GREENHOUSE
GAS PROTOCOL

Product Life Cycle Accounting and Reporting Standard

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01 Introduction

Emissions of the anthropogenic greenhouse gases (GHG) that drive climate change and its impacts around the world are growing. According to climate scientists, global carbon dioxide emissions must be cut by as much as 85 percent below 2000 levels by 2050 to limit global mean temperature increase to 2 degrees Celsius above pre-industrial levels.[1] Temperature rise above this level will produce increasingly unpredictable and dangerous impacts for people and ecosystems. As a result, the need to accelerate efforts to reduce anthropogenic GHG emissions is increasingly urgent. Existing government policies will not sufficiently solve the problem. Leadership and innovation from business is vital to making progress.

Corporate action in this arena also makes good business sense. By addressing GHG emissions, companies can identify opportunities to bolster their bottom line, reduce risk, and discover competitive advantages. As impacts from climate change become more frequent and prominent, governments are expected to set new policies and provide additional market-based incentives to drive significant reductions in emissions. These new policy and market drivers will direct economic growth on a low-carbon trajectory. Businesses need to start planning for this transition now as they make decisions that will lock in their investments for years to come.

An effective corporate climate change strategy requires a detailed understanding of a company's GHG impact. A corporate GHG inventory is the tool to provide such an understanding. It allows companies to take into account their emissions-related risks and opportunities and focus company efforts on their greatest GHG impacts. Until recently, companies have focused their attention on emissions from their own operations. But increasingly companies understand the need to also account for GHG emissions along their value chains and product portfolios to comprehensively manage GHG-related risks and opportunities.

Through the development of the GHG Protocol *Product Standard*, the GHG Protocol has responded to the demand for an internationally accepted method to enable GHG management of companies' goods and services. Following the release of this standard, the GHG Protocol and its partners will proactively work with industry groups and governments to promote its widespread use – along with the entire suite of GHG Protocol standards and tools – to enable more effective GHG management worldwide.

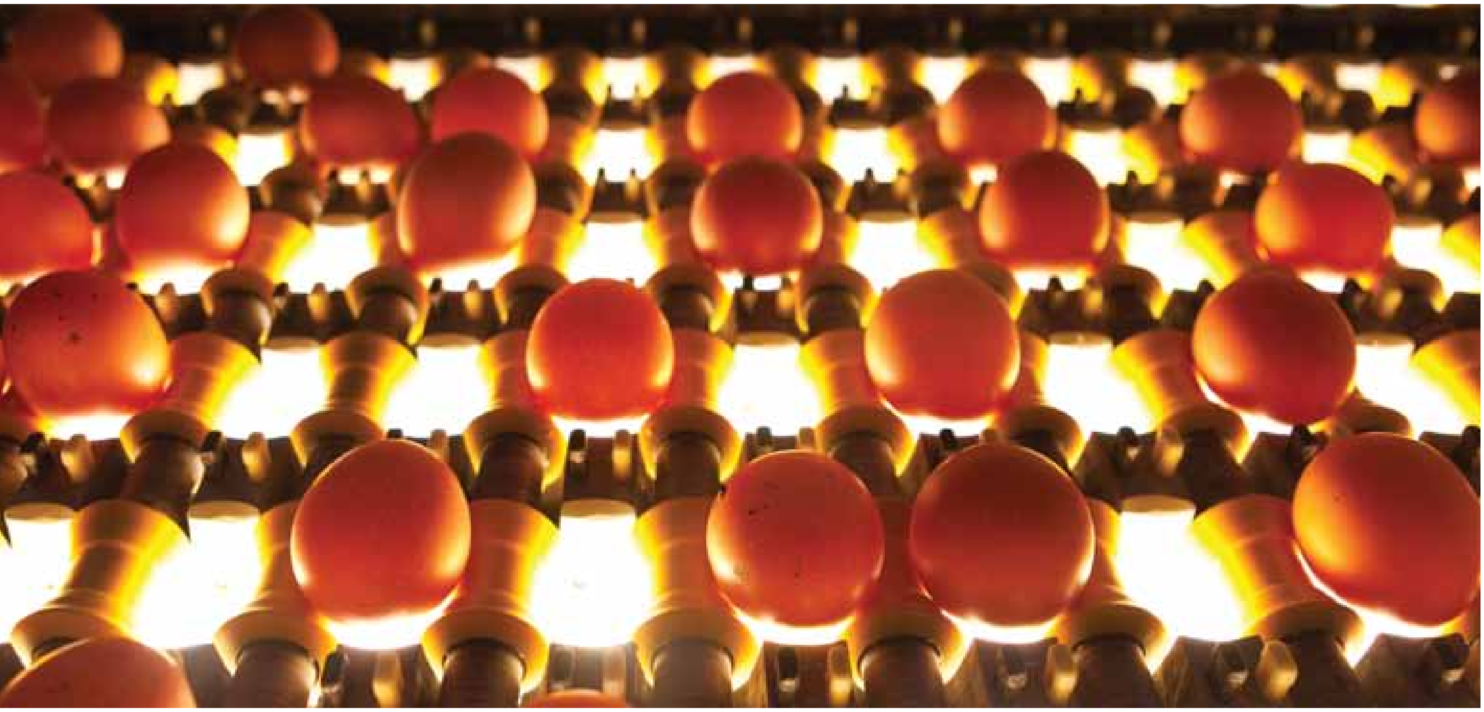
1.1 The Greenhouse Gas Protocol

The Greenhouse Gas (GHG) Protocol is a multistakeholder partnership of businesses, non-governmental organizations (NGOs), governments, and others convened by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). Launched in 1998, the mission of the GHG Protocol is to develop internationally accepted greenhouse gas (GHG) accounting and reporting standards and tools, and to promote their adoption in order to achieve a low emissions economy worldwide.

The GHG Protocol follows a broad, inclusive, consensus-based multi-stakeholder process to develop these standards with balanced participation from businesses, government agencies, non-governmental organizations, and academic institutions from around the world. The standards include detailed guidance to assist users with implementation and are freely available on the GHG Protocol website (www.ghgprotocol.org).

The GHG Protocol has produced the following separate, but complementary standards, protocols, and guidelines:

- ***GHG Protocol Corporate Accounting and Reporting Standard*** **(2004):** A standardized methodology for companies to quantify and report their corporate GHG emissions. Also referred to as the *Corporate Standard*.
- ***GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard*** **(2011):** A standardized methodology for companies to quantify and report their corporate value chain (scope 3) GHG emissions, to be used in conjunction with the *Corporate Standard*. Also referred to as the *Scope 3 Standard*.
- ***GHG Protocol for Project Accounting*** **(2005):** A guide for quantifying reductions from GHG-mitigation projects. Also referred to as the *Project Protocol*.
- ***GHG Protocol for the U.S. Public Sector*** **(2010):** A step-by-step approach to measuring and reporting emissions from public sector organizations, complementary to the *Corporate Standard*.
- ***GHG Protocol Guidelines for Quantifying GHG Reductions from Grid-Connected Electricity Projects*** **(2007):** A guide for quantifying reductions in emissions that either generate or reduce the consumption of electricity transmitted over power grids, to be used in conjunction with the *Project Protocol*.



- ***GHG Protocol Land Use, Land-Use Change, and Forestry Guidance for GHG Project Accounting* (2006):** A guide to quantify and report reductions from land use, land-use change, and forestry, to be used in conjunction with the *Project Protocol*.
- ***Measuring to Manage: A Guide to Designing GHG Accounting and Reporting Programs* (2007):** A guide for program developers on designing and implementing effective GHG programs based on accepted standards and methodologies.

1.2 Purpose of the GHG Protocol Product Life Cycle Accounting and Reporting Standard

The *GHG Protocol Product Life Cycle Accounting and Reporting Standard* (referred to as the *Product Standard*) provides requirements and guidance for companies and other organizations to quantify and publicly report an inventory of GHG emissions and removals[2] associated with a specific product. The primary goal of this standard is to provide a general framework for companies to make informed choices to reduce greenhouse gas emissions from the products (goods or services) they design, manufacture, sell, purchase, or use. In the context of this standard, public reporting refers to product GHG-related information reported publicly in accordance with the requirements specified in the standard.

As awareness about climate change increases and concerns grow, investors are demanding more transparency, and consumers are seeking greater clarity and environmental accountability. Companies are increasingly receiving requests from stakeholders to measure and disclose their corporate GHG inventories, and these requests often include a company's products and supply chain emissions. Companies must be able to understand and manage their product-related GHG risks if they are to ensure long-term success in a competitive business environment and be prepared for any future product-related programs and policies.

This standard focuses on emissions and removals generated during a product's life cycle and does not address avoided emissions or actions taken to mitigate released emissions. This standard is also not designed to be used for quantifying GHG reductions from offsets or claims of carbon neutrality.

Ultimately, this is more than a technical accounting standard. It is intended to be tailored to business realities and to serve multiple business objectives. Companies may find most value in implementing the standard using a phased approach, with a focus on improving the quality of the GHG inventory over time.

1.3 How this standard was developed

In 2008, WRI and WBCSD launched the three-year process to develop the *Product Standard*. A 25 member Steering Committee of experts provided strategic direction throughout the process. The first draft of the *Product Standard* was developed in 2009 by Technical Working Groups consisting of 112 members representing diverse industries, government agencies, academia, and non-profit organizations from around the world. In 2010, 38 companies from a variety of industry sectors "road tested" the first draft and provided feedback on its practicality and usability, which informed a second draft. Members of a Stakeholder Advisory Group (consisting of more than 1,600 participants) provided feedback on both drafts of the standard.

1.4 Who should use this standard

This standard is designed for companies and organizations[3] of all sizes in all economic sectors and in all countries. Companies seeking a better understanding of the GHG inventory of products they design, manufacture, sell, purchase, or use can benefit from the use of this standard. Interested users of the standard within companies could include staff from product design, procurement, research and development, marketing, energy, environment, logistics, and corporate sustainability departments. Policy makers and GHG programs may also be interested in incorporating the standard into their policy or program design.

1.5 Use of the Product Standard for product comparison

The *Product Standard* is intended to support performance tracking of a product's GHG inventory and emissions reductions over time. Additional prescriptiveness on the accounting methodology, such as allocation choices and data sources, are needed for product labeling, performance claims, consumer and business decision making based on comparison of two or more products, and other types of product comparison based on GHG impacts. See section 5.3.2 and Appendix A for more guidance on additional specifications needed for comparison.

Claims regarding the overall environmental superiority or equivalence of one product versus a competing product, referred to in ISO 14044 as comparative assertions, are not supported by the *Product Standard*.

1.6 Relationship to the Corporate and Scope 3 Standards

The GHG Protocol Scope 3 Standard and GHG Protocol Product Standard both take a value chain or life cycle approach to GHG accounting and were developed simultaneously. The Scope 3 Standard builds on the GHG Protocol Corporate Standard and accounts for value chain emissions at the corporate level, while the Product Standard accounts for life cycle emissions at the individual product level. Together, the three standards provide a comprehensive approach to value chain GHG measurement and management.

The reporting company's business goals should drive the use of a particular GHG Protocol accounting standard. The Scope 3 Standard enables a company to identify the greatest GHG reduction opportunities across the entire corporate value chain, while the Product Standard enables a company to target individual products with the greatest potential for reductions. The Scope 3 Standard helps a company identify GHG reduction opportunities, track performance, and engage suppliers at a corporate level, while the Product Standard helps a company meet the same objectives at a product level.

The GHG Protocol Scope 3 and Product Standards both take a value chain or life cycle approach to GHG accounting.

Common data is used to develop scope 3 inventories and product inventories, including data collected from suppliers and other companies in the value chain. Since there can be overlap in data collection, companies may find added business value and efficiencies in developing scope 3 and product inventories in parallel.

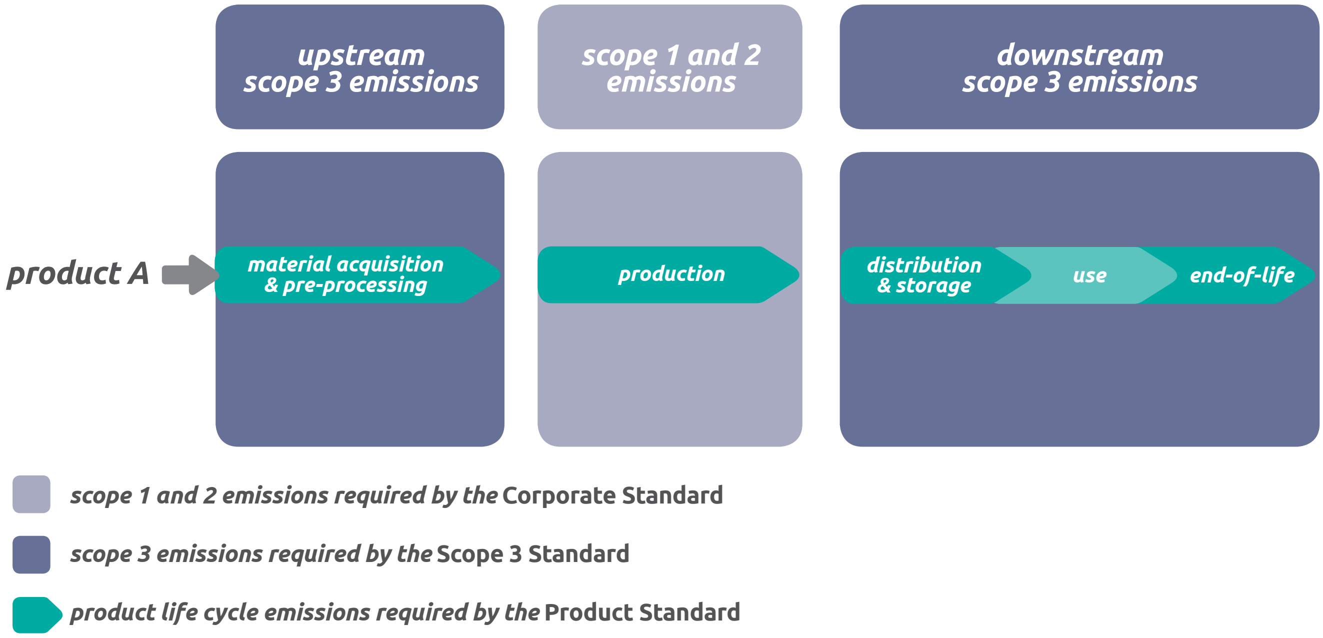
While each standard can be implemented independently, both standards are mutually supportive. Integrated use might include:

- Applying the Corporate Standard and Scope 3 Standard (to determine the company's total scope 1, scope 2, and scope 3 emissions) , using the results to identify products with the most significant emissions, then using the Product Standard to identify mitigation opportunities in the selected products' life cycles
- Using product-level GHG data based on the Product Standard as a source of data to calculate scope 3 emissions associated with selected product types
- Applying the Corporate Standard, Scope 3 Standard and the Product Standard and using the results to inform GHG-reduction strategies at both the product and corporate levels

The sum of the life cycle emissions of each of a company's products, combined with additional scope 3 categories[4] (e.g., employee commuting, business travel, and investments), should approximate the company's total corporate GHG emissions (i.e., scope 1 + scope 2 + scope 3). In practice, companies are not expected or required to calculate life cycle inventories for individual products when calculating scope 3 emissions.

Figure 1.1 illustrates the relationship between the Corporate Standard, Product Standard, and Scope 3 Standard. In this simplified example, a company manufactures one product (Product A). The example shows how scopes of emissions at the corporate level correspond to life cycle stages at the product level.

Figure [1.1] The relationship between the *Corporate, Scope 3, and Product Standards* for a company manufacturing product A



1.7 Limitations of product GHG inventories

The *Product Standard* accounts for the GHG emissions and removals that occur during a product's life cycle. A product assessment limited to only GHGs has the benefit of simplifying the analysis and producing results that can be clearly communicated to stakeholders. The limitation of a GHG-only inventory is that potential trade-offs or co-benefits between environmental impacts can be missed. Therefore, the results of a GHG-only inventory should not be used to communicate the overall environmental performance of a product. Non-GHG environmental impacts that occur during the life cycle of a product should also be considered when making decisions to reduce GHG emissions based on the inventory results. Examples of potentially significant non-GHG impacts for some products include ecosystem degradation, resource depletion, ozone depletion, and negative human health impacts.

Moreover, while this standard focuses solely on GHG emissions and removals, the accounting requirements and guidance provided can be used to collect data for other environmental impacts. Companies wishing to include non-GHG impacts along with their GHG inventory can do so using the same steps and methodologies provided in this standard.

Endnotes

1. IPCC, Summary for Policymakers (Table SPM.5: Characteristics of post-TAR stabilization scenarios), in *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* ed. B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2007).
2. In this standard, both emissions to the atmosphere and removals from the atmosphere are accounted for in order to calculate the total GHG inventory of a product. Removals of CO_2 generally occur during photosynthesis.
3. The term company is used throughout the standard to represent a company or organization that may use the standard.
4. A scope 3 category is one of 15 types of scope 3 emissions organized by activities that occur upstream and downstream from a company's ownership or control.

02 Defining Business Goals

Companies should first identify their business goals before conducting product GHG inventories. Doing so can bring clarity and assist in selecting the appropriate methodology and data to develop the inventory.

This standard has been designed as a comprehensive accounting and reporting framework to enable a company to gather information to serve all the business goals defined below and outlined in table 2.1.

2.1 Climate change management

Product GHG inventories, performed according to a consistent framework, provide a quantitative tool to help understand GHG risks along a product's life cycle. Product inventories also can be used to understand emissions reductions and cost savings opportunities, as GHG emissions generally relate to energy use and can be a proxy for inefficiencies in a product system. The use of product GHG inventories can help product manufacturers avoid the pitfall of focusing too heavily on the most proximate or obvious emission sources associated with a product's production while missing major emission reduction and cost-saving opportunities elsewhere in the life cycle.

Performing a product inventory can also be a proactive approach to assessing future risks related to life cycle GHG emissions. GHG regulations are already in place in a number of countries and may be enacted in many more in the future. Energy is becoming a scarcer resource, creating price volatility and reduced reliability. Understanding the location and amount of GHGs in a product's life cycle is valuable information when assessing a company's risk exposure from that product. Investors are becoming more wary of companies that are not evaluating and managing these and other GHG related risks.

A company can better model potential future costs of regulations by using a product inventory to evaluate a product's life cycle GHG risks. For example, completing a product inventory can increase understanding of where there are energy intensive operations in the life cycle. A company can then use this understanding to inform strategies for reducing dependency on fossil fuels, such as switching to a less energy intensive product material or increasing the use of intermodal transportation for product distribution. Stakeholders (e.g., investors) may also like to see this risk assessment publicly reported and there is growing demand for mandatory disclosure of GHG risk in some countries.

2.2 Performance tracking

Product inventories provide detailed information on the relative size and scale of emission sources within life cycle stages and across the entire product system. This information may be used to identify the largest emission

Table [2.1] Business goals served by a product GHG inventory

Business goal	Description
Climate change management	• Identify new market opportunities and regulatory incentives • Identify climate-related physical and regulatory risks in a product's life cycle • Assess risks from fluctuations in energy costs and material availability
Performance tracking	• Focus efforts on efficiency improvements and cost-saving opportunities through GHG reductions throughout a product's life cycle • Set product-related GHG reduction targets and develop strategies to achieve goals • Measure and report GHG performance over time • Track efficiency improvements throughout a product life cycle over time
Supplier and customer stewardship	• Partner with suppliers to achieve GHG reductions • Assess supplier performance for GHG aspects of green procurement efforts • Reduce GHG emissions and energy use, costs, and risks in the supply chain and avoid future costs related to energy and emissions • Launch a customer education campaign to encourage actions that reduce GHG emissions
Product differentiation	• Achieve competitive advantage by pursuing GHG reduction opportunities and cost savings to create a low-emitting product • Redesign a product to better respond to customer preferences • Strengthen brand image regarding GHG performance • Enhance employee retention and recruitment resulting from pride in product stewardship • Strengthen corporate reputation and accountability through public disclosure

sources – or "hot spots" – in the life cycle and focus efforts on the most cost effective emissions reduction activities.

Product GHG inventories, performed according to a consistent framework, provide a quantitative performance metric to set targets for improvement, track progress. and communicate successes to internal and external stakeholders. External stakeholders, including customers, investors, shareholders and others are increasingly interested in measured and reported progress in emissions reductions by companies. Therefore, identifying reduction opportunities, setting goals and reporting on progress to stakeholders may help differentiate a company in an increasingly environmentally conscious marketplace.

Internally, product GHG inventories may be used to support less GHG-intensive product design choices and production processes. For example, a shoe manufacturer seeking to meet a company target of 10 percent lower life cycle emissions from its most popular shoe might use a product GHG inventory to determine the most cost effective means of achieving the target, selecting from options such as optimizing the distribution network, using less GHG-intensive materials, or improving energy efficiency at production facilities. External uses of the performance results might include communications to regulators, investors, customers, and local communities, using tools such as an annual corporate sustainability report.

2.3 Supplier and customer stewardship

From raw material vendors to final consumers, product inventories provide an opportunity for companies to engage with stakeholders throughout a product's life cycle toward the common goal of reducing GHG emissions. This engagement may also lead to supply chain efficiencies and consequent cost savings, build stronger supply chain relationships, and uncover valuable information that can be shared to help build positive relationships with product users. For example, a product GHG inventory of a home appliance may show that much of the emissions occur in the use stage. This information can provide a platform for the manufacturer to communicate and collaborate with their customers (e.g., the users of the appliance) to achieve lower product life cycle emissions. If customers then reduced emissions by reducing electricity use, they would also reap benefits in the form of electricity cost savings. Another example is a product inventory of a beverage which shows significant emissions from packaging. These results may lead to a partnership with packaging suppliers to reduce packaging materials or replace them with less GHG-intensive content. Reporting on these types of efforts and the progress of a company's engagement with its suppliers can be useful information for stakeholders both external and internal to the reporting company.

2.4 Product differentiation

Product differentiation is a broad term, encompassing all the specific end uses of product GHG inventories that may help a company distinguish its products in the marketplace and create competitive advantage. For example, a company may realize product differentiation simply by conducting and publicizing a product GHG inventory that demonstrates to stakeholders that the brand is concerned with environmental impacts. With consumers increasingly concerned about the environmental impacts of their product choices, product GHG inventories enable companies to communicate with customers about their efforts to assess and reduce their product-related impacts. Products may also be differentiated by advertising that their use can lower consumers' own GHG emissions (and related energy expenses). Company efforts to address product emissions can also be an effective message to communicate to employees in order to enhance pride in the company's product stewardship and can have positive impacts on employee retention and recruitment.

Swire Beverages

As one of the Coca-Cola anchor bottlers, Swire Beverages undertakes the manufacture, sale, and distribution of Coca-Cola products. The company conducted life cycle GHG studies for nine of the Coca-Cola branded products produced in mainland China.

The results showed that packaging and refrigeration by retailers were the processes that contributed the most significant GHG emissions and risks, especially for small- and medium-sized products. Swire Beverages either leases or sells refrigerators at a discount to retailers. Following completion of the inventory and evaluation of reduction opportunities, the company installed energy-efficient refrigerator equipment and aggressively pursued hydrofluorocarbon (HFC) recovery and HFC-free technologies. The new equipment uses 35 - 40 percent less electricity while reducing the usage of HFC-134a, a refrigerant with high global warming potential. Swire also calculated that if all retailers installed the new refrigerators, it would save 5 -16 percent of the life cycle GHG emissions of drinking products depending on their size.

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5 - 16%

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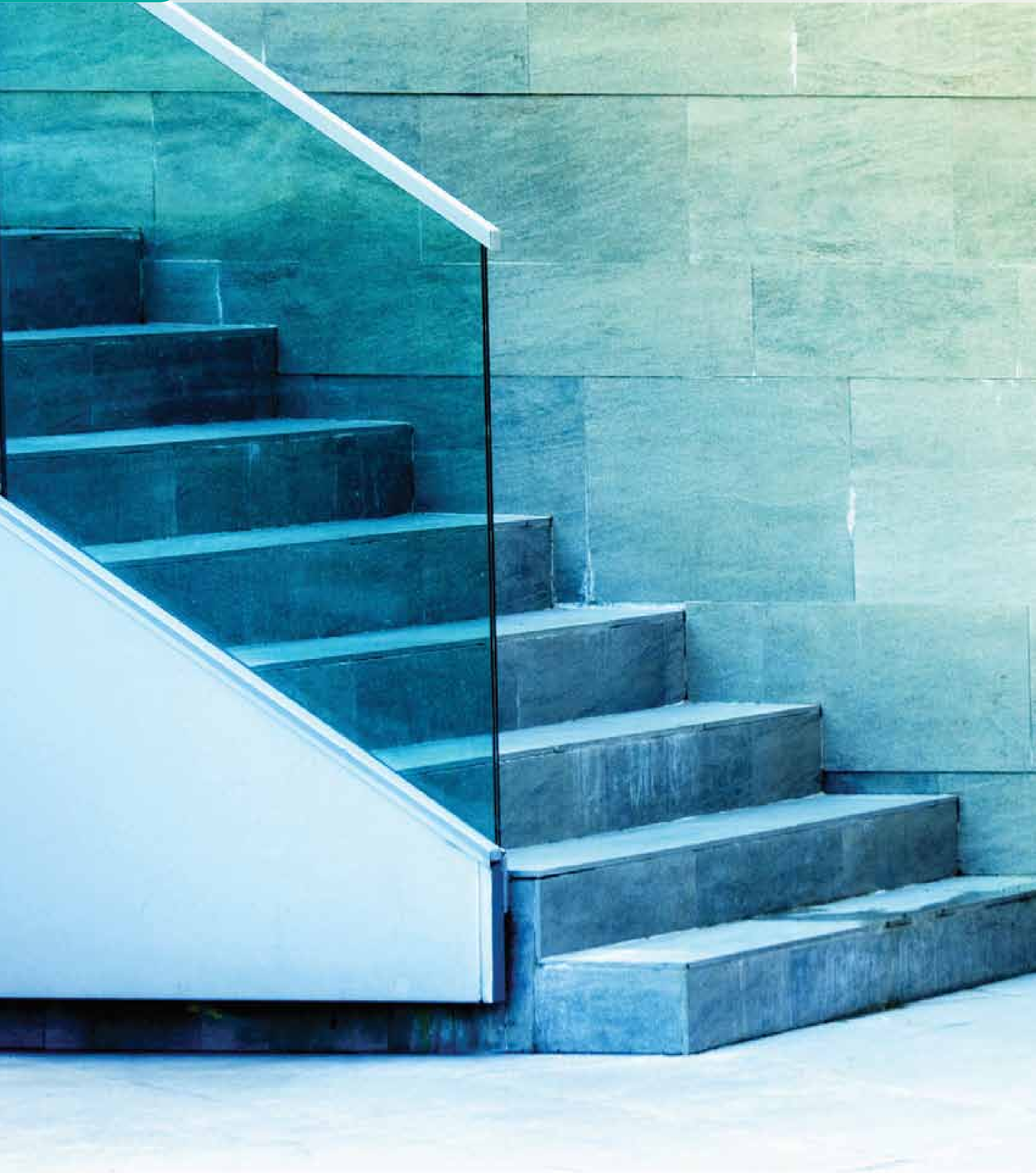
Swire Beverages and Coca-Cola also identified packaging reduction as a key climate mitigation strategy and rolled out a new packaging design for a bottled water product in China. The new plastic bottle design reduces packaging material weight by 34 percent and is estimated to reduce GHG emissions by 11 percent over the product life cycle. The new design also helps Swire Beverages to save on the procurement cost of packaging materials.

03 Summary of Steps and Requirements

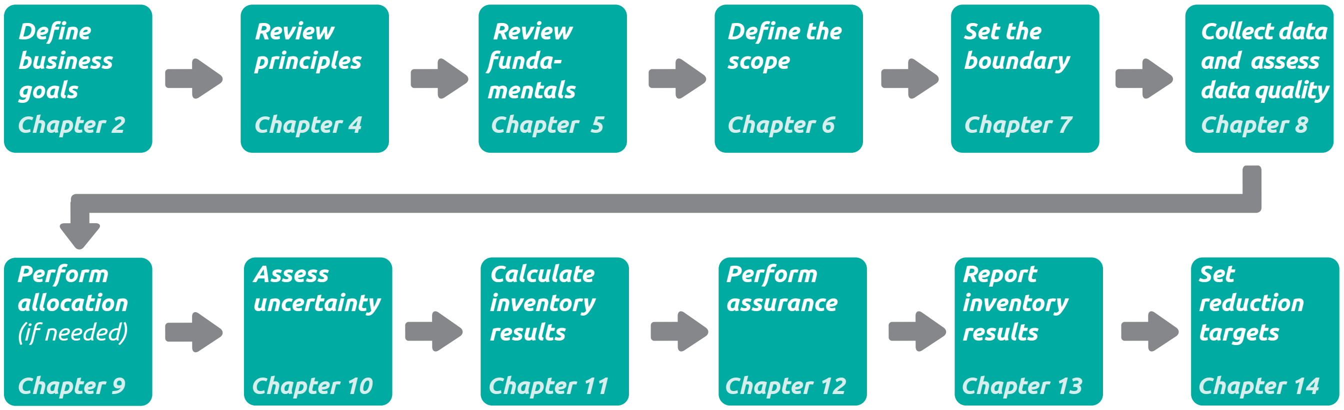


This chapter provides a summary of the steps involved in product accounting and reporting, as well as a list of the requirements that must be followed for a product inventory to be in conformance with this standard.

3.1 Standard terminology

This standard uses precise language to indicate which provisions of the standard are requirements, which are recommendations, and which are permissible or allowable options that companies may choose to follow. The term *"shall"* is used in this standard to indicate what is required for a GHG inventory to conform with the Product Standard. The term *"should"* is used to indicate a recommendation, but not a requirement. The term *"may"* is used to indicate an option that is permissible or allowable. Within the guidance sections, the term *"required"* is used to refer to *"shall"* statements given elsewhere in the standard. Also within the guidance sections, *"needs," "can,"* or *"cannot"* are sometimes used to provide guidance on implementing a requirement or to indicate when an action is or is not possible.

Figure [3.1] Overview of steps in product accounting and reporting



3.2 Overview of steps in product accounting and reporting

Figure 3.1 provides an overview of the steps taken to perform a product GHG inventory that is in conformance with this standard. Each of these steps is described in detail in the following chapters.

3.3 Summary of Product Standard requirements

Table 3.1 provides a summary of all the requirements in the *Product Standard*. Definitions and guidance are provided in the following chapters.

Table [3.1] Summary of requirements

Chapter	Requirements
4. Accounting and Reporting Principles	• GHG accounting and reporting of a product inventory shall follow the principles of relevance, accuracy, completeness, consistency, and transparency
5. Fundamentals of Product Life Cycle Accounting	• A GHG product inventory shall follow the life cycle and attributional approaches
6. Establishing the Scope of a Product Inventory	• Companies shall account for carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs) emissions to, and removals from, the atmosphere • Additional GHGs included in the inventory shall be listed in the inventory report • Companies shall define the product, unit of analysis, and reference flow • For all final products, companies shall define the unit of analysis as a functional unit • For intermediate products where the eventual function is unknown, companies shall define the unit of analysis as the reference flow
7. Boundary Setting	• The boundary of the product GHG inventory shall include all attributable processes • Companies shall report the life cycle stage definitions and descriptions • Companies shall disclose and justify any exclusions of attributable processes in the inventory report • Companies shall report attributable processes in the form of a process map • Companies shall report any non-attributable processes included in the boundary • The boundary for final products shall include the complete life cycle, from cradle-to-grave • The boundary of a cradle-to-gate partial life cycle inventory shall not include product use or end-of-life processes in the inventory results • Companies shall disclose and justify when a cradle-to-gate boundary is defined in the inventory report • Companies shall report the time period of the inventory • Companies shall report the method used to calculate land-use change impacts, when applicable
8. Collecting Data and Assessing Data Quality	• Companies shall collect data for all processes included in the inventory boundary • Companies shall collect primary data for all processes under their ownership or control • During the data collection process, companies shall assess the data quality of activity data, emission factors, and/or direct emissions data by using the data quality indicators • For significant processes, companies shall report a descriptive statement on the data sources, the data quality, and any efforts taken to improve data quality

Table [3.1] **Summary of requirements** (continued)

Chapter	*Requirements*
9. Allocation	• Companies shall allocate emissions and removals to accurately reflect the contributions of the studied product and co-product(s) to the total emissions and removals of the common process • Companies shall avoid allocation wherever possible by using process subdivision, redefining the functional unit, or using system expansion • If allocation is unavoidable, companies shall allocate emissions and removals based on the underlying physical relationships between the studied product and co-product(s) • When physical relationships alone cannot be established or used as the basis for allocation, companies shall select either economic allocation or another allocation method that reflects other relationships between the studied product and co-product(s) • Companies shall apply the same allocation methods to similar inputs and outputs within the product's life cycle • For allocation due to recycling, companies shall use either the closed loop approximation method or the recycled content method as defined by this standard • When using the closed loop approximation method, companies shall report displaced emissions and removals separately from the end-of-life stage • Companies shall disclose and justify the methods used to avoid allocation or perform allocation • When using the closed loop approximation method, companies shall report displaced emissions and removals separately from the studied product's end-of-life stage inventory

10. Assessing Uncertainty	• Companies shall report a qualitative statement on inventory uncertainty and methodological choices. Methodological choices include:
	  • Use and end-of-life profile
	  • Allocation methods, including allocation due to recycling
	  • Source of global warming potential (GWP) values used
	  • Calculation models

11. Calculating Inventory Results	• Companies shall apply a 100-year GWP factor to GHG emissions and removals data to calculate the inventory results in units of CO_2 equivalent (CO_2e)
	• Companies shall report the source and date of the GWP factors used
	• Companies shall quantify and report the following:
	  • Total inventory results in CO_2e per unit of analysis, which includes all emissions and removals included in the boundary from biogenic sources, non-biogenic sources, and land-use change impacts
	  • Percentage of total inventory results by life cycle stage
	  • Biogenic and non-biogenic emissions and removals separately when applicable
	  • Land-use change impacts separately when applicable
	  • Cradle-to-gate and gate-to-gate inventory results separately or a clear statement that confidentiality is a limitation to providing this information
	• Companies shall not include the following when quantifying inventory results: weighting factors for delayed emissions; offsets; and avoided emissions
	• Companies shall report the amount of carbon contained in the product or its components that is not released to the atmosphere during waste treatment, if applicable
	• For cradle-to-gate inventories, companies shall report the amount of carbon contained in the intermediate product

Table [3.1] Summary of requirements (continued)

Chapter	Requirements

12. Assurance	• The product GHG inventory shall be assured by a first or third party
	• Companies shall choose assurance providers that are independent of, and have no conflicts of interest with, the product GHG inventory process
	• Companies shall report the assurance statement in the inventory report The statement shall include:
	  • The level of assurance achieved (limited or reasonable) including assurance opinion or the critical review findings
	  • Whether the assurance was performed by a first or third party
	  • A summary of the assurance process
	  • The relevant competencies of the assurance providers
	  • How any potential conflicts of interest were avoided for first party assurance

13. Reporting	Companies shall publicly report the following information to be in conformance with the *GHG Protocol Product Standard*:
	General Information and Scope
	• Contact information
	• Studied product name and description
	• The unit of analysis and reference flow
	• Type of inventory: cradle-to-grave or cradle-to-gate
	• Additional GHGs included in the inventory
	• Any product rules or sector-specific guidance used
	• Inventory date and version
	• For subsequent inventories, a link to previous inventory reports and description of any methodological changes
	• A disclaimer stating the limitations of various potential uses of the report including product comparison
	Boundary Setting
	• Life cycle-stage definitions and descriptions
	• A process map including attributable processes in the inventory
	• Non-attributable processes included in the inventory
	• Excluded attributable processes and justification for their exclusion
	• Justification of a cradle-to-gate boundary, when applicable
	• The time period
	• The method used to calculate land-use change impacts, when applicable
	Allocation
	• Disclosure and justification of the methods used to avoid or perform allocation due to co-products or recycling
	• When using the closed loop approximation method, any displaced emissions and removals separately from the end-of-life stage
	Data Collection and Quality
	• For significant processes, a descriptive statement on the data sources, data quality, and any efforts taken to improve data quality
	Uncertainty
	• A qualitative statement on inventory uncertainty and methodological choices. Methodological choices include:
	  • Use and end-of-life profile
	  • Allocation methods, including allocation due to recycling
	  • Source of global warming potential (GWP) factors used
	  • Calculation models

Table [3.1] Summary of requirements (continued)

Chapter	Requirements

13. Reporting (continued)	**Inventory Results**
	• The source and date of the GWP factors used
	• Total inventory results in units of CO_2e per unit of analysis, which includes all emissions and removals included in the boundary from biogenic sources, non-biogenic sources, and land-use change impacts
	• Percentage of total inventory results by life cycle stage
	• Biogenic and non-biogenic emissions and removals separately, when applicable
	• Land use impacts separately, when applicable
	• Cradle-to-gate and gate-to-gate inventory results separately (or a clear statement that confidentiality is a limitation to providing this information)
	• The amount of carbon contained in the product or its components that is not released to the atmosphere during waste treatment, when applicable
	• For cradle-to-gate inventories, the amount of carbon contained in the intermediate product
	Assurance
	• The assurance statement including:
	  • Whether the assurance was performed by a first or third party
	  • Level of assurance achieved (limited or reasonable) and assurance opinion or the critical review findings
	  • A summary of the assurance process
	  • The relevant competencies of the assurance providers
	  • How any potential conflicts of interests were avoided for first party assurance
	Setting Reduction Targets and Tracking Inventory Changes
	• Companies that report a reduction target and/or track performance over time shall include the following:
	  • The base inventory and current inventory results in the updated inventory report
	  • The reduction target, if established
	  • Changes made to the inventory, if the base inventory was recalculated
	  • The threshold used to determine when recalculation is needed
	  • Appropriate context identifying and describing any significant changes that trigger base inventory recalculation
	  • The change in inventory results as a percentage change over time between two inventories on the unit of analysis basis
	  • An explanation of the steps taken to reduce emissions based on the inventory results

14. Setting Reduction Targets and Tracking Inventory Changes Over Time	*Note: Setting a reduction target and tracking inventory changes over time is not required to claim conformance with the Product Standard. However, if companies choose to set a reduction target, the following requirements apply.* To set reduction targets and track inventory changes over time, companies shall: • Develop and report a base inventory that conforms with the requirements of this standard • Recalculate the base inventory when significant changes in the inventory methodology occur and report those changes • Complete and disclose an updated inventory report including the updated results, the base inventory results, and the context for significant changes • Use a consistent unit of analysis to enable comparison and track performance over time

04

Principles of Product Life Cycle GHG Accounting and Reporting

4.1 Introduction

The five accounting principles are intended to underpin all aspects of GHG accounting and reporting for products. Their faithful application should help to ensure that the product inventory constitutes a true and fair representation of its GHG emissions and removals. Their primary function is to guide users in the implementation of this standard, in particular when making accounting choices not specified by the standard.

4.2 Requirements

GHG accounting and reporting of a product inventory shall follow the principles of relevance, accuracy, completeness, consistency, and transparency.

Relevance

Ensure that the product GHG inventory accounting methodologies and report serves the decision-making needs of the intended user. Present information in the report in a way that is readily understandable by the intended users.

Completeness

Ensure that the inventory report covers all product life cycle GHG emissions and removals within the specified boundaries; disclose and justify any significant GHG emissions and removals that have been excluded.

Consistency

Choose methodologies, data, and assumptions that allow for meaningful comparisons of a GHG inventory over time.

Transparency

Address and document all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to the methodologies and data sources used in the inventory report. Clearly explain any estimates and avoid bias so that the report faithfully represents what it purports to represent.

Accuracy

Ensure that reported GHG emissions and removals are not systematically greater than or less than actual emissions and removals and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable intended users to make decisions with reasonable assurance as to the reliability of the reported information.

05

Fundamentals of Product Life Cycle GHG Accounting

5.1 Introduction

Product life cycle GHG accounting is a subset of life cycle assessment (LCA), which seeks to quantify and address the environmental aspects and potential environmental impacts throughout a product's life cycle from raw material extraction through to end-of-life waste treatment.[1] LCA became internationally standardized by the International Organization for Standardization (ISO) with the publication of the 14040 series of life cycle assessment standards. In 2008, the British Standards Institution (BSI), in partnership with the UK Department of Environment Food and Rural Affairs (DEFRA) and the Carbon Trust, published a Publicly Available Specification (PAS) for the assessment of life cycle greenhouse gas emissions of goods and services, known as PAS 2050.[2]

The *Product Standard* builds on the framework and requirements established in the ISO LCA standards *(14040:2006, Life Cycle Assessment: Principles and Framework and 14044:2006, Life Cycle Assessment: Requirements and Guidelines) and PAS 2050,* with the intent of providing additional specifications and guidance to facilitate the consistent quantification and public reporting of product life cycle GHG inventories. Other standards and publications such as the *ILCD Handbook*[3] were also used as reference during the development of this standard. The following sections clarify the relationship between the ISO LCA framework and the *Product Standard* while identifying two fundamentals on which the *Product Standard* is based: the life cycle and attributional approaches to GHG accounting.

5.2 Requirements

A GHG product inventory shall follow the life cycle and attributional approaches.

Product GHG inventories,[4] also commonly known as product carbon footprints, are a subset of LCA because they focus only on the climate change impact category (the limitations of which are discussed in chapter 1). However, the accounting methodologies and requirements presented in this standard follow the life cycle approach as established by ISO LCA standards 14040 and 14044.

The requirements and guidance in this standard follow the attributional approach to life cycle accounting. The attributional approach is defined as a method in which GHG emissions and removals are attributed to the unit of analysis of the studied product by linking together attributable processes along its life cycle.[5] The attributional approach makes use of primary data provided by a supplier/customer or average (secondary) data for a given process. Explanation of the terms unit of analysis, attributable processes, and primary data are given in chapter 6, chapter 7, and chapter 8, respectively.

Box [5.1] The consequential approach

In addition to the attributional approach, another method of life cycle accounting is the consequential approach. The consequential approach is defined as an approach in which processes are included in the life cycle boundary to the extent that they are expected to change as a consequence of a change in demand for the unit of analysis.[6] The consequential approach makes use of data that is not constrained and can respond to changes in demand (e.g., marginal technology information), where change in demand can occur as a result of changes in production volumes, production technologies, public policies, and consumer behaviors. Although not followed in this standard, the consequential approach can provide valuable insight in certain applications such as evaluating reduction projects or making public policy decisions.

5.3 Guidance

5.3.1 Phases and steps of a GHG inventory

The ISO LCA standards define four phases of a LCA study: the goal and scope definition, inventory analysis, impact assessment, and interpretation. To report the results of an LCA study, ISO also defines critical review and reporting as additional steps. Figure 5.1 shows the general relationship between the ISO LCA phases of an LCA study defined by ISO and the steps to complete a GHG inventory in conformance with this standard.

The life cycle approach is by nature an iterative technique, where each phase or step is dependent on the results or methodologies used in another (previous or subsequent) phase or step. For example, defining the unit of analysis (as defined in chapter 6) is a step that directly impacts the subsequent steps of boundary setting, data collection, and allocation. However, a company may find that to avoid allocation (as defined in chapter 9) they need to redefine the unit of analysis. Likewise, setting the boundary (chapter 7) is the first step in identifying what data are needed by determining attributable processes, but data collection limitations (as defined in chapter 8) may result in excluding some processes from the inventory results and justifying those exclusions in the inventory report. Applying the principles of this standard and clearly setting business goals will help companies ensure that the decisions taken while conducting the inventory and interpreting the final results are relevant to those goals.

5.3.2 Use of product rules and sector guidance

As mentioned in chapter 1, product comparisons, beyond tracking product performance over time, need additional specifications to ensure consistent application of this standard for a product or product category. These specifications are provided within a product rule. A product rule is a document created by a group of stakeholders with an interest in a particular product or product category and the goal of building consensus on the additional specifications needed to

Figure [5.1] Comparison between the phases of an ISO LCA study and the steps of a *Product Standard* GHG inventory

Phases in an ISO LCA study	*Steps in a* product standard *GHG inventory*
goal and scope definition	*business goals (chapter 2)* *principles (chapter 4)* *fundamentals of product life cycle accounting (chapter 5)* *defining the scope (chapter 6)*
inventory analysis (LCI)	*boundary setting (chapter 7)* *data collection and quality assessment (chapter 8)* *allocation (chapter 9)*
impact assessment	*calculating inventory results (chapter 11)*
interpretation	*uncertainty (chapter 10)* *performance tracking (chapter 14)* *reporting (chapter 13)*
reporting & critical review (when applicable to the goal and scope)	*assurance (chapter 12)* *reporting (chapter 13)*

The life cycle approach is by nature an iterative technique, where each phase or step is dependent on the results or methodologies used in another (previous or subsequent) phase or step.

enable comparisons or declarations about the product. An example is a product category rule (PCR) as defined by ISO 14025:2006. Appendix A includes details on what specifications are needed in a product rule to enable different types of comparisons and gives some guidance on creating product rules.

Sector guidance is typically created by a group of stakeholders and sector representatives convened to build consensus on guidance for performing a product GHG inventory within their sector, but without the goal of enabling product comparison.

While using product rules and sector guidance is not required for conformance with this standard, each provides

Table [5.1] **Sector guidance and product rule specifications**

Inventory step	*Sector guidance and product rule specifications*
Chapter 6: Establishing the Scope	• Choosing a studied product (in sector guidance) • Choosing a unit of analysis (functional unit) • Identifying whether a cradle-to-gate inventory is appropriate • Identifying any additional GHGs that are applicable to the product or sector
Chapter 7: Boundary Setting	• Life cycle stage definitions and descriptions • Specific attributable processes • Relevant non-attributable processes • Justified excluded attributable processes (including insignificance threshold) • Use and end-of-life profiles • Time period • Method used to calculate land-use change impacts
Chapter 8: Collecting Data and Assessing Data Quality	• Type of primary data to collect for processes under the reporting company's control • Processes not under the reporting company's ownership/control where primary data should be collected • Secondary data sources and default data values
Chapter 9: Allocation	• Allocation method and appropriate allocation factor • Recycling allocation method
Chapter 10: Assessing Uncertainty	• Default uncertainty values • Likely sources of uncertainty
Chapter 11: Calculating Inventory Results	• The GWP values to use • Default emission factors
Chapter 12: Assurance	• The type of assurance to perform
Chapter 13: Reporting	• Optional reporting elements that would be beneficial to stakeholders • Additional requirements due to communication type (e.g., label)
Chapter 14: Setting Reduction Targets and Tracking Inventory Changes	• The base inventory to set • Definition of changes that would warrant base inventory recalculation

additional specifications that can be useful to companies as they prepare their inventories. Table 5.1 provides some examples of additional specifications for key inventory steps. For definitions and explanations of terms included in the table please see the respective chapters.

Companies using sector guidance and product rules still need to abide by the requirements of the *Product Standard*. For example, companies may use a product rule to help choose an allocation method as long as the method is in conformance with chapter 9 and performed using the attributional approach (e.g., primary supplier or average data). Companies may not use sector guidance or product rules to exclude attributable processes without justification. Any sector guidance or product rules used during the inventory process are disclosed in the inventory report following the reporting requirements (chapter 13).

Product rules and sector guidance should be developed through an inclusive multi-stakeholder process to ensure broad acceptance and facilitate increased consistency and credibility. Guidance and tools in conformance with the *Product Standard* can be found at (www.ghgprotocol.org).

Endnotes

1 International Organization for Standardization, ISO 14044:2006, Life Cycle Assessment: Requirements and Guidelines. Geneva.

2 British Standards Institution et al. PAS 2050:2008: Specification for the assessment of life cycle greenhouse gas emissions of goods and services.

3 European Commission - Joint Research Centre - Institute for Environment and Sustainability, *International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance.* First edition, March 2010. Luxembourg: Publications Office of the European Union, 2010.

4 In the Product Standard, a completed GHG assessment is called a GHG inventory to be consistent with corporate-level GHG accounting. The GHG inventory includes both the collection of data and the calculation of the global warming impact. This is different from the ISO LCA terminology which defines inventory as only the collection of data.

5 Adapted from UNEP and SETAC, *Global Guidance Principles for Life Cycle Assessment Databases.* 2011.

6 Adapted from UNEP and SETAC, *Global Guidance Principles for Life Cycle Assessment Databases.* 2011.

06

Establishing the Scope of a Product Inventory

6.1 Introduction

A well-defined scope[1], aligned with the five accounting principles and the company's business goals, can help ensure the final inventory meets the company's and stakeholder's needs. In addition to identifying which GHGs to account for, establishing the inventory scope involves choosing a product, defining the unit of analysis, and identifying the reference flow. Specific requirements and guidance are detailed in this chapter.

6.2 Requirements

Companies shall account for carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs) emissions to, and removals from, the atmosphere. Additional GHGs included in the inventory shall be listed in the inventory report.

Companies shall account for these six gases in their product GHG inventory if they are emitted during the product's life cycle. Companies should account for any other GHGs whose 100-year GWP values have been identified by the IPCC if they are emitted during the product's life cycle.[2] Any additional GHGs that are accounted for shall be listed in the inventory report to improve transparency.

Removals from the atmosphere typically occur when CO_2 is absorbed by biogenic sources (i.e. plants) and converted to energy during photosynthesis. However, removals may also occur when a product absorbs atmospheric CO_2 during use, or when CO_2 from the atmosphere is used during a processing step. Companies shall also account for all removals of CO_2 from the atmosphere if they are removed during the product's life cycle.

Companies shall define the studied product, unit of analysis, and reference flow.

The studied product is the product on which the GHG life cycle inventory is performed.

The unit of analysis is defined as the performance characteristics and services delivered by the product being studied. The reference flow is the amount of product on which the results of the study are based.

For all final products, companies shall define the unit of analysis as a functional unit.

Final products are goods and services that are ultimately consumed by the end user rather than used in the production of another good or service. Since the function of a final product is known, companies shall define the unit of analysis as a functional unit. The functional unit, like unit of analysis, is defined as the performance characteristics and services delivered by the product being studied. A defined functional unit typically includes the function (service) a product fulfills, the duration or service life (amount of time needed to fulfill the function), and the expected quality level.

For intermediate products where the eventual function is unknown, companies shall define the unit of analysis as the reference flow.

Intermediate products are goods that are used as inputs in the production of other goods and services. For example, a plastic resin that is eventually transformed into plastic car parts is an intermediate product.
In general, an intermediate product is a good that eventually becomes a material input into the life cycle of a final product. Therefore, the service an intermediate product fulfills is often dependent on the final product's function. When that function is unknown to the company performing a GHG inventory on an intermediate product, it is not always possible to define the unit of analysis as the functional unit. In this case, companies shall define the unit of analysis for an intermediate product as the reference flow or amount of product being studied.

6.3 Guidance

6.3.1 Choosing the studied product

A review or screening exercise of all the products a company produces, distributes, buys, or sells[3] is the first step to identifying an individual product to study. Companies should pick a product that is GHG intensive as well as strategically important and aligned with their business goals.

The results of a corporate GHG inventory following the *Corporate* and *Scope 3 Standards* can be used to easily identify products or product categories that are GHG intensive. If this inventory is not available, companies may use environmentally extended input-output (EEIO) tables to estimate the GHG intensity of products based on economic transactions. (See chapter 8 for more information on EEIO tables.) If neither is available, companies may use physical or economic factors to rank products by mass, volume, or spend. This option is least preferred because physical or economic factors alone may not correlate with GHG intensity.

Companies may decide to further evaluate a group of products in more detail. This further evaluation may include looking deeper into where reductions could occur along the product's life cycle, evaluating the company's potential influence on suppliers and customers, researching supplier relationships and potential for engagement, and ranking products based on the ability for marketplace differential. Companies may consult with their product design and/or research and development teams to choose a product for which potential reductions could be met through innovation such as design, material, or manufacturing advancements. Or they may choose a new or emerging product still in prototype or conceptual stage where GHG reductions could be achieved during the product design and implementation stages of development.

Companies should pick a product that is GHG intensive as well as strategically important and aligned with their business goals.

If it is still unclear through screening exercises and further evaluation which product to choose, companies should opt for a product with the largest anticipated strategic impact and GHG reduction potential in the life cycle.

6.3.2 Defining the unit of analysis

Defining the unit of analysis is a critical step in completing a GHG inventory because it directly influences the subsequent steps and results of the inventory. For example:

- The duration/service life is the basis for the product's use profile during boundary setting (chapter 7)
- The reference flow is the basis for all data collection since it defines the magnitude of material or energy inputs and outputs (chapter 8)
- A well-defined unit of analysis can avoid allocation by including the studied product and co-products together (chapter 9)
- The unit of analysis is the basis on which the inventory results are reported, and therefore a transparent unit of analysis is important to ensure inventory results are interpreted and used correctly (chapters 11 and 13)

The following sections provide guidance on defining a product's function, functional unit, and reference flow, as well as defining the unit of analysis for intermediate products and services.

Identifying the function

The function is the service a product provides. When the function is known (i.e., for final products and some intermediate products), the unit of analysis is the functional unit. Some questions a company may ask to help identify a product's function include:

- Why is the product created?
- What purpose does the product serve?
- What defining characteristics or expected level of quality does the product have?

For example, if the studied product is a light bulb, the product is created for the purpose of providing light. The amount of service (e.g., light) that the light bulb provides depends on characteristics such as the amount of luminance and spectrum. In many cases, a product can have several functions; in this step, companies should identify all functions before selecting one to serve as the basis of the functional unit.

Selecting the function(s)

If multiple functions are identified, companies should base the functional unit on the function(s) that best reflects what the studied product was designed to do. For example, paint fulfills the function of providing wall color and surface protection. If the goal of the company is to design paint with longer-lasting color that doesn't have to be reapplied as frequently, that is the function on which the functional unit should be based. More than one function can be represented in a functional unit if applicable to the goal of the company.

Defining the functional unit and reference flow

A well-defined functional unit consists of three general parameters: the magnitude of the function or service; the duration or service life of that function or service; and the expected level of quality. Although not all parameters may be relevant for all products (or some parameters may be mutually exclusive), considering them helps to ensure a robust functional unit definition and makes subsequent inventory steps easier, such as defining the use profile during boundary setting.

There are two approaches to defining the functional unit and reference flow: define the reference flow first and then determine the functional unit based on the amount of product; or define the functional unit first and then determine the amount of product needed to fulfill it. When defining the functional unit first, it is often helpful to base the parameters on product rules, sector guidance, or industry average use-profiles. On the other hand, the reference flow may be defined first to specify an amount of product included in the study. This could be an individual product, bulk packaging of a product, or government- or industry-regulated product specifications (e.g., government-recommended serving sizes for food products). It is helpful to consider which criterion would be most meaningful to the user of the report. For example, a functional unit that requires half a product may be hard for a consumer to understand.

To report efficiency improvements of a product over time, companies should define the functional unit so that, as improvements are made, the reference flow needed to fulfill the same functional unit decreases. Consider, for example, a laptop computer for which the functional unit is average daily use over a 3-year lifetime and the reference flow includes two batteries that each have a 1.5-year useful life. Extending the battery life will reduce the reference flow in subsequent inventories. (See chapter 14 for more information on performance tracking over time.)

Ecolab

Ecolab, the global leader in cleaning, sanitizing, food safety, and infection prevention products and services, performed a GHG inventory on the life cycle of their APEX™ automatic warewashing system. Ecolab selected the function as the delivery of clean and sanitized dishes through an automatic dish machine, which included the necessary individual functions that the APEX™ warewashing system provides (APEX™ Power, APEX™ Rinse Additive, and APEX™ Presoak). They chose the magnitude and duration of the function as its use in a typical food service facility for one year and set the expected level of quality as "clean and sanitized," which requires 180°F water during use.

Using this information, the functional unit was defined as delivering clean and sanitized dishes through an automatic dish machine in a typical food service facility for one year.

The reference flow was defined as the total pounds of product required to fulfill the function, namely:

- 500 racks per day of dishes washed at a typical location with 360 operating days per year
- 1800 parts per million (ppm) average detergent concentration within the dish machine (steady-state assumption)
- 0.15 grams of rinse additive per rack of dishes
- 4000 ppm presoak concentration, dispensed twice per day

By defining a detailed functional unit – considering all functions, quality, magnitude, and duration – Ecolab was able to quickly and accurately define their reference flow. Additionally, the information collected about the use of the product was used during boundary setting (chapter 7) to easily define the use profile.

In some cases, a company produces one product in multiple varieties (e.g., different flavors or colors). When the variation does not have an impact on GHG inventory results (chapter 11), companies may define the functional unit broadly enough so that the GHG inventory report is applicable to all product variations. If the functional unit and subsequent inventory results are applicable to several product variations, this should be noted in the inventory report.

6.3.3 Defining the unit of analysis for intermediate products

Intermediate products are used as inputs into final products, and the company performing the GHG inventory on an intermediate product may or may not know the function of the final product. For example, a steel bar has many uses and therefore the specific end use may be unknown to a steel producing company. On the other hand, a producer of a specialized intermediate product that is manufactured for a specific use will likely know the function of the final product. When the function of the final product is known, companies should define the unit of analysis as a functional unit.

For intermediate products where the function of the final product is unknown, the unit of analysis is the reference flow. A general rule of thumb when defining a reference flow without a functional unit is to use a value that provides meaningful GHG inventory results. This could be a single product or the amount or weight of a typical shipment of product (for example, a box of 50 units or a slab of 100 kilograms) depending on the size of the product and the relative GHG emissions and removals associated with its acquisition and production.

6.3.4 Defining the unit of analysis for services

Defining the unit of analysis for a service should follow the same general procedure outlined in this chapter. As with a good, the magnitude, duration, and quality parameters may be based on sector or product rules, industry average data, or a company-specific reference flow. For example, a home insurance company may define their functional unit as the provision of premium home insurance coverage for one year. The magnitude and quality of the insurance is specific to the definition of “premium.”

Endnotes

1 The product inventory scope is different from the concept of scopes as used in the *Corporate and Scope 3 Standards*.

2 A full list of long-lived GHGs is available in table 2.14 of the IPCC Fourth Assessment Report, 2007.

3 Whether the studied product is produced, distributed, or sold by the reporting company depends on the company’s position in the product’s life cycle. For example, a manufacturing company screens products they produce, while a retail company screens products they buy and sell. More guidance is available in chapter 7.

07 Boundary Setting

7.1 Introduction

The next step in the inventory process is to define the boundary. The boundary identifies which emissions and removals are included in the GHG inventory. During boundary setting, companies should complete the following steps:

- *Identify the attributable processes along the life cycle that are directly connected to the studied product and its ability to perform its function*
- *Group the attributable processes into life cycle stages*
- *Identify the service, material, and energy flows needed for each attributable process*
- *Illustrate the product's life cycle processes through a process map*

The following sections include requirements and guidance to help companies define the boundary of the inventory.

7.2 Requirements

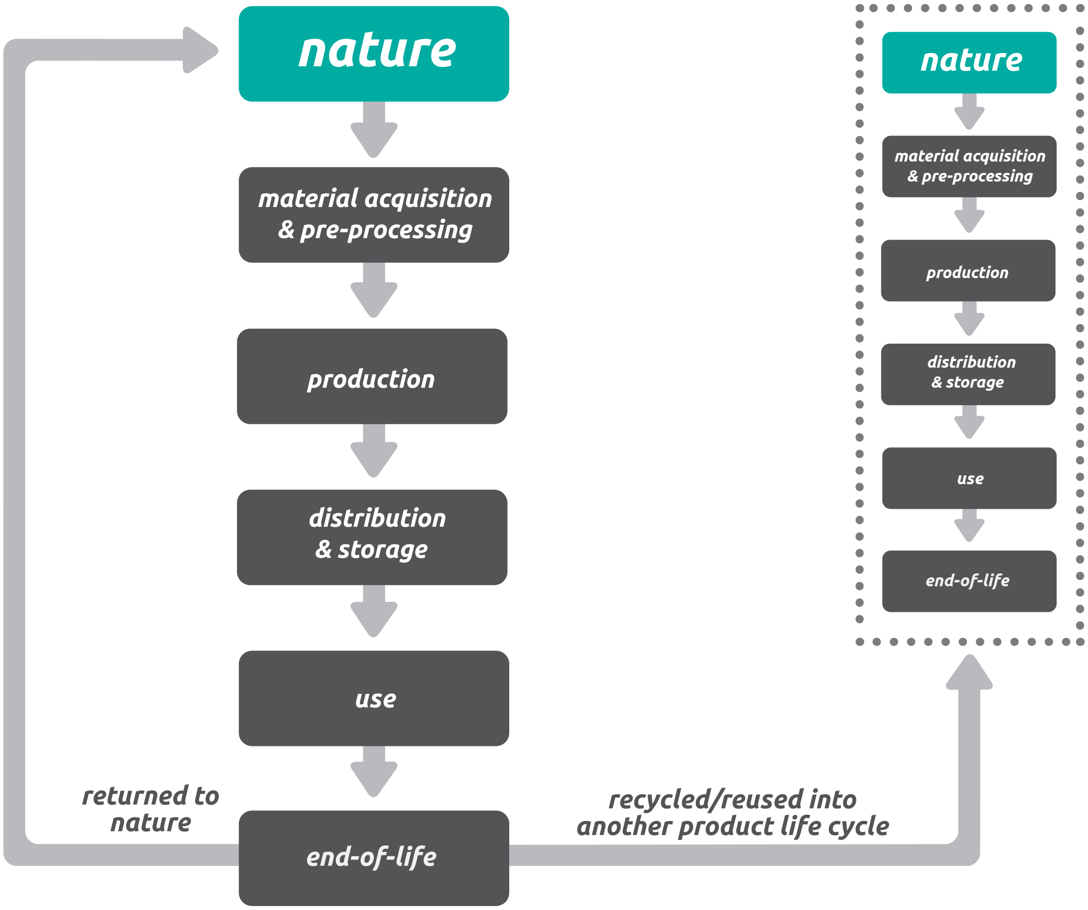
The boundary of the product GHG inventory shall include all attributable processes.

An inventory consists of service, material, and energy flows that become the product, make the product, and carry the product through its life cycle. These are defined as attributable processes. Examples include the studied product's components and packaging, processes that create the product, materials used to improve its quality (e.g., fertilizers and lubricants), and energy used to move, create, or store the product.

Companies shall report the life cycle stage definitions and descriptions.

Interconnected stages make up a product's life cycle, and these are a useful way to organize processes, data collection, and inventory results. The standard identifies

Figure [7.1] The five stages of a product life cycle (simplified for illustrative purposes)



five general life cycle stages, which are illustrated in figure 7.1 and referred to throughout the standard.

Companies may elaborate or classify the stages differently to better reflect a specific product's life cycle. For example, a company may want to disaggregate into more stages (such as separating distribution from storage) or use a term that better describes the processes taking place within the stage, such as service delivery when the studied product is a service. All stages should have clear and logical boundaries and be consecutive and interlinked throughout the life cycle.

Companies shall disclose and justify any exclusions of attributable processes in the inventory report.

Attributable processes may be excluded from the inventory if all of the following are true:

- A data gap exists because primary or secondary data cannot be collected
- Extrapolated and proxy data cannot be determined to fill the data gap
- An estimation determines the data are insignificant

Definitions of data types and guidance on filling data gaps are included in chapter 8.

Companies shall disclose and justify any exclusions of attributable processes in the inventory report. This should include a description of the estimation technique used and the insignificance threshold defined.

RSA

used the results to identify where significant GHG emissions arose in the insurance process

RSA, one of the world's leading multinational insurance groups, delivers services in over 130 countries. RSA performed a GHG inventory on their MORE TH>N® home insurance policy. The MORE TH>N® home insurance policy covers building and contents against damage, loss, or theft. They defined the unit of analysis as the provision of an insurance policy for a period of one year. Recognizing the need to build on the general stages for a service such as insurance, RSA adopted the following life cycle stages for their inventory:

- Customer requesting a quote
- RSA providing a quote
- RSA setting up the policy and any subsequent amendments
- RSA sending correspondence throughout the period of coverage
- RSA servicing claims throughout the period of coverage

RSA then grouped their attributable processes by life cycle stage, and used the results to identify where significant GHG emissions arose in the insurance process. This, in turn, underpins ongoing GHG-reduction work with suppliers.

Companies shall report attributable processes in the form of a process map.

Companies shall include a process map in their inventory report. A process map illustrates the services, materials, and energy needed to move a product through its lifecycle. If specific details are considered confidential, a company may create a simplified version for the report. At a minimum, the reported process map should identify the following items:

- The defined life cycle stages
- The generalized attributional processes in each stage
- The flow of the studied product through its life cycle
- Any attributable processes excluded from the inventory

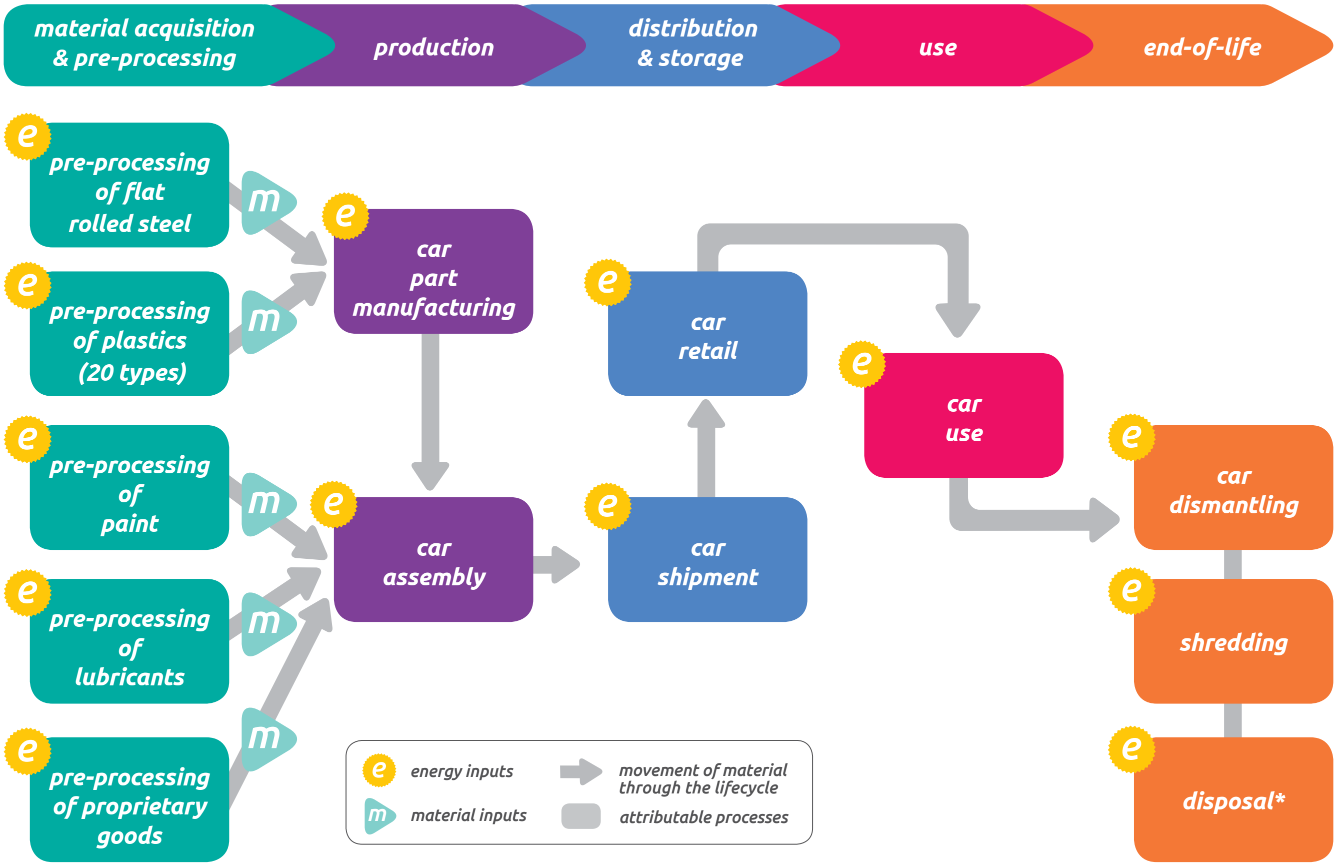
A company should create a detailed process map for internal use and assurance, as it serves as the basis for data collection.

An example of a minimal process map to be reported for the cradle-to-grave inventory of a car is given in figure 7.2.

Companies shall report any non-attributable processes included in the boundary.

Some service, material, and energy flows are not directly connected to the studied product during its lifecycle because they do not become the product, make the product, or directly carry the product through its life cycle. These are defined as non-attributable processes.

Figure [7.2] Sample process map for a car (cradle-to-grave inventory)



** Recycling of parts is not included in this simplified example*

Examples include service, material, and energy flows due to:

- Capital goods (e.g., machinery, trucks, infrastructure)
- Overhead operations (e.g., facility lighting, air conditioning)
- Corporate activities and services (e.g., research and development, administrative functions, company sales and marketing)
- Transport of the product user to the retail location
- Transport of employees to and from works

Companies are not required to include non-attributable processes. However, if non-attributable processes are included in the boundary, companies shall disclose this in the inventory report.

The boundary for final products shall include the complete life cycle, from cradle-to-grave.

The boundary for final products shall include the cradle-to-grave removals and emissions from material acquisition through to end-of-life.

For intermediate products, if the function of the corresponding final product is known, companies should complete a cradle-to-grave inventory.

The boundary of a cradle-to-gate partial life cycle inventory shall not include final product use or end-of-life processes in the inventory results. Companies shall disclose and justify when a cradle-to-gate boundary is defined in the inventory report.

If the function of the final product for which the intermediate product is an input is not known, a cradle-to-gate boundary is defined. Cradle-to-gate is a partial life cycle inventory, including all emissions and removals from material acquisition through to when the intermediate product leaves the reporting company's gate (typically immediately following its production) and excluding final product use and end-of-life. If a cradle-to-gate boundary is defined, companies shall disclose this in the inventory report.

Companies shall report the time period of the inventory.

The time period of the inventory is the amount of time a studied product takes to complete its life cycle, from when materials are extracted from nature until they are returned to nature at the end-of-life (e.g., incinerated) or leave the studied product's life cycle (e.g., recycled). Non-durable goods, like perishable foods or fuels, typically have a time period of one year or less. Durable goods, such as computers, cars, and refrigerators, will typically have a time period of three years or more.

Companies shall report the time period of the total inventory. The time period should be based on scientific evidence to the extent possible, and sector guidance or product rules may be a source of this information when available. If known science, sector guidance, or product rules do not exist, companies should assume a minimum time period of 100 years including the end-of-life stage (i.e., the time period cannot exclude end-of-life if the use stage is more than 100 years).

Companies shall report the method used to calculate land-use change impacts, when applicable.

For studied products whose life cycle includes biogenic materials, land use is reflected in two aspects of the inventory. One is through emissions and removals from attributable processes associated with agricultural and forestry practices such as growth, fertilizer application, cultivation, and harvesting. For example, rice cultivation produces CH_4 emissions that would be included as a material acquisition impact in the inventory of a rice product.

The second contributory aspect of land use is land-use change. Land-use change impacts may be attributable to the studied product's material acquisition and preprocessing stage, including:

- Biogenic CO_2 emissions and removals due to carbon stock change occurring as a results of land conversion within or between land use categories
- Biogenic and non-biogenic CO_2, N_2O, and CH_4 emissions resulting from the preparation of converted land, such as biomass burning or liming[1]

Guidance on determining when land-use change impacts are attributable to the studied product is given in Appendix B. The appendix also includes methods to calculate land-use change impacts for two situations: when the specific land from which the product or product component originates is known and when it is not known. When land-use change impacts are attributable, companies shall include these in the boundary and disclose the calculation method in the inventory report.

Indirect land-use change[2] is defined as land-use change that occurs when the demand for a specific land use (e.g., an increased demand for crops as a bioenergy feedstock in the United States) induces a carbon stock change on other land (e.g., increased need for cropland in Brazil causing deforestation). This displacement is a result of market factors and calculated using data consistent with a consequential approach. Therefore, the inclusion of indirect land-use change is not a requirement of this standard. (See chapter 5 for more information on the consequential versus attributional approach to life cycle GHG inventories.) However, if indirect land-use impacts can be calculated and are determined to be significant for a given product, the magnitude of the impacts should be reported separately from the inventory results.

7.3 Guidance

7.3.1 Defining life cycle stages and identifying attributable processes

The perspective of a company influences the life cycle stage boundaries and definitions. The following guidance provides examples of life cycle stage boundaries, descriptions, and attributable processes from the perspective of a company that is performing an inventory on a final product they produce or sell.

Box [7.1] The role of perspective in product GHG accounting

Multiple entities are involved in the production, distribution, use, and end-of-life of products – including raw material suppliers, manufacturers, distributors, retailers, consumers, etc. Each entity has a different perspective along the life cycle of a given product. Depending on an entity's position in the life cycle, a portion of the product's life cycle emissions and removals occurs prior to their involvement, while the remainder occurs subsequent to their involvement. Figure 7.3 is an example of a company that sells a final product called a widget. In this example, all material acquisition and material processing occurs prior to the company's involvement in the product's life cycle. Figure 7.4 is an example of a company that produces an intermediate product to be used in the production of the widget. In this example, widget production occurs subsequent to the company's involvement in the product's life cycle. Understanding a company's perspective within the life cycle of the studied product is important as it influences the definition of life cycle stages, data collection requirements, and supplier engagement opportunities.

Material acquisition and preprocessing

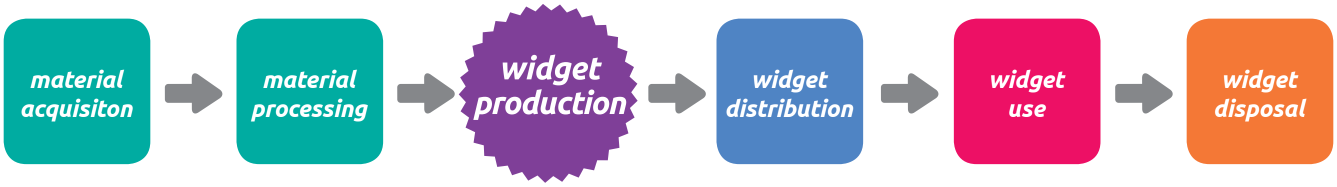
The material acquisition and preprocessing stage starts when resources are extracted from nature and ends when the product components enter the gate of the studied product's production facility. Other processes that may occur in this stage include recycled material acquisition, processing of materials into intermediate material inputs (preprocessing), and transportation of material inputs to the production facility. Transportation may also occur between processes and facilities within the stage, such as the transport of coal by trucks within a coal mining facility or the transport of a petrochemical from the refinery to a preprocessing facility. Examples of attributable processes may include:

Box [7.2] GHG removals

During boundary setting, it is important to document attributable processes for which GHG removals from the atmosphere may occur to ensure removal data are collected later in the inventory process.

The amount of removal calculated for materials of biogenic origin should only reflect the amount of carbon contained, or embedded, in that material. For example, if a product requires 50 tons of wood input that is 50 percent carbon, 25 tons of carbon removal is assumed. To convert carbon to CO_2, the tons of carbon are multiplied by the ratio of molecular weights of CO_2 (44) and carbon (12), respectively. Removals and emissions due to land-use change or other stock changes associated with the use of biogenic materials are accounted for as land-use change impacts and are defined in Appendix B.

Figure [7.3] Perspective of a company producing a final product



- Mining and extraction of materials or fossil fuels
- Photosynthesis (e.g., removal of CO_2 from the atmosphere) for biogenic materials
- Cultivation and harvesting of trees or crops
- Application of fertilizer
- Preprocessing of material inputs to the studied product, such as:
  - Chipping wood
  - Forming metals into ingots
  - Cleaning coal
  - Conversion of recycled material
- Preprocessing of intermediate material inputs
- Transportation to the production facility and within extraction and preprocessing facilities

Production

The production stage starts when the product components enter the production site of the studied product and ends when the finished studied product leaves the production gate. Site and gate are figurative terms, as a product may go through many processes and corresponding intermediate facilities before exiting the production stage as a finished product. Processes associated with co-products or the treatment of wastes formed during production may also be included in this stage. Examples of attributable processes may include:

- Physical or chemical processing
- Manufacturing
- Transport of semi-finished products between manufacturing processes
- Assembly of material components
- Preparation for distribution, e.g., packaging
- Treatment of waste created during production

Product distribution and storage

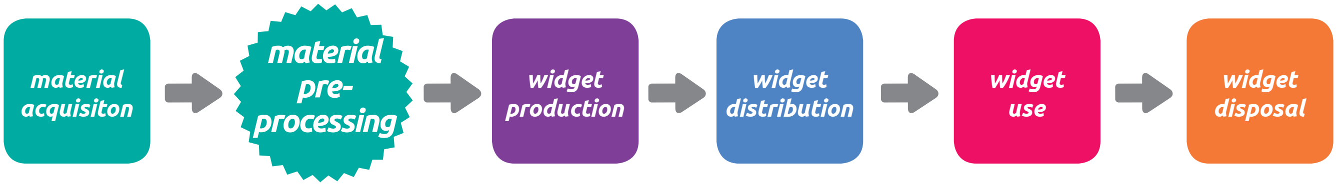
The product distribution and storage stage starts when the finished studied product leaves the gate of the production facility and ends when the consumer takes possession of the product. Several legs of distribution and storage may occur for one product, such as storage at a distribution center and a retail location. Examples of attributable processes may include:

- Distribution center or retail location operations including:
  - Receipt
  - Put away
  - Heating/refrigeration
- Shipping transportation
- Transportation between storage locations

Product use

The use stage begins when the consumer takes possession of the product and ends when the product is discarded for transport to a waste treatment location. The type

Figure [7.4] **Perspective of a company producing an intermediate product**



and duration of attributable processes in the use stage depends heavily on the function and service life of the product. For products that consume energy to fulfill their function, attributable processes in the use stage and their corresponding emissions may account for the largest fraction of impacts over the complete life cycle. Examples of attributable processes may include:

- Transportation to the use location (e.g., consumers driving to their residences)
- Refrigeration at the use location
- Preparation for use (e.g., microwaving)
- Use (e.g., power consumption)
- Repair and maintenance occurring during usage time[3]

End-of-life

The end-of-life stage begins when the used product is discarded by the consumer and ends when the product is returned to nature (e.g., incinerated) or allocated to another product's life cycle (e.g., recycled). Because the main attributable process in the end-of-life stage is the method used to treat the product (land filling, incineration, etc.), companies need to know or assume the fate of the product to map this stage. Examples of attributable processes may include:

- Collection and transport of end-of-life products and packages
- Waste management
- Dismantling of components
- Shredding and sorting
- Incineration and sorting of bottom ash
- Land filling and landfill maintenance

Requirements and guidance for end-of-life recycling are available in chapter 9.

For a service, the production and use stage may be combined into the service delivery stage. This stage encompasses all operations required to complete a service. For example, in the case of home appliance repair, attributable processes may include driving to the home, assessing the appliance, ordering or picking up parts, and returning to complete the final repair. All material flows (e.g., parts needed for the repair), energy flows (e.g., fuel to deliver the service person and/or parts), and end-of-life considerations of materials and wastes make up the attributable processes along the service life cycle.

7.3.2 Developing a process map

Developing a process map is an important requirement when completing an inventory, since processes and flows identified in the process map are the basis for data collection and calculation. Companies may use the following steps:

1. Identify the defined life cycle stages at the top of the map, from material extraction through to end-of-life (or production for cradle-to-gate inventories)
2. Identify the position on the map where the studied product is finished, and exits the reporting company's gate

3. Identify component inputs and upstream processing steps necessary to create and transport the finished product, aligning the processes with the appropriate life cycle stage
4. Identify the energy and material flows associated with each upstream process, including inputs that directly impact the product's ability to perform its function (e.g., fertilizers, lubricants) and outputs such as waste and co-products
5. For cradle-to-grave inventories, identify the downstream processing steps and energy and material flows needed to distribute, store, and use the studied product
6. For cradle-to-grave inventories, identify the energy and material inputs needed for the end-of-life of the studied product

Figure 7.5 illustrates the steps to develop a process map with a generic, simplified cradle-to-grave inventory.

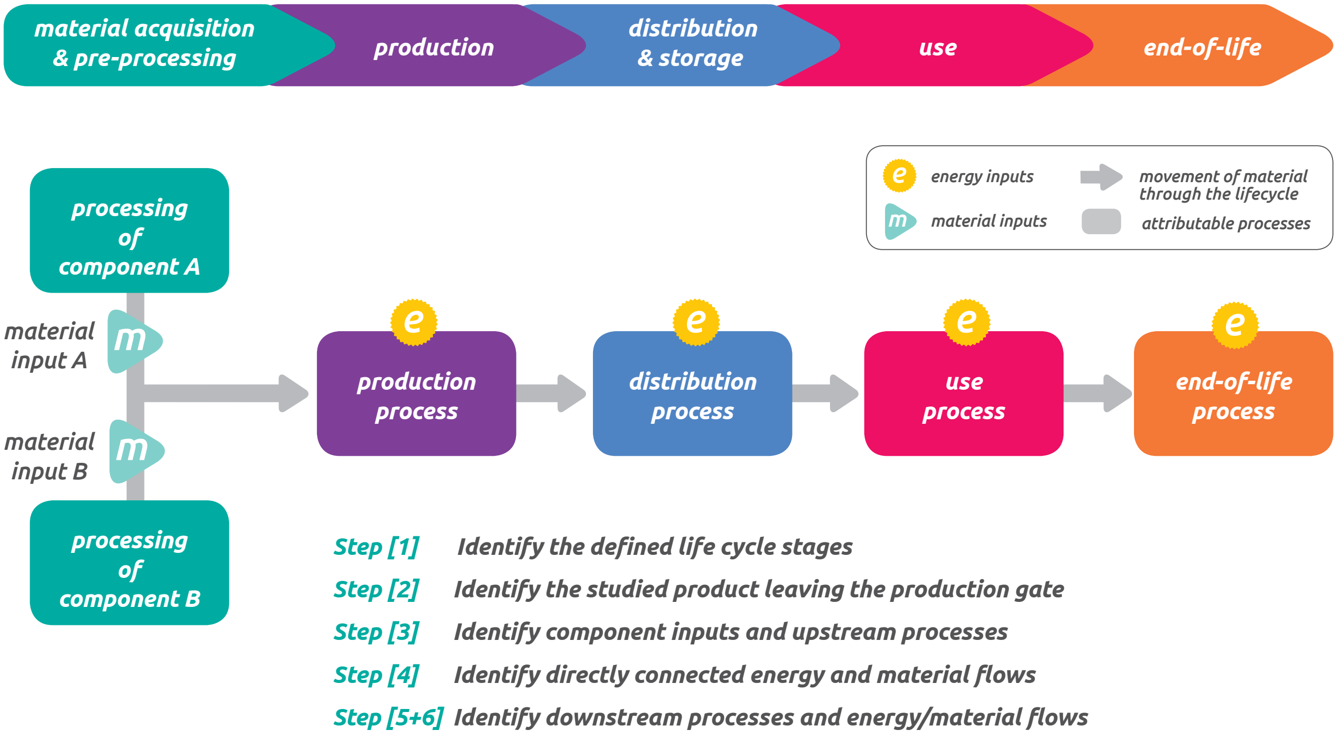
For a cradle-to-gate inventory, the use of the product is unknown and therefore the process map ends when the studied product is a finished intermediate product, typically when it leaves the production stage.

7.3.3 Identifying attributable processes in the use and end-of-life stages

Companies need to make assumptions about the specific attributable processes used to create, distribute, and sell the studied product as they develop their process map. Because the way a product is used (often referred to as the use profile) can vary significantly between users, companies often find it difficult to determine attributable processes for the use stage.

The first step is to look at the functional unit definition for the product. The defined function, as well as the duration and quality of service provided by the product, should help identify the use profile processes. Because the service life does not always correspond directly to the use profile, companies should assume a profile that most accurately represents the use of their product while

Figure [7.5] Illustrative steps to developing a process map for a company that produces a final product



Step [1] *Identify the defined life cycle stages*
Step [2] *Identify the studied product leaving the production gate*
Step [3] *Identify component inputs and upstream processes*
Step [4] *Identify directly connected energy and material flows*
Step [5+6] *Identify downstream processes and energy/material flows*

abiding by the attributional approach of the standard as well as the data collection requirement that specific data be used whenever possible. This could be data collected from customer surveys, when available, or data based on industry average values for the average product use.

Attributable processes in both the use and end-of-life stage can vary significantly between geographical locations. While companies can use global averages, they may find that focusing on a specific region or country provides greater insight into the GHG impacts of the product's use and end-of-life stages. Data collection requirements and guidance are available in chapter 8 to help companies determine the most appropriate use and waste treatment profile.

In the case where more than one use or end-of-life profile is possible, companies may assess the scenario uncertainty (i.e., sensitivity analysis) to understand the impact each potential profile may have on the total inventory results. For example, a company may want users of the report to know the impact that storing food in the freezer for three months versus one year has on the inventory results. More information on scenario uncertainty is available in chapter 10.

7.3.4 Estimating to determine insignificance

To determine insignificance, a company should estimate the process's emissions using data with upper limit assumptions to determine whether, in the most conservative case, the process is insignificant based on either mass, energy, or volume, as well as GHG relevance criteria.

To determine whether an estimate is insignificant or not, a company needs to establish a definition of insignificance which may include a rule of thumb threshold. For example, a rule of thumb for insignificance may be material or energy flows that contribute less than one percent of the mass, energy, or volume and estimated GHG significance over a process, life cycle stage, or total inventory.[4]

For example, consider a process for which there is no primary or secondary data available on material input X other than that it contributes 0.5 grams to the 100 gram total material input for the product. The company estimates that even if material X is a GHG intensive input, 0.5 grams does not exceed one percent of the mass or environmental impact; therefore, the material input is a justified exclusion. The definition of insignificance should reflect the company's business goals for conducting the inventory. As stated previously, companies are required to disclose and justify any exclusion of attributable processes in the inventory report.

TAL

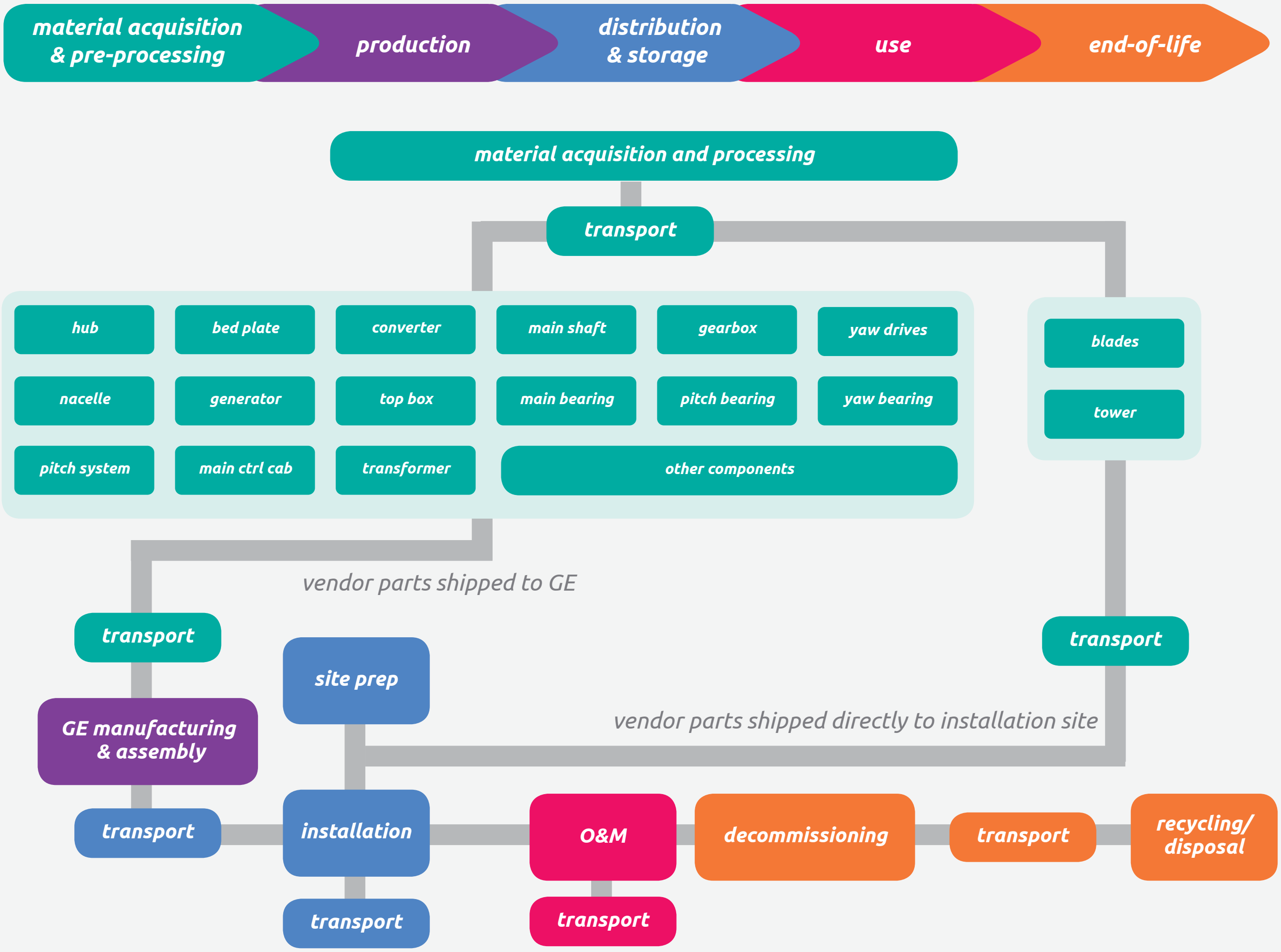
TAL Apparel is a major apparel manufacturer with multiple manufacturing facilities in China and Southeast Asia. While TAL has installed sub-meters for most attributable processes for their non-iron shirt, there are still some attributable processes, such as packing, whose energy use cannot be fully separated from non-attributable processes that also occur in the factory, such as R&D and product testing. After deducting the emissions of metered processes from the overall tally, TAL captured emissions from the remaining processes (attributable and non-attributable) that are not sub-metered by allocating across all products produced in the factory. As a result of using this approach, the product inventory was able to meet the boundary requirement to include all attributable processes. By clearly stating which non-attributable processes were included in the report, TAL also improved the transparency of their inventory results.

7.3.5 Non-attributable processes

Companies are not required to include non-attributable processes (processes that are not directly connected to the studied product) in the boundary. However, companies should include non-attributable processes in the inventory if they cannot be separated from attributable process data, or if the company determines that the process is relevant to the studied product. Relevance is determined by the company and may be based on many different factors including business goals and reduction potentials, product rules or sector guidance, and relative impact in relation to the rest of the inventory.

GE

GE performed a GHG inventory of their GE Energy 2.5xl wind turbine, with the unit of analysis defined as the quantity of electricity delivered to the grid by one 2.5xl wind turbine over its 20-year lifetime. Using the general life cycle stages defined by this standard, GE developed a process map to reflect how the various materials and activities should be categorized within the life cycle. The wind turbine contains over 10,000 parts, so the material acquisition and preprocessing stage processes were simplified to include only the main material inputs while still giving an idea of the magnitude compared to other stages. The production stage includes sub-assembly of various turbine components. The use stage includes operation and maintenance (O&M) that occurs over the 20 years the wind turbine is in operation, including any related transportation to the installation site. The end-of-life stage includes decommissioning (disassembly of turbine) and recycling or disposal of the turbine materials.



NOTE: The upstream and downstream material and energy inputs are not identified in this process map for simplicity.

The results of this inventory showed that 65 percent of the life cycle GHG emissions occur in the material acquisition and preprocessing stage. Including the process map in the inventory report will allow GE's stakeholders to have a visual understanding of not only the life cycle processes attributable to a wind turbine but also the inventory results.

Non-attributable process that may be relevant to some products are capital goods and infrastructure. For example, renewable energy generation such as hydroelectric and wind power require capital infrastructure that may have a large GHG impact relative to the rest of the inventory. This can be determined using the same basis and threshold defined when determining insignificance. Additionally, a company may see corporate activities, a non-attributable process, as a key area of reduction potential and therefore determine they are relevant to include in the product inventory.

7.3.6 Time period

The total inventory time period is dependent on the use and end-of-life stages. The use-stage time period is based on the service life of the product. For example, if the function of a laptop computer is to provide 5,000 computing hours, eight hours a day, five days a week, the use-stage time period would be 2.4 years.

The end-of-life time period is based on the average waste treatment profile of the studied product in the assumed geographic location, and can vary significantly depending on the type of waste treatment assumed and how long it takes for the product's carbon to return to nature. For example, waste that is incinerated has a very short time period compared to waste that is disposed of in a landfill. Additionally, not all waste treatment methods result in the release of the carbon contained in the product into the atmosphere. When a company knows that either all or a portion of a product's carbon does not return to the atmosphere during waste treatment, a company is required to disclose and justify this in the inventory report. For example, lignin is a carbon-based component of wood that does not degrade under anaerobic conditions.[5]

A company may not assume that carbon is stored in a product by shortening the end-of-life time period. It should be known that the carbon is stored indefinitely as a result of waste treatment. For example, a company cannot assign an end-of-life time period of five years to a product that aerobically degrades in ten years.

Box [7.3] Relevance and significance

Both relevance and significance are used in this standard to define similar concepts.

Significance is defined as the size of emissions, removals, or GHG intensity and is used quantitatively throughout the standard. Significance is used in data quality reporting (chapter 8) to describe data that has a large impact on the inventory results. Insignificance is also used in boundary setting and base inventory recalculation (chapter 14) to describe a threshold under which a process or change can be assumed insignificant to the inventory results.

Relevance is a qualitative term used to describe how decisions made during the inventory process impact a company's business goals. Examples of decisions that consider relevance include establishing the scope (chapter 6), including non-attributable processes, and screening during data collection (chapter 8). When making decisions based on relevance, it is usually recommended that companies also consider significance.

7.3.7 Cradle-to-gate inventories

There are two types of intermediate products: when the company manufacturing the intermediate product knows the use profiles of the final product it becomes and when the intermediate product can be used in many different final products and therefore has a variety of possible use profiles. Just like the unit of analysis of an intermediate product (see chapter 6), the boundary requirements are dependent on whether the company knows the use profile (e.g., function) of the final product.

If the use profile is known, companies should perform a full life cycle (cradle-to-grave) inventory of the intermediate product. This provides companies with more reduction opportunities by including the distribution, retail, use and end-of-life stages, and stakeholders with a complete picture of the product's life cycle. An innovative way to do this is to work with the final product producer; using the primary data and expertise they have on the final production, use, and end-of-life can improve the completeness and accuracy of the inventory.

If the use profile is unknown, companies may still decide to perform a cradle-to-grave inventory by picking a representative or average use profile. Alternatively, a cradle-to-gate inventory may be performed. Transparency is important when performing a cradle-to-gate inventory, particularly when a downstream customer of an intermediate product wants to use the cradle-to-gate data to calculate the cradle-to-grave inventory of their final product. As stated previously, companies are required to clearly disclose and justify in the inventory report when a cradle-to-gate boundary is used. For example, an appropriate justification could be lack of knowledge of the final product's use profile. The fact that a cradle-to-gate, and not cradle-to-grave, inventory was performed should also be made clear in the process map and the description of life cycle stages.

A cradle-to-gate inventory performed in conformance with this standard does not include the use and end-of-life stages of the final product. This is to preserve the continuous nature of the life cycle approach and avoid cherry picking (e.g., omitting a GHG-intensive use stage but including the end-of-life stage). In some cases, the company producing the intermediate product may have information on end-of-life processes that would improve the downstream customer's inventory, such as recycling rates or time period. Companies may include additional information about the end-of-life stage in the report of a cradle-to-gate inventory, as long as it is clearly separated from the inventory results (e.g., the total CO_2 equivalents [CO_2e] per unit of analysis) and process map.

Endnotes

1 This refers only to biomass burning, liming, and other practices used to prepare converted land. Biomass burning and fertilizer application due to agricultural and forestry practices are also included in the inventory as attributable processes, separate from land-use change impacts.

2 Indirect land use does not refer to the direct land used to produce an attributable input into the studied product (e.g., the land used to produce animal feed which is an attributable input for the studied product beef).

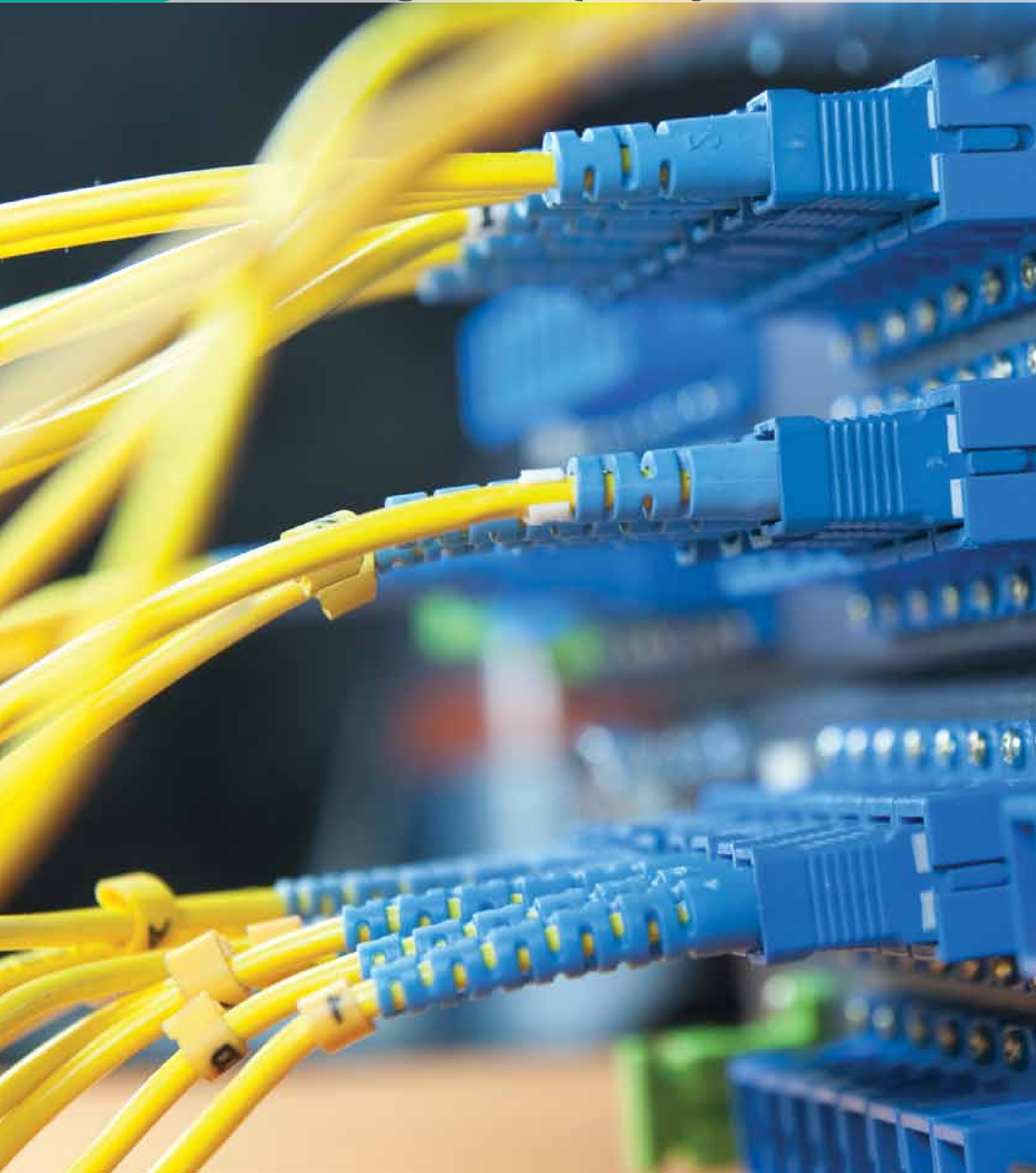
3 Material inputs such as part replacement due to operation and maintenance may fall within the use or material acquisition stage. Although the process occurs in the use stage, it may be easiest during data collection to include all emissions associated with that material input over the product's life cycle during material acquisition. For example, if the product requires two timing belts during its service life, companies can either assume one during material acquisition and one during use, or both during material acquisition. Either is appropriate as long as this is made transparent in the inventory report.

4 Companies may determine significance based on the process, life cycle stage, or inventory level as long as this is done consistently throughout the inventory.

5 Treating waste under anaerobic conditions means that the waste degrades with limited oxygen. This typically occurs in landfills where oxygen is unable to penetrate buried waste.

08

Collecting Data and Assessing Data Quality



8.1 Introduction

Data collection can be the most resource intensive step when performing a product GHG inventory. Data can also have a significant impact on the overall inventory quality. This chapter provides requirements and guidance to help companies successfully collect and assess the quality of their inventory data.

8.2 Requirements

Companies shall collect data for all processes included in the inventory boundary.

Companies shall collect primary data for all processes under their ownership or control.

Primary data are data collected from specific processes in the studied product's life cycle. Primary data can be process activity data (physical measures of a process that results in GHG emissions or removals), direct emissions data (determined through direct monitoring, stoichiometry, mass balance, or similar methods) from a specific site, or data that is averaged across all sites that contain the specific process. Primary data can be measured or modeled, as long as the result is specific to the process in the product's life cycle. It is important to note that using the reference flow of the studied product (e.g., mass of finished product) as process activity data is not considered primary data.

Allocated data are considered primary data as long as the data meets the other primary data requirements.

During the data collection process, companies shall assess the data quality of activity data, emission factors, and/or direct emissions data by using the data quality indicators.

Activity data are quantified measures of a level of activity that results in GHG emissions or removals. Emission factors are GHG emissions per unit of activity data. Direct emissions data are data on emissions released from a process (or removals absorbed from the atmosphere) determined through direct monitoring, stoichiometry, mass balance, or similar methods (see section 8.3.4 for more details on data types).

Box [8.1] Definition of ownership or control

A company owns or controls a process if it is under its operational or financial control. The *GHG Protocol Corporate Accounting and Reporting Standard* defines two types of control: financial control and operational control.

A company has financial control over a process if it has the ability to direct the financial and operating policies of the process with a view to gain economic benefits from the activity. For example, financial control usually exists if the company has the right to the majority of benefits of the operation. Similarly, a company is considered to financially control a process if it retains the majority of the risks and rewards of ownership of the operation's assets.

A company has operational control over a process if the company or one of its subsidiaries has the full authority to introduce and implement its operating policies to the process. This criterion is consistent with the current accounting and reporting practice of many companies that report on emissions from facilities for which they hold the operating license. If the company or one of its subsidiaries is the operator of a facility, it is expected that it has the full authority to introduce and implement its operating policies and thus has operational control, except in very rare circumstances.

For more information on ownership and control refer to chapter 3 of the *GHG Protocol Corporate Accounting and Reporting Standard.*

The standard defines five data quality indicators to use in assessing data quality. They are:

- **Technological representativeness:** the degree to which the data reflect the actual technology(ies) used in the process
- **Geographical representativeness:** the degree to which the data reflects actual geographic location of the processes within the inventory boundary (e.g., country or site)
- **Temporal representativeness:** the degree to which the data reflect the actual time (e.g., year) or age of the process
- **Completeness:** the degree to which the data are statistically representative of the process sites
- **Reliability:** the degree to which the sources, data collection methods, and verification procedures used to obtain the data are dependable

Assessing data quality during data collection allows companies to make data quality improvements more efficiently than when data quality is assessed after the collection is complete.

For significant processes, companies shall report a descriptive statement on the data sources, the data quality, and any efforts taken to improve data quality.

Companies need to determine which processes are significant in order to report the data sources, quality concerns, and quality improvement efforts. For example, a process that contributes a substantial amount of GHG emissions relative to the total life cycle emissions is significant. The criteria included in the screening steps below can be helpful to identify significant processes. See the guidance section for examples of reporting on data sources, quality, and improvement efforts for significant processes.

8.3 Guidance

Companies should follow the steps below when collecting data and assessing data quality:

Step 1. Develop a data management plan and document the data collection and assessment processes as they are completed

Step 2. Identify all data needs using the product's process map

Step 3. Perform a screening to help focus data collection efforts

Step 4. Identify data types

Step 5. Collect primary data for all processes under the ownership or control of the reporting company

Step 6. For all other processes, collect primary or secondary data. Assess and document the data quality of the direct emissions data, activity data, and emission factors as the data are collected

Step 7. Improve the data quality, focusing on processes that have a significant impact on the inventory results

The following sections provide guidance on completing each of these steps.

8.3.1 Data management plan

A data management plan is a tool to help companies organize and consistently document the data collection process, including sources of data, assumptions made, and data quality. Documenting the data collection process is useful for improving the data quality over time, preparing for assurance, and revising future product inventories to reflect changes in the product's life cycle. To ensure that all the relevant information is documented, a data management plan should be established early in the inventory process. Detailed guidance on how to create and implement a data management plan is given in Appendix C.

PepsiCo

PepsiCo, Inc. is a leading global food and beverage company whose brands include Pepsi, Lay's, Quaker Oats, Gatorade, and Tropicana. Working with Columbia University, and using sector guidance developed by the Beverage Industry Environmental Roundtable, PepsiCo inventoried the GHG emissions from a 64 ounce (1.9 liter) gable top carton of their Tropicana Pure Premium brand of orange juice using the following six step process:

1. Develop a comprehensive list of materials
2. Develop a process map
3. Collect emissions data
4. Perform a screening analysis
5. Fill data gaps with additional primary data and acceptable secondary data
6. Calibrate against sector guidance and report

By collecting secondary data through the screening analysis step, PepsiCo discovered that the orange growing process was a large emissions contributor to the product inventory. This result led PepsiCo to collect its own primary data since these would be specific to the growing processes used for Tropicana oranges and would allow the company to track performance over time. PepsiCo's selection of primary data was further validated when comparison of the data sources showed the secondary data were less complete and contained significant differences in the fertilizer, on-farm activities, and transportation data.

By using primary data, PepsiCo found that the orange growing process, which included fertilizer use and application, contributed approximately 35 percent of the product's emissions. As a result, PepsiCo is now working with one of its long-term orange growers to test two lower-GHG fertilizers in the growing process.

By using primary data, PepsiCo found that the orange growing process... contributed 35% of the product's emissions.

8.3.2 Identifying data needs

The attributable processes identified during boundary setting and in the process map provide a basis for the list of data that needs to be collected. The data management plan can also be used to organize attributable processes if it is not possible to include them all in a process map.

8.3.3 Data screening

Screening processes based on their estimated contribution to the total life cycle helps companies focus their data collection efforts. While such screening is not required, it may deliver surprising findings and help companies prioritize data collection resources more effectively.

The most effective way to perform screening is to estimate the emissions and removals of processes and process inputs using secondary data and rank the estimates in order of their contribution to the product's life cycle. Companies can then use this list to prioritize the collection of primary or quality secondary data on the processes and process inputs that have the largest impact on the inventory results. If companies choose not to estimate emissions and removals during screening, they should at a minimum identify and focus data collection on processes that are known to consume or produce large amounts of GHG-intensive energy or material inputs.

During the screening process it is also helpful to assess the estimated uncertainty. Processes that contribute significantly to the total life cycle emissions based on data with high levels of uncertainty should be priority areas for data collection.

Processes may be relevant for non-emissions-related reasons for some companies. Under such circumstances, companies may want to use the following criteria, in addition to the ones above, to establish data collection priorities:

- Processes that are significant by spend relative to other processes in the product's life cycle
- Processes with potential emissions reductions that could be undertaken or influenced by the company
- Processes that are controlled by suppliers with strategic importance to the company's core business
- Processes that meet additional criteria developed by the company or industry sector

8.3.4 Identifying data types

Identifying the data types used in an inventory will provide companies with a better understanding of the data and their quality. Typically, data can be gathered in one of two ways:

1. Directly measuring or modeling the emissions released from a process
2. Collecting activity data and emission factors for a process and multiplying the activity data by the emission factor

The sources of data used in the inventory should be documented in the data management plan (see Appendix C). Direct emissions data, activity data (process and financial), and emission factors are types of data defined in this standard.

Direct emissions data

Direct emissions data are derived from emission releases and are determined through direct monitoring, stoichiometry, mass balance, or similar methods. Examples of direct emissions data include:

- Emissions from an incinerator measured through a continuous emissions monitoring system (CEMS)
- A chemical reaction's emissions determined using stochiometric equation balancing
- Fugitive refrigerant emissions determined using a mass balance approach

Activity data

Activity data are the quantitative measure of a level of activity that results in GHG emissions. Activity data can be measured, modeled, or calculated.

There are two categories of activity data: process activity data and financial activity data.

Process activity data

Process activity data are physical measures of a process that results in GHG emissions or removals. These data capture the physical inputs, outputs, and other metrics of the product's life cycle. Process activity data, when combined with a process emission factor, result in the calculation of GHG emissions. Examples of process activity data include:

- Energy (e.G., Joules of energy consumed)
- Mass (e.G., Kilograms of a material)
- Volume (e.G., Volume of chemicals used)
- Area (e.G., Area of a production facility)
- Distance (e.G., Kilometers travelled)
- Time (e.G., Hours of operation)

Box [8.2] Using environmentally extended input-output emission factors

Environmentally extended input-output (EEIO) models estimate energy use and/or GHG emissions resulting from the production and upstream supply chain activities of different sectors and products within an economy. The resulting EEIO emissions factors can be used to estimate GHG emissions for a given industry or product category. EEIO data are particularly useful in screening emission sources when prioritizing data collection efforts.

EEIO models are derived by allocating national GHG emissions to groups of finished products based on economic flows between industry sectors. EEIO models vary in the number of sectors and products included and how often they are updated. EEIO data are often comprehensive, but the level of granularity is relatively low compared to other sources of data.[1]

Financial activity data

Financial activity data are monetary measures of a process that results in GHG emissions. Financial activity data, when combined with a financial emission factor (e.g., environmentally extended input-output [EEIO] emission factor), result in the calculation of GHG emissions.

While process activity data measure the physical inputs, outputs, and other metrics of a process, financial activity data measure the financial transactions associated with a process.

If a company initially collects financial activity data on a process input and then determines the amount of energy or material inputs using a conversion factor, the resulting activity data are considered process data. For example, a company that knows the cost of the fuel consumed in a process and the cost per liter of fuel can easily convert the fuel value into the physical amount of litres consumed in the process.

Emission factors

Emission factors are the GHG emissions per unit of activity data, and they are multiplied by activity data to calculate GHG emissions. Emission factors may cover one type of GHG (for example, CH_4/liter of fuel) or they may include many gases in units of CO_2 equivalents (CO_2e). Emission factors can include a single process in a product's life cycle, or they can include multiple processes aggregated together. Life cycle emission factors that include emissions from all attributable upstream processes of a product are often called cradle-to-gate emission factors. Companies should understand which processes are included in the inventory's emission factors to ensure that all processes in the product's life cycle are accounted for in the data collection process.

The types of emission factors needed depend on the types of activity data collected. For example, if companies collect financial activity data on a material input to a process, they can select an EEIO emission factor to calculate the upstream emissions. Conversely, a company may first collect available emission factors and then decide which type(s) of activity data to collect.

Examples of emission factor sources include life cycle databases, published product inventory reports, government agencies, industry associations, company-developed factors, and peer reviewed literature. A list of databases is available at (www.ghgprotocol.org). More information on calculating emissions and inventory results is available in chapter 11.

Box [8.3] Selecting electricity emission factors

As with data from other emission sources, companies should select electricity emission factors that are geographically specific to the electricity sources used in the product inventory. When an electricity supplier can deliver a supplier-specific emission factor and these emissions are excluded from the regional emission factor, the supplier's electricity data should be used. Otherwise, companies should use a regional average emission factor for electricity to avoid double counting.

8.3.5 Collecting primary data

To achieve conformance with this standard, primary data are collected for all processes[2] under the ownership or control of the reporting company. Primary data are defined as data from specific processes in the studied product's life cycle. Direct emissions data and process activity data can both be classified as primary data if they meet the definition.

Examples of primary data include:

- Liters of fuel consumed by a process in the product's life cycle, either from a specific site or an average across all production sites
- Kilowatt-hours consumed by a process from an individual site or an average across sites
- Kilograms of material added to a process
- GHG emissions from the chemical reaction of a process

Companies typically do not have control over the source of emission factors used to calculate the GHG emissions associated with process activity data, even if the activity data is primary. Therefore, the source of emission factor has no bearing on the classification to meet the primary

Box [8.4] Collecting supplier data

Quality data are important to develop a useful inventory report and to track reductions over time. Therefore, the best type of data from suppliers:

- Are based on process-specific information, not disaggregated site information from a corporate inventory; and
- Provide sufficient supporting information to enable users to understand how the data were gathered, what calculation methodologies were used, and the quality of inventory.

Guidance on how to collect supplier data and develop a data collection strategy is available at (www.ghgprotocol.org).

data requirement and emission factors do not need to be classified as primary or secondary.

If available and of sufficient quality, primary data should be collected for all processes in the product's life cycle. There are several reasons why collecting primary data can be beneficial to a company even if the processes are not under the company's ownership or control. For example:

- Collecting primary data from suppliers throughout the product's life cycle can expand transparency, accountability, and data management to partners in the value chain
- Primary data can better reflect changes in emissions resulting from operational changes taken to reduce emissions, whereas secondary data sources may not reflect such changes
- Collecting primary data enables companies to more effectively track and report progress toward its GHG-reduction goals

8.3.6 Collecting secondary data

Secondary data are defined as data that are not from specific processes in the studied product's life cycle. Direct emission data and process activity data that do not meet the definition of primary data can be classified as secondary. Financial activity data cannot be used to meet the primary data collection requirement and therefore are always classified as secondary.

Examples of secondary data include:

- Average number of liters of fuel consumed by a process, obtained from a life cycle database
- Kilowatt-hours consumed by another similar process used as a proxy in the studied product's life cycle
- Industry-average kilograms of material input into a process
- Industry-average GHG emissions from a process's chemical reaction
- Amount spent on process inputs, either specific to the process or a company/industry average

Secondary data can come from external sources (e.g., lifecycle databases, industry associations, etc.) or can be data from another process or activity in the reporting company's or supplier's control that is used as a proxy for a process in the inventory product's life cycle. This data can be adapted to the process or can be used "as-is" in the studied product's inventory. For example, suppose the studied product's life cycle includes a process using a steam-generating boiler. If the company does not have primary data for the boiler but does have process activity data for a boiler used in another product's life cycle, the company may use this data for the studied product's boiler process.

Box [8.5] Questions to assist with selecting a lifecycle database to use with the *Product Standard*

Many life cycle databases exist, and they vary in their geographic focus, cost, update frequency, and review processes. A few questions to use in the selection of a database are listed below. While these questions can be used to evaluate entire databases, companies are required to assess the quality (both in representativeness and data collection methods) of the individual data points chosen from databases as part of data quality assessment. A list of databases is available at (www.ghgprotocol.org).

1. Are the process data from a collection of actual processes or estimated/calculated from other data sources?
2. Were the data developed using a consistent methodology?
3. For agricultural and forest products, are land-use impacts included in the LCA emissions data? If yes, what impacts are included?
4. How long has the database existed, and how extensively has the database been used?
5. How frequently is the database updated?
6. How current are the data sources used for developing the LCA emissions data?
7. Can uncertainties be estimated for the data?
8. Is there any risk that the data will be perceived as biased and, if so, have the data and methodologies been independently reviewed?

8.3.7 Assessing data quality

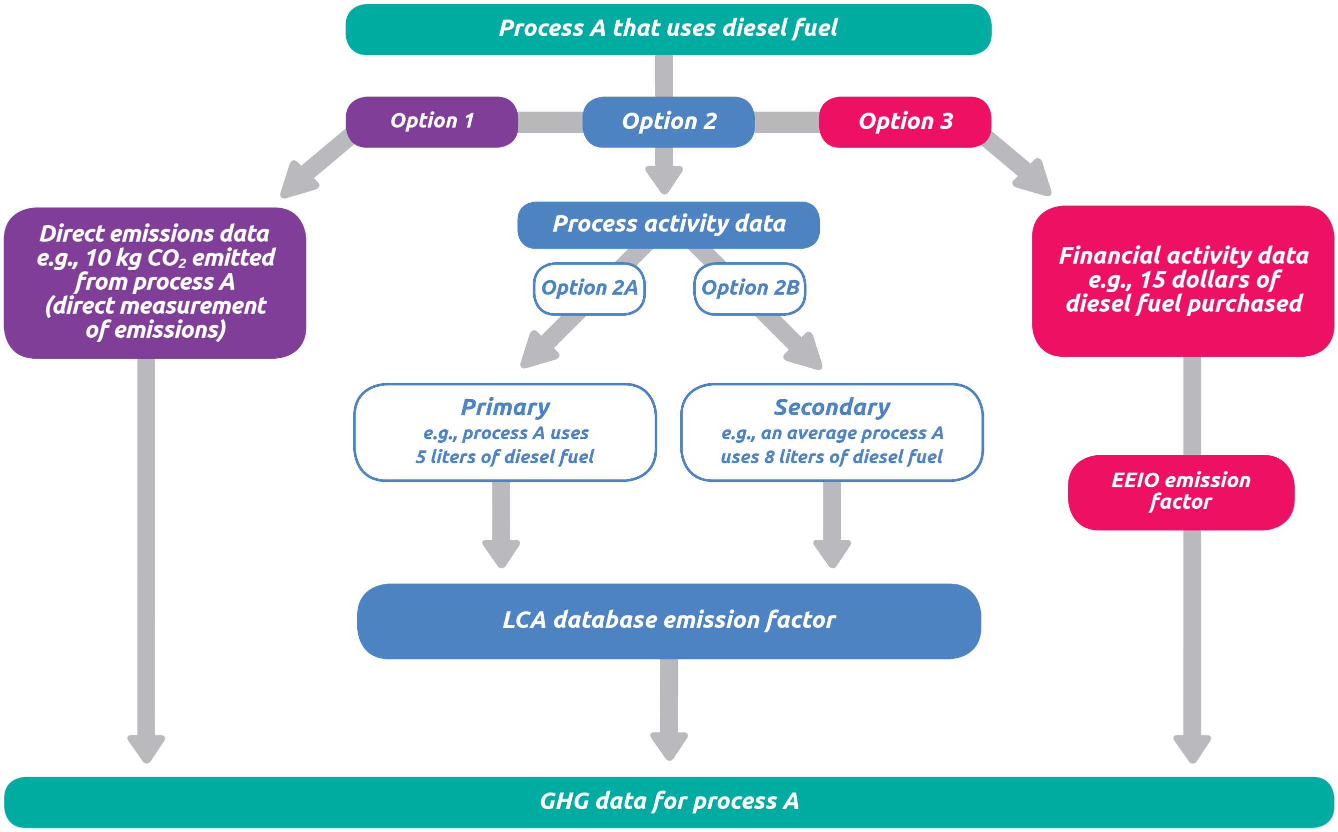
During data collection, there may be cases where several data types (direct emissions data, activity data, emission factors) and data classifications (primary and secondary) are available for the same process. Figure 8.1 illustrates this with an example of 4 different options for collecting the GHG data for process A: direct emissions data (option 1); primary process activity data (option 2A); secondary process activity data (option 2B); and financial activity data (option 3). Companies may also have several choices for emission factors. Assessing data quality during data collection helps companies determine which data most closely represents the actual emissions released by the process during the studied product's life cycle.

Data quality should not be based on intuition or assumption (e.g., primary data is always better than secondary). Companies are required to assess data quality using data quality indicators. Data quality indicators can be used to qualitatively or quantitatively address how well the data characterizes the specific process(es) in the product's life cycle. Generally, data quality can indicate how representative the data are (in time, technology, and geography) and the quality of the data measurement (completeness of data collection and the reliability of the data).

Assessing data quality is valuable for a number of reasons, including:

1. Improving the inventory's data quality. The results of a data quality assessment can identify which data sources are of low quality, allowing companies to improve the overall inventory quality by collecting different data of higher quality
2. Assisting the assurance process. An assurer may request information on the quality of the data used in the product inventory
3. Demonstrating to stakeholders the quality of the data used in the product inventory

Figure [8.1] Options available to calculate the GHG data for process A



Data quality indicators and methods

The five data quality indicators used to assess individual data points for processes in the product inventory are listed in table 8.1.

There are multiple methods for using indicators to assess data quality, including the qualitative data quality assessment method outlined in this standard. Regardless of the method used, companies should document the approach and results in the data management plan to support the assurance process, ensure internal inventory quality controls, and track data quality improvements over time.

Improving the quality of data for large emission sources can result in a significant improvement in the overall inventory quality. Therefore, if resource constraints exist, companies should focus data assessment and subsequent collection of higher quality data on the largest sources of emissions.

Qualitative data quality assessment

The qualitative data quality assessment approach applies scoring criteria to each of the data quality indicators. This rating system has elements of subjectivity. For example, some fuel emission factors do not change significantly over time. Therefore, a fuel emission factor that is over 10 years old, which would be assigned a temporal score of ‘poor’ with the data quality in table 8.2, may not be different from a factor less than 6 years old (a ‘good’ temporal score). Companies should consider the individual circumstances of the data when using the data quality

Table [8.1] Data quality indicators

Indicator	*Description*	*Relation to data quality*
Technological representativeness	The degree to which the data reflects the actual technology(ies) used	Companies should select data that are technologically specific.
Temporal representativeness	The degree to which the data reflects the actual time (e.g., year) or age of the activity	Companies should select data that are temporally specific.
Geographical representativeness	The degree to which the data reflects the actual geographic location of the activity (e.g., country or site)	Companies should select data that are geographically specific.
Completeness	The degree to which the data are statistically representative of the relevant activity. Completeness includes the percentage of locations for which data is available and used out of the total number that relate to a specific activity. Completeness also addresses seasonal and other normal fluctuations in data.	Companies should select data that are complete.
Reliability	The degree to which the sources, data collection methods and verification procedures[3] used to obtain the data are dependable.	Companies should select data that are reliable.

NOTE: Adapted from B.P. Weidema, and M.S. Wesnaes, “Data quality management for life cycle inventories - an example of using data quality indicators,” Journal of Cleaner Production. 4 no. 3-4 (1996): 167-174.

Table [8.2] Sample scoring criteria for performing a qualitative data quality assessment

Score	Representativeness to the process in terms of:				
	Technology	*Time*	*Geography*	*Completeness*	*Reliability*
Very good	Data generated using the same technology	Data with less than 3 years of difference	Data from the same area	Data from all relevant process sites over an adequate time period to even out normal fluctuations	Verified[4] data based on measurements[5]
Good	Data generated using a similar but different technology	Data with less than 6 years of difference	Data from a similar area	Data from more than 50 percent of sites for an adequate time period to even out normal fluctuations	Verified data partly based on assumptions or non-verified data based on measurements
Fair	Data generated using a different technology	Data with less than 10 years of difference	Data from a different area	Data from less than 50 percent of sites for an adequate time period to even out normal fluctuations or from more than 50 percent of sites but for shorter time period	Non-verified data partly based on assumptions or a qualified estimate (e.g., by sector expert)
Poor	Data where technology is unknown	Data with more than 10 years of difference or the age of the data are unknown	Data from an area that is unknown	Data from less than 50 percent of sites for shorter time period or representativeness is unknown	Non-qualified estimate

NOTE: Adapted from Weidema and Wesnaes, 1996.

Table [8.3] Example of reporting on data sources, quality, and improvement efforts for a significant process

Significant process name	*Data sources*	*Data quality*	*Efforts to improve data quality*
Fruit product transport from distribution center to retail store	Activity Data: Average kilometers traveled for produce in Germany Source: Trucking Association Emission Factor: U.K. Defra's Freight Transport	The activity data does not reflect the product's actual transport distance or our company's shipping efficiency practices. The transport emission factor is specific to United Kingdom transport operations and not specific to Germany's transportation system (poor geographic indicator score).	We are working to improve our internal data collection efforts on product distance traveled to obtain country-specific emission factors for truck transport.

criteria results as a basis for collecting new data or when using the results in an uncertainty assessment. (See chapter 10 for requirements and guidance on uncertainty.)

When companies do not know the uncertainty of individual data points in the inventory they may use the data quality indicator scores to estimate the level of uncertainty. For information on this approach see chapter 10. Additional uncertainty calculation guidance and tools are available at (www.ghgprotocol.org).

8.3.8 Reporting on data quality for significant processes

Companies are required to report on the data sources, data quality, and efforts to improve data quality for significant processes. Table 8.3 provides an example of reporting on data sources, quality, and improvement efforts for a significant process. The criteria included in the screening steps can be helpful to identify significant processes.

8.3.9 Additional data quality considerations

In addition to the data quality indicators in table 8.1, companies should consider the following quality considerations:

Allocated data

Data that has been collected to avoid allocation are preferable to data that require allocation. For example, with other data quality indicators being roughly equal, data gathered at the process level that does not need to be allocated is preferable to facility-level data that needs to be allocated between the studied product and other facility outputs. For requirements and guidance on performing allocation see chapter 9.

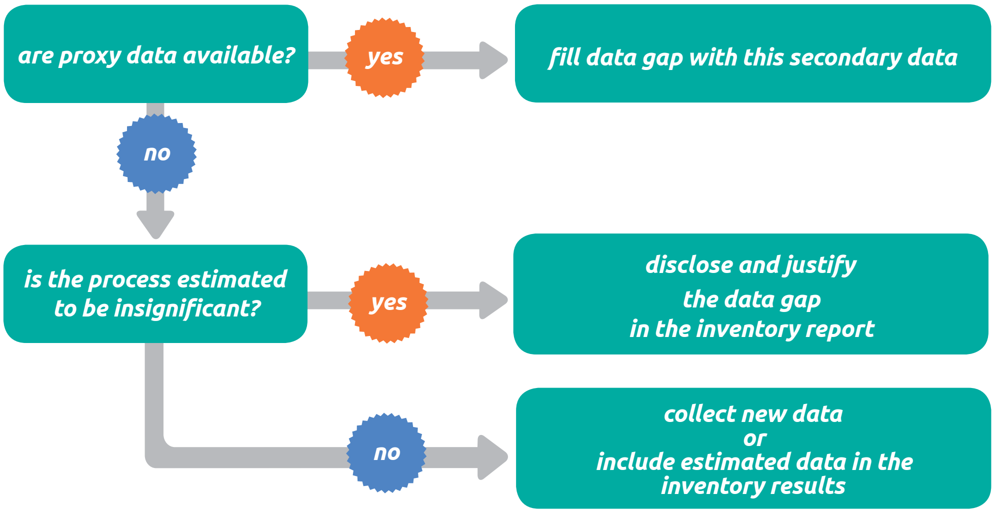
Data transparency

Companies should have enough information to assess the data with the data quality indicators. If there is not enough information on the collection procedures, quality controls, and relevant data assumptions, companies should use that data only if no other data of sufficient quality is available.

Uncertainty

Data with high uncertainty can negatively impact the overall quality of the inventory. More information on uncertainty is available in chapter 10.

Figure [8.2] Decision tree for filling data gaps



8.3.10 Data gaps

Data gaps exist when there is no primary or secondary data that is sufficiently representative of the given process in the product's life cycle. For most processes where data are missing, it should be possible to obtain sufficient information to provide a reasonable estimate. Therefore, there should be few, if any, data gaps. The following sections give additional guidance on filling data gaps with proxy and estimated data.

Proxy data

Proxy data are data from similar processes that are used as a stand-in for a specific process. Proxy data can be extrapolated, scaled up, or customized to represent the given process. Companies may customize proxy data to more closely resemble the conditions of the studied process in the product's life cycle if enough information exists to do so. Data can be customized to better match geographical, technological, or other metrics of the process. Identifying the critical inputs, outputs, and other metrics should be based on other relevant product inventories or other considerations (e.g., discussions with a stakeholder consultant) when product inventories do not exist. Examples of proxy data include:

- Using data on apples as a proxy for all fruit
- Using data on PET plastic processes when data on the specific plastic input is unknown
- Adapting an electricity grid emission factor for one region to another region with a different generation mix
- Customizing the amount of material consumed by a process from another product's life cycle to match a similar process in the studied product

Estimated data

When a company cannot collect proxy data to fill a data gap, companies should estimate the data to determine significance. If processes are determined to be insignificant based on estimated data, the process may be excluded from the inventory results. Criteria for determining insignificance are outlined in chapter 7.

To assist with the data quality assessment, any assumptions made in filling data gaps, along with the anticipated effect on the product inventory final results, should be documented. Figure 8.2 illustrates the guidance for filling data gaps with proxy data or estimated data.

8.3.11 Improving data quality

Collecting data and assessing its quality is an iterative process for improving the overall data quality of the product inventory. If data sources are identified as low quality using the data quality indicators, companies should re-collect data for the particular process. The following steps are useful when improving data quality.

Step 1: Identify sources of low quality data in the product inventory using the data quality assessment results.

Step 2: Collect new data for the low quality data sources as resources allow. Sources with low quality data that have also been identified as significant through the screening process should be given priority.

Step 3: Evaluate the new data. If it is of higher quality than the original data, use in its place. If the data are not of higher quality, either use the existing data or collect new data.

Step 4: Repeat as necessary and as resources allow.

If companies change data sources in subsequent inventories they should evaluate whether this change creates the need to update the base inventory. (See chapter 14 for more information.)

Endnotes

1 UNEP and SETAC, Global Guidance Principles for Life Cycle Assessment Databases. 2011.

2 Non-attributable processes under the control of the company may be included in the inventory without available primary data. This is to be expected if the general rules for collecting quality data are applied, since including non-attributable processes in the inventory is not a requirement of this standard.

3 Verification may take place in several ways, for example by on-site checking, reviewing calculations, mass balance calculations, or cross-checks with other sources.

4 Verification may take place in several ways, e.g., by on-site checking, by recalculation, through mass balance, or by cross-checks with other sources.

5 Includes calculated data (e.g., emissions calculated using activity data) when the basis for calculation is measurement (e.g., measured inputs). If the calculation is based partly on assumptions, the score should be good or fair.

09 Allocation

9.1 Introduction

In most product life cycles, there is at least one common process that has multiple valuable products as inputs or outputs and for which it is not possible to collect data at the individual input or output level. In these situations, the total emissions or removals from the common process need to be partitioned among the multiple inputs and outputs. This partitioning is known as allocation, an important and sometimes challenging element of a product inventory process. Accurately allocating emissions or removals to the studied product is essential to maintaining the quality of a GHG inventory.

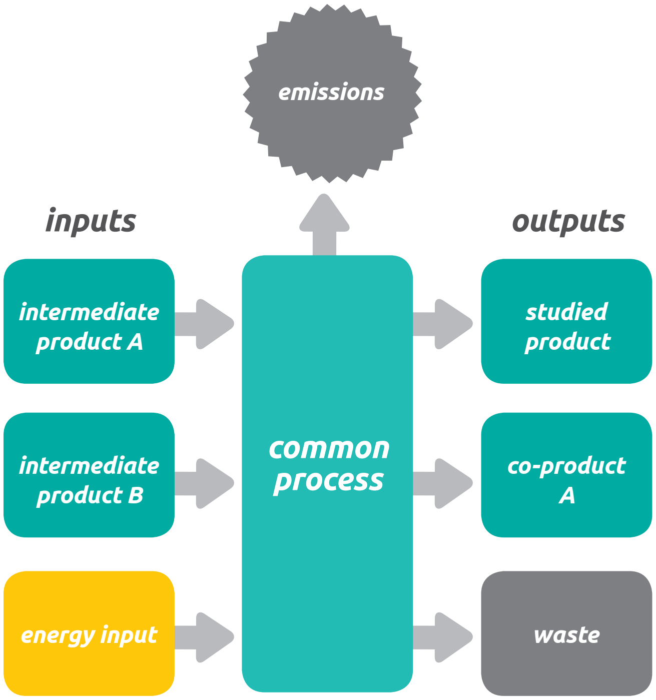
This standard defines two types of products produced from common processes:

- The studied product for which the GHG inventory is being prepared
- Co-product(s) that have value as an input into another product's life cycle

Inputs to the common process may be services, materials, or energy inputs. Outputs may be intermediate or final products, energy outputs (such as electricity or district heat), or waste. A typical common process is illustrated in figure 9.1.

This chapter provides requirements and guidance to help companies choose the most appropriate allocation method to address common processes in their product inventory. In addition, definitions and examples of the methods available to avoid or perform allocation are given. The chapter concludes with guidance, including how to choose between allocation methods. For simplicity, the methods and examples below focus only on emissions. However, removals are also subject to allocation following the same requirements and guidance.

Figure [9.1] Illustrative generic common process that requires allocation[1]



9.2 Requirements

Companies shall allocate emissions and removals to accurately reflect the contributions of the studied product and co-product(s) to the total emissions and removals of the common process.

A studied product, as defined in chapter 6, is the product on which the GHG inventory is performed. A co-product is produced during the studied product's life cycle and has value as an input into another product's life cycle. To abide by the principle of completeness and accuracy, companies shall allocate emissions and removals to accurately reflect the contribution of the studied product and co-product(s) to the total emissions and removals of the common process. A co-product without economic value is considered a waste and, hence, no emissions or removals are allocated.

Companies shall avoid allocation wherever possible by using process subdivision, redefining the functional unit, or using system expansion.

Table 9.1 describes the methods companies shall use to avoid or minimize the use of allocation in a product inventory.

If allocation is unavoidable, companies shall allocate emissions and removals based on the underlying physical relationships between the studied product and co-product(s). When physical relationships alone cannot be established or used as the basis for allocation, companies shall select either economic allocation or another allocation method that reflects other relationships between the studied product and co-product(s).

Table 9.2 describes the methods companies shall use to perform allocation, starting with physical allocation.

Companies shall apply the same allocation methods to similar inputs and outputs within the product's life cycle.

To abide by the principle of consistency, companies shall apply the same allocation methods to similar inputs and outputs, for example, when an allocated co-product output is also an input to another process within the life cycle.

For allocation due to recycling, companies shall use either the closed loop approximation method or the recycled content method as defined by this standard.

Table [9.1] Methods to avoid allocation

Method	*Definition*
Process subdivision	Dividing the common process into sub-processes.
Redefining the unit of analysis	Inclusion of the co-products (additional functions) in the functional unit.
System expansion	Using the emissions from an alternative product that comprises the same functional unit as a co-product to estimate the emissions of the co-product. Only applicable when companies have direct knowledge of the function and eventual use of the co-product.

Table [9.2] Method to perform allocation

Method	*Definition*
Physical allocation	Allocating the inputs and emissions of the system based on an underlying physical relationship between the quantity of product and co-product and the quantity of emissions generated.
Economic allocation	Allocating the inputs and emissions to the product and co-product(s) based on the market value of each when they exit the common process.
Other relationships	Allocating the inputs and emissions to the product and co-product(s) based on established and justifiable relationships other than physical or economic.

Allocation due to recycling processes can be especially challenging. Recycling occurs when a product or material exits the life cycle of the studied product to be reused or recycled as a material input into another product's life cycle. This creates a unique allocation scenario because the common processes for recycling are often shared between different life cycles.

When recycling occurs in a studied product's boundary, companies need to allocate the emissions and removals associated with the extraction and processing of raw materials and the final disposal of products (including recycling) between more than one product life cycle (i.e., the product that delivers the recycled material and the subsequent product which uses recycled material). Therefore, all allocation requirements for common processes also apply to allocation due to recycling.

However, because of the additional complexity associated with recycling processes, this standard provides two specific methods for allocating emissions and removals between product life cycles: the closed loop approximation method and the recycled content method. The closed loop approximation method is a type of system expansion that accounts for the impact that end-of-life recycling has on the net virgin acquisition of a material. The recycled content method allocates the recycling process emissions and removals to the life cycle that uses the recycled material.

If neither the closed loop approximation nor the recycled content method is appropriate, companies may use another method if all of the following are true:

- The method conforms to the allocation and all other requirements of this standard (including being disclosed and justified in the inventory report)
- The method accounts for all emissions and removals due to recycling (i.e., applies an allocation factor between 0 and 100 percent consistently between inputs and outputs to avoid double counting or undercounting emissions)
- The method uses as the basis for allocation (in the following order of preference, if feasible): a physical properties factor, an economic value factor, or a factor based on the number of subsequent uses[2]

Companies shall disclose and justify the methods used to avoid allocation or perform allocation due to co-products or recycling. When using the closed loop approximation method, companies shall report displaced emissions and removals separately from the studied product's end-of-life stage inventory.

Regardless of which allocation methods are used, companies shall report a brief explanation of the choice of specific allocation methods and factors (if applicable) used in the inventory, including why the methods and factors most accurately reflect the studied product's or co-product's contribution to the common process's total emissions and removals (See chapter 13).

When the closed loop approximation method is used in a GHG inventory, the virgin material displacement factor (as described in section 9.3.6) is subtracted from the total inventory results. However, the displacement factor shall be reported separately from the percentage of inventory results by stage to avoid a negative end-of-life value.

9.3 Guidance

9.3.1 Choosing an appropriate allocation method

This standard provides six valid methods for avoiding allocation or for allocating emissions from a common process, each suited to different scenarios.

Figure 9.2 presents a decision process for selecting the best method for avoiding or performing allocation for a given common process in various situations. As shown in figure 9.2, if the output is a waste no allocation is needed. In this case, all emissions are allocated to the studied-product, and the waste treatment is also included as an attributable process. This is because waste without value is not subsequently used. In the situation where waste is subsequently used, that output would have some economic value and is no longer classified as "waste."

9.3.2 Avoiding allocation

Process subdivision

Process subdivision is used to avoid allocation when it is possible to divide the common process into two or more distinct processes. Process subdivision may be done through sub-metering specific process lines and/or using engineering models to model the process inputs and outputs. The common process is disaggregated into sub-processes that separately produce the studied product and co-products. The common process needs to be sub-divided only to the point at which the studied product and its function is isolated, not to the point that every co-product has a unique and distinct process.

Process subdivision should be considered first and is often used together with other methods to avoid or perform allocation, particularly when a single material input is transformed into more than one product. In this case, process subdivision is not possible for all common processes because there is a physical, chemical, or biological separation of the material input. However, process subdivision may only be useful in a limited capacity for less technical common processes if transparent data are not available for all process steps.

EXAMPLE

A petroleum refinery produces many outputs including, but not limited to, gasoline, diesel fuel, heavy oil, petrol, coke, and bitumen. If the studied product is diesel fuel, then only a part of the refinery's total emissions should be allocated to the diesel product. Therefore, the refinery process should be subdivided as much as possible into processes that include only diesel fuel.

However, because diesel fuel comes from one material input (crude oil) which is chemically separated into many different products, process subdivision cannot be used for all allocations. After considering process subdivision and simplifying the common processes as much as possible, a company should allocate or avoid allocation of the remaining common processes using one of the other recommended allocation methods.

Redefining the unit of analysis

Another method to avoid allocation is to redefine the unit of analysis to include the functions of both the studied product and the co-product. For guidance on defining the unit of analysis, see chapter 6.

EXAMPLE

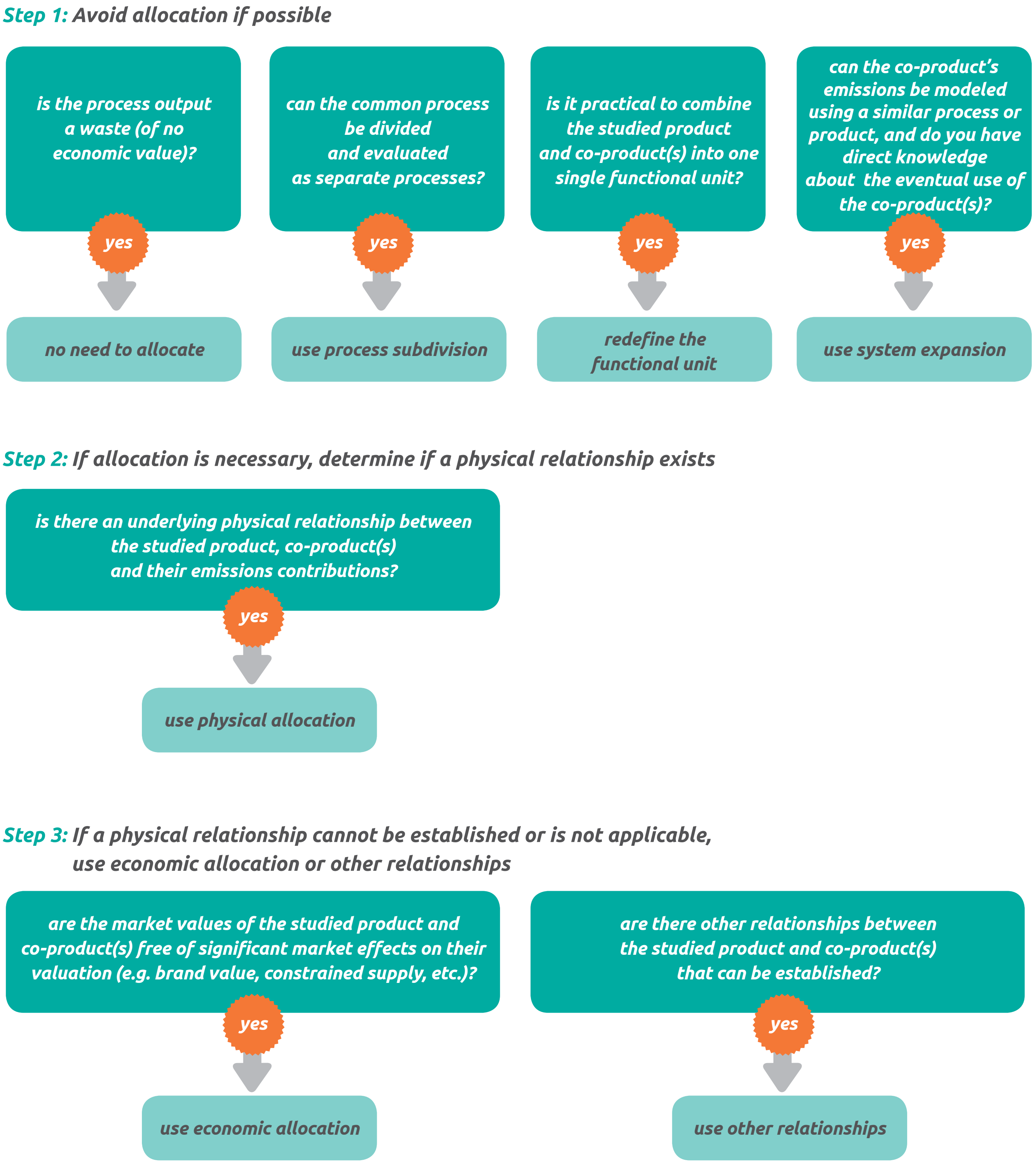
A company produces a PET bottle designed to contain beverages. The company defines the functional unit (unit of analysis) and inventory boundary to include only the processes attributable to producing, using, and disposing of the bottle. The production, use, and disposal processes of the beverage are excluded. However, many processes within the inventory boundary affect both the bottle and the beverage. To avoid allocation the company decides to redefine the functional unit to include the function of the beverage (to be consumed by customers). The functional unit is now defined as one bottle containing one liter of beverage consumed.

System expansion

The system expansion method estimates the emissions and removals contribution of the co-products to the common process by substituting the emissions and removals of a similar or equivalent product or the same product produced by a different product system.[3]

Some life cycle assessment practitioners consider system expansion as a consequential approach to allocation. (See chapter 5 for more information on consequential and attributional approaches to life cycle assessment.) This is true if marginal data or market trends are used to identify the substituted co-product. To ensure the attributional approach is used when performing system expansion, the

Figure [9.2] Steps to select an allocation method[4]



reporting company should know the exact use of the co-product and collect quality supplier-specific and/or average emission factor data to perform system expansion.

When disclosing and justifying which allocation methods were used, companies that use system expansion should explain how the selected substitute (and its associated emissions) a reasonable replacement for the co-product. Companies that are unsure whether system expansion is appropriate for their situation should explore other methods for avoiding or performing allocation.

EXAMPLE

One situation where system expansion may be particularly useful is in allocating incineration emissions between multiple inputs (including the studied product) and an energy co-product. For example, at a pulp mill, wood is converted into pulp and black liquor. Black liquor can be combusted for internal power generation and/or sold as excess power to the grid. To account for the electricity co-product from black liquor, system expansion should be used to identify the emissions associated with the electricity generated using the black liquor (based on average grid values at the mill location). Therefore, if the mill created 1000 kg of GHG emissions and 5 MW of electricity, and the grid data shows that 5 MW of average electricity on the grid is equivalent to 50 kg of GHG emissions, then the mill emissions allocated to the pulp product would be 950 kg (i.e., 1000 kg from the mill - 50 kg from the created

Levi Strauss & Company

Levi Strauss & Co. (LS&Co.) used process subdivision and physical allocation methods for different allocation challenges within the life cycle of a pair of Levi's® Jeans.

Production

LS&Co. collected primary data directly from the two suppliers of the studied product, a Levi's® Jean. The two suppliers were a fabric mill that creates the denim fabric from cotton fiber and a garment manufacturer responsible for cutting, sewing, and finishing the denim fabric into the final jeans.

Physical allocation

For the fabric mill, LS&Co. allocated the GHG emissions from fabric production using a mass allocation factor because mass is one of the main determinants of material and energy inputs during the milling process. The fabric mill provided aggregated data on material use, energy use, production outputs, and waste streams for their full production over the year. The fabric mill only produces denim fabric, so LS&Co. was able to estimate emissions per product by dividing the total facility emissions by the facility output. Emissions per product were then applied to the total LS&Co. fabric order from the mill to determine the total emissions attributable to LS&Co.

Process subdivision

For the garment manufacturer, LS&Co. created a process model to estimate the studied product's emissions. Each step in the garment manufacturing process was modeled according to the capital equipment used for that step. For example, sewing of the back pocket was modeled by the amount of machine minutes it takes to fully complete that assembly step.

Distribution-physical allocation

After production, the jeans are sent to a distribution center that packages and ships various products. LS&Co. allocated emissions from the energy and material used by the total number of products shipped during a year. This method assumes that all units shipped result in the same emissions, which LS&Co. considers to be reasonable since all products go through the same processes at the distribution center.

Retail- physical allocation

Each retail store sells a variety of products, which requires allocating total store emissions to each product type. LS&Co. allocated emissions according to the retail floor space occupied by each product compared to the entire store. They did this by determining the average floor space and emissions of a retail store along with the floor area (physical space) occupied by each product to estimate retail emissions per individual unit.

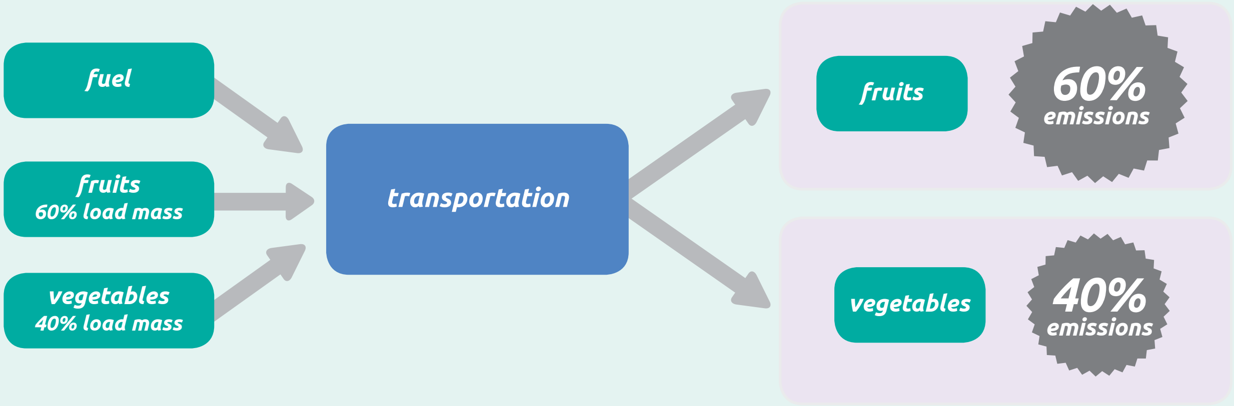
Box [9.1] Using physical relationships to allocate emissions from transportation

Allocating emissions from transportation is necessary when one or more products are transported but a company only knows the total emissions for the transport mode (e.g., a truck, train, aircraft, or vessel).

Transportation example

A truck transports two products: fruits and vegetables. There is a clear physical relationship between the two products and their emissions contributions because the fuel use per unit of product in a transport vessel is dependent on the mass or volume of their load. To determine which physical allocation factor best describes this relationship, a company should determine the limiting factor of the transportation mode (typically mass or volume).

Figure [9.3] Allocating emissions based on a mass physical factor



In figure 9.3, the amount of fruits and vegetables the truck transports are limited by the mass of the products. However, if the fruits and vegetables are transported by rail and the limiting factor is the volume of products, the most appropriate allocation factor would be volume.

Figure [9.4] Allocating emissions based on a volume physical factor

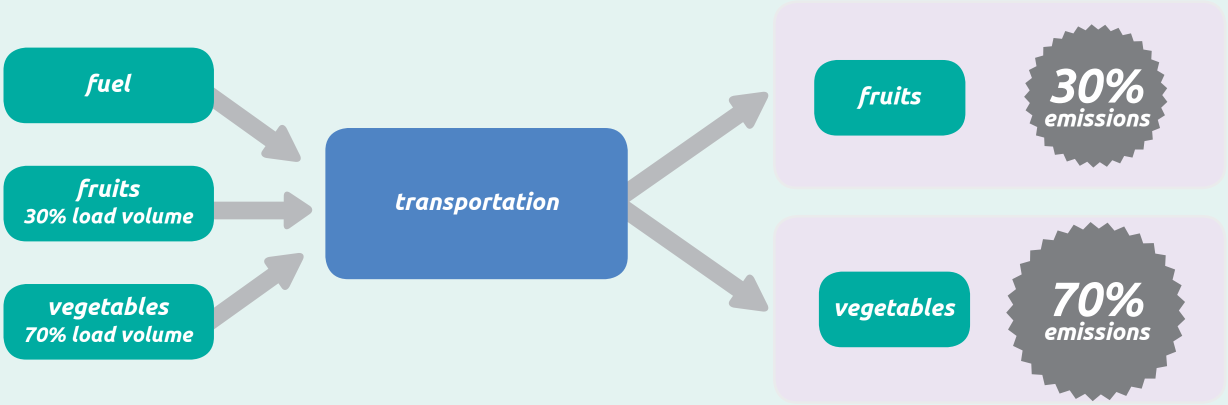


Figure 9.4 shows how the emissions would be allocated using a volume allocation factor.

electricity). In this example, system expansion would not be appropriate if it was not known that the black liquor created excess power or if a marginal emission factor was used as data for the electricity substitution.

9.3.3 Performing allocation

Physical allocation

When performing physical allocation, the factor chosen should most accurately reflect the underlying physical relationship between the studied product, co-product, and process emissions and removals. For example, if the mass of the process outputs determine the amount of emissions and removals, choosing an energy content factor would not provide the most accurate allocation. Examples of physical allocation factors include:

- Mass of co-product outputs
- Volume of cargo transported
- Energy content of heat and electricity co-products
- Number of units produced
- Protein content of food co-products
- Chemical composition

Economic allocation

Economic allocation is the division of emissions from a common process to the studied product and co-product(s) according to the economic values of the products when leaving the multi-output process.

When selecting an economic allocation factor, companies should use the price of the co-product(s) directly after it leaves the common process (i.e., its value prior to any further processing). When this direct price is not available or cannot be evaluated, market prices or prices at a later point of the life cycle may be used, but downstream costs should be subtracted to the fullest extent possible. The market price is the value of the product in a commercial market.

Other relationships

The “other relationships” allocation method uses established sector, company, academic, or other sources of conventions and norms for allocating emissions when neither physical nor economic allocation is applicable.

When no established conventions are available and the other allocation methods are not applicable to the common process, a company may make assumptions

GNP Company, makers of Just BARE Chicken

Net selling price data by meat cut were averaged over a one-year period to determine the economic allocation factor.

GNP Company, a U.S. poultry producer, conducted a product inventory on their Just BARE® Boneless and Skinless Chicken Breasts. Just BARE® products come from birds that receive no antibiotics and are fed special vegetarian feed formulations. The product package contains 2 to 3 individual chicken breasts packaged for retail purchase. Each package is traceable to the specific farm on which the chicken was raised and the product is shipped to retail locations in the continental United States.

The energy and material inputs for Just BARE® as well as other branded products are available on a facility-wide basis. GNP Company identified mass and economic allocation as two potential allocation methods. The chicken breasts represent 16 percent of the chicken’s total mass and about 35 percent of the revenue. While a range of products come from the whole chicken, the majority of consumer demand is for the boneless, skinless breasts. Other fresh chicken co-products such as tenders, thighs, and drumsticks would not be produced without also producing the chicken breasts. Additionally, about half of the weight of the chicken consists of inedible parts that have a low selling price and are not sold in retail stores. Therefore, GNP Company identified economic allocation as the most appropriate method.

Using economic allocation, 35 percent of the facility’s energy and material activity data were allocated to the boneless, skinless breasts. Net selling price data by meat cut were averaged over a one-year period to determine the economic allocation factor.

on the common process in order to select an allocation method. When using assumptions, companies should assess the scenario uncertainty to determine how the assumptions may impact the inventory results. (See chapter 10 for more guidance on assessing uncertainty.)

9.3.4 Choosing between physical and economic allocation

Step 3 in figure 9.2 states that if a physical relationship between the studied product, co-product, and the emissions and removals of a common process is not applicable or cannot be established, then companies should use economic or other relationships. Physical relationships cannot be established when the following conditions apply:

- There is no data available on the physical relationship between the studied product, co-products, and the process emissions and removals (e.g., the process is operated by a supplier and that information is proprietary)
- There are multiple co-products along with the studied product and no one common physical allocation factor is applicable (e.g., some outputs are measured in terms of energy and others in volume or mass)

However, in many cases it may not be clear whether a physical relationship can be established, and companies may struggle to determine if an economic relationship is more applicable. In general, physical allocation is preferred when:

- A physical relationship between the studied product and co-products can be established that reflects their relative emissions contributions
- A change in the physical output of the studied product and co-products is correlated to a change in the common process's emissions (e.g., if more co-product is produced more emissions occur)
- There is a strong brand influence on the market value of the various co-products which does not reflect the relative emissions contribution of the outputs. (e.g., a process creates the same product with different brand names that therefore has different prices, but the relative emissions are the same)

Economic allocation is preferred when:

- The physical relationship cannot be established (as described above)
- The co-products would not be produced using the common process without the market demand for the studied product and/or other valuable co-products (e.g., by-catch from lobster harvesting)
- The co-products were a waste output that acquires value in the market place as a replacement for another material input (e.g., fly ash in cement production)
- The physical relationship does not adequately reflect the relative emissions contributions

EXAMPLE

In the process of catching lobster, additional fish are often caught by default and sold as by-catch. By-catch is much less valuable than lobster, but in some cases can account for a substantial portion of the mass output of the catching process. Economic allocation is preferred in this case because the co-product (by-catch) would most likely not be caught in the same manner if the fisherman were not also catching lobster, and because a change in the physical output of products is not strongly correlated to a change in process emissions (i.e., depending on the day more or less by-catch and lobster are possible using the same amount of fuel).

Box [9.2] Allocating removals

CO_2 removals that occur upstream from a common process also need to be allocated when part of the material that removed the CO_2 from the atmosphere becomes a co-product. In the example illustrating system expansion, black liquor contains lignin and other biogenic materials separated from the wood during pulping. A company needs to determine the amount of the original wood that is exiting the boundary as electricity, and then subtract the equivalent amount of removals from the material acquisition stage. This is also true when a material that contributed to removals is recycled into another product's life cycle. Correctly allocating removals is important to avoid double counting among different products.

9.3.5 Comparing allocation results

When one allocation method is not clearly more suitable than another, companies should perform multiple allocations with different methods and compare the results. This is particularly important when companies are deciding whether physical, economic, or another allocation method is more appropriate. If several methods are performed and similar results are obtained, the choice between the methods should not impact the inventory results and the company should note this in the inventory. report. If the allocation method(s) result in different GHG emissions, companies should select the allocation method that provides the more conservative result (e.g., the method that allocates more emissions to the studied product as opposed to the co-products).

Companies are required to disclose and justify the methods used to avoid allocation or perform allocation. Companies may also report a range of results as part of the qualitative uncertainty description in the inventory report.

9.3.6 Methods for allocation due to recycling

Closed loop approximation method

The closed loop approximation method accounts for the impact that end-of-life recycling has on the net virgin acquisition of a material. Its name derives from the assumption that the material being recycled is used to displace virgin material input with the same inherent properties[5]. The closed loop approximation method is also known as the following: the 0/100 method; the end-of-life approach as defined and supported by many in the metal industry[6]; the recyclability substitution approach in the *ILCD Handbook*[7]; and the closed loop[8] method defined in ISO 14044:2006 and shown with examples in ISO 14049:2000.

Since the closed loop approximation method is defined as a method to allocate recycled materials that maintain the same inherent properties as its virgin material input, the properties (e.g., chemical, physical) of the recycled material have to be similar enough to the properties of the virgin material input to be used interchangeably without any additional changes to the product's life cycle. A process map illustrating the closed loop approximation method is given in figure 9.5.

Alcoa

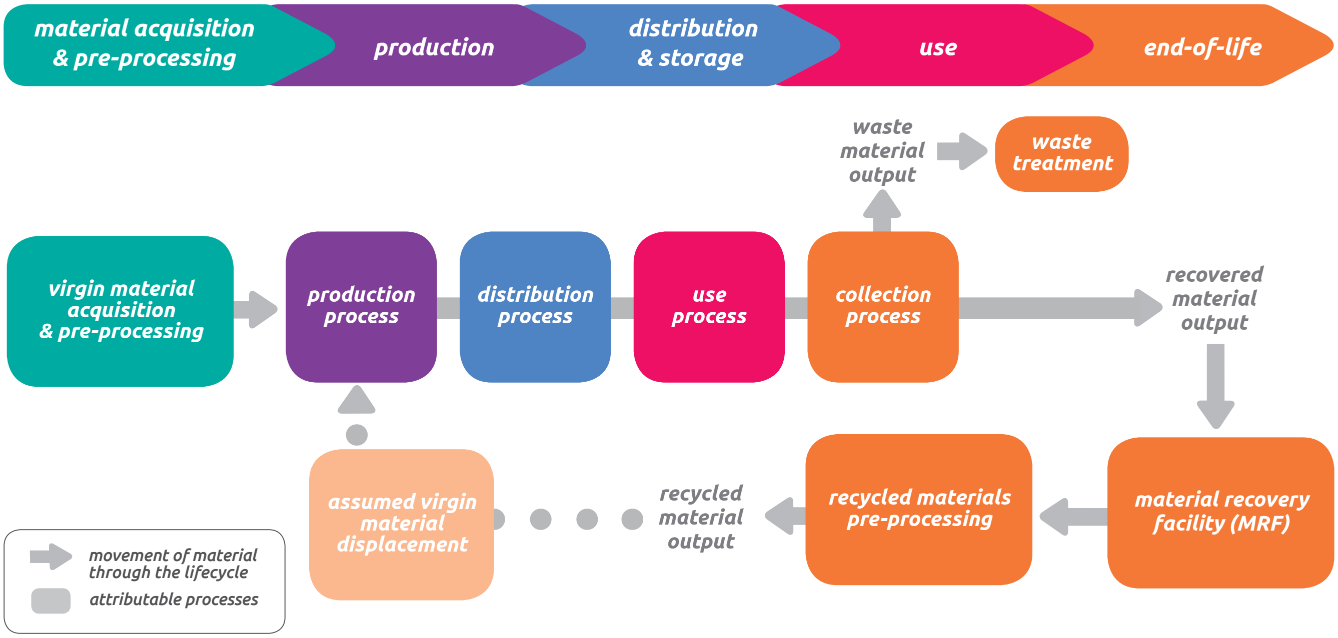
Alcoa, a leading producer of aluminum, performed a cradle-to-grave GHG inventory of their LvL One aluminum truck wheel. Recycling occurs twice during the life cycle of the wheel. First, scrap created during the wheel fabrication process is sent to be recycled in an ingot casting facility, and second, the wheels themselves are recycled at the end-of-life. Both metal streams fall into the category of the closed loop approximation method as described in the standard. The recycled metal is processed, remelted, and cast into secondary aluminum ingot with the same inherent properties as primary metal. Because of this, it can be assumed that the recycled metal displaces the production of virgin metal in another product's life cycle.

achieved a 10% reduction in the total inventory results compared to an LvL One aluminum wheel with no recycling

To account accurately for the recycling activity, Alcoa calculated the mass of recycled metal during the wheel fabrication process using a mass balance. For end-of-life recycling, Alcoa assumed a recycling rate of 95 percent based on peer-reviewed literature data specific to the recycling rates of aluminum in the commercial vehicle sector.

Alcoa achieved a 10 percent reduction in the total inventory results compared to an LvL One aluminum wheel with no recycling.

Figure [9.5] Example process map illustrating the closed loop approximation method



Material recovery facility and recycled material preprocessing are general terms for the attributable processes needed to convert recovered material (e.g., material collected for reuse) into a recycled material output ready to be used in another product system. Specific examples of potential attributable processes include sorting, shredding, cleaning, melting, and deinking.

In the closed loop approximation method no emissions or removals associated with recycling are allocated to another product system. However, the creation of recyclable material results in the displacement of virgin material and the emissions and removals associated with its creation.

The following illustrates how to calculate inventory results for the material acquisition, end-of-life stage, and virgin material displacement using the closed loop approximation method as illustrated in figure 9.5.

Virgin material acquisition and preprocessing stage: All attributable processes due to virgin material acquisition and preprocessing (assumes all input material is virgin).

End-of-life stage: All attributable processes due to end-of-life (including recycling). In figure 9.5 this includes collection[9], waste treatment, material recovery facility, and preprocessing of recycled material.

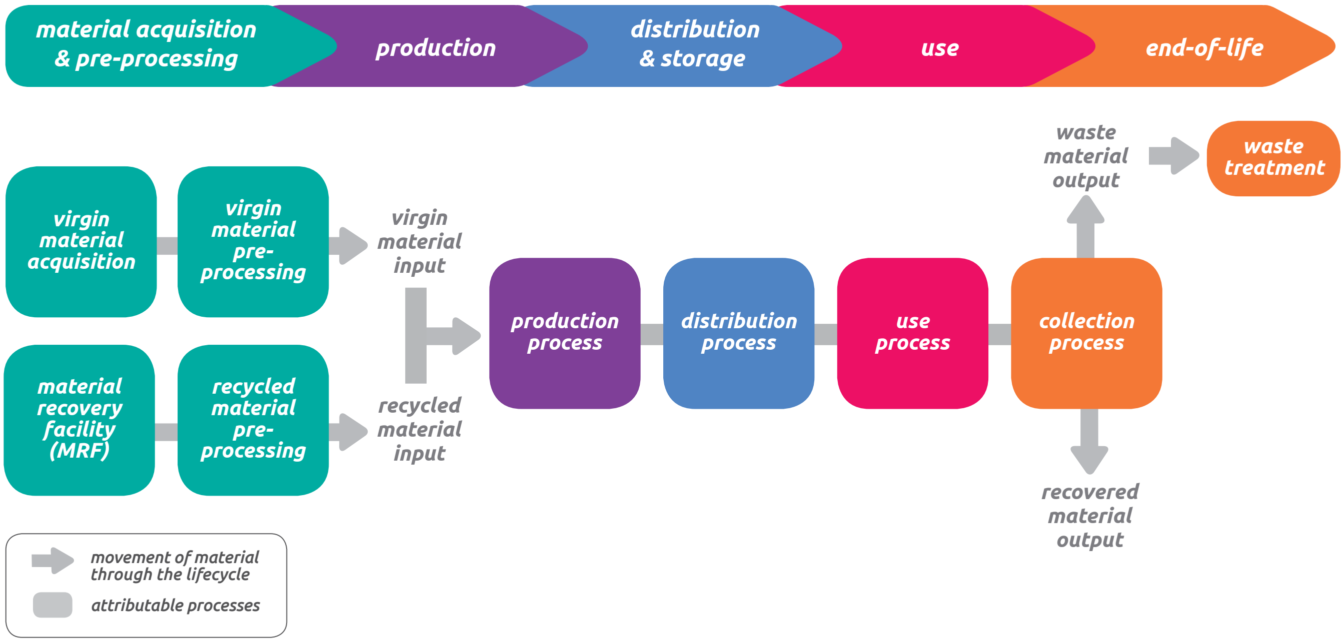
Virgin material displacement factor: Recycling rate of material (recycled output/virgin material input) multiplied by the attributable processes for virgin material acquisition and preprocessing.

The virgin material displacement factor is calculated only for the virgin material that has the same inherent properties as the recycled material. For products with several material inputs, only the attributable processes associated with the displaced material are considered.

Virgin material acquisition and preprocessing impacts should be calculated assuming that all material input is virgin. In the case where recycled material is also used as an input, the material acquisition and preprocessing impacts are calculated assuming all virgin input in order to correctly apply the closed loop approximation method. Alternatively, to avoid double accounting, the recycled content approach can be applied to the recycled input with a closed loop approach applied to the remaining net material output (displacing only the primary material input). However this could be difficult and therefore is not advised.

The closed loop approximation method can also be used for recycling within a life cycle stage (e.g., the creation and reuse of scrap during production).

Figure [9.6] Example process map illustrating the recycled content method



Recycled content method

The recycled content method allocates the recycling process emissions and removals to the life cycle that uses the recycled material. The recycled content method can be used in open loop situations[10] that include recycled material inputs and outputs. Figure 9.6 illustrates a simplified process map for a product that uses the recycled content method[11]. The recycled content method is also referred to as the cut–off method or the 100-0 method.

The following describes the calculation of the material acquisition and end-of-life stages using the recycled content method as illustrated in figure 9.6.

Material acquisition and preprocessing stage: All attributable processes due to virgin and recycled material acquisition and preprocessing. In figure 9.6 this includes virgin material preprocessing, virgin material acquisition, recycled material preprocessing, and material recovery facility.

End-of-life: All attributable processes due to end-of-life treatment of waste material output. In figure 9.6 this includes collection and waste treatment.

The recycled content method does not include attributable processes due to recovered material output.

While a virgin material displacement factor is not included in this method, figure 9.6 does illustrate two potential benefits due to recycling in the studied product's inventory: the reduction in the amount of waste entering waste treatment and the reduction of upstream virgin material acquisition. Reducing the amount of waste entering waste treatment reduces the GHG emissions from waste treatment in the end-of-life stage. Reducing upstream virgin material acquisition reduces the GHG emissions and removals from material acquisition if the recycling processes are less GHG intensive than virgin extraction. If this is not the case (e.g., recycling processes are more GHG intensive than virgin inputs), it is possible that using virgin inputs would result in a lower total product inventory than using recycled inputs. This is an example of when focusing on one impact category may drive companies to make product decisions that are desirable for one impact (e.g., GHG emissions) but unfavorable to another (e.g., material depletion). Companies are encouraged to consider all applicable environmental metrics before making reduction decisions, as discussed in chapter 14.

9.3.7 Choosing between closed loop approximation and the recycled content method

In cases where both the closed loop approximation and recycled content methods are equally applicable to the studied product, the following guidance provides insight on which method is most appropriate in certain situations.

The recycled content method should be used in the following situations:

- When the product contains recycled input, but no recycling occurs downstream
- When the market for the recycled material is saturated (e.g., not all material that is recovered is used as a recycled input, supply exceeds demand) and therefore the creation of recycled material may not displace the extraction of virgin material
- When the content of recycled material in the product is directly affected by the company's activities alone, and therefore the company has control over how much recycled material input to procure (which could potentially be used as a reduction mechanism)
- The time period of the product's use stage is long and/or highly uncertain and therefore the amount of material recycled at the end-of-life is also highly uncertain

The closed loop approximation method should be used in the following situations:

- When the recycled content of the product is unknown because recycled material is indistinguishable from virgin material in the market
- When the market for the recycled material is not saturated (e.g., all material that is recovered is used as a recycled input, demand exceeds supply) and therefore creating more recycled material is likely to increase the amount of recycled material used
- When the time period of the product's use stage is short and/or well known

There may be situations where a company feels neither method is appropriate for a given recycled material input or output. In these cases the method used should abide by the specifications given in the requirements section and be referenced from available sector guidance, product rules, technical reports, journal articles, or other standards. For example, companies with paper products may want to use the "number of subsequent uses" method recommended by the American Forest and Paper Association for recycling cellulosic fiber in paper products.[12] Another company may feel economic allocation is more appropriate for its product's inventory and therefore reference ISO 14049:2000.[13] If a company is using a method that is not published, the company is strongly encouraged to include details on the method, either in the inventory report or as a supplementary document, and to have the method externally verified to ensure its conformance with this standard.

When it is not obvious which method is most appropriate, companies should perform a scenario uncertainty assessment (e.g., sensitivity analysis) on the potential methods and include the results in the inventory report (see chapter 10 for more information on uncertainty).

Box [9.3] Recycling in a cradle-to-gate inventory

As defined in chapter 7, the boundary of a cradle-to-gate inventory does not include the use or end-of-life stages. If an intermediate product has recycled inputs, companies can use the recycled content method and account for the material recovery facility (MRF) and recycling process emissions and removals for that input. If an intermediate product is known to be recycled at its end-of-life regardless of its function during use, companies may report this separately in the inventory report along with any other end-of-life information that may be useful to a stakeholder. Companies may include end-of-life recycling in the inventory results for an intermediate product only if the company knows the function of the final product and performs a cradle-to-grave inventory.

9.3.8 Collecting recycling data

To abide by the attributional approach of the standard, data used to determine the amount of recycled material output is based either on specific recycling data of a product, or on average recycling data for the product in the geographic location where the product is consumed (as defined by the use profile). Recycling data is subject to the same requirements and guidance given in chapter 8 for data collection and quality.

Companies using the closed loop approximation method should ensure that the data used to determine recycled material output excludes material where the inherent properties have changed. Where the only data available aggregates recycled materials, and it is known that some inherent property change occurs, companies should assume a percentage of property loss based on other available data. Examples of other available data include reduction in economic value or percentage loss of material property such as elasticity. Where it is not possible to disaggregate the data but some portion of the material properties are known to change, it should be clearly noted as a data quality limitation in the inventory report.

Anvil Knitwear

Anvil Knitwear, Inc. performed a cradle-to-grave GHG inventory on two of their t-shirt lines: one that contains a pre-consumer recycled yarn input and the other a post-consumer recycled yarn input. The AnvilSustainable™ t-shirt is made from a blend of transitional cotton and recycled polyester (from recycled plastic bottles). The AnvilRecycled® t-shirt is produced from yarn spun from recycled textile waste clippings from textile cut and sew operations. Additionally, clippings from the cut and sew operations of the AnvilRecycled® t-shirt are sold as a recycled material output.

The AnvilSustainable™ t-shirt contains 50 percent post-consumer Polyethylene terephthalate (PET) from recycled plastic bottles and after use is assumed to be disposed of in a conventional landfill. Because no recycling occurs at the end-of-life, Anvil used the recycled content method to account for the recycled PET input. The attributable processes for the material acquisition and preprocessing of recycled PET included the curbside collection, sorting, and flaking of PET bottles.

However, accounting for recycling in the AnvilRecycled® t-shirt was more challenging because of the pre-consumer recycled yarn input and output. In previous assessments, Anvil took a conservative approach of assuming the pre-consumer yarn input had the same emission factor for material acquisition and preprocessing as virgin yarn. However, with the additional guidance provided by this standard and during the road testing process, Anvil determined that the recycled content method was also appropriate for the AnvilRecycled® t-shirt. Anvil performed the recycled content method by including the transport, cleaning, and production of the yarn made from recycled textile clippings as the attributable processes for the acquisition and preprocessing of the yarn. They also assumed no attributable processes for the end-of-life processing of the sold clipping from their cut and sew operations because they are used as a recycled input into other product life cycles. The use of the recycled content method reduced the GHG inventory of the AnvilRecycled® t-shirt significantly compared to the inventory conducted assuming a virgin yarn emission factor. The additional specificity provided in this standard gave Anvil confidence that they were using an established and accepted recycling allocation method.

the recycled content method reduced the GHG inventory of the AnvilRecycled® t-shirt significantly compared to the inventory conducted assuming a virgin yarn emission factor.

Box [9.4] Comparing closed loop approximation and the recycled content method

The closed loop approximation and recycled content method allocate emissions and removals differently, and choosing one method over the other can produce different inventory results. The following simplified example highlights this difference: in this case both methods are equally appropriate for a product that has virgin and recycling material input, recycled material output, and waste.

Example parameters

Data	*Value*	*Units*
Material input	5	tons
Material output	5	tons
Recycled material input	40%	Percent of total input
Virgin material input	60%	Percent of total input
Recycled material output	25%	Percent of total output
Waste output	75%	Percent of total output
Virgin material acquisition and preprocessing	10	kg CO_2e/ton
Recycled material acquisition (MRF) and preprocessing	3	kg CO_2e/ton
Waste treatment	5	kg CO_2e/ton

Example Results

Inventory results (CO_2e)	*Recycled content method*	*Closed loop approximation*
Material acquisition and preprocessing	36	50
End-of-life	19	23
Virgin material displacement factor	0	[13]
Total	55	60*

*Total = material acquisition & pre-processing + end-of-life - virgin material displacement factor

Box [9.4] Comparing closed loop approximation and the recycled content method (continued)

Although in this example using the recycled content method results in lower emissions and removals allocated to the studied product, a different scenario may have the opposite results. To avoid the misuse or misinterpretation of methodological choices, the standard includes the following requirements related to recycling:

- Disclose and justify the method used for recycling;
- Use that same method consistently over time to track performance, or if the method changes recalculate the base inventory as required in chapter 14; and
- Disclose the calculated virgin material displacement separately.

The standard also recommends that companies include quantitative uncertainty results in their inventory report (e.g., sensitivity analysis).

Additionally, a disclaimer is required as part of the inventory report to avoid incorrect comparisons of inventory results based on different allocation methods (see chapter 13 for more details). In cases where choices are needed in a general standard to accommodate a large range of products, companies are encouraged to look towards available product rules and sector guidance to ensure consistency and comparability (if desired) within a product category or sector. Companies can choose a method other than the recycled content or closed loop approximation based on product rules or sector guidance as long as this is disclosed and justified in the inventory report.

Endnotes

1 The term “common process” can be one or more processes that require allocation.

2 As defined in ISO 14044:2006, 4.3.4.3.

3 In some LCA literature, this method is known as the substitution or avoided-burden method.

4 Steps adapted from ISO 14044:2006, 4.3.4.2.

5 A true closed loop recycling scenario occurs when the recycled material does not leave the studied product’s life cycle and therefore does not require allocation.

6 John Atherton, “Declaration by the Metals Industry on Recycling Principles,” International Journal of Life Cycle Assessment, 12 no. 1 (2007):59-60.

7 European Commission - Joint Research Centre - Institute for Environment and Sustainability, International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance.

8 ISO 14044:2006 defines open and closed loop recycling as well as open and closed loop allocation procedures. In ISO 14044, an open loop recycling situation where there is no change in the inherent properties of the material is treated using a closed loop allocation procedure.

9 Collection may be considered part of the material recovery facility in some product life cycles.

10 Recycled material that does not leave a product system (e.g., scraps that do not leave the control of the production company) is an example of a closed loop situation. Material that is recycled at the end-of-life and then used in a different product (e.g., tires being recycled into asphalt) is an example of an open loop situation.

11 The collection process is listed as an attributable end-of-life process; however, the location of this process depends on how the recycled material is collected, as discussed above and in chapter 7.

12 International Working Group, Life Cycle Inventory Analysis: Enhanced Methods and Applications for the Products of the Forest Industry. (Washington DC: American Forest and Paper Association,1996).

13 International Organization for Standardization, ISO 14049:2000, Environmental management — Life cycle assessment — Examples of application of ISO 14041 to goal and scope definition and inventory analysis. Geneva.

10 Assessing Uncertainty

10.1 Introduction

The term uncertainty assessment refers to a systematic procedure to quantify or qualify the uncertainty in a product inventory. Understanding uncertainty can be crucial for properly interpreting inventory results. Identifying and documenting sources of uncertainty can assist companies in understanding the steps needed to improve inventory quality and increase the level of confidence users have in the inventory results. Because the audience for a product inventory report is diverse, companies should make a thorough yet practical effort to communicate the level of confidence and key sources of uncertainty in the inventory results.

This chapter provides requirements and guidance to help companies identify, assess, and report qualitative information on inventory uncertainty. Detailed descriptions of quantitative approaches to assess uncertainty, and an uncertainty calculation tool are available at (www.ghgprotocol.org). While remaining current with leading science and practice, the chapter is intended to favor practicality and feasibility for companies with a range of uncertainty expertise.

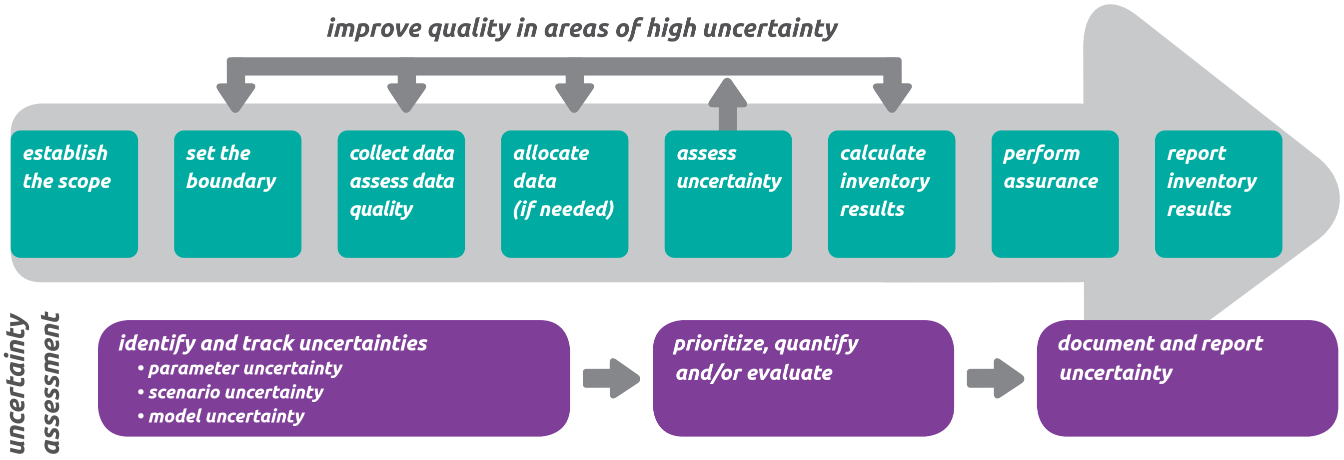
10.2 Requirements

Companies shall report a qualitative statement on sources of inventory uncertainty and methodological choices. Methodological choices include:

- ***Use and end-of-life profile***
- ***Allocation methods, including allocation due to recycling***
- ***Source of global warming potential (GWP) values used***
- ***Calculation models***

See table 10.2 for guidance on reporting on these choices.

Figure [10.1] Iterative process of tracking and evaluating uncertainty



10.3 Guidance

10.3.1 Role of the uncertainty assessment process

Figure 10.1 illustrates the role of uncertainty assessment within the GHG inventory process. Companies should keep a list of uncertainties throughout the inventory process in order to facilitate the uncertainty assessment, assurance, and reporting processes.

While the reporting requirements are focused on qualitative descriptions, quantitative assessments of uncertainty can assist companies in prioritizing data quality improvement efforts on the sources that contribute most to uncertainty and in understanding the influence methodological choices have on the overall product inventory. A quantitative approach can also add clarity and transparency in reporting on uncertainty to inventory report readers. When available, companies should report quantitative uncertainty results in the inventory report. Guidance on quantifying uncertainty can be found at (www.ghgprotocol.org).

10.3.2 Types of uncertainty

The results of a GHG inventory may be affected by various types of uncertainty, which can arise from different sources within the inventory process. Uncertainty is divided into three categories: parameter uncertainty, scenario uncertainty and model uncertainty, which are defined in the following section.

The categories are not mutually exclusive, but they are evaluated and reported in different ways. For example, the same uncertainty source might be characterized as either a component of parameter uncertainty and/or as a component of scenario uncertainty.

As shown in figure 10.1, these types of uncertainties arise throughout the stages of the GHG inventory compilation process. Table 10.1 illustrates these various types of uncertainties and how each type can be presented.

Parameter uncertainty

Parameter uncertainty is the uncertainty regarding whether a value used in the inventory accurately represents the process or activity in the product's life cycle. If parameter uncertainty can be determined it can typically be represented as a probability distribution of possible values including the value used in the inventory results. In assessing the uncertainty of a result, parameter uncertainties can be propagated within a model to provide a quantitative measure (also as a probability distribution) of uncertainty in the final inventory result.

Single parameter uncertainty

Parameter uncertainty addresses the question, how well do the data that are used to represent a parameter fit the process in the product inventory. Single parameter uncertainty refers to incomplete knowledge about the true value of a parameter[1]. It can arise in relation to three data types: direct emissions data, activity data, and emission

Table [10.1] Types of uncertainties and corresponding sources

Types of uncertainty	*Sources*
Parameter uncertainty	- Direct emissions data - Activity data - Emission factor data - Global warming potential (GWP) factors
Scenario uncertainty	- Methodological choices
Model uncertainty	- Model limitations

Box [10.1] Uncertainty of global warming potential factors

The uncertainty of the direct global warming potential (GWP) for CO_2, CH_4, N_2O, HFCs, and PFCs is estimated to be ± 35 percent for the 90 percent confidence interval (5 percent to 95 percent of the distribution). This is based on information provided in the IPCC's Fourth Assessment Report, and the range given is to reflect the uncertainty in converting individual GHG emissions into units of CO_2e. As identified in the requirements section 10.2, companies are required to report the source of GWP values used. If companies choose to quantify inventory uncertainty they may include the uncertainty of GWP values in their calculations.

factors. Measurement errors, inaccurate approximation, and how the data was modeled to fit the conditions of the process all influence parameter uncertainty.

For example, two data points of similar measurement precision may result in very different levels of uncertainty depending on how the data points represent the process's specific context (i.e., in temporal, technological, and geographical representativeness, and completeness terms).

EXAMPLE

An emission factor for the production of the plastic used in a toner cartridge is 4.5 kg of CO_2 per kg of plastic resin produced. The emission factor data might be based on a limited sampling of producers of such resin and may source from an older timeframe or different geography than that in which the resin in question is being produced. Therefore, there is parameter uncertainty in the emission factor value being used.

Propagated parameter uncertainty

Propagation of parameter uncertainty is the combined effect of each parameter's uncertainty on the uncertainty of the total computed result. Methods are available to propagate parameter uncertainty from single data points. Two prominent methods applied to propagation of parameter uncertainty include random sampling (such as the Monte Carlo method) and analytical formulas (such as the Taylor Series expansion method). These methods are described in the quantitative uncertainty guidance available at (www.ghgprotocol.org).

EXAMPLE

Company A inventoried their printer cartridge product and determined that the total inventory results equaled 155 kg CO_2e per functional unit of printing of 50,000 pages. The activity data, emission factor data and GWPs applied in this calculation each have a level of individual parameter uncertainty. Using the Monte Carlo method, the propagated parameter uncertainty assessment shows that there is a 95 percent confidence that the true value of the product inventory is between 140 and 170 kg CO_2e. This can also be presented as the inventory total is 155 kg CO_2e (+/-15 kg CO_2e)[2] per functional unit.

Scenario uncertainty

While parameter uncertainty is a measure of how close the data used to calculate the inventory results are to the true (though unknown) actual data and emissions, scenario uncertainty refers to variation in results due to methodological choices. The uses of standards reduce scenario uncertainty by constraining choices the user may make in their methodology. For example, the attributional approach and boundary setting requirements standardize the inventory approach for all products. However, when there are multiple methodological choices available in the standard scenario uncertainty is created. Methodological choices include but are not limited to:

- Allocation methods
- Product use assumptions
- End-of-life assumptions

To identify the influence of these selections on results, parameters (or combinations of parameters) are varied in an exercise known as scenario analysis. Scenario analysis is also commonly called sensitivity analysis. Scenario analysis can reveal differences in the inventory results due to methodological choices.[3]

EXAMPLES

EXAMPLE 1

A company may choose to allocate facility electricity consumption between the toner production and other production lines using the physical allocation factor of the number of units produced. Using this factor, 30 percent of the electricity consumption is allocated to the toner production process. However, allocating the electricity by the mass of products results in 40 percent of the electricity consumption allocated to the toner production process.

EXAMPLE 2

Company data indicates that 40 percent of the toner cartridges are recycled. Therefore, it can be assumed that 40 percent of the plastic in the cartridge's casing is recycled. For both the reporting company and stakeholders, it may be interesting to consider how a change in the overall recycling rate would change the inventory results. From an individual consumer's perspective, there might be interest in how the inventory results would change when an individual recycles (100 percent rather than 40 percent recycling) or does not recycle (0 percent recycling) the cartridge.

Model uncertainty

Model uncertainty arises from limitations in the ability of the modeling approaches used to reflect the real world. Simplifying the real world into a numeric model always introduces some inaccuracies.

In many cases, model uncertainties can be represented–at least in part–through the parameter or scenario approaches described above. However, some aspects of model uncertainty might not be captured by those classifications and are otherwise very difficult to quantify.

EXAMPLE

A model of soy production is involved in predicting emissions from the production of the cartridge's soy-based ink. Emissions of N_2O due to application of nitrogen fertilizers are based on a linear modeling of interactions of the fertilizer with the soil and plant systems. As these interactions are more complicated than the model assumes, there is uncertainty regarding the emissions resulting from this model.

10.3.3 Reporting qualitative uncertainty

Companies are required to report a qualitative description of uncertainty sources and methodological choices made in the inventory. These include the use and end-of-life profiles for cradle-to-grave inventories, allocation methods (including recycling allocation methods), the source of GWP used, and any calculation models used to quantify emissions and removals.

Quantitative uncertainty assessment is not required, but such an assessment is desirable since it can provide a more robust result that can identify specific areas of high uncertainty to track over time. Companies may wish to present both qualitative and quantitative uncertainty information in the inventory report. Companies may also describe their efforts to reduce uncertainty in future revisions of the inventory. Table 10.2 includes the required qualitative uncertainty sources to report.

10.3.4 Uncertainty in comparisons

Comparative uncertainty differs from the various types of uncertainty previously mentioned in that more than one product or system is considered. This standard is not intended to support product comparison beyond performance tracking (as described in chapter 1). However, even within a product inventory, comparative uncertainty may arise, such as when comparing the impact of one process or stage to another process or stage in the product's life cycle.

Whenever considering uncertainty in comparisons, the uncertainty ranges of each process, life cycle stage, or product should not be directly compared; instead, the uncertainty in the comparison itself should be assessed. That is, rather than comparing the distribution of A and the distribution of B, companies may assess the distribution of A divided by B. This can be done for both parameter uncertainty and scenario uncertainty.

Table [10.2] Qualitative description of required uncertainty sources

Source of uncertainty	Qualitative description
Scenario uncertainty	
• **Use profile**[4]	Describe the use profile of the product. If more than one use profile was applicable, disclose which method was used and justify the choice.
• **End-of-life profile**[4]	Describe the end-of-life profile of the product. If more than one end-of-life profile was applicable, disclose which method was used and justify the choice.
• **Allocation method(s)**	Describe any allocation problems in the inventory and which allocation method was used. If more than one allocation method was applicable, disclose which method was used and justify the choice.
• **Recycling allocation method(s)**	Disclose and reference which method was used (closed loop approximation method or recycled content method).
Parameter uncertainty[5]	
• **Global warming potential factors**	List the source of global warming potential (GWP) factors used.
Model uncertainty	
• **Model sources not included in scenario or parameter uncertainty**	Describe the models, identify their published source, and identify areas where they may deviate from real world conditions.

When comparing the uncertainties between two or more processes, stages, or products, it is important to track any common inputs, outputs, and/or processes. When the two items being compared share common elements their uncertainties are likely correlated, which should not be included in the uncertainty comparison result. Because of correlation, a comparison of two relatively uncertain results could have relatively high certainty. Identifying correlations is important in tracking any changes in the product's inventory over time.

EXAMPLE

The manufacturer of the toner cartridge determines the product inventory's parameter uncertainty is +/- 20 percent. The company develops a lighter weight cartridge body, reducing 30 percent of the weight of that component and 3 percent of the total product inventory result. Besides the difference in weight, the processes in the two inventories are the same and the data sources are also consistent. Therefore, while both the original and revised inventories each have a parameter uncertainty of +/- 20 percent and the difference in their results is 3 percent, the company can be confident that the new design has a lower GHG impact.

Endnotes

1 Parameter refers to the value(s) assigned to processes, inputs, outputs, within the product's life cycle.

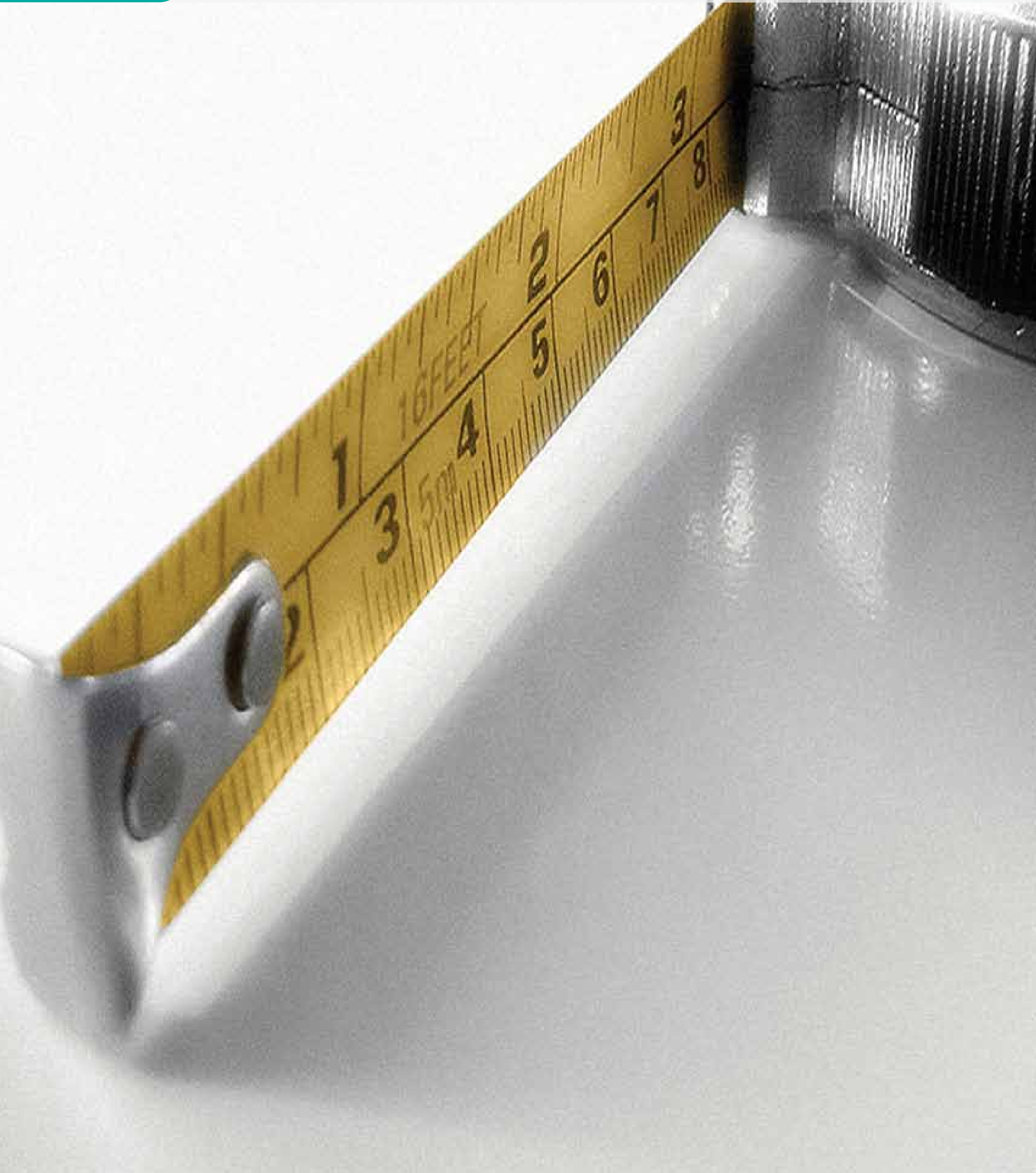
2 In some cases, such as in the use of log-normal distributions, the distribution around the mean is not symmetrical and the upper and lower confidence levels might need to be specified separately (e.g., "-10, +20", rather than "+/- 15).

3 Mark A. J. Huijbregts, "Application of uncertainty and variability in LCA. Part I: A General Framework for the Analysis of Uncertainty and Variability in Life Cycle Assessment."International Journal of Life Cycle Assessment, 3 no. 5 (1998):273 – 280.

4 For cradle-to-grave inventories.

5 The description of single parameter uncertainty is included in the data quality reporting requirements (see chapter 7).

11 Calculating Inventory Results



11.1 Introduction

This chapter outlines key requirements, steps, and procedures involved in quantifying the GHG inventory results of the studied product necessary for public reporting.

11.2 Requirements

Companies shall apply a 100 year global warming potential (GWP) factor to GHG emissions and removals data to calculate the inventory results in units of CO_2 equivalent (CO_2e). Companies shall report the source and date of the GWP factor used.

The global warming potential (GWP) is a metric used to calculate the cumulative radiative forcing impact of multiple GHGs in a comparable way. When emissions or removals are multiplied by their respective GWP, they become CO_2 equivalents (CO_2e). Companies should use GWP values from the Intergovernmental Panel for Climate Change (IPCC) Fourth Assessment Report, published in 2007, or the most recent IPCC values when the Fourth Assessment Report is no longer current. Although the IPCC provides GWP metrics for different time periods (e.g., 20 and 500 years), 100 years is used most often by programs and policies as the median metric and therefore shall be used to calculate inventory results in this standard.

Companies shall quantify and report the total inventory results in CO_2e per unit of analysis, which includes all emissions and removals included in the boundary from biogenic sources, non-biogenic sources, and land-use change impacts.

Once data collection, allocation, and data quality assessments are complete, companies shall quantify and report the total inventory results in CO_2e per unit of analysis (e.g., functional unit). For more information on the unit of analysis please refer to chapter 6.

In addition to the total inventory results, companies shall quantify and report:

- ***Percentage of total inventory results by life cycle stage***
- ***Biogenic and non-biogenic emissions and removals separately when applicable***
- ***Land-use change impacts separately when applicable***
- ***Cradle-to-gate and gate-to-gate inventory results separately or a clear statement that confidentiality is a limitation to providing this information***

Separately calculating and reporting these components of the inventory results adds transparency to the product's life cycle and provides companies and their stakeholders with a better understanding of what type of emissions and removals dominate the inventory and where they occur along the life cycle.

Companies shall not include the following when quantifying inventory results:

- ***Weighting factors for delayed emissions***
- ***Offsets***
- ***Avoided emissions***

In a life cycle, particularly for products that have long use and end-of-life time periods, emissions may occur at different points in time and have different impacts on the atmosphere. Some methodologies try to capture this in the life cycle results by applying a weighting factor to account for emissions delayed over time (also referred to as emission discounting). In this standard, inventory results shall not be calculated with weighting factors. This is true for both biogenic and non-biogenic emissions, removals, and products. Companies may show the impact of delayed emissions and removals separately from the inventory results. It is important to note that if a weighting factor is applied to calculate the impact of delayed emissions or removals in the end-of-life stage, the same factor needs to be applied to end-of-life allocation of co-products and recycled materials.

Offsets and avoided emissions are both classified as actions that occur outside the boundary of the product's life cycle. Offsets are emission credits (in the form of emission trading or funding of emission-reductions[1] projects) that a company purchases to offset the studied product's inventory results. Avoided emissions are quantified as emissions reductions that are indirectly caused by the studied product or a process that occurs in the studied product's life cycle. Avoided emissions as defined here are not the same as emissions reductions that occur due to directly attributable reduction projects, or allocated emissions using the system expansion allocation method. Purchased offsets and avoided emissions shall not be deducted from the product's total inventory results, but may be reported separately. Guidance on using offsets to meet reduction targets is available in chapter 14.

Companies shall report the amount of carbon contained in the product or its components that is not released to the atmosphere during waste treatment, if applicable. For cradle-to-gate inventories, companies shall report the amount of carbon contained in the intermediate product.

Many products contain carbon as part of their chemical makeup or composition. This carbon, which can be biogenic or non-biogenic, is either recycled or reused in another product cycle, released as CO_2 or CH_4 during waste treatment (due to combustion or decomposition), or stored as a result of waste treatment (due to land filling or other treatments that prevent decomposition). Companies shall report when carbon contained in a product or its components is not released to the atmosphere during waste treatment and therefore is considered stored. The amount of carbon stored will depend on the waste treatment process, the scientific understanding of the product's degradation in certain environments, and the time period chosen. More information on time period is available in chapter 7.

In cradle-to-gate inventories, contained carbon leaves the boundary of the inventory as part of the intermediate product. For intermediate product cradle-to-gate inventory results to be useful to a downstream customer doing a final product cradle-to-grave inventory, companies shall report the amount of carbon contained in the product leaving the boundary (e.g., gate). Companies may include additional information about the end-of-life properties of an intermediate product separate from the inventory results.

11.3 Guidance

11.3.1 Calculating the inventory results of the studied product

Companies should follow these steps when calculating the GHG impact of the studied product:

1. Choose a GWP value

Because radiative forcing is a function of the concentration of GHGs in the atmosphere, and because the methodology to calculate GWP continues to evolve, GWP factors are reassessed every few years by the IPCC. The most current GWP factors published by the IPCC at the time of this standard's publication are the factors published in the Fourth Assessment Report (2007). The Fifth Assessment Report is set to be completed in 2013-2014 and will likely contain updated factors. A table of the most recent GWP values is available at (www.ghgprotocol.org).

Companies may choose to use other GWP values. For example, some companies may want to use the second assessment report values to be consistent with national inventories following the UNFCCC. Although it is required that companies calculate inventory results using the 100-yr GWP, companies may choose to calculate and separately report results using a 20 or 500 year GWP factors or other impact assessment metrics such as global temperate potential (GTP) if they feel this would be useful information to their stakeholders.

Multipliers or other corrections to account for radiative forcing may be applied to the GWP of emissions arising from aircraft transport. When used, the type of multiplier and its source should be disclosed in the inventory report.

2. Calculate CO_2e using collected data

The following equations illustrate how to calculate CO_2e for an input, output, or process based on activity data, emission factors, and GWP. More information on data collection and sources of emission factors are available in chapter 8.

When process or financial activity data is collected, the basic equation to calculate CO_2e for an input, output, or process is:

$$\text{kg } CO_2e = \underset{\text{(unit)}}{\text{Activity Data}} \times \underset{\text{[kg GHG/unit]}}{\text{Emission Factor}} \times \underset{[\text{kg } CO_2e/\text{kg GHG}]}{\text{GWP}}$$

When direct emissions data has been collected, an emission factor is not needed and the basic equation to calculate inventory results for an input, output, or process is:

$$\text{kg } CO_2e = \underset{\text{(kg GHG)}}{\text{Direct Emissions Data}} \times \underset{[\text{kg } CO_2e/\text{kg GHG}]}{\text{GWP}}$$

If direct emissions data and activity data are available, companies may find benefit in completing and calculating both ways as a cross-check.

When CO_2 is removed from the atmosphere by the product during the use phase (e.g., CO_2 uptake by cement), the removal data may come in the form of a removal rate per mass or volume of product. However, the most typical form of atmospheric CO_2 removal is due to biogenic uptake during photosynthesis. In this case, companies usually only know the amount of biogenic carbon contained in the material or product. To convert this to CO_2, the amount of carbon is multiplied by the ratio of molecular weights of CO_2 (44) and carbon (12), respectively. CO_2 removal data, like direct emissions data, does not need to be multiplied by an emission factor and can simply be multiplied by the GWP of 1 for CO_2.

$$\text{kg } CO_2e = \text{kg Biogenic Carbon} \times (44/12) \times \underset{[\text{kg } CO_2e/\text{kg GHG}]}{\text{GWP}}$$

Alternatively, companies may want to sum all emissions and removals per GHG per unit of analysis before applying the GWP. This approach is recommended if companies wish to have the option of reporting results separately by GHG or using a different GWP value.

Companies should be cognizant of significant figures and rounding rules when calculating emissions and removals, particularly when using emissions factors from a life cycle database or software program that automatically calculates emissions when activity data are given as an input. The number of significant figures of the emission data should not exceed that of the activity data or emission factor with the least significant figures used in the calculation.

3. Calculate total inventory results (CO_2e/unit of analysis)

Once the inventory results in CO_2e are calculated, the company needs to ensure that all results are on the same reference flow basis. For example, if the reference flow for the studied product is 10 kg and the inventory results are per kg of product, all the inventory results need to multiplied by 10. Because the reference flow represents to amount of product needed to fulfil the unit of analysis, results on the reference flow basis are summed together to calculate the total CO_2e/unit of analysis. More information on reference flows and unit of analysis is available in chapter 6.

The following components make up the total inventory results:

$$\frac{\text{Total } CO_2e}{\text{unit of analysis}} = \frac{CO_2e \text{ Emissions (Biogenic)}}{\text{reference flow}} - \frac{CO_2e \text{ Removals (Biogenic)}}{\text{reference flow}} + \frac{CO_2e \text{ Emissions (Non-Biogenic)}}{\text{reference flow}} - \frac{CO_2e \text{ Removals (Non-Biogenic)}}{\text{reference flow}} + \frac{CO_2e \text{ Land Use Change Impacts}}{\text{reference flow}}$$

The total CO_2e/unit of analysis represents the amount of CO_2 equivalent GHGs entering the atmosphere as a result of fulfilling the function of a product. Therefore, emissions are treated as positive values and removals are treated as negative values.

Land-use change impacts are included in the total inventory results if they are attributable to the studied product. Guidance on calculating land-use change impacts is included in Appendix B. If no land-use change impacts are attributable and no removals occur during the product's life cycle, the total inventory results are simply the sum of emissions in CO_2e per reference flow.

4. Calculate percentage of total inventory results by life cycle stage

The inventory results per life cycle stage are calculated using the same equation given in step 3 above. Land-use change impacts and removals are typically included in the material acquisition and preprocessing or production stage depending on the perception of the reporting company. In some cases removals may occur during the use stage (e.g. the absorption of CO_2 by cement). If the removals are large enough to create a negative percent impact from that stage, this should be noted clearly in the inventory report.

The following equation is used to determine the percentage of total inventory results by life cycle stage:

$$\text{Percentage per life cycle stage} = \frac{CO_2e \text{ per life cycle stage}}{\text{Total } CO_2e \text{ inventory results}} \times 100$$

As required in chapter 9, the virgin material displacement factor is reported separately from the inventory results by life cycle stage to avoid a negative percent impact in the end-of-life stage. The percentage impact of the virgin material displacement can be reported next to the end-of-life stage results as shown in the reporting template (available at www.ghgprotocol.org). The virgin material displacement factor is included as part of the total inventory results.

5. Separate reporting of biogenic and non-biogenic emissions and removals and land-use change impacts, when applicable

Separate reporting of the total inventory result components provides transparency to the reporting company and their stakeholders.

Biogenic emissions include CO_2, CH_4, and N_2O that are produced as a result of the combustion and/or degradation of biogenic materials, wastewater treatment, and a variety of biological sources in soil and water. For example, if paper degrades in a landfill, the CO_2 and CH_4 emitted would be classified as biogenic emissions. Non-biogenic emissions include all GHG emissions from non-biogenic (e.g., fossil-based) materials. Biogenic removals are due to the uptake of CO_2 by biogenic materials during photosynthesis, while non-biogenic removals only occur if CO_2 is removed from the atmosphere by a non-biogenic product during its production or use stage. Appendix B provides guidance on calculating land-use change impacts.

If companies are unsure whether emissions are from a biogenic or non-biogenic source, they should include those emissions as non-biogenic. In some cases, a product may have no biogenic emissions, biogenic and non-biogenic removals, or land-use change impacts. If only non-biogenic emissions occur in the inventory, companies may report only the total inventory results and note this in the inventory report.

6. Calculate cradle-to-gate and gate-to-gate inventory results separately

In addition to reporting separately the inventory result components, reporting inventory results by cradle-to-gate and gate-to-gate gives some insight into what emissions and removals occur under the control of the reporting company. However, it is recognized that reporting gate-to-gate inventory results may jeopardize the reporting company's confidentiality. If this is the case, companies may state this as a limitation to reporting these results separately. For cradle-to-gate inventories, the total inventory results are the cradle-to-gate results and therefore do not need to be repeated here.

11.3.2 Offsets and avoided emissions

As previously stated, offsets are emission credits (in the form of emission trading or funding of emission-reduction projects) that a company purchases to offset the impact of the studied product's emissions. Companies typically purchase offsets for one of two reasons: to meet a reduction goal that they cannot reach with reductions alone, or to claim a product as carbon neutral. Companies are encouraged to set reduction targets and meet these with absolute reductions. However if a company wishes to purchase offsets for its product inventory, this standard does allow for offsets to be reported separately from the inventory results. For offsets to be reported separately in a product inventory, the company should:

- Purchase offsets based on the *GHG Protocol Project Protocol* or similar internationally accepted GHG mitigation project accounting methodologies for quantifying the GHG benefits of climate change mitigation projects; and
- Clearly separate corporate-level and product-level offset purchases to avoid double counting.

If a company purchases offsets to meet their corporate reduction goals, double counting can occur if the same offsets were reported in a product inventory. Similarly if a company sells reductions that occur at sources included in the boundary for use as offsets, these should not be included in tracking performance towards their own reduction target. Companies should separately report any sold offsets from sources that they own or control that are part of the product boundary.

In this standard, avoided emissions are quantified as emissions reductions that are indirectly caused by market responses to the studied product or process that occurs in the studied product's life cycle. For example, consider a company that performs a GHG inventory on energy-efficient appliances. Avoided emissions can be calculated by assuming that the energy-efficient appliances replace non-efficient appliances in the market place. The company also installs an energy-efficient wood-fired boiler in the production facility to reduce emissions. Avoided emissions can be calculated by assuming that the use of the wood-fired boiler reduces the demand for coal-fired power.

This standard does not allow avoided emissions to be subtracted from the total inventory results. However, companies may report avoided emissions separately in the inventory report. Avoided emissions are often calculated using the consequential approach, which among other things considers how emissions might change as a result of a shift in demand (see chapter 5 for more information). Companies calculating and reporting avoided emissions should also consider any indirect emissions caused by market responses to the studied product or its life cycle. For example, indirect land-use change impacts are a form of indirect impact that could increase the GHG inventory of a product and should also be reported separately if other avoided emissions are considered. It is not appropriate to consider only the emissions savings associated with indirect effects.

In LCA, the term avoided emissions is sometimes used to describe allocation due to system expansion, or emission reductions due to a reduction project within the product's boundary. These cases are not considered avoided emissions as defined by this standard and therefore are not required to be reported separately from the inventory results. However, the requirements for allocation (chapter 9) and performance tracking (chapter 14) are applicable in these cases.

DuPont™

DuPont™ Sorona® is an advanced polymer that contains 37 percent renewably sourced (e.g., biogenic) ingredients by weight and can be used in place of traditional petrochemical polymers in a wide range of applications such as fibers, fabrics, filaments, and engineering resins. Because of the range of functions and products Sorona® can be used for, DuPont performed a cradle-to-gate inventory. However, the resulting fate of the carbon in the molecule is an important evaluation for any cradle-to-grave inventory that uses Sorona® as a material input. To ensure that downstream customers have all the necessary information to perform a cradle-to-grave assessment, DuPont included in the inventory report the amount of carbon (fossil and biogenic) contained within the product as it leaves the cradle-to-gate inventory boundary. DuPont also has information on the fate of the contained carbon in different end-of-life scenarios that they included in the inventory report separate from the cradle-to-gate inventory results as optional information to help downstream customers define their end-of-life profiles.

Endnotes

1 Emissions increases can also be indirectly caused by the studied product or process that occurs in the studied product's life cycle and should also be reported separately with avoided emissions.

12 Assurance

12.1 Introduction

Assurance is the level of confidence that the inventory results and report are complete, accurate, consistent, transparent, relevant, and without material misstatements. Obtaining assurance over the product inventory is valuable for reporting companies and other stakeholders when making decisions using the inventory results. Carefully and comprehensively documenting the inventory process in a data management plan is a vital step in preparing for assurance.

12.2 Requirements

The product GHG inventory shall be assured by a first or third party.

Three key parties are involved in the assurance process:

1. The reporting company seeking assurance
2. Stakeholder users of the inventory report
3. The assurer(s)

When the reporting company also performs the assurance, this is known as first party assurance. When a party other than the reporting company performs the assurance, this is known as third party assurance. Table 12.1 explains the differences between first and third party assurance.

Both first and third party assurers should follow similar procedures and processes. For external stakeholders, third party assurance is likely to increase the credibility of the GHG inventory. However, first party assurance can also provide confidence in the reliability of the inventory report, and can be a worthwhile learning experience for a company prior to commissioning third party assurance.

Table [12.1] Types of assurance

Type of assurance	*Description*	*Independence mechanism*
First party assurance	Person(s) from within the reporting company but independent of the GHG inventory determination process conducts internal assurance.	Different lines of reporting
Third party assurance	Person(s) from an organization independent of the product GHG inventory determination process conducts third party assurance.	Different business entity from the reporting company

Companies shall choose assurance providers that are independent of, and have no conflict of interest with, the product GHG inventory process.

Assurers are defined as person(s) providing assurance over the product inventory and shall be independent of any involvement in the determination of the product inventory or development of any declaration. Assurers shall have no conflicts of interests, such that they can exercise objective and impartial judgment.

Inherently, assurance provided by a third party offers a higher degree of objectivity and independence. Companies receiving first party assurance are required to report how potential conflicts of interests were avoided during the assurance process (see the assurance statement reporting requirement below for more information). Typical threats to independence may include financial and other conflicts of interest between the reporting company and the assurer. These threats should be assessed throughout the assurance process.

Companies shall report the assurance statement in the inventory report. The statement shall include:

- ***Whether the assurance was performed by a first or third party***
- ***The level of assurance achieved (limited or reasonable) including assurance opinion or the critical review findings***
- ***A summary of the assurance process***
- ***The relevant competencies of the assurers***
- ***How any potential conflicts of interest were avoided for first party assurance***

Competencies of assurers

Selecting a competent assurer (also known as an assurance provider) is important for the assurance findings to have the credibility needed to support the reporting company's business goals and stakeholder needs.

A competent GHG inventory assurer has:

- Assurance expertise and experience using assurance frameworks
- Knowledge and experience in life cycle assessment and/or GHG corporate accounting, as well as familiarity with key steps in the product inventory process
- Knowledge of the company's activities and industry sector
- Ability to assess the emission sources and the magnitude of potential errors, omissions and misrepresentations
- Credibility, independence and professional skepticism to challenge data and information

Assurance process

Achieving assurance over the product inventory results can be achieved through two methods: verification and critical review.

Verification is an independent assessment of the reliability of the product GHG inventory. Verification engagements, whether performed by a first or third party, have common elements, including:

1. Planning and scoping (e.g., determine risks and material misstatements)
2. Identifying emission sources
3. Performing the assurance process (e.g., gathering evidence, performing analytics, etc.)
4. Evaluating results
5. Determining and reporting conclusions

The nature and extent of verification procedures can vary depending on whether the verification engagement is designed to obtain reasonable or limited assurance (as described below). Verification of inventory data may take place in several ways, for example by on-site checking, reviewing calculations, mass balance calculations, or cross-checks with other sources.

The critical review process is intended to ensure consistency between the product inventory and the principles and requirements of the *Product Standard*. It is an established practice in life cycle assessment. The critical review process ensures that:

- Methods used to carry out the product inventory are consistent with the *Product Standard*
- Methods used to carry out the product inventory are scientifically and technically valid
- Data used are appropriate and reasonable for public reporting
- The inventory report and any conclusions based on the results are appropriate for GHG-only inventories
- The inventory report is transparent and consistent

There are two types of critical review: those performed by an internal or external expert, and those performed by a review panel of interested parties.

For critical reviews conducted by a review panel, the panel should be comprised of at least three members. The members may come from life cycle assessment expert groups, government agencies, non-governmental organizations, industry groups, and other companies.

Levels of assurance

In verification, the level of assurance refers to the degree of confidence that stakeholders can have over the information in the inventory report. There are two levels of assurance: limited and reasonable. The level of assurance requested by the reporting company will determine the rigor of the verification process and the amount of evidence required. The highest level of assurance that can be provided is a reasonable level of assurance. Absolute assurance is never provided as 100 percent of the inputs to the GHG Inventory are not tested due to practicality and feasibility limitations.

The thoroughness with which the assurance evidence is obtained is less rigorous in limited assurance. Table 12.2 provides examples of limited and reasonable assurance opinions for an assertion of product inventory emissions.

Critical review findings

The critical review findings include whether the product inventory is in conformance with the *Product Standard* and the methodological choices and assumptions made are reasonable for public reporting.

For more information on critical review, companies should refer to the following texts:

1. ISO 14040, section 7
2. ISO 14044, section 6
3. The Society of Environmental Toxicology and Chemistry's (SETAC) Guidelines for Life Cycle Assessment: A 'Code of Practice'

Table [12.2] **Examples of limited and reasonable assurance opinions**

Assurance opinion	*Limited assurance*	*Reasonable assurance*
Nature of opinion	Negative opinion	Positive opinion
Example wording of opinion	"Based on our review, we are not aware of any material modifications that should be made to the company's assertion that the inventory product's emissions are 23 kilograms CO_2e and are in conformance with the requirements of the *GHG Protocol Product Life Cycle Accounting and Reporting Standard*."	"In our opinion the reporting company's assertion that the inventory product's emissions are 23 kilograms CO_2e is fairly stated, in all material respects, and is in conformance with the *GHG Protocol Product Life Cycle Accounting and Reporting Standard*."

12.3 Guidance

12.3.1 Benefits of assurance

Assuring product inventory results can provide a variety of benefits, including:

- Increased confidence in the reported information on which to base reduction targets and related decisions
- Enhanced internal accounting and reporting practices (e.g., data collection, calculation, and internal reporting systems), and facilitation of learning and knowledge transfer within the company
- Increased confidence in the results by other companies in the product's life cycle that may use the results in their own inventories
- Improved efficiency in subsequent inventory update processes and when undertaking inventories of other company products
- Greater stakeholder trust in the reported information

12.3.2 Key concepts in assurance

In the assurance field many different terms are used to describe various assurance processes (e.g., verification, validation, quality assurance, quality control, audit, etc.). Though not comprehensive, table 12.3 includes many key terms and concepts used in the assurance process.

12.3.3 Materiality

A material misstatement occurs when individual or aggregate known errors, omissions and misrepresentations have a significant impact on the GHG inventory results and could influence a user's decisions. Materiality has both quantitative and qualitative aspects. The assurer and reporting company should determine an appropriate threshold or benchmark of materiality during the assurance process.

Quantitative materiality is typically calculated as a percentage of the inventory (in total or on an individual line item basis). In determining the quantitative materiality benchmark, assurers should contemplate the risk of a potential misstatement and the history of previous misstatements. A materiality threshold (e.g., a point at which a discrepancy becomes material) can be pre-defined by the assurer.

Qualitative misstatements tend to be those that have immaterial quantitative effects but could materially affect the reporting company's emissions in the future as well as those that mislead the intended user.

Uncertainty is a separate concept from materiality because it is not a known error, rather an indicator of how well the data represents the processes in the product inventory.

12.3.4 Preparing for assurance

Preparing for assurance is a matter of ensuring that the evidence that the assurer needs is easily accessible. The type of evidence and documentation requested by the assurer will depend on the subject matter, the industry, and the type of assurance being sought. Maintaining documentation of the inventory process through the use of a data management plan (see Appendix C) is helpful for ensuring the assurance evidence is available.

Prior to starting the assurance process, the reporting company should ensure that the following are prepared and available to the assurer:

- The company's written assertion (e.g., inventory results);
- The completed data management plan; and
- Access to sufficient and appropriate evidence (i.e., invoices, bills of sale, etc.).

Timing of verification

Verification is conducted before the public release of the inventory report by the reporting company. This allows for material misstatements to be corrected prior to the release of the opinion (or revised opinion) and assertion. The work should be initiated far enough in advance of the inventory report release so that it is useful in improving the inventory when applicable. The period of the verification process is dependent on the nature and complexity of the subject matter and the level of assurance.

Table [12.3] Key assurance concepts

Assurance concept	*Description*	*Examples*
Assertion	A statement by the reporting company on the inventory results. The assertion is presented to the assurer.	• The studied product's emissions are 23 kilograms of CO_2e. They are calculated in accordance with the *Product Standard* and supplemented by our company-specific policies and methodologies described in the inventory report
Subject matter	The inventory results and supporting information included in the inventory report. The type of assurance performed will determine which subject matter(s) should be assessed.	• Inventory results • Other information presented in the inventory report (See chapter 13 for more information on reporting)
Criteria	The benchmarks used to evaluate or measure the subject matter.	• Requirements of the standard • Methodological choices • Data quality and uncertainty (assessed for appropriateness for a public report) • Others determined to be suitable by the reporting company and assurer
Evidence	Data sources and documentation used to calculate emissions and support the subject matter of the reporting company's assertion. Evidence should be sufficient in quantity and appropriate in quality.	• Physical observations, such as site tours to confirm the existence and completeness of the sources • Assurer's calculations • Statements by independent parties and/or the reporting company, such as an interview with the production manager about production capacity • Documents prepared by an independent party and/or the reporting company, such as invoices
Assurance standards	Standards, used by assurers, which set requirements on how the assurance process is performed.	• ISO 14064-3 Specification with Guidance for the Validation and Verification of Greenhouse Gas Assertions
Assurance opinion	The results of the assurer's assessment of the reporting company's assertion (i.e., inventory results). If the assurer determines that a conclusion cannot be expressed, the statement should cite the reason.	• See table 12.2 for examples of limited and reasonable assurance opinions

Timing of the critical review process

Critical review may be performed during the inventory process (known as an interactive review) or at the end (a posteriori). An interactive critical review may be useful in correcting any problems with the inventory before the inventory's completion, and it can reduce delays in publishing the inventory report. A posteriori review allows the panel members to have a fresh perspective when reviewing the inventory results. It is important that the critical review expert(s) remains objective and independent from the inventory development process during interactive reviews, and that the critical review findings are based on the final product inventory report.

12.3.5 Assurance challenges

There are several challenges in assuring product inventories. Emissions calculations rely on a mixture of data sources and assumptions. Inventory uncertainty, especially scenario uncertainty related to use and end-of-life stage emissions, may affect the quality of the inventory. It is important to consider the state of data collection systems and the integrity of the data and methodological choices for assurance.

One of the primary challenges is that the majority of emission sources are usually outside the reporting company's control and the assurer's ability to obtain sufficient appropriate evidence.

Three approaches to addressing this diminished control are:

1. Change the level of assurance i.e., reasonable to limited (for verification)
2. Change from verification to critical review
3. Rely on the assurance statement of another assurer for emission and removal sources outside of the company's control (i.e., assurance over a supplier's emission sources by a different assurance firm)

12.3.6 Assurance statement

The assurance statement conveys the assurer's conclusion about the inventory results, and it may take different forms depending on whether the company is conducting critical review or verification, as well as if the assurance was performed by a first or third party. The required contents of an assurance statement are listed in the requirements section. An assurance statement should also include the following:

Introduction

- A description of the studied product
- A reference to the reporting company's assertion included in the inventory report
- Description of assurance process
- List of the assurance criteria
- Description of the reporting company's and assurer's responsibilities
- The assurance standard or type of critical review process used to perform the assurance
- A summary of the work performed
- The materiality threshold or benchmark, if set

Conclusion

- Any additional details regarding the assurer's conclusion, including details regarding any exceptions noted or issues encountered in performing the assurance
- When there are material departures in the assertion from the assurance criteria, the reporting company should report the effect of the departures

Endnotes

1 Adapted from ISO 14064:3:2006, Greenhouse gases - Part 3: Specification with guidance for the validation and verification of greenhouse gas assertions.

2 Adapted from the GHG Protocol Corporate Standard.

3 Adapted from ISO 14040:2006, Environmental Management –Life Cycle Assessment –Principles and framework.

4 Adapted from ISO 14044:2006, 6.1

13 Reporting

13.1 Introduction

Reporting is crucial to ensure accountability and effective engagement with stakeholders. This chapter summarizes the various reporting requirements specified in other chapters and identifies additional reporting considerations that together provide a credible reporting framework and enable users of reported data to make informed decisions. It is essential that the reported information is based on the key accounting principles (relevance, accuracy, completeness, consistency, and transparency).

13.2 Requirements

Companies shall publicly report the following information to be in conformance with the GHG Protocol Product Standard:

General information and scope

- ***Contact information;***
- ***Studied product name and description;***
- ***The unit of analysis and reference flow;***
- ***Type of inventory, cradle-to-grave or cradle-to-gate;***
- ***Additional GHGs included in the inventory;***
- ***Any product rules or sector-specific guidance used;***
- ***Inventory date and version;***
- ***For subsequent inventories, a link to previous inventory reports and description of any methodological changes; and***
- ***A disclaimer stating the limitations of various potential uses of the report including product comparison.***

Boundary setting

- ***Life cycle stage definitions and descriptions;***
- ***A process map including attributable processes in the inventory;***
- ***Non-attributable processes included in the inventory;***
- ***Excluded attributable processes and justification for their exclusion;***
- ***Justification of a cradle-to-gate boundary, when applicable;***
- ***The time period; and***
- ***The method use to calculate land-use change impacts, when applicable.***

Allocation

- ***Disclosure and justification of the methods used to avoid or perform allocation due to co-products or recycling; and***
- ***When using the closed loop approximation method, any displaced emissions and removals separately from the end-of-life stage.***

Data collection and quality

- ***For significant processes, a descriptive statement on the data sources, data quality, and any efforts taken to improve data quality.***

Uncertainty

- ***A qualitative statement on inventory uncertainty and methodological choices. Methodological choices include:***
  - *Use and end-of-life profile;*
  - *Allocation methods, including allocation due to recycling;*
  - *Source of global warming potential (GWP) factors used;*
  - *Calculation models.*

Inventory results

- ***The source and date of the GWP factors used;***
- ***Total inventory results in units of CO_2e per unit of analysis, which includes all emissions and removals included in the boundary from biogenic sources, non-biogenic sources, and land-use change impacts;***
- ***Percentage of total inventory results by life cycle stage;***
- ***Biogenic and non-biogenic emissions and removals separately when applicable;***
- ***Land use impacts separately when applicable;***
- ***Cradle-to-gate and gate-to-gate inventory results separately (or a clear statement that confidentiality is a limitation to providing this information);***
- ***The amount of carbon contained in the product or its components that is not released to the atmosphere during waste treatment, when applicable; and***
- ***For cradle-to-gate inventories, the amount of carbon contained in the intermediate product.***

Assurance

The assurance statement including:

- *Whether the assurance was performed by a first or third party;*
- *Level of assurance achieved (limited or reasonable) and assurance opinion or the critical review findings;*
- *A summary of the assurance process;*
- *The relevant competencies of the assurance providers; and*
- *An explanation of how any potential conflicts of interest were avoided for first party assurance.*

Setting reduction targets and tracking inventory changes

Companies that report a reduction target and/or track performance over time shall report the following:

- *The base inventory and current inventory results in the updated inventory report;*
- *The reduction target, if established;*
- *Changes made to the inventory, if the base inventory was recalculated;*
- *The threshold used to determine when recalculation is needed;*
- *Appropriate context identifying and describing significant changes that trigger base inventory recalculation;*
- *The change in inventory results as a percentage change over time between the two inventories on the unit of analysis basis; and*
- *An explanation of the steps taken to reduce emissions based on the inventory results.*

13.3 Guidance

13.3.1 Goal of public reporting

The overarching goal of producing a GHG inventory in conformance with the GHG Protocol *Product Standard* is to create positive drivers to pursue GHG emission reductions across the product life cycle. The full process from developing the inventory to reporting results is designed to help improve the understanding of reduction opportunities as well as facilitate and leverage inputs from stakeholders to prioritize and reduce emissions. Identifying target audience and specific business goals is the first step and reporting is the final step to achieving this goal.

The following sections provide guidance on understanding the audience and completing some of the reporting requirements not included elsewhere in the standard[1]. A list of optional reporting elements is included, and a reporting template is provided at (www.ghgprotocol.org) to help companies organize their inventory report.

13.3.2 Identifying the audience

Keeping the audience in mind is important right from the start as companies set objectives and develop an inventory. A key opportunity to make a meaningful connection with the audience is when a company prepares their inventory report. Helping users understand the purpose, context, and rationale behind various accounting decisions as well as the limitations and potential uses of the inventory results are examples of objectives that a company should seek to address in the inventory report.

Table [13.1] **Potential audiences of a publicly disclosed product GHG inventory report**

Audience category/role	*Audience description*
General public	Lay person. No understanding or prior experience with LCA/GHG inventories may be assumed.
GHG inventory / LCA practitioner	Practitioner wishing to use the inventory results as data inputs to another study.
Assurance provider	Assurer performing assurance on the inventory.
Report partners	Employees, suppliers, product-owning organization, report-commissioning organization.
Sustainability / environmental practitioner	General interested party seeking to understand more about a specific product, a product sector, an industry sector, or other aspects of life cycle emissions and removals.
Green purchasing	Purchasing decision-maker seeking differentiation across products.
Downstream customers	Retail decision-maker making purchase decisions that may use the inventory results.
Environmental/carbon/ GHG labeling organizations	GHG programs that may provide a platform to report, register, and disseminate inventory results.
Policy makers and government program administrators	Government stakeholders that may use the inventory results to plan future programs and policies.

It is important to recognize that public disclosure does not mean there is one homogenous audience with a uniform set of requirements. Table 13.1 lists distinct audiences for a product GHG inventory report, and identifies how the reporting requirements can help address their needs. This is not an inclusive list as other audiences not identified here may still find value in reports produced following the reporting requirements in the *Product Standard*.

13.3.3 Disclaimer

Providing a disclaimer ensures that readers understand the scope and intended purpose of the inventory results and are aware of any limitations. (See box 13.1 for an example.)

13.3.4 Use of results

The audience of the public report may be most interested in what the company is doing, or plans to do, to reduce the GHG emissions associated with the product as a result of the inventory. Additionally, the

Box [13.1] Example disclaimer

The results presented in this report are unique to the assumptions and practices of company X. The results are not meant as a platform for comparability to other companies and/or products. Even for similar products, differences in unit of analysis, use and end-of-life stage profiles, and data quality may produce incomparable results. The reader may refer to the GHG Protocol Product Life Cycle Accounting and Reporting Standard (www.ghgprotocol.org) for a glossary and additional insight into the GHG inventory process.

audience may be interested in what they can do, as a user or consumer of the product, to reduce their impact on the inventory. Therefore, a company should inform its stakeholders of the steps it plans to implement as well as measures its customers or users can implement, in order to reduce emissions based on the inventory results. If this is a subsequent report, a company should also provide an overview of any reductions achieved. This should be brief and highlight key initiatives or results. Examples include:

- A plan to focus reductions around a few key emission sources;
- Information on how users/consumers can reduce key emission sources (e.g., reuse, following manufacturer use instructions, purchasing green power, etc.); and/or
- A summary of reductions or increases based on a previous inventory, highlighting the most effective initiatives or the reasons why emissions have increased.

Increases in emissions over the reduction-reporting period should be reported with a clear indication that the figure represents an increase rather than a reduction. A minus sign should not be used as this may confuse the audience.

A key step in completing the report is to review the purposes and context of the study and summarize the overall conclusions that can be drawn from the inventory. This step involves evaluating key accounting choices exercised in developing the inventory and providing a perspective on the significance and limitations in the product life cycle study. Companies should also clarify the purposes that the study sought to fulfill and the decisions that were outside its purview.

13.3.5 Optional reporting

In addition to required elements, a company should consider reporting on elements that meet the needs of its potential audience, its specific business goals, or the requirements of product rules and sector guideline developed in conformance with the *Product Standard*. These elements may be added to the public report or made available upon request and may include:

- Business goals met by performing a GHG inventory
- Additional background information on inventory results and how they are calculated
- Additional disclaimers around proper use of results SKU, NAICS code, UNSPSC code or other unique product/service identifier
- Additional details around why a particular unit of analysis was chosen
- The country(ies) where the raw material acquisition, production, and distribution stages occur
- Information on data collected from suppliers, including:
  - Percent engagement from supplier surveys
  - Data collection techniques and sources
- Quantitative uncertainty assessments
- Data for other GHGs that may be relevant to the studied product
- Inventory results using a 20 or 500 year GWP factor or other impact assessment metrics such as global temperate potential (GTP)
- If the functional unit and subsequent inventory results are applicable to multiple product varieties (e.g., different flavors or colors), information on those varieties
- Indirect land-use change impacts reported separately from the inventory results
- Additional disaggregation of GHG impacts. Examples include:
  - CO_2e emissions reported as a fraction of all GHG components (i.e., grams of CO_2, N_2O, CH_4, etc.)
  - For specific attributable processes or material, energy and service inputs, such as product packaging
  - The sum of transportation occurring throughout the life cycle
- Weighting factors for delayed emissions
- Information on offsets that have been purchased or developed outside the inventory boundary and reported separately from the inventory results. This information should:
  - Disaggregate offsets by emissions reductions and/or removals
  - Specify the types of offset project/s
  - Specify geographical and organizational origin
  - Specify how offsets have been quantified
  - Specify how double counting of offsets has been avoided
  - Specify whether they have been certified or recognized by an external GHG program (e.g., the Clean Development Mechanism) and
  - Specify whether and to what extent purchased offsets were used to meet reduction targets (if established)
- Information on any reductions sold as offsets from sources within the inventory boundary that are owned or controlled by the reporting company
- Avoided emissions and/or emissions caused by sources outside the inventory boundary reported separately from the inventory results
- Other emissions or removals calculated by consequential modeling reported separately from the inventory results
- Additional guidance on how the results should be interpreted and used
- Detailed reduction plans for future inventories
- A summary and explanation of any increase in emissions or decrease in removals since the last inventory, including what plans the company has to achieve inventory reductions in the future

Endnote

1 More information on reporting outputs from a specific inventory step are included in their respective chapters.

14

Setting Reduction Targets and Tracking Inventory Changes

14.1 Introduction

This standard is designed to help improve the quality and consistency of product inventories and public reporting with the ultimate goal of helping companies and other stakeholders reduce emissions of the products they design, manufacture, sell, purchase, and use. This step in the inventory process allows companies to set and meet reduction targets by consistently and accurately tracking inventory changes and identifying reduction opportunities.

14.2 Requirements

To set reduction targets and track inventory changes over time, companies shall:

- ***Develop and report a base inventory that conforms with the requirements of this standard;***
- ***Recalculate the base inventory when significant changes in the inventory methodology occur and report those changes;***
- ***Complete and disclose an updated inventory report including the updated results, the base inventory results, and the context for significant changes; and***
- ***Use a consistent unit of analysis to enable comparison and track performance over time.***

Companies can publicly report a GHG inventory in conformance with the *Product Standard* without setting a reduction target and tracking inventory changes. However, companies that do set reduction targets and track inventory changes shall abide by these requirements.

14.3 Guidance

14.3.1 Steps for setting reduction targets and tracking changes

Setting reduction targets and tracking changes involves the following steps:

1. Complete and report a base inventory done in conformance with the requirements of this standard.
2. Identify reduction opportunities.
3. Set a reduction target.
4. Achieve reductions and account for these by performing an updated inventory.
5. Recalculate the base inventory as needed when significant changes in the inventory occur, including, but not limited to: changes in the product's boundary; quality of data; and allocation or recycling methods.
6. Complete and disclose an updated inventory report including the updated results and the base inventory results. Companies should report the inventory results as a percentage change over time on the unit of analysis basis.

The following section describes each step in more detail.

Step 1: Complete and report a base inventory

The first step is to ensure that a base inventory has been completed and publically reported in conformance with this standard. The base inventory does not have to be the first inventory a company performs on a product; for example, companies may want to improve data quality before finalizing the base inventory. Once a company has identified the base inventory, however, any changes made that warrant a recalculation should be done following the guidance in step 5.

Step 2: Identify reduction opportunities

Companies can begin identifying potential emissions reduction opportunities along the product's life cycle while creating the base inventory. These opportunities can then be assessed based on the magnitude of the reductions and the company's level of influence. In general, companies have the largest influence on processes they control and therefore, a first step may be to identify energy savings or fuel switching opportunities within those processes.

In many cases the largest potential for improvement comes from processes that are under the control of suppliers and customers along the product's life cycle. To address these emissions, companies should identify suppliers and customers to engage with, based on both their level of influence and reduction potential. For use and end-of-life processes, the company may determine that improvements are influenced primarily by the design of a product and less by the behaviors of customers. In this case, companies should engage their product design or research and development team.

Step 3: Set a reduction target

A robust business strategy often includes setting targets for revenues, sales, and other core business indicators, as well as tracking performance against those targets. Likewise, although performance tracking a GHG product inventory over time can be done without a reduction target, effective GHG management involves setting a GHG target.

Companies should set a reduction target for the total product's life cycle to avoid the perception of cherry-picking. In addition companies may also set individual targets for stages or processes. A target should include both a completion date and a target level - the numeric value of the reduction target per unit of analysis (e.g., 20 percent reduction). In general, companies should set an ambitious target that reaches significantly beyond business-as-usual. "Stretch goals" tend to drive greater innovation and are seen as most credible by stakeholders.

It is important to note that all reduction targets set for a product inventory are made on the basis of the unit of analysis, and the unit of analysis cannot change when comparing inventories over time. This means that if an improvement made along the product's life cycle changes its unit of analysis, then a new inventory is completed and the company needs to redefine the base inventory and reduction goal based on the new unit of analysis.

Step 4: Achieve and account for reductions

Companies may achieve reductions in different ways, such as working within the company to improve the processing or design of the product or engaging with customers and suppliers. For the latter, the first step is to set up a strategy for supplier and customer engagement (See www.ghgprotocol.org for further guidance). Companies should work with partners along the product's life cycle to identify emissions reduction opportunities. This may include working with a supplier to help them manage and reduce their corporate (scope 1, 2, and 3) emissions. Other opportunities can include working with suppliers to come up with substitute materials that are less GHG intensive during production and/or reduce GHG impacts further upstream (e.g., a lighter car panel that reduces fuel use in the product use stage).

To account for reductions in emissions, companies are referred to the data collection requirements of this standard (chapter 8). Any reductions should be assessed using collected direct measurement data, activity data, or emission factors that abide by the attributional approach of the standard (i.e., historical, fact-based, and measurable) and have occurred prior to the updated inventory.

Box [14.1] Trade-offs between environmental impacts

One limitation of a GHG product inventory is that it focuses on a single environmental impact. Before making a decision to reduce GHG emissions by making changes in the product life cycle, companies should consider whether any environmental trade-offs could occur as a result of that change - for example, switching from a GHG intensive processing step to one that uses more water resources.

Step 5: Recalculate the base inventory

Overtime, changes and improvements may occur to activity data, emission factors[1], data quality, and methodologies. When such parameter or methodological changes influence the results of the base inventory, the base inventory should be recalculated to ensure comparability of emissions information over time. These changes may include redefining attributable processes, collecting higher quality data, or changing allocation or recycling methodologies. As required above, any changes made that warrant recalculation of the base inventory are reported in the updated inventory report.

Before recalculating a base year inventory, companies should develop a recalculation policy to clearly articulate the basis and context for any recalculation. Companies are required as part of reporting (see chapter 13) to disclose the threshold for insignificance above which a change warrants recalculation. For example, if a new emission factor is published that when used has a one percent impact on the inventory results, a company may decide that is below the threshold and opt not to recalculate the base inventory. If a threshold for insignificance was already established for justified exclusions (see chapter 7) then the same threshold should be used here.

If a change is made that causes the unit of analysis to be redefined, the base inventory cannot be recalculated. In this case, companies need to create a new base inventory and set a new reduction target.

Step 6: Update the inventory report

Once reductions have occurred, new data has been collected, and the base inventory has been recalculated (if needed), the inventory report should be updated to include results from both the new and base inventories. The updated inventory report must meet the requirements of the reporting chapter and include the same reporting elements as the base inventory. The introduction should be updated to reflect the purpose of the update including the reduction target, and any information that has changed since the base inventory should be clearly noted. The number of updated inventory reports for the studied product should be reported, with a link to previous reports as available. If the base inventory is recalculated, all changes are listed. If the base inventory was not recalculated, companies are required to report the threshold under which no recalculation was warranted. In either case, both the base inventory results and the updated results are included in the updated inventory.

In addition to the base inventory reporting requirements, companies should report a reduction percentage by taking the difference between the base inventory and the new inventory divided by the base inventory.

In the case that GHG emissions have actually increased since the last inventory, companies should report these results, adding an explanation for their stakeholders as to why the emissions increased and what plans the company has to reduce this value in the future.

14.3.2 Using offsets to achieve reduction targets

Companies should strive to achieve their reduction targets entirely from emission sources within the inventory boundary. If the company is unable to meet the target through those reductions, it can use offsets that are generated from sources external to its inventory boundary. Any purchased, sold, or banked offsets relevant to the inventory results are subject to the same reporting requirements as defined in chapter 13 and therefore are reported separately from the inventory results.

Although the inventory results are presented on a unit of analysis basis, companies that purchase offsets for their products should do so for all products sold in a particular time frame (e.g., a year). For example, a company produces a million products a year at 50 kg CO_2e per unit of analysis. To meet a zero-carbon reduction target for this product, the company needs to purchase 50,000 tons of offsets each year. In this case, the company would report the inventory results per unit of analysis and the total amount of products that are offset over the selected time frame. Companies should also disclose information on the credibility of the offset, including:

- The type of project
- Geographical and organizational origin
- How offsets have been quantified
- How double counting of offsets has been avoided
- Whether the offsets have been certified or recognized by external programs

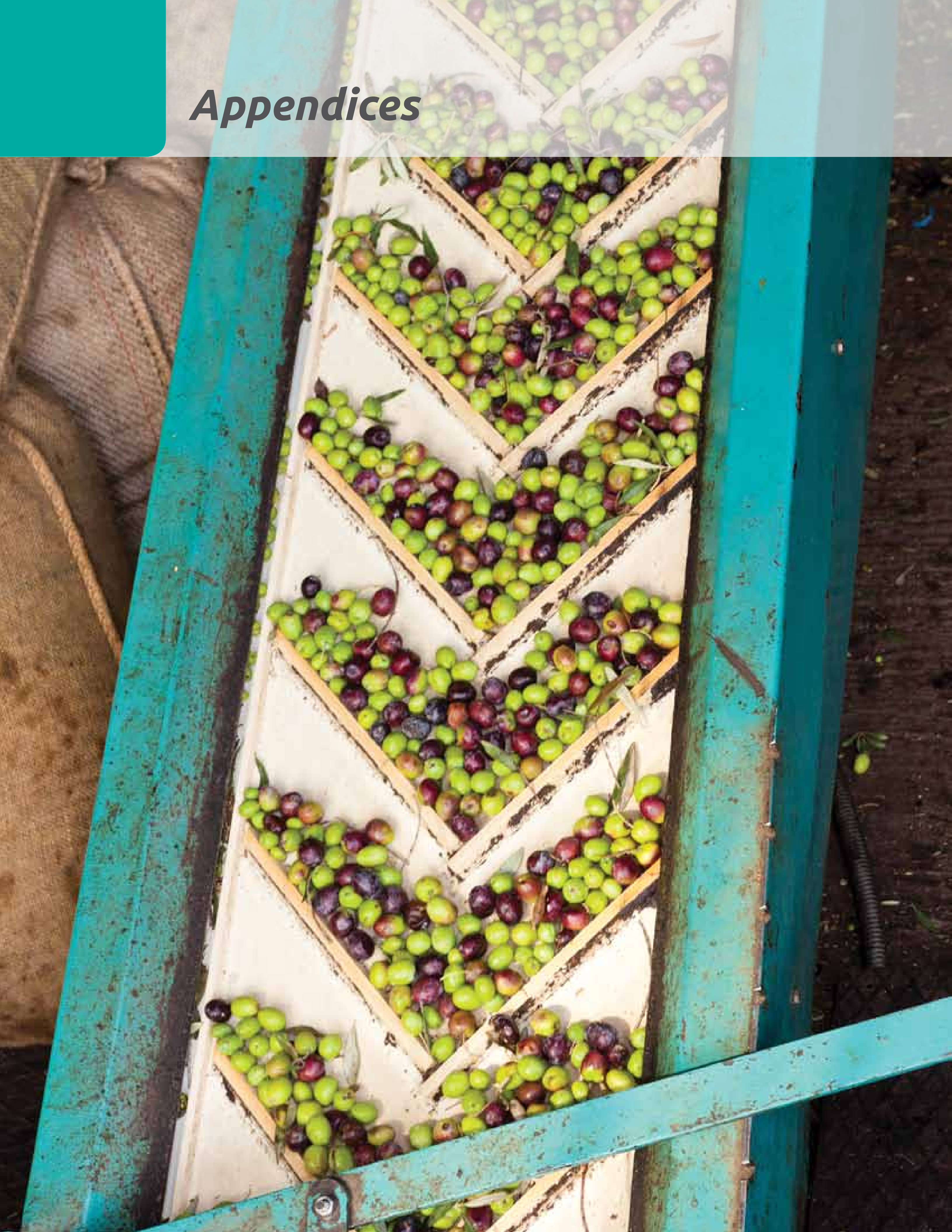
It is important to ensure the offsets used to meet a reduction target are based on credible accounting standards. In addition, companies should ensure steps to avoid double counting of reductions by multiple entities or in multiple targets. For example, if a company sells offsets that occur at sources included in its inventory boundary, these reductions should not be included in tracking performance towards a reduction target that is applicable to the same sources.

For additional guidance on using offsets that are based on credible accounting methodologies and standards see *GHG Protocol Guideline for Project Accounting* and to avoid double counting in achieving targets see the *Corporate Standard* (chapter 11, pp 81-83).

Endnote

1 If a change in emission factor represents an actual change in emissions, then the base inventory does not need to be updated. However, if an emission factor is updated to be more complete or have less uncertainty, this may warrant a base inventory recalculation.

Appendices



Appendix A. Guidance on Product Comparison

The quantification of GHG emissions and removals across a product's life cycle is complex and the results are highly dependent on methodological choices and assumptions. Valid product comparison requires the use of equivalent methodologies that minimize the methodological variability. In order to compare products on a fair and valid basis, companies need to supplement use of the *Product Standard****.***

As stated in chapter 1, this standard is intended to support performance tracking of one product over time. For other types of product comparison – including consumer and business purchasing decisions, product labels, and performance claims – additional specifications are needed. Claims regarding the overall environmental superiority or equivalence of one product versus a competing product, referred to in ISO 14044 as comparative assertions, are not supported by the *Product Standard*. Table A.1 provides descriptions and examples of types of product comparison, and table A.2 illustrates the applicability of this standard for each comparison type.

For companies and stakeholders that choose to perform product comparison, the following additional specifications are recommended.

Performance tracking:

- The unit of analysis should be identical
- If the parameters and methodologies change, the previous inventory shall be adjusted to permit comparison on the same basis

Table [A.1] **Types of comparisons that can be made using a product GHG inventory**

Comparison type	*Description*	*Example*
Performance tracking	Comparing the performance of the same product over time.	Product X emits 8 lbs. of CO_2e per unit of analysis in 2010 compared with a 2005 base inventory of 10 lbs. CO_2e per unit of analysis, demonstrating a 20-percent improvement.
Consumer and business purchasing decisions	A consumer or business changes purchasing habits based on the GHG performance of one product compared with a competing product.	A retailer increases milk purchases from the milk producer with the lowest GHG product inventory.
Product labels	A label printed on a product making a claim (either quantitative or qualitative) about the life cycle performance of the product.	A label on a bag of popcorn states the product GHG emissions are 7 grams.
Performance claims	Advertising the GHG benefits of a product by the company performing the inventory or a third party.	A consumer group advertises on their website a list of products they claim emit less GHG emissions than competing products.

Table [A.2] The use of *Product Standard* for product comparisons

Supported by the *Product Standard* "as-is"	Supported by the *Product Standard* with additional GHG program specifications or product specific guidance
Performance tracking	
	Consumer and business purchasing decisions
	Product labels
	Performance claims

See chapter 14 for more information on performance tracking and setting reduction targets.

Consumer and business purchasing decisions, quantitative product labeling, and performance claims:

- The unit of analysis should be identical
- The system boundaries and temporal boundary should be equivalent
- The same allocation methods should be used for similar processes
- The data types used and the data quality and uncertainty of data should be reported and assessed to determine if a fair comparison can be made
- The temporal and geographical representativeness of the inventories should be assessed to determine if a fair comparison can be made
- Third party assurance should be performed

ISO labels and declarations:

- Environmental Labels (Type I)[1], Self-declared Environmental Claims (Type II)[2], Environmental Product Declarations (Type III)[3], and comparative assertions[4] should meet the accounting and communication requirements of the respective standards

A.1 Role of product rules

Product rules provide additional specifications that enable valid comparisons of two or more products. Product rules may vary in quality. When developing a new product rule or evaluating the quality of an existing product rule before use, criteria to consider include whether:

- The rule is developed by a diverse group of stakeholders with relevant subject matter expertise
- The rule is peer-reviewed by qualified experts
- There are safeguards in place to prevent conflict of interest
- The rules apply internationally so they can be adopted by other programs and policies
- A policy is in place to determine when product rules are updated

Endnotes

1 International Organization for Standardization, ISO 14024:1999, Environmental labels and declarations -- Type I environmental labeling -- Principles and procedures. Geneva.

2 International Organization for Standardization, ISO 14021:1999, Environmental labels and declarations -- Self-declared environmental claims (Type II environmental labeling). Geneva.

3 International Organization for Standardization, ISO 14025:2006, Environmental labels and declarations -- Type III environmental declarations -- Principles and procedures. Geneva.

4 International Organization for Standardization, ISO 14044:2006, Life Cycle Assessment: Requirements and Guidelines.

Appendix B. Land-Use Change Impacts

This appendix provides guidance on identifying when land-use change impacts are attributable to the studied product. If they are attributable, guidance is also included for calculating and allocating those impacts.[1]

For studied products whose life cycle includes biogenic materials (materials produced by living organisms or biological processes, not fossilized or from fossil sources), attributable processes associated with those materials include emissions and removals associated with agricultural and forestry practices such as growth, fertilizer application, cultivation, and harvesting. In addition to these agricultural and forestry practices, land-use change impacts may be attributable to a studied product's material acquisition and preprocessing stage.

Land-use change impacts[2] include the following:

- Biogenic CO_2 emissions and removals due to carbon stock change occurring as a results of land conversion within or between land-use categories
- Biogenic and non-biogenic CO_2, N_2O, and CH_4 emissions resulting from the preparation of converted land, such as biomass burning or liming[3]

This appendix provides guidance for two situations: when the specific land that the product or product component originates from is known, and when it is not. The concepts of assessment period, amortization period, and distribution of impacts are used across both situations.

It is important to note that while this appendix focuses on agricultural and forest products, significant land-use change impacts are not limited to biogenic products. Any company with a studied product that uses a large amount of land, such as a new settlement, should use this guidance to determine whether the land use changed within the assessment period and whether that had any impact on the area's carbon stocks.

As referenced in chapter 7, companies are required to disclose the method used to calculate land-use change impacts in the inventory report.

Box [B.1] Key concepts in land-use impacts

Carbon stock refers to the total amount of carbon stored on a plot of land at any given time in one or more of the following carbon pools: biomass (above and below ground), dead organic matter (dead wood and litter), and soil organic matter.[4] A change in carbon stock can refer to additional carbon storage within a pool, the removal of CO_2 from the atmosphere to the carbon stock, or the emission of CO_2 to the atmosphere from the carbon stock.

Land-use change occurs when the demand for a specific land use results in a change in carbon stocks on that land. A change in carbon stock can occur from one land-use category to another (e.g., converting forest to cropland) or within a land-use category (e.g., converting a natural forest to a managed forest or converting agricultural land from till to no-till). Land-use change does not include changes in crop cover or crop rotations that occur within the cropland category or forest harvesting and regeneration into the same general forest type, for which the regenerated forest is expected to have comparable carbon stocks to the harvested forest. Land-use categories include forest land, cropland, grassland, wetlands, settlements, and other lands such as bare soil, rock, ice, etc.[5]

Land-use change impacts are the emissions and removals due to land-use change.

B.1 When the specific land is known

B.1.1 Determining attributable land-use impacts

Land-use impacts are attributable to a product if the following are true:

- The carbon stock change is the direct result of extraction or production of biogenic material to create a product
- The carbon stock change was caused by human intervention with the intent of creating a product
- The carbon stock change occurred within the assessment period – 20 years or a single harvest period from the extraction (e.g., harvesting) of a biogenic product or product component, whichever timeframe is longer

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1. *A product is made from an annual crop that was harvested in 2010. The crop is from a plot of land where the last known carbon stock change occurred 50 years ago. In this case no land-use change impacts are attributable to the product.*

2. *A product is made from wood that is extracted from a naturally grown forest (extraction and production occur in the same year). If the extraction of above-ground biomass causes a change in carbon stock of the land, the impacts of the land-use change are attributable to the product.*[6]

3. *A product is made from wood that is grown on a plantation. The wood takes 28 years to grow, and is harvested in 2010 from a plot of land that was converted from a natural growth forest in 1982. Because the length of the harvest cycle is longer than 20 years, the company must consider any carbon stock changes that may have occurred up to 28 years ago (from 2010 to 1982). Therefore, the impacts of the land-use change (i.e., the original clearing of the natural growth forest) are attributable to the product.*

4. *A product is made from a bi-annual crop that was harvested in 2010. The plot of land used to grow the crop was converted from forest in 2000 due to a naturally occurring fire.*[7] *Because the carbon stock change was not caused by human intervention with the intent of creating a product, the land-use change impacts are not attributable to the product.*

B.1.2 Calculating land-use change impacts

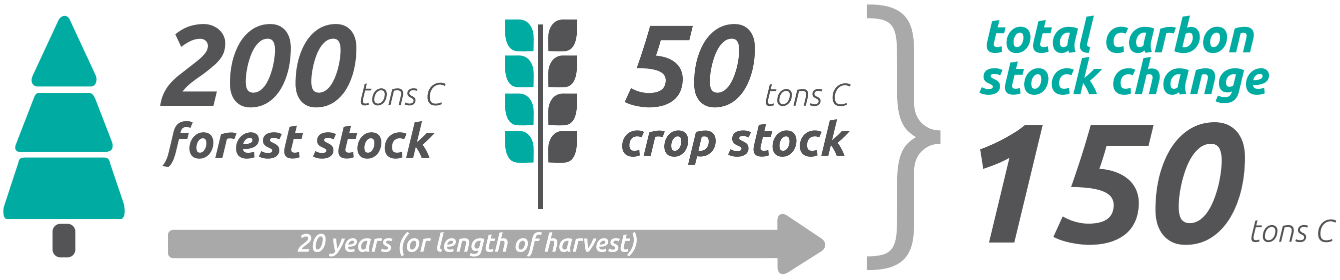
When information about the specific land is available, collecting data for land-use change impacts follows the same data collection and quality requirements given in chapter 8 of this standard. For example, if the reporting company owns the land from which a product is harvested, primary data are required. Primary data from a supplier is preferred for land not owned by the reporting company. These types of data are collected directly from the production site, with actual areas and the mass or volume of inputs used.

Even with primary data from the production site, it is unlikely that primary data is available for the measurement of carbon stock changes and emissions from soils. In some cases secondary data is available in peer-reviewed journals; otherwise, common sources include:

- Sector-specific activity data/emission factors: These data are usually provided by associations, cooperatives, and institutes representing a particular sector. It can include aggregate activity data/emissions from site-specific sources.
- Country-specific activity data/emission factors: Information that reflects country-specific biomes, agricultural practices, climate conditions, soil types, vegetation groups, etc. This can be further broken down into regional data. This type of information can be found in national greenhouse gas inventories and other official government publications, as well as from country experts.
- Generic activity data/emission factors: These are default values provided by the IPCC[8], FAOSTAT[9], etc. These data refer to broad categories, such as high activity clay soils and tropical rainforest, and usually include carbon stock change impacts as well as land-use change practice emissions within the default emission factor.

Figure B.1 is a simplified illustration to show how carbon stock information can be used to calculate land-use change impacts. In this example, forest land is converted into cropland, creating a 150-ton release of carbon due to the change in carbon stock. If several carbon stock changes occur within the assessment period, then the overall impact of all changes must be considered. If

Figure [B.1] Simplified illustration of a carbon stock change calculation



wood is harvested from a forest that is not converted (forest remaining forest), a carbon stock change can be calculated based on the change in forest density. To complete the land-use change impact calculation, companies need to consider what emissions may have occurred as a result of the carbon stock or land-use change unless these are already included in the default emission factors.

B.1.3 Distribution of land-use change impacts

Once land-use change impacts are deemed attributable and impacts are identified, a company needs to distribute those impacts between the studied product and other co-products that are outputs of the land. This is because, in most cases, land-use change occurs on land that produces products over many years, and therefore it is not appropriate to apply all the land-use change impacts to the first products generated within the area. Using the example from figure B.1 above, a company has calculated a carbon stock change associated with the product (in this example, a crop) of 150 tons. The next question is how to distribute those emissions to the products that are harvested from that land. Figure B.2 illustrates three ways land-use change impacts can be distributed over time: A) single year, B) 20 year constant, or C) 20 year decline.

In this standard, land-use change impacts are distributed using option B: evenly over an amortization period of either 20 years or the length of one harvest (whichever is longer). This option was chosen as the most consistent way to distribute impacts for use in a GHG inventory, as both option A and option C create an incentive for companies to delay inventory reporting in an effort to reduce land-use change impacts. It is recognized that applying any time period to amortize emissions creates an arbitrary cut off after which companies are free to grow products on the land without a land-use change burden. However, identifying no time period would create additional uncertainties and inconsistent inventories.

There are several ways a company may distribute land-use change impacts using the amortization period depending on the harvested product:

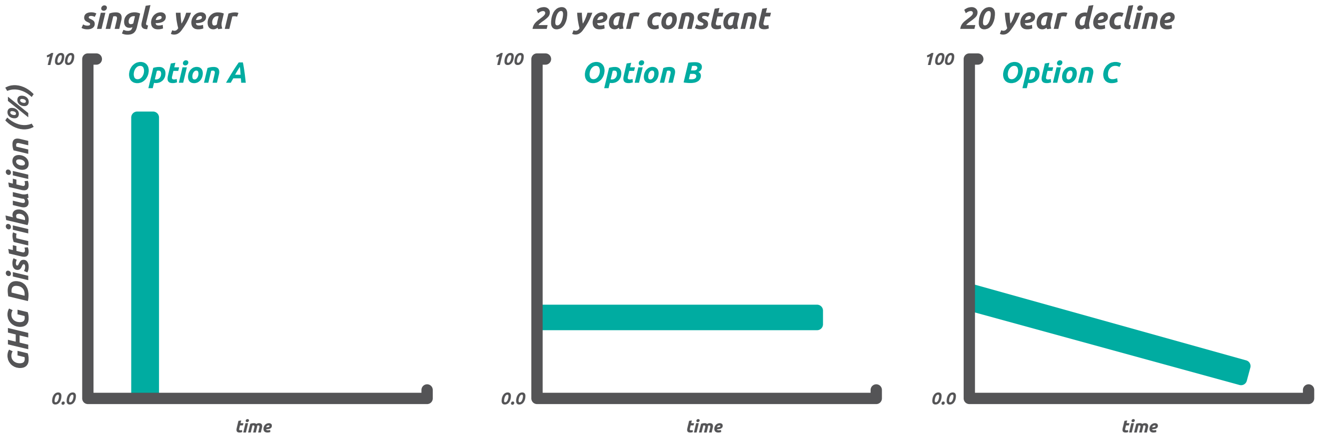
1. For an annually harvested crop, a company applies 1/20th of the impacts to the products produced from each yearly harvest
2. For a semi-annual crop or herbaceous plant, a company may estimate the production of the land over 20 years and then apply the impacts to each ton of harvested biomass
3. For biomass with an extended harvest period (greater than 20 years) or where additional cultivation of the land is not planned, all of the land-use change impacts are applied to the harvested products from the first harvest period

Methods 1 and 2 can be used for both annual and semi-annual crops depending on the preference of the company.

B.1.4 Forestry and wood products

Some forest products are grown on managed forest plantations that are harvested over relatively short time

Figure [B.2] Distributing GHG impacts over a 20 year time period



Source: Zaks, D.P.M., C. C. Barford, N. Ramankutty and J. A. Foley, "Producer and consumer responsibility for greenhouse gas emissions from agricultural production –a perspective from the Brazilian Amazon."Environmental Research Letters. 4 (2009).

frames, while others may be extracted from natural forests that take over 100 years to grow. Some forests are removed with the intent of producing annual crops, while others are removed for the stock of wood that can be extracted at the time of removal. Depending on the type of product or wood being studied and the location where that wood is cultivated, vastly different harvesting techniques occur which have a significant effect on the amount and distribution of land-use change impacts. Furthermore, co-product allocation (as defined in chapter 9) may be needed during land-use change if the converted land also produces biogenic co-products. If the studied product is a crop but the land-use change event created a co-product of wood, a company needs to accurately allocate these emissions. The following scenarios provide some insight into the correct distribution and allocation[10] of land-use impacts due to forest and wood products.

Scenario A: A forest is harvested for wood but the land is not converted into another category or the future use of the land is unknown.

In this scenario, any stock change that is calculated based on the density change of the forest is attributable to the products created from the harvested wood. No distribution is needed because additional growth is not planned, or is unknown.

Scenario B: A forest is harvested for wood then converted into another managed land category.

In this scenario, land-use change impacts should be distributed to all products produced by the land within the amortization period. Consider an example in which a stock change of 150 tons of carbon is calculated with an initial harvest of 100 tons of wood and an annual harvest of 1 ton of crop for the remaining 19 years of the amortization period. This means that 150 tons of carbon are distributed among 119 tons of products. The additional impacts of land-use change (e.g., liming applications) may also need to be distributed. This scenario is only applicable when the converted land is managed and the production of that land is known. In this context, managed refers to land that is continuously maintained for the purpose of cultivating and harvesting a product. Distribution is not applicable for forest land that has been harvested and replanted but is not maintained, or for a plot that is replanted and managed but with an extensive harvest period (greater than 50 years). In both cases the uncertainty associated with the eventual production of the replanted product makes it most accurate to apply all land-use change impacts to the first harvest of wood.

Scenario C: A forest is converted to another land category and the wood is not harvested into a co-product.

In this scenario, a company may not allocate any land-use change impacts to the wood as it was not used to create a co-product. All land-use change impacts (including the burning of the wood not recovered) must be distributed to the product produced on the converted land. If a company does not have data that justifies the use of scenario B (i.e., proof that the wood was harvested and used for a product) then scenario C is used.

B.2 When the specific land use is unknown

When a company has limited information on the specific land from which the product or product components are extracted or harvested, it can be difficult to determine how to attribute or distribute impacts. This situation occurs when a company buys crops or biomass from a supplier who receives indistinguishable shipments from a wide range of land-based sources. Under such circumstances, primary data are not available and secondary data are used to calculate stock changes and determine how much land-use change impacts should be distributed to a product.

The first step in estimating land-use changes impacts is to determine in what location the crops or biomass were likely grown. If the crop or biomass is grown only in certain locations due to climates and soil types, those locations should be used. If the crop or biomass is grown in many locations, a company may choose the largest producing location or the most likely location (e.g., due to proximity to the production facility). Companies are encouraged to perform scenario uncertainty if more than one location is plausible. Companies may also take an average of locations if data are available to support that calculation (e.g., all locations have carbon stock change data available). Once the location has been determined, companies may use the following data to estimate the carbon stock and land-use change impacts:

- Land-use imaging and/or agricultural demand-based models
- Average data, including:
  - International statistics
  - Country- or region-specific statistical databases
  - Statistical yearbooks

Land-use imaging and/or agricultural demand-based models include using remote sensing[11] or GIS data to estimate land-use change in a particular location or market-based models[12] to estimate land-use change based on the market trends of a crop or wood product. For example, if the studied product is a crop assumed to be produced in New Zealand, and satellite imagery shows that land use for that crop has remained constant in New Zealand for the past 20 years, then the company can assume that no land-use change impacts are attributable to their product. While these methods may be the most accurate, they are often complex, time consuming, and not freely available. Additionally, they may not provide an accurate representation for some countries. If a company has access to these tools they are encouraged to use them to determine land-use change impacts as long as the modeled results are justified and transparent.

When a company does not have access to models or imaging data, it may use average statistics to estimate land-use change impacts. For example, companies may use the agricultural or forestry statistic for the assumed location to determine the change in land occupation for the studied product versus the total land change in that location. The following example shows the steps companies can follow to use agricultural data to determine whether land-use change has occurred. The same technique may be used for managed wood products using forestry data. If the crop or biomass that is being studied is shown to occupy less land over the 20-year assessment period, the company can assume that no land-use change has taken place. If the amount of land occupied by the crop or biomass being studied has increased, then land-use change impacts are attributable. In this case the company needs to assume what the original land category was. This should be based on the type of land present in the assumed location and when more than one land type is possible the conservative choice should be made.

It is important to note that any assumptions made about land-use change impacts are only estimations and subject to much uncertainty. Because these estimation techniques cannot identify when the land-use change occurs, companies should always assume 1/20th of the land-use change impact, as shown in the following examples. Companies may also choose not to make any assumptions about land-use change and only use the worst case scenario (e.g., all land is converted from the most carbon rich land category). Information on the methods used to determine land-use change impacts should be included in the inventory report for transparency.

Box [B.2] Estimating land-use change impacts without specific data

In this example, the following steps were taken to determine whether land-use change impacts are attributable to palm oil and rice, and, if so, to produce the land-use impact estimate. The Food and Agriculture Organization's (FAO) statistical database is used to make the estimations, and both products are assumed to come from Malaysia. (See FAO website for more information: http://faostat.fao.org/site/567/default.aspx#ancor.)

1. *Determine the most-planted crops in the assumed location*

The first step is to determine the country profile for the most-planted crops. Because many agricultural products are harvested in Malaysia, only crops that on their own contribute more than 1 percent of the countries' harvested area are considered. If the studied crop is not within the top 1 percent of area harvested in the location, this is an indication that the assumed location is not appropriate. Companies should assume a location where a large amount, if not the largest amount, of the studied product is harvested from each year. Table B.1 shows these statistics, where the crops not shown (because they are less than 1 percent individually) contribute 4 percent to the total acreage.

2. *Collect historical land-use data for the studied product.*

The second step is to collect historical land-use data for the studied products to determine whether their land use has increased or decreased over the assessment period (20 years in this example). Because statistical land-use data are often published a few years behind schedule (e.g., 2008 data published in 2010), companies can use the data as long as the unknown period does not exceed three years. If the unknown period does exceed three years, companies should either supplement the data with more recent statistics or consider another method to estimate land-use change impacts.

In figure B.3, the total change in the area harvested for rice paddy over the 20-year period remains fairly steady (e.g., does not exceed a 1-percent increase). It can be assumed that land-use change did not occur in

Table [B.1] Area harvested for crops grown in Malaysia in 2008 that contribute more than 1 percent individually to total harvested hectares (ha).

Crop	*Area harvested 2008 [ha]*	*Percent total area harvested*
Cassava	41000	1%
Coconuts	174000	3%
Coffee, green	50000	1%
Natural rubber	1247000	19%
Oil palm fruit	3900000	60%
Oilseeds	150000	2%
Rice, paddy	667656	10%
Total	6478175	100%

Source: FAO, FAOSTAT. Available from http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor, 2011.

Box [B.2] Estimating land-use change impacts without specific data (continued)

Figure [B.3] Area harvested (1000 ha) for rice paddy production in Malaysia for the period from 1988-2008

Source: FAO, FAOSTAT. Available from http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor, 2011.

Figure [B.4] Area harvested (1000 ha) for oil palm fruit production in Malaysia for the period from 1988-2008

Source: FAO, FAOSTAT. Available from http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor, 2011.

Malaysia due to rice production over the assessment period. Assuming the GHG inventory is being assessed in 2010 companies should also consider whether any recent changes in land use in Malaysia may have caused an increase in rice production over the past two years not shown in the data. If there is no reason to believe this is the case, the company can assume that no land-use change impacts are attributable to the studied product rice.

Taking the same approach for palm oil, it is obvious from figure B.4 that there has been an increase in land used for palm production over the assessment period.

At this point a company can either assume that all the land is converted from a different land category (e.g., forest, grassland) to palm (see step 4), or they can estimate what percentage of land is converted within the cropland category and therefore not subject to land-use change.

3. Determine what percentage of land-use change is due to converted cropland

Looking at the major crops dynamics in Malaysia over the past 20 years, table B.2 shows a decrease in harvested area for some crops and an increase in harvested area for palm oil. This indicates that the total growth of harvested area in the country is driven by increases in palm oil production.

As table B.2 suggests, around 27 percent of the overall land-use growth could potentially come from the conversion of other cropland where area is decreasing. Therefore the company may assume that 72 percent of the palm oil produced in Malaysia comes from areas converted from a different land category. This assumption should not be made if the total area of cropland is decreasing, or if the country has specific efforts in place to convert degraded cropland to pasture land or another type of land category. In these cases, the decrease in other cropland may be due to those efforts and conversion to the studied product.

Box [B.2] Estimating land-use change impacts without specific data (continued)

Table [B.2] Top crops and the difference in areas harvested (ha) from 1988 to 2010 in Malaysia

Product	*Area harvested 1988 [ha]*	*Area harvested 2008 [ha]*	*Difference [ha]*
Coconuts	327,812	174,000	-153,812
Natural rubber	1,660,000	1,247,000	-413,000
Oil palm fruit	1,530,905	3,900,000	2,369,095
Rice, paddy	671,755	667,656	-4,099
Others in sum	566,686	489,519	-77,167
Total growth			2,369,095
Total decrease			648,078
% growth that can be covered by crop to crop conversion			27.4

Source: FAO, FAOSTAT. Available from http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor, 2011.

4. Determine type of land converted

Malaysia has a tropical climate, and according to statistics the majority of land is forest (66 percent) or cropland (31 percent).[13] Therefore, it should be assumed that the land-use change occurred from tropical forest to cropland to meet the increased demand for palm oil fruit. Companies can use the IPCC default values to determine what the carbon stock change associated with this land-use change would be. The company also needs to assume what the land-use change practices would typically be when forest land is converted to cropland in Malaysia – for example, whether the forest biomass is burned during conversion and what fertilizers are applied to prepare the land for crop production.

In some cases identifying the type of land converted may not be as straightforward. In such cases, companies should perform a scenario uncertainty analysis to show the impact of different assumptions. For example, if a crop is being produced in a country with tropical forest land and grassland that could be converted, companies should assume the tropical forest is being converted and use grassland conversion for an uncertainty calculation.

5. Distribute land-use change impacts

Unless the default data collected in step 4 is on an annual basis, the company needs to distribute the land-use change impacts across the amortization period for the product. Assuming palm oil is harvested on an annual basis, 1/20th of the land-use change impacts are applied to a yearly harvest of palm oil. This value is further normalized to the reference flow basis for inclusion in the inventory results.

B.2.1 Estimating significance for land-use change impacts

When specific land data are not available, companies may also chose to estimate the potential significance of land-use impacts on their products to determine if a justifiable exclusion is appropriate. For example, a product that uses a bio-based polymer as an input could estimate the impact of land-use change assuming the worst case scenario (e.g., all comes from land that was converted from natural forest) and determine whether this is insignificant, applying the same rules as described in chapter 7. If land-use impacts are deemed significant using this estimation, the company can either include the worst case values in the report or go back and try to estimate the potential impact using statistical data. If land-use impacts are insignificant, then this should be included as a justifiable exclusion in the inventory report.

B.3 Soil carbon

When land-use change occurs, some of the carbon stock change that results is due to changes in the carbon stock of the soil. For example, converting natural land to cultivated land reduces the amount of carbon the soil can store. The IPCC factors for calculating carbon stock changes due to land-use change include estimates of soil carbon change.

However, soil carbon loss can continue even after land-use change as a result of land-use practices such as harvesting and fertilizer application. On the other hand, switching land-use practices can improve the carbon stock of soil, resulting in CO_2 removal. Companies may include soil carbon change as a result of land-use practices in their inventory results if they are able to reasonably estimate the emissions or removals. Companies should report whether the soil carbon change is included in the inventory results.

Endnotes

1 The guidance presented here is based on methodologies and guidelines given in the 2006 IPCC Guidelines for National GHG Inventories, Volume 4: Agriculture, Forestry, and Other Land Use. A company is encouraged to look to the most recent IPCC guidelines to ensure accurate and up-to-date accounting of land use and land-use change emissions. However, it is important to note that while the IPCC guidelines have useful and comprehensive information, their focus is on national inventories and therefore some details are not applicable.

2 It is recognized that a change in carbon stock can result in either a removal or emission of carbon from or to the atmosphere. However, because this standard accounts for the GHG inventory of a product, it is more likely that the use of biomass (and not the planting or re-growth of biomass) will results in GHG emissions than removals. Growing biomass to create a GHG credit is not attributable to a product following this standard methodology. However in some cases, such as a carbon stock change from till to no-till crop rotation) or use of degraded lands, a company may see a net positive land-use change impact (e.g., more removal than emissions).

3 This refers only to biomass burning, liming, and other practices used to prepare converted land. Biomass burning and fertilizer application due to agricultural and forestry practices are also included in the inventory as attributable processes, separate from land-use change impacts.

4 IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, vol.4, Agriculture, Forestry and Other Land Use, eds. H.S. Eggleston, L. Buendia, K. Miwa, T. Ngara and K. Tanabe (Hayama, Japan: IGES,2006).

5 IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, vol.4, Agriculture, Forestry and Other Land Use, eds. H.S. Eggleston, L. Buendia, K. Miwa, T. Ngara and K. Tanabe (Hayama, Japan: IGES,2006).

6 The 2006 IPCC guidelines give values for forest land above and below a certain density of biomass. If the removal of biomass does not cause a change in carbon stock value, then land-use change impacts may be calculated as zero.

7 It is important to note that nearly all fires in tropical forests are man-made.

8 IPCC, 2006 IPCC Guidelines for National GHG Inventories, vol. 4: Agriculture, Forestry, and Other Land Use.

9 FAO, FAOSTAT. Available from http://faostat.fao.org, 2011.

10 Distribution is used in reference to land-use change impacts to refer to the apportionment of impacts over the amortization period. Allocation is defined in chapter 9 as portioning inputs and outputs of a common process to its product and co-products. Both can occur when calculating land-use change impacts.

11 Remote sensing is when current multispectral sensors provide spectral data for identifying and mapping the crop types allowing for precise monitoring of land-use changes. Current drawbacks of this method are the relatively recent systematic data collection (no regular multispectral coverage for 20 years ago timeframe), and the costs of images and processing.

12 Some examples of market-based models for the agriculture and forestry sector include the Food and Agricultural Policy Research Institute (FAPRI) and the Forest and Agricultural Sector Optimization Model (FASOM).

13 World Resources Institute, EarthTrends: Environmental Information. Available from http://earthtrends.wri.org. Washington DC: World Resources Institute.2007.

Appendix C. Data Management Plan

***A** data management plan documents the product inventory process and the internal quality assurance and quality control (QA/QC) procedures in place to enable the preparation of the inventory from its inception through to final reporting. It is a valuable tool to manage data and track progress of a product inventory over time, and can also be useful as an assurance readiness measure since it contains much of the data needed to perform assurance.*

This appendix provides guidance to help companies create and maintain an effective data management plan. Companies may already have similar procedures in place for other data collection efforts, such as meeting ISO standards or corporate GHG accounting requirements. Where possible, these processes should be aligned to reduce data management burdens.

C.1 Overview of the data management plan

The quality control portion of the data management plan outlines a system of routine technical activities to determine and control the quality of the product inventory data and the data management processes. The purpose is to ensure that the product inventory does not contain incorrect statements by identifying and reducing errors and omissions; providing routine checks to maximize consistency in the accounting process; and facilitating internal and external inventory review and assurance.

The quality assurance portion of the data management plan involves peer review and audits to assess the quality of the inventory. Table C.2 includes recommended quality assurance and control procedures. Peer review involves reviewing the documentation of the product accounting methodology and results, but typically does not rigorously review the data used or the references. This review aims to reduce or eliminate any inherent error or bias in the process used to develop the inventory and assess the effectiveness of the internal quality control procedures. The review evaluates whether the inventory complies with the quality control specifications outlined in the data management plan. Peer reviews and audits should be conducted by someone not involved in the development of the product inventory to reduce bias. Establishing data management plans is helpful in the product inventory assurance process and they should be made available to assurance providers (whether internal or external).

At a minimum the data management plans should contain the following items:

- Description of the studied product, unit of analysis, and reference flow
- Information on the entity(ies) or person(s) responsible for measurement and data collection procedures
- All information that describes the product's inventory boundary
- Criteria used to determine when a product inventory is re-evaluated
- Data collection procedures
- Data sources, including activity data, emission factors and other data, and the results of any data quality assessment performed
- Calculation methodologies, including unit conversions and data aggregation
- Length of time the data should be archived
- Data transmission, storage, and backup procedures
- All QA/QC procedures for data collection, input and handling activities, data documentation, and emissions calculations

The process of setting up a data management system should involve establishing standard procedures to address all of the data management activities, including the quality control and quality assurance aspects of developing a product inventory.

C.2 Creating a data management plan

To develop a data management plan, the following steps should be undertaken and documented.

1. ***Establish a product accounting quality person/team.*** This person/team should be responsible for implementing and maintaining the data management plan, continually improving the quality of product inventories, and coordinating internal data exchanges and any external interactions (such as with relevant product accounting programs and assurance providers). The person/team may be responsible for all product inventories undertaken by a company or for an individual product inventory.

2. ***Develop a data management plan.*** For publicly-disclosed product inventories, the plan should cover the components outlined in the section above (also see table C.1) Documenting this information should assist with completing repeat product inventories and assessing and improving the quality of the current product inventory.

   Development of the data management plan should begin before any data is collected to ensure all relevant information about the inventory is documented as it proceeds. The plan should evolve over time as data collection and processes are refined.

3. ***Perform generic data quality checks based on the data management plan.*** Generic checks should be applied to all aspects of the inventory process, focusing on data quality, data handling, documentation, and calculation procedures.

4. ***Perform specific data quality checks.*** Specific checks are more in-depth than generic and should be made for those sources, processes, and/or activities that are major contributors to the product inventory and/or have high levels of uncertainty (see chapter 10 on assessing uncertainty).

5. ***Review final product inventory and reports.*** Review procedures should be established that match the purpose of the inventory and the type of assurance performed. Internal reviews should be undertaken in preparation for the assurance process by the appropriate department within a company, such as an internal audit or accounting department.

6. ***Establish formal feedback loops to improve data collection, handling, and documentation processes.*** Feedback loops are needed to improve the quality of the product inventory over time and to correct any errors or inconsistencies identified in the review process.

7. ***Establish reporting, documentation, and archiving procedures.*** Establish record-keeping processes for what and how data should be stored over time, what information should be reported as part of internal and external inventory reports, and what should be documented to support data collection and calculation methodologies. The process may also involve aligning or developing relevant database systems for record keeping. Systems may take time to develop, and it is important to ensure that all relevant information is collected prior to the establishment of the system and then transferred to the system once it is operational.

The data management plan is likely to be an evolving document that is updated as data sources change, data handling procedures are refined, calculation methodologies improve, product inventory responsibilities change within a company, or the business objectives of the product inventory change.

Table C.1 outlines which components should be included in a data management plan and can be used as a guide for creating a plan or for pulling together existing documents to constitute the plan.

Table [C.1] Data management plan checklist

Component	Information	Rationale
Responsibilities	Name and contact details of persons responsible for: • Management of product inventory • Data collection for each process • Internal review or audit procedures • Assurance procedures	This ensures institutional knowledge is maintained and allows relevant person(s) to be identified as accountable for: • Confirming and checking information during any internal or external audit procedures • Producing consistent future product inventory
Product description	• Description of the product and functional unit	To provide internal auditors, assurance providers, and those doing future product inventories, with information on the product/functional unit
Inventory boundary	• Inventory boundary description (e.g., cradle-to-grave or cradle-to-gate) • How the boundary was derived • Attributable processes included in the inventory • Attributable processes excluded from the inventory (including rationale for exclusion) • Information on how the product use and end-of-life profile was determined	To provide internal auditors, assurance providers, and those doing future product inventories with sufficient information to understand and replicate boundary decisions
Allocation	• Allocation methodologies used and where they were used	To provide internal auditors, assurance providers, and those doing future product inventories with sufficient information to understand and replicate allocation decisions
Data summary	• Data collection procedures, including data sources for each process	Records all data sources and allows others to locate data sources (for audit or future product inventories). Also provides information on what suppliers have been approached for data
	• How data quality assessment and uncertainty assessment were undertaken	Enables data quality to be tracked over time and improved

Table [C.1] Data management plan checklist (continued)

Component	*Information*	*Rationale*
Data summary (continued)	• Data sources where better quality data is preferable and plan for how to improve that data	Identifies where data sources should be improved over time (e.g., needed emissions for laptop computer but could only obtain desktop computer information), including those suppliers who were asked to provide data and those that were not
	• Criteria used to determine when an inventory is to be re-evaluated, including the relevant information, changes to the system to be tracked over time, and how these changes should be tracked	This allows data and information sources to be tracked and compared over time. It may also involve identifying a system (e.g., document tracking and identification system) to ensure data and information is easily located and under what conditions this information/data was used or collected
	• Calculation methodologies used (and references). This includes documenting where the calculation methodology for any data used was not available.	Provides internal auditors, assurance providers, and those doing future product inventories with details on how emissions were calculated
Inventory results calculations	• Calculation methodologies and changes in methodologies over time	Noting methodological changes allows for easier baseline recalculation when tracking inventory improvements
	• GWP values used	Allows for consistency over time
Performance tracking	• When tracking performance, details of the base inventory adjustment policy	Prescribes clearly a trigger for adjusting a base inventory enabling tracking of performance over time
Data storage procedures	• How and where data is stored	Allows information to be easily located
	• Length of time data is to be archived	Keeps a record of how long information is stored to prevent looking for information that is no longer kept
	• Backup procedures	Ensures backup procedures are implemented
QA/QC procedures	• QA/QC procedures used (see table C.2 for detailed guidance)	Ensures that adequate processes are in place to check data collection, input and handling, data documentation, and emissions calculations

Table [C.2] Recommended quality assurance/quality control procedures

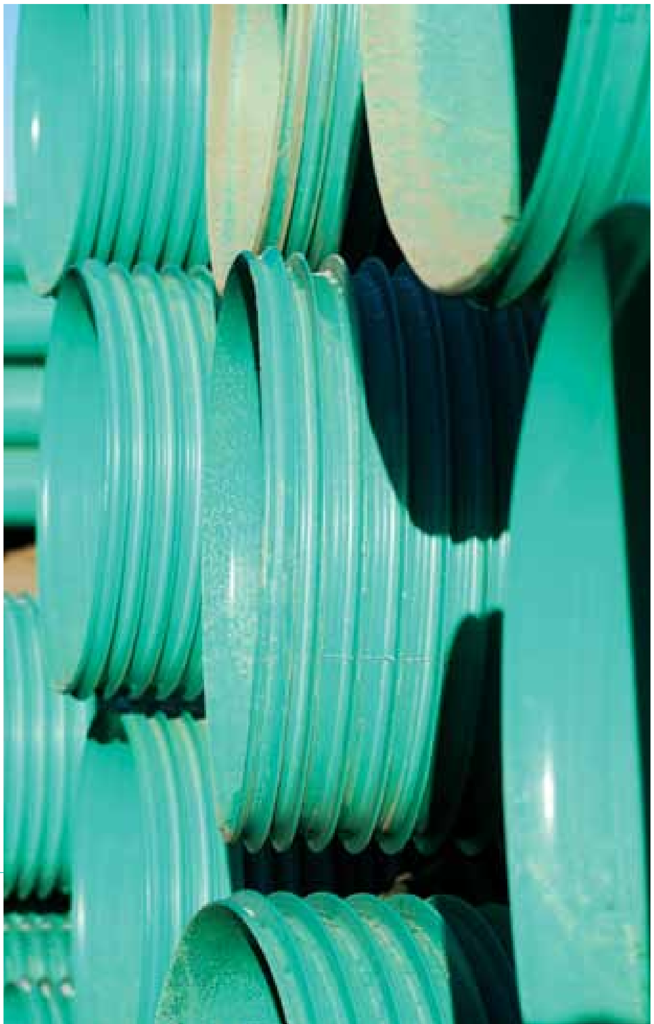
Activity	*Procedure*
Data collection, input, and handling activities • **Transcription errors in data collection**	• Check a sample of input data in each process for transcription errors
• **Uncertainty estimates**	• Check that the calculated uncertainties are complete and calculated correctly
Data documentation • **Transcription errors in references and storage of all references used**	• Confirm that bibliographical data in references are properly cited. • Ensure that all relevant references are archived
• **Storing information on inventory methodology, data, and data quality**	• Check that inventory boundary, base inventory (if relevant), GHGs included, allocation methodology uses, data sources, and any relevant assumptions are documented and archived • Check that all data quality indicators are described, documented, and archived for each process • Check for consistency in emissions sources and data sources to similar product inventories
• **Recording parameter and unit information**	• Check that all units are appropriately labeled in calculation sheets • Check that all units are correctly transferred through all calculations and aggregation of emissions in all processes • Check that conversion factors are correct • Check any temporal or spatial adjustment factors are appropriate and correctly used
• **Recording calculation methodologies**	• Check that all calculation methodologies are documented • Check that any changes to calculation methodologies are documented
• **Database/calculation sheet integrity**	• Ensure all fields and their units are labeled in database/calculation sheet • Ensure the database/calculation sheet is documented and the structure and operating details of the database/calculations sheets are archived
• **Review of internal documentation and archiving**	• Check there is sufficient internal documentation to support the estimates and enable the reproduction of the emissions and data quality assessment, and uncertainty estimations • Check that all data, supporting data and records are archived and stored to facilitate a detailed review • Check that the archive is securely stored

Table [C.2] Recommended quality assurance/quality control procedures (continued)

Activity	*Procedure*
Calculating emissions and checking calculations	
• **Aggregation of emissions**	• Ensure that the aggregation of emissions from all processes is correct
• **Emissions trends**	• Where possible, compare emissions from each process (or total product emissions) to previous estimates. If significant departures, check data inputs, assumptions and calculation methodologies • Where possible, compare material and energy purchases for each process (or in total) against generic industry averages
Calculation methodologies	• Reproduce a sample set of emissions and removals calculations to cross-check the application of calculation methodologies • Where possible, cross-check calculation methodologies used against more or less complex methodologies to ensure similar results are achieved

Abbreviations

BSI	British Standards Institution
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DEFRA	UK Department of Environment Food and Rural Affairs
EEIO	Environmentally Extended Input-Output
EPD	Environmental Product Declaration
FAO	Food and Agriculture Organization
GHG	Greenhouse Gas
GIS	Geographic Information System
GTP	Global Temperate Potential
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
ILCD	International Reference Life Cycle Data
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
kg	Kilogram
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
MW	Megawatt
NAICS	North American Industry Classification System
NGO	Non-Governmental Organization
N_2O	Nitrous Oxide
O&M	Operation and Maintenance
PAS 2050	Publicly Available Specification 2050
PCR	Product Category Rule
PET	Polyethylene Terephthalate
PFCs	Perfluorocarbons
QA/QC	Quality Assurance/Quality Control
R&D	Research and Development
SETAC	Society of Environmental Toxicology and Chemistry
SF_6	Sulfur Hexafluoride
SKU	Stock-Keeping Unit
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNSPSC	United Nations Standard Products and Services Code
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute



Glossary

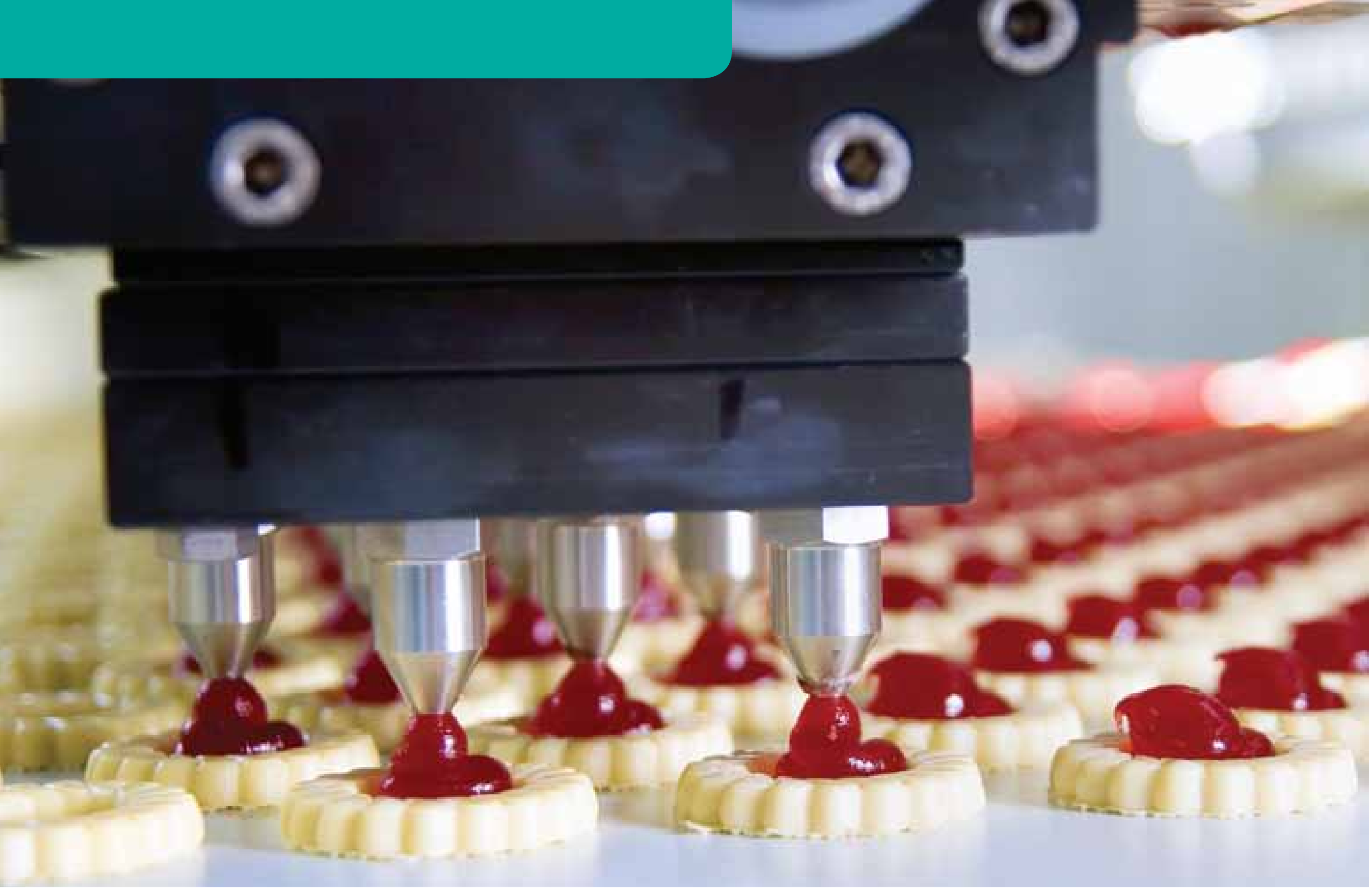
Allocation	The partitioning of emissions and removals from a common process between the studied product's life cycle and the life cycle of the co-product(s).[1]
Assurance	The level of confidence that the inventory results and report are complete, accurate, consistent, transparent, relevant, and without material misstatements.
Assurer	A competent individual or body who conducts the assurance process, whether internally within the company or externally.
Attributable processes	Service, material, and energy flows that become the product, make the product, and carry the product through its life cycle.
Attributional approach	An approach to LCA where GHG emissions and removals are attributed to the unit of analysis of the studied product by linking together attributable processes along its life cycle.[2]
Audit trail	Well organized and transparent historical records documenting how the GHG inventory was compiled.
Biogenic	Produced by living organisms or biological processes, but not fossilized or from fossil sources.[3]
Carbon stock	The total amount of carbon stored on a plot of land at any given time in one or more of the following carbon pools: biomass (above and below ground), dead organic matter (dead wood and litter), and soil organic matter.[4] A change in carbon stock can refer to additional carbon storage within a pool, the removal of CO_2 from the atmosphere, or the emission of CO_2 to the atmosphere.
Common process	One process that has multiple valuable products as inputs and/or outputs including the studied product and co-product(s).
Comparative assertion	An environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function.[5]
Consequential approach	An approach to LCA where processes are included in the life cycle boundary to the extent that they are expected to change as a consequence of a change in demand for the unit of analysis.[6]
Consumer	An individual that purchases and uses a product.
Co-product	A product exiting the common process that has value as an input into another product's life cycle.

Cradle-to-gate inventory	A partial life cycle of an intermediate product, from material acquisition through to when the product leaves the reporting company's gate (e.g., immediately following the product's production).
Cradle-to-grave inventory	Removals and emissions of a studied product from material acquisition through to end-of-life.
Customer	An entity that purchases, rents, or uses the products of another entity (i.e., a supplier).
Direct emissions data	Emissions released from a process (or removals absorbed from the atmosphere) determined through direct monitoring, stoichiometry, mass balances, or similar methods.
Downstream	GHG emissions or removals associated with processes that occur in the life cycle of a product subsequent to the processes owned or controlled by the reporting company.[7]
Emissions factor	GHG emissions per unit of activity data.
End-of-life stage	A life cycle stage that begins when the used product is discarded by the consumer and ends when the product is returned to nature (e.g., incinerated) or allocated to another product's life cycle.
Environmentally extended input-output (EEIO)	Emission factors developed through the analysis of economic flows and used to estimate GHG emissions for a given industry or product category.[8]
Extrapolated data	Data specific to another process or product that has been adapted or customized to resemble more closely the conditions of the given process in the studied product's life cycle.
Final product	Goods and services that are ultimately consumed by the end user rather than used in the production of another good or service.
Financial activity data	Monetary measures of a process that result in GHG emissions or removals.
First party (self or internal) assurance	Assurance performed by a person(s) from within the reporting company but independent of the GHG inventory determination process.
Function	The service provided by the studied product.
Functional unit	The quantified performance of the studied product.[9]
Gate-to-gate	The emissions and removals attributable to a studied product while it is under the ownership or control of the reporting company.
GHG impact	The results calculated when GHG emissions and removals are multiplied by the relevant global warming potential (GWP).

Global warming potential (GWP)	A factor used to calculate the cumulative radiative forcing impact of multiple specific GHGs in a comparable way.[10]
Indirect land-use change	When the demand for a specific land use induces a carbon stock change on other lands.
Insignificance threshold	The threshold below which a process, input, or output can be considered insignificant to the studied product's life cycle inventory.
Intermediate products	Goods that are used as inputs to the production of other goods or services.
Inventory report	The full reporting requirements, plus any optional information, reported publicly in conformance with the *Product Standard*.
Inventory results	The GHG impact of the studied product per unit of analysis.
Land use categories	Forest land, cropland, grassland, wetlands, settlements and other lands.[11]
Land-use change	Occurs when the demand for a specific land use results in a change in carbon stocks on that land, due to either a conversion from one land-use category to another or a conversion within a land-use category.
Land-use change impacts	Emissions and removals due to land-use change.
Level of assurance	The degree of confidence stakeholders can have over the information in the inventory report.
Life cycle	Consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to end-of-life.
Life cycle assessment	Compilation and evaluation of inputs, outputs and potential environmental impacts of a product system throughout its lifecycle.[12]
Life cycle stage	A useful categorization of the interconnected steps in a product's life cycle for the purposes of organizing processes, data collection, and inventory results.
Material acquisition and pre-processing stage	A life cycle stage that begins when resources are extracted from nature and ends when the product components enter the gate of the studied product's production facility.
Material misstatement	Individual or aggregate errors, omissions, and misrepresentations that significantly impact the GHG inventory results and could influence a user's decisions.
Non-attributable processes	Processes and services, materials and energy flows are not directly connected to the studied product because they do not become the product, make the product, or directly carry the product through its life cycle.

Primary data	Data from specific processes in the studied product's life cycle.
Process activity data	Physical measures of a process that result in GHG emissions or removals.
Product	Any good or service.
Product category	Group of products that can fulfill equivalent functions.[13]
Product distribution and storage stage	A life cycle stage that begins when the finished studied product leaves the gate of the production facility and ends when the consumer takes possession of the product.
Product GHG inventory	Compilation and evaluation of the inputs, outputs, and the potential GHG impacts of a product system throughout its life cycle.
Product rule	A document containing additional specifications needed to enable comparisons or declarations about a product or product category.
Production stage	A life cycle stage that begins when the product components enter the production site for the studied product and ends when the finished studied product leaves the production gate.
Proxy data	Data from a similar activity that is used as a stand-in for the given activity. Proxy data can be extrapolated, scaled up, or customized to represent the given activity.
Recycling processes	Processes that occur as a result of a product or material being reused or recycled as a material input into another product's life cycle.
Reference flow	The amount of studied product needed to fulfill the function defined in the unit of analysis.[14]
Removal	The sequestration or absorption of GHG emissions from the atmosphere, which most typically occurs when CO_2 is absorbed by biogenic materials during photosynthesis.
Reporting company	The company performing the product GHG inventory in conformance with the *Product Standard.*
Same inherent properties (recycling)	When a recycled material has maintained its properties (e.g., chemical, physical) such that it can be used as a direct replacement of virgin material.
Scope 3 inventory	A reporting organization's indirect emissions other than those covered in scope 2. A company's scope 3 inventory includes the upstream and downstream emissions of the reporting company.
Secondary data	Process data that are not from specific processes in the studied product's life cycle.
Sector guidance	A document or tool that provides guidance for performing a product GHG inventory within a given sector.

Service life	The amount of time needed for a product to fulfill the function defined in the unit of analysis.
Studied product	The product for which the GHG inventory is performed.
Third party (external) assurance	Assurance performed by a person(s) from an organization independent of the product GHG inventory determination process.
Time period	The period of time when attributable processes occur during the studied product's life cycle, from when materials are extracted from nature until they are returned to nature at the end-of-life (e.g., incinerated) or leave the studied product's life cycle (e.g., recycled).
Qualitative uncertainty	A general and imprecise term which refers to the lack of certainty in data and methodology choices, such as the application of non-representative factors or methods, incomplete data on sources and sinks, lack of transparency, etc.
Quantitative uncertainty	Measurement that characterizes the dispersion of values that could reasonably be attributed to a parameter (adapted from ISO 1995).[15]
Unit of analysis	The basis on which the inventory results are calculated; the unit of analysis is defined as the functional unit for final products and the reference flow for intermediate products.
Upstream	GHG emissions or removals associated with processes that occur in the life cycle of a product prior to the processes owned or controlled by the reporting company.[16]
Use stage	A life cycle stage that begins when the consumer takes possession of the product and ends when the used product is discarded for transport to a waste treatment location or recycled into another product's life cycle.
Waste	An output of a process that has no market value.



Endnotes

1 Adapted from ISO 14044:2006.

2 Adapted from UNEP and SETAC, Global Guidance Principles for Life Cycle Assessment Databases. 2011.

3 Adapted from British Standards Institution et al. PAS 2050:2008: Specification for the assessment of life cycle greenhouse gas emissions of goods and services.

4 IPCC, 2006 IPCC Guidelines for National GHG Inventories, Volume 4: Agriculture, Forestry, and Other Land Use.

5 International Organization of Standardization, ISO 14044:2006, Life Cycle Assessment: Requirements and Guidelines.

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7 Adapted from British Standards Institution et al. PAS 2050:2008: Specification for the assessment of life cycle greenhouse gas emissions of goods and services.

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13 International Organization for Standardization, ISO 14025:2006, Environmental labels and declarations-- Type III environmental declarations -- Principles and procedures.

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15 International Organization for Standardization, 1995, ISO/IEC Guide 98:1995. Guide to the expression of uncertainty in measurement (GUM).

16 Adapted from British Standards Institution et al. PAS 2050:2008: Specification for the assessment of life cycle greenhouse gas emissions of goods and services.

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