{CO}_2\text{e Emissions [MT CO}_2\text{e]} = \text{MT CO}_2 + (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP})$
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Example C-2: Estimate Employee Emissions from Commuting

The Department of Commerce is attempting to estimate total commuter emissions for a notional facility in Chicago to determine the emissions associated with their employees' commutes.

Step 1: Collect commuter data by frequency, distance, and mode of travel

The agency uses the mandatory commuter survey questions and, after tabulating mileage by mode, determines that respondents travel 5,000 miles by single occupant vehicle, 2,000 miles by transit rail, 1,000 by bus, and 4,000 by carpool per week. In addition, the survey determines that respondents commute an average of 225 days per year.

Step 2: Sum mileage by transportation mode for the typical working week and working day

The average daily mileages by commuting mode are calculated by dividing the total weekly mileages by 5. They are displayed by mode in the table below.

Mode of Transportation [type]	Number of trips per year	Average daily mileage [miles]
Single occupant vehicle	225	1,000
Transit Rail	225	400
Bus	225	200
Carpool	225	800

Step 3: Estimate the average number of commuting days within the agency and calculate emissions by transportation mode

Equation C-16 allows for the calculation to determine emissions by transportation mode. It is used one time for each mode listed in the table above. The number of commuting days per year was determined in step 1. The emission factors for passenger cars are found in Table D-11 and D-12.

Equation C-16: Emissions by Transportation Mode

➤ *Single occupant vehicle*

CO₂ emissions [kg] = Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor [kg/mi]
 = 1,000 [miles/day] • 225 • 0.364 [kg/mi]
 = 81,900 [kg CO₂]

CH₄ emissions [kg] = Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor [g/mi] • 0.001 [kg/g]
 = 1,000 [miles/day] • 225 • 0.031 [g/passenger-mile] • 0.001 [kg/g]
 = 6.975 [kg CH₄]

N₂O emissions [kg] = Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor [g/mi] • 0.001 [kg/g]
 = 1,000 [miles/day] • 225 • 0.032 [g/passenger-mile] • 0.001 [kg/g]
 = 7.2 [kg N₂O]

➤ *Transit Rail*

CO₂ emissions [kg] = Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor for transit rail [g/passenger-mile] 400 [miles/day] • 225 • 0.001 [kg/g]
 = 400 [miles/day] • 225 • 0.163 [kg/passenger-mile]
 = 14,670 [kg CO₂]

CH₄ emissions [kg] = Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor for transit rail [g/passenger-mile] 400 [miles/day] • 225 • 0.001 [kg/g]
 = 400 [miles/day] • 225 • 0.004 [g/passenger-mile] • 0.001 [kg/g]
 = 0.36 [kg CH₄]

N₂O emissions [kg] = Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor for transit rail [g/passenger-mile] • 0.001 [kg/g]
 = 400 [miles/day] • 225 • 0.002 [g/passenger-mile] • 0.001 [kg/g]
 = 0.18 [kg N₂O]

➤ *Bus*

CO₂ emissions [kg] = Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor for bus [kg/passenger-mile]
 = 200 [miles/day] • 225 • 0.107 [kg/passenger-mile]
 = 4,815 [kg CO₂]

CH₄ emissions [kg] = Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor for bus [g/passenger-mile] • 0.001 [kg/g]
 = 200 [miles/day] • 225 • 0.0006 [g/passenger-mile] • 0.001 [kg/g]
 = 0.027 [kg CH₄]

<p>N₂O emissions [kg]</p>	<p>= Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor for bus [g/passenger-mile] • 0.001 [kg/g]</p> <p>= 200 [miles/day] • 225 • 0.0005 [g/passenger-mile]) • 0.001 [kg/g]</p> <p>= 0.0225 [kg N₂O]</p>
<p>➤ <i>Carpool</i></p>	
<p>CO₂ emissions [kg]</p>	<p>= Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor for carpool [kg/passenger-mile]</p> <p>= 800 [miles/day] • 225 • 0.182 [kg/passenger-mile]</p> <p>= 32,760 [kg CO₂]</p>
<p>CH₄ emissions [kg]</p>	<p>= Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor for carpool [g/passenger-mile] • 0.001 [kg/g]</p> <p>= 800 [miles/day] • 225 • 0.016 [g/passenger-mile]) • 0.001 [kg/g]</p> <p>= 2.88 [kg CH₄]</p>
<p>N₂O emissions [kg]</p>	<p>= Average daily commute distance traveled by transportation mode [miles/day] • average agency commuting days [days/year] • emission factor for carpool [g/passenger-mile] • 0.001 [kg/g]</p> <p>= 800 [miles/day] • 225 • 0.016 [g/passenger-mile]) • 0.001 [kg/g]</p> <p>= 2.88 [kg N₂O]</p>
<p><i>Step 4: Sum single occupant and multiple passenger travel emissions and convert them to MT</i></p> <p>Use Equation C-17 to add the respective CO₂, N₂O, and CH₄ emissions from all employees.</p>	
<p align="center"><u>Equation C-17: Total Emissions Calculations</u></p>	
<p>Total CO₂ emission from commuter travel [MT]</p>	<p>= (CO₂ from mode 1 [kg] + CO₂ from mode 2 [kg] + CO₂ from mode 3 [kg] ...) • 0.001 [MT/kg]</p> <p>= (CO₂ single occupant [kg] + CO₂ transit rail [kg] + CO₂ bus [kg] + CO₂ carpool [kg]) • 0.001 [MT/kg]</p> <p>= (81,900 [kg] + 14,670 [kg] + 144450 [kg] + 32,760 [kg]) • 0.001 [MT/kg]</p> <p>= 134,145 [kg] • 0.001 [MT/kg]</p> <p>= 134.145 [MT CO₂]</p>
<p>Total CH₄ emission from commuter travel [MT]</p>	<p>= (CH₄ from mode 1 [kg] + CH₄ from mode 2 [kg] + CH₄ from mode 3 [kg] ...) • 0.001 [MT/kg]</p> <p>= (CH₄ single occupant [kg] + CH₄ transit rail [kg] + CH₄ bus [kg] + CH₄ carpool [kg]) • 0.001 [MT/kg]</p> <p>= (6.975 [kg] + 0.36 [kg] + 0.027 [kg] + 2.88 [kg]) • 0.001 [MT/kg]</p> <p>= 10.24 [kg] • 0.001 [MT/kg]</p> <p>= 0.0102 [MT CH₄]</p>
<p>Total N₂O emission from commuter travel [MT]</p>	<p>= (N₂O from mode 1 [kg] + N₂O from mode 2 [kg] + N₂O from mode 3 [kg] ...) • 0.001 [MT/kg]</p> <p>= (N₂O single occupant [kg] + N₂O transit rail [kg] + N₂O bus [kg] + N₂O carpool [kg]) • 0.001 [MT/kg]</p>

travel	= (7.2 [kg] +0.18 [kg] + 0.0225 [kg] +2.88 [kg]) • 0.001 [MT/kg]
[MT]	= 10.29 [kg] • 0.001 [MT/kg]
	= 0.0103 [MT N ₂ O]
<i>Step 5: Convert to CO₂e and determine total emissions</i>	
Use Equation C-18 to multiply the total N ₂ O and CH ₄ emissions by their respective GWP (see Table) to determine the total CO ₂ e emissions.	
Equation C-18: Commuter Travel MT CO₂e Emissions	
Total CO₂e emissions	= MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP)
[MT CO₂e]	= 134.145 [MT CO ₂] + (0.0102 [MT CH ₄] • 21) + (0.0103 [MT N ₂ O] • 310)
[MT CO₂e]	= 134.145 [MT CO ₂] + 0.214 [MT CO ₂ e] + 3.19 [MT CO ₂ e]
	= 137.55 [MT CO₂e]
Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Reporting Portal.	

C.6. Contracted Wastewater Treatment

Description

Appendix A.6 provides guidance on inventorying emissions from agency-controlled wastewater treatment. Although this contracted wastewater treatment calculation methodology is identical, the data sources for contracted wastewater treatment differ because of the inherent scope boundary issues between 1 and 3. As such, contracted wastewater treatment population inputs only include Federal employees.

Agencies should account for contracted wastewater treatment emissions associated with Federal employees in leased facilities. The agency maintains direct operational control over the presence of Federal employees at the facilities, so the agency should account for the employees' direct wastewater contribution to the wastewater treatment systems. The ownership status of the facility does not affect whether employees are included. Only Federal employees are required to be included in the calculation of an agency's emissions associated with Scope 3 wastewater treatment. An agency may also voluntarily include contractor employees and visitors in its calculation of Scope 3 wastewater treatment emissions. For example, an agency for which GOCO facilities constitute a significant portion of the agency may choose to voluntarily report the Scope 3 wastewater treatment emissions associated with contractor employees at those facilities, in an attempt to more realistically report the full impact of the wastewater treatment emissions from the agency's activities. If an agency's Scope 3 wastewater treatment emissions include contractor employees or visitors, the agency should explicitly note this in the qualitative statement accompanying its inventory. See Section A.6.1 for methods for estimating visitor populations served.

C.6.1. Default Methodology (to be Calculated by GHG Reporting Portal)

*Data Sources*¹⁰⁷

Table C-12 shows the data elements and their preferred and alternate sources.

Table C-12: Contracted Wastewater Treatment Default Data Sources

Data Element	Preferred Source	Alternate Source
Employees served ¹⁰⁸	<ul style="list-style-type: none"> Agency records 	<ul style="list-style-type: none"> N/A
Type of WWTP	<ul style="list-style-type: none"> Wastewater treatment contractor 	<ul style="list-style-type: none"> Default provided

Calculation Steps

Agencies must enter their respective employee-served data into the GHG Reporting Portal. The portal will utilize a national average composition of WWTP treatment and applies the default wastewater treatment methodology outlined in Appendix A.6.1.

C.6.2. Advanced Methodology (User Calculated)

Data Sources

Table C-13 shows the data elements and their sources.

Table C-13: Contracted Wastewater Treatment Data Sources

Data Element	Preferred Source
Employees served	<ul style="list-style-type: none"> Agency records
Wastewater treatment processes used	<ul style="list-style-type: none"> Wastewater treatment contractor
Digester gas [cu ft/day]	<ul style="list-style-type: none"> Wastewater treatment contractor
Fraction of CH ₄ in biogas	<ul style="list-style-type: none"> Wastewater treatment contractor
BOD ₅ load [kg BOD ₅ /day]	<ul style="list-style-type: none"> Wastewater treatment contractor
Fraction of overall BOD ₅ removal performance	<ul style="list-style-type: none"> Wastewater treatment contractor
N load	<ul style="list-style-type: none"> Wastewater treatment contractor

¹⁰⁷ Both the minimum required and advanced methodologies are based on EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks* and *LGO Protocol*, Chapter 10. Agencies should be aware that because there is no widely accepted methodology for calculating emissions associated with wastewater treatment and the *LGO Protocol* is not from a federal source. See www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/ for the *LGO Protocol*.

¹⁰⁸ For the purposes of the default Scope 3 contracted wastewater treatment methodology, only Federal employees should be considered as the subject agency maintains direct operational control over their presence at a Federal facility. Furthermore, the inclusion of “on-site contractors” introduces a host of definitional uncertainties and could potentially require new data collection to adequately determine operational control over on-site contract personnel in question.

Calculation Steps

See Appendix A.6 for advanced methodology wastewater calculations.

C.7. Fully Serviced Leased Space (Voluntary)

Description

Scope 3 emissions associated with agency operations in fully serviced leased space occur in leased facilities where the landlord has responsibility for operations and maintenance, including the payment of all utilities. They result from purchased electricity, stationary combustion, purchased steam and hot water, and purchased chilled water. In multi-tenant facilities, purchased electricity includes emissions associated with lighting, plug load, and centralized systems. Reporting emissions from fully serviced leased space is voluntary for FY 2012, but may become mandatory in FY 2013 for leases over 10,000 gross square feet.

The methodologies used to calculate the components of the fully serviced leased space emissions are identical to the related Scope 1 and Scope 2 categories. Details for purchased electricity are found in Section B.1, stationary combustion in Sections A.1 and A.2, purchased steam and hot water in Section B.2, and purchased chilled water in Section B.3.

Federal landlords of these facilities will report the same emissions as Scope 1 or 2, depending on the emissions source.

C.7.1. Default Methodology (to be Calculated by “Fully Serviced Lease Space Scope 3 Emissions” Supplemental Workbook)

FEMP has provided a supplemental “Full Service Leased Space Scope 3 Emissions” Excel workbook to help agencies perform these calculations. Beginning in FY 2012, the GHG Reporting Portal contains a tab specifically designed to collect data for voluntary reporting of results from this supplemental workbook.

Data Sources

In general, the data required for reporting of fully serviced leased space is managed by facility landlords. If the landlord is a Federal entity (e.g., GSA), the landlord should provide the tenant with the required data to calculate their emissions. For leases with a private landlord, agencies will need to work with their private landlords to obtain the necessary energy information at no additional cost to the government.

Where an agency has a lease in a multi-tenant building, the agency (the government tenant occupying the space) will need to work with their landlord to determine their share of energy consumption for centralized building systems and common areas to pro-rate their share of the building’s total energy consumption in addition to energy use in agency occupied space. In situations where the landlord is GSA, GSA will provide the pro-rated share to the tenant agency. In other situations, agencies and landlords may apply modeling or other methodologies to pro-rate facility energy used in common areas.

Calculation Steps

The supplemental “Full Service Leased Space scope 3 Emissions” Excel workbook calculates emissions from purchased electricity, stationary combustion, purchased steam and hot water, and purchased chilled water. The calculations are based on the methodologies developed for these emissions categories for other reporting as outlined in the TSD and implemented in the GHG Reporting Portal, to which agencies should refer for detailed discussions of the calculation steps. Table C-14 outlines the relevant TSD references and data inputs.

Table C-14: Fully Serviced Leased Space Scope 3 Emissions Calculations

Leased Space Emissions Subcategory	TSD Reference Section	Agency Data Input
Purchased electricity	B.1	<ul style="list-style-type: none">• Electricity consumption• Zip code
Stationary combustion	A.1 and A.2	<ul style="list-style-type: none">• Fuel volumes consumed in the on-site generation of electricity, steam and heat
Purchased steam and hot water	B.2	<ul style="list-style-type: none">• Energy content of purchased steam or hot water consumed
Purchased chilled water	B.3	<ul style="list-style-type: none">• Energy content of purchased chilled water

Once agencies complete data entry in the supplemental workbook, results may be directly entered into the GHG Reporting Portal.

Appendix D—Emission and Conversion Factors

Table D-1 summarizes the emission and conversion factors found in this appendix.

Table D-1: Summary of Emission Factors and Conversion Factors with Sources

Factor Type	Data Source Reference	Reference Section	Appendix D Table #	Applicable Scope
CO ₂ Emission Factors and HHVs for Various Types of Fuel (Stationary Combustion)	U.S. EPA, GHGRP; <i>Federal Register / Vol. 74, No. 209 / Friday, October 30, 2009 / Rules and Regulations</i> ;	Table C-1 to Subpart C of Part 98	D-2	Scope 1, Biogenic
CH ₄ and N ₂ O Emission Factors for Various Types of Fuel (Stationary Combustion)	http://www.epa.gov/ghgreporting/documents/pdf/2009/GHG-MRR-FinalRule.pdf	Table C-2 to Subpart C of Part 98	D-3	Scope 1
N ₂ O and CH ₄ Emission Factors for Highway Vehicles	EPA, EPA Climate Leaders, Mobile Sources Guidance, www.epa.gov/climateleaders/documents/resources/mobilesource_guidance.pdf	Table 2	D-4	Scope 1 & 3
N ₂ O and CH ₄ Emission Factors for Alternative Fuel Vehicles		Table A-7	D-5	Scope 1 & 3
N ₂ O and CH ₄ Emission Factors for Non-Highway Vehicles		Table A-6	D-6	Scope 1
Default F-Gas Emission Factors for Refrigeration/Air Conditioning Equipment	EPA Climate Leaders, Direct HFC and PFC Emissions from Use of Refrigeration and Air Conditioning Equipment, www.epa.gov/stateply/documents/resources/mfgrfg.pdf	Table 2	D-7	Scope 1
eGRID Subregion Output Emission Rate Factors	eGRID2012 Version 1.0 Year 2009 Summary Tables, p.4, ¹⁰⁹ www.epa.gov/cleanenergy/documents/egridzips/eGRID2012V1_0_year09_SummaryTables.pdf	eGRID2012 Version 1.0 Year 2009 Summary Tables	D-8	Scope 2 & 3

¹⁰⁹ The GHG Reporting Portal will include the latest eGRID output emission rate factors.

Factor Type	Data Source Reference	Reference Section	Appendix D Table #	Applicable Scope
U.S. Territories Output Emission Rate Factors	DOE 1605(b): Voluntary Reporting of Greenhouse Gases: www.eia.doe.gov/oiaf/1605/pdf/Appendix%20F_r071023.pdf	Appendix F Electricity Emission Factors	D-8	Scope 2 & 3
Steam/Hot Water Emission Factor	DOE 1605(b): Technical Guidance: www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf	Part F: Indirect Emissions	D-9	Scope 2 & 3
Chilled Water Factors	DOE 1605(b), Technical Guidance: www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf	Part F: Indirect Emissions and Appendix N	D-10	Scope 2 & 3
Ground Business and Commuter Personal Vehicle Emission Factors	EPA, Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport, www.epa.gov/stateply/documents/resources/commute_travel_product.pdf	Table 1	D-11	Scope 3
Commuter and Mass Transit Emission Factors		Table 1, Table 2, and Table 3	D-12	Scope 3
Airline Business Travel (Default Methodology)		Table 4	D-13	Scope 3
Global Warming Potentials (100-Year)	U.S. EPA, GHGRP; <i>Federal Register / Vol. 74, No. 209 / Friday, October 30, 2009 / Rules and Regulations</i> ;	Table A-1 to Subpart A of Part 98	D-14	All
General Conversion Factors	http://www.epa.gov/ghgreporting/documents/pdf/2009/GHG-MRR-FinalRule.pdf	Table A-2 to Subpart A of Part 98	D-15	All
Gasoline Gallon Equivalent Conversion Factors	E.O. 13514, Guidance for Federal Agencies on E.O. 13514 Section 12 – Federal Fleet Management http://www.hss.doe.gov/nuclearsafety/env/air/cawg/fleetguidance_13514.pdf	Table 5-2	D-16	Scope 1

The following section describes emission factors by scope and emission category, GWP, and conversion factors in more detail.

Scope 1 Combustion Emission Factors

For Scope 1 emissions, the methodologies use emission factors from the EPA's GHGRP and Climate Leaders guidance (Table D-2). Table D-3 lists key combustion factors.

Table D-2: Default CO₂ Emission Factors and Higher Heating Values¹¹⁰ for Various Types of Fuel

Fuel Type	Default HHV	Default CO ₂ Emission Factor
Coal and coke	MMBtu/short ton	kg CO₂/MMBtu
Anthracite	25.09	103.54
Bituminous	24.93	93.40
Subbituminous	17.25	97.02
Lignite	14.21	96.36
Coke	24.80	102.04
Mixed (commercial sector)	21.39	95.26
Mixed (industrial coking)	26.28	93.65
Mixed (industrial sector)	22.35	93.91
Mixed (electric power sector)	19.73	94.38
Natural gas	MMBtu/scf	kg CO₂/MMBtu
Pipeline (weighted U.S. average)	1.028 x 10 ⁻³	53.02
Petroleum products	MMBtu/gallon	kg CO₂/MMBtu
Distillate Fuel Oil No. 1	0.139	73.25
Distillate Fuel Oil No. 2	0.138	73.96
Distillate Fuel Oil No. 4	0.146	75.04
Distillate Fuel Oil No. 5	0.140	72.93
Distillate Fuel Oil No. 6	0.150	75.10
Still gas	0.143	66.72
Kerosene	0.135	75.20
LPG	0.092	62.98
Propane	0.091	61.46
Propylene	0.091	65.95
Ethane	0.096	62.64
Ethylene	0.100	67.43

¹¹⁰ Heating value is the amount of energy released when a fuel is burned completely. There is a difference between HHVs used in the United States and Canada, and lower heating values used in all other countries. HHV is the amount of heat released from the complete combustion of a fuel, including water vapor produced in the process. Lower heating value is the amount of heat released from the complete combustion of a fuel after netting out the heat that is released with the water vapor produced in the process.

Fuel Type	Default HHV	Default CO ₂ Emission Factor
Isobutene	0.097	64.91
Isobutylene	0.103	67.74
Butane	0.101	65.15
Butylene	0.103	67.73
Naphtha (<401 degrees F)	0.125	68.02
Natural gasoline	0.110	66.83
Other oil (>401 degrees F)	0.139	76.22
Pentanes plus	0.110	70.02
Petrochemical feedstocks	0.129	70.97
Petroleum coke	0.143	102.41
Special naphtha	0.125	72.34
Unfinished oils	0.139	74.49
Heavy gas oils	0.148	74.92
Lubricants	0.144	74.27
Motor gasoline	0.125	70.22
Aviation gasoline	0.120	69.25
Kerosene-type jet fuel	0.135	72.22
Asphalt and road oil	0.158	75.36
Crude oil	0.138	74.49
Fossil fuel-derived fuels (solid)	MMBtu/short ton	kg CO₂/MMBtu
Municipal solid waste	9.95	90.7
Tires	26.87	85.97
Fossil fuel-derived fuels (gaseous)	MMBtu/scf	kg CO₂/MMBtu
Blast furnace gas	0.092 x 10 ⁻³	274.32
Coke oven gas	0.599 x 10 ⁻³	46.85
Biomass fuels—solid	MMBtu/short ton	kg CO₂/MMBtu
Wood and wood residuals	15.38	93.80
Agricultural byproducts	8.25	118.17
Peat	8.00	111.84
Solid byproducts	25.83	105.51
Biomass fuels—gaseous	MMBtu/scf	kg CO₂/MMBtu
Biogas (captured methane)	0.841 x 10 ⁻³	52.07
Biomass fuels—liquid	MMBtu/gallon	kg CO₂/MMBtu
Ethanol (100%)	0.084	68.44
Biodiesel (100%)	0.128	73.84
Rendered animal fat	0.125	71.06

Fuel Type	Default HHV	Default CO ₂ Emission Factor
Vegetable oil	0.120	81.55

Source: U.S. EPA, GHGRP; Federal Register / Vol. 74, No. 209 / Friday, October 30, 2009 / Rules and Regulations; Table C-1 to Subpart C of Part 98. See www.epa.gov/ghgreporting/documents/pdf/2009/GHG-MRR-FinalRule.pdf.

Table D-3: Default CH₄ and N₂O Emission Factors for Various Types of Fuel

Fuel Type	Default CH ₄ emission factor (kg CH ₄ /MMBtu)	Default N ₂ O emission factor (kg N ₂ O/MMBtu)
Coal and coke (all fuel types in Table D-2)	1.1 x 10 ⁻²	1.6 x 10 ⁻³
Natural gas	1.0 x 10 ⁻³	1.0 x 10 ⁻⁴
Petroleum (all fuel types in Table D-2)	3.0 x 10 ⁻³	6.0 x 10 ⁻⁴
Municipal solid waste	3.2 x 10 ⁻²	4.2 x 10 ⁻³
Tires	3.2 x 10 ⁻²	4.2 x 10 ⁻³
Blast furnace gas	2.2 x 10 ⁻⁵	1.0 x 10 ⁻⁴
Coke oven gas	4.8 x 10 ⁻⁴	1.0 x 10 ⁻⁴
Biomass fuels—solid (all fuel types in Table D-2)	3.2 x 10 ⁻²	4.2 x 10 ⁻³
Biogas	3.2 x 10 ⁻³	6.3 x 10 ⁻⁴
Biomass fuels—liquid (all fuel types in Table D-2)	1.1 x 10 ⁻³	1.1 x 10 ⁻⁴

Source: U.S. EPA, GHGRP; Federal Register / Vol. 74, No. 209 / Friday, October 30, 2009 / Rules and Regulations; Table C-2 to Subpart C of Part 98. See www.epa.gov/ghgreporting/documents/pdf/2009/GHG-MRR-FinalRule.pdf.

Scope 1 Mobile Combustion Emission Factors

Table D-4, Table D-5, and Table D-6 show the relevant Scope 1 mobile source factors.

Table D-4: CH₄ and N₂O Emission Factors for Highway Vehicles

Fuel Type	CH ₄ Emission Factor (g CH ₄ /mile)	N ₂ O Emission Factor (g N ₂ O/mile)
Gasoline passenger cars		
Low emission vehicles	0.0105	0.015
Tier 2	0.0173	0.0036
Tier 1	0.0271	0.0429
Tier 0	0.0704	0.0647
Oxidation catalyst	0.1355	0.0504
Non-catalyst	0.1696	0.0197

Fuel Type	CH ₄ Emission Factor (g CH ₄ /mile)	N ₂ O Emission Factor (g N ₂ O/mile)
Uncontrolled	0.178	0.0197
Gasoline light-duty trucks		
Low emission vehicles	0.0148	0.0157
Tier 2	0.0163	0.0066
Tier 1	0.0452	0.0871
Tier 0	0.0776	0.1056
Oxidation catalyst	0.1516	0.0639
Non-catalyst	0.1908	0.0218
Uncontrolled	0.2024	0.022
Gasoline heavy-duty trucks		
Low emission vehicles	0.0303	0.032
Tier 2	0.0333	0.0134
Tier 1	0.0655	0.175
Tier 0	0.263	0.2135
Oxidation catalyst	0.2356	0.1317
Non-catalyst	0.4181	0.0473
Uncontrolled	0.4604	0.0497
Diesel passenger cars		
Advanced	0.0005	0.001
Moderate	0.0005	0.001
Uncontrolled	0.0006	0.0012
Diesel light trucks		
Advanced	0.001	0.0015
Moderate	0.0009	0.0014
Uncontrolled	0.0011	0.0017
Diesel heavy-duty trucks		
Advanced	0.0051	0.0048
Moderate	0.0051	0.0048
Uncontrolled	0.0051	0.0048
Motorcycles		
Non-Catalyst	0.0672	0.0069
Uncontrolled	0.0899	0.0087

Source: EPA Climate Leaders, Mobile Sources Guidance, Table A-1. See www.epa.gov/stateply/documents/resources/mobilesource_guidance.pdf.

Table D-5: CH₄ and N₂O Emission Factors for Alternative Fuel Vehicles

Fuel Type	CH ₄ Emission Factor (g CH ₄ /mile)	N ₂ O Emission Factor (g N ₂ O/mile)
Light-duty vehicles		
Methanol	0.018	0.067
CNG	0.737	0.05
LPG	0.037	0.067
Ethanol	0.055	0.067
Heavy-duty vehicles		
Methanol	0.066	0.175
CNG	1.966	0.175
LNG	1.966	0.175
LPG	0.066	0.175
Ethanol	0.197	0.175
Buses		
Methanol	0.066	0.175
CNG	1.966	0.175
Ethanol	0.197	0.175

Note: CO₂ Emission Factors for Alternative Fuel Vehicles can be found in Table D-2.

Source: EPA Climate Leaders, Mobile Sources Guidance, Table A-7. See www.epa.gov/stateply/documents/resources/mobilesource_guidance.pdf.

Table D-6: CH₄ and N₂O Emission Factors for Non-Highway Vehicles

Fuel Type	Fuel Density (kg/gal)	CH ₄ Emission Factor (g CH ₄ /gal fuel)	N ₂ O Emission Factor (g N ₂ O/gal fuel)
Ships and boats			
Residual fuel oil	3.75	0.86	0.3
Diesel fuel	3.2	0.74	0.26
Gasoline	2.8	0.64	0.22
Locomotives			
Diesel Fuel	3.2	0.8	0.26
Agricultural equipment			
Gasoline	2.8	1.26	0.22
Diesel fuel	3.2	1.44	0.26
Construction equipment			
Gasoline	2.8	0.5	0.22

Fuel Type	Fuel Density (kg/gal)	CH ₄ Emission Factor (g CH ₄ /gal fuel)	N ₂ O Emission Factor (g N ₂ O/gal fuel)
Diesel fuel	3.2	0.58	0.26
Other non-highway			
Snowmobiles (gasoline)	2.8	0.5	0.22
Other recreational (gasoline)	2.8	0.5	0.22
Other small utility (gasoline)	2.8	0.5	0.22
Other large utility (gasoline)	2.8	0.5	0.22
Other large utility (diesel)	3.2	0.58	0.26
Aircraft			
Jet fuel	3.08	0.27	0.31
Aviation gasoline	2.67	7.04	0.11

Source: EPA Climate Leaders, Mobile Sources Guidance, Table A-6. See www.epa.gov/stateply/documents/resources/mobilesource_guidance.pdf.

Scope 1 Fugitive F-Gas Emission Factors

Table D-7 shows Scope 1 fluorinated gas fugitive emission and leak rate estimation factors.

Table D-7: Default F-Gas Emission Factors for Refrigeration/Air Conditioning Equipment

Type of Equipment	Capacity (kg)	Installation Emission Factor <i>k</i> (% of capacity)	Operating Emission Factor <i>x</i> (% of capacity/yr)	Refrigerant Remaining at Disposal <i>y</i> (% of capacity)	Recovery Efficiency <i>z</i> (% of remaining)
Domestic refrigeration	0.05–0.5	1	0.50	80	70
Standalone commercial applications	0.2–6	3	15	80	70
Medium and large commercial refrigeration	50–2,000	3	35	100	70
Transport refrigeration	3–8	1	50	50	70
Industrial refrigeration, including food processing and cold storage	10–10,000	3	25	100	90

Type of Equipment	Capacity (kg)	Installation Emission Factor <i>k</i> (% of capacity)	Operating Emission Factor <i>x</i> (% of capacity/yr)	Refrigerant Remaining at Disposal <i>y</i> (% of capacity)	Recovery Efficiency <i>z</i> (% of remaining)
Chillers	10–2,000	1	15	100	95
Residential and commercial air conditioning, including heat pumps	0.5–100	1	10	80	80
Mobile air conditioning	0.5–1.5	0.50	20	50	50

Source: EPA, Climate Leaders Direct HFC and PFC Emissions from Use of Refrigeration and Air Conditioning Equipment, Table 2. See www.epa.gov/stateply/documents/resources/mfgrfg.pdf.

Scope 2 Emission Factors

Scope 2 purchased electricity output emission rate factors are provided by the EPA eGRID database. The eGRID database divides the national electricity grid into 26 subregions with unique output emission rate factors on the basis of the regional electricity generation mix as shown in Table D-8. Agencies can map a facility's ZIP code to the corresponding eGRID subregion using the EPA Power Profiler website.¹¹¹ Supplemental purchased steam, hot water, and chilled water emission factors are leveraged from both eGRID and DOE 1605b Program technical guidance resources, and are provided in Tables D-9 and D-10.

Table D-8: eGRID 2012 Year 2009 Subregion Emission Rate Factors

eGRID Subregion Acronym	eGRID Subregion Name	Output Emission Rates			Fossil Fuel Output Emission Rates CO ₂ (kg/MWh)	Non-Baseload Output Emission Rates		
		CO ₂ (kg/MWh)	CH ₄ (kg/GWh)	N ₂ O (kg/GWh)		CO ₂ (kg/MWh)	CH ₄ (kg/GWh)	N ₂ O (kg/GWh)
AKGD	ASCC Alaska Grid	582.7365 80.984	12.29558 1	3.37448 7	631.682634. 810	618.3285 99.077	15.8720 40	3.1532. 875
AKMS	ASCC Miscellaneous	243.0012 36.439	10.2729. 880	2.0301. 942	633.254663. 649	663.2846 66.524	27.9799 11	5.5234 88
AZNM	WECC Southwest	568.1725 40.385	8.528678	7.51606 8	741.492726. 219	549.6775 38.716	9.32510 .090	4.2211 39
CAMX	WECC California	308.8982 98.773	12.83313 .127	2.82779 7	488.261472. 868	474.1384 50.818	17.8831 5.203	2.1501. 847
ERCT	ERCOT All	568.1515 36.020	8.0547.5 76	6.3465. 944	667.243653. 420	497.2195 24.094	8.93091 5	2.5563. 443
FRCC	FRCC All	553.4305	18.68517	6.91913	583.957619.	583.5045	19.6881	5.2164

¹¹¹ EPA Power Profiler. See www.epa.gov/cleanenergy/energy-and-you/how-clean.html.

eGRID Subregion Acronym	eGRID Subregion Name	Output Emission Rates			Fossil Fuel Output Emission Rates CO ₂ (kg/MWh)	Non-BaseLoad Output Emission Rates		
		CO ₂ (kg/MWh)	CH ₄ (kg/GWh)	N ₂ O (kg/GWh)		CO ₂ (kg/MWh)	CH ₄ (kg/GWh)	N ₂ O (kg/GWh)
		33.697	.798	8	639	90.302	6.350	01
HIMS	HICC Miscellaneous	609.5446 13.101	61.30232 .839	9.8476. 261	778.701782. 231	746.4167 32.990	55.7664 1.305	9.6737. 799
HIOA	HICC Oahu	735.1617 22.727	41.29846 .150	9.47597 0	726.212710. 551	739.7567 35.460	48.1629 62	8.3994 95
MROE	MRO East	767.6207 21.957	13.05910 .877	13.1761 2.266	979.268942. 465	864.1698 47.411	15.9881 3.335	13.600 791
MROW	MRO West	803.5457 38.718	13.38106 3	13.6031 2.605	1,043.51402 3.596	902.0519 59.310	24.3082 8.046	14.959 16.970
NEWE	NPCC New England	375.5513 30.399	34.91833 0	6.89528 4	560.702515. 712	546.5335 25.003	27.5309 94	6.0835 47
NWPP	WECC Northwest	389.5383 71.585	7.4116.9 37	6.1895. 670	861.250813. 426	580.4036 37.089	19.6461 7.490	7.1458. 523
NYCW	NPCC NYC/Westchester	319.6922 76.993	11.89410 .773	1.51927 3	499.512453. 956	559.7555 07.142	17.0781 0.192	2.2151. 049
NYLI	NPCC Long Island	643.5266 11.434	41.05243 .937	5.94361 2	616.448571. 676	634.0296 06.262	19.9951 3.964	3.1721. 592
NYUP	NPCC Upstate NY	308.6642 25.851	7.899230	4.4903. 069	700.891636. 748	625.2886 11.040	14.3131 8.635	7.3446 53
RFCE	RFC East	480.4974 29.742	12.42917 3	7.7256. 787	722.819765. 542	758.3867 38.884	15.1001 4.941	10.067 186
RFCM	RFC Michigan	748.9297 52.713	14.76724 7	12.6056 50	807.255908. 249	818.1118 32.185	14.5541 5.951	12.397 13.221
RFCW	RFC West	703.7526 89.726	8.333219	11.7604 00	902.604929. 033	899.0409 07.977	11.0231 38	14.277 558
RMPA	WECC Rockies	992.1878 27.581	12.10810 .092	15.1831 2.333	1,044.66291 5.345	705.0527 96.783	10.5106 79	7.4631 0.211
SPNO	SPP North	815.8758 23.609	9.624529	13.2451 05	978.1431,00 4.774	888.2299 74.100	11.5209 40	12.587 14.433
SPSO	SPP South	736.6427 25.298	11.12210 .545	10.1689 .883	808.123809. 211	651.0126 86.611	11.3554 39	5.9596. 855
SRMV	SERC Miss Valley	455.4484 54.684	9.8878.8 21	5.0564. 833	645.730649. 762	531.1765 45.060	12.8151 1.665	3.1362 25
SRMW	SERC Midwest	807.0597 93.670	9.3318.8 77	13.4281 46	946.056980. 513	882.5339 94.653	10.8951 1.360	13.465 16.281
SRSO	SERC South	678.3316 01.317	10.72310 2	11.1469 .424	859.221805. 504	703.5427 35.724	12.9283 45	9.8401 0.660
SRTV	SERC Tenn Valley	698.9146 15.844	9.0157.8 37	11.5581 0.018	937.620901. 592	869.6458 71.403	11.7864 14	13.631 883
SRVC	SERC Virginia/ Carolina	507.2984 69.860	10.0959. 757	8.6527. 914	831.641851. 422	753.4617 60.831	17.2414 87	11.119 595

eGRID Subregion Acronym	eGRID Subregion Name	Output Emission Rates			Fossil Fuel Output Emission Rates CO ₂ (kg/MWh)	Non-BaseLoad Output Emission Rates		
		CO ₂ (kg/MWh)	CH ₄ (kg/GWh)	N ₂ O (kg/GWh)		CO ₂ (kg/MWh)	CH ₄ (kg/GWh)	N ₂ O (kg/GWh)
U.S. Territories		858.000	34.43	7.77	N/A	N/A	N/A	N/A
U.S.		589.4545 51.646	11.40210 .902	8.9552	795.474790. 655	689.5067 05.549	14.6181 3.986	8.3519 61

Source 1: Derived from EPA, eGRID2012 Version 1.0 Year 2009 Summary Tables. See http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2012V1_0_year09_SummaryTables.pdf.

Source 2: Derived from DOE, Office of Policy and International Affairs, 1605(b) Program, Voluntary Reporting of Greenhouse Gases (1605(b)) Program (October 2007). See www.eia.doe.gov/oiaf/1605/pdf/Appendix%20F_r071023.pdf.

Table D-9: Steam/Hot Water Emission Factor[◇]

Chiller Type	CO ₂ Emission Factor (Kg CO ₂ /MMBtu)	CH ₄ Emission Factor (kg CH ₄ /MMBtu)	N ₂ O Emission Factor (kg N ₂ O/MMBtu)
Steam/Hot Water (default)	53.02	1.0 x 10 ⁻³	1.0 x 10 ⁻⁴
Steam (w/losses)*	98.19	1.85 x 10 ⁻³	1.85 x 10 ⁻⁴
Hot water (w/losses)†	73.64	1.4 x 10 ⁻³	1.0 x 10 ⁻⁴

◇ See calculation step 2 under the default methodology for the source of the steam/hot water emission factors and default efficiency percentages

* Steam Emission Factor ÷ (0.80 x 0.75 x 0.90), where 0.80 is the default boiler efficiency in %, 0.75 is the default steam production efficiency in %, and 0.90 is 1-distribution loss in %

† Hot Water Emission Factor ÷ (0.80 x 0.90), where 0.80 is the default boiler efficiency, and 0.90 is 1-distribution loss in %

Source: DOE, Office of Policy and International Affairs, 1605(b) Program, Technical Guidelines to the Voluntary Reporting of Greenhouse Gases (1605(b)) Program (January 2007). See www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf.

Table D-10: Chilled Water Factors

Chiller Type	Energy Source	Coefficient of Performance	Transmission Loss Adjustment*
Absorption chiller	Natural gas	0.8	1.11
Engine-driven chiller	Natural gas	1.2	1.11
Electric-driven chiller	Electricity	4.2	1.11

* Assumes a 10 percent loss during transmission.

Source: DOE, Office of Policy and International Affairs, 1605(b) Program, Technical Guidelines to the Voluntary Reporting of Greenhouse Gases (1605(b)) Program (January 2007). See www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf.

Scope 3 Emission Factors

For Scope 3 emissions, or emissions not covered by the GHGRP or eGRID database, agencies performing advanced methodology calculations should first use the relevant emission factors from the EPA Climate Leaders Guidance and then AP 42, fifth edition.¹¹² Ground business and commuter personal vehicle, commuter and mass transit, and airline business travel emission factors from Climate Leaders are used in the default methodology and provided in Tables D-11, D-12, and D-13.

Agencies should refer to the EPA AP 42 website to ensure the emission factors they use are current when calculating advanced emission estimates.

Table D-11: Ground Business and Commuter Personal Vehicle Emission Factors

Vehicle type	CO ₂ Emission Factor (kg CO ₂ /vehicle-mile)	CH ₄ Emission Factor (kg CH ₄ /vehicle-mile)	N ₂ O Emission Factor (kg N ₂ O/vehicle-mile)
Passenger car	0.364	0.031 x 10 ⁻³	0.032 x 10 ⁻³
Light-duty truck/van/SUV	0.519	0.036 x 10 ⁻³	0.047 x 10 ⁻³
Motorcycle	0.167	0.070 x 10 ⁻³	0.007 x 10 ⁻³

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport. See www.epa.gov/stateply/documents/resources/commute_travel_product.pdf.

Table D-12: Commuter and Mass Transit Emission Factors

Vehicle type	CO ₂ Emission Factor (kg CO ₂ /passenger-mile)	CH ₄ Emission Factor (kg CH ₄ /passenger-mile)	N ₂ O Emission Factor (kg N ₂ O/passenger-mile)
Car pool*	0.182	0.016 x 10 ⁻³	0.016 x 10 ⁻³
Van pool†	0.130	0.009 x 10 ⁻³	0.012 x 10 ⁻³
Bus	0.107	0.0006 x 10 ⁻³	0.0005 x 10 ⁻³
Transit rail	0.163	0.004 x 10 ⁻³	0.002 x 10 ⁻³
Commuter rail	0.172	0.002 x 10 ⁻³	0.001 x 10 ⁻³
Intercity rail	0.185	0.002 x 10 ⁻³	0.001 x 10 ⁻³

* Assumes 2 passengers

† Assumes 4 passengers

◇ Car and Van pool emission factors were derived using values from Table 1 in the source document

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport. See: www.epa.gov/stateply/documents/resources/commute_travel_product.pdf.

¹¹² EPA, AP 42. See www.epa.gov/ttn/chief/ap42/index.html.

Table D-13: Airline Business Travel Emission Factors

Segment Travel Distance	CO ₂ Emission Factor (kg CO ₂ /passenger-mi)	CH ₄ Emission Factor (g CH ₄ /passenger-mi)	N ₂ O Emission Factor (g N ₂ O/passenger-mi)
Long Haul ¹ (≥ 700 miles)	0.189	0.0084	0.0060
Medium Haul ¹ (≥300 and < 700 miles)	0.165	0.0084	0.0053
Short Haul ¹ (< 300 miles)	0.290	0.0084	0.0092
Unknown Segment Class ²	0.189	0.0084	0.0060

Source¹: DECC and Defra, 2012 Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting. See: www.defra.gov.uk/publications/files/pb13773-ghg-conversion-factors-2012.pdf.

Source²: Unknown distance emission factors are assumed to fit into the Long Haul category based on GSA travel data showing that the average distance for federal business flights is 1,265 miles.

Global Warming Potentials

Table D-14, Table D-15, and Table D-16 show the relevant conversion reference factors.

Table D-14: Global Warming Potentials

Name	CAS No.	Chemical formula	Global Warming Potential (100 yr.)
Carbon dioxide	124-38-9	CO ₂	1
Methane	74-82-8	CH ₄	21
Nitrous oxide	10024-97-2	N ₂ O	310
HFC-23	75-46-7	CHF ₃	11,700
HFC-32	75-10-5	CH ₂ F ₂	650
HFC-41	593-53-3	CH ₃ F	150
HFC-125	354-33-6	C ₂ HF ₅	2,800
HFC-134	359-35-3	C ₂ H ₂ F ₄	1,000
HFC-134a	811-97-2	CH ₂ FCF ₃	1,300
HFC-143	430-66-0	C ₂ H ₃ F ₃	300
HFC-143a	420-46-2	C ₂ H ₃ F ₃	3,800
HFC-152	624-72-6	CH ₂ FCH ₂ F	53
HFC-152a	75-37-6	CH ₃ CHF ₂	140
HFC-161	353-36-6	CH ₃ CH ₂ F	12
HFC-227ea	431-89-0	C ₃ HF ₇	2,900
HFC-236cb	677-56-5	CH ₂ FCF ₂ CF ₃	1,340
HFC-236ea	431-63-0	CHF ₂ CHFCF ₃	1,370

Name	CAS No.	Chemical formula	Global Warming Potential (100 yr.)
HFC-236fa	690-39-1	C ₃ H ₂ F ₆	6,300
HFC-245ca	679-86-7	C ₃ H ₃ F ₅	560
HFC-245fa	460-73-1	CHF ₂ CH ₂ CF ₃	1,030
HFC-365mfc	406-58-6	CH ₃ CF ₂ CH ₂ CF ₃	794
HFC-43-10mee	138495-42-8	CF ₃ CFHCFHCF ₂ CF ₃	1,300
Sulfur hexafluoride	2551-62-4	SF ₆	23,900
Trifluoromethyl sulphur pentafluoride	373-80-8	SF ₅ CF ₃	17,700
Nitrogen trifluoride	7783-54-2	NF ₃	17,200
PFC-14 (Perfluoromethane)	75-73-0	CF ₄	6,500
PFC-116 (Perfluoroethane)	76-16-4	C ₂ F ₆	9,200
PFC-218 (Perfluoropropane)	76-19-7	C ₃ F ₈	7,000
Perfluorocyclopropane	931-91-9	C-C ₃ F ₆	17,340
PFC-3-1-10 (Perfluorobutane)	355-25-9	C ₄ F ₁₀	7,000
Perfluorocyclobutane	115-25-3	C-C ₄ F ₈	8,700
PFC-4-1-12 (Perfluoropentane)	678-26-2	C ₅ F ₁₂	7,500
PFC-5-1-14 (Perfluorohexane)	355-42-0	C ₆ F ₁₄	7,400
PFC-9-1-18	306-94-5	C ₁₀ F ₁₈	7,500
HCFE-235da2 (Isoflurane)	26675-46-7	CHF ₂₀ CHC ₁ CF ₃	350
HFE-43-10pccc (H-Galden 1040x)	E1730133	CHF ₂ OCF ₂ OC ₂ F ₄ OCHF ₂	1,870
HFE-125	3822-68-2	CHF ₂ OCF ₃	14,900
HFE-134	1691-17-4	CHF ₂ OCHF ₂	6,320
HFE-143a	421-14-7	CH ₃ OCF ₃	756
HFE-227ea	2356-62-9	CF ₃ CHFOCF ₃	1,540
HFE-236ca12 (HG-10)	78522-47-1	CHF ₂ OCF ₂ OCHF ₂	2,800
HFE-236ea2 (Desflurane)	57041-67-5	CHF ₂ OCHF ₂ CF ₃	989
HFE-236fa	20193-67-3	CF ₃ CH ₂ OCF ₃	487
HFE-245cb2	22410-44-2	CH ₃ OCF ₂ CF ₃	708
HFE-245fa1	84011-15-4	CHF ₂ CH ₂ OCF ₃	286
HFE-245fa2	1885-48-9	CHF ₂ OCH ₂ CF ₃	659
HFE-254cb2	425-88-7	CH ₃ OCF ₂ CHF ₂	359
HFE-263fb2	460-43-5	CF ₃ CH ₂ OCH ₃	11
HFE-329mcc2	67490-36-2	CF ₃ CF ₂ OCF ₂ CHF ₂	919

Name	CAS No.	Chemical formula	Global Warming Potential (100 yr.)
HFE-338mcf2	156053-88-2	CF ₃ CF ₂ OCH ₂ CF ₃	552
HFE-338pcc13 (HG-01)	188690-78-0	CHF ₂ OCF ₂ CF ₂ OCHF ₂	1,500
HFE-347mcc3	28523-86-6	CH ₃ OCF ₂ CF ₂ CF ₃	575
HFE-347mcf2	E1730135	CF ₃ CF ₂ OCH ₂ CHF ₂	374
HFE-347pcf2	406-78-0	CHF ₂ CF ₂ OCH ₂ CF ₃	580
HFE-356mec3	382-34-3	CH ₃ OCF ₂ CHF ₂ CF ₃	101
HFE-356pcc3	160620-20-2	CH ₃ OCF ₂ CF ₂ CHF ₂	110
HFE-356pcf2	E1730137	CHF ₂ CH ₂ OCF ₂ CHF ₂	265
HFE-356pcf3	35042-99-0	CHF ₂ OCH ₂ CF ₂ CHF ₂	502
HFE-365mcf3	378-16-5	CF ₃ CF ₂ CH ₂ OCH ₃	11
HFE-374pc2	512-51-6	CH ₃ CH ₂ OCF ₂ CHF ₂	557
HFE-449sl (HFE-7100) Chemical blend	163702-07-6 163702-08-7	C ₄ F ₉ OCH ₃ (CF ₃) ₂ CF ₂ OCH ₃	297
HFE-569sf2 (HFE-7200) Chemical blend	163702-05-4 163702-06-5	C ₄ F ₉ OC ₂ H ₅ (CF ₃) ₂ CF ₂ OC ₂ H ₅	59
Sevoflurane	28523-86-6	CH ₂ FOCH(CF ₃) ₂	345
HFE-356mm1	13171-18-1	(CF ₃) ₂ CHOCH ₃	27
HFE-338mmz1	26103-08-2	CHF ₂ OCH(CF ₃) ₂	380
(Octafluorotetramethylene) hydroxymethyl group	N/A	X-(CF ₂) ₄ CH(OH)-X	73
HFE-347mmy1	22052-84-2	CH ₃ OCF(CF ₃) ₂	343
Bis(trifluoromethyl)- methanol	920-66-1	(CF ₃) ₂ CHOH	195
2,2,3,3,3- pentafluoropropanol	422-05-9	CF ₃ CF ₂ CH ₂ OH	42
PFPME	N/A	CF ₃ OCF(CF ₃)CF ₂ OCF ₂ OCF ₃	10,300

Source: U.S. EPA, GHGRP; Federal Register / Vol. 74, No. 209 / Friday, October 30, 2009 / Rules and Regulations; Table A-1 to Subpart A of Part 98. See <http://www.epa.gov/ghgreporting/documents/pdf/2009/GHG-MRR-FinalRule.pdf>.

Conversion Factors

Table D-15: General Conversion Factors

To Convert From	To	Multiply By
Weight		
Kilograms (kg)	Pounds (lb)	2.20462
Pounds (lb)	Kilograms (kg)	0.45359
Pounds (lb)	Metric tons	4.53592 × 10 ⁻⁴

To Convert From	To	Multiply By
Short tons	Pounds (lb)	2,000
Short tons	Metric tons	0.90718
Metric tons (MT)	Short tons	1.10231
Metric tons (MT)	Kilograms (kg)	1,000
Million MT CO ₂ e (MMT CO ₂ e)	MT CO ₂ e (MT CO ₂ e)	1,000,000
Metric tons (MT)	Tons	1
Volume		
Cubic meters (m ³)	Cubic feet (cu ft or ft ³)	35.31467
Cubic feet (cu ft or ft ³)	Cubic meters (m ³)	0.028317
Gallons (liquid, U.S.)	Liters (l)	3.78541
Liters (l)	Gallons (liquid, U.S.)	0.26417
Barrels of Liquid Fuel (bbl)	Cubic meters (m ³)	0.15891
Cubic meters (m ³)	Barrels of Liquid Fuel (bbl)	6.289
Barrels of Liquid Fuel (bbl)	Gallons (liquid, U.S.)	42
Gallons (liquid, U.S.)	Barrels of liquid fuel (bbl)	0.023810
Gallons (liquid, U.S.)	Cubic meters (m ³)	0.0037854
Liters (l)	Cubic meters (m ³)	0.001
Distance		
Feet (ft)	Meters (m)	0.3048
Meters (m)	Feet (ft)	3.28084
Miles (mi)	Kilometers (km)	1.60934
Kilometers (km)	Miles (mi)	0.62137
Area		
Square feet (ft ²)	Acres	2.29568×10^{-5}
Square meters (m ²)	Acres	2.47105×10^{-4}
Square miles (mi ²)	Square kilometers (km ²)	2.58999
Temperature		
Degrees Celsius (°C)	Degrees Fahrenheit (°F)	$^{\circ}\text{C} = (5/9) \times (^{\circ}\text{F} - 32)$
Degrees Fahrenheit (°F)	Degrees Celsius (°C)	$^{\circ}\text{F} = (9/5) \times ^{\circ}\text{C} + 32$
Degrees Celsius (°C)	Kelvin (K)	$\text{K} = ^{\circ}\text{C} + 273.15$
Kelvin (K)	Degrees Rankine (°R)	1.8
Energy		
Joules	Btu	9.47817×10^{-4}
Btu	MMBtu	1×10^{-6}
Btu	BBtu	1×10^{-9}
Ton hour	Btu	1.2×10^4

To Convert From	To	Multiply By
Ton hour	MMBtu	1.2×10^{-2}
MWh	MMBtu	3.413
Pressure		
Pascals (Pa)	Inches of mercury (in Hg)	2.95334×10^{-4}
Inches of mercury (in Hg)	Pounds per square inch (psi)	0.49110
Pounds per square inch (psi)	Inches of mercury (in Hg)	2.03625

Source 1: U.S. EPA, GHGRP; Federal Register / Vol. 74, No. 209 / Friday, October 30, 2009 / Rules and Regulations; Table A-2 to Subpart A of Part 98. See <http://www.epa.gov/ghgreporting/documents/pdf/2009/GHG-MRR-FinalRule.pdf>.

Source 2: DOE, Office of Policy and International Affairs, 1605(b) Program, Technical Guidelines to the Voluntary Reporting of Greenhouse Gases (1605(b)) Program (January 2007). See www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf.

Table D-16: GGE Conversion Factors

Alternative Fuel	Natural Units	Gasoline Gallon Equivalent (GGE)
B100	Gallons	101.5% (gal x 1.015 = GGE)
B20	Gallons	112.6% (gal x 1.126 = GGE)
CNG	Gallons at 2,400 psi	18% (gal x 0.18 = GGE)
CNG	Gallons at 3,000 psi	22.5% (gal x 0.225 = GGE)
CNG	Gallons at 3,600 psi	27% (gal x 0.27 = GGE)
CNG	Hundred cubic feet	83% (ccf x 0.83 = GGE)
Diesel	Gallons	114.7% (gal x 1.147 = GGE)
Diesel—emergency, special purpose, and military	Gallons	114.7% (gal x 1.147 = GGE)
Diesel—law enforcement vehicles	Gallons	114.7% (gal x 1.147 = GGE)
E-85	Gallons	72% (gal x 0.72 = GGE)
Electric	kWh	3% (kWh x 0.03 = GGE)
Gasoline	Gallons	No conversion needed
Gasoline—emergency, special purpose, and military	Gallons	No conversion needed
Gasoline—law enforcement vehicles	Gallons	No conversion needed
LNG	Gallons @ 14.7 psi and -234 degrees F	66% (gal x 0.66 = GGE)
LPG	Gallons	74% (gal x 0.74 = GGE)
M-85	Gallons	57% (gal x 0.57 = GGE)

Source: DOE and GSA, Federal Automotive Statistical Tool Program. See: <https://fastweb.inel.gov/>.

Appendix E—Acronyms and Abbreviations

BBtu	Billion British Thermal Units
BOD	Biochemical Oxygen Demand
C&A	Certification and Accreditation
CAA	Clean Air Act
CAS	Chemical Abstract Service
CEQ	Council on Environmental Quality
CFC	Chlorofluorocarbons
CFR	Code of Federal Regulations
CHP	Combined Heat and Power
CH ₄	Methane
CNG	Compressed Natural Gas
CO ₂	Carbon Dioxide
CO ₂ e	Carbon Dioxide Equivalent
COP	Coefficient of Performance
DOC	Degradable Organic Carbon
DoD	Department of Defense
DOE	Department of Energy
DTMO	Defense Travel Management Office
DTS	Defense Travel System
EF	Emission Factor
eGRID	Emissions and Generation Resource Integrated Database
EIA	Energy Information Administration
EIG	Emission Inventory Guidebook
EISA	Energy Independence and Security Act
E.O.	Executive Order
EPA	Environmental Protection Agency
EPAct	Energy Policy Act
EPCRA	Emergency Planning and Community Right-To-Know Act
ETS	E-Gov Travel Service
F-gas	Fluorinated Gas (HFCs, PFCs, SF ₆)

FAST	Federal Automotive Statistical Tool
FEMP	Federal Energy Management Program
FIA	Forest Inventory and Analysis
FT	Full-Time Employees/Contractors
FY	Fiscal Year
GE	Goal-Excluded
GGE	Gasoline Gallon Equivalent
GHG	Greenhouse Gas
GHGRP	EPA's Greenhouse Gas Reporting Program (previously the Greenhouse Gas Mandatory Reporting Rule or MRR)
GOCO	Government-Owned, Contractor-Operated
GS	Goal-Subject
GSA	General Services Administration
GWh	Gigawatt Hour
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbon Group of Gases
HHV	Higher Heating Value
HVAC	Heating, Ventilation and Air Conditioning
IPCC	Intergovernmental Panel on Climate Change
KCUFT	Thousand Cubic Feet
KGal	Thousand Gallons
LandGEM	Landfill Gas Emission Model
LEV	Low Emissions Vehicle
LFG	Landfill Gas
LGO Protocol	<i>Local Government Operations Protocol</i>
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gases
MIS	Management Information Service
MMBtu	Million British Thermal Units
MSDS	Material Safety Data Sheet
MSW	Municipal Solid Waste
MT	Metric Tons

MWh	Megawatt Hour
NASA	National Aeronautics and Space Administration
NMOC	Non-Methane Organic Compounds
N ₂ O	Nitrous Oxide
OFEE	Office of the Federal Environmental Executive
OMB	Office of Management and Budget
PFC	Perfluorocarbon Group of Gases
PNR	Passenger Name Record
POC	Point of Contact
POV	Personal Vehicle
PT	Part-Time Employees/Contractors
REC	Renewable Energy Certificate
SF ₆	Sulfur Hexafluoride
SUV	Sport Utility Vehicle
T&D	Transmission and Distribution
TMC	Travel Management Center
TSD	<i>Technical Support Document for Federal GHG Accounting and Reporting Guidance</i>
USFS	U.S. Forest Service
VE	Vehicles and Equipment
WBCSD	World Business Council for Sustainable Development
WTE	Waste-to-Energy
WRI	World Resources Institute
WWTP	Wastewater Treatment Plant