PDHonline Course C744 (4 PDH)

How to Develop a Greenhouse Gas Emissions Plan

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How to Develop a Greenhouse Gas Management Plan

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This course is based on information provided in the U.S. Environmental Protection Agency's program, "Guide for Greenhouse Gas Management for Small Business and Low Emitters." For more information visit www.EPA.gov

Introduction

There are segments of society that believe greenhouse gases, such as Carbon Dioxide (CO_2) have a negative impact on the environment and that reducing these greenhouse gases will improve the quality of life. Regardless of whether you feel greenhouse gases pose a serious environmental threat, it may make good business sense to take a proactive approach to managing greenhouse gases. Managing greenhouse gases – and taking credit for "being green" – can, in some cases, have a rather minor financial impact and may yield significant positive public relations.

Let's begin with a brief introduction to the general concept of greenhouse gases. *The greenhouse gas (GHG) footprint*, refers to the amount of GHG that are emitted during the creation of products or services. It is more comprehensive than the commonly used *carbon footprint*, which measures only carbon dioxide, one of many greenhouse gases.

Greenhouse gases are be emitted through transport, land clearance, and the production and consumption of food, fuels, manufactured goods, materials, wood, roads, buildings, and services. For simplicity of reporting, it is often expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs, emitted.

Greenhouse gases trap heat and make the planet warmer. If we just look at the impacts of humans on greenhouse gas emissions (there are many other sources) the largest source of greenhouse gas emissions is from burning fossil fuels for electricity, heat, and transportation.

GHG Sources

The primary sources of greenhouse gas emissions in the United States are:

- Electricity production - Electricity production generates the largest share of greenhouse gas emissions. Over 70% of electricity production comes from burning fossil fuels, mostly coal and natural gas.

- Transportation - Greenhouse gas emissions from transportation primarily come from burning fossil fuel for cars, trucks, ships, trains, and planes. Over 90% of the fuel used for transportation is petroleum based, which includes gasoline and diesel.

- Industry - Greenhouse gas emissions from industry primarily come from burning fossil fuels for energy as well as greenhouse gas emissions from certain chemical reactions necessary to produce goods from raw materials.

- Commercial and Residential - Greenhouse gas emissions from businesses and homes arise primarily from fossil fuels burned for heat, the use of certain products that contain greenhouse gases, and the handling of waste.

- Agriculture - Greenhouse gas emissions from agriculture come from livestock such as cows, agricultural soils, and rice production.

- Land Use and Forestry - Land areas generally absorb CO_2 from the atmosphere but can also be a source of greenhouse gas emissions.

Figure 1 is a pie chart showing the breakdown of the various CO_2 emission sources.

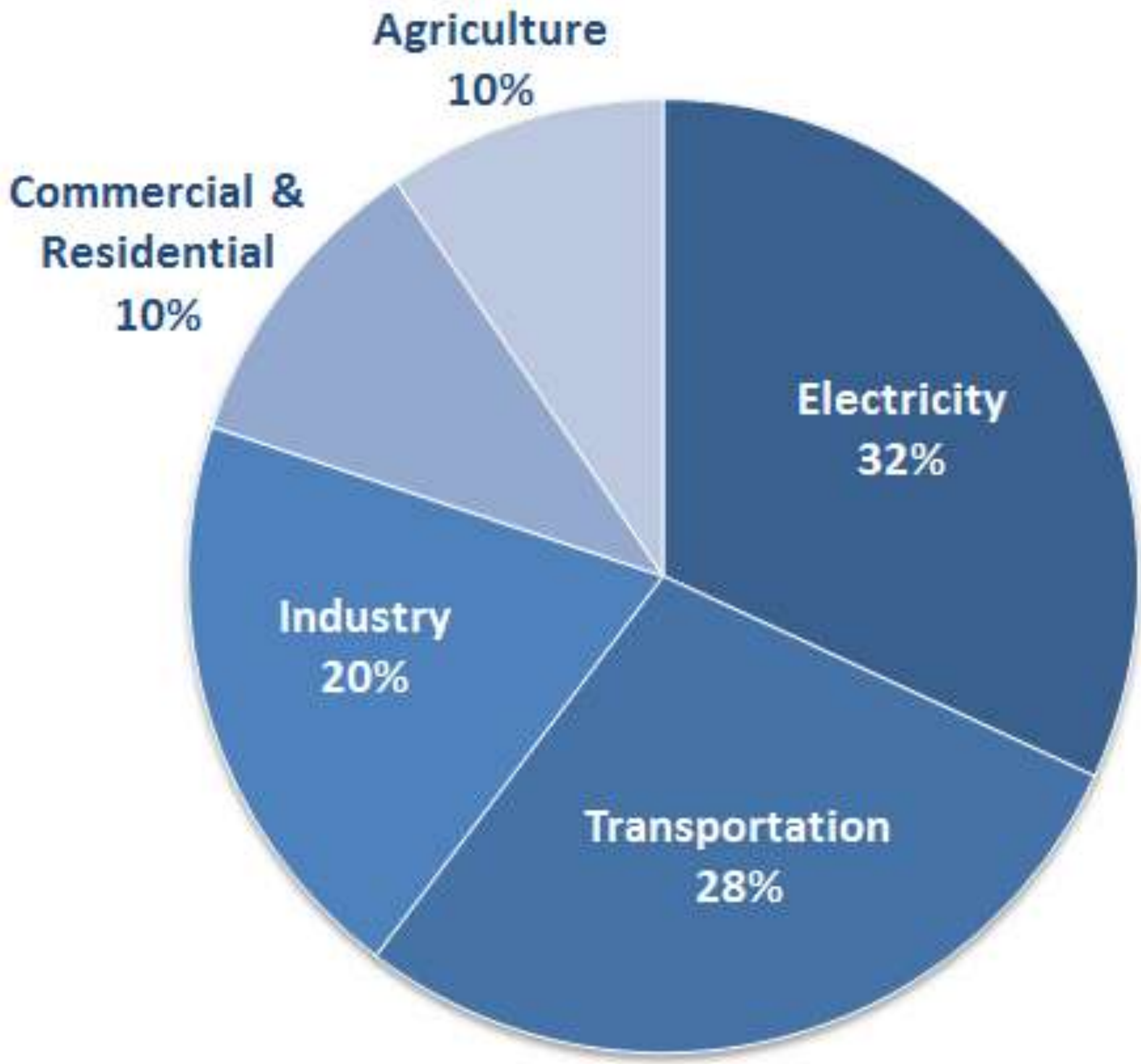

Figure 1

Types of Greenhouse Gases

The most common greenhouse gases include carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), and Flourinated gases such as SF_6.

This section provides information on emissions and removals of the main greenhouse gases to and from the atmosphere.

- **Carbon dioxide (CO_2)** : Carbon dioxide enters the atmosphere through burning fossil fuels, solid waste, trees and wood products, and also as a result of certain chemical reactions. Carbon dioxide is removed from the atmosphere when it is absorbed by plants as part of the biological carbon cycle.

- **Methane (CH_4)** : Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

- **Nitrous oxide (N_2O)** : Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

- **Fluorinated gases** : Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes.

See Figure 2 for the relative greenhouse gas potential of each of these gases.

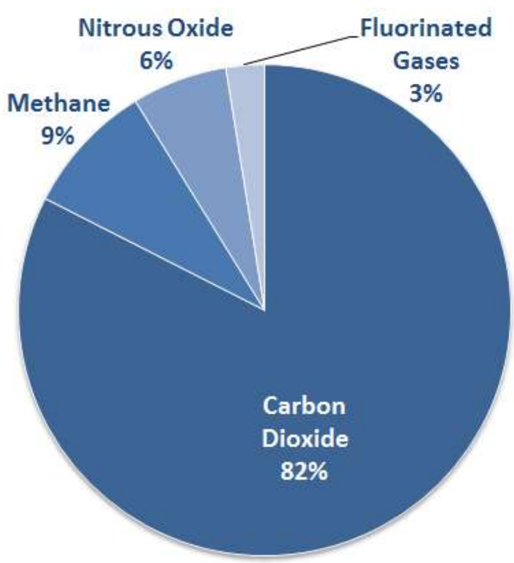

Figure 2

Each gas's effect on climate change depends on three main factors:

1. **How much** of these gases are in the atmosphere? The *concentration,* or *abundance,* is the amount of a particular gas in the air. Larger emissions of greenhouse gases lead to higher concentrations in the atmosphere. Greenhouse gas concentrations are measured in parts per million, parts per billion, and even parts per trillion.

2. **How long** do they stay in the atmosphere? Each of these gases can remain in the atmosphere for different amounts of time, ranging from a few years to thousands of years. All of these gases remain in the atmosphere long enough to become well mixed, meaning that the amount that is measured in the atmosphere is roughly the same all over the world, regardless of the source of the emission.

Global-warming potential (GWP) is a relative measure of how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide. A GWP is calculated over a specific time interval and is expressed as a factor of carbon dioxide (whose GWP is standardized to 1).

3. **How strongly** do they impact global temperatures? Some gases are more effective than others at making the planet warmer. For each greenhouse gas, a *Global Warming Potential* (GWP) has been calculated to reflect how long it remains in the atmosphere, on average, and how strongly it absorbs energy. Gases with a higher GWP absorb more energy, per pound, than gases with a lower GWP, and thus contribute more to warming Earth.

GHG Management Plan

This course is a guide to estimating and reducing a company's GHG emissions. It is based on the Environmental Protection Agency's (EPA's) "Guide for Greenhouse Gas Management for Small Business and Low Emitters". While the course presents an overview of how to inventory and calculate GHG gas emissions for businesses, the EPA has an excellent computer spreadsheet that makes the task very simple. The spreadsheet may be found at www.epa.gov.

The purpose of the tools presented in this course is to enable small businesses to:

- Create a comprehensive inventory of all GHG emissions;
- Develop an Inventory Management Plan (IMP) for data consistency over time; and

- Set a GHG reduction goal and track progress.

This course walks the user through the four key steps of developing a greenhouse gas management plan. Briefly, the steps include:

Step 1: Set base expectations.
This first step includes defining the GHG inventories, discussing the principles of greenhouse gas accounting, choosing a base year, and determining the organizational boundaries for the company.

Step 2: Calculate Greenhouse Gas Emissions.
In this step we decide on what sources are covered and how to identify ease emission source type and the how to quantify the emissions.

Step 3: Create an Inventory Management Plan.
This step includes documenting the inventory procedures and developing and inventory management plan.

Step 4: Set a Goal and Track Progress.
In this step we develop a GHG inventory summary and develop goals for managing and reducing GHGs at the company.

The course begins in Chapter 1 with an overview of the GHG inventory methodology and how to calculate GHGs. Chapters 2, 3, and 4 show how to inventory and calculate the GHG impact of various sources. Chapter 5 explains how to develop an Inventory Management Plan (IMP). And finally, Chapter 6 brings it all together with a case study of a small manufacturing plant and shows an actual example of how to calculate GHG emissions.

Chapter 1
Greenhouse Gas Inventory Methodology

An *emissions inventory* is a list of emission sources and the associated emissions quantified using standardized methods. This inventory guidance is based on the World Resources Institute/ World Business Council for Sustainable Development (WRI/WBCSD) GHG Protocol Corporate Accounting and Reporting Standard (GHG Protocol), which has become the global standard for calculating GHG emissions.

Calculating GHG emissions involves the following process which is explained in this course:

- Choose a base year for the emissions inventory, against which future emissions will be tracked.
- Identify the facilities to include in the inventory (organizational boundaries).
- Identify the sources within the facilities to include in the inventory (operational boundaries).
- Follow a standardized and accepted methodology to calculate the GHG emissions from each identified source.
- Include each of the six major GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydroflurocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Principles of Greenhouse Gas Accounting

The GHG Protocol is based on five principles. When in doubt regarding the application of the tools explained in this course to ambiguous issues or situations, refer back to these principles to ensure the creation of a high-quality credible inventory:

1. Relevance: Ensure the GHG inventory appropriately reflects the GHG emissions of the company and serves the decision-making needs of users.
2. Completeness: Account for and report on all GHG emission sources and activities within the chosen inventory boundary.
3. Consistency: Use consistent methodologies to allow for meaningful comparisons of emissions over time. Document any changes to the data, inventory boundary, methods, or any other relevant factors in the time series.

4. Transparency: Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Note any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used.
5. Accuracy: Ensure that the quantification of GHG emissions is as accurate as possible and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the integrity of the reported information.

Choosing a Base Year

For the inventory, collect data for a full year of operating activities, on a calendar year basis. The emissions calculated from this data will then serve as the *base year* data, against which emissions will be compared over time. The base year data should be high quality in order to provide a meaningful comparison; therefore, choose a recent year. For example, for a company starting this process in 2015, collecting data for a base year of 2014 will likely provide the most robust data for its inventory.

Identifying Organizational Boundaries

An *organizational boundary* is used to determine which facilities or operations will be included in the GHG emissions inventory. Business operations vary in their legal and organizational structures; they include wholly owned operations, incorporated and non-incorporated joint ventures, subsidiaries, and others. For the purposes of financial accounting, they are treated according to established rules that depend on the structure of the organization and the relationships among the parties involved. For corporate reporting, two distinct approaches can be used to consolidate GHG emissions: the *equity share* and the *control approach*. Either of these two approaches may be used in determining an organizational boundary, an equity share or a control approach:

1. Using an equity share approach, account for GHG emissions based on the company's share of equity (typically by percentage ownership) in a facility or operation.
2. A control approach is divided into either financial or operational control:
    a. Under financial control, include operations for which the company has the ability to direct financial and operating policies with a view to gaining economic benefits from those activities.
    b. Under operational control, include operations for which the company has full authority to implement operating policies.

Calculating Greenhouse Gas Emissions

Emission sources of all six major GHGs are accounted for in the inventory: CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6. Based on key characteristics of emissions sources, such as the control the organization has to affect them, the GHG Protocol organizes sources into the following three categories:

1. Emissions from sources that the company owns or controls, like natural gas-fired boilers or vehicle fleets. These are also called *direct emissions*. See Chapter 2 for direct emission sources.

2. Emissions that are a consequence of the operations of the company, but occur at sources owned or controlled by another company, most typically electricity, heat, or steam. These are also called *indirect emissions*. See Chapter 3 for indirect emissions.

3. Indirect emissions are items not covered by either direct or indirect accounting and include items such as employee travel and product transport. These may or may not be included in the inventory and are called *optional emissions*. See Chapter 4 for optional emissions.

For a graphic overview of the three types of emissions see Figure 3 below.

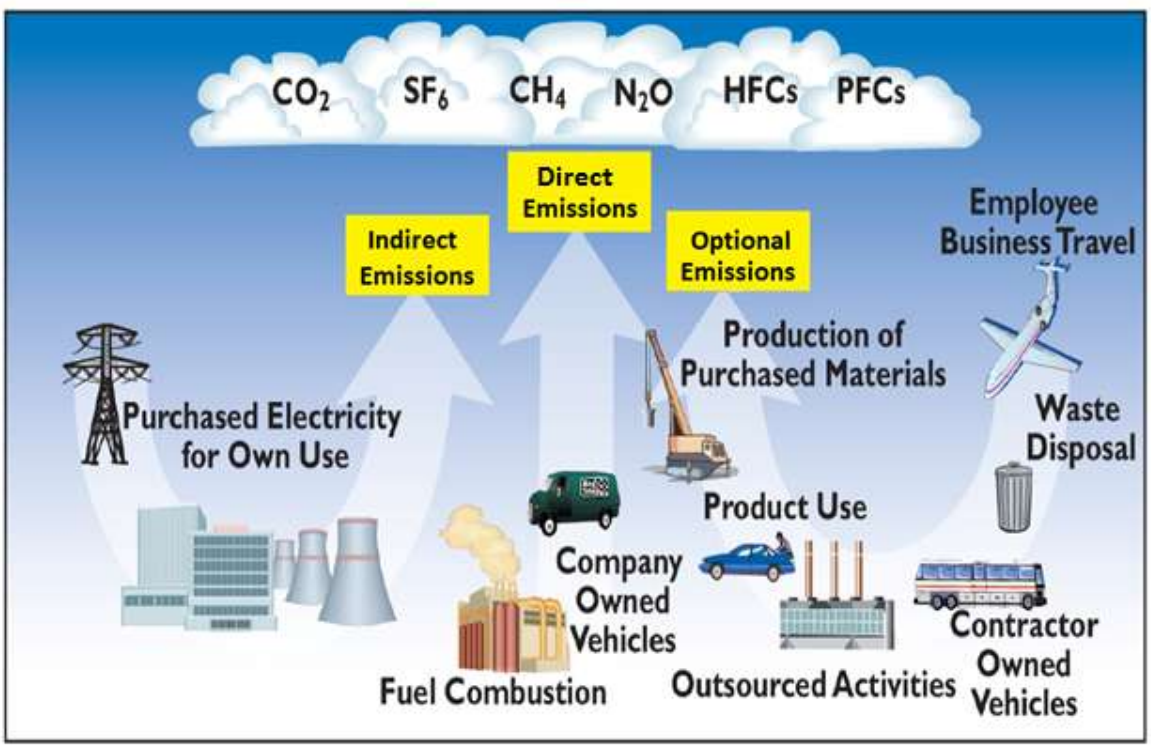

Figure 3

The procedures in this course allow the user to estimate GHG emissions from direct, indirect, and optional emissions. Companies using this process will likely find that most of their emissions come from building heating and cooling, fleet vehicles, electricity use, and employee travel.

Some industrial sectors, such as pulp and paper, cement, chemicals, and iron and steel, may have sector-specific emission sources that are not covered by this procedure. To quantify these emissions, refer to sector-specific guidance developed by the WRI/WBCSD, which has a full list of sectors with sector-specific emissions and guidance on calculating emissions from industrial processes.

The following table describes the data required to complete the GHG inventory. Once this data is gathered the procedures in Chapters 2-4 will enable the user to calculate the GHG impacts from each source.

Table 1

Source Data Requirements for GHG Inventory Calculations

Base Data	
For Each Facility	• Facility Name • Address • Floor area • Number of Employees • Open and Close Date of Facility • Type of Facility
Direct Source Emissions	
Stationary Sources (Each Fuel Type)	• Monthly Consumption data by facility
Mobile Sources	• List of Vehicles (Year, Make, Model, Fuel Type) • Fuel Consumption by Vehicle • Miles Traveled by Vehicle

Refrigeration & AC	• Inventory of Equipment by Facility • Refrigerant Capacity of Equipment • Refrigerant Purchase, Inventory, and Disposal Data
Fire Suppression Systems	• Inventory of Equipment by Facility • Fire Suppressant Capacity of Equipment • Fire Suppressant Purchase, Inventory, and Disposal Data • Disposal Data
Purchased Gases	• Types of Gas Purchased • Amount of Gas Purchased
Waste Gases	• Type and Composition of Waste Gases Combusted • Amount of each Waste Gas Combusted
Indirect Source Emissions	
Electricity	• Monthly Consumption Data by Meter or Facility
Steam	• Monthly Consumption Data by Meter or Facility • Steam Provider Emission Factors • Fuel Type Used to Generate Steam • Boiler Efficiency
Optional Source Emissions	
Business Travel	• Mode of Transportation • Mileage by Trip
Employee Commuting	• Mode of Transportation per Employee • Mileage by Trip
Product Transport	• Mode of Transportation for each Shipment • Weight of Product Transported for each Shipment • Distance Product Transported for each Shipment
RECs	• Number of RECs purchased • CO_2e of the RECs
GHG Offsets	• Metric tons of CO_2e purchased

Emissions Summary

Totals are calculated in metric tons of *CO_2 equivalent* (CO_2e), which is the standard unit for comparing the degree of potential climate impact caused by emissions of different GHGs

Once the data has been collected and emissions calculated as explained in chapters 2 – 4, the results should be collated and summarized in a format similar to Form 1 shown below. Use this summary sheet as an Annual GHG Inventory Summary form. The total GHG emissions from each source category should be included in this form. Enter the data below into the appropriate line of the Annual GHG Inventory Summary (Form 1.)

If you have multiple files covering sub-sets of your inventory for particular a reporting period, sum each of the emission categories (e.g. Stationary Combustion) to a corporate total.

Enter company information into the space provided.

Form 1 **Annual GHG Inventory Summary**		
Company Information	Name: Location: Year: Date Prepared: By:	
Emissions Type	**Source**	**CO_2-e (Metric Tons)**
Direct Emissions	Stationary Combustion	
	Mobile Sources	
	Refrigeration / AC Equipment Use	
	Fire Suppression	
	Purchased Gases	
	Total Direct emissions	
Indirect Emissions	Purchased and Consumed Electricity	
	Purchased and Consumed Steam	
	Total Indirect Emissions	
Optional Emissions	Employee Business Travel	

	Employee Commuting	
	Product Transport	
	RECs and Green Power Purchases	
	Offsets	
	Total Optional Emissions	
Total Facility Emissions		

Conversion Factors

It is important to pay attention to units (e.g., cubic feet, gallons). The units from the data collected must match the units in the forms for that particular data requirement. For example, fuel usage for vehicles must be entered into the forms in gallons. For situations where the data collected does not match the units in the forms, please refer to the conversion factors in Tables 2 and 3 to locate a factor to convert the data to the appropriate units.

Table 2
Conversion Factors

Conversion		Multiply by	Units
From	To		
Mass			
pounds (lb)	gram (g)	453.6	g / lb
pounds (lb)	kilogram (kg)	0.4536	kg / lb
pounds (lb)	metric ton	0.0004536	metric ton / lb
kilogram (kg)	pounds (lb)	2.205	lb / kg
short ton	pounds (lb)	2,000	lb / short ton
short ton	kilogram (kg)	907.2	kg / short ton
metric ton	pounds (lb)	2,205	lb / metric ton
metric ton	kilogram (kg)	1,000	kg / metric ton
metric ton	short ton	1.102	short ton / metric ton
Volume			

standard cubic foot (scf)	US gallon (gal)	7.4805	gal / scf
standard cubic foot (scf)	barrel (bbl)	0.1781	bbl / scf
standard cubic foot (scf)	liters (L)	28.32	L / scf
standard cubic foot (scf)	cubic meters (m3)	0.02832	m3 / scf
US gallon (gal)	barrel (bbl)	0.0238	bbl / gal
US gallon (gal)	liters (L)	3.785	L / gal
US gallon (gal)	cubic meters (m3)	0.003785	m3 / gal
barrel (bbl)	US gallons (gal)	42	gal / bbl
barrel (bbl)	liters (L)	158.99	L / bbl
barrel (bbl)	cubic meters (m3)	0.1589	m3 / bbl
liters (L)	cubic meters (m3)	0.001	m3 / L
liters (L)	US gallon (gal)	0.2642	gal / L
cubic meters (m3)	barrel (bbl)	6.2897	bbl / m3
cubic meters (m3)	US gallon (gal)	264.2	gal / m3
cubic meters (m3)	liters (L)	1,000	L / m3
Energy			
kilowatt hour (kWh)	Btu	3,412	Btu / kWh
kilowatt hour (kWh)	kilojoules (KJ)	3,600	KJ / kWh
megajoule (MJ)	gigajoules (GJ)	0.001	GJ / MJ
gigajoule (GJ)	million Btu (mmBtu)	0.9478	mmBtu / GJ
gigajoule (GJ)	kilowatt hours (kWh)	277.8	kWh / GJ
Btu	joules (J)	1,055	J / Btu
million Btu (mmBtu)	gigajoules (GJ)	1.055	GJ / mmBtu
million Btu (mmBtu)	kilowatt hours (kWh)	293	kWh / mmBtu
therm	Btu	100,000	Btu / therm
therm	gigajoules (GJ)	0.1055	GJ / therm
therm	kilowatt hours (kWh)	29.3	kWh / therm

Distance			
mile	kilometers (km)	1.609	km / mile
nautical mile	miles	1.15	mile / nautical mile
kilometer (km)	miles	0.622	mile / km
Other			
Kilo	1,000		
Mega	1,000,000		
Giga	1,000,000,000		
Tera	1,000,000,000,000		
Molecular Weight of C	12		
Molecular Weight of CO_2	44		

Table 3 has the heat content conversion factors for various fuel sources.

Table 3

Heat Content Conversion Factors

Fuel Type	Conversion From	Conversion To	Multiply by	Units
Natural gas	mmBtu	scf	972.8	scf / mmBtu
Natural gas	Dth (Decatherm)	scf	972.8	scf / Dth
Natural gas	therm	scf	97.3	scf / therm
Natural gas	ccf	scf	100	scf / ccf
Natural gas	Mcf	scf	1000	scf / Mcf
Natural gas	cubic meter	scf	35.31	scf / cubic meter
Natural gas	kWh	scf	3.319	scf / kWh
Anthracite Coal	mmBtu	Short ton	0.03986	short ton / mmBtu
Bituminous Coal	mmBtu	Short ton	0.04011	short ton / mmBtu
Sub-bituminous Coal	mmBtu	Short ton	0.05797	short ton / mmBtu
Coke	mmBtu	Short ton	0.04032	short ton / mmBtu

Lignite Coal	mmBtu	Short ton	0.07037	short ton / mmBtu
Unspecified (electric utility)	mmBtu	Short ton	0.05068	short ton / mmBtu
Wood and Wood Waste	mmBtu	Short ton	0.06502	short ton / mmBtu
Distillate Fuel Oil (#1, 2, & 4)	mmBtu	gallon	7.2464	gallon / mmBtu
Residual fuel Oil (#5 & 6)	mmBtu	gallon	6.667	gallon / mmBtu
Kerosene	mmBtu	gallon	7.407	gallon / mmBtu
LPG / Propane	mmBtu	gallon	10.870	gallon / mmBtu
Petroleum Coke	mmBtu	gallon	6.993	gallon / mmBtu
Landfill Gas (50% CH_4, 50% CO_2)	mmBtu	scf	1189	scf / mmBtu
Steam	Mlb (1,000 lbs)	mmBtu	1.194	mmBtu / Mlb
Steam	lb	mmBtu	0.001194	mmBtu / lb
Steam	short ton	mmBtu	0.002388	mmBtu / short ton

Chapter 2
Direct Emission Sources

This chapter explains how to calculate greenhouse gases from *direct sources*. Direct GHG emissions occur from sources that are owned or controlled by the company. Examples include boilers used to heat buildings, refrigerant leakage from air conditioners, or travel in a company-owned vehicle. Direct emission sources may also include leased vehicles or equipment for which the company pays the fuel bills or can access the fuel use data. These sources are categorized into six types of direct sources: stationary combustion, mobile sources, refrigeration and air conditioning equipment, fire suppression equipment, purchased gases and waste gases. While most companies will have at least some direct sources, it is possible for an office-based organization to have few or no direct emission sources. In this chapter we will discuss each type in detail and explain how to report emissions from each source type.

Stationary Combustion

Combustion emission sources are stationary sources that combust fuel, like a natural gas hot water heater for an office building or an oil burning boiler. Emissions result from the actual combustion of the fuels to produce useful products, like heat and hot water.

To account for these sources, collect information about the type of fuel used and the quantity of fuel combusted at each facility. Sources of data can vary, but the data are often provided by the utility company that supplies the fuel to the company. A monthly natural gas bill, for example, can be used to provide information regarding how much natural gas was purchased for the previous billing cycle.

Enter data for each combustion unit, facility, or site (by fuel type) in Form 2 shown below. In this form the light blue areas are for data input. The brown areas are for factors for the particular source being discussed, and the blue areas for the calculated results (usage multiplied by the relevant factor).

Form 2 Direct Emissions from Stationary Sources							
Description	Usage	Factors			CO_2 (kg)	CH_4 (g)	N_20 (g)
		CO_2	CH_4	N_20			
[Input Data]		[From Tables]			[Calculate]		
Totals							
Convert CH_4 and N_20 to CO_2 equivalents							
Metric Tons							
Total CO_2e							

After the data has been collected, it should be entered into the appropriate columns on Form 2. After the data are entered the CO_2e emissions factors from Table 4 are entered and the emission values can then be calculated and summed.

The values in Form 2 (and subsequent forms) must be converted to metric tons. In addition to the factors in Table 4, the CH_4 and N_20 values must be converted to a “global warning potential” value using the factors in Table 8. Note that these values are in kilograms and grams and must be converted to metric tons. To convert the kilograms to metric tons divide by 1,000 and divide by 1,000,000 to convert grams to metric tons.

Table 4

Stationary Combustion Emission Factors

(Used for Steam and Stationary Combustion)

Fuel Type	CO_2 Factor kg/mmBtu	CH_4 Factor g/mmBtu	N_2O Factor g/mmBtu	CO_2 Factor kg/Unit	CH_4 Factor g/unit	N_2O Factor g/unit	Unit
Anthracite Coal	103.54	11	1.6	2,598	276	40	short tons
Bituminous Coal	93.40	11	1.6	2,328	274	40	short tons
Sub-bituminous Coal	97.02	11	1.6	1,674	190	28	short tons

Lignite Coal	96.36	11	1.6	1,369	156	23	short tons
Unspecified (Electric Utility)	94.38	11	1.6				
Coke	102.04	11	1.6				
Natural Gas	53.02	1.0	0.10	0.05450	0.001028	0.000103	scf
Distillate Fuel Oil (#1, 2 & 4)	73.96	3.0	0.60	10.21	0.41	0.08	gallons
Residual Fuel Oil (#5 & 6)	75.10	3.0	0.60	11.27	0.45	0.09	gallons
Kerosene	75.20	3.0	0.60	10.15	0.41	0.08	gallons
Petroleum Coke	102.41	3.0	0.60				
LPG / Propane	62.98	3.0	0.60	5.79	0.28	0.06	gallons
Wood and Wood Waste	0	32	4.2	1,443	492	65	short tons
Landfill Gas (50% CH4, 50% CO2)	0	3.2	0.63	0.04379	0.002691	0.000530	scf

Mobile Source Emissions

Mobile sources, like company owned cars and heavy duty vehicles, generate emissions by burning fuel. The fuel usage for any vehicle that is under the company's operational control should be reported in this section as a direction emission.

Determine the types of vehicles, types and amount of fuel, and the miles driven for each vehicle or vehicle type. Data sources vary but fuel usage is often determined from fuel receipts or purchase records, and mileage from vehicle records. Mileage or fuel use can also be estimated based on vehicle fuel economy from the manufacturer or www.fueleconomy.gov if the other data sources are not readily available.

Enter data for each vehicle or group of vehicles (grouped by vehicle type, vehicle year and fuel type) in Form 3. Select "Vehicle Type" from Table 6 (closest type available). Enter fuel used in appropriate units. If either the mileage or fuel usage is unknown you may estimate the values by using approximate fuel economy values.

Form 3 Mobile Sources (Company owned/leased Vehicles)											
Vehicle Type	Fuel Type	Year	Description	Annual Mileage	Fuel Used	Factors			CO_2 (kg)	CH_4 (g)	N_20 (g)
						CO_2	CH_4	N_20			
			[Input Data]				[From Tables]		[Calculate]		
Totals											
Convert CH_4 and N_20 to CO_2 equivalents											
Metric Tons											
Total CO_2e											

Use Tables 5, 6 and 7 to determine the factors. When using biofuels, typically the biofuel (biodiesel or ethanol) is mixed with a petroleum fuel (diesel or gasoline) for use in vehicles. Enter the biodiesel and ethanol percentages of the fuel if known, or use these default values.

Biodiesel Percent: 20%
Ethanol Percent: 85%

Biomass CO_2 emissions from biodiesel and ethanol are not reported in the total emissions, but may be reported separately if desired.

Enter the data into the appropriate column on Form 3. If the company owns or leases biofuel or ethanol vehicles, the percentage of biologically based fuel should be reported. Once the data are entered into the Form 3, the CO_2e emissions can be calculated and summarized. Remember, just like with Form 2, the CH_4 and N_20 must always be converted into their global warming potential equivalent.

Table 5 **Mobile Combustion Emission Factors** CO_2 Emissions for Road Vehicles		
Fuel Type	**CO_2 Emission Factor (kg CO_2 / unit)**	**Unit**
Motor Gasoline	8.78	gallon
Diesel Fuel	10.21	gallon

Residual Fuel Oil (#5, & 6)	11.27	gallon
Aviation Gasoline	8.31	gallon
Jet Fuel	9.75	gallon
LPG	5.79	gallon
Ethanol	5.75	gallon
Biodiesel	9.45	gallon
Liquefied Natural Gas (LNG)	4.46	gallon
Compressed Natural Gas (CNG)	0.0545	scf

Table 6

CH_4 and N_2O Emissions for Highway Vehicles

Vehicle Type	Year	CH_4 Factor (g / mile)	N_2O Factor (g / mile)
Gasoline Passenger Vehicles	1984-93	0.0704	0.0647
	1994	0.0531	0.0560
	1995	0.0358	0.0473
	1996	0.0272	0.0426
	1997	0.0268	0.0422
	1998	0.0249	0.0393
	1999	0.0216	0.0337
	2000	0.0178	0.0273
	2001	0.0110	0.0158
	2002	0.0107	0.0153
	2003	0.0114	0.0135
	2004	0.0145	0.0083
	2005	0.0147	0.0079
	2006	0.0161	0.0057
	2007	0.0170	0.0041

	2008	0.0172	0.0038
	2009-present	0.0173	0.0036
Gasoline Light-Duty Trucks	1987-93	0.0813	0.1035
Gasoline Vans, Pickup Trucks, SUVs	1994	0.0646	0.0982
	1995	0.0517	0.0908
	1996	0.0452	0.0871
	1997	0.0452	0.0871
	1998	0.0391	0.0728
	1999	0.0321	0.0564
	2000	0.0346	0.0621
	2001	0.0151	0.0164
	2002	0.0178	0.0228
	2003	0.0155	0.0114
	2004	0.0152	0.0132
	2005	0.0157	0.0101
	2006	0.0159	0.0089
	2007	0.0161	0.0079
	2008	0.0163	0.0066
	2009-present	0.0163	0.0066
Gasoline Heavy-Duty Vehicles	1985-86	0.4090	0.0515
	1987	0.3675	0.0849
	1988-89	0.3492	0.0933
	1990-95	0.3246	0.1142
	1996	0.1278	0.1680
	1997	0.0924	0.1726
	1998	0.0641	0.1693
	1999	0.0578	0.1435
	2000	0.0493	0.1092
	2001	0.0528	0.1235

	2002	0.0546	0.1307
	2003	0.0533	0.1240
	2004	0.0341	0.0285
	2005	0.0326	0.0177
	2006	0.0326	0.0175
	2007	0.0327	0.0173
	2008	0.0327	0.0171
	2009-present	0.0327	0.0169
Diesel Passenger Cars	1960-82	0.0006	0.0012
	1983-present	0.0005	0.0010
Diesel Light-Duty Trucks	1960-82	0.0011	0.0017
	1983-95	0.0009	0.0014
	1996-present	0.0010	0.0015
Diesel Heavy-Duty Vehicles	1960-present	0.0051	0.0048
Gasoline Motorcycles (Non-Catalyst)	Non-Catalyst Control	0.0672	0.0069
Gasoline Motorcycles (Uncontrolled)	Uncontrolled	0.0899	0.0087
CNG Light-Duty Vehicles		0.737	0.050
CNG Heavy-Duty Vehicles		1.966	0.175
CNG Buses		1.966	0.175
LPG Light-Duty Vehicles		0.037	0.067
LPG Heavy-Duty Vehicles		0.066	0.175

LNG Heavy-Duty Vehicles		1.966	0.175
Ethanol Light-Duty Vehicles		0.055	0.067
Ethanol Heavy-Duty Vehicles		0.197	0.175
Ethanol Buses		0.197	0.175

Use Table 7 for Non-highway vehicles, such as equipment, aircraft, boats, etc.

Table 7

CH_4 and N_2O Emissions for Non-Highway Vehicles

Vehicle Type	CH_4 Factor (g / mile)	N_2O Factor (g / mile)
LPG Non-Highway Vehicles	0.50	0.22
Residual Oil Ships and Boats	0.86	0.30
Diesel Ships and Boats	0.74	0.26
Gasoline Ships and Boats	0.64	0.22
Diesel Locomotives	0.80	0.26
Gasoline Agricultural Equip.	1.26	0.22
Diesel Agricultural Equip.	1.44	0.26
Gasoline Construction Equip.	0.50	0.22
Diesel Construction Equip.	0.58	0.26
Jet Fuel Aircraft	0.27	0.31
Aviation Gasoline Aircraft	7.04	0.11
Biodiesel Vehicles	0.58	0.26
Other Diesel Sources	0.58	0.26
Other Gasoline Sources	0.50	0.22

Refrigeration and Air Conditioning Leakage

Refrigeration and Air Conditioning (AC) Equipment sources can vary in size based on the type of organization. Emissions from refrigeration and AC devices in facilities or vehicles are caused by the leakage of chemicals with global warming impact during use, maintenance and/or disposal of the device. They are often small sources for office based organizations. For example, a small office building may have one rooftop air conditioning unit while a grocery store chain may have several rooftop air conditioning units per store as well as a multitude of other refrigeration equipment.

You may choose one of three different calculation methods available for refrigeration and AC. The types of refrigerants along with the data needs for each method should be listed in the form. Data for these sources are often collected from maintenance and inspection records, work orders, or invoices from contractors that service this equipment. Refrigerants not included on the list may be chemicals that do not need to be included in the inventory. For example, ozone depleting substances, such as chlorofluorocarbons (CFCs) or Freon and hydrochlorofluoro-carbons (HCFCs), are regulated internationally and are typically excluded from a GHG inventory or reported as a memo item. However, HFC, PFC, CO_2, and SF_6 refrigerants from facilities and vehicles should be included in the GHG inventory.

Form 4
Refrigeration Gas CO2 Equivalent Emissions
Simplified Material Balance Method

Gas	GWP Factor	New Units			Existing Units	Disposed Units			CO_2 Equiv Emissions (lbs)
		Charge (lbs)	Capacity (lbs)	Net (lbs)	Recharge (lbs)	Capacity (lbs)	Recovered (lbs)	Net (lbs)	
[Input Data]	[From Tables]	[Input Data]		[Calculate]		[Input Data]		[Calculate]	
								Totals	

There are three options with which to estimate emissions. They are: the *Material Balance Method*, *Material Balance Method – Simplified*, and the *Screening Method*. The Material Balance Method is considered the preferred method, but the Material Balance Method – Simplified is easier to implement and is sufficiently accurate and this is the only method discussed in this course.

To use this method, begin by first entering company-wide total gases in units (by gas) in Form 4 then choose the appropriate gas from either Table 8 or Table 9.

New units are those installed during reporting period (do not include any data for new units pre-charged by supplier) disposed units were disposed of during the reporting period, and existing units are all others. Charge/Recharge is the gas added to units by company or a contractor (do not include pre-charge by manufacturer). Capacity is the sum of the full capacity for all units (do not include new units pre-charged by manufacturer). Amount recovered is the total gas recovered from all retired units.

Enter the data into the appropriate sections of Form 4. Once the data are entered, the CO_2e emissions are calculated and summarized in the blue colored box.

Table 8
Refrigerants
Global Warming Potentials (GWPs)

Gas	GWP
CO_2	1
CH_4	21
N_2O	310
SF_6	23,900
HFC-23	11,700
HFC-32	650
HFC-125	2,800
HFC-134a	1,300
HFC-143a	3,800
HFC-152a	140
HFC-227ea	2,900
HFC-236fa	6,300
CF_4	6,500
C_2F_6	9,200
C_3F_8	7,000
c-C_4F_8	8,700
C_4F_{10}	7,000
C_5F_{12}	7,500
C_6F_{14}	7,400

Factors for blended refrigerants are shown in Table 9.

Table 9 **Blended Refrigerants (ASHRAE #)**		
ASHRAE #	**Blend GWP HFC/PFC**	**Blend Make-up**
R - 401A	18	53% HCFC-22 , 34% HCFC-124 , 13% HFC-152a
R - 401B	15	61% HCFC-22 , 28% HCFC-124 , 11% HFC-152a
R - 401C	21	33% HCFC-22 , 52% HCFC-124 , 15% HFC-152a
R - 402A	1,680	38% HCFC-22 , 6% HFC-125 , 2% propane
R - 402B	1,064	6% HCFC-22 , 38% HFC-125 , 2% propane
R - 403B	2,730	56% HCFC-22 , 39% PFC-218 , 5% propane
R - 404A	3,260	44% HFC-125 , 4% HFC-134a , 52% HFC 143a
R - 406A	0	55% HCFC-22 , 41% HCFC-142b , 4% isobutane
R - 407A	1,770	20% HFC-32 , 40% HFC-125 , 40% HFC-134a
R - 407B	2,285	10% HFC-32 , 70% HFC-125 , 20% HFC-134a
R - 407C	1,526	23% HFC-32 , 25% HFC-125 , 52% HFC-134a
R - 407D	1,428	15% HFC-32 , 15% HFC-125 , 70% HFC-134a
R - 407E	1,363	25% HFC-32 , 15% HFC-125 , 60% HFC-134a
R - 408A	1,944	47% HCFC-22 , 7% HFC-125 , 46% HFC 143a
R - 409A	0	60% HCFC-22 , 25% HCFC-124 , 15% HCFC-142b
R - 410A	1,725	50% HFC-32 , 50% HFC-125
R - 410B	1,833	45% HFC-32 , 55% HFC-125
R - 411A	15	87.5% HCFC-22 , 11 HFC-152a , 1.5% propylene
R - 411B	4	94% HCFC-22 , 3% HFC-152a , 3% propylene
R - 413A	1,774	88% HFC-134a , 9% PFC-218 , 3% isobutane
R - 414A	0	51% HCFC-22 , 28.5% HCFC-124 , 16.5% HCFC-142b

R - 414B	0	5% HCFC-22 , 39% HCFC-124 , 9.5% HCFC-142b
R - 417A	1,955	46.6% HFC-125 , 5% HFC-134a , 3.4% butane
R - 422A	2,532	85.1% HFC-125 , 11.5% HFC-134a , 3.4% isobutane
R - 422D	2,232	65.1% HFC-125 , 31.5% HFC-134a , 3.4% isobutane
R - 423A	2,060	47.5% HFC-227ea , 52.5% HFC-134a ,
R - 424A	2,011	Mixture of: HFC-125 , HFC-134a , butane, pentane. GWP reported by comstarproducts.com
R - 426A	1,349	Mixture of: HFC-125 , HFC-134a , butane, pentane. GWP reported by comstarproducts.com
R - 428A	2,930	77.5% HFC-125 , 2% HFC-143a , 1.9% isobutane
R - 434A	2,652	Mixture of: HFC-125 , HFC-134a , HFC-143a. GWP reported by comstarproducts.com
R - 500	37	73.8% CFC-12 , 26.2% HFC-152a , 48.8% HCFC-22
R - 502	0	48.8% HCFC-22 , 51.2% CFC-115
R - 504	313	48.2% HFC-32 , 51.8% CFC-115
R - 507	3,300	5% HFC-125 , 5% HFC143a
R - 508A	10,175	39% HFC-23 , 61% PFC-116
R - 508B	10,350	46% HFC-23 , 54% PFC-116

Fire Suppression Systems

Fire Suppression emission sources can range in scale from a small portable fire extinguisher to a large scale fire suppression system for an office building or warehouse. The emissions are caused by chemicals (e.g., HFCs or CO_2) emitted from fire suppression devices during use, maintenance, and disposal.

HFC, PFC and CO_2 fire suppressants are required to be included in the GHG inventory. Other fire suppressants such as Halon compounds, HCFCs, aqueous solutions, or inert gases are typically excluded from a GHG inventory.

Choose one of three different calculation methods available for fire suppression are described below. In each method, choose the types of fire suppression gases used and then gather the corresponding emissions data. Data for these sources are often collected from maintenance and inspection records, work orders, or invoices from contractors that service this equipment.

Form 5 Fire Suppression Gas CO2 Equivalent Emissions Simplified Material Balance Method									
Gas	GWP Factor	New Units			Existing Units	Disposed Units			CO_2 Equiv Emissions (lbs)
		Charge (lbs)	Capacity (lbs)	Net (lbs)	Recharge (lbs)	Capacity (lbs)	Recovered (lbs)	Net (lbs)	
[Input Data]	[From Tables]	[Input Data]		[Calculate]		[Input Data]		[Calculate]	
								Total lbs	
								Total CO2e	

Just like the refrigerant gas procedure, there are three options with which to estimate emissions. They are: the Material Balance Method, Material Balance Method – Simplified, and the Screening Method. The Material Balance Method is considered the preferred method, but the Material Balance Method – Simplified is easier to implement and is sufficiently accurate and is the only method described in this course.

Enter company-wide fire suppression gas in units (by gas) in Form 5. New units are those installed during reporting period (do not include any data for new units pre-charged by supplier) disposed units were disposed of during the reporting period, and existing units are all others. Charge/Recharge is the gas added to units by company or a contractor (do not include pre-charge by manufacturer). Capacity is the sum of the full capacity for all units (do not include new units pre-charged by manufacturer). Amount recovered is the total gas recovered from all retired units.

Enter the data into the appropriate sections of Form 5. Once the data are entered into the form the CO_2e emissions are calculated and summarized in the blue colored box.

Purchased Gases

Industrial gases are sometimes used in processes such as manufacturing, testing, or laboratory uses. For example, CO_2 gas is often used in welding operations. These gases are typically released to the atmosphere after use.

Determine if CO_2, CH_4, N_2O, PFCs, HFCs, or SF_6 are used in processes such as those mentioned above. If so, collect the mass of gas purchased. If data are not available in mass units, the user may need to convert from volume to mass using the density of the specific gas.

Any use and release of the six major greenhouse gases (CO_2, CH_4, N_2O, PFCs, HFCs, and SF_6) should be included in the GHG inventory. Ozone depleting substances, such as CFCs and HCFCs, are regulated internationally and are typically excluded from a GHG inventory or reported as a memo item. Table 9 has the GWP factors for various gases.

Enter the data into the appropriate columns in Form 6 for purchased gases. Once the data are entered the CO_2e emissions may be calculated and summarized.

Form 6
Purchased Gases

Description	Quantity (lbs)	GWP Factor	CO_2 (lb)
			[Calculate]
		Total lbs	
		Total CO_2e	

It is assumed that all gas purchased in the reporting period used and released during the reporting period. If your business makes bulk purchases and plans on using the gas for several years, divide the bulk amount by the years of usage and report that amount.

Tip: If you purchase bulk gas, remember to report it for future years as well.

Waste Gases

Some operations, such as printing operations or paint booths, emit organic compounds. In some cases these waste gas streams are combusted with a flare or thermal oxidizer. This combustion results in CO_2 emissions that should be included in GHG inventories. These are uncommon sources for most office-based organizations.

Collect information about the volume of waste gas that was combusted. Because of the variable composition of waste gas streams, the user will also need to find out what chemicals are present in the waste gas stream, and the quantity of each chemical. Please note that two other data needs, oxidation factor and gas density, should be also collected if practicable; however, default values can be used if needed. The oxidation factor accounts for the amount of carbon in the fuel that is converted to CO_2 during combustion.

Form 7 Waste Gases			
Description	**Quantity (lbs)**	**Factor CO_2**	**CO_2 (lb)**
			[Calculate]
		Total lbs	
		Total CO_2e	

Enter the data into the appropriate columns in Form 7 for waste gases. Once the data are entered, the CO_2e emissions can be calculated and summarized.

Calculation of CO_2 emissions from waste gases is slightly more complicated than for purchased gases. The determination of CO_2 for waste gases is outside the scope of this course.

Chapter 3
Indirect Emission Sources

Indirect emissions are emissions from energy consumed in owned or controlled equipment or operations but generated by another company. For example, although the company may own equipment that runs off of electricity, like office computers and copy machines, a power plant is burning the fuel to generate the electricity it is using. Therefore, the power plant is the direct source of GHG emissions.

For many companies, purchased electricity is the largest source of GHG emissions and the most significant opportunity to reduce those emissions. The separate indirect emissions are separated into two types: purchases of electricity and purchases of steam.

Purchases of Electricity

GHGs are emitted when fossil fuels are combusted to generate electricity. Companies account for their responsibility for these emissions by reporting them as indirect emissions.

Collect electricity purchase information in units of kWh for each facility. The company's best data source is typically its electricity bill or invoice.

Tip: Enter electricity usage by location and then look up the eGRID region for each location.

The following map (Figure 4) has the three electricity grids of the U.S. divided into sub-regions. Select the sub-region in which the company's facilities are located to determine the correct CO_2 emissions factor to use, since different parts of the country use different fuels to generate electricity. Multiple facility locations can be entered as separate line items in the Form 8.

Figure 4

Enter total electricity purchased (kWh) for each facility or site in Form 8 for each eGRID sub-region. Use the map in Figure 4 to determine appropriate eGRID sub-region and then Table 10 to find the emission factors for that sub-region using the “baseload” factors.

Form 8
Electricity Purchases
(MWh)

Meter Account	Description	Usage (Mwh)	Sub-Region	Factors			CO_2 (lb)	CH_4 (lb)	N_20 (lb)
				CO_2	CH_4	N_20			
		[Input Data]			[From Tables]			[Calculate]	
						Total lbs			
						Total CO_2e			

Enter the data into the appropriate columns in Form 8. Once the data are entered, the CO_2e emissions can be calculated and summarized.

Table 10

Electricity Emission Factors (System Average)

CO_2, CH_4 and N_2O System Average Emission Factors by Sub-region (2007 Data)

Sub-region	Baseload Factors			Non-Baseload Factors (Green Power/ REC factors)		
	CO_2 Factor (lb/MWh)	CH_4 Factor (lb/MWh)	N_2O Factor (lb/MWh)	CO_2 Factor (lb/MWh)	CH_4 Factor (lb/MWh)	N_2O Factor (lb/MWh)
AKGD (ASCC Alaska Grid)	1,284.72	0.02711	0.00744	1,363.19	0.03499	0.00695
AKMS (ASCC Miscellaneous)	535.73	0.02265	0.00448	1,462.30	0.06168	0.01218
AZNM (WECC Southwest)	1,252.61	0.01880	0.01657	1,211.84	0.02056	0.00931
CAMX (WECC California)	681.01	0.02829	0.00623	1,045.30	0.03942	0.00474
ERCT (ERCOT All)	1,252.57	0.01776	0.01399	1,096.19	0.01969	0.00563
FRCC (FRCC All)	1,220.11	0.04119	0.01525	1,286.41	0.04340	0.01150
HIMS (HICC Miscellaneous)	1,343.82	0.13515	0.02171	1,645.57	0.12294	0.02133
HIOA (HICC Oahu)	1,620.76	0.09105	0.02089	1,630.89	0.10618	0.01852
MROE (MRO East)	1,692.32	0.02879	0.02905	1,905.18	0.03525	0.02998
MROW (MRO West)	1,722.67	0.02897	0.02919	1,988.69	0.05359	0.03298
NEWE (NPCC New England)	827.95	0.07698	0.01520	1,204.91	0.06069	0.01341
NWPP (WECC Northwest)	858.79	0.01634	0.01364	1,279.58	0.04331	0.01575
NYCW (NPCC NYC/Westchester)	704.80	0.02622	0.00335	1,234.06	0.03765	0.00488
NYLI (NPCC Long Island)	1,418.74	0.09050	0.01310	1,397.80	0.04408	0.00699
NYUP (NPCC Upstate NY)	683.27	0.01741	0.00990	1,384.20	0.03155	0.01619
RFCE (RFC East)	1,059.32	0.02740	0.01703	1,671.96	0.03329	0.02219
RFCM (RFC Michigan)	1,651.11	0.03255	0.02779	1,803.64	0.03209	0.02733
RFCW (RFC West)	1,551.52	0.01837	0.02593	1,982.05	0.02430	0.03148
RMPA (WECC Rockies)	1,906.06	0.02363	0.02889	1,554.38	0.02317	0.01645
SPNO (SPP North)	1,798.71	0.02122	0.02920	1,958.22	0.02540	0.02775

SPSO (SPP South)	1,624.03	0.02452	0.02242	1,435.24	0.02503	0.01314
SRMV (SERC Mississippi Valley)	1,004.10	0.02180	0.01115	1,171.05	0.02825	0.00691
SRMW (SERC Midwest)	1,779.27	0.02057	0.02960	1,945.66	0.02402	0.02969
SRSO (SERC South)	1,495.47	0.02364	0.02457	1,551.05	0.02850	0.02169
SRTV (SERC Tennessee Valley)	1,540.85	0.01987	0.02548	1,917.25	0.02598	0.03005
SRVC (SERC Virginia/Carolina)	1,118.41	0.02226	0.01908	1,661.11	0.03801	0.02451

Purchases of Steam

Similar to electricity production, GHGs are emitted when fossil fuels are combusted to generate heat or steam. If the company purchases heat or steam, the emissions are accounted for as indirect emissions.

Determine the amount of steam purchased, boiler efficiency, and either the emission factors provided by the steam supplier or the types of fuel that the steam supplier uses to generate the steam. If values for boiler efficiency are unavailable, use a default value of 80%.

Form 9
Purchased Steam

ID	Description	Fuel Type	Boiler Eff %	Steam Purchased (mmBTU)	Factors			CO_2 (kg)	CH_4 (g)	N_20 (g)
					CO_2	CH_4	N_20			
		[Input Data]			[From Tables]			[Calculate]		
Totals										
Convert CH_4 and N_20 to CO_2 equivalents										
Metric Tons										
Total CO_2e										

Enter data for each facility of site in Form 9. Enter amount of steam purchased. Using the fuel type, select the appropriate emission factors from Table 4 for the fuel and enter into Form 9. If more than one fuel type is used, enter multiple rows, apportioning the steam using the same percentages as the fuel mix.

<u>Preferred Method</u> (use this is steam emission factors are available from your supplier).

Enter supplier emission factors for CO_2, CH_4 and N_2O if available, otherwise see Table 4 for the appropriate values to use. Heat Content conversions can be found in Table 3. Boiler Efficiency is not necessary if emission factors are available.

Alternative Method (supplier-specific emission factors are NOT available). Using this approach, we will need the boiler efficiency. If boiler efficiency is not known, use 80% as default value.

CO_2 emissions from biomass-generated steam are not included in the total emissions for steam or reported separately because this does not represent direct combustion of biomass. If emission factors are available from the steam provider and a biomass fuel is used (e.g., wood and wood waste or landfill gas) the CO_2 emission factor should always be zero, and the CH_4 and N_2O emission factors from the steam provider should be entered as provided.

Chapter 4
Optional Emission Sources

Optional emissions are a consequence of the activities of a company but are not owned or controlled by the company, such as airline travel. Companies may choose to report optional emissions sources, which include indirect sources such as employee commuting or transporting products to market using contract carriers.

While not all companies choose to include optional emission sources, estimating optional emissions can provide a more complete picture of the company's climate change impact and offer the company more opportunities to reduce emissions. For example, if employee commuting emissions are included, it may also be beneficial to report the emission reductions from implementing a tele-worker or employee carpool program.

Optional emissions sources discussed below include three types of traditional optional sources most commonly reported: employee business travel, employee commuting, and product transport. Additionally, the company may want to report purchased Green Power/Renewable Energy Certificates (REC's) and Offsets if either of these are applicable.

Employee Business Travel

Optional employee business travel emissions differ from the required mobile source emission reporting in that they account for employee business travel in vehicles not owned or leased by the company, such as taxis, trains, commercial airplanes, and personal vehicles used for sales.

Collect information about employees' business travel method. For travelers that use a personal vehicle, enter the vehicle on Form 10 and collect data for the vehicle miles during the reporting period. For rail, bus, and air travel, the mode of travel and an estimate of the passenger mileage data should be provided for each. Table 11 has estimated emission factors for each form of travel and the factors are listed on either a "passenger-mile" or "vehicle-mile" basis.

Form 10
Employee Business Travel

ID	Description	Vehicle Type	Miles	Factors			CO_2	CH_4	N_20
				CO_2	CH_4	N_20	(kg)	(g)	(g)
	[Input Data]				[From Tables]			[Calculate]	

Totals			
Convert CH_4 and N_20 to CO_2 equivalents			
Metric Tons			
Total CO_2e			

Enter the data into the appropriate columns in Form 10 and then calculate and summarize the data.

Table 11
Business Travel Emission Factors

Vehicle Type	CO_2 Factor (kg / unit)	CH_4 Factor (g / unit)	N_2O Factor (g / unit)	Units
Passenger Car	0.364	0.031	0.032	vehicle-mile
Light-Duty Truck	0.519	0.036	0.047	vehicle-mile
Motorcycle	0.167	0.070	0.007	vehicle-mile
Intercity Rail	0.185	0.002	0.001	passenger-mile
Commuter Rail	0.172	0.002	0.001	passenger-mile
Transit Rail	0.163	0.004	0.002	passenger-mile
Bus	0.107	0.0006	0.0005	passenger-mile
Short Haul (< 300 miles)	0.286	0.0083	0.0091	passenger-mile
Medium Haul (>= 300 miles, < 2300 miles)	0.168	0.0008	0.0053	passenger-mile
Long Haul (>= 2300 miles)	0.193	0.0008	0.0062	passenger-mile

Employee Commuting

Employee commuting emissions differ from the required mobile source emission reporting in that they account for employee travel to and from work in vehicles not owned or leased by the company, including personal vehicles, buses, and trains.

Collect information about each employee's commuting method. For commuters that use a personal vehicle, the appropriate vehicle type should be entered on Form 11 and data collected for the vehicle miles during the reporting period. For rail, bus, and air travel, the mode of transport should also be entered on Form 11 and an estimate of the passenger mileage data provided for each. Table 11 has estimated emission factors for each form of travel and the factors are listed on either a "passenger-mile" or "vehicle-mile" basis.

Tip: If more than one employee travels by the same vehicle type or transport type, miles can be combined and entered in one row.

Enter data for each facility in Form 11. After the data has been collected, enter the data into the appropriate columns and the emissions can then be calculated and summarized.

Form 11
Employee Commuting
(Personal Vehicles)

Description	Vehicle Type	Miles Driven	Factors			CO_2 (kg)	CH_4 (g)	N_20 (g)
			CO_2	CH_4	N_20			
	[Input Data]			[From Tables]			[Calculate]	
					Totals			
					Convert CH_4 and N_20 to CO_2 equivalents			
					Metric Tons			
					Total CO_2e			

Product Transport

Optional emissions from product transport include product and material shipments by vehicles not owned or leased by the company. For example, the company could hire another company to transport product from the manufacturing location to distribution centers or final markets. (Note: if a company owns or leases the trucks or other transport vehicles, these would be part of its direct mobile source emissions). Another example of optional product transport is paying a courier to transport documents from one office to another.

Collect information about shipment methods (on-road vehicle, waterborne craft, freight rail, or aircraft). For road shipments, the user may enter data based on vehicle mileage or "ton-miles" of product transported. If the vehicle mileage option is chosen, then the company should select the type of vehicle and enter the total mileage for that vehicle type. The ton-miles option is only applicable for heavy duty trucks and the company need only enter the total ton-miles traveled.

For product transport via Freight Rail, waterborne, or air transport, the company should enter the total ton-miles data. Table 12 has the emission factors for various product transport options.

Table 12
Product Transport Emission Factors

Vehicle Type	CO_2 Factor (kg / unit)	CH_4 Factor (g / unit)	N_2O Factor (g / unit)	Units
Medium- and Heavy-Duty Truck	1.726	0.021	0.017	vehicle-mile
Passenger Car	0.364	0.031	0.032	vehicle-mile
Light-Duty Truck	0.519	0.036	0.047	vehicle-mile
Truck	0.297	0.0035	0.0027	ton-mile
Rail	0.0252	0.002	0.0006	ton-mile
Waterborne Craft	0.048	0.0041	0.0014	ton-mile
Aircraft	1.527	0.0417	0.0479	ton-mile

After the data has been collected, enter the data into the appropriate columns and then the emissions can be calculated and summarized.

Form 12
Product Transport

ID	Description	Vehicle Type	Miles or Ton-Miles	Factors			CO_2 (kg)	CH_4 (g)	N_20 (g)
				CO_2	CH_4	N_20			
		[Input Data]			[From Tables]			[Calculate]	
						Totals			
						Convert CH_4 and N_20 to CO_2 equivalents			
						Metric Tons			
						Total CO_2e			

Purchase of Renewable Energy Certificates and Green Power

"Green power" is renewable electricity produced from solar, wind, geothermal, biogas, biomass, and low impact small hydroelectric sources. Green power sources theoretically produce electricity with an environmental profile superior to conventional power technologies and produce no anthropogenic (human-caused) GHG emissions. The most common ways a company can buy green power are through RECs or utility green power products. A company can purchase RECs or green power to reduce the emissions associated with its electricity use.

If the company is buying RECs or green power, they should be collected for reporting. If possible, determine the location of the renewable energy projects from which the RECs and green power are purchased.

After the data has been collected, enter the data into the appropriate columns in Form 13 and then the emissions can be calculated and summarized. The appropriate factors are found in Table 10 by using the "non-baseload" factors.

Form 13
Renewable Energy Certificates
(RECs)

Description	Usage (Mwh)	Sub-Region	Factors			CO_2 (lb)	CH_4 (lb)	N_20 (lb)
			CO_2	CH_4	N_20			
[Input Data]			[From Tables]			[Calculate]		
					Total lbs			
					Total CO_2e			

Purchased Offsets

Offsets are project-based emission reductions and/or removals that occur outside the organizational boundary of the reporting company. Offsets can be purchased by a company to offset emissions from direct, other indirect and optional emissions sources. Quantity of offsets purchased in metric tons CO_2e for each offset project.

After the data has been collected, enter the data into the appropriate columns in Form 14 and then the emissions can be calculated and summarized.

Form 14 **Offsets**	
Description	CO_2e (metric tons)
Total CO_2e	

Chapter 5
Inventory Management Plan

An Inventory Management Plant (IMP) is a useful tool for accurately documenting the processes used to collect the inventory data so that a high quality inventory can be completed year after year. An IMP documents the answers to questions like,

- What facilities did we include in the inventory?
- Which sources are included?
- Who in the company collects the utility bill information?
- How do we account for new facilities or acquisitions?

Companies develop and maintain an IMP that describes their process for completing a high-quality, corporate-wide inventory. The IMP is a protocol developed by each company which addresses their unique procedures for creating a credible corporate-wide GHG emissions inventory on an annual basis.

The seven major components of an IMP are:

1. General Information: Company name, address, and inventory contact information.
2. Boundary Conditions: Organizational and operational boundary descriptions.
3. Emissions Quantification: Quantification methodologies and emissions factors.
4. Data Management: Data sources, collection process, and quality assurance.
5. Base Year Adjustments: Adjustments for structural and methodology changes.
6. Management Tools: Roles and responsibilities, training, and file maintenance.
7. Auditing & Verification: Auditing, management review, and corrective action.

To help the user develop a complete IMP, each of the above components are described in more detail below.

General Information

This section provides organizational information such as, company name, corporate address, inventory contact and inventory contact information.

Boundary Conditions

Emission sources to be included in a GHG inventory depend greatly on the boundary conditions selected by an organization. A company may use either an equity share approach or a control approach to define its organizational boundaries This section of the IMP should also include a list of operations or facilities in the inventory based on the chosen organizational boundary, as well as procedures used to identify each operation or facility. Finally, a list of the type of GHGs emitted from each operation or facility should be included in this section.

Emissions Quantification

This section provides the specific methodologies and emission factors used to estimate all of the company's GHG emissions. A credible GHG inventory requires accurate data and verifiable quality assurance procedures. These EPA instituted inventory protocols are based on the GHG Protocol and default emissions factors based on U.S. and international standards. These protocols require the collection and reporting of the six major GHG emissions. All emissions are reported as CO_2e based on the global warming potential (GWP) value of each gas.

Data Management

A description for each data source should be included in the IMP which also contains information on how data are gathered from that data source, and where the data are maintained. The data sources may be specific operations or may be emission categories (i.e. mobile sources, refrigerants, electrical usage, etc.). Details on any normalization factors used and quality assurance procedures, as well as information on data security and storage procedures should also be included for each data source.

Base Year Adjustments

A company will choose a base calendar year for their emissions inventory, reflecting the most recent year that data are available. When a significant change occurs that might confound the tracking of emissions over time or progress towards goal achievement, then the company may retroactively recalculate their base year emissions. This recalculation may be done for significant changes to the data, inventory boundary, methods, or any other relevant factors. The company's best judgment is used to define the significance of any changes that might trigger a base year adjustment.

Significant changes that may trigger a base year recalculation include:

- Structural changes to ownership or control (e.g. mergers, acquisition, divestiture, and outsourcing and in-sourcing of emitting activities);
- Changes in status of leased assets (ending leases or obtaining new leases);
- Changes in calculation methodology or improvement in the accuracy of emission factors or activity data; and
- Discovery of significant errors.

Base year emissions are not recalculated if the company makes an acquisition or divestiture of operations that did not exist in its base year, though historic data after the base year should be adjusted. Base year emissions and any historic data in general are not recalculated for organic growth or decline.

The specific corporate policies for base year adjustments due to structural or methodology changes should be outlined in this section of the IMP.

Management Tools

The management tools serve to identify the roles and responsibilities, training procedures and file maintenance procedures of the company.

Auditing and Verification

Identifies procedures for auditing (internal and external), management review, and how corrective actions are taken.

Set a Goal and Track Progress

This section provides an introduction to topics on how to reduce GHG emissions. This section can help answer questions like, "Now that I've calculated my GHG emissions, how do I track these emissions from year to year?" or "How do I set a goal to reduce my GHG emissions?"

Setting a goal is a tangible action that communicates to stakeholders a company's climate strategy and commitment. Having a target can motivate staff, help drive long-term strategies, and save money for the company through energy efficiency projects. A credible goal should meet the following criteria:

1. Corporate-wide: Including at least all U.S. operations.

2. Forward-looking: Based on the most recent base year for which data are available.

3. Long-term: Achieved over 5 to 10 years. Shorter goals may be necessary for some organizations.

4. Reduction from baseline emissions: Expressed as an absolute GHG reduction, a decrease in GHG intensity, or as a goal to be carbon neutral.

5. Aggressive: In comparison to the projected GHG performance for the company's sector.

The annual inventory can contain the company's historical data and help track progress towards meeting an absolute, intensity-based, or carbon neutral GHG reduction goal.

Goals may be expressed as an absolute GHG emissions reduction or as a decrease in GHG intensity. Absolute GHG reduction goals compare total GHG emissions in the goal year to those in a base year. GHG intensity goals allow a company to account for increases or decreases in production over time. The ratio of GHG emissions to an appropriate normalizing factor becomes the company's key performance indicator for measuring GHG intensity. Companies with emissions primarily from office space should use square footage of space as their normalizing factor. Companies may choose to use number of employees if employee business travel is a large percentage of their total emissions.

In addition to absolute and intensity-based GHG reduction goals, some companies set a goal to be carbon neutral, which is a commitment to achieve and maintain net zero GHG emissions in a company's operations. A carbon neutral goal should include the following:

1. Have a robust, transparent GHG inventory and IMP in place and include at least one significant optional emissions source to capture the full climate change impact of the company's operations.

2. Look for opportunities to reduce the company's internal emissions - for example, through energy efficiency or employee commuting programs. Set an absolute or intensity based internal reduction goal to motivate the company to implement these changes.

3. Purchase Green Power, RECs, and/or Offsets for the part of the inventory not reduced through internal projects. The company can purchase Green Power or RECs to reduce the emissions associated with its electricity use. It can then purchase project-based reductions (offsets) to offset the remaining emissions from direct, other indirect and optional emissions sources.

Chapter 6
GHG Case Study

This chapter is a fictitious case study in how a small manufacturing operation collected and reported its Greenhouse Gas emissions. The owner was ambivalent to the political discussions about whether the impacts of man-made emissions contribute to global warming, or whether it is even a serious problem. What the owner saw though, was an opportunity to capitalize on the public and customer relations benefits of "being green". By gathering this data as a baseline, he would be able to track changes in is GHG emissions as processes improved, more environmentally friendly vehicles replaced older units, and as his power supplier reduced their GHG emissions and be able to report improvements in his global footprint.

This manufacturing operation is a small wood processing plant located in South Georgia. The plant has one manufacturing site and has 40 employees. The company has a few company owned trucks for product transport and also uses commercial shippers. The company employs two salesmen who travel extensively by automobile and occasionally by commercial airline travel. The owner also travels to customer sites frequently and uses a company car and a company aircraft for travel.

The plant has a natural gas boiler and a significant portion of the plant is air conditioned for humidity control in South Georgia. The following table summarizes the data collected by the owner for his "base year" of 2013. See "Table 1 - Case Study".

Table 1-Case Study **Source Data Requirements for GHG Inventory Calculations**	
Base Data	
Facility Base Data	• Name: Sample Wood Processing Plant • Address: South Georgia • Plant square footage: 100,000 • Number of Employees: 40 • Type of Facility: Wood Processing
Direct Source Emissions	

Stationary Sources (Each Fuel Type)	• Natural Gas Boiler • 10,000 MMBTU
Mobile Sources	• Automobiles: 3 (annual mileage, 10,000, 50,000, 50,000) • LT Duty Trucks: 3 (annual mileage, 8000, 8000, 6000) • Diesel Tractor/Trailers: 3-diesel (annual mileage, 100,000 ea) • GA aircraft:1- Avgas (250 hrs/yr @ 15 gph)
Refrigeration & AC	• HFC-134a New: 50 lbs Recharge: 25 lbs Disposed: 50 lbs • CF_4 New: 1.0 lbs Recharge: None Disposed: None
Fire Suppression Systems	• CO2 New: 1500 lbs Recharge: 500 lbs Disposed: None
Purchased Gases	• CH4, 2500 lbs
Waste Gases	• None
Indirect Source Emissions	
Electricity	• Sub-Region: SERC – SO Meter 1 200,000 kWh year Meter 2 15,000 kWh year
Steam	• Natural Gas Boiler Efficiency: 80% Purchased: 5,000 MMBTU

Optional Source Emissions	
Business Travel	• Passenger Car, 1,000 miles
Employee Commuting	• Passenger Car, 20 employees, 50,000 miles total • Pickup Truck, 20 employees, 50,000 miles total
Product Transport	• Heavy Duty Truck, 2,000 miles
RECs	• None
Power Offsets	• None

Using this data, the owner entered data into the appropriate forms starting with the direct emission sources.

Direct Emissions – Case Study

For this business, the direct emissions include stationary sources (natural gas boiler), mobile sources (vehicles), refrigerant, fire suppression, and purchased gas. For the stationary source, we use Table 4 for the factors. The values must be converted to metric tons. In addition to the factors in Table 4, the CH_4 and N_20 values must be converted to a "global warning potential" value using the factors in Table 8. These values are 21 and 310 respectively. To convert the kilograms to metric tons divide by 1,000 and divide by 1,000,000 to convert grams to metric tons.

Form 2 – Case Study
Direct Emissions from Stationary Sources

Description	Usage	Factors			CO_2 (kg)	CH_4 (g)	N_20 (g)
		CO_2	CH_4	N_20			
Natural Gas Boiler	10,000 MMBTU	53.02	1.0	0.1	530,200	10,000	1,000
				Totals	530,200	10,000	1,000
Convert CH_4 and N_20 to CO_2 equivalents (21 and 310 respectively)						210,000	310,000
				Metric Tons	530.2	0.2	0.3
				Total CO_2e	530.7		

For the mobile sources, we use tables 5, 6 and 7 for the factors.

Form 3 – Case Study
Mobile Sources
(Company owned/leased Vehicles)

Vehicle Type	Fuel Type	Year	Description	Annual Mileage	Fuel Used	Factors CO_2	Factors CH_4	Factors N_20	CO_2 (kg)	CH_4 (g)	N_20 (g)
Diesel Heavy-Duty	Diesel	1990	Tractor 1	100,000	16,000	10.21	0.0051	0.0048	163,360	510	480
		2005	Tractor 2	100,000	16,000	10.21	0.0051	0.0048	163,360	510	480
		2006	Tractor 3	100,000	16,000	10.21	0.0051	0.0048	163,360	510	480
Passenger Car	Gas	2009	Salesman 1	50,000	2,300	8.78	0.0173	0.0036	20,194	865	180
		2009	Salesman 2	50,000	2,300	8.78	0.0173	0.0036	20,194	865	180
		2009	Owner	10,000	560	8.78	0.0173	0.0036	4,917	173	36
Pick-up Truck	Gas	2005	General Use 1	8,000	500	8.78	0.0157	0.0101	4,390	126	81
		2007	General Use 2	8,000	500	8.78	0.0161	0.0079	4,390	129	63
		2009	General Use 3	6,000	400	8.78	0.0163	0.0066	3,512	98	40
Aviation Gasoline	AvGas	2000	A-36 Bonanza	45,000	3,750	8.31	7.04	0.11	31,162	26,400	413
Totals									578,839	30,186	2,430
Convert CH_4 and N_20 to CO_2 equivalents (21 and 310 respectively)										633,906	753,300
Metric Tons									578.8	0.63	0.75
Total CO_2e									580.2		

For the refrigerant gas, we use Table 8 or Table 9 for the factors. In this calculation the CO_2 is calculated in pounds and must be converted to metric tons by dividing by 2,200.

Form 4 – Case Study
Refrigeration Gas CO_2 Equivalent Emissions
Simplified Material Balance Method

Gas	GWP Factor	New Units Charge (lbs)	New Units Capacity (lbs)	Existing Units Recharge (lbs)	Disposed Units Capacity (lbs)	Disposed Units Recovered (lbs_	CO_2 Equiv Emissions (lbs)
HFC-134a	1,300	50.0	50.0	25.0	50.0	0.0	97,500
CF_4	6,500	1.0	1.0	0	0	0	0

Total	97,500
Total CO_2e	44.3

For the fire suppression gas, we use Table 8 or Table 9 for the factors. In this calculation the CO_2 is calculated in pounds and must be converted to metric tons by dividing by 2,200.

Form 5 – Case Study
Fire Suppression Gas CO_2 Equivalent Emissions
Simplified Material Balance Method

Gas	GWP Factor	New Units		Existing Units	Disposed Units		CO_2 Equiv Emissions (lbs)
		Charge (lbs)	Capacity (lbs)	Recharge (lbs)	Capacity (lbs)	Recovered (lbs)	
CO_2	1	1500.0	1500.0	500.0	0.0	0.0	500.0
						Total	500.0
						Total CO_2e	0.2

For the purchased gas, use Table 8 for the factors. In this calculation the CO_2 is calculated in pounds and must be converted to metric tons by dividing by 2,200.

Form 6 – Case Study
Purchased Gases

Description	Quantity (lbs)	Factor	CO_2 (lb)
		CO_2	
CH_4	2500	21	52,500
		Total	52,500
		Total CO_2e	23.8

Indirect Emissions – Case Study

In this example, the indirect emissions include electricity purchases and steam purchases.

The factors for the electricity purchases are found in Table 10.

Form 8 – Case Study Electricity Purchases (MWh)									
Meter Account	Description	Usage (Mwh)	Sub-Region	Factors			CO_2 (lb)	CH_4 (lb)	N_20 (lb)
				CO_2	CH_4	N_20			
5680003	Main Supply to Plant	200	SRSO	1495.47	0.02364	0.02457	299,094	4.7	4.9
5680004	Meter to new building	15	SRSO	1495.47	0.02364	0.02457	22,432	0.4	.4
						Lbs CO_2	321,526	5.1	5.3
						Total CO_2e	146.2		

The factors for the purchased steam is found in Table 4. In this example, be sure to divide the steam purchase by the boiler efficiency. For 5,000 mmBTU at an efficiency of 80% this yields 6,250 mmBTU.

Form 9 – Case Study Purchased Steam										
ID	Description	Fuel Type	Boiler Eff %	Steam Purchased (mmBTU)	Factors			CO_2 (kg)	CH_4 (g)	N_20 (g)
					CO_2	CH_4	N_20			
-	Boiler	Natural Gas	80%	5000	53.02	1.0	0.1	331,375	6,250	625
							Convert CH_4 and N_20 to CO_2 equivalents (21 and 310 respectively)		131,250	193.750
							Metric Tons	331.4	0.1	0.2
							Total CO_2e	331.7		

Optional Emissions – Case Study

The business owner has three sources of optional emissions he wishes to include in the summary: Employee business travel, employee commuting, and leased product transport. The owner does not have any renewable energy certificates or carbon offsets.

For the employee business travel, the factors are in Table 11.

Form 10 – Case Study Employee Business Travel									
ID	Description	Vehicle Type	Miles	Factors			CO_2 (kg)	CH_4 (g)	N_20 (g)
				CO_2	CH_4	N_20			
-	Various	Passenger Car	1,000	0.364	0.031	0.032	364	31	32
Convert CH_4 and N_20 to CO_2 equivalents (21 and 310 respectively)								651	9,920
Metric Tons							0.36	0	0.01
Total CO_2e							0.37		

For the employee commuting, use Table 11 for the factors.

Form 11 – Case Study Employee Commuting (Personal Vehicles)								
Description	Vehicle Type	Miles Driven	Factors			CO_2 (kg)	CH_4 (g)	N_20 (g)
			CO_2	CH_4	N_20			
20 employees	Passenger Car	50,000	0.364	0.031	0.032	18,200	1,550	1,600
20 employees	Light Duty Truck	50,000	0.519	0.036	0.047	25,950	1,800	2,350
Totals						44,150	3,350	3,950
Convert CH_4 and N_20 to CO_2 equivalents (21 and 310 respectively)							70,350	1,224,500
Metric Tons						44.2	0.0	1.2
Total CO_2e						45.4		

For product transport, use Table 12 for the factors.

Form 12 – Case Study Product Transport									
ID	Description	Vehicle Type	Miles or Ton-Miles	Factors			CO_2 (kg)	CH_4 (g)	N_20 (g)
				CO_2	CH_4	N_20			
-	Common Carrier	Medium/HD Truck	2,000	1.726	0.021	0.017	3,452	42.0	34.0
Convert CH_4 and N_20 to CO_2 equivalents (21 and 310 respectively)								882	10,540
Metric Tons							3.45	0.0	0.0
Total CO_2e							3.5		

Summary – Case Study

Once the data is calculated the owner can compile the data into Form 1 for a summary of his greenhouse gas emissions.

Form 1 – Case Study **Annual GHG Inventory Summary**		
Company Information	Name: Sample Wood Processing Plant Location: South Georgia Year: 2013 Date Prepared: 2014 By: Owner	
Emissions Type	**Source**	**CO_2-e (Metric Tons)**
Direct Emissions	Stationary Combustion	530.7
	Mobile Sources	580.2
	Refrigeration / AC Equipment Use	44.3
	Fire Suppression	0.2
	Purchased Gases	23.8
	Total Direct emissions	**1179.2**
Indirect Emissions	Purchased and Consumed Electricity	146.2
	Purchased and Consumed Steam	331.7
	Total Indirect Emissions	**477.9**
Optional Emissions	Employee Business Travel	0.37
	Employee Commuting	45.4
	Product Transport	3.5
	RECs and Green Power Purchases	0
	Offsets	0
	Total Optional Emissions	**49.3**
	Total Facility Emissions	**1706.4**

From the "Form 1, Case Study" we see that the total greenhouse gas emissions from this company was 1706.4 metric tons of CO_2e for the base year of 2014. The owner now has compiled a base line with which he can compare future years. Purchasing newer vehicles and upgrading his boiler efficiency will be simple ways to improve is emissions footprint. He can then begin to use this as his “base case” for comparison in future years. Hopefully he will have positive information to report…

Summary

Whether you motive is to "save the world" or to promote your business as "eco-friendly" developing a GHG management plan may be good business.

As we have just learned, developing a greenhouse gas management plan is relatively easy to set up and maintain. Developing the plan requires gathering data and setting the boundaries of what will be included in the plan. Once the data is obtained, the calculations are straight forward and easy to accomplish either manually or using existing GHG spreadsheets.

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