

CALCULATION OF GREENHOUSE GAS EMISSIONS

Mike Bradford and Lan Cheah, Jacobs Consultancy Inc., Houston, TX, USA

Bill Keesom, Jacobs Consultancy Inc., Chicago, IL, USA

Introduction

There are multiple protocols that define how to calculate and report greenhouse gas (GHG) emissions. The purpose of the calculation and/or reporting must be defined and the protocol(s) followed must match that purpose. In some cases multiple purposes may apply, and the calculation/reporting may need to be modified for each applicable protocol.

The calculation of emissions—and the reporting of emissions in a way that provides information to management—is the first step in the reduction of GHG emissions.

This paper summarizes the major international and U.S. protocols that govern the calculation and reporting of GHG emissions. Calculation procedures are provided for the following units: fuel firing and energy purchases, including electricity, cogeneration, and mobile sources, as well as other miscellaneous sources.

Protocols for Calculating and Reporting GHG Emissions

Different protocols set different standards of accuracy, sometimes referred to as “tiers.” The utilized calculation approach should match the most stringent protocol tier that applies. Depending on the use of the information, the calculations and report may need to be certified by an accredited 3rd party. ISO-14064 Part 3 requires that if a public statement is to be made concerning the data, a 3rd party should certify the emissions estimate.

Program protocols, guidelines and instructions that may apply include:

- DOE/EIA, Form EIA-1605, Voluntary Reporting of Greenhouse Gas, Instructions
- ISO14064 Part 1: Specification with Guidance at the Organizational Level for Quantification and Reporting Greenhouse Gas Emissions and Removals
- ISO14064-2: Specification with Guidance at the Project Level for Quantification, Monitoring and Reporting of Greenhouse Gas Emission reductions or Removal Enhancements
- IPCC 2006, IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme.

- GHG Protocol for Project Accounting—World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD)
- GHG Protocol Corporate Accounting and Reporting Standards, 2004
- California Climate Action Registry General Reporting Protocol, 2008
- The Climate Registry General Reporting Protocol, May 2008
- Compendium of Greenhouse Gas Emissions, Estimation Methodologies for the Oil and Gas Industry (API Compendium), 2004
- Petroleum Industry Guidelines for Reporting Greenhouse Gas Emissions (IPIECA), December 2003
- OpenEco Calculation Methodology
- U.S. Environmental Protection Agency (U.S. EPA). 2007a. Emissions & Generation Resource Integrated Database 2006 Version 2.1 (eGRID2006 Version 2.1). April.

The protocols divide the reporting into multiple categories. One of the major ways to separate the emissions is by direct, indirect, and other indirect, which are described below:

- Direct emissions—emissions that are generated, owned or controlled by the organization.
- Indirect emissions—these are emissions that are not generated by the organization, but are generated because of the organization and for the organization. The standard indirect emissions are energy purchases: electricity purchases, steam purchases, purchases from cogeneration, and heating & air conditioning purchases.
- Other indirect emissions—these are indirect emissions from sources other than energy purchases. Some protocols require reporting specific “other indirects,” but most do not.

List of GHG Compounds and Global Warming Potential

Table 1 lists the compounds that are internationally recognized as GHGs. Also listed is the “global warming potential” (GWP) of each compound. The GWP reflects the relative impact each compound has on climate change. When the calculations are complete, each compound is multiplied by its GWP and added together to give an “equivalent CO₂ emission.” For simplicity, ranges are shown in the table for classes of compounds. Many of the protocols list the specific GWP for specific compounds

Table 1. List of GHG Compounds

Greenhouse Gas	Global Warming Potential
CO ₂	1
CH ₄	21
N ₂ O	310
HFCs	140 to 9800
PFCs	4800 to 9200
SF ₆	23,900

GHG Calculation Procedures

This section provides calculation information on the following major sources of GHG emissions:

- Fuel firing
- Energy purchases
- Cogeneration
- Mobil sources
- Miscellaneous other sources

Fuel Firing

The recommended approach to calculating GHG emissions from fuel firing is to measure the fuel consumption and the composition of the fuel. Measuring the composition of the fuel is especially important when firing offgases since the composition tends to be variable. Given the fuel firing rate and fuel composition, the CO₂ emissions can be directly calculated.

If the fuel composition is not known, standard factors can be used. DOE/EIA, the Climate Registry, and the API Compendium all provide standard factors. Methane and N₂O emissions cannot be directly calculated, so standard factors are always used.

Energy Purchases

Energy purchases include:

- Electricity
- Steam
- Heating and air conditioning

There are multiple approaches to accounting for GHG emissions from the purchase of electricity:

- Use specific emission factors from the electricity provider
- Use eGrid power pool factors
- Use factors for your state or area provided by the DOE/EIA or the API Compendium

For steam purchases, the emissions should be based on the actual fuel fired to generate the steam.

For purchases of heating and air conditioning, emission factors should be obtained from the supplier of the energy. If specific factors are not known, generic factors can be used. Some of the protocols provide generic factors.

Cogeneration—Standard Approach

For electricity and steam from cogeneration facilities, the emissions must be divided between power production and steam production, and also need to be allocated to the various steam levels. The API Compendium lists four different approaches to allocating the emissions. One approach tends to give most of the savings to the steam, whereas another gives the savings to the electricity. The remaining two approaches attempt to split the savings based on the relative efficiency of power generation and steam production. All of the approaches allocate the emissions based on enthalpy, with one using both enthalpy and entropy as the basis.

Mobile Sources

The estimating of mobile sources is complex, requiring information on some of the following: the types of mobile sources, fuel types, vehicle fleet age, maintenance procedures, operating conditions, operating frequency, emissions controls, and fuel consumption. The ideal is to have actual fuel use data and composition, although generic factors are available.

Miscellaneous Other Sources

Calculation procedures for many sources are available in the protocols. The API Compendium provides procedures for many of the refining units and some of the chemical processes. The Climate Registry provides procedures for many processes.

Summary

There are multiple protocols that define how to calculate and report GHG emissions. The purpose of the calculation and/or reporting must be defined and the protocol(s) followed

that match that purpose. In some cases, multiple purposes may apply and the calculation/reporting may need to be modified for each matching protocol.

Different protocols set different standards of accuracy, sometimes referred to as "tiers." The calculation approach used should match the most stringent protocol tier that applies. Depending on the use of the information, the calculations and report may need to be certified by an accredited 3rd party.

The first step in the reduction of GHG emissions is the calculation of emissions and reporting the emissions in a way that provides information to management.