Identifying and calculating GHG emissions

Once the organizational and operational boundaries have been established, companies generally calculate GHG emissions via the following steps:

- identify GHG emissions sources
- select an emissions calculation approach
- collect activity data and choose emissions factors
- apply calculation tools to estimate GHG emissions
- roll-up GHG data to corporate level

These steps are described in the following sections. A short description of the calculation tools developed by the *GHG Protocol* is also provided. The calculation tools are available on the *GHG Protocol* website at www.ghgprotocol.org

Identify GHG emissions sources

To facilitate the selection of applicable calculation tools, emissions of GHGs are categorized here in terms of key sources. Appendix 2 relates emissions sources with the activities identified in Chapter 4: Setting operational boundaries.

Emissions of GHGs typically occur from the following source categories:

- **stationary combustion**: combustion of fuels in stationary equipment such as boilers, furnaces, burners, turbines, heaters, incinerators, engines and flares
- **mobile combustion**: combustion of fuels in transportation devices such as automobiles, trucks, trains, aeroplanes, and ships
- **process emissions:** emissions from physical or chemical processes, e.g. CO_2 from the calcination step in cement manufacturing, CO_2 from catalytic cracking in a petrochemical processing, PFC emissions from aluminum smelting, etc.
- **fugitive emissions:** intentional and unintentional releases such as equipment leaks from joints, seals, packing and gaskets, etc. This may also include fugitive emissions from coal piles, wastewater treatment, pits, cooling towers, fugitive CH_4 emissions from gas processing facilities

Every business has some processes, products or services that generate direct and/or indirect emissions from one or more of the above source categories. Appendix 2 provides an overview of direct and indirect GHG emissions sources organized by scopes and industry sectors. It may be used as an initial guide to identify your major GHG sources.

Identifying scope 1 emissions

As a first step in identifying GHG sources, a company should undertake an exercise to track down its direct emissions sources in each of the four broad categories described above – stationary combustion, mobile combustion, process, and fugitive. The power industry has direct emissions from all the main source categories, except process emission sources. Process emissions are specific to certain industry sectors like oil and gas, aluminum, cement, etc. Manufacturing companies that generate process emissions and also own or control a power production facility, will have direct emissions from all the main source categories. Office based organizations may not have any direct GHG emissions except in cases where they own or operate a combustion device or refrigeration and air-conditioning equipment. Often companies are surprised to realize that a significant amount of emissions come from sources which are not initially obvious (see UTC box).

Identifying scope 2 emissions

The next step is to identify indirect emissions sources from the use of purchased electricity, heat, or steam. Almost all businesses generate indirect emissions due to the use of imported electricity for their processes or products/services.

Identifying scope 3 emissions

This step is needed if a company also plans to report its scope 3 emissions. It involves identification of other indirect emissions from the reporting company's upstream and downstream activities. All companies use raw materials or goods that have generated emissions during their mining or processing phases. Indirect emissions due to transportation are also common to all businesses. These include transportation in vehicles owned or controlled by another organization, e.g. transport of raw materials/goods and products, employees commuting to and from work, and business-related travel by employees. Product use is an important category of indirect emissions for companies manufacturing automobiles, appliances, and fuels.

United Technologies Corporation (UTC): More than meets the eye

Back in 1996, the team responsible for setting boundary conditions for UTC's new Natural Resource Conservation, Energy and Water Use Reporting Program, met to decide what sources of energy were going to be included in the program's annual report of energy consumption. The team decided to include jet fuel in the annual report; jet fuel was used by a number of UTC divisions for engine and flight hardware testing and for test firing. Although the amount of jet fuel used in any given year was subject to wide variability due to changing test schedules, the total amount consumed in an average year was not expected to be large. Jet fuel consumption reports, however, proved that UTC's initial belief was wrong. Jet fuel had accounted for between nine and 13 percent of the corporation's total annual use of energy since the program commenced. Had UTC not included the use of jet fuel in annual data collection efforts, a significant energy source would have been overlooked.

A comprehensive identification of indirect emissions sources also includes accounting for GHGs associated with 'outsourcing/contract manufacturing' or franchises, e.g. drilling operations, building construction, facilities management, printing, waste management, retail outlets, etc.

By looking at scope 3 emissions, businesses are encouraged to expand their inventory boundary across their value chain and

to identify all relevant GHG emissions. Figure 2 in Chapter 4: Setting operational boundaries (guidance), provides an overview of activities that generate GHG emissions along a company's value chain.

Identification of emissions sources does not imply that a business will be able to calculate emissions for all indirect emissions sources. In some cases it may be difficult to obtain good quality data from contractors/suppliers. Nevertheless, identification of GHG sources along the value chain provides a broad overview of various linkages and possible opportunities for GHG reductions.

Select an emissions calculation approach

Direct measurement of GHG emissions by monitoring exhaust gas concentration and flow rate is rare. In most instances accurate estimates can be obtained by using appropriate calculation methods employing derived emissions factors. Table 5 in Chapter 8: Managing inventory quality, provides a comparison of various calculation methods. The IPCC guidelines (IPCC, 1996b) refer to several calculation approaches or techniques ranging from the application of derived emissions factors, through to direct monitoring. One important exception to this hierarchy is the calculation of CO_2 emissions from fuel use data. In many instances, even small users know both the amount of fuel consumed, and the carbon content of the fuel. CO_2 emissions can then be calculated with an accuracy of two to three percent. This is far better than the accuracy achieved by direct monitoring of CO_2 emissions.

Apart from some process emissions, which can be calculated based on a mass balance, the most common approach for calculating GHG emissions is through application of emissions factors. Emissions factors are documented information relating GHG emissions to some characteristic of the emissions sources. The emissions are calculated by multiplying the emissions factor by an appropriate activity factor (fuel consumed, quantity of output produced, etc.). Activity factors relating to transportation include: total fuel consumed, vehicle miles traveled, passenger miles traveled, or volume of goods transported. Usually activity data based on fuel use will provide the most accurate estimate of GHG emissions for transportation sources.

Collect activity data and choose emissions factors

For most small to medium-sized companies and for many larger companies, scope 1 emissions will be calculated based on the purchased quantities of commercial fuels (such as natural gas and heating oil) using published emissions factors. Scope 2 emissions will be calculated from metered electricity consumption using published emissions factors. Scope 3 emissions will be calculated from activity factors such as passenger miles and published or third-party emissions factors. In all these cases, if source/facility specific emissions factors are available, it is preferable that they be used. User-friendly calculation tools are available on the *GHG Protocol* website to assist in these calculations.

Companies involved in fuels extraction and processing, chemicals, minerals, waste management, and primary metals will be faced with a wider range of alternative approaches/methodologies. They should seek guidance from the sector specific guidelines on the *GHG Protocol* website (where available) or from their industry associations, e.g. International Aluminium Institute, American Petroleum Institute, WBCSD project: Toward a Sustainable Cement Industry, etc.

Apply calculation tools to estimate GHG emissions

This section provides an overview of the GHG calculation tools available on the *GHG Protocol* website (www.ghgprotocol.org). Use of these tools is encouraged as they have been peer reviewed by experts and industry leaders and are believed to be the best available. The tools, however, are optional. Companies may use their own GHG calculation tools, provided they are consistent with the approaches described.

There are two main categories of calculation tools:

- **cross-sector tools** that can be applied to many different sectors: stationary combustion, mobile combustion, and HFC use in refrigeration and air-conditioning
- **sector-specific tools**, e.g. aluminium, iron and steel, cement, etc.

Most companies will need to apply more than one calculation tool to cover all their GHG sources. For example, to calculate GHG emissions from an aluminium smelter, the company would use the calculation tools for aluminium production, stationary combustion (for any import of electricity, steam and heat, generation of energy on-site), and mobile combustion (for transportation of materials and products, vehicles employed on-site, and employee business travel).

Structure of calculation tools

All cross-sector and sector-specific calculation tools are based on a similar structure and offer step-by-step guidance on measuring and calculating emissions data. Each calculation tool comprises of a guidance section and automated worksheets with explanations on how to use them.

The general structure of the guidance section is as follows:

- **overview:** provides an overview of the purpose and scope of the tool, the calculation method used in the tool, and a process description
- **choosing activity data and emissions factors:** provides good practice guidance and references for default emissions factors
- **calculation methods:** describes different calculation methods depending on the availability of site-specific activity data and emissions factors
- **quality control:** provides good practice guidance
- **internal reporting and documentation:** provides guidance on internal documentation to support emissions calculations

In the automated worksheet section, it is only necessary to insert activity data into the worksheets and to select the appropriate emissions factors. Default emissions factors are provided, but it is also possible to insert customized emissions factors if more accurate emissions factors are available. The emissions of different GHGs are calculated separately and then converted to CO_2 equivalents on the basis of their global warming potential.

Some of the tools take a tiered approach, offering a choice between a simple and a more advanced calculation approach. The more advanced approach results in more accurate emissions data but usually require a higher level of data detail

Table 4: Overview of GHG calculation tools available on the ***GHG Protocol*** website

	Calculation tools	Main features
Cross-sector tools	Stationary combustion	• calculates direct and indirect CO_2 emissions from combustion of fuels in stationary equipment • provides two options for allocating emissions from a co-generation facility • default emission factors provided for different fuels, and country averages for grid electricity
	Mobile combustion	• calculates direct and indirect GHG emissions (CO_2) from mobile sources • mobile sources included are road, air, water, and rail transport • default emission factors provided
	HFC from air conditioning and refrigeration	• calculates direct HFC emissions during manufacture of refrigeration and air-conditioning (RAC) equipment, and use of RAC equipment in commercial applications • two calculation methodologies are provided: a sales-based approach, and an emission factor based approach
Sector-specific tools	Aluminium and other non-ferrous metals production	• calculates direct GHG emissions from aluminium production (CO_2 from anode oxidation and PFC emissions from the 'anode effect') • guideline and calculation approach provided for emissions of SF_6 used in non-ferrous metals production as a cover gas
	Iron and steel	• calculates direct GHG emissions (CO_2) from oxidation of the reducing agent and calcination of the flux used in steel production and from the removal of carbon from the iron ore and scrap steel used
	Nitric acid manufacture	• calculates direct GHG emissions (N_2O) from the production of nitric acid
	Ammonia manufacture	• calculates direct GHG emissions (CO_2) from ammonia production. This is for the removal of carbon from the feedstock stream only; combustion emissions are calculated with the stationary combustion module.
	Adipic acid manufacture	• calculates direct GHG emissions (N_2O) from adipic acid production
	Cement	• calculates direct GHG emissions from cement manufacturing (CO_2 from the calcination process) • two calculation methodologies are provided: cement-based approach and clinker-based approach
	Lime	• calculates direct GHG emissions from lime manufacturing (CO_2 from the calcination process)
	HFC-23 from HCFC-22 production	• calculates direct HFC-23 emissions from production of HCFC-22
	Semiconductors	• calculates direct PFC emissions from production of semiconductor wafers

and a more thorough understanding of the technologies used in the business operations.

Table 4 provides an overview of the calculation tools available at the *GHG Protocol* website, and their main features. In addition, a user-friendly guide for calculating GHG emissions from small office-based organizations is under development.

Roll-up GHG data to corporate level

To report a corporation's total GHG emissions, companies will usually need to gather and summarize data from multiple sites, possibly in different countries and business divisions. It is important to plan this process carefully to minimize the reporting burden, and to reduce the risk of random errors that might occur while compiling data. Ideally, corporations will integrate GHG reporting with their existing reporting tools and processes, and take advantage of any relevant data already collected or reported by sites to division or corporate offices.

The tools and processes chosen for a site to report data will depend upon the information and communication infrastructure already in place (i.e. how easy is it to include new data categories in corporate databases). It will also depend upon the amount of detail that corporate headquarters wish to be reported from sites. Data collection and management tools could include:

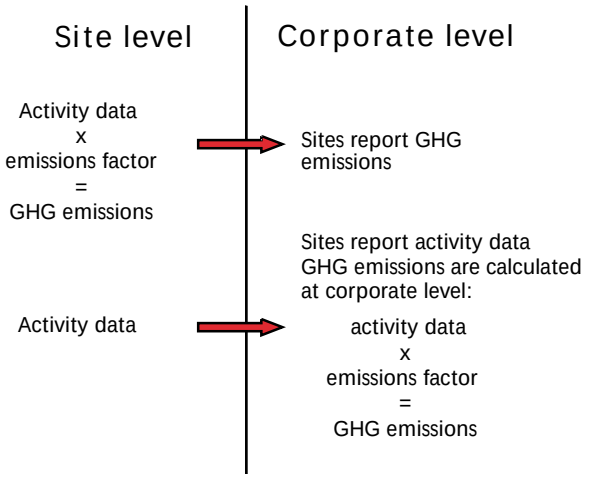
- secure databases available over the company intranet or internet, for direct data entry by sites
- spreadsheet templates filled out and e-mailed to a corporate or division office, where data is processed further
- paper reporting forms faxed to a corporate or division office where data is re-entered in a corporate database. However, this method will increase the likelihood of random errors.

For internal reporting up to the corporate level, it is recommended that standardized reporting formats be used to ensure that data received from different business units and facilities is comparable, and that internal reporting rules are observed (see BP box). Standardized formats can significantly reduce the risk of random errors.

There are two basic approaches for gathering data on GHG emissions from a corporation's sites:

- individual sites directly calculate their GHG emissions and report this data to the corporate level
- individual sites report activity/fuel use data (such as quantity of fuel used) to the corporate level, where GHG emissions are calculated

The difference between these two approaches is where the emissions calculations occur, i.e. where activity data is multiplied by the appropriate emissions factors.



Individual sites collect GHG emissions data

Asking facilities to calculate GHG emissions themselves will help to increase their awareness and understanding of the issue. However, it may also lead to resistance, increased training needs, an increase in calculation errors, and a greater need for auditing of calculations. Requesting that facilities calculate GHG emissions themselves may be the preferred option if:

- emissions calculations require detailed knowledge of the kind of equipment being used at facilities
- emissions calculations are not standardized across a number of facilities
- process emissions (in contrast to emissions from burning fossil fuels) make up an important share of total GHG emissions
- resources are available to train facility staff to conduct these calculations and to audit them
- a user-friendly tool is available to simplify the calculation and reporting task for site-level staff

Individual sites collect activity/fuel use data

This approach may be particularly suitable for office-based organizations. Requesting that facilities report their own activity/fuel use data may be the preferred option if:

- the staff at the corporate or division level can calculate emissions data in a straightforward manner on the basis of activity/fuel use data
- emissions calculations are standardized across a number of facilities

The choice of collection approach depends on the needs and characteristics of the reporting company. Corporations have taken different approaches. BP provides sites with a calculation protocol, requests that they calculate and report their total GHG emissions, and follows up with audits to ensure calculations are correct and documented. United Technologies Corporation requests that its sites report fuel and travel details, leaving the choice of emissions factors and

calculations to corporate staff. The two approaches should produce the same result and they are not mutually exclusive.

To maximize accuracy and minimize reporting burdens, some companies combine both approaches. A small number of large, complex sites with process emissions are asked to calculate their emissions at the site level, and these calculations are carefully reviewed. Larger numbers of small sites with uniform emissions from standard sources are asked only to report fuel use and travel activity. The corporate database or reporting tool then calculates total emissions for each of these standard activities.

Even when facilities calculate their own emissions, corporate staff may still wish to gather activity/fuel use data to double-check calculations and to better understand the opportunities for emissions reductions. Corporate staff should also verify that facility-reported data is based on approved reporting periods, units, and inventory boundaries.

Internal reporting of emissions data to corporate level

Reports from site level to corporate or division offices should include all relevant information as specified in Chapter 9: Reporting GHG emissions, and a number of additional reporting categories. Some reporting categories are common to both facility level data collection approaches. These include:

- a brief description of the emissions sources
- a list and justification of specific exclusion or inclusion of sources
- comparative information from previous years
- the reporting period covered
- any trends seen in data
- progress toward any business targets
- an estimation of accuracy of activity/fuel use data reported
- a description of events and changes that have an impact on reported data (acquisitions, divestitures, closures, technology upgrades, changes of reporting boundaries or calculation methodologies applied, etc.)

Individual sites report GHG emissions data to corporate level

In addition to the aforementioned common categories of reporting data, facilities using this approach should also report the following details:

- description of GHG calculation methodologies, and any changes made to methodologies relative to previous reporting periods
- ratio indicators (see Chapter 9: Reporting GHG emissions)
- details on any data references used for the calculations, in particular information on emissions factors used

Clear records of calculations undertaken to derive emissions data should be kept for any future internal or external verification.

Individual sites report activity/fuel use data to corporate level

In addition to the aforementioned common categories of reporting data, facilities using this approach should also report the following details:

- fuel use data (fuel types used at facility and electricity consumption)
- activity data for freight and passenger transport activities (e.g. freight transport in tonnes x kilometers)
- activity data for process emissions (e.g. tonnes of fertilizer produced, tonnes of waste landfilled)
- clear records of calculations undertaken to derive activity/fuel use data
- any other conversion factors necessary to translate fuel use into CO_2 emissions

BP: A standardized system for internal reporting of GHGs

BP has been collecting GHG data from the different parts of its operations for more than four years and has recently consolidated its internal reporting processes into one central database system. The responsibility for reporting emissions lies with about 320 individual BP facilities and business departments, which are termed ‘reporting units‘. All reporting units have to complete a standard Excel reporting pro-forma every quarter stating actual emissions for the preceding three months, and updates to forecasts for the current year and the next two years. In addition, reporting units are asked to account for all significant variances, including sustainable reductions. The reporting units all use the same BP reporting guidelines (BP, 2000) for quantifying their emissions of carbon dioxide and methane.

All pro-forma spreadsheets are e-mailed automatically by the central database to the reporting units, and the completed e-mail returns are uploaded into the database by a corporate team, who check the quality of the incoming data. The data is then compiled, by the end of the month following each quarter end, to provide the total emissions inventory and forecasts for analysis against BP’s GHG targets. Finally the inventory is reviewed by a team of independent external auditors to provide assurance on the quality and accuracy of the data.