Managing Inventory Quality

For the purposes of reporting for the Climate Leaders program, it is sufficient to document inventory assumptions and to note major sources of uncertainty (i.e., as part of the Inventory Management Plan). An uncertainty analysis is not required.

A corporate GHG *inventory management plan (IMP)* includes all institutional, managerial, and technical arrangements made for the collection of data, preparation of the inventory, and implementation of steps to manage the quality of the inventory. *An IMP* provides a systematic process for preventing and correcting errors, and identifies areas where investments will likely lead to the greatest improvement in overall inventory quality. However, the primary objective of *an IMP* is ensuring the credibility of a company's GHG inventory information.

Chapter 1 outlines five accounting principles that set an implicit standard for the faithful representation of a company's GHG emissions through its technical, accounting, and reporting efforts. Putting these principles into practice will result in a credible and unbiased treatment and presentation of issues and data. The goal of *an IMP* is to ensure that these principles are put into practice.

This chapter addresses the implementation of an *IMP*, practical inventory quality measures for implementation, as well as inventory quality and inventory uncertainty (i.e., types and limitations of uncertainty estimates).

An Inventory Program Framework

A practical framework is needed to help companies conceptualize and design a quality management system and plan for future improvements. This framework focuses on the following institutional, managerial, and technical components of an inventory. *Climate Leaders calls this framework an Inventory Management Plan.* An effective and efficient *Inventory Management Plan* should address the following four fundamentals.

- Methods
- Data
- Inventory processes and systems
- Documentation

Table 7-1 summarizes the four fundamentals of inventory development. The exact inventory management plan components, the associated detail required, and issues to consider for each component are outlined in more detail in Chapter 9 and Appendix 3.

Table 7-1: Fundamentals of Inventory Development

Methods – the technical aspects of inventory preparation	■ *Define inventory boundaries, treatment of joint ventures, identify sources, etc. Chapters 3, 4, and 6 help with this.* ■ *Identify methodologies for estimating emissions (Climate Leaders provides many default methods and Protocols to help companies with this effort.)* ■ *Establish procedures for applying and updating inventory methodologies in response to new business activities, new technical information, or new reporting requirements.*
Data – the basic information on activity levels, emission factors, processes, and operations	■ *Develop approach, and assign roles and responsibilities to facilitate collection of high quality inventory data.* ■ *Create process for the maintenance and improvement of data collection procedures.*
Inventory processes and systems – the institutional, managerial, and technical procedures for preparing GHG inventories	■ *Define all institutional, managerial, and formal procedural aspects required to develop and maintain a GHG inventory that meets the Climate Leaders accounting and reporting standards.* ■ *Whenever reasonable, integrate these processes with other corporate processes.*
Documentation – the record of methods, data, processes, systems, assumptions, and estimates used to prepare an inventory	■ *Identify internal and external audiences and develop procedures to document information intended for their use.* ■ *Establish documentation sufficient for an inventory development team to accurately and efficiently continue preparing and improving all four fundamentals in the company's inventory.* ■ *Ensure that documentation provides sufficient transparency to facilitate potential internal or external verification.*

Implementing an Inventory Management *Plan*

An IMP for a company's program should address all four of the components described above. To implement the system, a company should take the following steps:

1. **Establish an inventory team.** This team should be responsible for implementing *the IMP,* and continually improving inventory quality, as well as coordinating activities between relevant business units and facilities.

2. **Develop *an IMP*** that describes the steps the company is taking in the implementation of *calculating an inventory.* The plan should include procedures for all organizational levels and inventory development processes (i.e., from initial data collection to final reporting of accounts). For efficiency and comprehensiveness, *Partners* are encouraged to consider the integration of their inventory management *plan* with their overall corporate and environmental information management systems, including any procedures in place as part of their International Standards Organization (ISO) 9000 (Quality Management) or ISO 14001 (Environmental Management) certifications.

3. **Perform generic quality checks.** Generic quality checking procedures applicable to

inventory data and processes at all levels (i.e., data handling, documentation, and emission calculation activities, as noted in further detail in Table 7-2).

4. **Perform source category-specific quality checks.** This includes more rigorous investigations into the appropriate application of boundaries, recalculation procedures, and adherence to accounting and reporting principles for specific source categories, as well as the quality of the data input used, and a qualitative description of the major causes of uncertainty in the data (see section on implementation below).

5. **Review final inventory estimates and reports,** including internal technical and managerial reviews and potential external verification.

6. **Institutionalize formal feedback loops** so that errors are corrected and improvements are made following quality checks, investigations, and reviews.

7. **Establish reporting, documentation, and archiving procedures,** including internal recordkeeping procedures, information for external stakeholders, etc. These procedures should also include formal feedback mechanisms.

Table 7-2: Generic Quality Management Measures

Data Gathering, Input, and Handling Activities	■ Check a sample of input data for transcription errors ■ Identify spreadsheet modifications that could provide additional controls or checks on quality ■ Ensure that adequate version control procedures for electronic files have been implemented ■ Others
Data Documentation	■ Confirm that bibliographical data references are included in spreadsheets for all primary data ■ Check that copies of cited references have been archived ■ Check that assumptions and criteria for selection of methods, activity data, emission factors, and other parameters are documented ■ Check that changes in data or methodology are documented ■ Others
Calculating Emissions and Checking Calculations	■ Check whether emission units, parameters, and conversion factors are appropriately labeled ■ Check if units are properly labeled and correctly carried through from beginning to end of calculations ■ Check that conversion factors are correct ■ Check the data processing steps (e.g., equations) in the spreadsheets ■ Check that spreadsheet input data and calculated data are clearly differentiated ■ Check a representative sample of calculations, by hand or electronically ■ Check some calculations with abbreviated calculations (i.e., back of the envelope checks) ■ Check the aggregation of data across source categories, business units, etc. ■ When methods or data have changed, check consistency of time series inputs and calculations ■ Others

As part of Climate Leaders, EPA assists Partners by providing technical assistance on completing their inventory and IMP. This includes desktop reviews that encompass some of the quality management checks listed in Table 7-2. For more details on technical assistance refer to Chapter 9.

Practical Measures for Implementation

Although principles and broad program design guidelines are important, any guidance on *inventory* management would be incomplete without a discussion of practical inventory *management* measures. A company should implement these measures at multiple levels within the company, from the point of primary data collection to the final corporate inventory approval process. It is important to implement these measures at points in the inventory program where errors are most likely to occur, such as the initial data collection phase and during calculation and data aggregation. While corporate-level inventory quality may initially be emphasized, it is important to ensure quality measures are implemented at all levels of disaggregation (e.g., facility, process, geographical, according to a particular *category of emission*, etc.).

Companies also need to ensure the quality of their historical emission estimates and trend data. They can achieve this by employing inventory quality measures to minimize biases that can arise from changes in the characteristics of the data or methods used to calculate historical emission estimates.

Step 3 in implementing *an IMP* is to perform generic quality checking measures, which apply to all source categories and all stages of inventory preparation. Table 7-2 provides a sample list of such measures.

Step 4 in implementing *an IMP* is source category-specific data quality investigations.[1] The following discussion addresses the types of source-specific quality measures that can be employed for emission factors, activity data, and emission estimates.

Emission Factors and Other Parameters

For a particular source category, emissions calculations will generally rely on emission factors and other parameters (e.g., utilization factors, oxidation rates, and methane conversion factors)[2]. These factors and parameters may be published or default factors, based on company-specific data, site-specific data, or direct emission or other measurements. For fuel consumption, published emission factors based on fuel energy content are generally more accurate than those based on mass or volume, except when mass-based or volume-based factors have been measured at a company-specific or site-specific level. Quality investigations need to assess the representative data and applicability of emission factors and other parameters to the specific characteristics of a company. Differences between measured and default values need to be qualitatively explained and justified based upon the company's operational characteristics.

1 The information gathered from these investigations is to be used in the assessment of data uncertainty (see section on uncertainty in Chapter 7).

2 Some emission estimates may be derived using mass or energy balances, engineering calculations, or computer simulation models. In addition to investigating the input data to these models, companies should also consider whether the internal assumptions (including assumed parameters in the model) are appropriate to the nature of the company's operations.

Activity Data

The collection of high quality activity data will often be the most significant limitation for corporate GHG inventories. Therefore, establishing robust data collection procedures needs to be a priority in the design of any company's inventory program. The following are useful measures for ensuring the quality of activity data:

- Develop data collection procedures that allow the same data to be efficiently collected in future years.
- Fuel consumption data should be converted to energy units before applying carbon content emission factors, which may be better correlated to a fuel's energy content than its mass. *The CO_2 emissions from burning a unit of a specific fuel will be more accurately determined if the amount of energy units burned is used to calculate emissions.*
- Current year data should be compared with previous year's data and historical trends. If data do not exhibit relatively consistent changes from year to year, but rather undergo sharp increases or decreases, then the causes for this pattern should be investigated (e.g., changes of over 10 percent from year to year may warrant further investigation).
- Activity data from multiple reference sources (e.g., government survey data or data compiled by trade associations) should be compared with corporate data when possible. Although all data may have the same origin, such checks can ensure that consistent data is being reported to all parties. Data can also be compared among facilities within a company.
- Investigate activity data that is generated for purposes other than preparing a GHG inventory. In doing so, companies will need to check the applicability of this data to inventory purposes, including completeness, consistency with the source category definition, and consistency with the emission factors used. For example, data from different facilities may be examined for inconsistent measurement techniques, operating conditions, or technologies. Quality control measures (e.g., ISO) may have already been conducted during the data's original preparation. These measures can be integrated with the company's inventory quality management system.
- Check that base year recalculation procedures have been followed consistently and correctly.
- Check that operational and organizational boundary decisions have been applied correctly and consistently to the collection of activity data.
- *Partners* should investigate whether biases or other characteristics that could affect the data quality have already been previously identified (e.g., by communicating with experts at a particular facility or elsewhere). For example, a bias could be the unintentional exclusion of operations at smaller facilities or data that does not correspond exactly with the company's organizational boundaries.
- If *Partners* are using additional data to estimate emission intensities or other ratios (i.e., sales, production, etc.), quality management measures should also extend to these additional data.
- *If Partners are reporting data to the EPA for other reporting purposes, such as reporting under Title IV or Title V of the U.S. Clean Air*

Act, then the same data should form the basis for Climate Leaders reporting.

Title V of the U.S. Clean Air Act requires an operating permit for each industrial facility that is a "major source" of air pollution. Under this operating permits program, a facility is considered a major source when it emits minimum levels of a specific air pollutant. This can be a little as 10 tons per year. Data collected under Title V that may be relevant to GHG reporting includes identification of sources of emissions at a facility and potentially data on energy flows.

Title IV of the U.S. Clean Air Act requires owners or operators of affected units to measure and report sulfur dioxide (SO_2), nitrogen oxide (NO_x), and CO_2 emissions under the U.S. EPA's Acid Rain Program. Data on CO_2 emissions reported under Title IV can be used directly in the Climate Leaders program.

Emission Estimates

Estimated emissions for a source category can be compared with historical data or other estimates to ensure that they fall within a reasonable range. Potentially unreasonable estimates provide cause for checking emission factors or activity data and determining whether changes in methodology, market forces, or other events are sufficient reasons for the change. In situations where actual emission monitoring occurs (e.g., power plant CO_2 emissions), the data from monitors can be compared with estimated emissions using activity data and emission factors.

If any of the above emission factor, activity data, emission estimate, or other parameter checks indicate a problem, *Climate Leaders encourages Partners* to consider more detailed investigations into the accuracy of the data or appropriateness of the methods to reduce inventory error. These more detailed investigations can also be utilized to better assess the quality of data. One potential measure of data quality is a quantitative and qualitative assessment of their uncertainty.

Inventory Quality and Inventory Uncertainty

Preparing a GHG inventory is inherently both an accounting and a scientific exercise. Most applications for company-level emissions and removal estimates require that these data be reported in a format similar to financial accounting data. In financial accounting, it is standard practice to report individual point estimates (i.e., a single value versus a range of possible values). In contrast, the standard practice for most scientific studies of GHG and other emissions is to report quantitative data with estimated error bounds (i.e., uncertainty). Just like financial figures in a profit and loss or bank account statement, point estimates in a corporate emission inventory have obvious uses. However, the addition of some quantitative measure of uncertainty to an emission inventory may also have some uses.

In an ideal situation, in which a company had perfect quantitative information on the uncertainty of its emission estimates at all levels, the primary use of this information would almost certainly be comparative. Such comparisons might be made across companies, across business units, across source categories, or through time. In this situation, inventory estimates could be rated or discounted based on their quality before they were used, with uncertainty being the objective quantitative metric for quality. Unfortunately, such objective uncertainty estimates rarely exist.

Types of Uncertainties

Uncertainties associated with GHG inventories can be broadly categorized into scientific uncertainty and estimation uncertainty. Scientific uncertainty arises when the science of the actual emission and/or removal process is not completely understood. For example, many of the direct and indirect factors associated with GWP values that are used to combine emission estimates for various GHGs involve significant scientific uncertainty. Analyzing and quantifying such scientific uncertainty is extremely problematic and is likely to be beyond the scope of most company inventory programs.

Estimation uncertainty arises any time GHG emissions are quantified. Therefore all emission or removal estimates are associated with estimation uncertainty. Estimation uncertainty can be further classified into two types: model uncertainty and parameter uncertainty[3].

Model uncertainty refers to the uncertainty associated with the mathematical equations (i.e., models) used to characterize the relationships between various parameters and emission processes. For example, model uncertainty may arise either due to the use of an incorrect mathematical model or inappropriate input into the model. As with scientific uncertainty, estimating model uncertainty is also likely to be beyond most company's inventory efforts; however, some companies may wish to utilize their unique scientific and engineering expertise to evaluate the uncertainty in their emission estimation models.

Parameter uncertainty refers to the uncertainty associated with quantifying the parameters used as inputs (e.g., activity data and emission factors) into estimation models. Parameter uncertainties can be evaluated through statistical analysis, measurement equipment precision determinations, and expert judgment. Quantifying parameter uncertainties and then estimating source category uncertainties based on these parameter uncertainties will be the primary focus of companies that choose to investigate uncertainty in their emission inventories.

Limitations of Uncertainty Estimates

Given that only parameter uncertainties are within the feasible scope of most companies, uncertainty estimates for corporate GHG inventories will, of necessity, be imperfect. Complete and robust sample data will not always be available to assess the statistical uncertainty in every parameter. For most parameters (e.g., liters of gasoline purchased or tons of limestone consumed), only a single data point may be available. In some cases, companies can utilize instrument precision or calibration information to inform their assessment of statistical uncertainty. However, to quantify some of the systematic uncertainties (defined below) associated with parameters and to supplement statistical uncertainty estimates, companies will usually have to rely on expert judgement[4]. The problem with expert judgement, though, is that it is difficult to obtain in a comparable (i.e., unbiased) and consistent manner across parameters, source categories, or companies.

3 Emissions estimated from direct emission monitoring will generally only involve parameter uncertainty (e.g., equipment measurement error).

4 The role of expert judgement in the assessment of the parameter can be twofold: Firstly, expert judgement can be the source of the data that are necessary to estimate the parameter. Secondly, expert judgement can help (in combination with data quality investigations) identify, explain, and quantify both statistical and systematic uncertainties (see following section).

For these reasons, almost all comprehensive estimates of uncertainty for GHG inventories will be not only imperfect but also have a subjective component and, despite the most thorough efforts, are themselves considered highly uncertain. In most cases, uncertainty estimates cannot be interpreted as objective measures of quality, nor can they be used to compare the quality of emission estimates between source categories or companies.

An exception to this includes the following case in which it is assumed that either statistical or instrument precision data are available to objectively estimate each parameter's statistical uncertainty (i.e., expert judgement is not needed):

- When two operationally similar facilities use identical estimation methodologies, the differences in scientific or model uncertainties can, for the most part, be ignored. Then quantified estimates of statistical uncertainty can be treated as being comparable between facilities. This type of comparability is what is aimed for in some trading programs that prescribe specific monitoring, estimation, and measurement requirements. However, even in this situation, the degree of comparability depends on the flexibility that participants are given for estimating emissions, the homogeneity across facilities, as well as the level of enforcement and review of the methodologies used.

Given these limitations, the role of uncertainty assessments in developing GHG inventories includes:

- Promoting a broader learning and quality feedback process.
- Supporting efforts to qualitatively understand and document the causes of uncertainty and help identify ways of improving inventory quality. For example, collecting the information needed to determine the statistical properties of activity data and emission factors forces one to ask hard questions and to carefully and systematically investigate data quality.
- Establishing lines of communication and feedback with data suppliers to identify specific opportunities to improve the quality of the data and methods used.
- Providing valuable information to reviewers, verifiers, and managers for setting investment priorities to improve data sources and methodologies.

The GHG Protocol has developed a supplementary guidance on uncertainty assessments ("Guidance on uncertainty assessment in GHG inventories and calculating statistical parameter uncertainty") along with an uncertainty calculation tool, both of which are available on the GHG Protocol website. The guidance document describes how to use the calculation tool in aggregating uncertainties. It also discusses in more depth the different types of uncertainties, the limitations of quantitative uncertainty assessment, and how uncertainty estimates should be properly interpreted.

Additional guidance and information on assessing uncertainty—including optional approaches to developing quantitative uncertainty estimates and eliciting judgments from experts—can be found in Volume VI of EPA's Emissions Inventory Improvement Program documents on Quality Assurance/Quality Control and in chapter 6 of the IPCC's Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

Characterizing uncertainty is not required under Climate Leaders.