



**The Climate Registry**

**Draft GHG Reporting Guidance  
for Small Businesses**

---

**Accurate, transparent, and consistent measurement of  
greenhouse gases across North America**

**October 2019**

## **Acknowledgments**

The Climate Registry (TCR) wishes to acknowledge the generous support of Southern California Edison® for sponsoring the development and early stakeholder review of this draft guidance. TCR would also like to thank the San Diego Foundation, whose initial sponsorship of this effort supported the literature review and Methods White Paper that laid the groundwork, together with TCR’s General Reporting Protocol, for the content of this draft guidance.

This draft guidance was developed with feedback and input from over 40 small businesses and related non-profits. Special acknowledgments are also due to The Better World Group and Bowman Design Company for their support in engaging the small business community. Finally, TCR staff members Michelle Zilinkas, Chelsea Hasenauer, Peggy Kellen, Anna-Elise Smith and Alexandria Chalmers played important roles in developing this guidance and interim resources.

## Table of Contents

Acknowledgments .....	i
Introduction .....	1
Reporting Greenhouse Gas Emissions .....	3
Reporting Boundaries .....	4
Miniscule Sources .....	7
Simplified Estimation Methods .....	8
Calculating GHG Emissions .....	9
Calculating Scope 1 - Direct Emissions .....	12
Scope 1 - Stationary Combustion .....	12
Scope 1 - Mobile Combustion.....	14
Calculating CO <sub>2</sub> Emissions from Mobile Combustion.....	15
Calculating CH <sub>4</sub> and N <sub>2</sub> O Emissions from Mobile Combustion .....	17
Scope 1 – Fugitive Emissions.....	20
Simplified Mass Balance Method.....	21
Screening Method.....	22
Scope 1 - Process Emissions .....	23
Calculating Scope 2 - Indirect Emissions from Consumed Energy .....	24
The Known Electricity Use Method .....	26
The Area Method.....	26
The Cost Method.....	26
The Average Intensity Method.....	26
Selecting Location-Based Emission Factors .....	27
Selecting Market-Based Emission Factors .....	29
Ensure Contractual Instruments Meet TCR Eligibility Criteria for Electricity .....	31
Calculating Scope 3 - Other Indirect Emissions .....	34
Scope 3 - Business Travel.....	34
Scope 3 - Employee Commuting .....	36
Scope 3 - Shipping Emissions.....	36
Next Steps: Turning GHG Data into Climate Action .....	38
Accounting for Offsets .....	38
External Review and Assurance .....	38
Tracking Emissions Over Time & Setting a Goal.....	40
Conclusion .....	41
Appendix A: Common Units, Abbreviations and Conversions .....	42
Appendix B: Global Warming Potentials .....	44
Appendix C: Refrigerant Blends Default Emission Factors and GWPs .....	46

## INTRODUCTION

### Purpose of this Guidance

This document was designed specifically for small businesses committed to reducing their impact on climate change. By developing a corporate greenhouse gas (GHG) emissions inventory, you will be able to understand both the direct and indirect impacts of your business's operations in order to most effectively reduce GHG emissions. This guidance provides step-by-step instructions for how to build a GHG inventory, from identifying which emission sources you will report to calculating your emissions and verifying their accuracy.

### Benefits of Reporting

Quantifying and reporting your GHG inventory will help your business identify opportunities for reducing GHG emissions. This is important because, by reducing GHG emissions, scientists hope we can limit the increase in average global surface temperature over the pre-industrial average to 2 °Celsius. Climate models predict that a 4 °Celsius rise would likely be an unstable state, leading to unprecedented heat waves, severe drought, and major floods in many regions. In addition to your contribution to the state of the global climate, quantifying and reporting your emissions will have many benefits for your business, including:

- **Saving money and improving your energy efficiency:** Having a thorough understanding of your GHG inventory means that you can better understand how and where you can reduce your emissions – and reducing emissions is almost always associated with reducing operational and energy costs.
- **Building your reputation:** The issues of climate change and resource management are increasingly important to government, customers, and your local community. Showing that you are making an effort to operate more sustainably will build your reputation in the eyes of the community.
- **Building competitive advantage:** Your GHG inventory can help drive cost savings, improve operational efficiency, and reduce emissions. As a result, you may have the opportunity to re-design your business operations and processes or improve your products and services in order to build sustainable competitive advantage.
- **Managing risk:** Measuring your emissions will help you identify opportunities to reduce the impact of potential increases in energy costs and other expenses.

### Reporting to The Climate Registry

Reporting your inventory to an established GHG registry is an excellent way to get recognition for measuring, publicly reporting and verifying your greenhouse gas emissions. The Climate Registry (TCR) operates an established GHG reporting and verification program in North America. TCR Members have access to hands-on technical assistance with their GHG measurement, reporting and verification, online calculation and reporting tools, and opportunities to network with other TCR Members and policy leaders. TCR also offers Members recognition for their carbon achievements through its website, public newsletter and social media platforms.

### GHG Reporting and Accounting Principles

This guidance incorporates best practices in GHG accounting. Five accounting and reporting principles are accepted internationally as critical for ensuring accurate and credible GHG data. These accounting principles are listed below:

- **Relevance:** Ensure that your GHG inventory appropriately reflects your business's GHG emissions and serves the decision-making needs of users.

- **Completeness:** Account for and report all GHG emission sources and activities within your defined inventory boundary.
- **Consistency:** Use consistent methodologies to allow for meaningful comparisons of emissions over time. Clearly document any changes to the data, inventory boundary, methods, or any other relevant factors.
- **Transparency:** Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to accounting and calculation methodologies and data sources used.
- **Accuracy:** Ensure that your quantification of GHG emissions is neither systematically overstating nor understating true emissions, and that uncertainties are reduced as much as practicable. Achieve sufficient accuracy enabling users of the data to be able to make decisions with reasonable assurance of the integrity of the reported information.

### What is a GHG Inventory?

Gases that trap heat in the atmosphere are called greenhouse gases (GHGs). The GHGs covered in this guidance are: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF<sub>6</sub>), and nitrogen trifluoride (NF<sub>3</sub>). A GHG inventory is a list of your business's GHG emissions sources and quantities. GHG inventories are generally broken down by facilities and further by particular types of emission sources in each facility. By breaking down your emissions this way, you can get a clear picture of which sources are contributing to your emissions and develop a plan to reduce emissions throughout your whole business or at specific facilities.

## REPORTING GREENHOUSE GAS EMISSIONS

### Overview of the Reporting Process

The five main steps to greenhouse gas reporting are outlined in Figure 1 below.

The first step to reporting your GHG emissions is to define your organizational and reporting boundaries. The next step is to identify all facilities within your reporting boundary and their associated emissions sources. Once you have identified which emission sources your business will report, you need to collect activity data for each source. Then use that activity data to calculate GHG emissions following the process described in the [Calculating GHG Emissions](#) section. The final step is to review and publish your emission report, either externally or internally. Verifying and publicly reporting your business’s emissions is optional, but clearly communicates your commitment to environmental leadership and accountability to your customers, investors and regulators.

Figure 1



## PLANNING A GHG INVENTORY AND DETERMINING WHAT TO REPORT

The first step in creating your inventory is to determine which emission sources should be included, based on your organizational and reporting boundaries. You will then collect and calculate GHG emissions from the sources within the boundaries you have defined.

### Identifying the Organizational Boundary

Organizational boundaries are the sum of the operations, facilities, and sources that make up your business. Well-determined boundaries provide clarity and ensure reported data are consistent. Identifying your organizational boundary will help you answer many important questions such as: Is there double counting? How are leases addressed? What if I am in a building managed by another company? GHG emissions inventories can be constructed to reflect three different views of an organizational boundary: operational control, financial control, or equity share. For more information on these boundary approaches, refer to the General Reporting Protocol (GRP) [Inventory Boundaries Module](#).

- 1. Operational Control:** Reflects the activities where the organization or its subsidiaries has the full authority to introduce and implement operating policies. The organization that holds the operating license for an activity typically has operational control.
- 2. Financial Control:** Reflects activities where the organization has the ability to direct the financial policies of the activity with an interest in gaining economic benefits from the activity. An organization has financial control over an activity if the activity is fully consolidated in the organization’s financial accounts.
- 3. Equity Share:** Reflects activities that are wholly owned and partially owned according to the organization’s equity share in each.

You must apply the same organizational boundary approach consistently to all activities. If your business wholly owns and controls all of its activities, its organizational boundary will be the same using each approach.

## Reporting Boundaries

You may define your own reporting boundary to include the GHG sources that are relevant to your business's operational and sustainability goals in accordance with the principles of GHG accounting. The reporting boundary may match the organizational boundary (i.e., all the emission sources within the organizational boundary are included) or may be a subset of the organizational boundary. You must publicly define and disclose your own inventory reporting boundary using the following parameters, which are described in the following sections:

- GHGs;
- Geography/business units;
- Reporting Period; and,
- GHG Sources.

TCR members must disclose their reporting boundary on the *Self-Defined Boundary Form* in the Climate Registry Information System (CRIS), unless they are reporting a "complete" inventory that meets TCR's criteria for relevance.

### Relevant GHG Sources

To fulfill the GHG accounting principle of completeness, the inventory must include all relevant direct and indirect emissions within the defined reporting boundary. For the purposes of reporting to TCR, all Scope 1 and Scope 2 emissions, combustion-based direct biogenic emissions, and combustion-based indirect biogenic emissions associated with the consumption of energy are relevant<sup>1</sup>, and must be included within the reporting boundary for TCR to consider the inventory "complete."

<sup>1</sup> TCR does not consider the following emission sources relevant: approved miniscule sources, biogenic emissions other than those associated with the combustion of biomass, and emission sources identified as optional in the protocols.

## Greenhouse Gases

Organizations may define their reporting boundary to include all internationally recognized GHGs regulated under the Kyoto Protocol, or a subset of these gases. These are:

- Carbon dioxide (CO<sub>2</sub>);
- Methane (CH<sub>4</sub>);
- Nitrous oxide (N<sub>2</sub>O);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons (PFCs);
- Sulfur hexafluoride (SF<sub>6</sub>); and,
- Nitrogen trifluoride (NF<sub>3</sub>).

A complete list of the Kyoto GHGs, including individual HFCs and PFCs, is provided in Tables 5.1 and 5.2.<sup>1</sup> You must account for emissions of each gas separately, in metric tons of each gas.<sup>2</sup>

<sup>1</sup> Emission factor tables are available at [www.theclimateregistry.org](http://www.theclimateregistry.org).

<sup>2</sup> Emissions total of the HFC and PFC categories are reported in metric tons of carbon dioxide equivalents (CO<sub>2</sub>e) of each respective category.

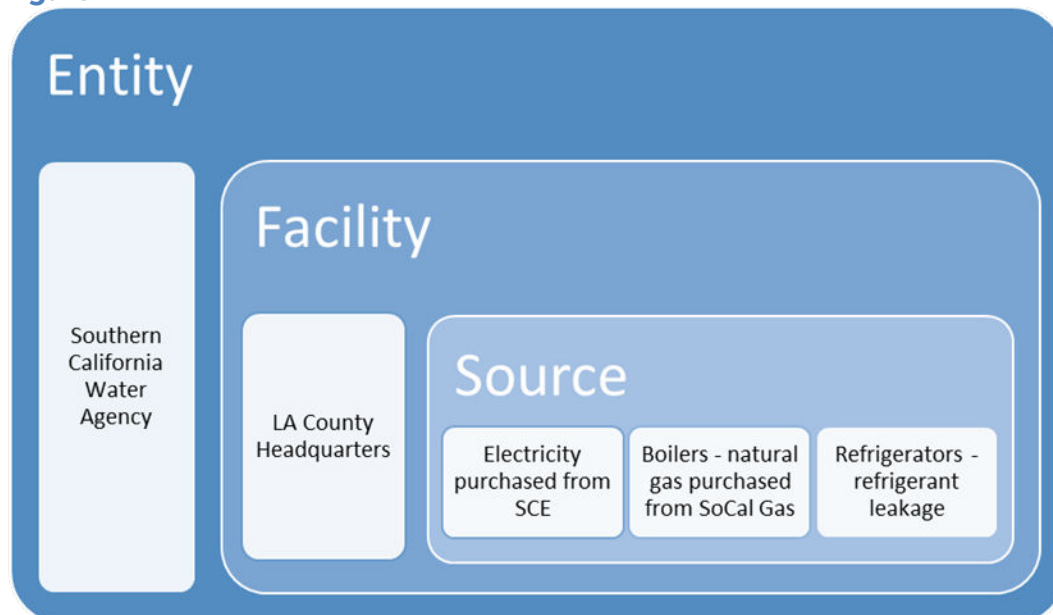
## Defining the Geographic Boundary

If your business has offices or facilities in more than one location, you will need to define your geographic boundary. All emissions sources that fall within your self-defined boundary should be reported. If you have multiple facilities, when you first start reporting your inventory you may find it more manageable to report emissions from facilities in one community, or even to limit your inventory to your headquarters office. For example, you can define your geographic boundary by selecting one or more:

- Country;
- State, Province or Territory;
- Business Unit; or,
- Office.

Figure 2 illustrates the different levels of data granularity available to TCR reporters. You may enter your business’s GHG emissions data into CRIS at the source, facility, or entity level, and choose whether to report publicly at the facility-level or entity-level.<sup>3</sup>

Figure 2



## GHG Sources

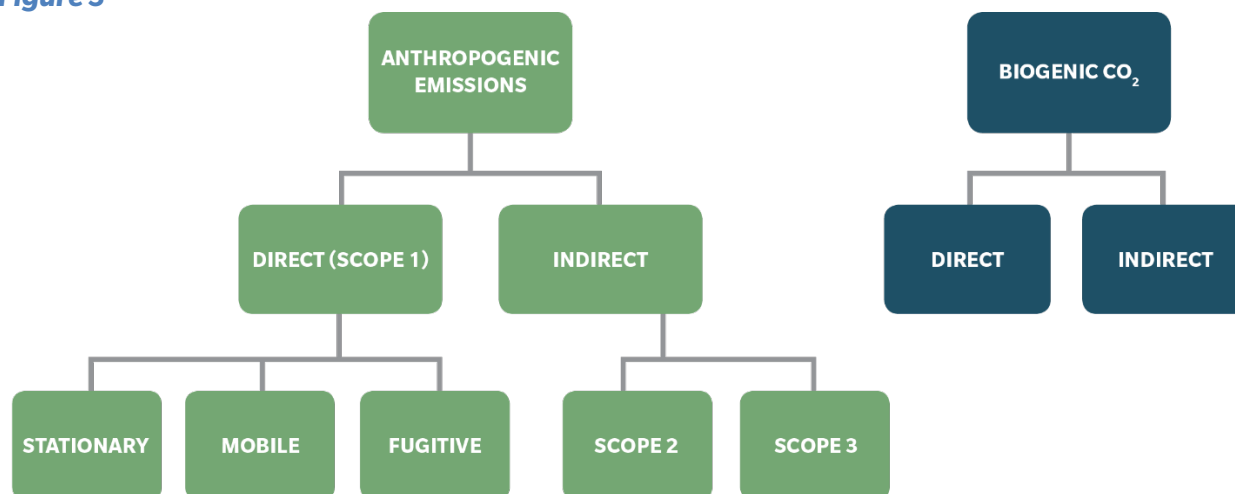
GHG emissions inventories are divided into two broad categories: direct and indirect. **Direct emissions** are those that your business physically emits into the atmosphere, such as CO<sub>2</sub> from a gasoline-fueled company vehicle, or HFCs or PFCs from an air conditioning unit. **Indirect GHG emissions** are those that your business influences but does not ultimately control. This means that the physical GHG emission source is not within your organizational boundary but your demand for the process that generated the emissions contributed to its release.

A standardized format for GHG inventories breaks out direct and indirect emission sources into three ‘Scopes’. Within this framework, Scope 1 consists of all direct emissions, Scope 2 consists of indirect emissions associated with the consumption of energy (electricity or imported heat or

<sup>3</sup> In public reports, source-level data is aggregated to the facility-level. Reporters seeking verification must be prepared to provide source-level information for each sampled facility to their verification body upon request.

cooling), and Scope 3 consists of all other sources of indirect emissions. Examples of Scope 3 sources for small businesses include emissions associated with employee commuting, business travel, upstream suppliers, and shipping. Figure 3 outlines the inventory framework for small businesses.

**Figure 3**

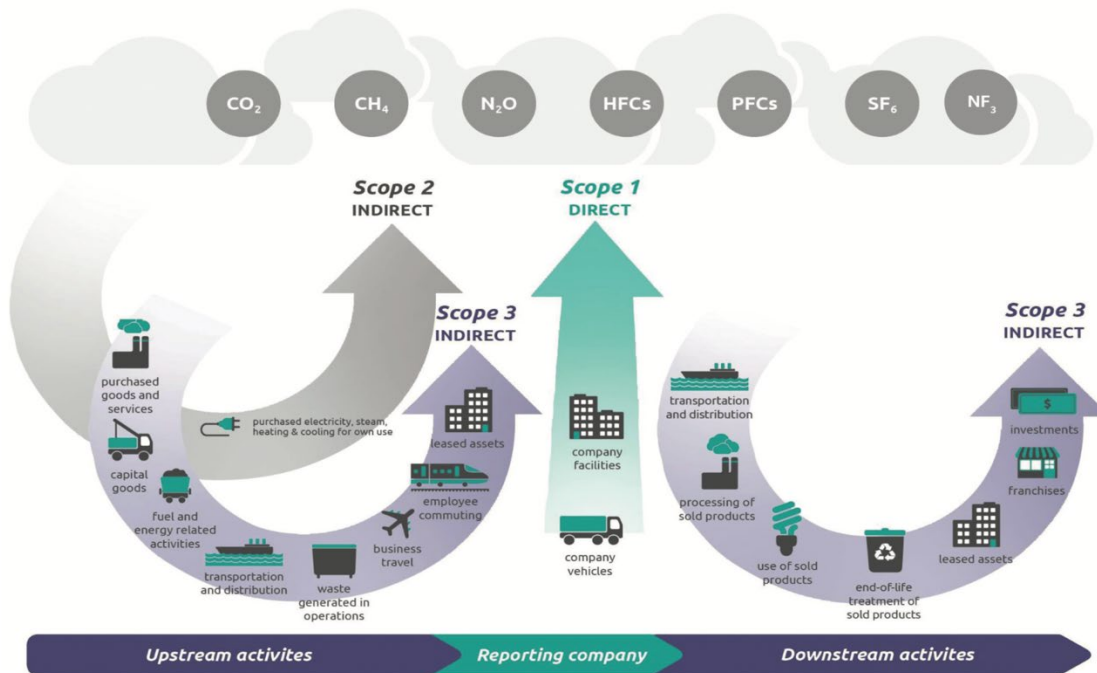


- **Scope 1:** Direct anthropogenic GHG emissions.<sup>4</sup>
- **Scope 2:** Indirect anthropogenic GHG emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling (collectively referred to as consumed energy).
- **Scope 3:** All other (non-Scope 2) indirect anthropogenic GHG emissions that occur in the value chain.
- **Additional GHGs:** Biogenic GHG emissions are excluded from the scope categories and are reported separately. Non-Kyoto GHG emissions are also outside of the scopes.

Figure 4 provides an overview of the relationship between the scopes and the activities that generate direct and indirect emissions along the value chain. You will report anthropogenic emissions within your organizational boundary directly in Scope 1, and anthropogenic emissions that result indirectly from your activities in Scope 2 and Scope 3.

<sup>4</sup> Anthropogenic emissions are GHGs emitted into the atmosphere as a direct result of human activities, rather than through natural ecological processes

**Figure 4 – Overview of Scopes & Emissions throughout a Business’s Operations**



Source: Adapted from WRI/WBCSD GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard.

### Emissions from Biomass

The combustion of biomass generates CO<sub>2</sub> emissions, which must be reported separately from the Scopes. This is because the carbon in biomass was recently contained in living organic matter, whereas the carbon in fossil fuels has been trapped in geologic formations for millennia.

The separate reporting of CO<sub>2</sub> emissions from biomass combustion applies only to CO<sub>2</sub> and not to methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O), which are also emitted during biomass combustion. Unlike CO<sub>2</sub> emissions, the CH<sub>4</sub> and N<sub>2</sub>O emitted from biomass combustion are not of a biogenic origin and are therefore Scope 1 emissions.

### Reporting Period

Businesses must disclose the period for which emissions are reported. You must report emissions on an *annual basis* (i.e., calendar year or fiscal year). The year in which the emissions occurred is known as the reporting year (RY). For example, if an inventory is reported in 2019 for an organization’s 2018 emissions, the reporting year is 2018. You must include emissions from the activities within your boundary for the part of the year each activity is within your control. For most activities, this will be the total annual emissions from the operation. On the other hand, if you opened a new office midway through the year, you would only report emissions from that office for the second half of the year.

### Miniscule Sources

Miniscule sources are very small sources of emissions in a member’s inventory that represent a high reporting burden, such as hand-held fire extinguishers, refrigerant in office water coolers, or CO<sub>2</sub> from soda fountains. Refer to the GRP [Inventory Boundaries Module](#) for more guidance on when it is appropriate to exclude miniscule sources from your inventory.

## Simplified Estimation Methods

Businesses must quantify emissions using TCR-accepted methods. However, in some cases, organizations may have difficulty applying these methods to every source within their boundaries—either because it is not possible or not efficient to use them. Therefore, TCR accepts emissions estimated using simplified methods in certain cases. Members may use Simplified Estimation Methods (SEMs) for any combination of emission sources and/or gases, provided that the corresponding emissions do not exceed 10% of the CO<sub>2</sub>e sum of reported Scope 1, Scope 2, combustion-based direct biogenic emissions and combustion-based indirect biogenic emissions associated with consumed electricity. In developing SEMs, you should follow the principle of conservativeness (i.e., erring on the side of overestimating rather than underestimating emissions). Members must document emissions that have been estimated using SEMs for verification.<sup>5</sup>

---

<sup>5</sup> For more information, refer to TCR's [Accounting for Small Emission Sources Guidance](#).

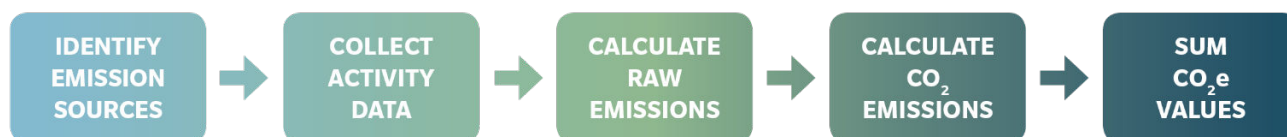
## CALCULATING GHG EMISSIONS

There are five basic steps to calculate the GHG emissions from each of your sources. The following sections describe the calculation methods for Scope 1, Scope 2 and Scope 3 emissions in more detail. Figure 5 outlines the five basic steps to calculate the GHG emissions from each of your sources.

1. Identify the emission sources you are going to report.
2. Collect activity data for each source.
3. Calculate raw emission quantities for each gas you are reporting by multiplying the activity data by the appropriate emission factor.
4. Multiply the emissions from each gas by that gas' GWP to convert emissions to mt CO<sub>2</sub>e.
5. Sum the emissions of each gas in mt CO<sub>2</sub>e to obtain total emissions for the source.

Note: Steps 3-5 can be done automatically with the help of TCR's Climate Registry Information System (CRIS).

**Figure 5**



### Identify Emission Sources

First, identify the emission sources within your reporting boundary. The most common types of emission sources for small businesses are listed in the sections that follow. You will find a definition of each emission source and a description of the calculation process for each source.

### Collect Activity Data

After you have identified all the emission sources you are going to report, you will need to collect activity data for each source. Activity data can include data on fuel consumption, distance travelled, and type of equipment. The better records you keep, the easier it will be to complete your inventory. In the process of developing your first inventory, be sure to write down ideas for improving how this activity data is collected and stored so it will be easier to complete your next GHG inventory. TCR offers a number of resources to help reporters track and calculate their emissions offline.

### Apply Emission Factors

Emission factors are metrics that describe how much of a GHG is emitted based on a measurable quantity of an activity (for example, metric tons of CO<sub>2</sub> emitted per kWh of electricity consumed). You will likely rely on default emission factors developed by third parties to complete your GHG inventory.<sup>6</sup> A comprehensive list of default emission factors for activities in the U.S. and Canada is published annually by TCR and is available for your reference.<sup>7</sup> In most cases, when you are reporting emissions data from previous years, you can use the most up to date emission factors available when the inventory is being reported.<sup>8</sup> For electricity, you must use the factor corresponding to the reporting year, or when unavailable, the most recent previous year.<sup>9</sup> If you

<sup>6</sup> You can also use site-specific emission factors, where measurements are taken on-site.

<sup>7</sup> Emission factor tables are available at [www.theclimateregistry.org](http://www.theclimateregistry.org).

<sup>8</sup> From TCR's annual emission factor update or a more recent peer-reviewed publication.

<sup>9</sup> The most recent supplier-specific emission factor (meeting TCR's eligibility criteria for electricity) may be used in lieu of a more recent residual mix or grid-average emission factor to calculate market-based Scope 2

are using the CRIS calculator to report your emissions, you will generally not need to track down and calculate emissions using emission factors, but will simply select the appropriate type of emission factor based on the activity data entered into the tool. If you are calculating offline, please refer to the references in TCR’s default emission factor document, published annually.<sup>10</sup>

### Using Global Warming Potentials to Convert to Carbon Dioxide Equivalents

The GHGs covered by this Guidance are the seven internationally-recognized GHGs regulated under the Kyoto Protocol: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF<sub>6</sub>), and Nitrogen trifluoride (NF<sub>3</sub>).<sup>11</sup> Each GHG has a different heat-trapping ability and lifetime in the atmosphere. The global warming effect of the various GHGs can be measured by applying specific global warming potential (GWP) values. GWP represents the heat-trapping impact of a GHG relative to carbon dioxide, which has a GWP of 1.0, and functions as a global warming “index.” For example, methane (CH<sub>4</sub>) has a GWP of 28, so each metric ton of CH<sub>4</sub> emissions has 28 times the impact on global warming (over a 100-year time horizon) as one metric ton of CO<sub>2</sub> emissions.

All emissions are reported in metric tons of carbon dioxide equivalent (mt CO<sub>2</sub>e) to provide a single metric that embodies all GHGs. If you are using CRIS to report your emissions, the software will convert emissions to CO<sub>2</sub>e using automatically pre-selected GWPs.<sup>12</sup>

If you do not use CRIS to report your GHG inventory, convert metric tons of each gas to CO<sub>2</sub>e by multiplying the mass of emissions of each gas by the appropriate GWP. The following equation demonstrates how emissions from individual gases are converted to CO<sub>2</sub>e. Use the same process to convert individual HFC and PFC gases to CO<sub>2</sub>e. Refer to the references in Appendix B to select the appropriate GWPs.

CONVERTING TO CO <sub>2</sub> E AND DETERMINING TOTAL EMISSIONS		
<b>CO<sub>2</sub> Emissions</b> (metric tons CO <sub>2</sub> e)	=	CO <sub>2</sub> Emissions (metric tons) × 1 (GWP)
<b>CH<sub>4</sub> Emissions</b> (metric tons CO <sub>2</sub> e)	=	CH <sub>4</sub> Emissions (metric tons) × 28 (GWP)
<b>N<sub>2</sub>O Emissions</b> (metric tons CO <sub>2</sub> e)	=	N <sub>2</sub> O Emissions (metric tons) × 265 (GWP)
<b>Total Emissions</b> (metric tons CO <sub>2</sub> e)	=	CO <sub>2</sub> (metric tons CO <sub>2</sub> e) + CH <sub>4</sub> (metric tons CO <sub>2</sub> e) + N <sub>2</sub> O (metric tons CO <sub>2</sub> e)

emissions, provided the supplier-specific emission factor is no more than five years older than the most recent residual mix or grid-average emission factor.

<sup>10</sup> Emission factor tables are available at [www.theclimateregistry.org](http://www.theclimateregistry.org).

<sup>11</sup> The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets.

<sup>12</sup> At the start of the reporting process, reporters select which IPCC Assessment Report they are using and CRIS automatically selects the appropriate GWPs.

### Figure 6 – Options for Reporting Emissions

To pre-calculate emissions data:

**Activity Data x EF**  
*You Measure/Calculate*

**x GWP = CO<sub>2</sub>e**  
*CRIS Calculates*

To use the CRIS calculator:

**Activity Data**  
*You Measure*

**x EF x GWP = CO<sub>2</sub>e**  
*CRIS Calculates*

## CALCULATING SCOPE 1 - DIRECT EMISSIONS

Direct emissions are those that your business physically emits to the atmosphere. They are further subdivided into subcategories based on the types of sources they result from:

- Stationary Combustion
- Mobile Combustion
- Fugitive Emissions
- Process Emissions

The sections below describe how to calculate emissions from the most common direct emission sources for small businesses: stationary combustion, mobile combustion and refrigeration and air conditioning.

### SCOPE 1 - STATIONARY COMBUSTION

Stationary combustion refers to the combustion of fuels in stationary equipment, such as boilers, furnaces, turbines, or heaters. Typical fuels combusted in stationary equipment include natural gas, diesel fuel, fuel oil, liquid petroleum gas, and kerosene. The most common type of stationary combustion source of GHG emissions for small businesses is the on-site combustion of liquid fuels, such as natural gas, for heat, hot water, and cooking.

#### Reporting for Leased Spaces

Natural gas is a very common source of emissions but accounting for it in leased spaces can be a bit confusing. You should report emissions from stationary combustion used for heating as direct emissions in Scope 1 when:

- There are heating units (e.g., natural gas boilers) located on the physical premise of the building space within your boundary.
- Your business contracts directly for heating/natural gas with a utility (you pay the bill directly to the utility, rather than to a landlord). If you pay the bill to the landlord these emissions will be reported as indirect Scope 2 emissions instead.

#### Overview of steps to calculate emissions from stationary combustion:

1. Determine annual consumption of each fuel;
2. Determine the appropriate CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O emission factors for each fuel;
3. Calculate CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions; and
4. Convert to CO<sub>2</sub>e and calculate total annual emissions.

#### Collect Activity Data:

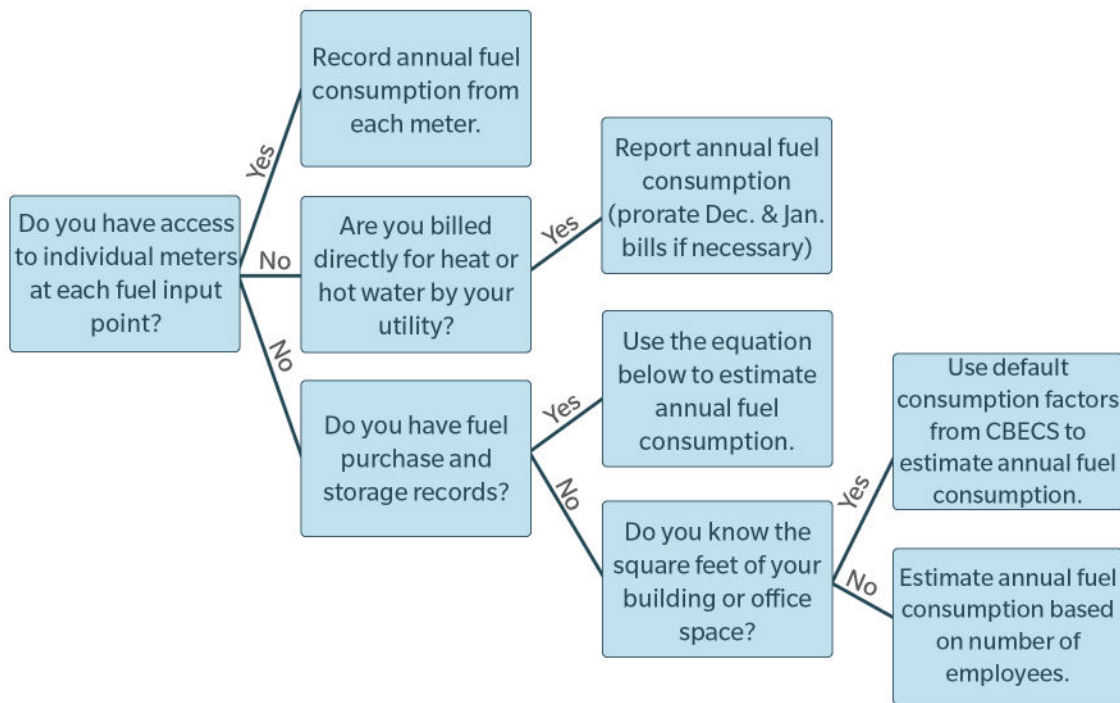
For each facility, identify all of the fuels combusted, and then determine annual fuel consumption for each type of fuel, measured in terms of physical units (mass or volume).

Follow the flowchart below to determine what activity data to collect to estimate fuel combusted in stationary equipment.

#### Activity Data for Stationary Combustion

- Amount of fuel use, such as diesel fuel or natural gas, broken down by fuel type
- Sq. ft. and purpose of facilities where stationary combustion occurs
- Number of employees (to estimate sq. ft. if information is unavailable)

**Figure 7- Activity Data for Stationary Combustion**



ACCOUNTING FOR CHANGES IN FUEL STOCKS								
<b>Total Annual Fuel Consumption</b>	=	<i>Annual Fuel Purchases</i>	–	<i>Annual Fuel Sales</i>	+	<i>Fuel Stock at Beginning of Year</i>	–	<i>Fuel Stock at End of Year</i>

## Record or estimate activity data according to one of the following options:

**If you have access to individual meters** located at the fuel input point, determine the amount of fuel combusted at each combustion unit by reading the meter.<sup>13</sup>

**If you have fuel receipts or purchase and storage records**, use the equation above to estimate annual fuel consumption.

**If you are billed directly by your utility for heat or hot water**, determine the total annual fuel consumption. Note: When a utility bill does not begin exactly on January 1 or end on December 31, you must prorate January and December bills (for those two months only) to determine annual fuel use. To calculate emissions for January from a bill spanning part of December and part of January, first divide total fuel consumed in the period by the number of days in the billing cycle. Then, determine the number of days from the bill that fall in January. Multiply the fuel consumed per day by the number of days in January. Add this amount to any other electric bill that includes days in January. Follow the same process to calculate emissions for December from a bill spanning December and January.

**If you know the square footage and main activity type of your facility (e.g., office)**, you can estimate fuel use based on default fuel consumption factors derived from studies such as the Commercial Buildings Energy Consumption Survey (CBECS), which publishes fuel consumption estimates per square foot for various building types.<sup>14,15</sup>

**If information on the size of your office is unavailable**, you can estimate the area based on the number of employees.<sup>16</sup>

### Find the Emission Factor:



Use the default CO<sub>2</sub> emission factors provided by fuel type in Tables 1.1 to 1.3 of TCR's default emission factor document.<sup>17</sup>



If only the type of fuel is known, use Tables 1.9 and 1.10 to obtain CH<sub>4</sub> and N<sub>2</sub>O emission factors by fuel type and sector. If either the specific type of combustion equipment used at a facility or a facility's specific sector can be determined, use factors from Tables 1.4 to 1.8 to select emission factors for CH<sub>4</sub> and N<sub>2</sub>O.<sup>18</sup>



## SCOPE 1 - MOBILE COMBUSTION

Mobile combustion refers to fuels combusted in transportation sources. The most common source of mobile combustion emissions for small businesses is on-road vehicles that are owned and operated by the business as part of a fleet. Other sources may include marine vessels, small

<sup>13</sup> If you are able to obtain information on measured heat content or carbon content of your fuels, either from direct measurement by obtaining it from your fuel supplier, please refer to the GRP [Quantification Methods Module](#).

<sup>14</sup> U.S. Energy Information Administration. (2012). *Commercial Buildings Energy Consumption Survey: Table C1*. Retrieved from <https://www.eia.gov/consumption/commercial/data/2012/>

<sup>15</sup> For additional guidance on using square foot data, refer to the GRP [Quantification Methods Module](#).

<sup>16</sup> CarbonFund.org. *How We Calculate*. Retrieved from <http://www.carbonfund.org/how-we-calculate>

<sup>17</sup> Emission factor tables are available on TCR's website at [www.theclimateregistry.org](http://www.theclimateregistry.org).

<sup>18</sup> Ibid.

aircraft, or off-road vehicles such as those used in construction and landscaping. CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O are emitted as a result of mobile combustion.

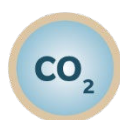
Mobile sources may also emit hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) from mobile air conditioning and transport refrigeration leaks. See the next section on fugitive emissions for guidance on estimating these additional mobile source emissions.

#### Sources of Mobile Combustion

- Vehicle fleet
- Marine vessels
- Small aircraft
- Off-road vehicles

#### Reporting Emissions from Electric Vehicles

One way that your business can reduce its GHG emissions is to use electric vehicles, which are powered by the electric grid rather than motor fuel. If your business operates electric vehicles, you will need to rely on the methods used to calculate emissions from electricity consumption, found in the [Calculating Scope 2 from Electric Vehicles section](#) of this document.



### Calculating CO<sub>2</sub> Emissions from Mobile Combustion

#### Overview of steps to calculate CO<sub>2</sub> emissions from mobile combustion:

1. Determine annual consumption of each fuel type;
2. Select the appropriate emission factor; and
3. Calculate total CO<sub>2</sub> emissions.

#### Activity Data for Mobile Combustion (CO<sub>2</sub>)

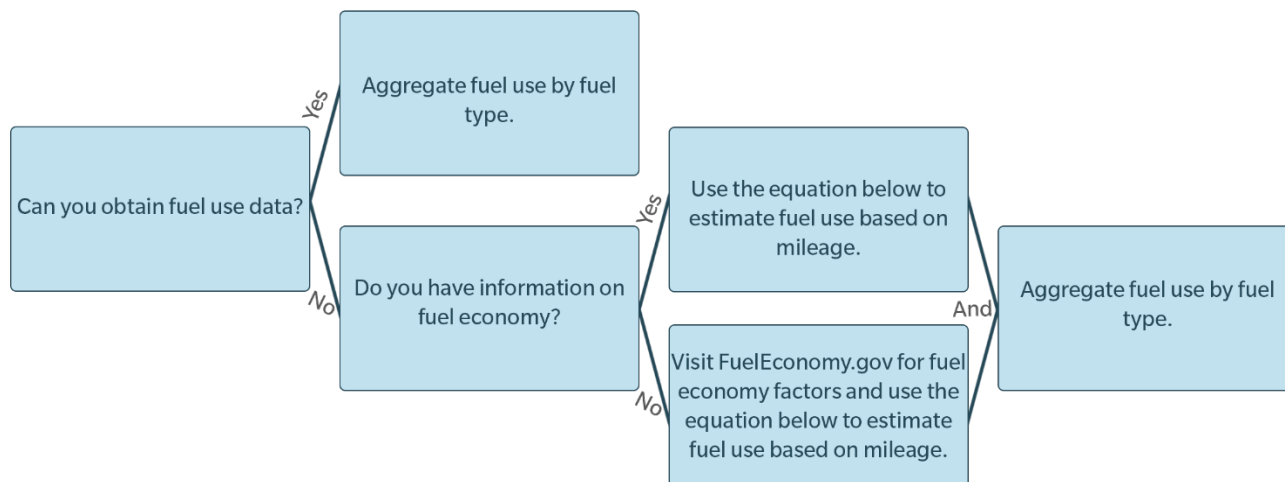
- Vehicle make and model
- Vehicle fuel used
- Quantity of fuel consumed
- Vehicle miles per gallon

#### Collect Activity Data:

CO<sub>2</sub> emissions, which account for the majority of emissions from mobile sources, are directly related to the quantity of fuel combusted and thus can be calculated using fuel consumption data. You can also estimate CO<sub>2</sub> emissions from mobile combustion based on vehicle fuel use and data on miles travelled. CO<sub>2</sub> emissions from vehicles are based on the type of fuel that is combusted, so you need to separate your vehicles by the type of fuel that they consume – diesel, gasoline, compressed natural gas, etc.

Follow Figure 8 below to determine what activity data to collect to calculate CO<sub>2</sub> emissions from mobile combustion.

#### Figure 8 – Activity Data for CO<sub>2</sub> from Mobile Combustion



ESTIMATING FUEL USE BASED ON DISTANCE	
Fuel Use (gallons)	$= \frac{\text{Distance (miles)}}{(\text{City FE} \times \text{City percentage}) (\text{mpg}) + (\text{Highway FE} \times \text{Highway percentage}) (\text{mpg})}$
FE = Fuel Economy City percentage = percentage a vehicle's annual mileage that is city driving Hwy percentage = percentage of a vehicle's annual mileage that is highway driving	

### Determine fuel consumption according to one of the following options:

**If you can obtain fuel use data**, simply aggregate total fuel consumption by fuel type.<sup>19</sup> Fuel use data may be obtained from bulk fuel purchases, fuel receipts, or direct measurements of fuel use. If your business operates more than one type of vehicle, you should calculate the fuel use for each vehicle type and then sum them together.

**If you cannot obtain fuel use data, but have information on mileage and fuel economy**, follow the steps below to estimate your fuel consumption:

1. Identify the vehicle make, model, fuel type, and model years for all operated vehicles;
2. Identify the distance traveled by vehicle type;
3. Determine the fuel economy of each vehicle; and
4. Convert mileage to fuel consumption using the equation above.

Sources of mileage data include odometer readings or trip manifests that include distance to destinations. It is best to use business records by specific vehicle, such as the miles per gallon (mpg) values listed on the sticker when the vehicle was purchased, vehicle manufacturer documentation or other business records.

<sup>19</sup> For additional guidance on using fuel use data, refer to GRP [Quantification Methods Module](#).

**If you do not have access to fuel economy information for your vehicles**, you may obtain fuel economy factors for passenger cars and light trucks from the U.S. EPA website [www.fueleconomy.gov](http://www.fueleconomy.gov), which lists city, highway, and combined fuel economy factors by make, model, model year, and specific engine type. If you have accurate information about the driving patterns of the fleet, you should apply a specific mix of city and highway driving, using the equation above. Otherwise use the combined fuel economy factor, which assumes 45 percent of a vehicle’s mileage is highway driving and 55 percent is city driving.

If it is not feasible to determine the specific control technologies of the vehicle by checking the under-the-hood label, you can estimate vehicle control technologies using each vehicle’s model year. Table 2.5 provides emission factors for highway vehicles by model year and vehicle type based on a weighted average of available control technologies for each model year.<sup>1</sup>

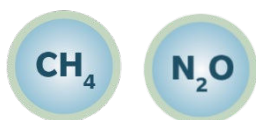
<sup>1</sup>Emission factor tables are available at [www.theclimateregistry.org](http://www.theclimateregistry.org).

**If your fleet includes heavy trucks**, fuel economy data for heavy-duty trucks may be available from vehicle suppliers, manufacturers or in business records. If no specific information is available, you should assume fuel economy factors of 8.0 mpg for medium trucks (10,000-26,000 lbs) and 5.8mpg for heavy trucks (greater than 26,000 lbs).<sup>20</sup>

### Find the Emission Factors:

Use TCR’s default CO<sub>2</sub> emission factors by fuel type, found in Table 2.1 (U.S.) and Table 2.2 (Canada).<sup>21</sup> If you can obtain actual fuel characteristics from the fuel supplier, such as heat content or fuel density, you will be able to apply a more precise emission factor.<sup>22</sup>

## Calculating CH<sub>4</sub> and N<sub>2</sub>O Emissions from Mobile Combustion



### Overview of steps to calculate CH<sub>4</sub> and N<sub>2</sub>O emissions from mobile combustion:

1. Identify the vehicle type, fuel type and technology type or model year of each vehicle;
2. Identify the annual mileage by vehicle type;
3. For each vehicle type, multiply the annual mileage by the emission factor for CH<sub>4</sub> and N<sub>2</sub>O to estimate CH<sub>4</sub> and N<sub>2</sub>O emissions;
4. Convert to CO<sub>2</sub>e and sum CH<sub>4</sub>, N<sub>2</sub>O, and CO<sub>2</sub> to calculate total emissions.

#### Activity Data for Mobile Combustion (CH<sub>4</sub> & N<sub>2</sub>O)

- Vehicle make and model
- Vehicle fuel used
- Vehicle miles driven
- Emissions control technology

### Collect Activity Data:

CH<sub>4</sub> and N<sub>2</sub>O emissions depend on the emission control technologies employed in the vehicle and distance travelled. Calculating emissions of CH<sub>4</sub> and N<sub>2</sub>O requires data on vehicle characteristics (which take into account emission control technologies) and vehicle miles traveled.

<sup>20</sup> US Department of Energy, *Transportation Energy Data Book*, Ed. 31, 2012, Table 5.4.

<sup>21</sup> Emission factor tables are available at [www.theclimateregistry.org](http://www.theclimateregistry.org).

<sup>22</sup> For additional guidance please refer to GRP [Advanced Methods Module](#).

### Collect information on vehicle characteristics:

For each vehicle your business owns and operates, identify:

- The vehicle type (such as passenger car or heavy-duty truck);
- The fuel type (such as gasoline or diesel); and
- The vehicle’s emission control technology or model year.

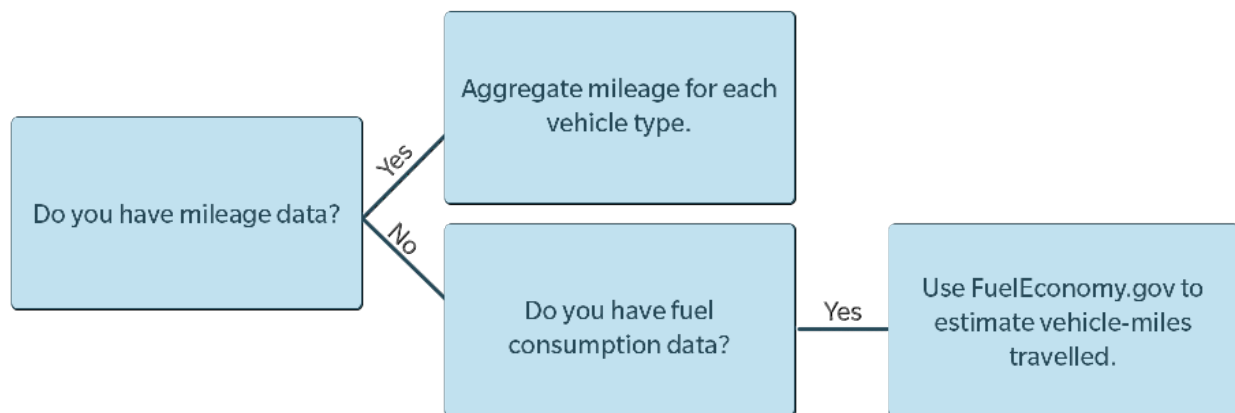
### Identifying the emissions control technology

The most accurate approach is to determine the actual control technology employed in each vehicle. Tables 2.3 and 2.4 provides the names of control technologies for each vehicle type.<sup>23</sup> Information on the control technology type for each vehicle is posted on an under-the-hood label.

### Collect mileage data for each vehicle type

Follow the flowchart below to determine mileage for each vehicle type.

**Figure 9 – Activity Data for CH<sub>4</sub> and N<sub>2</sub>O from Mobile Combustion**



**Aggregate annual mileage data for each vehicle type if it is available.** Sources of annual mileage data include odometer readings or trip manifests that include distance to destinations. If you already used information about distance traveled to estimate fuel consumption, use the same information to estimate CH<sub>4</sub> and N<sub>2</sub>O emissions.

**If you do not have mileage data, but you do have fuel consumption data,** you can estimate the vehicle distance traveled using the fuel economy factors on the U.S. EPA website [www.fueleconomy.gov](http://www.fueleconomy.gov) for each vehicle type. If you operate more than one type of vehicle, you must separately calculate the fuel use for each vehicle type. If only bulk fuel purchase data is available, you should allocate consumption across vehicle types and model years based on usage data. Then use the equation below to estimate distance.

<sup>23</sup> Emission factor tables are available at [www.theclimateregistry.org](http://www.theclimateregistry.org).

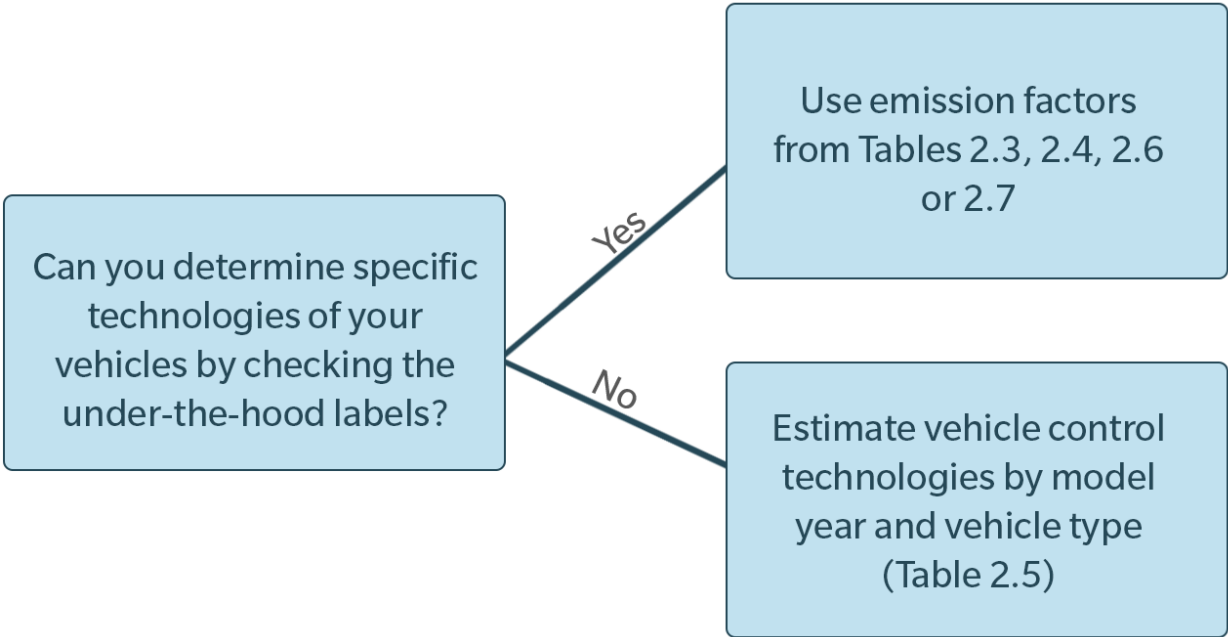
**ESTIMATING DISTANCE BASED ON FUEL USE**

<b>Distance (miles)</b>	=	$Fuel\ use\ (gallons) \times [(City\ FE \times City\ percentage)(mpg) + (Highway\ FE \times Highway\ percentage)(mpg)]$
-------------------------	---	---

FE = Fuel Economy  
 City percentage = percentage a vehicle's annual mileage that is city driving  
 Hwy percentage = percentage of a vehicle's annual mileage that is highway driving

**Find the Emission Factors:**

**Figure 10 – Emission Factors for CH<sub>4</sub> and N<sub>2</sub>O from Mobile Combustion**



If you know your vehicles' specific control technologies, obtain CH<sub>4</sub> and N<sub>2</sub>O emission factors for highway vehicles from Tables 2.3 or 2.4. Use Tables 2.6 and 2.7 for alternative fuel and non-highway vehicles. If you have data on vehicles' model years (rather than control technologies), obtain emission factors for highway vehicles from Table 2.5.<sup>24</sup>

<sup>24</sup> Emission factor tables are available at [www.theclimateregistry.org](http://www.theclimateregistry.org).

## Simplified Estimation Method for Mobile CH<sub>4</sub> & N<sub>2</sub>O Emissions from Gasoline and Diesel Passenger Cars and Light-Duty Trucks

If you are only able to obtain information on the quantity of gasoline and diesel fuel gallons consumed by your vehicles, you may use a simplified method which estimates CH<sub>4</sub> and N<sub>2</sub>O emissions for on-road vehicles based on the CO<sub>2</sub> emissions quantified in the previous section.<sup>1</sup>

### Applying the Simplified Estimation Method

1. Determine the total annual quantity of gasoline and diesel fuel gallons consumed, by fuel-type.
2. Calculate the CO<sub>2</sub> emission totals using the methods in this section.
3. To calculate the CH<sub>4</sub> and N<sub>2</sub>O emissions, multiply the metric tons of CO<sub>2</sub> by the CH<sub>4</sub> and N<sub>2</sub>O emission factor from Table 2.4.<sup>2</sup>

<sup>1</sup> This method applies an emission factor that describes a default ratio of CH<sub>4</sub> or N<sub>2</sub>O to corresponding CO<sub>2</sub> emissions. The default ratio is based on GHG emission trend data reported as part of the U.S. National Inventory of Greenhouse Gas Emissions and Sinks every year to estimate CH<sub>4</sub> and N<sub>2</sub>O emissions

<sup>2</sup> Emission factor tables are available at [www.theclimateregistry.org](http://www.theclimateregistry.org).

## Calculating CH<sub>4</sub> and N<sub>2</sub>O for Non-Highway Vehicles

Note that the procedure described in this section applies to highway vehicles and alternative fuel vehicles, but not to non-highway vehicles such as ships, locomotives, aircraft, and non-road vehicles. For these vehicles, use the same fuel consumption data used to estimate CO<sub>2</sub> emissions in the previous section. Use default factors provided in Table 2.7 to estimate CH<sub>4</sub> and N<sub>2</sub>O emissions.<sup>1</sup>

<sup>1</sup> Emission factor tables are available at [www.theclimateregistry.org](http://www.theclimateregistry.org).

## Reporting Emissions from Biofuels

Biofuels such as ethanol, biodiesel, and various blends of biofuels and fossil fuels are frequently combusted in mobile sources. Due to their biogenic origin, you should report CO<sub>2</sub> emissions from the combustion of biomass separately from fossil fuel CO<sub>2</sub> emissions. For biofuel blends such as E85 (85% ethanol and 15% gasoline), E10 (10% ethanol and 90% gasoline) and B20 (20% biodiesel and 80% diesel), combustion results in emissions of both fossil CO<sub>2</sub> and biogenic CO<sub>2</sub>. If you have purchased a blended (biofuel and fossil fuel) fuel product, those emissions must be apportioned as fossil CO<sub>2</sub> and biogenic CO<sub>2</sub> based on the blend composition.

In many cases, standard gasoline is blended with some biofuel. However, fuel mixes can vary with location and the time of year. When using default emission factors to quantify CO<sub>2</sub> emissions, unless documentation of specific information about the particular gasoline blend is available, you should use TCR's default emission factor for motor gasoline. This will result in all CO<sub>2</sub> emissions being reported in Scope 1.

## SCOPE 1 – FUGITIVE EMISSIONS

Fugitive emissions are released from equipment as a result of leaks or vents. Fugitive emissions are most common in large industrial operations, but there are some smaller sources of fugitive emissions such as refrigeration and air conditioning equipment in buildings and vehicles, as well as fire suppression systems. Emissions from refrigerants must be pre-calculated in all cases.

## Overview of steps to calculate fugitive emissions

1. Determine the types and quantities of each refrigerant used
2. Estimate annual emissions of each refrigerant

## Collect Activity Data

Refrigeration and air conditioning systems include motor vehicle air conditioning, retail food refrigeration, refrigerated transport, and air conditioning systems. These systems often leak hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) when they are used, installed, and disposed. Two methods for estimating emissions of HFCs and PFCs from refrigeration and air conditioning equipment are provided in this section:

- Simplified mass balance method; and,
- Screening method, which may be used as a SEM provided that total emissions estimated with SEMs fall below the 10% SEMs threshold.

### Reporting HFC and PFC Blends

Please note that some refrigerant blends include both HFCs and PFCs. When reporting emissions associated with these blends, the HFC and PFC components must be reported by gas. To report the emissions from these blends, you must multiply the amount of each refrigerant used by the percent composition of each HFC and PFC listed in Table 5.2. Use the equation below and the GWP factors from Table 5.2 to convert each HFC and PFC into units of CO<sub>2e</sub>.<sup>1</sup>

<sup>1</sup> Emission factor tables are available at [www.theclimateregistry.org](http://www.theclimateregistry.org).

### CONVERTING HFC AND PFC EMISSIONS TO CO<sub>2e</sub>

$$\text{HFC Type A Emissions (mt CO}_2\text{e)} = \text{HFC Type A Emissions (mt HFC Type A)} \times \text{GWP (HFCA)}$$

$$\text{PFC Type A Emissions (mt CO}_2\text{e)} = \text{PFC Type A Emissions (mt PFC Type A)} \times \text{GWP (PFCA)}$$

### Reporting Montreal Protocol Refrigerants

Common refrigerants R-22, R-12, and R-11 are not part of the GHGs required to be reported to TCR because they are either HCFCs or chlorofluorocarbons (CFCs). The production of HCFCs and CFCs is being phased out under the Montreal Protocol and as a result, HCFCs and CFCs are not defined as GHGs under the Kyoto Protocol. Emissions of non-Kyoto-defined GHGs must not be reported as emission sources in the inventory, regardless of the GWP of the gas. Businesses that opt to disclose emissions of these refrigerants must include that information in a supplemental document.

## Simplified Mass Balance Method

### 1. Determine the types and quantities of each refrigerant used

For each refrigerant used, determine the following quantities used or recovered during the reporting year, if applicable:

- Quantity of refrigerant used to charge new equipment during installation (if new equipment was installed that was not pre-charged by the manufacturer);
- Total full charge (capacity) of new equipment using this refrigerant (if new equipment was installed that was not pre-charged by the manufacturer);
- Quantity of refrigerant used to service equipment;
- Total full charge (capacity) of retiring equipment (if equipment was disposed during the reporting year); and,
- Quantity of refrigerant recovered from retiring equipment (if equipment was disposed during the reporting year).

If you use contractors to service refrigeration equipment, you should obtain the required information from the contractor. Always track and maintain the required information carefully in order to obtain accurate emissions data.

Note that “total full charge” refers to the full and proper charge of the equipment rather than to the actual charge, which may reflect leakage. For more information, see the description of “Net Increase in Total Full Charge of Equipment” in the advanced mass balance method.<sup>25</sup>

## 2. Calculate annual emissions of each HFC and PFC gas

Use the equation below to calculate emissions for each refrigerant used.

CALCULATING EMISSIONS OF EACH REFRIGERANT USING THE SIMPLIFIED MASS BALANCE METHOD	
Total Annual Emissions (mt)	$= \frac{(P_N - C_N + P_S - P_R + C_D - R_D)(kg)}{1,000 \left(\frac{kg}{mt}\right)}$
<p>Where:</p> <p><math>P_N</math> = Purchases of refrigerant used to charge new equipment*</p> <p><math>C_N</math> = Total full charge (capacity) of the new equipment*</p> <p><math>P_S</math> = Quantity of refrigerant used to service equipment</p> <p><math>P_R</math> = Quantity of refrigerant recycled</p> <p><math>C_D</math> = Total full charge (capacity) of retiring equipment</p> <p><math>R_D</math> = Refrigerant recovered from retiring equipment</p> <p>* Omitted if the equipment has been pre-charged by the manufacturer</p>	

## Screening Method

The screening method is a Simplified Estimation Method (SEM) which may be used to estimate HFC and PFC emissions from refrigeration and air conditioning systems by multiplying the quantity of refrigerants used by default emission factors. Because default emission factors are highly uncertain, the resulting emissions estimates are not considered accurate.

You may only use the screening method if total, entity-wide emissions estimated with SEMs do not exceed 10% of the CO<sub>2</sub>e sum of reported Scope 1, Scope 2, combustion-based direct biogenic emissions and combustion-based indirect biogenic emissions associated with consumed energy (i.e., the 10% SEMs threshold).

### 1. Determine the Types and Quantities of Refrigerants Used

To estimate emissions, you must determine the number and types of refrigeration and air conditioning equipment, by equipment category; the types of refrigerant used, and the

<sup>25</sup> For more on Advanced Mass Balance Method, see the GRP [Advanced Methods Module](#).

refrigerant charge capacity of each piece of equipment.<sup>26</sup> If the refrigerant charge capacity of each piece of equipment is unknown, use the upper bound of the range provided by equipment type in Table 4.1.<sup>27</sup>

## 2. Estimate Annual Emissions of Each Refrigerant

For each refrigerant, use the equation below to estimate annual emissions. Default emission factors are provided in Table 4.1 by equipment type.<sup>23</sup> The equation includes emissions from installation, operation, and disposal of equipment. If your business did not install or dispose of equipment during the reporting year, you should not include emissions from these activities in the estimation.

**3. Convert to CO<sub>2</sub>e:** After using either method to calculate emissions by gas, use the appropriate GWP factors from Appendix B to convert each type of refrigerant to units of CO<sub>2</sub>e.

ESTIMATING EMISSIONS OF EACH REFRIGERANT USING THE SCREENING METHOD	
For each refrigerant: Total Annual Emissions (mt)	= $\frac{(C_N \times k) + (C \times w \times T) + [C_D \times y \times (1 - z)] (kg)}{1,000 \left(\frac{kg}{mt}\right)}$
<p>Where:</p> <p><math>C_N</math> = Quantity of refrigerant charged into the new equipment*</p> <p><math>C</math> = Total full charge (capacity) of the equipment</p> <p><math>T</math> = Time in years equipment was in use (e.g., 0.5 if used only during half the year and then disposed)</p> <p><math>C_D</math> = Total full charge (capacity) of equipment being disposed of**</p> <p><math>k</math> = Installation emission factor*</p> <p><math>w</math> = Operating emission factor</p> <p><math>y</math> = Refrigerant remaining at disposal**</p> <p><math>z</math> = Recovery efficiency**</p> <p>* Omitted if no equipment was installed during the reporting year or the installed equipment was pre-charged by the manufacturer</p> <p>** Omitted if no equipment was disposed of during the reporting year</p>	

## SCOPE 1 - PROCESS EMISSIONS

Process emissions are GHG emissions resulting from chemical processes such as semiconductor manufacturing or cement production.<sup>28</sup> This class of emissions is often also referred to as industrial process emissions, as it primarily occurs as a result of large-scale industrial activities and manufacturing. It is unusual for small businesses to have sources of process emissions.

<sup>26</sup> See table 4.2 of TCR's default emission factors or Appendix B and C of this document.

<sup>27</sup> Emission factor tables are available at [www.theclimateregistry.org](http://www.theclimateregistry.org).

<sup>28</sup> Please refer to [TCR's GRP](#) for more information.

## CALCULATING SCOPE 2 INDIRECT EMISSIONS FROM CONSUMED ENERGY

Scope 2 indirect GHG emissions are a consequence of activities that take place within the organizational boundary of the reporting organization but occur at sources owned or controlled by another organization. In other words, indirect emissions are GHG emissions that your business influences but does not ultimately control. This means that the physical GHG emission source is not within your organizational boundary, but your demand for the process that generated the emissions contributed to its release.

An example of an indirect emission source is the electricity you purchase from your electric utility. The utility controls the power generation source, but your demand for the electricity contributed to the decision to generate the power. Scope 2 is a special category of indirect emissions and refers only to indirect emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling. Since Scope 2 emissions typically make up a large portion of small businesses' GHG inventories, it can be a key area to implement emissions reduction strategies.

### Reporting Scope 2 Emissions for Leased Spaces

Natural gas is a very common source of emissions but accounting for it in leased spaces can be confusing. If you are reporting using operational control, are individually metered and pay the bills for the gas that you use (i.e., you contract directly with the gas provider), then you should report the emissions as Scope 1. If you are not individually metered and don't pay the natural gas bills, you should report the emissions as Scope 2 purchased heating, as the combustion process takes place elsewhere on your behalf.

### Calculating Emissions from Electric Vehicles

Emissions from electric vehicles should be reported as Scope 2. To calculate emissions from electric vehicles (EVs), determine the annual distance travelled for each vehicle type, divide it by the default mpg equivalent (Defaults available at [www.fueleconomy.gov](http://www.fueleconomy.gov) based on the year and model of the vehicle), and multiply by the default 33.7 kWh/gallon.<sup>1</sup> Sum the total electricity use for the electric vehicle fleet. (See the equation that follows.) Return to Steps 2 and 3 above to apply the appropriate emission factor and convert the CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions to CO<sub>2</sub>e.

<sup>1</sup> U.S. EPA assumes a default of 33.7, based on the energy content of a gallon of gasoline (equal to 34.12 kWh) discounted for losses in the battery.

### CALCULATING INDIRECT EMISSIONS FROM ELECTRICITY USE FOR ELECTRIC VEHICLES

Electricity Use EV Type 1 (kWh)	=	$\frac{\text{Annual Distance (miles)}}{\text{Default mpg Equivalent (miles/gallon)}} \times 33.7 \text{ (kWh)}$
Electricity Use EV Type 2 (kWh)	=	$\frac{\text{Annual Distance (miles)}}{\text{Default mpg Equivalent (miles/gallon)}} \times 33.7 \text{ (kWh)}$
Total EV Electricity Use (kWh)	=	Electricity Use EV Type 1 (kWh) + Electricity Use EV Type 2 (kWh)

Scope 2 emissions are reported in two ways, using the location-based method and the market-based method.

**1. Location-based method:** The location-based method quantifies the average emissions from electricity generated and consumed in your business’s geographic region(s) of operations within your defined boundaries, primarily using grid-average emission factors. This method reflects the GHG emissions from locally-generated electricity delivered through the grid and transparently demonstrates local conditions and the impacts of energy conservation. It does not reflect any purchasing choice(s) that your business has made.

**2. Market-based method:** The market-based method quantifies emissions from electricity generated and consumed that your business has purposefully purchased, using emission factors conveyed through contractual instruments between your business and the electricity or product provider. This method reflects the GHG emissions associated with the choices your business has made about its electricity supply or product. It allows you to claim the specific emission rate associated with these purchases; for instance, a utility-specific emission factor from TCR’s Electric Power Sector (EPS) delivery metrics. Energy conservation (i.e., reduced energy consumption) also impacts the GHG emissions reflected in the market-based method.

If you are reporting a complete inventory with all relevant emissions, you must report both location and market-based emissions. These two methods are referred to throughout the GRP as the Scope 2 methods.<sup>29</sup>

#### Important Distinction between Direct and Indirect Emissions

Indirect emissions reported by one company may also be reported as direct emissions by another company. For example, the indirect emissions from electricity use reported by an office-based small business may also be reported as direct emissions by the utility that generated the electricity. This dual reporting does not constitute double counting of emissions since the companies report the emissions associated with the electricity production and its use in different Scopes (Scope 1 for the electricity generating utility and Scope 2 for the small business). Therefore, emissions can only be aggregated meaningfully *within* a Scope, not across Scopes. Scope 2 and Scope 3 emissions will always be part of another entity’s Scope 1 emissions.

#### Overview of steps to calculate indirect emissions from electricity

1. Determine annual electricity use from each facility;
2. Select the appropriate emission factors for the location-based method and market-based method;
3. Determine total annual emissions in metric tons of CO<sub>2</sub>e for the location-based method and market-based method.

#### Determining Total Annual Electricity Consumption

There are several methods you can use to determine annual electricity consumption.

- Known electricity use method;
- Area method;
- Cost method; or,
- Average intensity method.

<sup>29</sup> For more on Location versus Market-based reporting, see the GRP [Inventory Boundaries](#) and [GHG Emissions Quantification Methods](#) Modules.

### The Known Electricity Use Method

Monthly electric bills or electric meter records provide the number of kilowatt-hours (kWh) or megawatt-hours (MWh) of electricity consumed. Record the electricity consumed each month at each facility. Then, aggregate monthly bills to determine annual electricity use (in kWh or MWh) for each facility.

Note: Be careful not to accidentally report Scope 1 emissions from purchased natural gas as Scope 2 using the known use method. If your business contracts directly with a utility to purchase natural gas or another fuel used for heating, it should be reported in Scope 1.

### The Area Method

Use the area method to estimate energy use based on your business’s share of the building’s floor space and total electricity consumption. This method is less accurate than the known electricity use method.

You will need to collect the following information from the building’s property manager:

- Total building area (square feet);
- Area of organization’s space (square feet);
- Total building annual electricity use (kWh); and,
- Building occupancy rate (e.g., if 75% of the building is occupied, use 0.75).

Use this information and the equation below to estimate your business’s share of the building’s electricity use.

ESTIMATING ELECTRICITY CONSUMPTION USING THE AREA METHOD	
Electricity Use (kWh)	$= \frac{\text{Organization's Area (ft}^2\text{)} \times \text{Building Electricity Use (kWh)}}{\text{Building Area (ft}^2\text{)} \times \text{Occupancy Rate}}$

### The Cost Method: (Only for U.S. Commercial Facilities and Warehouses)

If it is not feasible to obtain kWh data for commercial facilities and warehouses, you can estimate electricity consumption using electricity expenditures and average kWh costs. To use this method, first determine annual electricity expenditures for each facility. This data is often found in utility bills or financial records. Then, to estimate annual kWh, divide the annual facility-level electricity expenditures by the average electricity cost by U.S. state from Table 3.5, as shown in the equation below.<sup>30</sup>

ESTIMATING ELECTRICITY CONSUMPTION USING THE EXPENDITURE RECORDS	
Electricity Use (kWh)	$= \frac{\text{Facility Expenditures (dollars)} \times 100}{\text{Average Kilowatt Hour (} \frac{\text{cents}}{\text{kWh}} \text{)}}$

### The Average Intensity Method:

You may need to use the average intensity method for calculating indirect emissions from leased space if you do not receive information about electricity use from an electric utility and you are unable to obtain information about the building’s electricity use from the landlord/property manager. The average intensity method is less accurate than those listed above.

This method involves the following steps:

<sup>30</sup> Emission factor tables are available at [www.theclimateregistry.org](http://www.theclimateregistry.org).

1. Determine the leased space’s square footage;
2. Determine the average annual electricity intensity for the building space; and,
3. Estimate electricity consumption.

### 1. Determine the Leased Space’s Square Footage

First, review the lease to determine the leased space’s usable square footage. Usable square footage is the space contained within the walls of the leased space, including storage space. It does not include other ‘rentable’ areas such as building bathrooms, common areas, etc.

### 2. Determine the Average Annual Electricity Intensity for Building Space

Next, select the most appropriate average electricity intensity according to the operations of the building space using Table 3.6 (Canada) and Table 3.7 (U.S.).<sup>31</sup>

### 3. Calculate Electricity Consumption

Use the equation below to estimate the electricity consumption for each leased space.

ESTIMATING ANNUAL ELECTRICITY CONSUMPTION			
Annual Electricity Consumption	=	Leased Space (useable space) (ft <sup>2</sup> ) (from landlord)	× Annual Electricity Intensity (kWh/ft <sup>2</sup> ) (from table)

#### Estimating Usable Office Space When Data is Unavailable

If information on the size of your office is unavailable, you can estimate the area of usable office space based on the number of employees.<sup>1</sup>

<sup>1</sup> Carbonfund.org assumes a typical employee needs 225 sq. ft., based on industry assumptions. (<http://www.carbonfund.org/how-we-calculate>).

### Select the appropriate emission factor

The location-based and market-based methods for Scope 2 accounting use different emission factors based on what data is available to you.

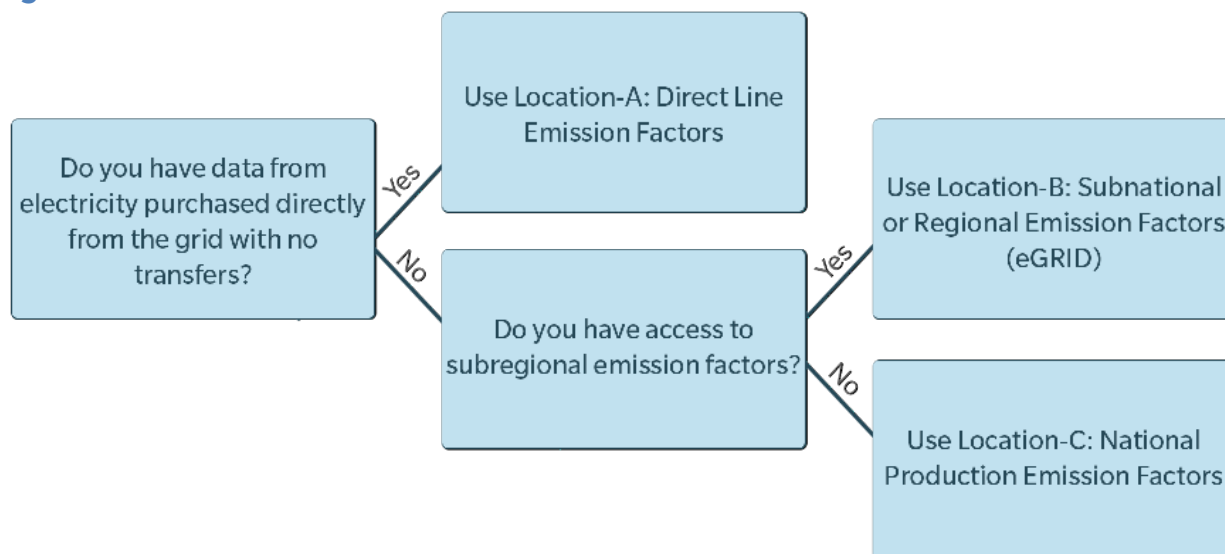
Emission factors for the location-based method reflect the GHG emissions intensity from locally generated electricity delivered either through the grid or through a direct line transfer. You must select an emission factor for each unit of electricity consumed. Three categories of location-based emission factors are listed in order from most specific to least specific in the location-based hierarchy and are described in the sections that follow. You should use the most specific emission factors available.

## SELECTING LOCATION-BASED EMISSION FACTORS

Follow Figure 11 to select your location-based emission factor.

<sup>31</sup> Ibid.

**Figure 11 – Select Location-Based Emission Factors**



### Location-A: Direct Line Emission Factors

Direct line emission factors represent emissions from electricity purchased directly from a generation source with no grid transfers. The emission factor is ineligible to be claimed when energy attribute certificates are transferred to a third-party.

Examples:

- Landfill waste-to-energy generator that sends power to nearby organization without connecting to the grid; and,
- Solar or wind generator that sends power to the organization without connecting to the grid.

**Find the emission factors:** Your contract with the generator should specify the emission factor; if not contact them to obtain the emission factor.

### Location-B: Regional or Subnational emission factors

Regional or subnational emission factors represent average emissions from all electricity produced in a defined grid distribution region. These emission factors should reflect net physical energy imports and exports across the grid boundary.

**Find the emission factors:** These emission factors are available in CRIS if you are using TCR’s emissions calculator. If you are pre-calculating your emissions you can find the appropriate emission factors for a facility in the U.S. with the U.S. EPA’s online Power Profiler tool to determine the facility’s Emissions & Generation Resource Integrated Database (eGRID) subregion.<sup>32</sup> Then, based on the subregion, find the emission factors for each gas in Table 3.1.<sup>33</sup>

### Location-C: National production emission factors

National production emission factors represent average emissions from all energy produced within state or national borders. If applying national production emission factors, use the value for the reporting year, or the most recent year available.

<sup>32</sup> U.S. EPA Power Profiler tool available at [www.epa.gov/cleanenergy/powerprofiler.html](http://www.epa.gov/cleanenergy/powerprofiler.html)

<sup>33</sup> Emission factor tables are available at [www.theclimateregistry.org](http://www.theclimateregistry.org).

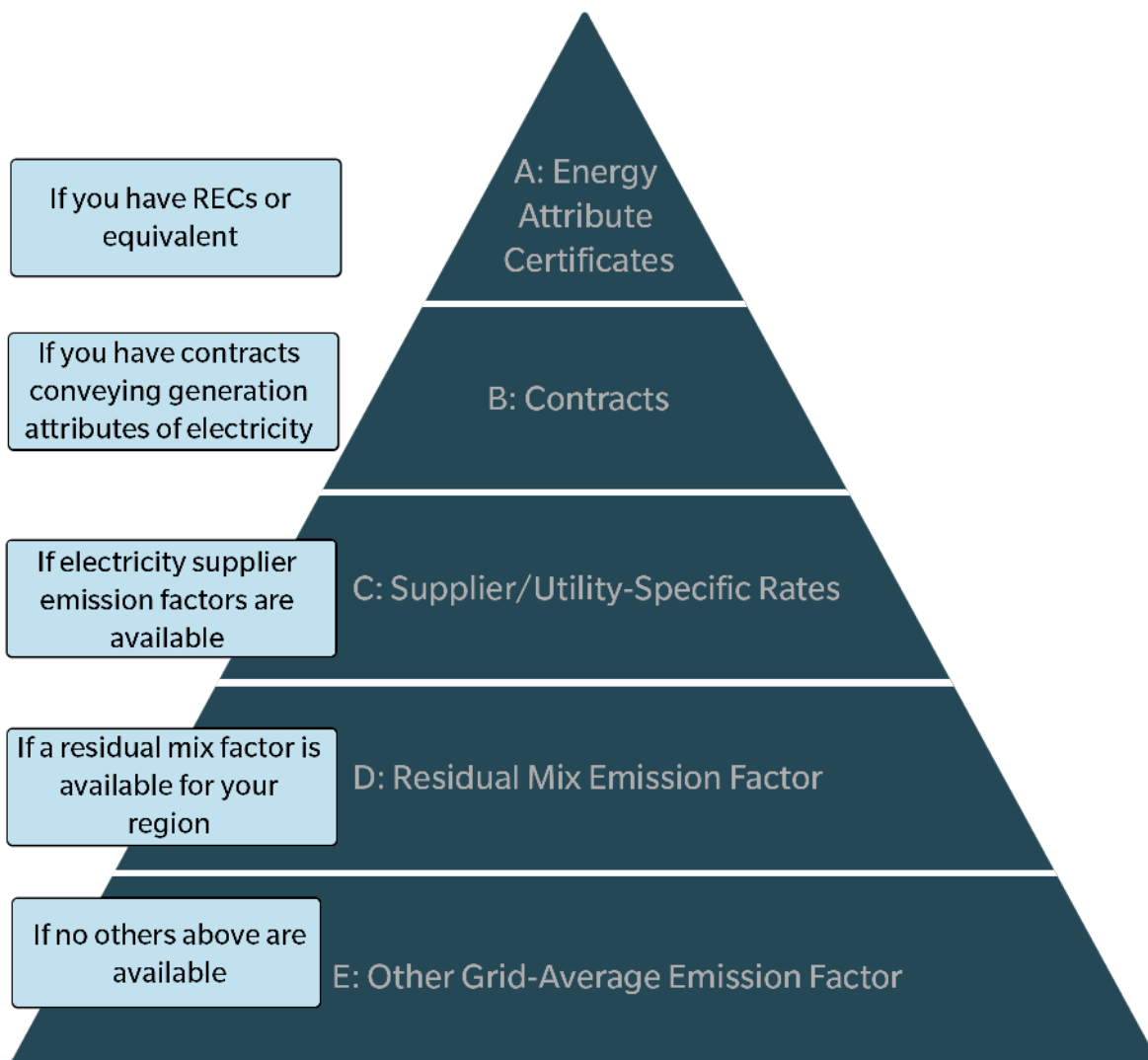
**Find the emission factors:** Country-specific Scope 2 emission factors can be obtained from the International Energy Agency (IEA) for operations outside of North America.

## SELECTING MARKET-BASED EMISSION FACTORS

Emission factors for the market-based method reflect the emission factor from electricity that your business has purposefully purchased, using contractual instruments between the business and the electricity or product provider. Types of contractual instruments that convey specific emission factors for the market-based method are listed in order from most specific to least specific in the hierarchy below and are described in the sections that follow. You should select the most specific emission factor available given your eligible contractual instruments for each unit of electricity that you consume.

Follow Figure 12 below to select your market-based emission factor.

**Figure 12 – Select Market-Based Emission Factors**



## Market-A: Energy Attribute Certificates (or equivalent instruments)

Energy attribute certificates convey information about energy generation to organizations involved in the sale, distribution, consumption, or regulation of electricity. They provide proof of electricity generation from a specific energy source and represent the rights to claim the environmental, social, and low or zero emissions characteristics resulting from the use of that electricity generation. Certificates can be unbundled, bundled with electricity, conveyed in a contract, or delivered by a utility. Where energy attribute certificates are issued, the certificates themselves serve as the emission factor for the market-based method.

Examples of Energy Attribute Certificates:

- Renewable Energy Certificates (RECs) (U.S., Canada, Australia, others);
- Electricity contracts that convey RECs;
- Certificates for non-renewable generation in regions where all-generation tracking systems are in operation; and,
- Any other energy certificates that meet the TCR eligibility criteria as described in [Table 1](#).

**Find the emission factors:** Power Purchase Agreements and contracts for RECs often specify emission factors that you can claim.

## Market-B: Contracts

Contracts can convey electricity generation attributes where energy attribute certificates do not exist or where attributes or certificates are not required to claim use. These may apply to specified sources of electricity, both renewable and fossil fuels. Contracts are also commonly present when electricity is conveyed from a specific source through a direct line transfer. The guidance on direct line emission factors for the location-based method also applies to the market-based method.

Examples of Contracts:

- Power purchase agreements (PPAs) or contracts for electricity from specific non-renewable sources (e.g., coal, nuclear) outside of regions where all-generation tracking systems are in operation;
- Direct line transfers;
- Contracts that convey attributes to the power consumer where certificates do not exist; and,
- Contracts for power that are silent on attributes, but where attributes are not otherwise tracked or claimed.

**Find the emission factors:** Find the emission factors in the contract or Power Purchase Agreement with the electricity supplier.

## Market-C: Supplier/Utility-Specific Emission Factors

Supplier/utility-specific emission factors quantify indirect emissions associated with a standard product offer, green power program, or a customized power product. You may use electricity delivery metrics reported and verified in accordance with TCR's EPS Protocol,<sup>34</sup> or other publicly certified delivery metrics developed by a supplier or utility as described in the GRP [Advanced Methods Module](#).

Examples of Supplier/Utility Specific Emission Factors:

- Retail emission factor, representing a delivered energy product (e.g., TCR EPS delivery metrics, Table 3.8)<sup>31</sup>

---

<sup>34</sup> Ibid.

- Special power product (SPP, also known as green power products or green energy tariffs); and,
- Voluntary renewable electricity program or product.

**Find the emission factors:** Utility-specific emission factors that have been reported and verified to TCR's EPS Protocol are listed on TCR's website. These emission factors are also available in CRIS.

### **Market-D: Residual Mix**

Residual mix emission factors quantify subnational or national energy production, factoring out voluntary purchases to prevent double counting of these claims. Many businesses will either be unable to obtain supplier-specific or utility-specific emission factors and/or will purchase some electricity exclusively from the grid. In these cases, you should use a residual mix emission factor, or must publicly disclose if a residual mix emission factor is not available.<sup>35</sup>

#### **Find the emission factors:**

Residual mix emission factors are always developed by a third party. You should obtain a residual mix emission factor that has been publicly documented and developed by industry experts or has been through a reasonable regulatory or peer review process. Contact TCR to determine the applicability of a residual mix emission factor for your region.

### **Market-E: Other Grid-Average Emission Factors (eGRID)**

Refer to the location-based emission factor hierarchy for the subnational/regional or national production emission factors. Organizations using a grid-average emission factor in the market-based method must publicly disclose the lack of an available residual mix emission factor if one is not available.<sup>36</sup>

Examples of Other Grid-averages Emission Factors:

- Regional or subnational emission factors (Tables 3.1, 3.2).<sup>37</sup>
- National production emission factors (Table 3.3).<sup>38</sup>

#### **Find the emission factors:**

Refer to the location-based emission factor hierarchy to select the emission factor.

### **Ensure Contractual Instruments Meet TCR Eligibility Criteria for Electricity**

TCR defines certain eligibility criteria that are designed to ensure that emission factors used to calculate the market-based method Scope 2 total are consistent with GHG accounting best practices. Only emission factors that meet the criteria in the table below are eligible to be claimed. Where contractual instruments do not meet these criteria, emission factors from either Market-D or Market-E must be used. Reporters must upload a public document identifying the contractual instrument certification program(s) or other documentation that demonstrates clear and explicit ownership and TCR eligibility in CRIS (e.g., REC certification document, self-attestation form). Follow Table 1 below to determine your emission factor eligibility.

---

<sup>35</sup> Members may contact TCR at [help@theclimateretry.org](mailto:help@theclimateretry.org) to assess the applicability of a residual mix emission factor.

<sup>36</sup> This disclosure is made automatically on the *Indirect Emissions Disclosure Form*.

<sup>37</sup> Emission factor tables are available at [www.theclimateretry.org](http://www.theclimateretry.org).

<sup>38</sup> Ibid.

**Table 1: Eligibility Requirements for Contractual Instruments**

CRITERIA	DESCRIPTION
<b>CONTRACTUAL INSTRUMENTS MUST:</b>	
1. Convey GHG information	» Convey the direct GHG emission rate attribute associated with produced electricity.
2. Prevent double counting	» Be the only instrument that carries the GHG emission rate attribute claim associated with that quantity of electricity generation. Clear and explicit ownership must be demonstrated by either third-party verification that includes a chain of custody audit, or documentation of permanent retirement in an electronic tracking system in a dedicated, named retirement subaccount for a particular TCR reporting year.  » Be distinct from offsets. A MWh generated by a renewable energy project and claimed as an offset cannot also be claimed as a contractual instrument (e.g., REC).
3. Be retired	» Be tracked, redeemed, retired, or canceled by or on behalf of the reporting organization.
4. Be of recent vintage	» Have been generated within a period of six months before the reporting year to up to three months after the reporting year.
5. Be sourced from same market as operations	» Be sourced from the same market in which the reporting organization’s electricity consuming operations are located and to which the instrument is applied. Market boundaries are assumed to match national boundaries, except where international grids are closely tied.
<b>UTILITY-SPECIFIC EMISSION FACTORS MUST BE:</b>	
6. Calculated based on delivered electricity	» Calculated based on contractually-delivered electricity, incorporating RECs or other instruments sourced and retired on behalf of customers.
<b>DIRECT LINE GENERATION OR ORGANIZATIONS CONSUMING ON-SITE GENERATION MUST:</b>	
7. Convey GHG claims to the organization	» Ensure that all emission claims are transferred to the reporting organization only.
<b>ALL CONTRACTUAL INSTRUMENTS MUST OPERATE IN MARKETS WITH A:</b>	
8. Residual mix	» Adjusted, residual mix emission factor characterizing the GHG intensity of unclaimed or publicly shared electricity. Organizations must disclose the lack of an available residual mix emission factor if one is not available.

### Electricity Generated On-Site

If your business generates its own electricity from an on-site system that you control, you must report any emissions associated with that power in Scope 1 stationary combustion and must leave out the emissions associated with consuming that power in Scope 2. If the on-site system generates zero-emission power, no emissions should be reported for this source in any Scope.

However, make sure that the on-site system is within your operational boundary. For example, if you host the solar panels for someone else, and you are reporting under operational control, you should not include the emissions (or lack thereof) in your inventory. Hosting panels for someone else (even if you are directly consuming the power from those panels) does not give you the ability to claim that your emissions are zero, because the attributes of that power belong to someone else.

### Calculating Indirect Emissions from Imported Heating or Cooling in Leased Spaces

Some small businesses that lease space (such as office space) use heat/steam or cooling that is generated within the facility they are in, but where the heat or cooling generation unit is outside of their organizational boundary. For example, if you lease office space on the third floor of a 24-

story building with a central heating system in the basement and you do not contract for heating fuel directly from the utility, the boilers are considered outside of your organizational boundary. Emissions from these sources can be reported as Scope 2 emissions (imported heat and imported cooling).

Often in leased spaces, you may not separately contract for imported heat and may be unable to obtain that information from your landlord. In these cases, you can utilize default consumption rates such as natural gas consumption defaults to determine the energy used to generate the heat you consume.<sup>39</sup> Refer to the GRP [Quantification Methods Module](#) for information on calculating emissions from imported heat and cooling.

### **Calculating Indirect Emissions Associated with Renewable Energy Products**

For many small businesses, a large part of your GHG inventory comes from indirect emissions from electricity consumption. One of the most effective ways to reduce your emissions from electricity consumption is to purchase renewable energy. Renewable energy generation results in the creation of Renewable Energy Certificates (RECs), which provide proof of renewable electricity generation from a recognized renewable energy source and represent the rights to the environmental, social and other non-power qualities of that renewable electricity generation.

RECs can be bundled with the renewable electricity or sold separately (unbundled) to customers interested in supporting renewable energy.<sup>40</sup> In both cases, ownership and retirement of RECs are required in order to include the GHG impact of the renewable energy product in your GHG inventory.

---

<sup>39</sup> U.S. Energy Information Administration. *Commercial Building Energy Consumption Survey*. Retrieved from <https://www.eia.gov/consumption/commercial/data/2012/c&e/cfm/c24.php>  
Natural Resources Canada. *Commercial and Institutional Building Energy Use Survey*. Retrieved from [http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/data\\_e/Cibeus/tables/cibeus\\_12\\_1\\_1.cfm?attr=0](http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/data_e/Cibeus/tables/cibeus_12_1_1.cfm?attr=0)

<sup>40</sup> Once the RECs are unbundled the underlying energy is considered null (non-renewable) power and no green claims can be made for use or ownership of this null electricity.

## CALCULATING SCOPE 3 - OTHER INDIRECT EMISSIONS

Scope 3 emissions include all indirect emissions other than those from the generation of purchased electricity, heat, or cooling. This Guidance includes calculation methodology information on business travel, employee commuting emissions, and shipping emissions which are common sources of Scope 3 emissions for small businesses.

### Overview of steps for each category:

1. Identify the total distance traveled for each transportation type in each category
2. Multiply the distance travelled for each transportation type by the appropriate emission factor in Tables 2-5 to calculate emissions from CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O.<sup>41</sup>
3. Convert to CO<sub>2</sub>e and sum CH<sub>4</sub>, N<sub>2</sub>O, and CO<sub>2</sub> to calculate total emissions for each category of Scope 3 emissions.

## SCOPE 3 - BUSINESS TRAVEL

Employees traveling on company business generally use their own vehicles or shared transportation outside of the business's organizational boundary. For this reason, emissions associated with business travel are reported in Scope 3. This section provides emission factors to estimate emissions from automobile, bus, rail, and airline business travel.

### Collect activity data:

For automobile, bus and rail travel, the best way to estimate emissions from business travel is to follow the procedure described in the [Calculating Emissions from Mobile Combustion](#) section. This method is based on fuel usage, vehicle mileage, and vehicle control technology.

If you are unable to obtain this data, use the steps listed above and the default emission factors for automobile, bus and rail business travel based on vehicle miles traveled in the Scope 3 Tables for Business Travel below to estimate emissions. If more than one passenger travels in the car, divide the total emissions for that trip by the number of passengers to calculate the emissions per passenger.

For airline travel, follow the steps listed above and the use emission factors in the table below to estimate emissions from airline business travel for each type of business flight. The emission factors are based on the length of the flight, and are categorized by long, medium, and short haul flights. If you are not able to determine the length of the flight, use the emission factor for "Distance Not Known." Miles travelled are often listed on flight itineraries, or you can look it up using free online air miles calculators based on the departure and arrival airports.<sup>42</sup> Make sure to calculate emissions separately for multi-leg journeys that include stop overs.

<sup>41</sup> Tables of Scope 3 default emission factors taken from: U.S. EPA. *Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance: Optional Emissions from Commuting, Business Travel and Product Transport*. Retrieved from [http://www.epa.gov/climateleadership/documents/resources/commute\\_travel\\_product.pdf](http://www.epa.gov/climateleadership/documents/resources/commute_travel_product.pdf). (Distance Unknown for air travel is taken from the May 2008 publication of this document, and has not been updated by the EPA along with other emission factors in 2017.)

<sup>42</sup> Online calculators include [www.airmilescalculator.com](http://www.airmilescalculator.com) and [WebFlyer.com](http://WebFlyer.com)

## Difference between Vehicle-Mile and Passenger-Mile

The emission factors listed in the tables below are expressed in either vehicle-miles or passenger-miles. An emission factor for vehicle miles is used to calculate emissions if there is only one occupant in the vehicle. A passenger-miles emission factor is used to calculate emissions if there is more than one occupant in the vehicle (and therefore fewer per-person emissions). Business travel and employee commuting often takes place in shared transportation, such as on a bus, train or plane. In these cases, your business's Scope 3 GHG emissions should only reflect the portion of the vehicle's emissions associated with the employee(s) using it.<sup>1</sup>

<sup>1</sup>Putt del Pino, Samantha and Bhatia, Pankaj. World Resources Institute. (December 2002). *Working 9 to 5 on Climate Change: An Office Guide*. Step 6: Reduce Your CO<sub>2</sub> Emissions (Page 45). Retrieved from <http://www.wri.org/publication/working-9-5-climate-change>.

### Find the emission factors:

The emission factors for all forms of business travel are listed in the tables below by vehicle type.

### Scope 3 Emission Factors for Business Travel

**Table 2: Emission Factors for Automobile Business Travel (vehicle-mile)**

Vehicle Type	CO <sub>2</sub> Emission Factor (kg CO <sub>2</sub> /vehicle-mile)	CH <sub>4</sub> Emission Factor (g CH <sub>4</sub> /vehicle-mile)	N <sub>2</sub> O Emission Factor (g N <sub>2</sub> O/vehicle mile)
Car	0.343	0.019	0.011
Light-duty truck	0.472	0.019	0.018
Motorcycle	0.189	0.070	0.007

**Table 3: Emission Factors for Bus Business Travel (passenger-mile)**

CO <sub>2</sub> Emission Factor (kg CO <sub>2</sub> /passenger-mile)	CH <sub>4</sub> Emission Factor (g CH <sub>4</sub> /passenger-mile)	N <sub>2</sub> O Emission Factor (g N <sub>2</sub> O/passenger-mile)
0.056	0.0013	0.0009

**Table 4: Emission Factors for Rail Business Travel (passenger-mile)**

Rail System Type	CO <sub>2</sub> Emission Factor (kg CO <sub>2</sub> /passenger-mile)	CH <sub>4</sub> Emission Factor (g CH <sub>4</sub> /passenger-mile)	N <sub>2</sub> O Emission Factor (g N <sub>2</sub> O/passenger-mile)
Intercity Rail (e.g. Amtrak)	0.140	0.0087	0.0031
Commuter Rail	0.161	0.0081	0.0032
Transit Rail (e.g. Subway or Tram)	0.119	0.0025	0.0017

**Table 5: Emission Factors for Airline Business Travel (passenger-mile)**

Airline Travel Distance	CO <sub>2</sub> Emission Factor (kg CO <sub>2</sub> /passenger-mile)	CH <sub>4</sub> Emission Factor (g CH <sub>4</sub> /passenger-mile)	N <sub>2</sub> O Emission Factor (g N <sub>2</sub> O/passenger-mile)
Long Haul (≥ 2300 miles)	0.166	0.0006	0.0053
Medium Haul (≥ 300 miles and < 2300 miles)	0.136	0.0006	0.0043
Short Haul (< 300 miles)	0.225	0.0039	0.0072

Distance Not Known	0.271	0.0104	0.0085
--------------------	-------	--------	--------

## SCOPE 3 - EMPLOYEE COMMUTING

Similar to business travel, GHGs emitted by employees when commuting to and from work, either in their own vehicles or on public transportation, are indirectly caused by the business to which they are commuting. Many businesses, large and small, account for employee commuting in their GHG inventories due to the relative ease of accessing the information necessary to estimate the emissions.

### Collect activity data and find the emission factors:

To calculate emissions from employee commuting, follow the steps and use the emission factors in the previous section on estimating emissions from employee business travel using ground transportation. Types of employee commuting include automobiles, buses, transit rail (e.g., subway, tram), commuter rail, and intercity rail (e.g., Amtrak). To gather this data, try distributing a survey to employees requesting the following information: type of transportation used to commute, the number of days per week each type of transportation is used, the roundtrip distance travelled daily using each type of transportation, and the number of weeks worked per year. You can then estimate the total annual distance travelled per employee (for each transportation type used) by multiplying the number of days commuted each week times the number of weeks worked per year times the roundtrip distance travelled.

### Tips for Collecting Employee Travel Data

It is often challenging for small businesses to collect detailed information on mileage and vehicle technology data used to calculate emissions. The simplified methods above rely mostly on gathering information about miles travelled in each transportation type. Some of this information can be gathered from travel reimbursement requests from employees, or accounting of business travel expenses. Try using a travel reimbursement form that includes lines to record mileage and transportation type, as well as the number of people and employees travelling in automobiles. For rental vehicles, you can also check receipts to determine miles travelled in the rental vehicle.

## SCOPE 3 - SHIPPING EMISSIONS

Businesses that produce products or purchase goods indirectly contribute to the GHG emissions associated with transporting those goods. Where the production of goods is core to a business's operations, this source of Scope 3 emissions is often included in the GHG inventory. This section includes emission factors to estimate emissions from transporting purchased or sold goods using on-road vehicles, rail, ships, and aircraft. Shipment of goods is divided into two categories: upstream and downstream.

- Upstream emissions come from shipment of goods you purchased.
- Downstream emissions come from shipment of goods you sold.

Calculate and report upstream and downstream shipping emissions separately using the emission factors in the tables below. If the transportation of purchased or sold goods occurred in company-owned vehicles, the emissions should be reported in Scope 1.

### Collect activity data:

You will need to collect data on the mass of the products bought or sold, actual distances travelled, or online maps to calculate distance traveled. You can find this data in your purchase orders or from your shipping provider or carrier.

### Find the emission factors:

If you have access to information on vehicle miles traveled, but do not have data on the mass of the transported goods, use Table 6 to estimate emissions from on-road shipping. Use Table 7 if you have data on the mass of transported goods. Multiply the mass (in tons) by the miles traveled by the emission factors provided, and convert to CO<sub>2</sub>e to calculate the emissions from on-road shipping.<sup>43</sup>

To estimate emissions from rail, ship, and aircraft product transport, multiply the mass of the transported goods in tons by the miles traveled by the appropriate emission factors from Table 8, and convert to CO<sub>2</sub>e.

## Scope 3 Emission Factors for Product Transport

**Table 6: Emission Factors for On-Road Vehicle Product Transport (vehicle-mile)**

Vehicle Type	CO <sub>2</sub> Emission Factor (kg CO <sub>2</sub> /vehicle-mile)	CH <sub>4</sub> Emission Factor (g CH <sub>4</sub> /vehicle-mile)	N <sub>2</sub> O Emission Factor (g N <sub>2</sub> O/vehicle-mile)
Passenger Car	0.343	0.019	0.011
Light-duty truck	0.472	0.019	0.018
Medium- and Heavy-Duty truck	1.467	0.014	0.010

**Table 7: Emission Factors for On-Road Vehicle Product Transport (ton-mile)<sup>44</sup>**

CO <sub>2</sub> Emission Factor (kg CO <sub>2</sub> /ton-mile)	CH <sub>4</sub> Emission Factor (g CH <sub>4</sub> /ton-mile)	N <sub>2</sub> O Emission Factor (g N <sub>2</sub> O/ton-mile)
0.202	0.0020	0.0015

**Table 8: Emission Factors for Rail, Ship, and Aircraft Product Transport (ton-mile)**

Transport Type	CO <sub>2</sub> Emission Factor (kg CO <sub>2</sub> /ton-mile)	CH <sub>4</sub> Emission Factor (g CH <sub>4</sub> /ton-mile)	N <sub>2</sub> O Emission Factor (g N <sub>2</sub> O/ton-mile)
Rail	0.023	0.0018	0.0006
Waterborne Craft	0.059	0.0005	0.0040
Aircraft	1.308	0.0000	0.0402

<sup>43</sup> A ton-mile describes the amount of GHGs necessary to move a ton of product one mile.

<sup>44</sup> Assumed to be medium- to heavy-duty truck by EPA emission factors hub

## NEXT STEPS: TURNING GHG DATA INTO CLIMATE ACTION

### ACCOUNTING FOR OFFSETS

When reducing your business's GHG emissions, you should first work to decrease the GHG emissions under your control. Once your business has done everything it can to reduce GHG emissions in-house, you may consider purchasing offsets to compensate for the emissions you cannot eliminate from your inventory. Offsets represent the reduction, removal, or avoidance of GHG emissions from a specific project that is used to compensate for (i.e., offset) GHG emissions occurring elsewhere, for example, to meet a voluntary GHG target.<sup>45</sup> A carbon offset represents one ton of carbon dioxide equivalent. Some regulatory and voluntary programs generate carbon credits from certified carbon offsets projects, which can then be tracked, traded and retired for compliance or voluntary purposes. The purchase and retirement of offset credits may be disclosed as additional information items. Offsets may be applied to Scope 1, Scope 2, Scope 3 or biogenic emissions in a net inventory, separately from the primary inventory totals. If offsets are applied to Scope 2 emissions, the same offsets must be applied to both the location-based emissions and market-based emissions totals.

For example, if your goal is to have zero emissions from employee commuting, you may implement programs to incentivize biking to work, or offer opportunities to telecommute. To offset your remaining emissions from commuting, you may purchase offsets.

#### Quality Criteria for Offsets

Some offsets are higher quality than others, so it is important to make sure you buy high-quality offsets that represent **real**, **permanent** and **additional** emissions reductions. Additional means that the offsets are not legally required and would not have occurred without the incentive provided by the offset credit. The offsets should also be registered to transparently document **ownership** and should come from projects that have been **verified** by an independent third party. Offsets can be used once and only once and must be retired when you incorporate them in your inventory. When you apply offsets to adjust your inventory, you must report them separately from your inventory totals.<sup>46</sup>

#### Where to Purchase Offsets

There are a variety of third-party retailers that sell offsets to small businesses, including Carbonfund.org's Small Business CarbonFree program,<sup>47</sup> TerraPass,<sup>48</sup> and 3Degrees.<sup>49</sup> When purchasing carbon offsets in the retail market, you can gain assurance about the validity and quality of your purchases by seeking out retail offset product certification. One such certification program is Green-e Climate, which certifies that emission reductions from projects meet the high-quality standards described above.<sup>50</sup> You can look for Green-e Climate certified logos on offsets in the retail market. Before purchasing offsets from a third-party retailer, look on their website or speak with a sales representative to ensure that the offsets you are considering are high quality.

### EXTERNAL REVIEW AND ASSURANCE

<sup>45</sup> For more information on the criteria used to determine whether offsets are high quality, refer to the GRP [Inventory Completion Module](#).

<sup>46</sup> Ibid.

<sup>47</sup> Carbonfund.org website: <http://www.carbonfund.org/offset/businesses>

<sup>48</sup> TerraPass Website: <http://www.terrapass.com/>

<sup>49</sup> 3Degrees website: <http://www.3degreesinc.com/products/carbon-offsets>

<sup>50</sup> Green-e Climate website: [http://www.green-e.org/getcert\\_qhg\\_products.shtml](http://www.green-e.org/getcert_qhg_products.shtml)

It is easy to make mistakes when compiling and calculating GHG emissions data, especially if it is an activity that is done infrequently using basic data management tools. An external review or audit, sometimes called verification, can help ensure that your GHG inventory is free of large errors that might result in decisions that would not have been made if the inventory had been accurate. Verification is an optional step in the reporting process that expresses your business's commitment to the GHG accounting principles of completeness, accuracy and transparency. It also improves your eligibility for various recognition programs such as TCR's Climate Registered™ program. It is important to understand that verification is an iterative process and is not a one-time evaluation of your inventory that results in a "pass" or "fail." If the verifier or reviewer identifies errors, they will allow you to go back to the inventory or calculations and fix them.

Small businesses can choose the extent or rigor of verification based on the goals of measuring their carbon footprint. However, verification is typically an added expense that many small businesses have had trouble justifying. Some types of verification that eliminate or minimize costs include internal review, third-party critical review and verification to a limited level of assurance.

### Internal Review

Internal review occurs when someone within your business who is not directly involved with the development of the inventory reviews the emissions calculations to double-check that no errors have been made. This individual can either be a peer or someone in management. If the individual is in management, they might also be well positioned to evaluate whether everything that should be accounted for has been included.

### Third-Party Critical Review

Third-party critical reviews are conducted by an independent third party who, at a minimum, ensures that the measurement methodologies and data collection processes are consistent with international best practice and are scientifically and technically valid. These are generally coupled with a written statement from the reviewer that confirms the data used to estimate emissions are appropriate and reasonable for public reporting. It is considered to be more accurate than an internal review, because the reviewer has less of a vested interest in confirming that the initial results are accurate.<sup>51</sup>

### Limited Assurance

You can also hire a third-party verifier to review your GHG inventory to a limited level of assurance.<sup>52</sup> Third-party verification is defined as an independent expert assessment of the accuracy and conformity of an emissions inventory based on the reporting and verification requirements contained in the GRP. The verifier will review the activity data and the calculations used to develop your inventory and will issue a statement about the inventory.

Limited assurance statements are usually crafted in a negative fashion; a verifier asserts that there is no evidence that an emission report is not materially correct.<sup>53</sup> Limited assurance statements generally involve less detailed testing of GHG data and less examination of supporting documentation than is conducted when seeking a reasonable level of assurance.

---

<sup>51</sup> For more information on third-party critical review, see GRP [Reporting an Inventory Module](#).

<sup>52</sup> Limited assurance is a level of assurance that can be provided under ISO 14064-3, the international standard for GHG verification and validation. This standard specifies principles and requirements and provides guidance for those conducting or managing the validation and/or verification of greenhouse GHG assertions.

<sup>53</sup> In TCR's voluntary reporting program, materially correct means that the verifier did not find anything to indicate that more than 5% of Scope 1 and 5% of Scope 2 is incorrect. Other programs may have different materiality thresholds.

### Reasonable Assurance

For a reasonable level of assurance, a verification body expresses an opinion on whether the emission report is free from material misstatement, which is based on tests of sampled data and recalculation estimates. Verifying to a reasonable level of assurance will provide more confidence that your inventory is correct, but it is often prohibitively expensive for small businesses. Although a verifier will not necessarily look as closely at your source data or conduct a site visit to see operations first hand as is common in verifications to a reasonable level of assurance, verification to a limited level of assurance will still include a review of activity data and the calculations used to develop your inventory. A limited level of assurance also does not mean that an inventory is ultimately less accurate than one verified to a reasonable level of assurance, as an inventory that could not be verified to a reasonable level of assurance also should be verified to a limited level of assurance.

### Verification Services through GHG Reporting Programs

Some GHG reporting programs have developed streamlined verification opportunities for small businesses.<sup>54</sup> TCR, for example, has a program called Batch Verification that reduces the financial and administrative burden on small businesses. TCR also provides businesses with step-by-step instructions for collecting and providing the necessary information to the Batch Verification Body so the process goes smoothly.

## TRACKING EMISSIONS OVER TIME & SETTING A GOAL

Now that you have calculated your GHG inventory, you can use this information to track your emissions over time. Tracking GHG emissions over time will allow you to establish and measure progress towards GHG reduction goals and manage risks and opportunities for your business. The first step to tracking corporate-level GHG emissions over time is to set a base year.

### Setting a Base Year

A base year consists of the total emissions from a previous year in which the organizational boundary is the same as that of your current inventory. The base year will serve as a benchmark against which your business's emissions are compared over time. It is important to choose a base year for which complete and reliable information is available. Many businesses choose the first year for which they have compiled a complete GHG inventory.

Base year emissions may need to be adjusted to reflect organizational changes such as mergers, acquisitions, or divestments. For each year you report, you must ensure that the organizational boundary of the base year does not differ significantly from the boundary of your current emission report. In TCR's program, "significant" is defined as a cumulative change of *five percent or larger* in your business's total base year emissions on a CO<sub>2</sub>e basis. Base year emissions may also need to be adjusted if there are significant changes in GHG emissions accounting methodologies or if significant errors are identified. If your base year inventory differs significantly from the current year's report, you must either adjust or update the base year. For more information about setting a base year, see TCR's [Tracking Emissions Over Time Guidance](#).

### Developing a GHG Reduction Goal

Once you have selected a base year, you can set a goal to reduce your GHG emissions by a certain amount compared to the base year emissions. Setting a strong and meaningful goal is an excellent way to communicate your business's climate commitment to the public and is also a way to motivate staff and management to innovate and implement emission reduction

---

<sup>54</sup> Defined as office-based organizations with less than 1000 metric tons of CO<sub>2</sub>e.

opportunities. The list below includes some recommendations for setting a strong GHG reduction goal:<sup>55</sup>

- The reduction goal should be set in absolute terms. Absolute GHG reduction goals compare total GHG emissions in the goal year to those in the base year. An absolute goal might be framed as, “Climate Company will reduce its Scope 1, Scope 2, business travel and commuting emissions 25% by 2025 from 2014 levels.” Another type of goal is a GHG intensity reduction goal, which allows you to account for increases or decreases in production over time. Absolute reduction goals are more meaningful because they guarantee a specific amount of GHG reductions. Intensity-based goals may not necessarily result in GHG reductions if business operations expand.
- The chosen base year should be recent (generally no more than 3 years in the past).
- The goal should be forward-looking, achievable within 10 to 12 years.
- The goal should incorporate all of your business’s operations.
- The goal should be aggressive and go beyond “business as usual”, considering the projected GHG performance of your sector.<sup>56</sup> The goal should also be significant beyond mandatory requirements.
- The goal should be announced to the public early. Engage your customers by announcing your GHG reduction goal through your newsletter or press release. It should also be incorporated in your annual report.

### Tips for Reducing Emissions

There are many ways to reduce GHG emissions, and opportunities to reduce emissions will be specific to your particular business. Developing your GHG inventory will help you identify areas that are GHG-intensive and areas where GHG reductions are possible. Some common strategies for reducing emissions in office-based organizations are provided by the U.S. EPA,<sup>57</sup> CoolCalifornia.org<sup>58</sup> and the World Resources Institute.<sup>59</sup>

## CONCLUSION

Measuring your GHG emissions and building a GHG inventory is the essential first step in reducing your business’s impact on the climate. By building your emissions inventory you will gain insight into which parts of your business’s operations are producing GHG emissions so that you can generate ideas for how to reduce them. Document the challenges and solutions you found while gathering activity data and calculating emissions for your first inventory to make the process easier and more streamlined the next year. Knowing exactly what information you need will help make sure you have systems in place to gather reliable data to incorporate into your inventory in the future. If you ever need more information about a certain methodology or concept, you can refer to the resources notes throughout this document, or to the GRP. Thank you for demonstrating your commitment to reducing your business’s GHG emissions!

<sup>55</sup> EPA Climate Leaders. (August 2008). *Guide to Greenhouse Gas Management for Small Business & Low Emitters*. Retrieved from [http://www.epa.gov/climateleadership/documents/resources/lowemitter\\_guidance.pdf](http://www.epa.gov/climateleadership/documents/resources/lowemitter_guidance.pdf).

<sup>56</sup> The [EPA Corporate GHG Goal Evaluation Model](#) is a publicly available benchmarking resource to help evaluate and establish new or existing GHG goals that go beyond “business as usual” for individual sectors.

<sup>57</sup> U.S. EPA. *What You Can Do: At the Office*. Retrieved from [https://19january2017snapshot.epa.gov/climatechange/what-you-can-do-office\\_.html](https://19january2017snapshot.epa.gov/climatechange/what-you-can-do-office_.html).

<sup>58</sup> CoolCalifornia.org. *Small Biz Actions*. Retrieved from <https://coolcalifornia.arb.ca.gov/small-business>.

<sup>59</sup> Putt del Pino, Samantha and Bhatia, Pankaj. World Resources Institute. (December 2002). *Working 9 to 5 on Climate Change: An Office Guide*. Step 6: Reduce Your CO<sub>2</sub> Emissions (Page 45). Retrieved from <http://www.wri.org/publication/working-9-5-climate-change>.

## APPENDIX A: COMMON UNITS, ABBREVIATIONS AND CONVERSIONS

**Table A1: Common Units and Abbreviations**

Type	Unit
Mass	pound (lb) gram (g) kilogram (kg) short ton (ton) metric ton (tonne)
Volume	cubic foot (ft <sup>3</sup> ) gallon (gal) barrel (bbl) liter (l) cubic meter (m <sup>3</sup> )
Energy	kilowatt hour (kWh) megajoule (MJ) joule (J) kilojoule (KJ) gigajoule (GJ) Btu (Btu) million Btu (million Btu) therm (therm)
Other	Kilo Mega Giga Tera land mile nautical mile
Source: Putt del Pino, Samantha and Bhatia, Pankaj. World Resources Institute. (December 2002). <i>Working 9 to 5 on Climate Change: An Office Guide</i> . Retrieved from <a href="http://www.wri.org/publication/working-9-5-climate-change">http://www.wri.org/publication/working-9-5-climate-change</a> .	

**Table A2: Unit Conversion Factors**

Type	Unit	Equals	Equals	Equals
Mass	1 pound	453.6 grams	0.4536 kilograms	0.0004536 metric tons
	1 kilogram	2.205 pounds		
	1 short ton	2,000 pounds	907.2 kilograms	
	1 metric ton	2,205 pounds	1,000 kilograms	1.102 short tons
Volume	1 cubic foot	7.4805 gallons	0.1781 barrel	
	1 cubic foot	28.32 liters	0.02832 cubic meters	0.003785 cubic meters
	1 gallon	0.0238 barrel	3.785 liters	0.1589 cubic meters
	1 barrel	42 gallons	158.99 liters	
	1 liter	0.001 cubic meters	0.2642 gallons	
	1 cubic meter	6.2897 barrels	264.2 gallons	1,000 liters
Energy	1 kilowatt hour	3,412 Btu	3,600 kilojoules	
	1 megajoule	0.001 gigajoules		
	1 gigajoule	0.9478 million Btu	277.8 kilowatt hours	
	1 Btu	1,055 joules		
	1 million Btu	1.055 gigajoules	293 kilowatt hours	
1 therm	100,000 Btu	0.1055 gigajoules	29.3 kilowatt hours	
Other	Kilo	1,000		
	Mega	1,000,000		
	Giga	1,000,000,000		
	Tera	1,000,000,000,000		
	1 land mile	1.609 land kilometers		
	1 nautical mile	1.15 land miles		
	1 metric ton carbon	3.664 metric tons CO <sub>2</sub>		

Source: Putt del Pino, Samantha and Bhatia, Pankaj. World Resources Institute. (December 2002). *Working 9 to 5 on Climate Change: An Office Guide*. Retrieved from <http://www.wri.org/publication/working-9-5-climate-change>.

## APPENDIX B: GLOBAL WARMING POTENTIALS

**Table B1: Global Warming Potential Factors for Required GHGs**

Common Name	Formula	SAR	TAR	AR4	AR5
Carbon dioxide	CO <sub>2</sub>	1	1	1	1
Methane	CH <sub>4</sub>	21	23	25	28
Nitrous oxide	N <sub>2</sub> O	310	296	298	265
Nitrogen trifluoride	NF <sub>3</sub>	NA	10,800	17,200	16,100
Sulfur hexafluoride	SF <sub>6</sub>	23,900	22,200	22,800	23,500
<b>Hydrofluorocarbons (HFCs)</b>					
HFC-23 (R-23)	CHF <sub>3</sub>	11,700	12,000	14,800	12,400
HFC-32 (R-32)	CH <sub>2</sub> F <sub>2</sub>	650	550	675	677
HFC-41 (R-41)	CH <sub>3</sub> F	150	97	92	116
HFC-43-10mee (R-4310)	C <sub>5</sub> H <sub>2</sub> F <sub>10</sub>	1,300	1,500	1,640	1,650
HFC-125 (R-125)	C <sub>2</sub> HF <sub>5</sub>	2,800	3,400	3,500	3,170
HFC-134 (R-134)	C <sub>2</sub> H <sub>2</sub> F <sub>4</sub>	1,000	1,100	1,100	1,120
HFC-134a (R-134a)	C <sub>2</sub> H <sub>2</sub> F <sub>4</sub>	1,300	1,300	1,430	1,300
HFC-143 (R-143)	C <sub>2</sub> H <sub>3</sub> F <sub>3</sub>	300	330	353	328
HFC-143a (R-143a)	C <sub>2</sub> H <sub>3</sub> F <sub>3</sub>	3,800	4,300	4,470	4,800
HFC-152 (R-152)	C <sub>2</sub> H <sub>4</sub> F <sub>2</sub>	NA	43	53	16
HFC-152a (R-152a)	C <sub>2</sub> H <sub>4</sub> F <sub>2</sub>	140	120	124	138
HFC-161 (R-161)	C <sub>2</sub> H <sub>5</sub> F	NA	12	12	4
HFC-227ea (R-227ea)	C <sub>3</sub> HF <sub>7</sub>	2,900	3,500	3,220	3,250
HFC-236cb (R-236cb)	C <sub>3</sub> H <sub>2</sub> F <sub>6</sub>	NA	1,300	1,340	1,210
HFC-236ea (R-236ea)	C <sub>3</sub> H <sub>2</sub> F <sub>6</sub>	NA	1,200	1,370	1,330
HFC-236fa (R-236fa)	C <sub>3</sub> H <sub>2</sub> F <sub>6</sub>	6,300	9,400	9,810	8,060
HFC-245ca (R-245ca)	C <sub>3</sub> H <sub>3</sub> F <sub>5</sub>	560	640	693	716
HFC-245fa (R-245fa)	C <sub>3</sub> H <sub>3</sub> F <sub>5</sub>	NA	950	1,030	858
HFC-365mfc	C <sub>4</sub> H <sub>5</sub> F <sub>5</sub>	NA	890	794	804
<b>Perfluorocarbons (PFCs)</b>					
PFC-14 (Perfluoromethane)	CF <sub>4</sub>	6,500	5,700	7,390	6,630
PFC-116 (Perfluoroethane)	C <sub>2</sub> F <sub>6</sub>	9,200	11,900	12,200	11,100
PFC-218 (Perfluoropropane)	C <sub>3</sub> F <sub>8</sub>	7,000	8,600	8,830	8,900
PFC-3-1-10 (Perfluorobutane)	C <sub>4</sub> F <sub>10</sub>	7,000	8,600	8,860	9,200
PFC-318 (Perfluorocyclobutane)	c-C <sub>4</sub> F <sub>8</sub>	8,700	10,000	10,300	9,540
PFC-4-1-12 (Perfluoropentane)	C <sub>5</sub> F <sub>12</sub>	NA	8,900	9,160	8,550
PFC-5-1-14 (Perfluorohexane)	C <sub>6</sub> F <sub>14</sub>	7,400	9,000	9,300	7,910
PFC-9-1-18 (Perfluorodecalin)	C <sub>10</sub> F <sub>18</sub>	NA	NA	>7,500	7,190
Source: IPCC Second Assessment Report (SAR) published in 1995, Third Assessment Report (TAR), published in 2001, Fourth Assessment Report (AR4) published in 2007 and Fifth Assessment Report					

<p>(AR5) published in 2014. All defaults 100-year GWP values. Where the source provides a range, you should use the upper limit. NA = data not available. <b>Please note:</b> you should include emissions of all Kyoto-defined GHGs (including all HFCs and PFCs) in your inventory. If HFCs or PFCs are emitted that are not listed above, you should use industry best practice to calculate CO<sub>2</sub>e from those gases.</p>	
---	--

## APPENDIX C: REFRIGERANT BLENDS DEFAULT EMISSION FACTORS AND GWPs

**Table C1: Default Emission Factors for Refrigeration/Air Conditioning Equipment**

Type of Equipment	Refrigerant Capacity (kg)	Installation Emission Factor k (% of capacity)	Operating Emission Factor w (% of capacity/year)	Refrigerant Remaining at Disposal y (% of capacity)	Recovery Efficiency z (% of remaining)
Domestic Refrigeration	0.05 - 0.5	1%	0.50%	80%	70%
Stand-alone Commercial Applications	0.2 - 6	3%	15%	80%	70%
Medium & 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: IPCC, *Guidelines for National Greenhouse Gas Inventories* (2006), Volume 3: Industrial Processes and Product Use, Table 7.9.

Note: Emission factors above are the most conservative of the range provided by the IPCC. The ranges in capacity are provided for reference. You should use the actual capacity of your equipment. If you do not know your actual capacity, you should use the high end of the range provided (e.g., use 2,000 kg for chillers).

**Table C2: Default Global Warming Potential Factors for Refrigerant Blends**

Refrigerant Blend	Gas	SAR	TAR	AR4	AR5
R-401A	HFC	18.2	15.6	16.12	17.94
R-401B	HFC	15	13	14	15
R-401C	HFC	21	18	18.6	20.7
R-402A	HFC	1680	2040	2100	1902
R-402B	HFC	1064	1292	1330	1205
R-403A	PFC	1400	1720	1766	1780
R-403B	PFC	2730	3354	3444	3471
R-404A	HFC	3260	3784	3922	3943
R-407A	HFC	1770	1990	2107	1923
R-407B	HFC	2285	2695	2804	2547
R-407C	HFC	1526	1653	1774	1624
R-407D	HFC	1428	1503	1627	1487
R-407E	HFC	1363	1428	1552	1425
R-407F	HFC	1555	1705	1825	1674
R-407G	HFC	1387	1334	1463	1331
R-408A	HFC	1944	2216	2301	2430
R-410A	HFC	1725	1975	2088	1924
R-410B	HFC	1833	2118	2229	2048
R-411A	HFC	15	13	14	15
R-411B	HFC	4.2	3.6	3.72	4.14

R-412A	PFC	350	430	442	445
R-415A	HFC	25.2	21.6	22.32	24.84
R-415B	HFC	105	90	93	104
R-416A	HFC	767	767	843.7	767
R-417A	HFC	1955	2234	2346	2127
R-417B	HFC	2450	2924	3027	2742
R-417C	HFC	1570	1687	1809	1643
R-418A	HFC	3.5	3	3.1	3.45
R-419A	HFC	2403	2865	2967	2688
R-419B	HFC	1982	2273	2384	2161
R-420A	HFC	1144	1144	1258	1144
R-421A	HFC	2170	2518	2631	2385
R-421B	HFC	2575	3085	3190	2890
R-422A	HFC	2532	3043	3143	2847
R-422B	HFC	2086	2416	2526	2290
R-422C	HFC	2491	2983	3085	2794
R-422D	HFC	2232	2623	2729	2473
R-422E	HFC	2135	2483	2592	2350
R-423A	HFC	2060	2345	2280	2274
R-424A	HFC	2025	2328	2440	2212
R-425A	HFC	1372	1425	1505	1431

R-426A	HFC	1352	1382	1508	1371
R-427A	HFC	1828	2013	2138	2024
R-428A	HFC	2930	3495	3607	3417
R-429A	HFC	14	12	12	14
R-430A	HFC	106.4	91.2	94.24	104.88
R-431A	HFC	41	35	36	40
R-434A	HFC	2662	3131	3245	3075
R-435A	HFC	28	24	25	28
R-437A	HFC	1567	1684	1805	1639
R-438A	HFC	1890	2151	2264	2059
R-439A	HFC	1641	1873	1983	1828
R-440A	HFC	158	139	144	156
R-442A	HFC	1609	1793	1888	1754
R-444A	HFC	85	72	87	88
R-444B	HFC	284	240	293	295
R-445A	HFC	117	117	128.7	117
R-446A	HFC	442	374	459	460
R-447A	HFC	540	493	582	571
R-447B	HFC	666	646	739	714
R-448A	HFC	1170	1300	1386	1273
R-449A	HFC	1184	1308	1396	1282

R-449B	HFC	1199	1320	1411	1296
R-449C	HFC	1067	1167	1250	1146
R-450A	HFC	546	546	600.6	546
R-451A	HFC	132.6	132.6	145.86	132.6
R-451B	HFC	145.6	145.6	160.16	145.6
R-452A	HFC	1724	2067	2139	1945
R-452B	HFC	632	607	697	675
R-452C	HFC	1789	2143	2219	2018
R-453A	HFC	1534	1664	1765	1636
R-454A	HFC	228	193	236	237
R-454B	HFC	448	379	465	466
R-454C	HFC	140	118	145	146
R-456A	HFC	624	618	684	626
R-457A	HFC	131	113	136	138
R-458A	HFC	1457	1576	1650	1564
R-500	HFC	37	31	32	36
R-503	HFC	4692	4812	5935	4972
R-504	HFC	313	265	325	326
R-507 or R-507A	HFC	3300	3850	3985	3985
R-509 or R-509A	PFC	3920	4816	4945	4984
R-512A	HFC	198	179	189.3	196.1

R-513A	HFC	572	572	629.2	572
R-513B	HFC	540	539.5	593	539.5
R-515A	HFC	348	420	386	402

Source: Refrigerant blend GWPs are calculated using a weighted average from the blend composition and the IPCC GWP values. The blend compositions are from ASHRAE Standard 34-2016. The GWP values are 100- year values from the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR) published in 1995, Third Assessment Report (TAR) published in 2001, Fourth Assessment Report (AR4) published in 2007, and Fifth Assessment Report (AR5) published in 2013.

R-410A	HFC	1725	1975	2088	1924
R-410B	HFC	1833	2118	2229	2048
R-411A	HFC	15	13	14	15
R-411B	HFC	4.2	3.6	3.72	4.14
R-412A	PFC	350	430	442	445
R-415A	HFC	25.2	21.6	22.32	24.84
R-415B	HFC	105	90	93	104
R-416A	HFC	767	767	843.7	767
R-417A	HFC	1955	2234	2346	2127
R-417B	HFC	2450	2924	3027	2742
R-417C	HFC	1570	1687	1809	1643
R-418A	HFC	3.5	3	3.1	3.45
R-419A	HFC	2403	2865	2967	2688
R-419B	HFC	1982	2273	2384	2161
R-420A	HFC	1144	1144	1258	1144
R-421A	HFC	2170	2518	2631	2385
R-421B	HFC	2575	3085	3190	2890
R-422A	HFC	2532	3043	3143	2847
R-422B	HFC	2086	2416	2526	2290
R-422C	HFC	2491	2983	3085	2794
R-422D	HFC	2232	2623	2729	2473

R-422E	HFC	2135	2483	2592	2350
R-423A	HFC	2060	2345	2280	2274
R-424A	HFC	2025	2328	2440	2212
R-425A	HFC	1372	1425	1505	1431
R-426A	HFC	1352	1382	1508	1371
R-427A	HFC	1828	2013	2138	2024
R-428A	HFC	2930	3495	3607	3417
R-429A	HFC	14	12	12	14
R-430A	HFC	106.4	91.2	94.24	104.88
R-431A	HFC	41	35	36	40
R-434A	HFC	2662	3131	3245	3075
R-435A	HFC	28	24	25	28
R-437A	HFC	1567	1684	1805	1639
R-438A	HFC	1890	2151	2264	2059
R-439A	HFC	1641	1873	1983	1828
R-440A	HFC	158	139	144	156
R-442A	HFC	1609	1793	1888	1754
R-444A	HFC	85	72	87	88
R-444B	HFC	284	240	293	295
R-445A	HFC	117	117	128.7	117
R-446A	HFC	442	374	459	460
R-447A	HFC	540	493	582	571

R-447B	HFC	666	646	739	714
R-448A	HFC	1170	1300	1386	1273
R-449A	HFC	1184	1308	1396	1282
R-449B	HFC	1199	1320	1411	1296
R-449C	HFC	1067	1167	1250	1146
R-450A	HFC	546	546	600.6	546
R-451A	HFC	132.6	132.6	145.86	132.6
R-451B	HFC	145.6	145.6	160.16	145.6
R-452A	HFC	1724	2067	2139	1945
R-452B	HFC	632	607	697	675
R-452C	HFC	1789	2143	2219	2018
R-453A	HFC	1534	1664	1765	1636
R-454A	HFC	228	193	236	237
R-454B	HFC	448	379	465	466
R-454C	HFC	140	118	145	146
R-456A	HFC	624	618	684	626
R-457A	HFC	131	113	136	138
R-458A	HFC	1457	1576	1650	1564
R-500	HFC	37	31	32	36
R-503	HFC	4692	4812	5935	4972

R-504	HFC	313	265	325	326
R-507 or R-507A	HFC	3300	3850	3985	3985
R-509 or R-509A	PFC	3920	4816	4945	4984
R-512A	HFC	198	179	189.3	196.1
R-513A	HFC	572	572	629.2	572
R-513B	HFC	540	539.5	593	539.5
R-515A	HFC	348	420	386	402

Source: Refrigerant blend GWPs are calculated using a weighted average from the blend composition and the IPCC GWP values. The blend compositions are from ASHRAE Standard 34-2016. The GWP values are 100-year values from the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR) published in 1995, Third Assessment Report (TAR) published in 2001, Fourth Assessment Report (AR4) published in 2007, and Fifth Assessment Report (AR5) published in 2013.

**Table C2: Refrigerant Blends (Contain HFCs and PFCs)**

Blend	Constituents	Composition (%)
R-405A	HCFC-22/HFC-152a/HCFC-142b/PFC-318	(45.0/7.0/5.5/42.5)
R-413A	PFC-218/HFC-134a/HC-600a	(9.0/88.0/3.0)
R-508A	HFC-23/PFC-116	(39.0/61.0)
R-508B	HFC-23/PFC-116	(46.0/54.0)

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3, Table 7.8, page 7.44.