

Federal Greenhouse Gas Accounting and Reporting Guidance

Technical Support Document

October 6, 2010

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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) Federal Energy Management Program (FEMP)—in coordination with the Environmental Protection Agency (EPA), Department of Defense (DoD), 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). 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.¹

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

¹ 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.

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.

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. 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) buildings²
Allowable Exclusions from the Target ³	<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"> • Description of verification and validation procedures completed • Inventory management plan, if available • Known or potential double-counting • Second- or third-party verifier, if applicable
Other Information	<ul style="list-style-type: none"> • Other information as necessary to explain report

² 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.

³ These are emissions excluded from GHG targets; they are not excluded from comprehensive inventory reporting requirements.

Agency Reporting Point of Contact (POC)

Although each agency's Senior Sustainability Officer (SSO) 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 data⁴
- 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:⁵

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

⁴ 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.

⁵ For FY 2010 reporting, agencies should compare to their FY 2008 inventory, where applicable.

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 CEQ and 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 (see Chapter 5.4 of the main Guidance document for more information). 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.
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

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.

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. This section lists the default data elements for reporting scope 1, 2, and 3 emissions, biogenic CO₂ emissions for scope 1, 2, and 3 activities, and voluntary reporting.⁶ 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 CO₂e emissions will be calculated for each emissions category and maintained over time.

⁶ 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.

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.⁷ Because agencies will also be using the GHG Reporting Portal for FEMP energy reporting, they must report emissions from goal-subject (GS) energy, goal-excluded (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).

⁷ 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 Report⁸ 	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"> 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 FY 2008 base year and FY 2010 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

⁸ 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.⁹ Agencies using advanced methodologies should ensure they calculate and report biogenic emissions in those categories, as applicable.

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), 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) 	<ul style="list-style-type: none"> Facility human resource records Facility security records 	Yes
On-Site Landfill/Municipal Solid Waste	<ul style="list-style-type: none"> Landfill open date Landfill close date Total mass of MSW disposed on-site [short tons] 	<ul style="list-style-type: none"> Facility Title V reporting materials E.O.s 13423 and 13514 solid waste and diversion reporting 	Yes
Others	<ul style="list-style-type: none"> Agency- and facility-specific data required 	<ul style="list-style-type: none"> Facility Title V, Mandatory Reporting Rule (MRR), 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 metric tons (MT) for each GHG type emitted. There are no default methodologies for process emissions because they are site- and/or

⁹ 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 carbon dioxide. This contrasts with carbon from fossil fuels, which was removed from the atmosphere millions of years ago.

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.

Some agencies may find that supporting data on their process emissions are already used to prepare their reports under the CAA Title V, EPA’s Greenhouse Gas MRR, 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 (NF₃).

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 [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	<ul style="list-style-type: none"> Renewable energy, or RECs, purchased [MWh] eGRID subregions in which the renewable 	<ul style="list-style-type: none"> FEMP Energy Report[†] 	No

Emissions Category	Default Data	Current Reporting	Advanced Methodology Available?
Purchases	energy was generated <ul style="list-style-type: none"> • Generator on- or off-agency site and whether on the agency side of meter, separately metered, or off grid 		

* 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.¹⁰ 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 recent eGRID subregion output emission rate factors. Because agencies will also be using the GHG Reporting Portal for FEMP energy reporting, they must report goal-subject (GS) and goal-excluded (GE) energy separately according to the definitions previously established under EPAct 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 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 renewable energy certificates (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.

¹⁰ 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.

Required FY 2010 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 will 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 to 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.

For 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 MTCO₂e) in their scope 3 target.¹¹

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

- Federal employee business air travel
- Federal employee business ground travel
- Federal employee commuting
- Contracted solid waste disposal (Municipal solid waste 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 not owned or operated by the agency)
- T&D losses associated with purchased electricity.¹²

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

Required FY 2011 Scope 3 Data

For FY 2011 reporting, agencies will continue to report scope 3 emissions categories required for FY 2010, and will also be required to report emissions associated with the following:

¹¹ Base year inventories should be provided for all of emission categories reported. Refer to Chapter 5.4 for more information on calculating base year inventories when FY 2008 data is not available.

¹² Emissions associated with T&D losses from purchased steam, hot water, and chilled water are categorized as scope 2 emissions.

- Facilities operated under private-sector and GSA leases.
- Additional scope 3 categories as directed by CEQ.

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 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 2-6). Information on commuter travel can come from national or regional travel survey data for the default category or through agency- or site-specific commuter surveys using the advanced methodology. Agencies should coordinate with their facilities to investigate the availability of commuter data and/or existing surveys.

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. If using the advanced methodologies, agencies must report scope 3 emissions in metric tons (MT) for each GHG type emitted.

Table 2-5: Data Needed for FY 2010 Reporting: Scope 3 Emissions

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
Contracted Municipal Solid Waste Disposal	<ul style="list-style-type: none"> • Municipal solid waste 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"> • Frequency of commute • Average one-way distance traveled by employee per day 	<ul style="list-style-type: none"> • No current reporting 	Yes

Emissions Category	Default Data	Current Reporting	Advanced Methodology Available?
	<ul style="list-style-type: none"> Percentage modes of transport used by employees (such as personal vehicle, train, bus) 		
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 associated with land management agencies include emissions associated with the following:

- 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.

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.

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 MRR given top priority when applicable, followed by other Federal sources. Emission factors and methodologies were selected from the following sources:

1. EPA, *Mandatory Greenhouse Gas Reporting Rule (MRR)*, *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. 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. 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 (CEM) 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?
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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	EPA MRR, Table A-1 to Subpart A of Part 98	Yes
		Conversion factors	EPA MRR, Table A-2 to Subpart A of Part 98	Yes
Scope 1 (including biogenic)	Stationary combustion (agency-owned and -controlled heat and steam)	CO ₂ emission factors and HHVs for various types of fuel	EPA MRR, Table C-1 to Subpart C of Part 98	Yes
		CH ₄ and N ₂ O emission factors for various types of fuel	EPA MRR, Table C-1 to Subpart C of Part 98	Equipment-specific
	Mobile combustion (agency-owned and -controlled vehicles, airplanes, etc.)	CO ₂ emission factors and HHVs for various types of fuel	EPA MRR, Table C-1 to Subpart C of Part 98	Yes
		CH ₄ and N ₂ O emission factors for various types of fuel	EPA MRR, Table C-1 to Subpart C of Part 98	Vehicle-specific
Scopes 1 and 3	Landfill/MSW	Emission model equation defaults	EPA MRR, Table HH-1 to Subpart H of Part 98 and 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	No, plant-specific [†]
	Chilled water	CO ₂ , CH ₄ and N ₂ O emission factors	DOE 1605(b), Technical Guidelines	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	CO ₂ , CH ₄ and N ₂ O emission factors by	EPA, eGRID Emission Rate Summary Tables	Yes

Applicable Scope	Emissions Categories	Factor Type	Default Methodology Emission Factor Source	Emission Factor Applies to Advanced Methodology?
	purchases	eGRID subregion		
Scope 3	Business air travel	Custom air travel CO ₂ , CH ₄ and N ₂ O emission factor model	GSA Travel MIS	N/A
	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

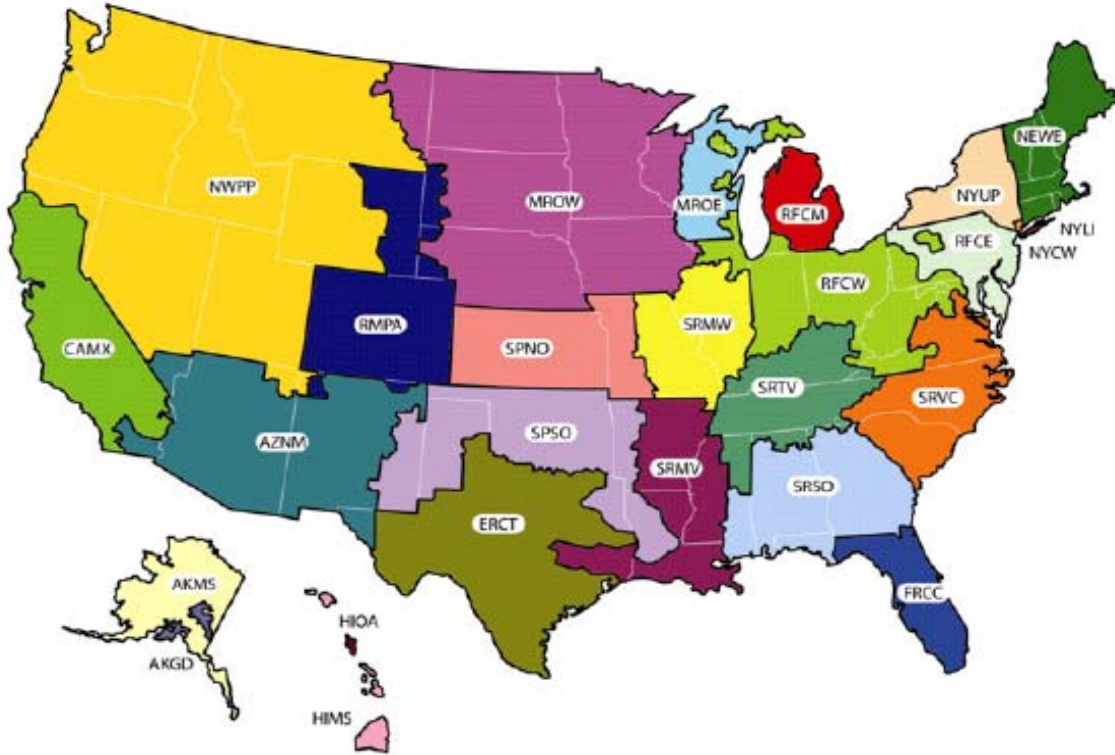
For scope 2 purchased electricity, the GHG Reporting Portal will use the eGRID subregion output emission rate factors provided by the EPA eGRID database to calculate default category GHG emissions. This database divides the electric grid into 26 subregions with unique emission factors based on the regional 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.¹³ 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.¹⁴

¹³ EPA Power Profiler. See www.epa.gov/powerprofiler.

¹⁴ DOE 1605(b) Emission Factors. See www.eia.doe.gov/oiaf/1605/emission_factors.html.

Figure 2-1: eGRID Subregions



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.¹⁵ 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.)

¹⁵ In the EPA MRR, 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 Steps¹⁶

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 metric tons (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 High Heat Values (HHVs) available in Table D-2.¹⁷ 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.

¹⁶ Primary reference: EPA, Technical Support Document (TSD) for Stationary Fuel Combustion Emissions: Proposed Rule for Mandatory Reporting of Greenhouse Gases (MRR), 40 CFR 98, Subpart C, January 30, 2009.

¹⁷ Also see TSD MRR Stationary Sources, 40 CFR 98, Subpart C, Tables C-1 and C-2 for emission factors.

Equation A-1: Stationary Combustion Fuel Consumed

$\text{Fuel consumed [MMBtu]} = \text{Fuel consumed [units of fuel type]} \bullet \text{HHV [MMBtu/units of fuel type]}$
--

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).¹⁸

Step 4: Calculate each fuel's GHG emissions and convert to metric tons (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). It will convert units into metric tons (MT).

Equation A-2: Stationary Combustion GHG Emissions¹⁹

$\text{CO}_2 \text{ emissions [MT]} =$
--

$\text{Fuel consumed [MMBtu]} \bullet \text{CO}_2 \text{ emission factor [kg/MMBtu]} \bullet 0.001 \text{ [MT/kg]}$

$\text{CH}_4 \text{ Emissions [MT]} =$
--

$\text{Fuel consumed [MMBtu]} \bullet \text{CH}_4 \text{ emission factor [kg/MMBtu]} \bullet 0.001 \text{ [MT/kg]}$

$\text{N}_2\text{O Emissions [MT]} =$

$\text{Fuel consumed [MMBtu]} \bullet \text{N}_2\text{O emission factor [kg/MMBtu]} \bullet 0.001 \text{ [MT/kg]}$
--

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

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

¹⁸ 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.

¹⁹ 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>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/scf²⁰]</p> <p>= (100 [KCUFT] • 1000 [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>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>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 metric tons (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 Portal.**</p>	

No advanced methodologies for stationary combustion are available for reporting.

²⁰ 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.). Biofuels can include landfill gas and biodiesel in generators.

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.)

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

Data Element	Preferred Source
Biomass by type: Total amount [MMBtu]	<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

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 metric tons (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 consumed [MMBtu]	= Fuel consumed [short tons] • HHV [MMBtu/ton]
	= 134 [short tons] • 15.38 [MMBtu/short ton]
	= 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.	

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

The wood waste emission factors for CH₄ and N₂O are 0.032 and 0.0042 kg/MMBtu.

Step 4: Calculate each fuel's GHG emissions and convert them to metric tons (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:*

$$\begin{aligned} \text{CO}_2\text{e} &= (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP}) \\ \text{Emissions} &= (0.0659 \text{ [MT CH}_4\text{]} \bullet 21) + (0.0087 \text{ [MT N}_2\text{O]} \bullet 310) \\ \text{[MT CO}_2\text{e]} &= 1.385 \text{ [MT CO}_2\text{e]} + 2.683 \text{ [MT CO}_2\text{e]} \\ &= \mathbf{4.08 \text{ [MT CO}_2\text{e]}} \end{aligned}$$

➤ *Reported as biogenic in scope 1:*

$$\begin{aligned} \text{CO}_2\text{e} &= \text{MT CO}_2 \\ \text{Emissions} &= \mathbf{193.31 \text{ [MT CO}_2\text{]}} \\ \text{[MT CO}_2\text{e]} & \end{aligned}$$

****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 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), E-85, and other fuels derived from fossil fuel sources.

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

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 [Gal]*	<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 Steps²¹

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 7.

1. Determine the total amount of fuel consumed by type
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. Convert the CH₄ and N₂O emission factors from g/mile to kg/gal of fuel using default assumptions
5. Calculate the total CO₂ emissions and convert them to metric tons (MT)
6. Calculate the total CH₄ and N₂O emissions and convert them to metric tons (MT)
7. Convert CH₄ and N₂O emissions to MT CO₂e and determine the total emissions

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

²¹ EPA, Climate Leaders Technical Guidance, *Direct Emissions from Mobile Combustion Sources*, May 2008.

The FAST system includes agency-level information on fuel consumption per fuel type. To the greatest extent feasible, these data will be automatically imported from the FAST system into the GHG Reporting Portal. Agencies should review this data for accuracy. The agency can modify the imported 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-15.

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

To the greatest extent feasible, the GHG Reporting Portal will select the appropriate emission factor for each fuel. Table D-2 shows CO₂ emission factors by fuel. It will multiply the default higher heating value (HHV) [MMBtu/gal] by the default emission factor [kg/MMBtu] to determine the kg/gal CO₂ emission factor automatically.

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

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.²² For FY 2010 reporting, the GHG Reporting Portal will use the emission factors for a 2005 gasoline light-duty truck with LEV technology or advanced controls (0.0148 g CH₄/mile and 0.0157 g N₂O/mile) (See Table D-4).²³

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.

Step 4: Convert the CH₄ and N₂O emission factors from g/mile to kg/gal of fuel using default assumptions

For FY 2010 reporting, the GHG Reporting Portal will use the example 2005 light-duty truck with a fuel efficiency of 16.2 miles per gallon (MPG) for the fleet.²⁴ The GHG Reporting Portal then will multiply the default MPG (16.2 MPG for FY 2010) by the CH₄ and N₂O emission factors in g/mile (Step 3) to determine a kg/gal emission factor.

²² 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. Future revisions will revisit and update these assumptions as new emission factor data become available.

²³ EPA, Climate Leaders, *Mobile Combustion Sources*, May 2008, Tables A-1, A-6, and A-7.

²⁴ US DOT, FHWA, Highway Statistics 2005, Table VM-1. See www.fhwa.dot.gov/policy/ohim/hs05/pdf/vm1.pdf.

Equation A-4: Mobile Combustion Converted Emission Factor (Default)

Converted mobile emission factor [kg/gal] =

$$\text{CH}_4 \text{ or N}_2\text{O emission factor [g/mi]} \bullet \text{Default vehicle efficiency [mi/gal]} \bullet 0.001 \text{ [kg/g]}$$

Step 5: Calculate the total CO₂ emissions and convert them to metric tons (MT)

To determine CO₂ emissions from mobile combustion, the GHG Reporting Portal will multiply fuel use (Step 1) by the CO₂ emission factor (Step 2), and then convert kilograms (kg) to metric tons (MT).

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

CO₂ emissions [MT CO₂] =

$$\text{Vehicle fuel consumption [gal]} \bullet \text{CO}_2 \text{ emission factor [kg/gal]} \bullet 0.001 \text{ [MT/kg]}$$

Step 6: Calculate the total CH₄ and N₂O emissions and convert them to metric tons (MT)

The GHG Reporting Portal will multiply the fuel use (Step 1) by the converted mobile emission factors for CH₄ and N₂O (Step 4) and then convert kg to metric tons (MT).

Equation A-6: Mobile Combustion CH₄ and N₂O Emissions (Fossil Fuels—Default)

CH₄ emissions [MT CH₄] =

$$\text{Vehicle fuel consumption [gal]} \bullet \text{CH}_4 \text{ emission factor [kg/gal]} \bullet 0.001 \text{ [MT/kg]}$$

N₂O emissions [MT N₂O] =

$$\text{Vehicle fuel consumption [gal]} \bullet \text{N}_2\text{O emission factor [kg/gal]} \bullet 0.001 \text{ [MT/kg]}$$

Step 7: Convert CH₄ and N₂O emissions to MT CO₂e and determine the total emissions

The GHG Reporting Portal will use the 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-7: Mobile Combustion MT CO₂e Emissions (Fossil Fuels—Default)

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

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

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

The agency fleet consumed 500,000 gallons of gasoline.

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

$$\text{CO}_2 = \text{Gasoline HHV [MMBtu/gal]} \bullet \text{Gasoline emission factor [kg/MMBtu]}$$

emission factor [kg/gal] = 0.125 [MMBtu/gal] • [70.22 kg/MMBtu] = 8.78 [kg/gal]
<p><i>Step 3: Determine the appropriate CH₄ and N₂O emission factors for each fuel using default assumptions</i></p> <p>The default emission factors for the default vehicle (light truck, LEV technology, 2005) are 0.0148 g/mi for CH₄ and 0.0157 g/mi for N₂O.</p> <p><i>Step 4: Convert the CH₄ and N₂O emission factors from g/mile to kg/gal of fuel using default assumptions</i></p>
<p align="center">Equation A-4: Mobile Combustion Converted Emission Factor (Default)</p> CH₄ emission factor [kg/gal] = CH ₄ emission factor [g/mi] • Default vehicle efficiency [mi/gal] • 0.001 [kg/g] = 0.0148 [g/mi] • 16.2 [mi/gal] • 0.001 [kg/g] = 2.40 x 10 ⁻⁴ [kg/gal]
N₂O emission factor [kg/gal] = N ₂ O emission factor [g/mi] • Default vehicle efficiency [mi/gal] • 0.001 [kg/g] = 0.0157 [g/mi] • 16.2 [mi/gal] • 0.001 [kg/g] = 2.54 x 10 ⁻⁴ [kg/gal]
<p><i>Step 5: Calculate the total CO₂ emissions and convert them to metric tons (MT)</i></p>
<p align="center">Equation A-5: Mobile Combustion CO₂ Emissions (Fossil Fuels)</p> CO₂ emissions [MT CO₂] = Vehicle fuel consumption [gal] • CO ₂ emission factor [kg/gal] • 0.001 [MT/kg] = 500,000 [gal] • 8.78 [kg/gal] • 0.001 [MT/kg] = 4,390 [MT CO ₂]
<p><i>Step 6: Calculate the total CH₄ and N₂O emissions and convert them to metric tons (MT)</i></p>
<p align="center">Equation A-6: Mobile Combustion CH₄ and N₂O Emissions (Fossil Fuels—Default)</p> CH₄ emissions [MT CH₄] = Vehicle fuel consumption [gal] • CH ₄ emission factor [kg/gal] • 0.001 [MT/kg] = 500,000 [gal] • 2.40 x 10 ⁻⁴ [kg/gal] • 0.001 [MT/kg] = 1.20 x 10 ⁻¹ [MT CH ₄]
N₂O emissions [MT N₂O] = Vehicle fuel consumption [gal] • N ₂ O emission factor [kg/gal] • 0.001 [MT/kg] = 500,000 [gal] • 2.54 x 10 ⁻⁴ [kg/gal] • 0.001 [MT/kg] = 1.27 x 10 ⁻¹ [MT N ₂ O]
<p><i>Step 7: Convert CH₄ and N₂O emissions to MT CO₂e and determine total emissions</i></p>
<p align="center">Equation A-7: Mobile Combustion MT CO₂e Emissions (Fossil Fuels—Default)</p> CO₂e Emissions [MT CO₂e] = MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP) = 4,390 [MT CO ₂] + (1.20 x 10 ⁻¹ [MT CH ₄] • 21) + (1.27 x 10 ⁻¹ [MT N ₂ O] • 21) = 4,390 [MT CO ₂] + 2.52 [MT CO ₂ e] + 39.37 [MT CO ₂ e] = 4,431.89 MT CO₂e
<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 Portal.**</p>

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: 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 metric tons (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.²⁵

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 metric tons (MT)

²⁵ EPA, Climate Leaders, *Direct Emissions from Mobile Combustion Sources*, Appendix A, May 2008. See www.epa.gov/climateleaders/documents/resources/mobilesource_guidance.pdf.

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)

CH₄ emissions [MT CH₄] = Total miles traveled [mi] • CH ₄ emission factor [g/mi] • 0.001 [kg/g] • 0.001 [MT/kg]
N₂O emissions [MT N₂O] = Total miles traveled [mi] • N ₂ O emission factor [g/mi] • 0.001 [kg/g] • 0.001 [MT/kg]

Step 5: Determine the total annual MT CO₂e

To determine the total CO₂e 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 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)
--

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

CO₂ emission factor [kg/gal]	=	HHV [MMBtu/gal] • Diesel emission factor [kg/MMBtu]
	=	0.138 [MMBtu/gal] • 73.96 [kg/MMBtu]
	=	10.21 [kg/gal]

Step 3: Calculate the total CO₂ emissions and convert them to metric tons (MT)

Equation A-5: Mobile Combustion CO₂ Emissions (Fossil Fuels)		
CO₂ emissions [MT]	=	Vehicle fuel consumption [gal] • CO ₂ emission factor [kg/gal] • 0.001 [MT/kg]
	=	2,350 [gal] • 10.21 [kg/gal] • 0.001 [MT/kg]
	=	23.99 [MT CO ₂]

➤ **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 metric tons (MT)

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

$$\text{CH}_4 \text{ emissions [MT]} = \text{Total miles traveled [mi]} \bullet \text{CH}_4 \text{ emission factor [g/mi]} \bullet 0.001 \text{ [kg/g]} \bullet 0.001 \text{ [MT/kg]}$$

$$= 35,250 \text{ miles} \bullet 0.0009 \text{ [g/mi]} \bullet 0.001 \text{ [kg/g]} \bullet 0.001 \text{ [MT/kg]}$$

$$= 3.17 \times 10^{-5} \text{ [MT CH}_4\text{]}$$

$$\text{N}_2\text{O emissions [MT]} = \text{Total miles traveled [mi]} \bullet \text{N}_2\text{O emission factor [g/mi]} \bullet 0.001 \text{ [kg/g]} \bullet .001 \text{ [MT/kg]}$$

$$= 35,250 \text{ miles} \bullet 0.0014 \text{ [g/mi]} \bullet 0.001 \text{ [kg/g]} \bullet 0.001 \text{ [MT/kg]}$$

$$= 4.94 \times 10^{-5} \text{ [MT N}_2\text{O]}$$

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

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

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

$$= 23.99 \text{ [MT CO}_2\text{]} + (3.17 \times 10^{-5} \text{ [MT CH}_4\text{]} \bullet 21) + (4.94 \times 10^{-5} \text{ [MT N}_2\text{O]} \bullet 310)$$

$$= 23.99 \text{ [MT CO}_2\text{]} + 6.66 \times 10^{-4} \text{ [MT CO}_2\text{e]} + 1.53 \times 10^{-2} \text{ [MT CO}_2\text{e]}$$

$$= \mathbf{24.01 \text{ [MT CO}_2\text{e]}}$$

****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 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*²⁶

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).²⁷ 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

²⁶ Primary Reference: EPA, Climate Leaders Technical Guidance, *Direct Emissions from Mobile Combustion Sources*, May 2008.

²⁷ Additional agency-specific analogous data systems may potentially be linked to the GHG Reporting Portal.

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 Energy Policy Act of 1992 and will be considered standard gasoline or petrodiesel in the GHG Reporting Portal.

When using the FAST system, agencies do not have to concern themselves with the conversion of natural gallons to gasoline gallon equivalent (GGE) or distinguishing between blends (i.e. E85, B20). For example, an agency will enter X 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)

Biofuel CO₂ emissions [MT] =

Total volume of biofuel in fuel consumed [gal] • CO₂ emission factor [kg/gal] • 0.001 [MT/kg]

Fossil fuel CO₂ emissions [MT] =

Total volume of fossil fuel in fuel consumed [gal] • CO₂ emission factor [kg/gal] • 0.001 [MT/kg]

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% of the emissions factor for ethanol (E100) and 15% 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] =

$$\begin{aligned} & (\text{Total fraction of biofuel [\%]} \bullet \text{CH}_4 \text{ emission factor [g/mile]}) \\ & + (\text{Total fraction of fossil fuel [\%]} \bullet \text{CH}_4 \text{ emission factor [g/mile]}) \end{aligned}$$

Blended N₂O emission factor [g/mile] =

$$\begin{aligned} & (\text{Total fraction of biofuel [\%]} \bullet \text{N}_2\text{O emission factor [g/mile]}) \\ & + (\text{Total fraction of fossil fuel [\%]} \bullet \text{N}_2\text{O emission factor [g/mile]}) \end{aligned}$$

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.

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

Blended CH₄ emission factor [g/mile] =

$$\begin{aligned} & (\text{Total fraction of biofuel [\%]} \bullet \text{CH}_4 \text{ emission factor [g/mile]}) \\ & + (\text{Total fraction of fossil fuel [\%]} \bullet \text{CH}_4 \text{ emission factor [g/mile]}) \end{aligned}$$

Blended N₂O emission factor [g/mile] =

$$\begin{aligned} & (\text{Total fraction of biofuel [\%]} \bullet \text{N}_2\text{O emission factor [g/mile]}) \\ & + (\text{Total fraction of fossil fuel [\%]} \bullet \text{N}_2\text{O emission factor [g/mile]}) \end{aligned}$$

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	=	Total fraction of ethanol in fuel consumed [gal] • CO ₂ emission factor [kg/gal] •
CO₂		0.001 [MT/kg]
emissions	=	2,125 [gal] • 5.75 [kg/gal] • 0.001 [MT/kg]
[MT]	=	12.22 [MT CO ₂]
Gasoline	=	Total fraction of gasoline in fuel consumed [gal] • CO ₂ emission factor [kg/gal] •
CO₂		0.001 [MT/kg]
emissions	=	375 [gal] • 8.78 [kg/gal] • 0.001 [MT/kg]
[MT]	=	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-6 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	=	(Total fraction of biofuel [%] • CH ₄ emission factor [g/mile]) + (Total fraction of
emission		fossil fuel [%] • CH ₄ emission factor [g/mile])
factor	=	(.85 • 0.055) + (.15 • 0.0148)
[g/mile]	=	0.049 [g/mi]
E85 N₂O	=	(Total fraction of biofuel [%] • N ₂ O emission factor [g/mile]) + (Total fraction of
emission		fossil fuel [%] • N ₂ O emission factor [g/mile])
factor	=	(.85 • 0.067) + (.15 • 0.0157)
[g/mile]	=	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 Emissions [MT CO₂e]	= MT CO ₂
	= 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 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 (CFCs and HCFCs) are not considered 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.²⁸

F-gas fugitive emissions can occur during the manufacture, installation, use, service, and disposal of heating, ventilation, and air conditioning (HVAC) and refrigeration equipment;

²⁸ 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).

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 assumed that all agency emissions of F-gases are “fugitive.” 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 must 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 (discussed further below) or calculating emission rates (such as kg HFC emitted per kg HFC charge).²⁹

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.

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.

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

Default and Advanced Methodologies³⁰

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 screening approach (default)
2. Material balance approach (advanced)

²⁹ 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.

³⁰ 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.

3. Simplified material balance approach (advanced)
4. Screening approach (advanced)

The default method is a simplified screening 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.

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 ODSs. 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 surrogate for 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.³¹ If the agency knows that its total charge is declining significantly, it can 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.

³¹ 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 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 storage [lb]	<ul style="list-style-type: none">• GSA• Defense Logistics Agency• Agency logistics/supply organizations• Chemical inventory tracking system	<ul style="list-style-type: none">• Local hazardous material management/distribution centers• 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-14 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.

$$\text{Total mass of gas [lb]} = \text{volume of gas [cu ft]} \bullet \text{conversion factor [cu m/cu ft]} \bullet \text{density of gas [lb/cu m]}$$

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

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

$$\text{Annual Emissions [MT F-gas]} = (I - R) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]}$$

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)

$$\begin{aligned} \text{Annual Emissions} &= (I - R) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]} \\ &= (220 \text{ [lb]} - 55 \text{ [lb]}) \bullet 4.536 \times 10^{-4} \text{ [MT/lb]} \\ \text{[MT HFC-23]} &= 7.48 \times 10^{-2} \text{ [MT HFC-23]} \end{aligned}$$

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 3: Convert annual emissions to MT CO₂e and sum emissions

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

$$\begin{aligned} \text{CO}_2\text{e} &= \text{Annual Emissions [MT]} \bullet \text{F-gas GWP} \\ \text{[MT F-gas]} &= 7.48 \times 10^{-2} \text{ [MT]} \bullet 11,700 \\ &= \mathbf{875.16 \text{ [MT CO}_2\text{e]}} \end{aligned}$$

****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 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)

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

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)

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

****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 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 have 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 C.F.R. 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

F-gas acquisitions during the reporting period [lb] ³²	<ul style="list-style-type: none"> • Maintenance records • Chemical inventory tracking system
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] ³³	
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,²⁹ sales and other disbursements,³⁰ and net change of total equipment capacity for a given F-gas during the year.³⁴

Step 3: Calculate the annual emissions

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

³² 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.

³³ 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.

³⁴ 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.

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]

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)

CO₂e emissions [MT F-gas] = Annual Emissions [MT] • F-gas GWP
 = 0.25 [MT] • 11,700
 = **2,925 [MT]**

****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 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, or 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 charge of the new equipment [lb]

P_S = Quantity of F-gas used to service equipment [lb]

C_D = Total full charge 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 charge of the new equipment = 882 lb
- Quantity of HFC-23 used to service equipment = 441 lb
- Total full charge 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)

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 [MT HFC-23]

Where:*

P_N	=	Purchases of F-gas used to charge new equipment [lb]
C_N	=	Total full charge of the new equipment [lb]
P_S	=	Quantity of F-gas used to service equipment [lb]
C_D	=	Total full charge 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)

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

****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 Portal.**

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

Advanced Methodology 3: Screening Approach³⁵

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

³⁵ Although this enhanced screening approach would enhance the fidelity of estimates over the default methodology, the fugitive emission estimates are still uncertain.

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-14 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)

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)

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

* 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 = 1764 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 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. Wastewater from domestic (municipal sewage) and industrial sources is treated to remove soluble organic matter, suspended solids, pathogenic organisms, and chemical contaminants. Wastewater treatment plant (WWTP) processes can produce anthropogenic CH₄ and N₂O emissions.

This section focuses solely on calculating the CH₄ and N₂O emissions created by centralized 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 wastewater treatment plant and uses default 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.³⁶ 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 applies population-based calculations that use national average defaults. The population served includes not only Federal employees, but also on-site contractors and visitors who are contributing biological oxygen demand to the treatment stream at the WWTP (Table A-10). The GHG Reporting Portal will allow for customization in the number of hours the population is using the system (default is 12 hours).

³⁶ 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*.

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

Data Element	Preferred Source	Alternate Source
Type of WWTP	• Default provided	• Wastewater operations division
Population served (includes employees, on-site contractors, and visitors) ³⁷	• Agency records	• 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.

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

Step 1: Determine which wastewater treatment processes are used

The emissions from WWTPs depend on the wastewater treatment processes used. Agencies should coordinate with their wastewater operations division to determine which of the

³⁷ 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 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 is available, this should be used and converted to full time equivalent population served as an advanced methodology.

processes outlined in Table A-11 are part of the agency wastewater treatment operations. The agency enters the population served by each type of process.

As much as possible, agencies may need to adjust the population served for some wastewater treatment processes if there are significant industrial contributions to the system. The contribution factor from industry is calculated by dividing units of nitrogen or biological oxygen demand (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 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 CH ₄ in biogas, default value of 0.65
ρ(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 *Local Government Operations Protocol (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.³⁸

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 N₂O Emissions from WWTP with Nitrification/Denitrification (Default)

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

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	=	Emission factor for a WWTP with nitrification/denitrification [g N ₂ O/person/day],

³⁸ 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).

nit/denit	default value of 0.019
10^{-6}	= Conversion from g to MT [MT/g]

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)

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

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}^{39}	=	Per capita nitrogen load [kg N/person/day], default value of 0.026
N_{uptake}^{40}	=	Nitrogen uptake for cell growth in aerobic system/anaerobic system [kg N/kg BOD ₅],

³⁹ 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.

		default values of 0.05* for aerobic and 0.005* for anaerobic
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

⁴⁰ 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.

$MCF_{\text{anaerobic}}$	=	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 CH_4 in the process. If an agency has operational control of septic systems, fugitive CH_4 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 CH_4 Emissions from Septic Systems (Default)

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

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)
$\text{BOD}_5 \text{ load}$	=	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 CO_2e .

Equation A-25: Fugitive Wastewater Treatment MT CO_2e Emissions (Default)

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

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 N_2O , 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 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
2. Calculate emissions from each wastewater treatment process used
3. Sum emissions from all processes

Step 1: Determine which wastewater treatment processes are used

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.

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 *Code of Federal Regulations* (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)

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

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.⁴¹

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).

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

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

⁴¹ 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).

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)

Annual CH₄ 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)

Annual CH₄ emissions [MT] = BOD₅ load • B_o • MCF_{septic} • 365.25 • 0.001

Where:

BOD ₅ load	=	Amount of BOD ₅ produced per day [kg BOD ₅ /day]
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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 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)

$CO_2e \text{ Emissions [MT CO}_2e] = (MT \text{ CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (MT \text{ N}_2\text{O} \bullet \text{N}_2\text{O GWP})$
--

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

Description

This category includes emissions from the disposal and treatment of municipal solid waste (MSW) generated as a result of agency operations. This category does not include construction and demolition wastes. 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.

The default approach for calculating solid waste emissions is based on both the EPA’s Landfill Gas Emissions Model (LandGEM)⁴² 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.

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

Data Sources

The EPA’s LandGEM model is well established tool for regulatory reporting purposes.⁴³ 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),

⁴² 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.

⁴³ LandGEM is a first order decay (FOD) 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.

non-methane organic compounds, and individual air pollutants from municipal solid waste landfills. However, this model does not consider emission reductions from LFG capture.

The GHG Reporting Portal will assume 50 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 and landfill open year and close year for LandGEM. Table A-15 shows the data sources.

Table A-15: Fugitive Emissions—Landfills/Municipal Solid Waste 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
Methane 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
NMOC concentration, ppmv		<ul style="list-style-type: none"> Default provided by GHG Reporting Portal
Methane 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 Steps ⁴⁴

Landfill fugitive emission can be calculated using the following steps:

1. Use EPA’s LandGEM to calculate the CO₂ and CH₄ generation and input into GHG Reporting Portal
2. Calculate emissions from municipal solid waste landfills

Step 1: 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 municipal solid waste.

⁴⁴ 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.

LandGEM’s most accurate estimates are calculated when past and current year quantities of municipal solid waste are entered.⁴⁵ 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 disposed⁴⁶, landfill open and close date, and the mass of CH₄ and CO₂ determined by LandGEM into the GHG Reporting Portal.

Step 2: Calculate emissions from municipal solid waste 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).

Equation A-33 does not take into account landfill gas flaring, which is a stationary combustion emission source. Flaring is 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-33 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-33: Fugitive Emissions from Solid Waste Facilities (Default)

CO₂e Emissions [MT] =	
	$\frac{((CH_{4gen} \bullet CH_{4release} \bullet (1 - OX_B)) + (CH_{4gen} \bullet (1 - CH_{4release}) \bullet (1 - \eta_{LFGsystem}) \bullet (1 - OX_B))) \bullet GWP}{GWP}$
Where:	
CH _{4gen}	= CH ₄ generated by landfill, calculated in LandGEM [MT]
CH _{4release}	= 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
η _{LFGsystem}	= Efficiency of LFG collection system, default value of 0.75
GWP	= Global Warming Potential of CH ₄ , 21

⁴⁵ 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.

⁴⁶ 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 Clean Air Act 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.

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.

Step 1: Use EPA’s LandGEM to calculate the CO₂ and CH₄ 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 the LandGEM. LandGEM outputs that the waste generates 1,000 MT of CO₂ and 1,000 MT of CH₄. As no site-specific data are available, the agency uses available default values.

➤ *Reported as biogenic emissions in scope 1* = 1,000 MT CO₂

Step 2: Calculate emissions from landfills and solid waste facilities

Equation A-33: 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:

- CH_{4gen} = CH₄ generated by landfill, calculated in LandGEM [MT]
- CH_{4release} = Percentage of uncontrolled release of CH₄, default national average value of 0.5
- OX_B = Methotropic Bacteria Oxidation Factor, default value of 0.10
- η_{LFGsystem} = Efficiency of LFG collection system, default value of 0.75
- GWP = Global Warming Potential of CH₄, 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 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 MRR, 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/Municipal Solid Waste 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
Methane concentration rate, k		• Waste operations division
Potential methane generation capacity, Lo		• Waste operations division
NMOC concentration, ppmv		• Waste operations division
Methane 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-34: Fugitive Emissions from Solid Waste Facilities (Advanced)

<p>CO₂e Emissions [MT] = $((CH_{4gen} \bullet CH_{4release} \bullet (1 - OX_B)) + (CH_{4gen} \bullet (1 - CH_{4release}) \bullet (1 - \eta_{LFGsystem}) \bullet (1 - OX_B))) \bullet GWP$</p> <p>Where:</p> <p>CH_{4gen} = CH₄ generated by landfill, calculated in LandGEM [MT]</p> <p>CH_{4release} = Percentage of uncontrolled release of CH₄ (either 1.0 or 0 depending on presence of LFG-collection system)</p> <p>η_{LFGsystem} = Efficiency of LFG collection system, default value of 0.75</p>
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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 MRR 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 MRR 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 MRR Technical Support Document: 40 CFR 98, Subpart G
 - IPCC 2006 Guidelines, Volume 3, Chapter 3, Equation 3.3
- Cement production (process CO₂ emissions)
 - EPA MRR 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 MRR 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 MRR 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 MRR 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 MRR 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 MRR 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

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) facility⁴⁷
- Steam purchases from a municipal solid waste (MSW) waste-to-energy (WTE) facility
- Reductions from RECs⁴⁸

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.

Table B-1: Purchased Electricity Default Data Sources

Data Element	Preferred Source
Purchased Electricity [MWh]	• FEMP Energy Report or purchasing records by eGRID subregion
Emission Factor [kg/MWh] or	• Standardized emission factors provided in Table D-8

⁴⁷ CHP methodology can be used for advanced methodology for estimating the emissions associated with the purchased electricity generated at a waste-to-energy facility.

⁴⁸ Note that this appendix also includes a calculation methodology for GHGs associated with RECs because they can be used to reduce scope 2 emissions.

[kg/GWh]	
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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 metric tons (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.⁴⁹ Agencies should refer to the Federal Energy Management Guidance⁵⁰ 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 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 that is closest to the year of their inventory activity data.⁵¹ Agencies are not expected to

⁴⁹ 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.
⁵⁰ FEMP, Federal Energy Management Guidance. See www1.eere.energy.gov/femp/regulations/guidance.html.
⁵¹ eGRID publishes data regularly but reflects the operational data from power plants from 2-3 years prior. For example, eGRID2007 has year 2005 operational data but is configured to company ownerships and industry structures as of year 2007.

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 metric tons (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 metric tons (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>
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Transmission and Distribution 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).

Example B-1: Purchased Electricity (Default)

<p>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.</p> <p><i>Step 1: Determine annual use of purchased electricity from all facilities within the agency’s operational control</i></p>

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 = 514.77 [kg/MWh]
- CH₄ emission factor = 10.78 [kg/GWh]
- N₂O emission factor = 8.98 [kg/GWh]

Step 3: Calculate total CO₂, CH₄, and N₂O emissions, and convert them to metric tons (MT)

Equation B- 1: Purchased Electricity GHG Emissions

CO₂ Emissions [MT] = Electricity use [MWh] • CO₂ emission factor [kg CO₂/MWh] • 0.001 [MT/kg]
 = 30,000 [MWh] • 514.77 [kg CO₂/MWh] • 0.001 [MT/kg]
 = 15,443.1 [MT CO₂]

CH₄ Emissions [MT] = Electricity use [MWh] • CH₄ emission factor [kg CH₄/MWh] • 0.001 [MT/kg] • 0.001 [GWh/MWh]
 = 30,000 [MWh] • 8.98 [kg CH₄/GWh] • 0.001 [MT/kg] • 0.001 [GWh/MWh]
 = 0.269 [MT CH₄]

N₂O Emissions [MT] = Electricity use [MWh] • N₂O emission factor [kg N₂O/MWh] • 0.001 [MT/kg] • 0.001 [GWh/MWh]
 = 30,000 [MWh] • 10.78 [kg CH₄/GWh] • 0.001 [MT/kg] • 0.001 [GWh/MWh]
 = 0.3234 [MT N₂O]

Step 4: Convert to MT CO₂e and calculate total emissions

Equation B-2: Purchased Electricity MT CO₂e Emissions

Total Emissions [MT CO₂e] = MT CO₂ + (MT CH₄ • CH₄ GWP) + (MT N₂O • N₂O GWP)
 = 15,443.1 [MT CO₂] + (0.2694 [MT CH₄] • 21) + (0.3234 [MT N₂O] • 310)
 = **15,549.01 [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 Portal.**

B.1.2. Alternative Data Estimation Methods (User Calculated)⁵²

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 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

⁵² The Climate Registry, *Local Government Operations Protocol*, Version 1.0, September 2008.

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.⁵³

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.

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

Data Element	Preferred Source
Size of the facility [sq ft]	• Building Manager
Size [sq ft] and annual electricity	• Buildings Manager of

⁵³ National Climate Data Center. See: www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp#.

use [MWh] of comparable facilities	comparable facilities
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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. Energy Information Administration’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 CO_{2e} 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 metric tons (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.⁵⁴ 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),⁵⁵ steam production efficiency (75 percent),⁵⁶ and distribution loss (10 percent).^{57,58}

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>

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

⁵⁴ 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.

⁵⁵ DOE, Industrial Technology Programs, Energy Use and Loss Footprints, Assumption and Definitions. See www1.eere.energy.gov/industry/program_areas/footprints.html.

⁵⁶ eGRID2007 Technical Support Document, EPA. See www.epa.gov/cleanenergy/documents/eGRIDzips/eGRIDwebV1_0_UsersManual.pdf.

⁵⁷ 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.

⁵⁸ 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.

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)⁵⁹ and distribution loss (10 percent).⁶⁰

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 metric tons (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]

⁵⁹ DOE EERE, Industrial Technology Programs, Energy Use and Loss Footprints, Assumption and Definitions. See www1.eere.energy.gov/industry/program_areas/footprints.html.

⁶⁰ 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 metric tons (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

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

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]	$= \text{CO}_2 \text{ emission factor [kg/MMBtu]} \div (\text{boiler efficiency [\%]} \bullet (1- \text{distribution loss [\%]}))$ $= 53.02 \text{ [kg CO}_2\text{/MMBtu]} \div (0.80 \bullet 0.90)$ $= 73.64 \text{ [kg CO}_2\text{/MMBtu]}$
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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 metric tons (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 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*⁶¹

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 metric tons

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

⁶¹ 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 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 loss⁶² adjustment factor (default percentage of loss 10%)⁶³ then dividing by the COP of the cooling plant. The cooling plant energy input is represented by the following equation:

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.

⁶² 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.

⁶³ 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.

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

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 metric tons) by the GWP value, included in Table D-13. The GHG Reporting Portal will sum the CO₂e emissions of each of the three gases to obtain total GHG emissions.

Equation B-21: 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

$$\begin{aligned} \text{Conversion from ton hours to MMBtu} &= 320,000 \text{ [ton hours]} \bullet 0.012 \text{ [MMBtu/ton hour]} \\ &= 3,840 \text{ [MMBtu]} \end{aligned}$$

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

$$\begin{aligned} \text{Energy Input from Cooling Plant} &= \text{Agency cooling demand [MMBtu]} \bullet \text{Transmission loss adjustment factor [\%]} \div \\ &\quad \text{Cooling plant COP} \\ &= 3,840 \text{ [MMBtu]} \bullet (1/(1 - 0.10))/0.80 \\ &= 3,840 \text{ [MMBtu]} \bullet 1.11/0.80 \\ &= 5,328 \text{ [MMBtu]} \end{aligned}$$

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

$$\begin{aligned} \text{Convert to MWh} &= \text{Electricity input [MMBtu]} \bullet \text{conversion factor [MWh/MMBtu]} \\ &= 5,328 \text{ [MMBtu]} \bullet 1/3.413 \text{ [MWh/MMBtu]} \\ &= 5,328 \text{ [MMBtu]} \div 3.413 \text{ [MWh]} \\ &= 1,561.09 \text{ [MWh]} \end{aligned}$$

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 = 697.54 [lb/MWh]
- CH₄ = 8.27 [lb/GWh] = 8.27 [lb/GWh] • 0.001 = 0.00827 [lb/MWh]
- N₂O = 11.66 [lb/GWh] = 11.66 [lb/GWh] • 0.001 = 0.01166 [lb/MWh]

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

The agency multiplies the energy input in MWh by the emission factor and converts them to metric tons (MT).

$$\begin{aligned} \text{CO}_2 &= 1561.09 \text{ [MWh]} \bullet 697.54 \text{ [lb CO}_2\text{/MWh]} \bullet 4.53592 \times 10^{-4} \text{ [MT/lb]} \\ \text{Emissions} &= 493.93 \text{ [MT CO}_2\text{]} \\ \text{[MT CO}_2\text{]} & \end{aligned}$$

$$\begin{aligned} \text{CH}_4 &= 1561.09 \text{ [MWh]} \bullet 0.00827 \text{ [lb CH}_4\text{/MWh]} \bullet 4.53592 \times 10^{-4} \text{ [MT/lb]} \\ \text{Emissions} &= 0.00586 \text{ [MT CH}_4\text{]} \\ \text{[MT CH}_4\text{]} & \end{aligned}$$

$$\begin{aligned} \text{N}_2\text{O} &= 1561.09 \text{ [MWh]} \bullet 0.01166 \text{ [lb N}_2\text{O/MWh]} \bullet 4.53592 \times 10^{-4} \text{ [MT/lb]} \\ \text{Emissions} &= 0.00826 \text{ [MT N}_2\text{O]} \\ \text{[MT N}_2\text{O]} & \end{aligned}$$

Equation B-12: Conversion to CO₂e and Determination of Total Emissions

$$\begin{aligned} \text{CO}_2 &= \text{MT CO}_2 + (\text{MT CH}_4 \bullet \text{CH}_4 \text{ GWP}) + (\text{MT N}_2\text{O} \bullet \text{N}_2\text{O GWP}) \\ \text{Emissions} &= 493.93 \text{ [MT CO}_2\text{]} + (0.005856 \text{ [MT CH}_4\text{]} \bullet 21) + (0.008256 \text{ [MT N}_2\text{O]} \bullet 310) \\ \text{[MT CO}_2\text{e]} &= 493.9276 + 0.122975611 + 2.55949 \\ &= \mathbf{496.61 \text{ [MT CO}_2\text{e]}} \end{aligned}$$

****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 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 Combined Heat and Power 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: Combined Heat and Power 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: Combined Heat and Power 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 metric tons 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 Guidance⁶⁴ 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

⁶⁴ FEMP, Energy Report guidance. See www1.eere.energy.gov/femp/regulations/guidance.html.

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)
- 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

<p>eGRID CHP Steam Emission Factor [lb CO₂/MMBtu] = $\frac{[(UNCO_2 - PLCO_2AN) \bullet STLC]}{[(USETHRMO \bullet SP) \bullet (1 - DL)]}$</p>

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: eGRID2007 Technical Support Document, EPA. See www.epa.gov/cleanenergy/documents/egridzips/eGRID2007TechnicalSupportDocument.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

$$\text{eGRID CHP Hot Water Emission Factor [lb CO}_2\text{/MMBtu]} = \frac{[(\text{UNCO}_2 - \text{PLCO}_2\text{AN}) \bullet \text{STLC}] \div [\text{USETHRMO} \bullet (1 - \text{DL})]}$$

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: eGRID2007 Technical Support Document, EPA. See www.epa.gov/cleanenergy/documents/egridzips/eGRID2007TechnicalSupportDocument.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 metric tons 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

<p>CO₂ Emissions [MT CO₂] = Hot water use [MMBtu] • Emission factor [lb CO₂/MMBtu] ÷ 2,204.62 [lb/metric ton]</p>
<p>CH₄ Emissions [MT CH₄] = Hot water use [MMBtu] • Emission factor [lb CH₄/MMBtu] ÷ 2,204.62 [lb/metric ton]</p>
<p>N₂O Emissions [MT N₂O] = Hot water use [MMBtu] • Emission factor [lb N₂O/MMBtu] ÷ 2,204.62 [lb/metric ton]</p>

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 metric tons (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

<p>CO₂e Emissions [MT CO₂e] = MT CO₂ + (MT CH₄ • CH₄ GWP) + (MT N₂O • N₂O GWP)</p>
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Example B-4: Heat and Power Purchases from a Combined Heat & 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 Olympus Power, LLC. 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 and its Electricity Emission Factors in eGRID Plant File

- CO₂ Emission Factor [lb CO₂/MWh] = PLCO₂RTA = 1230.9 [lb CO₂/MWh]
- CH₄ Emission Factor [lb CH₄/GWh] = PLCH₄RTA = 23.8 [lb CH₄/GWh]
- N₂O Emission Factor [lb N₂O/GWh] = PLN₂O RTA = 2.3833 [lb N₂O/GWh]

Step 3: Calculate CHP Plant Steam Emission Factors from eGRID

<p>CO₂ Emission Factor [lb/MMBtu]</p>	<p>= [(UNCO₂ – PLCO₂AN) • STLC] ÷ [(USETHRMO • SP) • (1 – DL)] = [(1,095,258.8 [short tons CO₂] – 1,093,667.6 [short tons CO₂]) • 2000[lb/short ton]] ÷ [(11,765.4 [MMBtu] • 0.75) • (1 – 0.10)] = [1,591.2 [short tons CO₂] • 2000 [lb/short ton]] ÷ [8,824.1 [MMBtu] • 0.90] = 3,182,400 [lb CO₂] ÷ 7941.7 [MMBtu] = 400.7 [lb CO₂/MMBtu]</p>
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<p>CH₄ Emission Factor [lb]</p>	<p>= [(UNCH₄ – PL CH₄AN)] ÷ [(USETHRMO • SP) • (1 – DL)] = [(42,413.1 [lb CH₄] – 42,351.5 [lb CH₄])] ÷ [(11,765.4 [MMBtu] • 0.75) • (1 –</p>
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CH₄/MMBtu	$0.10]$ $= 61.6 \text{ [lb CH}_4] \div [8,824.1 \text{ [MMBtu]} \bullet 0.90]$ $= 61.6 \text{ [lb CH}_4] \div 7941.7 \text{ [MMBtu]}$ $= 0.00776 \text{ [lb CH}_4/\text{MMBtu}]$
N₂O Emission Factor [lb N₂O/MMBtu]	$= [(UNN_2O - PLN_2OAN)] \div [(USETHRMO \bullet SP) \bullet (1 - DL)]$ $= [(4241.3 \text{ [lb N}_2\text{O]} - 4235.1 \text{ [lb N}_2\text{O]})] \div [(11,765.4 \text{ [MMBtu]} \bullet 0.75) \bullet (1 - 0.01)]$ $= 6.2 \text{ [lb N}_2\text{O]} \div [8,824.1 \text{ [MMBtu]} \bullet 0.90]$ $= 6.2 \text{ [lb N}_2\text{O]} \div 7941.7 \text{ [MMBtu]}$ $= 0.00078 \text{ [lb N}_2\text{O/MMBtu]}$
<i>Step 4: Locate CHP plant and electricity emission factors in eGRID</i>	
CO₂ Emission Factor [lb CO₂/MMBtu]	$= [(UNCO_2 - PLCO_2AN) \bullet STLC] \div [USETHRMO \bullet (1 - DL)]$ $= [(1,095,258.8 \text{ [short tons CO}_2] - 1,093,667.6 \text{ [short tons CO}_2]) \bullet 2000 \text{ [lb/short ton]}] \div [11,765.4 \text{ [MMBtu]} \bullet (1 - 0.10)]$ $= [1,591.2 \text{ [short tons CO}_2] \bullet 2000 \text{ [lb/short ton]}] \div [11,765.4 \text{ [MMBtu]} \bullet 0.90]$ $= 3,182,400 \text{ [lb CO}_2] \div 10,558.9 \text{ [MMBtu]}$ $= 301.4 \text{ [lb CO}_2/\text{MMBtu}]$
CH₄ Emission Factor [lb CH₄/MMBtu]	$= [(UNCH_4 - PLCH_4AN)] \div [USETHRMO \bullet (1 - DL)]$ $= [(42,413.1 \text{ [lb CH}_4] - 42,351.5 \text{ [lb CH}_4])] \div [11,765.4 \text{ [MMBtu]} \bullet (1 - 0.10)]$ $= 61.6 \text{ [lb CH}_4] \div [11,765.4 \text{ [MMBtu]} \bullet 0.90]$ $= 61.6 \text{ [lb CH}_4] \div 10,558.9 \text{ [MMBtu]}$ $= 0.00583 \text{ [lb CH}_4/\text{MMBtu}]$
N₂O Emission Factor [lb N₂O/MMBtu]	$= [(UNN_2O - PLN_2OAN)] \div [USETHRMO \bullet (1 - DL)]$ $= [(4241.3 \text{ [lb N}_2\text{O]} - 4235.1 \text{ [lb N}_2\text{O]})] \div [11,765.4 \text{ [MMBtu]} \bullet (1 - 0.10)]$ $= 6.2 \text{ [lb N}_2\text{O]} \div [11,765.4 \text{ [MMBtu]} \bullet 0.90]$ $= 6.2 \text{ [lb N}_2\text{O]} \div 10,558.9 \text{ [MMBtu]}$ $= 0.00059 \text{ [lb N}_2\text{O/MMBtu]}$
<i>Step 5: Calculate annual emissions in metric tons (MT) of GHGs by type of energy</i>	
Equation B-14: Electricity Use GHG Emissions	
Electric CO₂ Emissions [MT CO₂]	$= \text{Electricity use [MWh]} \bullet \text{CO}_2 \text{ emission factor [lb/MWh]} \div 2,204.62 \text{ [lb/MT]}$ $= 750 \text{ [MWh]} \bullet 1230.9 \text{ [lb CO}_2/\text{MWh]} \div 2,204.62 \text{ [lb/MT]}$ $= 418.7 \text{ [MT CO}_2]$
Electric CH₄ Emissions [MT CH₄]	$= \text{Electricity Use [MWh]} \bullet \text{CH}_4 \text{ emission factor [lb/ GWh]} \div 1,000 \text{ [MWh/GWh]} \div 2,204.62 \text{ [lb/MT]}$ $= 750 \text{ [MWh]} \bullet 23.8 \text{ [lb CH}_4/\text{ GWh]} \div 1,000 \text{ [MWh/GWh]} \div 2,204.62 \text{ [lb/MT]}$ $= 0.0081 \text{ [MT CH}_4]$
Electric N₂O Emissions [MT N₂O]	$= \text{Electricity use [MWh]} \bullet \text{N}_2\text{O emission factor [lb/ GWh]} \div 1,000 \text{ [MWh/GWh]} \div 2,204.62 \text{ [lb/MT]}$ $= 750 \text{ [MWh]} \bullet 2.3833 \text{ [lb N}_2\text{O/ GWh]} \div 1,000 \text{ [MWh/GWh]} \div 2,204.62 \text{ [lb/MT]}$ $= 0.00081 \text{ [MT N}_2\text{O]}$
Equation B-15: Purchased Steam GHG Emissions	
Steam CO₂ Emissions [MT CO₂]	$= \text{Steam use [MMBtu]} \bullet \text{CO}_2 \text{ emission factor [lb/MMBtu]} \div 2,204.62 \text{ [lb/MT]}$ $= 300 \text{ [MMBtu]} \bullet 400.7 \text{ [lb CO}_2/\text{MMBtu]} \div 2,204.62 \text{ [lb/MT]}$ $= 54.5 \text{ [MT CO}_2]$
Steam CH₄ Emissions	$= \text{Steam use [MMBtu]} \bullet \text{CH}_4 \text{ emission factor [lb/MMBtu]} \div 2,204.62 \text{ [lb/MT]}$ $= 300 \text{ [MMBtu]} \bullet 0.00776 \text{ [lb CH}_4/\text{MMBtu]} \div 2,204.62 \text{ [lb/MT]}$

[MT CH₄]	= 0.00106 [MT CH ₄]
Steam N₂O Emissions [MT N₂O]	= Steam use [MMBtu] • N ₂ O emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT] = 300 [MMBtu] • 0.00078 [lb N ₂ O/MMBtu] ÷ 2,204.62 [lb/MT] = 0.00011 [MT N ₂ 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] • 301.4 (lb CO ₂ /MMBtu) ÷ 2,204.62 [lb/MT] = 20.5 [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] • 0.00583 [lb CH ₄ /MMBtu] ÷ 2,204.62 [lb/MT] = 0.000397 [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] • 0.00059 [lb N ₂ O/MMBtu] ÷ 2,204.62 [lb/MT] = 0.000040 [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) = 418.7 [MT CO ₂] + (0.0081[MT CH ₄] • 21) + (0.00081[MT N ₂ O] • 310) = 418.7 [MT CO ₂] + 0.1701 [MT CO ₂ e] + 0.2511 [MT CO ₂ e] = 419.1 [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) = 54.5 [MT CO ₂] + (0.00106 [MT CH ₄] • 21) + (0.00011 [MT N ₂ O] • 310) = 54.4 [MT CO ₂] + 0.02223 [MT CO ₂ e] + 0.0329 [MT CO ₂ e] = 54.6 [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) = 20.5 [MT CO ₂] + (0.000397 [MT CH ₄] • 21) + (0.000040 [MT N ₂ O] • 310) = 20.5 [MT CO ₂] + 0.00834 [MT CO ₂ e] + 0.0124 [MT CO ₂ e] = 20.52 [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] = 419.1 [MT CO ₂ e] + 54.6 [MT CO ₂ e] + 20.52 [MT CO ₂ e] = 494.2 [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 Portal.	

Advanced Calculation Methodology 2: CHP Facilities Not Present in eGRID⁶⁵

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:

⁶⁵ EPA, Climate Leaders, Indirect Emissions from Purchases/Sales of Electricity and Steam, June 2008.

1. Obtain total emissions, power, and heat generation information from CHP facility
2. Determine emissions attributable to net heat production⁶⁶ and electricity production
 - 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:

⁶⁶ 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 2a: Determine the Total Scope 1 Emissions from the CHP System

Calculate total scope 1 GHG emissions using the methods described in Appendix A.

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

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 a Municipal Solid Waste (MSW) Waste-to-Energy (WTE) Facility

Description

GHG emissions from municipal solid waste (MSW) waste-to-energy (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. For 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.⁶⁷

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

⁶⁷ 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 carbon dioxide. This contrasts with carbon from fossil fuels, which was removed from the atmosphere millions of years ago.

Emission factors	• eGRID Derived Default	• MSW WTE Plant-Provided
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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
2. Utilize the most recent eGRID derived emission factors that apply to the delivered steam
3. Determine the total annual emissions in metric tons (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)⁶⁸
- Steam conversion efficiency (75 percent)⁶⁹
- Distribution loss (10 percent)⁷⁰

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

eGRID MSW WTE Delivered Steam [MMBtu] = DS

$$DS = PLHTIAN \bullet BE \bullet SP \bullet (1 - DL)$$

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

eGRID MSW WTE Delivered Steam Emission Factor [lb CO₂/MMBtu] =

$$(UNCO_2 \bullet STLC) \div DS$$

Where:

UNCO ₂	=	Plant unadjusted annual CO ₂ emissions [short tons CO ₂]
STLC	=	Short-ton-to-lb conversion (2000) [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

⁶⁸ DOE, Industrial Technology Programs, Energy Use and Loss Footprints, Assumption and Definitions. See www1.eere.energy.gov/industry/program_areas/footprints.html.

⁶⁹ eGRID2007 Technical Support Document, EPA. See www.epa.gov/cleanenergy/documents/egridzips/eGRIDwebV1_0_UsersManual.pdf.

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.

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

$$\text{eGRID MSW WTE Delivered Steam Emission Factor [lb CO}_2 \text{ (Biogenic)/MMBtu]} = \frac{[(\text{UNCO}_2 \bullet \text{STLC}) \bullet (\text{PLTRPR}/\text{PLTNPR})] \div \text{DS}}$$

Where:

- UNCO₂ = Plant unadjusted annual CO₂ emissions [short tons CO₂]
- STLC = Short-ton-to-lb conversion (2000) [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 metric tons (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 MRR, 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 metric tons (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 metric tons (MT).

Equation B-26: Purchased Steam Use GHG Emissions

<p>CO₂ Emissions [MT] = Steam use [MMBtu] • CO₂ emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT]</p>
<p>CH₄ Emissions [MT] = Steam use [MMBtu] • CH₄ emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT]</p>
<p>N₂O Emissions [MT] = Steam use [MMBtu] • N₂O emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT]</p>
<p>Biogenic CO₂ Emissions [MT] = Steam use [MMBtu] • Biogenic CO₂ emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT]</p>

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 metric tons (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

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

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 Waste-to-Energy Plant

A notional 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 metric tons (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 [MT CO ₂]	= 218.06 [MT CO ₂]

Purchased Steam	= 1,500 [MMBtu] • 0.1475 [lb CH ₄ /MMBtu] ÷ 2,204.62 [lb/MT]
CH₄ Emissions [MT CH ₄]	= 0.1004 [MT CH ₄]

Purchased Steam	= 1,500 [MMBtu] • 0.0165 [lb N ₂ O/MMBtu] ÷ 2,204.62 [lb/MT]
N₂O Emissions [MT N ₂ O]	= 0.01123 [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 [MT CO ₂]	= 265.7 [MT Biogenic 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 e]	= 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)
	= 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 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 renewable energy certificates (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.

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 orSupplied 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

$$\text{Emission reduction}_{i,sr} = RE_{sr} \bullet ERate_avoided_{i,sr}$$

Where:

- Emission reduction_{i,sr} = Quantity [lb] of avoided GHG of type *i* in each subregion *sr*
- RE_{sr} = Quantity of renewable energy purchased from each eGRID subregion *sr* as distinct from the agency's electricity supplier's system mix of energy resources
- ERate__{avoided}_{i,sr} = Emission factor for each GHG of type *i* (such as lb CO₂/MWh, lb CH₄/MWh, lb N₂O/MWh) for each eGRID subregion *sr* 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 ERate_{baseline}_{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 ERate_{baseline}_{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.⁷¹ 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.

⁷¹ 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.

Appendix C—Calculating Scope 3 Emissions

Scope 3 emissions are indirect emissions not covered by scope 2. They occur as a consequence of agency activities, but originate from sources not controlled by the agency. They are the scope 1 or scope 2 emissions from other agencies or organizations. Refer to Chapter 2 of the main Guidance document for further information on organizational boundaries.

Scope 3 categories selected for inclusion in the FY 2010 annual inventory (which will be submitted in January 2011) are shown in Table C-1. 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 FY 2010 Scope 3 Emission Categories
<ul style="list-style-type: none">• Federal Employee Business Air Travel• T&D Losses from Purchased Electricity• Contracted Municipal Solid Waste 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 main 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.

For FY 2011 reporting, agencies will report scope 3 emissions associated with facilities operated under private-sector and GSA leases, in addition to those scope 3 categories included in 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.⁷²

⁷² Given the scientific debate surrounding radiative forcing impacts of air travel and existing EPA Climate Leaders guidance, the default air travel methodology does not incorporate radiative forcing adjustments for these GHG emissions. As such, agencies should note that these emissions may be an under-estimate of the CO₂e impact.

This category excludes aircraft owned and leased by the reporting agency as they are captured under scope 1.

Agencies or activities that do not have access to the advanced methodology GSA Travel Management Information Service (GSA Travel MIS)⁷³ (see Section C.1.2) may utilize the default methodology delineated in Section C.1.1).

C.1.1. Default Methodology (to be Calculated by GHG Reporting Portal)⁷⁴

Data Sources

Agencies without access to the GSA Travel MIS tool may use this default methodology that is based on passenger air miles traveled. Agencies must work with their travel agents and systems to compile air travel data presented in Table C-2, which shows the data elements and their sources.

Table C-2: Federal Employee Air Travel Default Data Sources

Data Element	Preferred Source
Passenger Miles Traveled by segment categorized by short, medium, or long haul [miles]	<ul style="list-style-type: none"> • Agency Travel records
Emission Factors [kg GHG/passenger-mile] by short, medium, or long haul	<ul style="list-style-type: none"> • Table C-3

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 to be utilized by the GHG Reporting Portal:

1. Identify the total passenger-miles by segment class (i.e., short, medium, long) for all scope 3 agency flights
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) for all scope 3 agency flights

⁷³ The GSA Travel MIS methodology for calculating air travel emission is based on the TRX Airline Carbon Emissions Calculator, a detailed and well-accepted for calculating air travel emissions.

⁷⁴ 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.

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 C-3.

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 C-3 and are derived from aggregated data of typical emissions per passenger-miles.

Table C-3: Emission Factors for Airline Business Travel

Segment Travel Distance	CO ₂ Emission Factor (kg CO ₂ /passenger-mi)	N ₂ O Emission Factor (g N ₂ O/passenger-mi)	CH ₄ Emission Factor (g CH ₄ /passenger-mi)
Short Haul (< 300 miles)	0.277	0.0085	0.0104
Medium Haul (≥ 300 and < 700 miles)	0.229	0.0085	0.0104
Long Haul (≥ 700 miles)	0.185	0.0085	0.0104
Unknown segment class	0.271	0.0085	0.0104

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 metric tons.

Equation C-1: Airline Business Travel Emissions

<p>CO₂ emissions[MT] = Passenger-miles traveled [miles] • appropriate CO₂ emission factor [kg/mi] • 0.001 [MT/kg]</p>
<p>CH₄ emissions[MT] = Passenger-miles traveled [miles] • appropriate CH₄ emission factor [g/mi] • 0.000001 [MT/g]</p>
<p>N₂O emissions [MT] = Passenger-miles traveled [miles] • appropriate N₂O emission factor [g/mi] • 0.000001 [MT/kg]</p>

Step 4: Determine total annual emissions in MT CO₂e

The Portal will use the GWP values found in 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

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

Example C-1: Calculate Airline Business Travel Emissions

A Federal energy manager calculates the emissions for his travel in FY 2008. He works in Chicago, but attended two separate work events in San Francisco and New Orleans during the year. His New Orleans trip was via a direct flight; his flight to San Francisco had a stop in Denver. To determine the emissions associated with his 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 based upon the flight characteristics

Table C-2 indicates that all flight segments are long haul. The EFs for this situation are as follows:

- 0.185 kg CO₂/passenger-mile
- 0.0085 g N₂O /passenger-mile
- 0.0104 g CH₄/passenger-mile

Step 3: Calculate the GHG emissions associated with each trip and convert to metric tons

Use Equation C-1 to calculate the emissions from each segment in metric tons.

Equation C-1: Airline Business Travel Emissions

$$\begin{aligned} \text{CO}_2 \text{ emissions [MT]} &= \text{Passenger-miles traveled [miles]} \bullet \text{appropriate CO}_2 \text{ emission factor [kg/mi]} \bullet 0.001 \text{ [MT/kg]} \\ &= (831 + 831 + 891 + 970 + 970 + 891) \text{ [miles]} \bullet 0.185 \text{ [kg/mi]} \bullet 0.001 \text{ [MT/kg]} \\ &= 5387 \text{ [miles]} \bullet 0.185 \text{ [kg/mi]} \bullet 0.001 \text{ [MT/kg]} \\ &= 0.996 \text{ [MT]} \end{aligned}$$

$$\begin{aligned} \text{CH}_4 \text{ emissions [MT]} &= \text{Passenger-miles traveled [miles]} \bullet \text{appropriate CH}_4 \text{ emission factor [g/mi]} \bullet 0.000001 \text{ [MT/g]} \\ &= (831 + 831 + 891 + 970 + 970 + 891) \text{ [miles]} \bullet 0.0104 \text{ [g/mi]} \bullet 0.000001 \text{ [MT/g]} \\ &= 5387 \text{ [miles]} \bullet 0.0104 \text{ [g/mi]} \bullet 0.000001 \text{ [MT/g]} \\ &= 5.602 \times 10^{-5} \text{ [MT]} \end{aligned}$$

$$\text{N}_2\text{O} = \text{Passenger-miles traveled [miles]} \bullet \text{appropriate N}_2\text{O emission factor [g/mi]} \bullet$$

emissions	0.000001 [MT/g]
[MT]	= (831 + 831 + 891 + 970 + 970 + 891) [miles] • 0.0085 [g/mi] • 0.000001 [MT/g] = 5387 [miles] • 0.0085 [g/mi] • 0.000001 [MT/g] = 4.58 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.	
Equation C-2: Convert GHG MT to CO₂e Emissions	
CO₂e	= MT CO ₂ + (MT CH ₄ • CH ₄ GWP) + (MT N ₂ O • N ₂ O GWP)
Emissions	= .996 [MT CO ₂] + (5.602 x 10 ⁻⁵ [MT CH ₄] • 21) + (4.58 x 10 ⁻⁵ [MT N ₂ O] • 310)
[MT CO₂e]	= .996 [MT CO ₂] + 1.17 x 10 ⁻³ [MT CO ₂ e] + 1.42 x 10 ⁻² [MT CO ₂ e] = 1.011 [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 Portal.	

C.1.2. Advanced Methodology (User Calculated)

Data Sources

This advanced methodology calculates air travel emissions using GSA’s Travel MIS.⁷⁵ This system can calculate emissions for air travel on behalf of all government agencies. Agencies may choose to use another advanced methodology other than that employed by GSA Travel MIS, but they must provide the advanced methodology to CEQ and OMB through the reporting process in the GHG Reporting Portal.

Data required for the Travel MIS tool is simply the Passenger Name Record (PNR), as indicated in Table C-4. 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-4: 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 (CTO)

Most agencies and commissions 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 2 weeks if they use any of the TMCs or ETSs with established data feed capabilities. Federal agencies

⁷⁵ The GSA Travel MIS methodology for calculating air travel emission is based on the TRX Airline Carbon Emissions Calculator, a detailed and well-accepted for calculating air travel emissions.

with TMCs or ETSs that do not yet have a data feed established with GSA may require 4 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.

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

Agencies are required to report business air travel emissions for FY 2010. Agencies must use the PNR as the data source and the GSA Travel MIS to conduct the GHG emissions calculation. The GSA Travel MIS standardizes the calculation and the reporting of the data, while also providing a tool for planning reductions in emissions. Agencies are required to report their estimated business air travel GHG emissions via the GHG Reporting Portal.

This is achieved through the following steps.

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
3. Access the GSA Travel MIS
4. Generate the GHG emissions estimate and report

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. GSA can be reached via e-mail, Travel.programs@gsa.gov, or 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 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

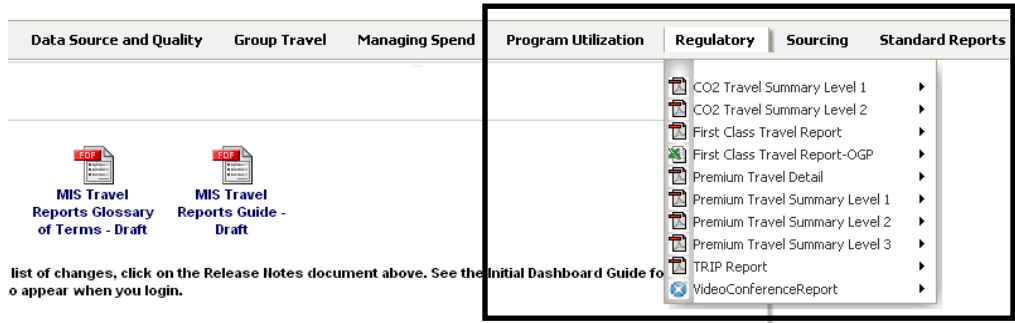
After successfully logging in to the GSA Travel MIS, select the Regulatory tab. There are two GHG emission estimate reports available under that tab:

1. CO₂ Travel Summary Level 1
2. CO₂ Travel Summary Level 2

The Level 1 report provides the GHG emissions for the entire agency. Level 2 breaks down emissions data at the second level of the agency's organizational hierarchy. For example, a DoD level 1 report would list total DoD-wide emissions, and the level 2 report would list emissions by the associated services (such as Army, Air Force, Navy, or Marine Corps).⁷⁶ The level 2 breakdown is provided at the bureau level on the basis of codes assigned by the U.S. Treasury: www.whitehouse.gov/omb/circulars/a11/current_year/app_c.pdf.

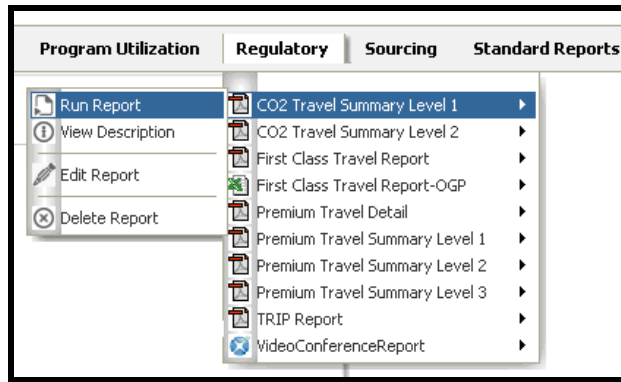
⁷⁶ This Level 1/Level 2 breakdown holds for all agencies except the Department of Homeland Security (DHS). For more information on DHS specifics, contact Travel.programs@gsa.gov or telephone 888-472-5585.

Figure C-2: GSA Travel MIS Regulatory Tab



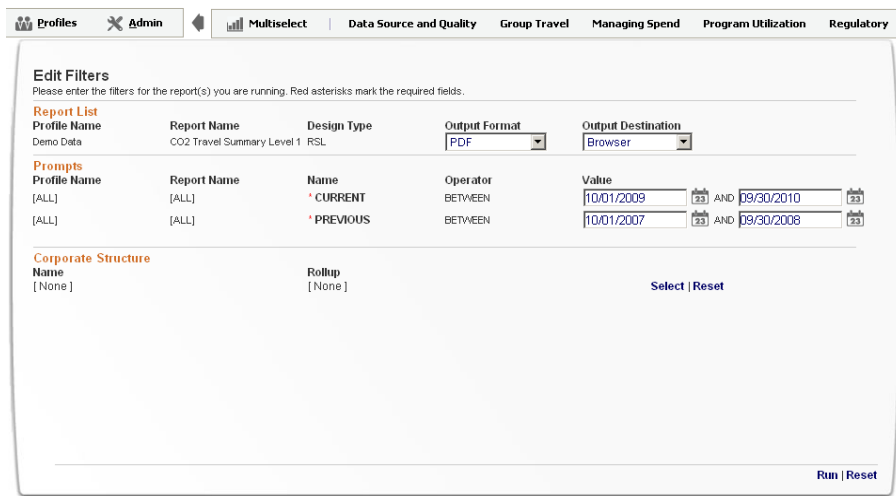
To run the report, move the cursor to the left and highlight *Run Report*.

Figure C-3: Running the Report



Enter the dates you wish to report. The following example compares the FY 2008 baseline to the first reporting year of FY 2010. After entering the dates, click *Run* in the lower right corner of the screen, and the GHG emissions estimate report will be generated as a PDF file.

Figure C-4: Entering Dates



The following is an example of the Level 1 report.

Figure C-5: Page 1 of the Emissions Report

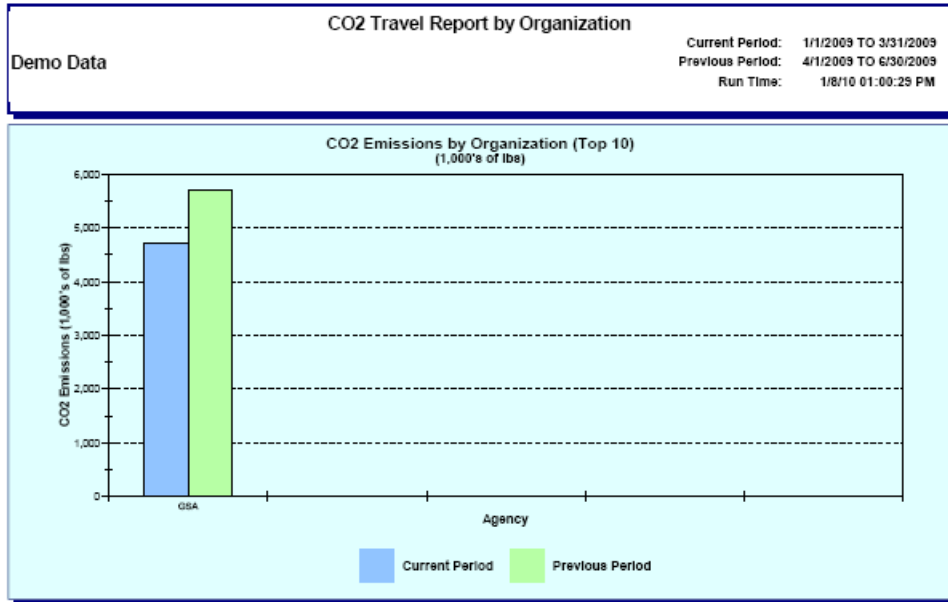


Figure C-6: Page 2 of the Emissions Report

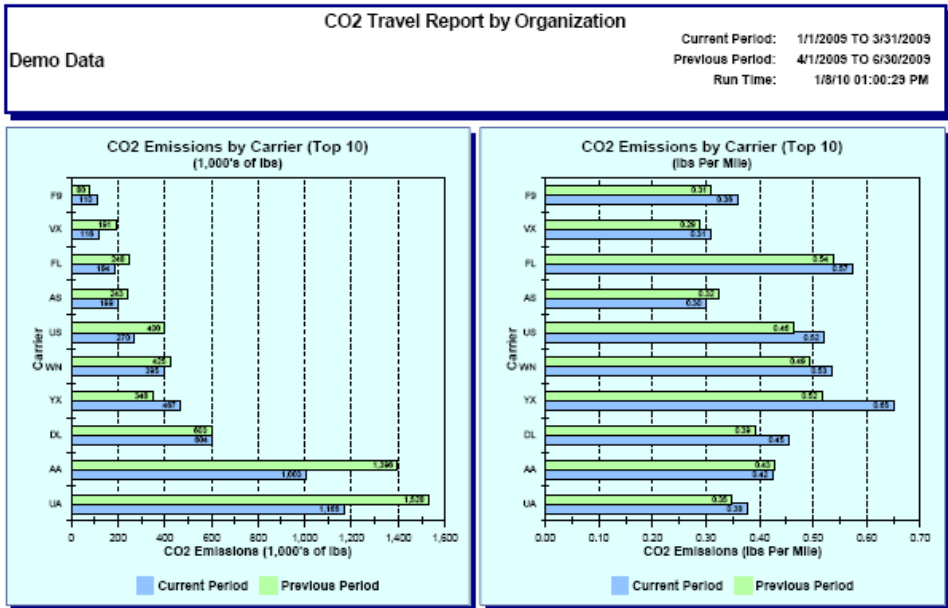


Figure C-7: Page 3 of the Emissions Report

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 hard disk. Find the total quantity of GHG listed in the GSA Travel MIS report by type. Submit via the GHG Reporting Portal to report the agency’s FY 2010 and subsequent year business air travel emissions.⁷⁷

Calculation Methodology

GSA’s travel tool follows an advanced methodology to calculate 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. The fuel burn rate per passenger is calculated as fuel burned 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. Also, the occupancy rate of the seats in each cabin class must be included.

⁷⁷ 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.

An accurate fuel burn rate is obtained from the 2006 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^{78,79}

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.

Step 4: Determine the cargo and passenger allocation

Cargo and passenger data has been gathered for U.S. carriers from the U.S. Department of Transportation, Bureau of Transportation Statistics. Cargo includes baggage, freight, mail, and passengers. 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 or international), and aircraft type for each carrier.

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 full. 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 International Civil Aviation Organization (ICAO), an agency of the United Nations. ICAO is an authoritative source of passenger load factor information for U.S. and non-U.S. carriers. Data from calendar year 2006 is used to avoid seasonality issues. These values are updated annually. If a carrier is not in the

⁷⁸ 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.

⁷⁹ Future iterations of the GSA Travel MIS tool will include an expanded capability to more fully calculate emissions in terms of MT CO₂e.

list, the average load factor of 75.93 percent is used for U.S. carriers and 67.35 percent for non-U.S. carriers.

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)⁸⁰

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-5). The GHG Reporting Portal will calculate the lost quantity of energy and estimate its resultant GHG emissions using the appropriate emission factors.

Table C-5: T&D Losses Default Data Sources

Data Element	Preferred Source
Total electricity purchases [MWh]	• FEMP Energy Report Records
National average T&D loss factor [%]	• Electricity: 6.18 % ⁸¹

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

⁸⁰ 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.

⁸¹ Diem, A. 2010. Personal Communication. Clear Air Markets Division Emission Monitoring Branch, Office of Air and Radiation, U.S. Environmental Protection Agency.

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

<p>Distribution Loss Adjustment Factor = $T \div (1-T)$</p> <p>Where:</p> <p>T = T&D loss factor, 0.0618 (or 6.18%) national average.</p>

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.

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-13 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

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

Example C-2: Determine Transmission and Loss Emissions for Purchased Electricity

<p>A Federal energy manager for a VA 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:</p>

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

CO₂ emissions [MT] = Electricity purchased [MWh] • CO₂ emission factor [kg/MWh] • T&D adjustment factor • 0.001 [MT/kg]
 = 20,000 [MWh] • 600.71 [kg/MWh] • 0.0659 • 0.001 [MT/kg]
 = 791.74 [MT] CO₂

CH₄ emissions [MT] = Electricity purchased [MWh] • CH₄ emission factor [kg/MWh] • T&D adjustment factor • 0.001 [MT/kg]
 = 20,000 [MWh] • 8.46 [kg/MWh] • 0.0659 • 0.001 [MT/kg]
 = 11.15 [MT] CH₄

N₂O emissions [MT] = Electricity purchased [MWh] • N₂O emission factor [kg/MWh] • T&D adjustment factor • 0.001 [MT/kg]
 = 20,000 [MWh] • 6.85 [kg/MWh] • 0.0659 • 0.001 [MT/kg]
 = 9.03 [MT] N₂O

Step 4: Determine total annual emissions in MT CO₂e

Using the appropriate GWP, convert all GHG gases to CO₂e, then sum to determine the total emissions in CO₂e.

Equation C-5: Convert GHG MT to CO₂e Emissions

CO₂e Emissions [MT CO₂e] = MT CO₂ + (MT CH₄ • CH₄ GWP) + (MT N₂O • N₂O GWP)
 = 791.74 [MT CO₂] + (11.15 [MT CH₄] • 21) + (9.03 [MT N₂O] • 310)
 = 791.74 [MT CO₂] + 234.15 [MT CO₂e] + 2799.3 [MT CO₂e]
 = **3825.19 [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 Portal.**

C.3. Contracted Municipal Solid Waste Disposal

Description

Contracted disposal of agency waste refers to the off-site disposal of municipal solid waste performed by an independent entity. Appendix A provides guidance on inventorying emissions

from agency-controlled municipal solid waste disposal. However, the mass balance methodology⁸² for contracted landfill disposal of municipal solid waste generation of 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 municipal solid waste 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 incineration waste disposal options when agencies compare the implications of their various waste disposal options.

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

Data Sources

Table C-6 shows the data elements and their sources.

Table C-6: Contracted Solid Waste Disposal Default Data Sources

Data Element		Preferred Source
Mass of solid waste disposed [short ton]		<ul style="list-style-type: none"> Reporting to OFEE under E.O. 13514, Sec. 2(e) Waste management contractor
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
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)

⁸² This method is based upon the estimate approach used in the EPA Inventory of US 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.

Calculation Steps

To calculate scope 3 emissions from contracted MSW disposal, do the following:

1. Input solid waste deposition 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 deposition data in GHG Reporting Portal to calculate the CH₄ and CO₂ generation

The agency must input the annual deposition of solid waste into the GHG Reporting Portal. 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 municipal solid waste's anthropogenic CH₄ and biogenic CO₂ emissions over time. The derived calculations are outlined in Equation C-6 and Equation C-7, respectively.

Equation C-6: CH₄ Generation per Short Ton of Municipal Solid Waste

$$\text{CH}_4 \text{ Generation [MT]} = \text{MSW}_{\text{mass}} \bullet 0.90718 \bullet \text{DOC} \bullet \text{DOC}_f \bullet \text{MCF} \bullet F \bullet 16/12$$

Where:

CH ₄ _{gen}	=	CH ₄ 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%
16/12	=	Molecular weight ratio CH ₄ /C

Source: EPA Inventory of US 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 Municipal Solid Waste

$$\text{CO}_2 \text{ Generation [MT]} = \text{MSW}_{\text{mass}} \bullet 0.90718 \bullet \text{DOC} \bullet \text{DOC}_f \bullet \text{MCF} \bullet F \bullet 44/12$$

Where:

CO ₂ _{gen}	=	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 US 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

Step 2: Calculate emissions from landfills and solid waste facilities

The GHG Reporting Portal will automatically calculate the quantities of CH₄ and biogenic CO₂ in metric tons. 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.

C.3.2. Advanced Methodology (User Calculated)⁸³

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.

C.4. Federal Employee Business Ground Travel: Rail, Rentals, Buses

Business ground travel refers to official business travel by Federal employees aboard third-party-owned or -operated ground vehicles.⁸⁴ 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 (FTR). 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:

⁸³ 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.

⁸⁴ 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.

- Passenger vehicle business travel: personal vehicles, rental vehicles, and taxi cabs
- Rail business travel: transit rail (such as subway, tram), commuter rail, and intercity rail (such as Amtrak)
- Bus business travel: Buses driven by diesel and, to a lesser extent, other fuels such as compressed natural gas (CNG)

Due to the current lack of consistent data for many modes of business ground travel, the default methodology addresses emissions only from rental vehicles and not from other modes of ground travel. Agencies are encouraged to utilize the advanced methodology, which addresses all modes of ground travel, because the advanced methodology is anticipated to become the default methodology in subsequent revisions of this document.

C.4.1. Default Methodology (to be Calculated by GHG Reporting Portal)⁸⁵

Data Sources

The default calculation methodology is derived from average travel statistics provided by GSA. The current method is intended to give agencies an initial estimate of ground travel emissions based on the primary source (rental vehicles) and national averages (Table C-7). A more robust and accurate default method, to address issues associated with biofuels use, is under development for FY11.

Table C-7: Ground Travel Default Data Sources

Data Element	Preferred Source
Number of rentals	<ul style="list-style-type: none"> • GSA Travel MIS or Agency’s Travel Agent

Calculation Steps

The GHG Reporting Portal will use the following steps to calculate emissions:

1. Report the number of agency-wide rentals
2. Calculate miles traveled using a given conversion factor
3. Determine total annual GHG emissions

Step 1: Report the number of agency-wide rentals

Agencies should work with their GSA Travel MIS Rental Car report or their travel agent to determine how many times agency employees rented vehicles during the fiscal year. The GHG Reporting Portal will only require the agencies to report the number of rentals, not the distance traveled per rental or number of days the vehicle was rented.

Step 2: Calculate miles traveled using a given conversion factor

⁸⁵ This methodology is based on correspondence with the GSA Office of Travel and Transportation.

The GHG Reporting Portal will multiply the number of car rentals by an average factor of 419 miles traveled per rental (an average duration of 5.1 days).⁸⁶

Step 3: Determine total annual GHG emissions

The GHG Reporting Portal will use Equation C-6 and the distance-traveled emission factors in Table D-11 to calculate the CO₂, N₂O, and CH₄ emissions for the applicable car rentals. It will multiply each GHG quantity by the appropriate GWP value from Table D-13 and then calculates the total emissions in CO₂e.

C.4.2. Advanced Methodology 1: Detailed Rental Data (to be Calculated by GHG Reporting Portal)

This advanced methodology is designed to provide an alternative to the Default Methodology for agencies that have vehicle rental data beyond just the number of rentals. This methodology is primarily intended for rental vehicles but could likewise be appropriately applied for POV use while on business travel.

Data Sources

Agencies should obtain, in the order presented, at least one of the following pieces of information:

- The duration of individual rentals
- The class of rental vehicle
- The mileage for each rental

This methodology is flexible in that not all data elements are required, but by adding more data elements, the resulting GHG calculations will be more accurate. The Portal will rely on government-wide averages where data elements are not provided.

Table C-8: Advanced Methodology 1 Data Sources

Data Element	Preferred Sources
Number of rental days by vehicle class	<ul style="list-style-type: none"> • Rental Vehicles: GSA Travel MIS or Agency’s Travel Agent • POVs: Travel reimbursement forms
Mileage per rental	<ul style="list-style-type: none"> • Rental Vehicles: GSA Travel MIS or Agency’s Travel Agent
Vehicle-class specific CO ₂ emission factors	<ul style="list-style-type: none"> • Table C-11
Vehicle specific N ₂ O and CH ₄ emissions factors	<ul style="list-style-type: none"> • Table D-4

⁸⁶ This factor is provided by the GSA Office of Travel and Transportation, based on correspondence with rental agencies. The factor is a national average of all government rentals with three rental companies. These agencies constitute about 40 percent of total Federal rentals.

Calculation Steps

Calculation steps include the following:⁸⁷

1. Report mileage or determine the appropriate mileage estimate for agency rentals or POVs
2. Determine the appropriate auto class for each vehicle used
3. Use the vehicle class to determine the appropriate emissions factor
4. Determine the GHG emissions for each vehicle used
5. Sum the total annual GHG emissions for all vehicles used
6. Convert emissions to CO₂e

Step 1: Report mileage or determine the appropriate mileage estimate for agency rentals (and/or POVs)

Agencies should gather available distance-traveled data on all vehicle-based business ground travel. For POVs and where available for rental vehicles, use the exact mileage that was devoted to business travel. If exact mileage is unavailable, rentals should use the average miles per day of federal rentals, which is 91 miles. If duration of the rental is unknown, use the average mileage per federal rental of 434 miles.⁸⁸

Step 2: Determine the appropriate auto class for each vehicle used

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-11. If an auto class cannot be determined, assign the class as “unknown” in the Portal.

Step 3: Use the vehicle class to determine the appropriate CO₂, N₂O and CH₄ emissions factor

Based upon the class of automobile used, the Portal will select the appropriate emissions factor from Table C-10. If the auto class is unknown, an average fleet emission factor is assigned. These emissions factors are mileage-based, but users may use fuel-based emissions factors if they have specific fuel usage data available. Vehicle type N₂O and CH₄ emissions factors are presented in Table D-4. All standard passenger vehicles are considered Low Emissions Vehicles, assuming that all rental vehicle fleets consist of vehicles less than 5 years old.

Table C-10: CO₂ Emission Factors by Auto Class

Auto Class	kg CO ₂ /mile
Economy	0.31

⁸⁷ Advanced calculation methodology is derived in part from the EPA Climate Leaders guidance for *Optional Emissions from Commuting, Business Travel and Product Transport*.

⁸⁸ Both of these figures are based upon an average of aggregated Federal rental car data provided from three major rental companies collected from October through December of 2009. It represents approximately 150,000 vehicle rentals totaling over 700,000 rental days. It is expected to change in the future, as additional data from multiple years become available.

Compact	0.29
Midsized	0.31
Full Size	0.39
Luxury / Prem	0.45
Minivan/Wagon	0.44
Small SUV	0.44
Medium SUV	0.53
Large SUV	0.56
12/15 Pass Vans	0.59
Other Car/Truck	0.41
1/2 Ton Pickup	0.54

Note: Using data provided by the Defense Travel Management Office (DTMO), these emissions factors were derived for the 2006-2010 model year vehicles fleet of the federal government's large rental car vendor. MPG ratings use an average of city and highway EPA estimates for each vehicle type. The standard EPA MRR CO2 emission factor for gasoline (Table D-2) was used for all vehicle types.

Step 4: Determine the GHG emissions for each vehicle

The Portal will use Equation C-8 to determine 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 3: 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 metric tons

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] ...) •</p>

0.001MT/kg
Total N₂O emission from ground travel [MT] = (N ₂ O from vehicle class 1 [kg] + N ₂ O from vehicle class 2 [kg] + N ₂ O from vehicle class 3 [kg] ...) • 0.001MT/kg
Total CH₄ emission from ground travel [MT] = (CH ₄ from vehicle class 1 [kg] + CH ₄ from vehicle class 2 [kg] + CH ₄ from vehicle class 3 [kg] ...) • 0.001MT/kg

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Step 4: Convert emissions to CO₂e

The Portal will use Equation C-10, the N₂O and CH₄ emissions, and their respective GWPs to determine these gases to CO₂e, then, sum all CO₂ and CO₂e emission to generate the total emissions for business ground travel.

Equation C-10: 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.4.3. Advanced Methodology 2: Distance Traveled by Mode (User Calculated)

Data Sources

Agencies can use this advanced distance-traveled methodology to calculate emissions from employee business ground travel.⁸⁹ Agencies can use distance-traveled activity data captured by mode of ground transportation to calculate their emissions (Table C-11). If agencies are unable to obtain adequate distance-traveled data, they may extrapolate total ground-travel emissions from a representative sample of distance-based activity data. Distance-based methodologies were chosen for their alignment with agency data availability rather than for their superior accuracy.

If agency data are available, fuel-based methodologies specific to particular vehicle classes (see Appendix A.3.1 and A.3.2) can be used to produce more accurate GHG emission estimates.

⁸⁹ 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.

Table C-11: Ground Travel Required Data Sources

Data Element	Preferred Sources
Distance traveled (miles) by mode of ground transport (rental car, POV/taxis, bus, train) [mi]	<ul style="list-style-type: none"> • Rental Vehicles: GSA Travel MIS or Agency’s Travel Agent • Personal Vehicles, Rail, Bus: Travel reimbursement forms • Representative sample of distance based data
Emission factor [kg/passenger-mi] or [kg/vehicle-mi]	<ul style="list-style-type: none"> • Table D-11 and Table D-12

Calculation Steps

Calculation steps include the following:⁹⁰

1. Determine distance traveled for each mode of transportation
2. Calculate emissions for each mode of transportation
3. Determine the total annual GHG emissions in metric tons
4. Convert emissions to CO₂e

Step 1: Determine distance traveled for each mode of transportation

Agencies should gather distance-traveled data on all business ground travel. The distance-traveled data for each mode of transportation can typically be found in travel agent records or travel reimbursement forms. If agencies are unable to obtain complete ground travel data, they may extrapolate from a representative sample of employees to represent the total business travel of all employees but must report their extrapolation methodology.

Step 2: Calculate emissions for each mode of transportation

Agencies should use Equation C-11 and the distance-traveled emission factors found in Table D-11 and Table D-12 to calculate the CO₂, N₂O, and CH₄ emissions for each mode of travel. It is important to note that the emission factors used are determined by how they are allocated. For instance, a single occupancy rental passenger car or a POV SUV would each have separate emission factors because of the difference in vehicle used. Agencies could choose to modify these emission factors for multiple-occupant trips if sufficiently granular data become available. More detailed information on multiple occupant allocations is provided in the commuter methodologies in Appendix C.5.

Equation C-11: Emissions by Transportation Mode

<p>CO₂ emissions[kg] = Distance traveled for a given mode [miles] • CO₂ emission factor for each mode [kg/mi]</p>
<p>N₂O emissions [kg] =</p>

⁹⁰ Advanced calculation methodology is derived from the EPA Climate Leaders guidance for *Optional Emissions from Commuting, Business Travel and Product Transport*.

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 metric tons

To determine the total CO₂, N₂O, and CH₄ emissions, sum the emissions of each gas for all ground transportation modes and convert them to metric tons.

Equation C-12: Total Emissions Calculations

Total CO₂ emission from ground travel [MT] =
--

(CO ₂ from node 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 node 1 [kg] + N ₂ O from mode 2 [kg] + N ₂ O from mode 3 [kg] ...) • 0.001MT/kg

Total CH₄ emission from ground travel [MT] =
--

(CH ₄ from node 1 [kg] + CH ₄ from mode 2 [kg] + CH ₄ from mode 3 [kg] ...) • 0.001MT/kg
--

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Step 4: Convert emissions to CO₂e

Multiple the N₂O and CH₄ emissions by their respective GWP to determine the CO₂e for business ground travel.

Equation C-13: Ground Travel MT CO₂e Emissions

CO₂e Emissions [MT CO₂e] = MT CO₂ + (MT CH₄ • CH₄ GWP) + (MT N₂O • N₂O 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 should, if at all possible, use voluntary questionnaires to obtain information on average employee commuting habits.^{91, 92} At a minimum, agencies should seek information on the following:

- Frequency of commute
- Average one-way distance traveled by employee per day
- Modes of transport used by employees (personal vehicle, carpools, train, bus, etc.)

Agencies should collect employee commuting questionnaire data from as many employees as possible. However, some extrapolation will likely be necessary. Agencies may extrapolate using a representative sample of employees to represent the total commuting patterns of all employees.

If agencies are unable to send questionnaires to their employees, they 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-12). 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-12: Commuter Travel Data Sources

Data Element	Preferred Source	Alternate Source
Number of passengers (by mode)	<ul style="list-style-type: none"> • Commuter questionnaire 	<ul style="list-style-type: none"> • N/A
Mode	<ul style="list-style-type: none"> • Commuter questionnaire 	<ul style="list-style-type: none"> • Public transit records • Regional/national transportation surveys
Number of trips (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)
Distance of trip (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

⁹¹ Agencies should be aware that there are privacy rights to be considered when developing and administering any voluntary survey.

⁹² 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.

Calculation Steps

1. Collect commuter data by frequency, distance, and mode of travel
2. Segregate commuter data by single occupant or multiple passenger categories and compute annual travel averages
3. Calculate emissions of single occupant and multiple passenger commuters
4. Sum single occupant and multiple passenger travel emissions and convert them to metric tons
5. Convert to CO₂e and determine total emissions

Step 1: Collect commuter data by frequency, distance, and mode of travel

Agencies should collect activity data for commuters using a commuter questionnaire, if possible. 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. To account for emission-saving strategies that focus on modifying employee commuting behavior (such as encouraging use of carpooling or public transit), agencies will need to use commuter survey data specific to the agency population.

Transportation modes for which emission factors are provided in Table D-11 and D-12 include:

- Passenger car
- Light-duty truck / van / SUV
- Motorcycle
- Car pool
- Van pool
- Bus
- Transit rail
- Commuter rail
- Intercity rail

Step 2: Segregate commuter data by single occupant or multiple passenger categories and compute annual travel averages

Agencies should categorize the available data by those who commute to work alone and those who commute in multiple occupant vehicles (such as carpools, bus, or subway). For the respective groups, agencies determine the average distance traveled and the average frequency of trips per year, and then enter these data into the GHG Reporting Portal.

Step 3: Calculate emissions of single occupant and multiple passenger commuters

The GHG Reporting Portal will use Equation C-14 to calculate GHG emission for single occupant vehicle travel and Equation C-15 should be used to calculate GHG emission for each mode of multi-occupant travel. (See Table 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-3.

Equation C-14: Emissions from Single Occupant Vehicle Travel

<p>CO₂ emissions [kg] = Number of trips per year • number of single occupant travelers at the agency • average mileage per trip [mi] • emission factor [kg/mi]</p>
<p>N₂O emissions [kg] = Number of trips per year • number of single occupant travelers at the agency • average mileage per trip [mi] • emission factor [g/mi] • 0.001 [kg/g]</p>
<p>CH₄ emissions [kg] = Number of trips per year • number of single occupant travelers at the agency • average mileage per trip [mi] • emission factor [g/mi] • 0.001 [kg/g]</p>

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport

Equation C-15: Emissions by Transportation Mode for Multiple Occupant Travel*

<p>CO₂ emissions [kg] = Number of trips per year • number of agency employees traveling by mode • average mileage per trip [mi] • (emission factor for each mode [kg/passenger-mile])</p>
<p>N₂O emissions [kg] = Number of trips per year • number of agency employees traveling by mode • average mileage per trip [mi] • (emission factor for each mode [g/passenger-mile]) • 0.001 [kg/g]</p>
<p>CH₄ emissions [kg] = Number of trips per year • number of agency employees traveling by mode • average mileage per trip [mi] • (emission factor for each mode [g/passenger-mile]) • 0.001 [kg/g]</p>

* The individual equations for each gas in Equation C-15 should be repeated for each transportation mode

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport

Step 4: Sum single occupant and multiple passenger travel emissions and convert them to metric tons

Use Equation C-16 to add the respective CO₂, N₂O, and CH₄ emissions from single occupant vehicle travel and each mode of multiple-occupant vehicle travel.

Equation C-16: 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 to CO₂e and determine total emissions

Use Equation C-17 to multiply the N₂O and CH₄ emissions by their respective GWP (See Table D-13) to determine the total CO₂e emissions.

Equation C-17: Commuter Travel MT CO₂e Emissions

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

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 creates an online questionnaire and, after tabulating the data, determines that of the 1,000 employees of the facility, 25 percent drive in a single occupant vehicle, and 75 percent commute in multiple occupant vehicles.

Step 2: Segregate commuter data by single occupant or multiple passenger categories and compute annual travel averages

The single occupant vehicle commuters average 30 miles per daily roundtrip in passenger cars. The multiple-occupant vehicle commuters are broken down in the following way: 40 percent commute the Chicago Transit Authority's transit train system, averaging 16 miles per daily round trip. Thirty percent rely on bus travel for 20 miles per daily round trip. The remaining 5 percent of employees carpool, with an average daily roundtrip of 40 miles (and a passenger load of two passengers per vehicle). All commuters average 225 daily roundtrip commutes per year.

Mode of Transportation [type]	Number of employees	Number of trips per year	Average daily mileage [miles]
Single occupant vehicle	250	225	30
Transit Rail	400	225	16
Bus	300	225	20
Carpool	50	225	40

Step 3: Calculate emissions of single occupant and multiple passenger commuters

Equation C-14 allows for the calculation to determine single occupant emissions. The emission factors for passenger cars are found in Table D-11 and D-12.

Equation C-14: Emission from Single Occupant Vehicle Travel

CO₂ emissions [kg] = Number of trips per year • number of single occupant travelers at the agency • average mileage per trip [miles] • emission factor [kg/mile]
 = 225 • 250 • 30 [mi] • 0.364 [kg/mi]
 = 614250 [kg CO₂]

CH₄ emissions [kg] = Number of trips per year • number of single occupant travelers at the agency • average mileage per trip [mi] • emission factor [kg/mi]
 = 225 • 250 • 30 [mi] • 0.031 [g/passenger-mile] • 0.001 [kg/g]
 = 52.31 [kg CH₄]

N₂O emissions [kg] = Number of trips per year • number of single occupant travelers at the agency • average mileage per trip [mi] • emission factor [kg/mile]
 = 225 • 250 • 30 [mi] • 0.032 [g/passenger-mile] • 0.001 [kg/g]
 = 54.00 [kg N₂O]

Equation C-15 allows for the calculation to determine multiple occupant emissions. Emission factors are pulled from Table D-12. The following equations are repeated for each transportation mode.

Equation C-15: Emissions by Transportation Mode for Multiple Occupant Travel

➤ **Transit Rail**

CO₂ emissions [kg]	= Number of trips per year • number of agency employees traveling by transit rail • average mileage per trip [mi] • emission factor for transit rail [kg/passenger-mile] = 225 • 400 • 16 [mi] • 0.163 [kg/passenger-mile] = 234720 [kg CO ₂]
CH₄ emissions [kg]	= Number of trips per year • number of agency employees traveling by transit rail • average mileage per trip [mi] • emission factor for transit rail [g/passenger-mile] • 0.001 [kg/g] = 225 • 400 • 16 [mi] • 0.004 [g/passenger-mile] • 0.001 [kg/g] = 5.76 [kg CH ₄]
N₂O emissions [kg]	= Number of trips per year • number of agency employees traveling by transit rail • average mileage per trip [mi] • emission factor for transit rail [g/passenger-mile] • 0.001 [kg/g] = 225 • 400 • 16 [mi] • 0.002 [g/passenger-mile] • 0.001 [kg/g] = 2.88 [kg N ₂ O]

➤ **Bus**

CO₂ emissions [kg]	= Number of trips per year • number of agency employees traveling by bus • average mileage per trip [mi] • emission factor for bus [kg/passenger-mile] = 225 • 300 • 20 [mi] • 0.107 [kg/passenger-mile] = 144450 [kg CO ₂]
CH₄ emissions [kg]	= Number of trips per year • number of agency employees traveling by bus • average mileage per trip [mi] • emission factor for bus [g/passenger-mile] • 0.001 [kg/g] = 225 • 300 • 20 [mi] • 0.0006 [g/passenger-mile] • 0.001 [kg/g] = 0.81 [kg CH ₄]
N₂O emissions [kg]	= Number of trips per year • number of agency employees traveling by bus • average mileage per trip [mi] • emission factor for bus [g/passenger-mile] • 0.001 [kg/g] = 225 • 300 • 20 [mi] • 0.0005 [g/passenger-mile] • 0.001 [kg/g] = 0.675 [kg N ₂ O]

➤ **Carpool**

CO₂ emissions [kg]	= Number of trips per year • number of agency employees traveling by carpool • average mileage per trip [miles] • emission factor for carpool [kg/passenger-mile] = 225 • 50 • 40 [miles] • 0.182 [kg/passenger-mile] = 491400 [kg CO ₂]
CH₄ emissions [kg]	= Number of trips per year • number of agency employees traveling by mode • average mileage per trip [miles] • emission factor for each mode [g/passenger-mile] • 0.001 [kg/g] = 225 • 50 • 40 [miles] • 0.016 [g/passenger-mile] • 0.001 [kg/g] = 41.85 [kg CH ₄]
N₂O emissions [kg]	= Number of trips per year • number of agency employees traveling by mode • average mileage per trip [miles] • emission factor for each mode [g/passenger-mile] • 0.001 [kg/g] = 225 • 50 • 40 [miles] • 0.016 [g/passenger-mile] • 0.001 [kg/g] = 43.2 [kg N ₂ O]

Step 4: Sum single occupant and multiple passenger travel emissions and convert them to metric tons

Use Equation C-16 to add the respective CO₂, N₂O, and CH₄ emissions from all employees.

Equation C-16: Total Emissions Calculations

Total CO₂ emission from commuter travel [MT] = (CO₂ from mode 1 [kg] + CO₂ from mode 2 [kg] + CO₂ from mode 3 [kg] ...) • 0.001 [MT/kg]
 = (CO₂ single occupant [kg] + CO₂ transit rail [kg] + CO₂ bus [kg] + CO₂ carpool [kg]) • 0.001 [MT/kg]
 = (614250 [kg] + 234720 [kg] + 144450 [kg] + 491400 [kg]) • 0.001 [MT/kg]
 = 1484820 [kg] • 0.001 [MT/kg]
 = 1484.82 [MT CO₂]

Total CH₄ emission from commuter travel [MT] = (CH₄ from mode 1 [kg] + CH₄ from mode 2 [kg] + CH₄ from mode 3 [kg] ...) • 0.001 [MT/kg]
 = (CH₄ single occupant [kg] + CH₄ transit rail [kg] + CH₄ bus [kg] + CH₄ carpool [kg]) • 0.001 [MT/kg]
 = (52.31 [kg] + 5.76 [kg] + 0.81 [kg] + 41.85 [kg]) • 0.001 [MT/kg]
 = 100.73 [kg] • 0.001 [MT/kg]
 = 0.101 [MT CH₄]

Total N₂O emission from commuter travel [MT] = (N₂O from mode 1 [kg] + N₂O from mode 2 [kg] + N₂O from mode 3 [kg] ...) • 0.001 [MT/kg]
 = (N₂O single occupant [kg] + N₂O transit rail [kg] + N₂O bus [kg] + N₂O carpool [kg]) • 0.001 [MT/kg]
 = (54.00 [kg] + 2.88 [kg] + 0.675 [kg] + 43.2 [kg]) • 0.001 [MT/kg]
 = 100.755 [kg] • 0.001 [MT/kg]
 = 0.101 [MT N₂O]

Step 5: Convert to CO₂e and determine total emissions

Use Equation C-17 to multiply the total N₂O and CH₄ emissions by their respective GWP (see Table D-13) to determine the total CO₂e emissions.

Equation C-17: Commuter Travel MT CO₂e Emissions

Total CO₂e emissions [MT CO₂e] = MT CO₂ + (MT CH₄ • CH₄ GWP) + (MT N₂O • N₂O GWP)
 = 1484.82 [MT CO₂] + (0.101 [MT CH₄] • 21) + (0.101 [MT N₂O] • 310)
 = 1484.82 [MT CO₂] + 2.12 [MT CO₂e] + 31.31 [MT CO₂e]
 = **1518.25 [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 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.

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

*Data Sources*⁹³

Table C-13 shows the data elements and their preferred and alternate sources.

Table C-13: Contracted Wastewater Treatment Default Data Sources

Data Element	Preferred Source	Alternate Source
Employees served ⁹⁴	<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-14 shows the data elements and their sources.

Table C-14: 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

⁹³ 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*.

⁹⁴ 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.

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	EPA, Mandatory Greenhouse Gas Reporting Rule, <i>Federal Register</i> , Friday, October 30, 2009, www.epa.gov/climatechange/emissions/ghgrulemaking.html	Table C-1 to Subpart C of Part 98	D-2	Scope 1
CH ₄ and N ₂ O Emission Factors for Various Types of Fuel		Table C-2 to Subpart C of Part 98	D-3	Scope 1, Other reporting
N ₂ O and CH ₄ Emission Factors for Highway Vehicles	EPA, EPA Climate Leaders, Mobile Sources Guidance, www.epa.gov/stateply/documents/resources/commute_travel_product.pdf	Table A-1	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	eGRID2007 Version 1.1 Year 2005 Summary Tables, p.6, output emission rates column, ⁹⁵ www.epa.gov/cleanenergy/documents/egridzips/eGRID2007V1_1_year05_SummaryTables.pdf	eGRID2007 Version 1.1 Year 2005 Summary Tables	D-8	Scope 2 & 3
U.S. Territories Output Emission Rate Factors	DOE 1605(b): Voluntary Reporting of Greenhouse Gases: www.eia.doe.gov/oiaf/1605/emission_factors.html	Appendix F. Electricity Emission Factors	D-8	Scope 2 & 3
Steam/Hot Water	DOE 1605(b): Technical	Part F: Indirect	D-9	Scope 2 &

⁹⁵ 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
Emission Factor	Guidance: www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf .	Emissions		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		D-11	Scope 3
Commuter & Mass Transit Emission Factors			D-12	Scope 3
Global Warming Potentials (100-Year)	EPA, Mandatory Greenhouse Gas Reporting Rule, <i>Federal Register</i> , Friday, October 30, 2009 www.epa.gov/climatechange/emissions/ghgrulemaking.html	Table A-1 to Subpart A of Part 98	D-13	All
General Conversion Factors		Table A-2 to Subpart A of Part 98	D-14	All
Gasoline Gallon Equivalent Conversion Factors	DOE and GSA, Federal Automotive Statistical Tool, https://fastweb.inel.gov/		D-15	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 Mandatory Greenhouse Gas Reporting Rule (MRR) and Climate Leaders guidance. Table D-2 and Table D-3 list key combustion factors.

Table D-1: Default CO₂ Emission Factors and Higher Heating Values⁹⁶ for Various Types of Fuel

Fuel Type	Default HHV	Default CO₂ 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
Isobutene	0.097	64.91
Isobutylene	0.103	67.74
Butane	0.101	65.15
Butylene	0.103	67.73

⁹⁶ Heating value is the amount of energy released when a fuel is burned completely. There is a difference between higher heating values (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
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
Vegetable oil	0.120	81.55

Source: EPA Mandatory Reporting Rule, Federal Register, Friday, October 30, 2009. Table C-1 to Subpart C of Part 98. See www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.pdf.

Table D-2: 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: EPA Mandatory Reporting Rule, *Federal Register*, Friday, October 30, 2009. Table C-2 to Subpart C of Part 98. See www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.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-1: 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
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

Fuel type	CH ₄ Emission Factor (g CH ₄ /mile)	N ₂ O Emission Factor (g N ₂ O/mile)
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-2: CH₄ and N₂O Emission Factors for Alternative Fuel Vehicles

Fuel type	CH₄ Emission Factor (g CH₄/mile)	N₂O Emission Factor (g N₂O/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-3: 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
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 factors.

Table D-1: 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
Chillers	10–2,000	1	15	100	95
Residential and commercial A/C, 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 and TCR General Reporting Protocol, Version 1.1, May 2008, Table 16.3

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.⁹⁷ 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 Table D-9 and Table D-10.

⁹⁷ EPA Power Profiler. See www.epa.gov/cleanenergy/energy-and-you/how-clean.html.

Table D-1: eGRID2007 Year 2005 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	558.985	11.612	2.952	633.196	668.332	16.515	3.735
AKMS	ASCC Miscellaneous	226.277	9.413	1.849	642.847	660.932	27.428	5.384
AZNM	WECC Southwest	594.679	7.917	8.136	766.430	544.963	9.434	3.858
CAMX	WECC California	328.454	13.715	3.663	568.532	491.248	17.800	2.517
ERCT	ERCOT All	600.712	8.458	6.856	695.770	507.502	9.140	2.574
FRCC	FRCC All	598.091	20.831	7.684	635.783	614.033	21.845	5.876
HIMS	HICC Miscellaneous	687.155	142.736	21.266	769.919	759.379	153.511	23.322
HIOA	HICC Oahu	821.894	49.654	10.712	816.597	841.455	54.480	9.428
MROE	MRO East	832.210	12.516	13.772	1,005.369	829.448	13.075	11.430
MROW	MRO West	826.371	12.700	13.928	1,049.128	979.204	20.669	15.977
NEWE	NPCC New England	420.787	39.233	7.714	613.924	596.259	35.138	7.268
NWPP	WECC Northwest	409.247	8.677	6.758	894.921	604.924	22.353	8.495
NYCW	NPCC NYC/Westchester	369.881	16.340	2.475	642.547	691.750	25.764	4.119
NYLI	NPCC Long Island	697.079	52.351	8.206	654.561	684.852	27.362	4.891
NYUP	NPCC Upstate NY	326.947	11.258	5.077	705.034	686.784	20.549	8.349
RFCE	RFC East	516.673	13.731	8.489	758.942	812.154	18.873	11.047
RFCM	RFC Michigan	709.088	15.391	12.324	768.781	754.386	13.334	11.903
RFCW	RFC West	697.542	8.271	11.661	897.185	903.942	11.108	14.388
RMPA	WECC Rockies	854.147	10.380	13.041	936.383	733.777	10.171	9.134
SPNO	SPP North	889.464	10.803	14.553	1,035.756	984.173	14.143	14.511
SPSO	SPP South	752.114	11.330	10.253	804.663	625.525	11.068	5.463
SRMV	SERC Miss Valley	462.543	11.029	5.310	644.772	570.206	13.381	4.454
SRMW	SERC Midwest	830.301	9.592	13.835	954.141	953.064	11.638	14.933
SRSO	SERC South	675.640	11.917	11.554	885.171	769.841	15.964	11.980
SRTV	SERC Tenn Valley	685.122	9.093	11.630	953.170	906.435	12.813	14.905
SRVC	SERC Virginia/Carolina	514.770	10.782	8.976	861.680	807.973	18.184	12.455
U.S. Territories		858.000	34.43	7.77	N/A	N/A	N/A	N/A
U.S.		602.978	12.368	9.345	815.381	718.160	16.227	9.06

Source 1: Derived from EPA, eGRID2007 Version 1.1 Year 2005 Summary Tables. See www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

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-2: 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	98.19	1.9 x 10 ⁻³	1.9 x 10 ⁻⁴
Hot water	73.64	1.4 x 10 ⁻³	1.4 x 10 ⁻⁴

* 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.

Table D-3: 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 MRR 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.⁹⁸ Ground business travel and commuter emission factors from Climate Leaders are used in the default methodology and provided in Table D-11 and Table D-12. 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-1: 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

⁹⁸ EPA, AP 42. See www.epa.gov/ttn/chief/ap42/index.html.

Motorcycle	0.167	0.070×10^{-3}	0.007×10^{-3}
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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-2: Commuter & 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	0.016×10^{-3}	0.016×10^{-3}
Van pool†	0.130	0.009×10^{-3}	0.012×10^{-3}
Bus	0.107	0.0006×10^{-3}	0.0005×10^{-3}
Transit rail	0.163	0.004×10^{-3}	0.002×10^{-3}
Commuter rail	0.172	0.002×10^{-3}	0.001×10^{-3}
Intercity rail	0.185	0.002×10^{-3}	0.001×10^{-3}

* Assumes 2 passengers

† Assumes 4 passengers

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport. See: www.epa.gov/stateply/documents/resources/commute_travel_product.pdf.

Global Warming Potentials

Table D-1: 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
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

Name	CAS No.	Chemical formula	Global warming potential (100 yr.)
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
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 CHFCF 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

Name	CAS No.	Chemical formula	Global warming potential (100 yr.)
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: EPA Mandatory Reporting Rule, Federal Register, Friday, October 30, 2009, Table A-1 to Subpart A of Part 98. See www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.pdf.

Conversion Factors

Table D-1: 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}
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

To convert from	To	Multiply by
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
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: EPA Mandatory Reporting Rule, Federal Register, Friday, October 30, 2009, Table A-2 to Subpart A of Part 98. See www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.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-2: 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

BOD	Biochemical Oxygen Demand
CAS	Chemical Abstract Service
CEQ	Council on Environmental Quality
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
DOC	Degradable Organic Carbon
DoD	Department of Defense
DOE	Department of Energy
EERE	Energy Efficiency and Renewable Energy
eGRID	Emissions & Generation Resource Integrated Database
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
F-gas	Fluorinated Gas (HFCs, PFCs, SF ₆)
FAST	Federal Automotive Statistical Tool
FEMP	Federal Energy Management Program
FY	Fiscal Year
GE	Goal-Excluded
GHG	Greenhouse Gas
GS	Goal-Subject
GSA	General Services Administration
GWP	Global Warming Potential
HFC	Hydrofluorocarbon Group of Gases
HHV	Higher Heating Value

HVAC	Heating, Ventilation and Air Conditioning
ICFPA	International Council of Forest and Paper Associations
IPCC	Intergovernmental Panel on Climate Change
LandGEM	Landfill Gas Emission Model
LFG	Landfill Gas
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gases
MRR	EPA's Greenhouse Gas Mandatory Reporting Rule
MSDS	Material Safety Data Sheet
MSW	Municipal Solid Waste
MT CO ₂ e	metric tons CO ₂ e
NMOC	Non-Methane Organic Compounds
NF ₃	Nitrogen Trifluoride
N ₂ O	Nitrous Oxide
ODS	Ozone Depleting Substance
OFEE	Office of the Federal Environmental Executive
PFC	Perfluorocarbon Group of Gases
PNR	Passenger Name Record
POC	Point-of-Contact
REC	Renewable Energy Certificate
SF ₆	Sulfur Hexafluoride
LGO Protocol	<i>Local Government Operations Protocol</i>
T&D	Transmission and Distribution
TSD	<i>Technical Support Document for Federal GHG Accounting and Reporting Guidance</i>
VE	Vehicles and Equipment
WBCSD	World Business Council for Sustainable Development
WTE	Waste-to-Energy
WRI	World Resources Institute
WWTP	Wastewater Treatment Plant