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The Greenhouse Gas Protocol Initiative
the foundation for sound and sustainable climate strategies

Product Life Cycle
Accounting and Reporting Standard

Draft for Road Testing
January 2010

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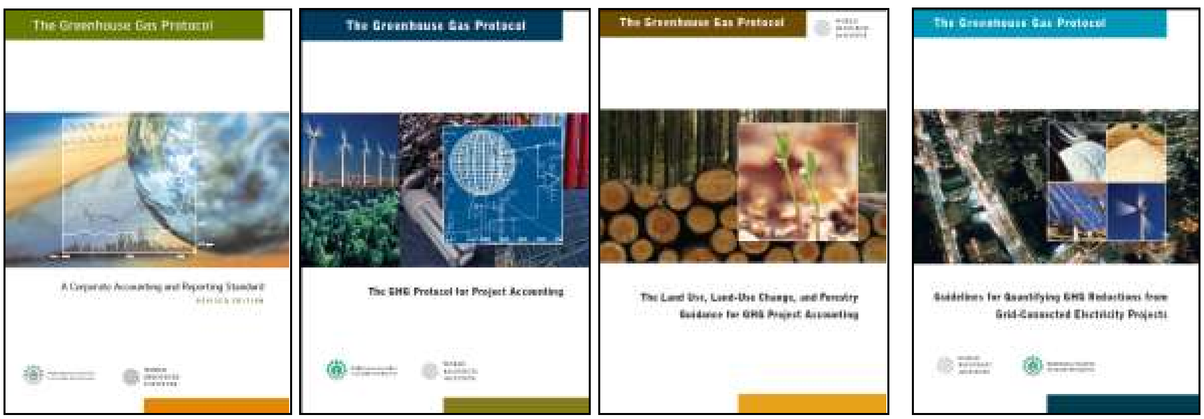
1. Introduction

The Greenhouse Gas Protocol Initiative (*GHG Protocol*) is a multi-stakeholder partnership of businesses, non-governmental organizations (NGOs), governments and others convened by the World Resources Institute (WRI), a U.S. based environmental NGO and the World Business Council for Sustainable Development (WBCSD), a Geneva, Switzerland-based coalition of over 200 international companies. Launched in 1998, the Initiative's mission is to develop internationally accepted accounting and reporting standards and guidelines for corporate greenhouse gas (GHG) emissions inventories and GHG projects, and to promote their use by businesses, governments, NGOs and other organizations.

The GHG Protocol Initiative has previously produced the following standards and guidelines:

- GHG Protocol *Corporate Accounting and Reporting Standard*[1] (2004)
- GHG Protocol for Project Accounting (2005)
- GHG Protocol *Land Use, Land-Use Change and Forestry Guidance for GHG Project Accounting* (2006)
- GHG Protocol *Guidelines for Quantifying GHG Reductions from Grid-Connected Electricity Projects* (2007)



The GHG Protocol launched a new initiative in 2008 to develop two new standards for:

- Product life cycle accounting and reporting
- Corporate scope 3 (value chain) accounting and reporting

1.1. Introduction to Draft for Road Testing

Standard Development Process

The GHG Protocol Initiative follows a multi-stakeholder, consensus-based process to develop greenhouse gas accounting and reporting standards with participation from businesses, government agencies, nongovernmental organizations, and academic institutions from around the world.

This draft standard was developed between January and October 2009 by five technical working groups collectively comprised of over 100 members from a diversity of businesses, government agencies, NGOs, and academic institutions. The development was led and coordinated by WRI and WBCSD. A Steering Committee

[1] The GHG Protocol *Corporate Standard* is sometimes referred to as "the GHG Protocol." The term GHG Protocol is an umbrella term for the collection of standards, tools and other publications provided by the WRI/WBCSD GHG Protocol Initiative.

consisting of 25 organizations met three times between September 2008 and September 2009 to provide strategic and technical direction to the process.

Process Structure

Timeline

Date	Activity
November 2007	✓ Survey and consultations to assess need for new standards
September 2008	✓ Steering Committee Meeting #1 (Washington DC) ✓ Technical Working Group Meeting #1 (London)
January 2009	✓ Working groups begin drafting
March 2009	✓ Steering Committee Meeting #2 (Geneva)
June 2009	✓ Technical Working Group Meeting #2 (Washington DC)
August 2009	✓ Stakeholder webinar and comment period
October 2009	✓ Steering Committee Meeting #3 (Washington DC)
November - December 2009	✓ First draft of standards released for stakeholder review ✓ Five stakeholder workshops (in Berlin, Germany; Guangzhou, China; Beijing, China; London, UK; Washington, DC, USA) ✓ Stakeholder comment period on first drafts
January - June 2010	▪ Pilot testing by several companies
Summer 2010	▪ Public comment period on second drafts
December 2010	▪ Publication of final standards

Process for Revising the Draft Standard

In 2010, WRI and WBCSD, in collaboration with the Steering Committee and Technical Working Groups, will:

- Revise the draft standard based on feedback received during five stakeholder workshops and the stakeholder comment period (November 11 – December 21, 2009)

- Road test the draft standard with companies from a diversity of industry sectors and geographic locations during January to June 2010
- Revise the draft standard based on feedback received during road testing
- Circulate a second draft for public comment in mid-2010
- Revise the second draft based on feedback received
- Publish the final standard in December 2010

Terminology: Shall, should and may

The term "***shall***" is used in this standard to indicate what is required in order for a GHG inventory to be in conformance with the *GHG Protocol 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.

1.2 Goal and Scope of the Product Standard

The Greenhouse Gas Product Standard provides guidance for companies and other organizations to prepare an inventory of emissions associated with a product. The primary purpose of this standard is to support public reporting of product life cycle greenhouse gas (GHG) emissions to help users reduce these emissions by making informed choices about the products they design, manufacture, sell, purchase or use. In the context of this standard, public reporting refers to providing emissions-related information for a product, in accordance with the reporting requirements specified under the standard, by making it available in the public domain.

As awareness about climate change increases and concerns grow, investors are demanding more transparency, and consumers are seeking greater clarity and environmental accountability. Companies increasingly expect their customers to demand that they measure and reveal their GHG inventory annually, and this demand is expected to increase in the future. Public reporting serves to satisfy stakeholder demands for greater disclosure around GHG inventory of products. It provides stakeholders, including customers, with information that may favorably influence their decisions.

Public reporting boosts corporate image as stakeholders learn about companies' efforts to measure product lifecycle GHG emissions. Moreover, when a company publicly discloses emissions-related information, it is more likely to take steps to reduce these emissions and incorporate addressing GHG impacts as an integral part of its overall sustainability strategy. Public reporting provides impetus to management to go beyond measurement and begin looking for opportunities to reduce emissions along the supply chain. This has the potential to bring increased positive media attention to the company and its products.

> *Product* – any goods or service.
>
> *Product life cycle* – Consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to end of life, inclusive of any recycling or recovering activity.
>
> *Product level GHG* inventory – Compilation and evaluation of the inputs, outputs and the potential GHG impacts of a product system throughout its life cycle.
>
> *Comparative assertion* – This refers to an environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function.

This standard provides an overarching framework for reporting of GHG emissions associated with products. It is not intended to support mandatory GHG reporting as mandatory reporting programs have their own set of rules and regulations. However, organizations may use the guidance provided in this standard to develop their own policies and programs.

This standard is sufficiently flexible to support GHG quantification and reporting for many different types of products. This flexibility, though, results in a standard that does not directly enable comparative assertions or product labeling. Comparative assertion refers to an environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function. Valid assertions or labeling requires a greater degree of prescriptiveness than is provided in this standard.[2]

Further, this standard is not intended to support the accounting of GHG emission offsets or claims of carbon neutrality. This standard focuses on emissions generated during a product's life cycle and does not address avoided emissions or actions taken to compensate for released emissions.

[2] The Standard will include guidance on how programs, developers, and organization can apply additional constraints to the Standard requirements so that valid assertions and claims can be made. This section is currently under development.

1.3. Who should use this Standard

This standard is designed for companies and organizations[3] of all sizes in all economic sectors. (*To be developed further*)

Box 1-1: GHG Protocol Standards

Companies and organizations may carry out a GHG inventory at a corporate, project and/or product level using the appropriate GHG Protocol standard. Three other standards exist besides the *GHG Protocol Product Standard*, which helps in developing a product-level GHG inventory. The *GHG Protocol Corporate Accounting and Reporting Standard* enables corporate level GHG inventory development. The *Scope 3 Standard* provides additional guidance to cover the full breadth of information related to the corporate supply chain. The *Project Protocol* enables businesses to quantify the GHG emissions associated with the development of specific emission reduction projects.

All the standards serve the purpose of assisting companies to account for and reduce GHG emissions. However, they differ in terms of their applications, purpose, and users. Companies can select the appropriate standard to implement based on their individual reason for undertaking the GHG analysis, for example:

- ***The GHG Protocol Corporate Standard:*** Companies who seek to develop an understanding of their corporate level GHG emissions establish an inventory following the Corporate Standard. They may also be participating in voluntary or regulatory reporting programs based on the Corporate Standard. In addition, as companies establish corporate level emissions reduction targets, they can use the Corporate Standard to measure and demonstrate progress against these targets. At an operational level, main users of the standard include personnel responsible for data collection and GHG emission estimation for the company, as well as corporate GHG inventory developers.

- ***The GHG Protocol Scope 3 Standard (Draft):*** As stakeholders request increased disclosure from businesses, companies are being asked to report a more complete picture of their corporate emissions. The Scope 3 Standard provides guidance to companies who wish to broaden their corporate level reporting to include upstream and downstream emissions. Undertaking the exercise of accounting of these emissions can also facilitate stakeholder engagement and dialogue with partners along the value chain. Main users of this standard would be personnel responsible for data collection for selected scope 3 activities (e.g., supply chain managers and vehicle fleet managers), and corporate GHG inventory developers.

- ***The GHG Protocol Project Standard:*** As voluntary and regulatory GHG markets develop globally, companies seek opportunities to develop discrete emission reduction projects. The Project Protocol provides companies with a step by step methodology for developing such a project, which will support companies' engagement in global GHG markets or in meeting internal objectives. Project developers and auditors will be the main users of the standard.

- ***The GHG Protocol Product Standard (Draft):*** The Product Standard supports the development of GHG inventories of specific company products and services for the goal of public disclosure. This product level GHG analysis supports various business purposes, such as identifying emission reduction opportunities along a product's supply chain, performance tracking and product differentiation. LCA practitioners and personnel responsible for development and marketing of products (e.g., product designers and managers) constitute the main user group for this standard.

Additional information on all GHG Protocol Standards is available at the GHG Protocol Website: http://www.ghgprotocol.org/

[3] The term company is used throughout the standard to represent a company or organization that may use the standard.

1.3.1. Business Goals

Companies conducting product level GHG inventories may find that the process creates business value through:

- Identification of GHG reduction opportunities in the supply chain of a product,
- Performance tracking,
- Product differentiation, and
- Supply chain engagement and improved disclosure practices.

As a good practice, users of this standard are encouraged to identify at the outset potential value creation or end uses driving their decision to undertake product level inventory. Doing so should bring clarity and help in selecting the right methodology and data to develop the inventory.

Identifying GHG reduction opportunities in the supply chain

Business Goal	Description
Identifying GHG reduction opportunities in the supply chain	An organization applies product analysis to investigate new GHG reduction and cost-saving opportunities throughout the supply chain of a product

Product level GHG inventories, performed according to a consistent framework, provide a quantitative tool to help identify emissions—as well as cost—reduction opportunities along a product's supply chain. Product inventories provide detailed information on the relative importance of emission sources in the life cycle, information which may be used to guide emission reduction action plans. Utilizing product level GHG inventories helps product manufacturers to avoid the pitfall of focusing too heavily on the most proximate or obvious emission sources associated with a product's manufacture while missing major emission reduction and cost saving opportunities elsewhere in the supply chain.

This business goal may have internal and external end uses. Internally, product level GHG inventories may be utilized to support green product design choices. For example, a shoe manufacturer seeking to meet a company target of 10% lower life cycle emissions from its most popular shoe might employ a product level GHG inventory to decide the most cost effective means to achieve this target. Externally, the shoe manufacturer may communicate its product level GHG reductions to consumers as a component of a broader product launch.

Performance tracking

Business Goal	Description
Performance tracking	An organization utilizes product GHG inventory to establish performance metrics and targets for continual improvement

Environmental and sustainability management systems, which are a popular means in the corporate sector to systematically manage and communicate environmental performance, demand the use of performance measurement to confirm the success of continual improvement processes. A product level GHG inventory provides a quantitative performance metric that may be used within a broader management system that sets targets for improvement, tracks progress and communicates successes to customers and other stakeholders. Uses of a product level performance tracking metric may be both internal and external. External uses might include an annual corporate sustainability report that is distributed publicly. Internal uses might include an annual report to company executives charged with ensuring continual improvement in environmental performance.

Product Differentiation

Business Goal	Description
Product differentiation	An organization conducts a product level GHG inventory and pursues reduction opportunities to differentiate its product in the marketplace and better respond to customer desires

Product differentiation is a broad term, encompassing all the specific end uses of product level GHG inventory that may help a company distinguish its product in the market place. Comparative assertions fall under the broader business goal of product differentiation. However, these two terms are not equivalent. For example, a company may realize product differentiation simply by conducting and publicizing a product level GHG inventory that demonstrates to consumers that the brand is concerned with environmental impacts of their product's life cycle. With consumers increasingly concerned about the environmental impacts of their product choices, product level GHG inventories provide a new avenue for product managers to better connect with these consumer concerns and differentiate their product in the marketplace.

Supply chain engagement and better disclosure practices

Business Goal	Description
Supply chain engagement and improvement in disclosure practices	An organization engages stakeholders through its supply chain to reduce emissions and strengthen connections

Product level GHG inventories require communication with multiple stakeholders and suppliers along the product life cycle. From raw material vendors to final consumers, product level inventories provide an opportunity for firms to engage with their supply chain towards the common goal of reducing GHG emissions. Product inventories should support engagement with suppliers to reduce product life cycle GHG emissions. The analysis process may require soliciting measurements that suppliers may have never taken. In accordance with the axiom "what gets measured gets managed", this process may encourage emissions reductions. A product level GHG inventory may also uncover valuable information that may be shared to help build positive relationships with product users. For example, a product level GHG inventory of a home appliance may show that a large proportion of the product's emissions occur in the use stage. This information may provide a platform for the product manufacturer to communicate and collaborate with their customers to achieve lower product life cycle emissions.

1.4. Choosing a Product

Product GHG inventories can require a significant commitment in terms of time and resources, and companies should carefully plan their investment towards such an exercise to achieve maximum benefits around GHG reductions. Therefore, careful consideration should be taken of the products within the company and the potential impact a product may have on reducing emissions and meeting other business goals. This should enable the company to efficiently and effectively achieve its objectives.

Some basic examples of how a company may select the products for GHG inventories include:

- *Preliminary review* – A cursory review or screening exercise may highlight energy intensive or high volume products which may be a prime candidate for GHG inventories
- *Products designed to enable GHG abatement* – Adequate information on lifecycle GHG emissions of such products as a result of GHG inventories may strengthen a company's credibility.
- *New and emerging products* – GHG reduction is usually more cost effective during product design phase than after a product has been launched. Additionally, these may have a longer life expectancy than established products and deliver more cumulative GHG emission reductions.

Box 1-2: Influence of Business Goals

Once a product is chosen, a company should still consider business goals while performing the GHG inventory. Although minimum requirements around public disclosure are set in the standard, a company may also choose to consider collection efforts on specific data types or sources depending on the business goal.

Product differentiation often involves documenting and communicating the GHG impacts of specific actions to demonstrate the company's commitment to reducing GHG emissions. If the business goal is to demonstrate commitment to developing environmentally superior products, it is crucial to get specific data that differentiates the company's product in the marketplace. It is also necessary to document the GHG impact of the changes made to the product.

GHG reductions in the supply chain may depend on identifying specific opportunities to cut emissions through product/process design, choice of raw materials, and/or choice of suppliers. This goal can be supported by documenting the largest emission sources along the supply chain during the inventory process, and then testing various change scenarios for their impact on these sources and the life cycle GHG emissions.

Performance tracking helps to reduce the company's GHG emissions and demonstrates continuous improvement. Given this goal, there is a greater need for accurate data for those elements that are changing the most over time. For example, tracking if a new material is selected for a product (e.g., steel versus plastic) and the accuracy of emissions associated with these materials will be key to tracking changes in the emissions associated with the product.

Supply chain engagement establishes a closer dialogue with partners along the value chain to more broadly improve GHG performance and business relations. It is important to specify the objective for such engagement and the type of data to be exchanged to meet that objective. For example, a producer of fertilizers may be interested in reducing the GHG emissions of its products. It would then be important to engage its chemical suppliers and specify the objective and mutual benefits of such an engagement.

2. Principles of Product GHG Accounting

The five accounting principles below are intended to underpin all aspects of GHG accounting and reporting for products. Their faithful application should help ensure that a GHG emission inventory constitutes a true and fair representation of the company's product-level GHG emissions. These principles have been derived from financial and GHG accounting standards, sustainability reporting guidelines and life cycle assessment (LCA) standards. Their primary function is to guide users in the implementation of this standard, in particular when facing decisions related to the quality and quantity of information used in the inventory development process.

Relevance
Ensure the product GHG report serves the decision-making needs of all users identified within the report. Present information in the report in a way that is readily understandable by the intended users with a reasonable knowledge of GHG accounting and who are willing to study the information.

Completeness
Ensure that the GHG report covers all product life cycle emissions within the specified boundaries (including temporal), state clearly any life cycle stages or significant non-GHG environmental impacts that have been excluded and justify these exclusions.

Consistency
Use methodologies to allow for meaningful comparisons of emissions over time. Transparently document any changes to the data, inventory boundary, methods, or other relevant factors in the time series.

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. Clearly explain any estimates and avoid bias so that the report faithfully represents what it purports to represent.

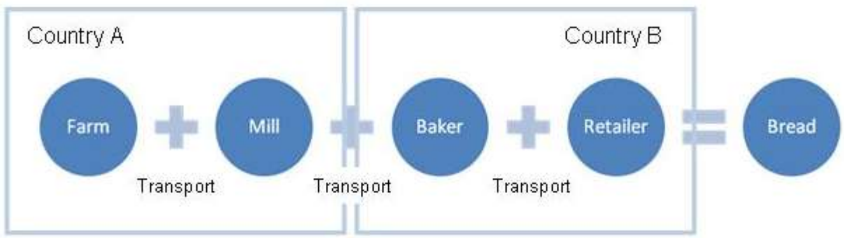
Accuracy
Ensure that reported GHG emissions are not consistently greater than or less than actual emissions and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the reliability of the reported information.

3. Overview of Product GHG Accounting

3.1. Key Concepts

Many of today's products are supported by long and complex supply chains, making accounting for their GHG emissions along the product's life cycle challenging. **Figure 3-1** illustrates some of the complexities for a seemingly simple product: a loaf of bread. The upstream GHG emissions from the production of bread are spread across farms, mills, bakers, retailers and transport providers which may or may not be part of one company or corporation. Additionally, these activities may or may not take place in the same country. Finally, the company needs to consider the downstream emissions of the bread due to its purchase, consumption and disposal.

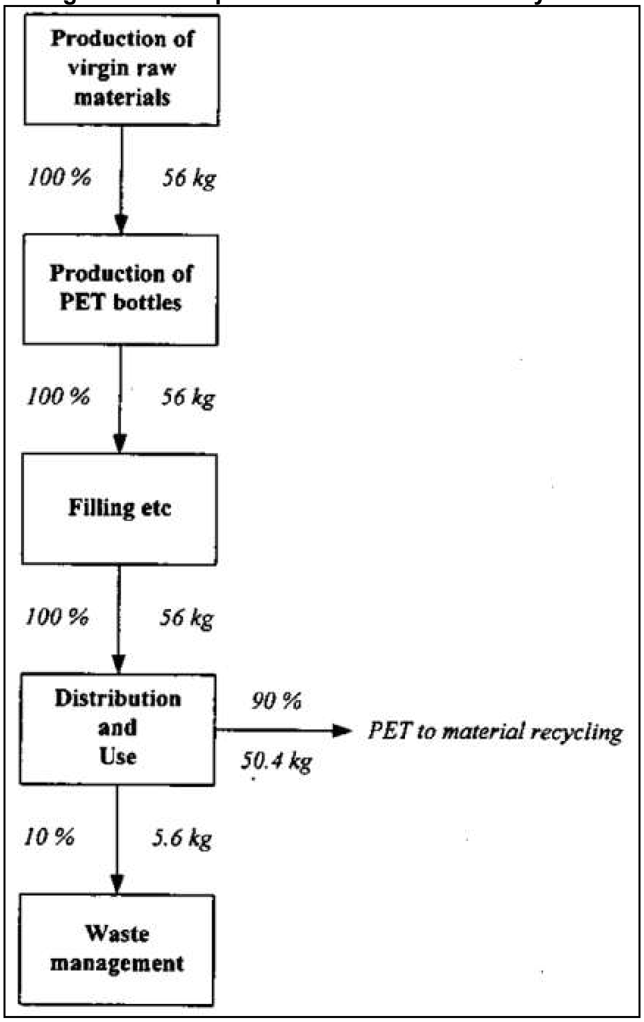
Figure 3-1: A simplified life cycle for bread showing that the emissions associated with the final product occur across a range of organizations and countries



To begin understanding how to calculate the emissions of a product, the company first defines the functional unit. The functional unit is the quantified performance of a product system for use as a reference unit (ISO 14044:2006, 3.20), and establishes the basis for which the GHG inventory is calculated and reported. Some examples of functional units include drying 1000 pairs of hands; delivery of 1000 liters of fruit drink; provision of 890 lumens over 1 year; transport of 6 people and cargo by a vehicle over 100,000 miles; and many others.

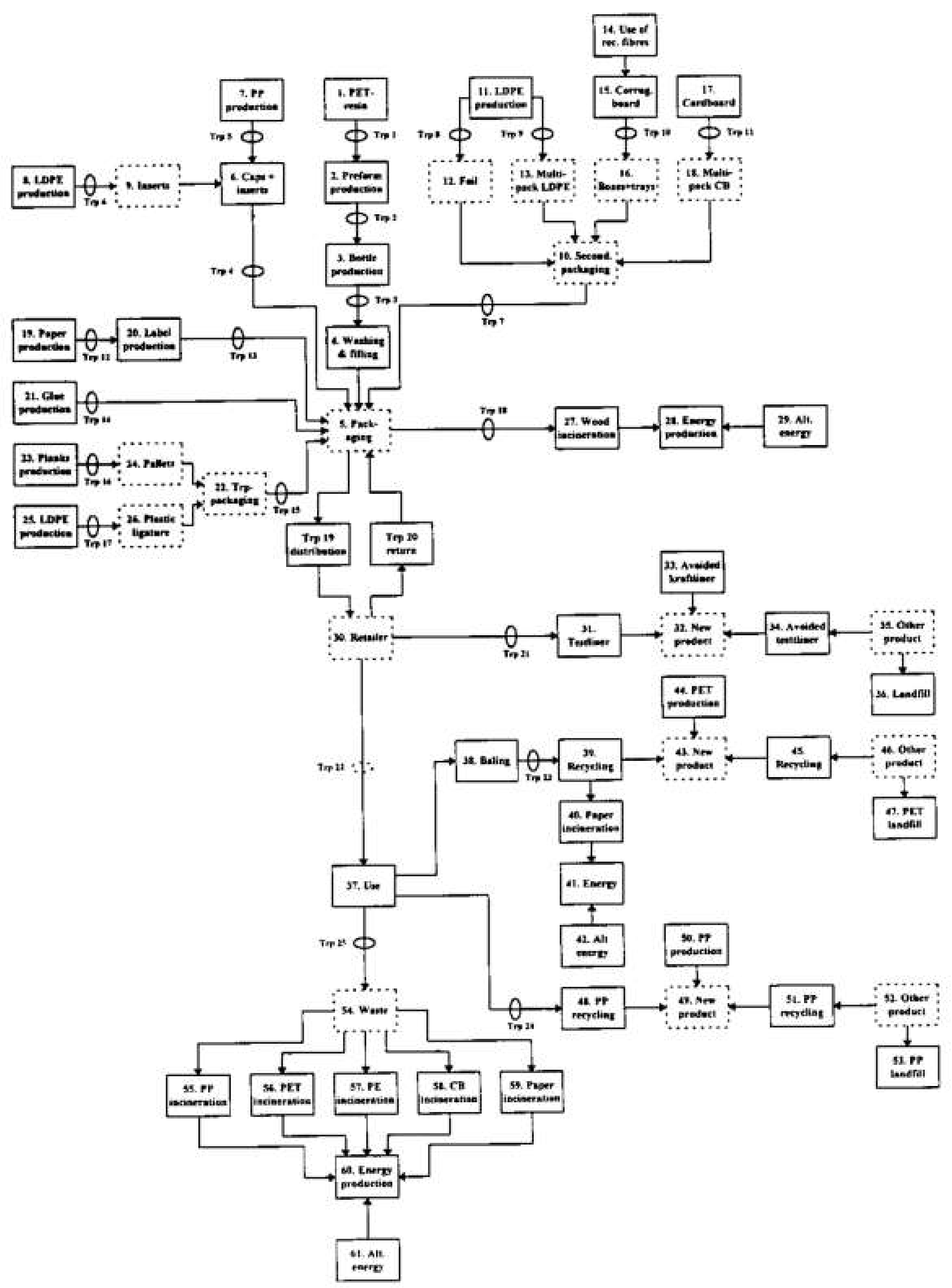
The total GHG inventory over the functional unit of a product represent the sum of GHGs resulting from all stages of its associated life cycle within the specified system boundaries, also referred to as the product system. While **Figure 3-1** represents a simplified example, product systems may be very complex. **Figure 3-2** and **Figure 3-3** provide more detail by examining the product system of glass bottles used in the packaging of beer (Note: in this example the functional unit of the product system is 1000 liters of beer delivered and 439 kg of PET bottles are required to support this function). **Figure 3-2** identifies the key processes that compose the PET bottle product system. **Figure 3-3** examines the same product system in greater detail by providing a process view of the PET bottle product system with the same functional unit of 1000 L delivered.

Figure 3-2: Simplified PET Bottle Product System



Source: Widheden, J,, Ekvall, T and Neilsen, P. H. (1998)
http://www2.mst.dk/Udgiv/Publications/1998/87-7909-014-1/pdf/87-7909-014-1.PDF

Figure 3-3: Complete Product System for PET Bottles, Expanded from Figure 3-2



Source: Widheden, J,, Ekvall, T and Neilsen, P. H. (1998)
http://www2.mst.dk/Udgiv/Publications/1998/87-7909-026-5/pdf/87-7909-026-5.PDF

Box 3-1: The Role of Perspective in Product GHG Accounting

Multiple entities are involved in the production, distribution, use and disposal of products – including raw material suppliers, manufacturers, distributors, retailers, consumers, etc. Each entity in the supply chain has a different perspective in the life cycle of a given product. Depending on an entity's position in a supply chain, a portion of the product's life cycle emissions has occurred prior to their involvement in the life cycle, while the remainder of life cycle emissions will occur subsequent to their involvement in the product's life cycle. **Figure 3-4** is an example of a company that sells a final good called a widget. In this example, all material acquisition, material processing, and widget production has occurred prior to the company's involvement in the product's life cycle. **Figure 3-5** is an example of a company that produces an intermediate good to be used in the production of the widget. In this example, material processing and widget production occur subsequent to the company's involvement in the product's life cycle.

Figure 3-4: Perspective of a Company Selling Final Goods

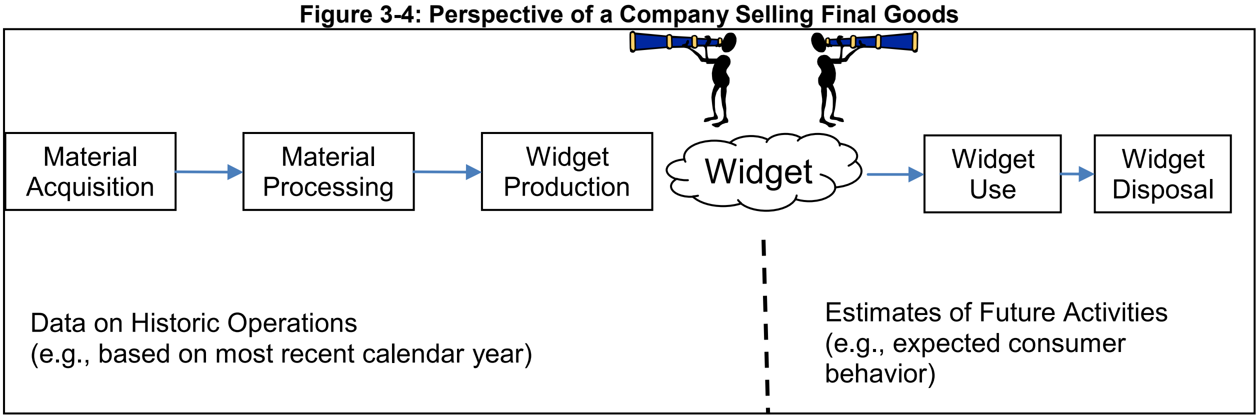
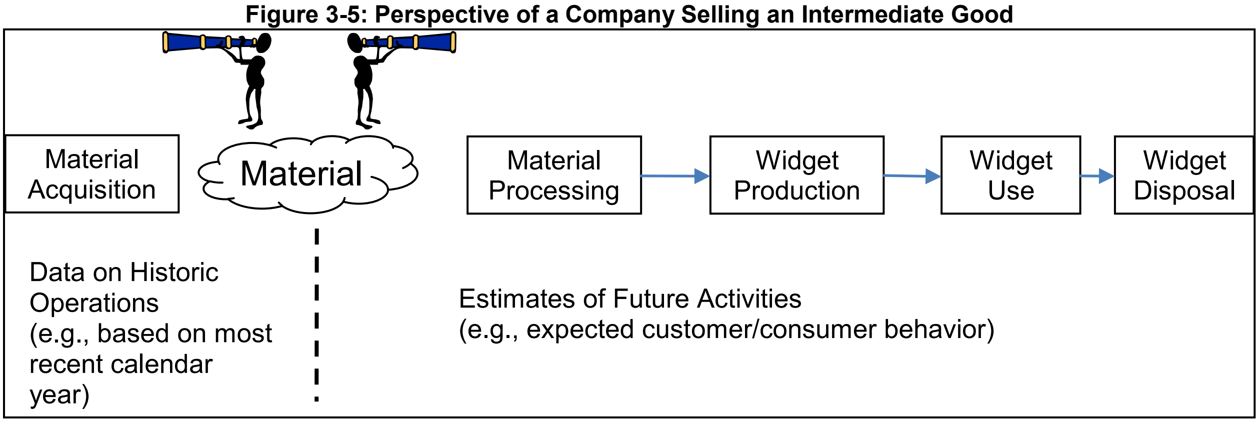


Figure 3-5: Perspective of a Company Selling an Intermediate Good



Understanding perspective in a product's life cycle is important for several reasons. Perspective affects the types and quality of data a company is able to obtain, the level of influence a company has to make GHG reductions over portions of the product's life cycle, and the methods for estimating emissions (i.e. past emissions may be measured using historical data while future emissions may be forecasted based on assumptions and models)

(Additional examples to be provided, as needed)

Mapping out the product system allows a company to identify the processes which are directly attributable to the functional unit, all of which need to be accounted for in the product GHG inventory. Collecting data on the GHG emissions of the processes may be time consuming; therefore, a company may benefit from organizing data needs and performing a data screening assessment.

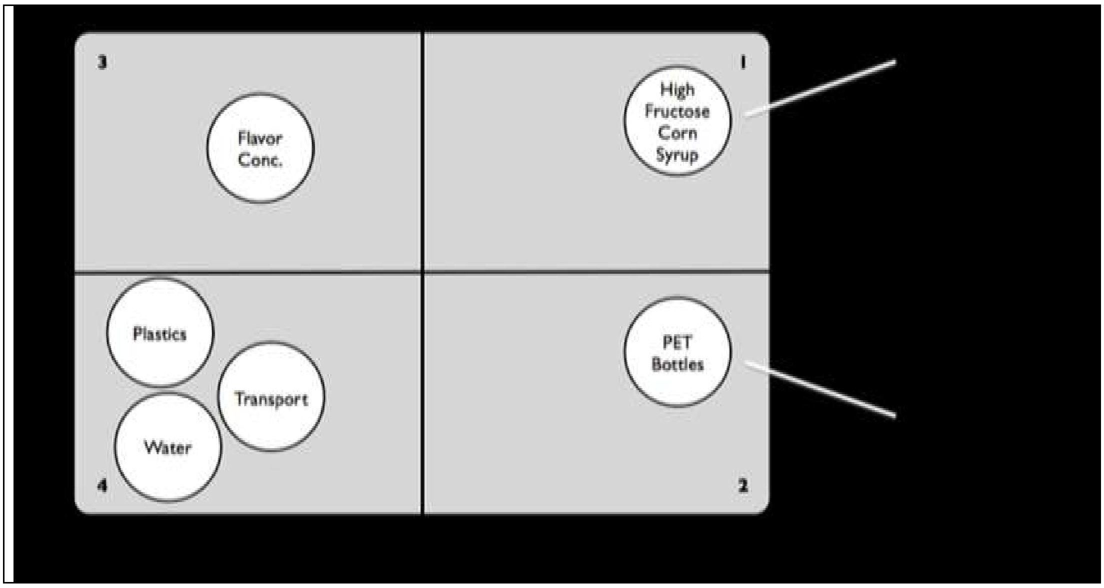
Such screening assessments use readily available data to enable a quick, visual guide to assist in data collection efforts. **Figure 3-6** and **Figure 3-7** provide examples of how a screening assessment may be used to identify high priority areas for further in-depth analysis. In both cases, the main product elements are assessed using GHG emission factors derived from modeled data. Their relative GHG impact is then used to gauge their overall significance. In the case of **Figure 3-7,** data uncertainty is used in addition to help further differentiate the main product elements. This screening analysis of high level inputs may be combined with more qualitative assessments (for example, of data quality or uncertainty) to create a risk matrix that may further inform decision-making. Although data for all processes are included in the product system GHG inventory, a data screening may help a company prioritize data collection on processes or inputs with the largest impact, as they require the best quality data.

Figure 3-6: An Illustrative Example of how a Screening Analysis may Result in a High Level Analysis of GHG Emission Contributions for a Plastic Bottle of Soda

ILLUSTRATIVE

Component	Potential Contribution	Priority
PET	10%	Medium
PP (closure)	<1%	Low
Caffeine	8%	Medium
HFCS	50%	High

Figure 3-7: Example of a Screening Assessment for a Plastic Soda Bottle which Combines Estimated GHG Emissions Data and a Qualitative Assessment of Uncertainty



Once data has been collected for the GHG emissions of each process, the global warming potential of the product life cycle is determined. A company then uses these results to identify areas along the supply chain of a product where GHG reductions may be achieved.

Other environmental impacts occur during the life cycle of a product that may be important to consider in business or organization-level decisions. Therefore, while this standard only addresses the global warming potential of a product, it is worthwhile for users of this standard to consider the complete suite of environmental impacts when making decision on how to reduce their environmental impacts. Examples of potentially significant non-GHG impacts for some products include: clearing forests for palm oil production causing environmental degradation, excessive use of scarce resources such as freshwater in production of beverages, and health impacts from using lead-based paints.

The complexity of performing a product GHG inventory brings to light the need for consistent and accurate accounting standards. The concepts outlined in this standard are based on the concepts of life cycle assessment and derived from standards published on the subject (ISO 14040 and ISO 14044). A full list of standards and publications that may be beneficial for a company to refer to for more information on GHG inventories is given in Appendix F. It is important to note that the term GHG inventory is often used synonymously with a life cycle assessment considering only one impact category (global warming potential), or a carbon or GHG footprint.

3.2. Steps to Performing a Product GHG Inventory

Figure 3-8 outlines the steps to perform a product GHG inventory in conformance with the GHG Protocol Product Standard.

Figure 3-8: Overview of Steps to Perform a Product GHG Inventory

Standard requirements and guidance for each step is described in the following chapters.

4. Establishing the Methodology

4.1. Requirements

This standard is based on a process life cycle approach to product GHG accounting. Under the process life cycle accounting approach, companies shall quantify and aggregate the emissions from each specific process within the established boundary of the product system.

This standard is based on an attributional approach to product GHG accounting. Companies shall use an attributional approach to assign life cycle GHG emissions to an individual product system for the purpose of public reporting, unless existing sector-specific or program guidance stipulate the need to address indirect or consequential emissions sources. An attributional approach to GHG emissions accounting in products provides information about the GHG emitted *directly* by a product and its life cycle.

Companies shall account for and report emissions of all Kyoto Protocol greenhouse gases from the product life cycle. These include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbon compounds (HFCs), and perfluorocarbon compounds (PFCs). Companies may additionally report non-Kyoto gases as applicable.

4.2. Guidance

The total life cycle GHG emissions for a product are determined by aggregating the emissions associated with each process within the product system. This procedure is commonly known as the process approach to GHG inventory accounting. The process approach method involves quantifying and aggregating the emissions from each specific process within the established boundary of the product system. The information gathered during a process-based inventory allows a company to identify hot spots and reduction potentials throughout the supply chain. Other approaches to estimate GHG emissions of a product that do not facilitate reductions over the product supply chain (and are therefore not appropriate for this standard) include allocation of a corporate or county level inventory to represent an individual product, or using the economics and energy use of a product sector to estimate emissions.

4.2.1. Assigning Emissions Responsibility Following the Attributional Approach

A core concept of process-based GHG inventories is that the reported GHG emissions should not cover only one facility or stage in a product's life cycle stage but rather consider the full set of processes that are associated with the product's entire life cycle. Two methodologies for performing process-based GHG inventories have been distinguished: the attributional approach and the consequential approach.

An **attributional approach** to GHG emissions accounting in products provides information about the GHG emitted directly by a product and its life cycle. The product system includes processes that are directly linked to the product by material, energy flows or services following a supply-chain logic.

A **consequential approach** to GHG emissions accounting in products provides information about the GHG emitted, directly or indirectly, as a consequence of changes in demand for the product. This approach typically describes changes in GHG emissions levels from affected processes, which are identified by linking causes with effects.

In general, the attributional approach is most applicable to product-level GHG accounting and reporting. Therefore, GHG inventories performed in conformance to this standard follow the attributional approach. Additionally, the attributional approach is:

- Consistent with existing GHG emissions accounting in the GHG Protocol *Corporate Standard*.
- Consistent with the intent of public reporting as a direct accounting of emissions attributable to a product.
- Consistent with traditional approaches to management and control of emissions.

However, there are some cases where the consequential approach identifies indirect impacts that are important to consider for certain products, such as the impacts of indirect land use change on biofuels. If sector or product specific guidance exists, such as a product category rule (see **Box 4-1**), that identifies a need to include consequential impacts in a product-level GHG inventory, a company should follow that guidance. Additionally, a company using GHG inventory results to reduce emissions should consider the consequences of any decisions that may indirectly impact the market or demand for other products or energy sources.

Box 4-1: Product Category Rules

Sector or product category specific guidance plays an important role in clarifying accounting procedures for specific products. These product-level guidance documents, sometimes referred to as Product Category Rules (PCRs)[4], contain information on functional units, product system boundaries, allocation procedures, and other product specific considerations. A PCR is a set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories. (Source: ISO 14025, 3.5) An Type III environmental declaration is an environmental declarations providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information. (Source: ISO 14025, 3.2)

Throughout this document, sector or category specific resources such as PCRs may be referenced as a secondary source of information beyond this standard to aid a company in making important inventory decisions. Additionally, in the reporting requirements a company is asked to disclose any sector or category specific literature that was used to complete the inventory.

Box 4-2: Comparison of Attributional and Consequential Accounting

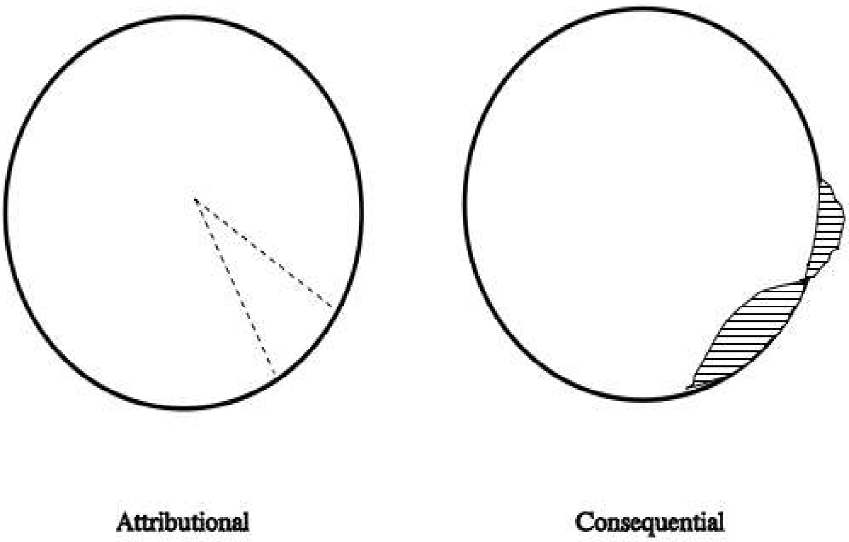
The objective of the attributional approach is to assign responsibility for the total emissions associated with a process to the process outputs. In contrast, the objective of the consequential approach is to assign responsibility for emissions based on changes in the system characteristics. While the attributional approach focuses on how to assign a known quantity of emissions to multiple products, the consequential approach focuses on how the total quantity of emissions changes as a result of the production and consumption of a given product.

Under the attributional approach, the general rule for determining whether a process should be considered in life cycle GHG accounting is to determine whether the process is part of the supply chain of one of the life cycle stages of the product, i.e. is it possible to link the product with the process by following flows purchased materials, energy and services. This is a common approach to assignment of emissions, see the example below.

The main objective of the *consequential* approach, on the other hand, is to determine how global emissions of GHG may change based on the decision to produce and consume more of a specific product (or, equivalently, of a specific model of a product). The general rule for determining whether a process should be considered in the life cycle GHG accounting of a product is to determine whether the process may change its output based on the increased (or reduced) demand for the product. Information on how specific markets respond to changes in demand is used to determine what processes are affected. The consequential approach sometimes results in the *exclusion* of processes in the direct supply chain of a product because their output is unaffected, or in the *inclusion* of processes not part of the supply chain of a product because they are nonetheless affected.

Figure 4-1: Illustrative Comparison of Attributional versus Consequential Approaches

[4] A list of existing PCRs/PSRs worldwide can be found in the website of GEDnet (Global Type III Environmental Product Declarations Network).



Source: *B P Weidema (2003)* · Market information in life cycle assessment. Copenhagen: Danish Environmental Protection Agency. (Environmental Project no. 863).

Example

Factory A's operations are associated with the emission of 10,000 kg of CO2e annually. Factory A produces 5,000 units of a product (call this Product A) over the same time period. Company B purchases Product A for use in production of Product B.

Under an attributional approach Product A is assigned 2 kg CO2e/unit (i.e., 10,000 kg CO2e/5,000 units).

Under a consequential approach examining the effects of increasing consumption of Product B, the emissions contribution from manufacturing for Product A to the life cycle of Product B depends on the cause-and-effect relationship between Product A and Product B. For example, one possibility would be that Factory A is operating at full capacity and additional units would necessitate facility expansion or outsourcing. This shift could have implications for the fuel mix used in manufacturing Product A and thus the GHG emissions contribution from manufacturing Product A to the life cycle of Product B.
(Additional examples added if needed)

5. Defining the Functional Unit

5.1. Requirements

Companies shall define the unit of analysis as the functional unit of the product. Companies shall consider the following elements when determining the functional unit:

- The function or performance characteristics provided by the product system
- Reference flow (i.e., amount of product necessary to fulfill the function and the quantity to which assessment results shall be normalized)
- Relevance to the study goal (i.e., why a particular functional unit was chosen in the context of a particular goal)

Companies should consider the following elements if relevant:

- Product/system properties that differentiate the function being provided based on properties such as technical quality and aesthetics
- Market segment characteristics such as geographic location, customer preferences and temporal scales

5.2. Guidance

In order to properly calculate the GHG inventory of a product it is necessary to develop a description of the product system that is being analyzed. The product system description should be in clear language, be as quantitative as possible, and be consistent with the goal of the study. The description should include the performance characteristics (function) of the product system and the functional unit.

What is a functional unit?

The functional unit is the quantified performance of the product system which is used as a reference unit (ISO 14044: 2006). The functional unit is necessary as it is the reference against which all relevant inputs and outputs of the product system are normalized. A functional unit is particularly useful for comparisons between products and services that provide the same function.

The description of the functional unit may be relatively uncomplicated for simple products and it may be multifaceted for complex products. For example, the functional unit for a study focused on calculating the GHG inventory of a basic material such as zinc might be defined as the primary production of a kilogram of special high grade zinc. For a more complex product, such as an appliance, the GHG inventory calculation might take into consideration the GHG emissions associated with the raw materials that go into the appliance, the emissions from manufacturing and the supply chain, the expected lifetime of the appliance, and the emissions associated with the use stage energy consumption and end-of-life. Therefore, the functional unit of the appliance needs to be more detailed and depending on the goal of the study it might need to include information on all of these aspects[5].

How to define the functional unit

How a company defines the functional unit may vary depending on the material or product of interest and to whom the results are communicated. Regardless, the following elements need to be addressed when defining the study's functional unit:

- The quality of the product
- Service life
- Use Patterns
- Technical performance characteristics and maintenance requirements
- End-of-life of the product (e.g. availability of recycling infrastructure and ultimate fate of material(s), components or subcomponents)

[5] For further guidance on functional units the reader is referred to the list of standards and publications in the Appendix.

Examples of Functional Units[6]

Hand drying

For the service of drying hands, a number of options are possible. The selected functional unit for a study may be expressed in terms of *the identical number of pairs of hands dried for the systems studied*. For each system, it is possible to determine the reference flow, e.g. the average number of paper towels required for one hand-dry. It is also possible to compile an inventory of inputs and outputs on the basis of the reference flows and calculate the associated GHG inventory. At its simplest level, in the case of paper towel, this would be related to the paper consumed. The required elements to be included in the functional unit description for the paper towel product, for example, could be presented as follows:

- The paper towel product shall be of sufficient quantity to provide 1,000 individual hand-dryings following washing with water
- Each hand-drying requires 2 "sheets" of X" x X" size of X lb quality; therefore the reference flow is 2,000 sheets
- The goal of this study is to establish the GHG inventory of typical hand towels under common usage conditions.

Lighting

In the provision of lighting, the quality and intensity of the light may be an important consideration. In industrial applications maintenance considerations may also be important as waste management (e.g. how often do the lights need to be cleaned or replaced) and whether they contain any hazardous materials that require special handling).

- The functional unit could be expressed as *Lighting 10 square meters with 3000 lux for 50000 hours with daylight spectrum at 5600 K* (modified from The Product, Functional Unit and Reference Flows in LCA[7])
- The reference flow to fulfill the above function could be: 300 light bulbs
- The goal of the study is to establish the GHG inventory of a specific light bulb over its full life cycle.

(Additional examples to be provided as needed)

Using Sector Specific Guidance to Define a Functional Unit

This Standard recognizes the need for consistent functional units across product categories[8]. There are a number of Environmental Product Declarations systems around the globe that are defining functional units for a variety of product categories. Category or sector specific guidelines are a useful source of functional unit definitions within product categories, assuming they meet the specifications of this standard. These guidelines should be used as the source of the functional unit if they: 1) exist for the specific product category being evaluated, 2) meet the requirements of this standard for the functional unit definition as stated above, and 3) meet the goal of the study. In the absence of category guidance, industry groups, in consultation with appropriate stakeholders, may want to establish common definitions.

[6] Examples were taken from ISO 14048

[7] http://www2.mst.dk/common/Udgivramme/Frame.asp?http://www2.mst.dk/udgiv/publications/2004/87-7614-233-7/html/indhold_eng.htm

[8] Functional units shall be consistent to perform product comparisons.

6. Boundary Setting

6.1. Introduction

Determining the boundary of the product system is an important step in performing a product inventory, as it defines the bounds for data collection. Additionally, rigorous and well defined product systems are necessary to meet the standard's goal of public reporting and disclosure. A life cycle consists of consecutive and interlinked stages; within each stage, processes that are attributable to the function of the studied product or service are considered within the product system boundary.

This Chapter establishes the standards for setting the product system boundary around the product life cycle to establish easy to follow, consistent rules. Although data collection is not considered specifically when establishing the product system boundary, the concepts of boundary and data are closely intertwined. Therefore, the boundary setting requirements of this standard were developed to allow all companies the ability to calculate emissions for a comprehensive product life cycle, all stakeholders easy to understand emissions calculations, and all readers or users of reported data actionable information.

6.2. Requirements

A company shall map the life cycle of the product from raw material acquisition through to end-of-life and disposal. This is referred to as a process map. Companies shall perform full life cycle GHG inventories (cradle-to-grave) for all final products. In some cases, the use or end-of-life stages of a product may not be reasonably assumed. For these intermediate products, a cradle-to-gate may be performed. The temporal boundary of all GHG inventories shall be based on the product's lifetime and clearly reported. If the product's lifetime is unknown, a company shall assume a temporal boundary of 100 years.

Processes that are attributable to the function of the product shall be included in the boundary of the product system. These processes are directly connected over the product's life cycle by material or energy flows, from extraction and pre-processing of product components through to the product's end-of-life. These processes are referred to as foreground processes throughout this standard.

Processes that are not directly attributable to the function of a product include facility operations, corporate activities, and capital goods. These are referred to as background processes throughout this standard.

- Capital goods shall be included in the product system if deemed significant for the studied product or product sector
- Facility operations and corporate activities should be included in the product system where relevant

Significance shall be proven for capital goods using a qualitative or quantitative test. Qualitative significance is based on existing literature and/or sector specific data, while quantitative significance is based on the contribution of capital goods to the total system impacts. Companies shall perform the qualitative significance test first. If significance is not determined, a company should try to collect or estimate data before using the quantitative significance test. If neither test provides sufficient evidence of the insignificance of capital goods for the studied product or product sector, capital goods shall be considered significant and shall be included in the product system boundary. Use of either significance test shall be reported and assured.

6.3. Guidance

Foreground processes are identified by first mapping out the life cycle of a product. Five life cycle stages have been defined in this standard, which are illustrated in **Figure 6-1**.

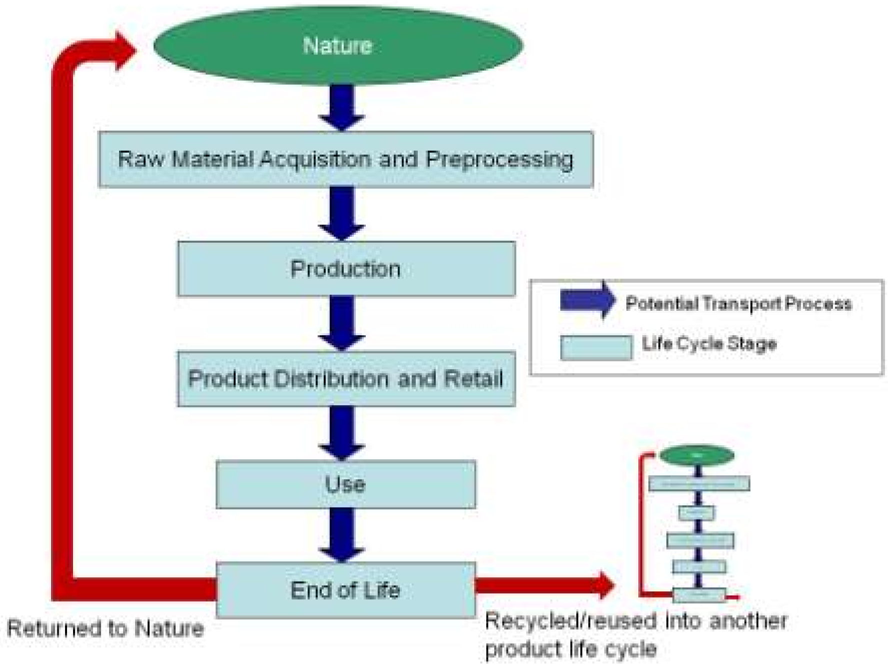


Figure 6-1: The Five Stages of a Product Life Cycle (Simplified for Illustrative Purposes)

Clear life cycle stage definitions are used to define boundaries and report emissions consistently across all products using this standard. The following identifies general boundaries and foreground processes associated with each life cycle stage:

Raw Material Acquisition and Preprocessing:

The raw material acquisition and preprocessing stage starts when the material is extracted from nature, and ends when the product components reach the gate of the production facility or service delivery operation. Raw material is defined as a primary or secondary material that is used to produce a product, which is typically supplied in the form of ingots, granules, powders, etc. as needed for the production process (note: secondary includes recycled material). If several materials are used for the product, several raw material acquisition stages may be included within the boundary. This stage often includes foreground processes such as

- Mining and extraction (materials or fossil fuels)
- Cultivation of land and harvesting of trees or crops
- Use of fertilizers
- Additional processes to make sure that the raw material meets the customer requirements, e. g. of form and chemical composition.
    - Cleaning and sizing
    - Chipping of wood for use in wood products
    - Conversion of crops for use in food products
- Land use impacts as defined in Appendix B

Because the stages are defined to represent the continuous path of a product through its life cycle, transportation occurs within these stages. For the raw material acquisition and preprocessing stage the boundary ends when the component reaches the gate of the production stage; therefore, the transportation of the component from one to the other is an important foreground process. Equally important are transportation processes that occur during the operations of a stage, an example being the transport of coal by trucks within the coal mine.

Production:

The production stage starts with the product components entering the production site and ends with the final product leaving the production gate. Site and gate are used here figuratively, as a product may go though many foreground processes and corresponding intermediate facilities before exiting the production stage as a final product. During production, the product undergoes the transformation from product component, to intermediate product, to the final product; additionally, any co-products or wastes formed during production are considered in this stage. Production includes foreground processes such as:

- Production of the intermediate (semi-finished) product(s);
- Transport of intermediate products between foreground processes;
- Production of the final product by assembling of the intermediate products;
- Use of catalysts or other ancillary materials during production
- Any additional preparing of the finished product including forming, surface treatment, machining and other processes, as appropriate.

Product Distribution and Storage:

The product distribution and storage stage starts with the product leaving 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, including storage at a distribution center and a retail location if applicable. Product distribution and storage includes foreground processes such as:

- Storage Operations
- Receipt
- Put away
- Cycle counting
- Picking
- Stock care
- Shipping activities
- Transportation between locations
- Retail activities

Use Stage:

The use stage begins when the consumer takes possession of the product and ends with the used product entering the end of life. For some products the use stage does not required energy or product emissions (i.e. a chair); for these products transportation from the storage facility to the use-location to the end-of-life location may be the major foreground processes. Typical foreground processes for distribution and use include:

- Transportation to the use location and during use
- Storage at the use location;
- Normal use;
- Repair and maintenance occurring during the usage time;
- Preparation of a product;
- Transportation to end-of-life.

End-of-Life Stage:

The end-of-life stage boundary begins when the used product is ready for disposal, recycling, reuse, etc. and ends when the product is buried, returned to nature (combustion, deterioration), or transformed to be recycled or reused. Few cases exist where the use stage and end-of-life stage occur simultaneously (i.e., food products, energy). However, in these cases a company should still consider the end of life of any waste, including packaging, accumulated throughout the life cycle. Processes that occur as a result of the disposal are also included within the end of life stage. End-of-life foreground processes may include:

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. Considering the example of a home appliance repair person, these foreground processes include driving to the home, assessing the appliance, ordering or picking up parts, and returning to complete the final repair. All material flows (i.e. parts needed for the repair), energy flows (fuel to deliver the service person and/or parts), and end-of-life considerations of materials and wastes make up the foreground processes along the service life cycle.

6.3.1. Identifying Use and End-of-Life Foreground Processes

For most products, the product components and product manufacturing are well known processes. Once the product enters into the control of the user, it is less certain what the use phase and end-of-life of that product may be. For example, although a frozen meal has instructions on how it should be prepared and how long it should be stored, a company cannot prevent a user from disobeying those instructions. This could have an impact on the GHG inventory if a user keeps a product in the freezer for 1 year instead of the recommended 3 months. Therefore, it is imperative that a company relays to the user what use and end-of-life assumptions have been made and how the user's actions could impact the GHG inventory of a product. This includes transport distances, storage (place and length), preparation, and disposal. A company should base their use and end-of life assumptions on manufacturer recommended use phase instructions and typical disposal. In the case where no manufacturer's recommendations exist, a company should refer to one of the following:

- Sector-specific guidance that specifies the requirements and guidance for developing scenarios and service life for the use stage of the product being assessed;
- Published international standards that specifies the requirements and guidance for developing scenarios and service life for the use stage of the product being assessed;
- Published national guidelines that specifies guidance for developing scenarios and service life for the use stage of the product being assessed;
- Published industry guidelines that specifies guidance for developing scenarios and service life for the use stage of the product being assessed;
- A scenario and service life for the use stage defined by the organization undertaking the product inventory.

Distance from use to disposal and disposal procedures (i.e. landfill, incineration) should be based on the average values for the area (state, region, country) where the product is used. If recycling is part of a product's end-of-life, a company should account for those processes following the procedures and guidance given in **Chapter 8.**

Carbon storage may arise during the use phase of a product when biogenic carbon forms part or all of a product (e.g. wood fiber in a table), or when atmospheric carbon is taken up by a product over its life cycle (e.g. cement). Due to the uncertainty of the use phase of a product, carbon storage should not be included as a carbon credit in the GHG inventory; however, the carbon storage potential of a product should be reported separately, as identified in the reporting requirements.

6.3.2. Temporal Boundary

The temporal boundary of a study effects data considerations over the life cycle, particularly in the use and end-of-life stages. Some products have distinct temporal boundaries, while others could vary largely depending on the user. Additionally, products may remain in a landfill indefinitely. All products should be assessed until the end of their distinct service life and disposal. However, if no distinct lifetime is known, a temporal boundary of 100 year should be assumed.

6.3.3. Intermediate Products

Products are divided into two categories: final products and intermediate products.

For final products, a cradle-to-grave assessment is required. For intermediate products, a cradle-to-grave assessment may not be feasible if the eventual fate of a product is unknown. For example, a manufacturer of plastic resin may sell its product to a customer without knowing whether the plastic resin may eventually be transformed into plastic bottles, car parts, laptops, etc. In such a case, companies may conduct a cradle-to-gate assessment. Producers of intermediate products should provide cradle-to-gate assessments of their products to their customers as a step toward the calculation of complete cradle-to-grave assessments of final products.

Companies conducting a cradle-to-gate inventory for an intermediate product shall clearly disclose in the public report that the inventory represents the cradle-to-gate, rather than cradle-to-grave, emissions of the product. Companies shall justify that their product is an intermediate product and that the final use of the product is unknown. .For example, although general resins may be considered an intermediate product, if a company makes a specific resin that is only used in one final product, then a cradle-to-grave inventory is required because the final use of the intermediate product is known. Additionally, a cradle-to-grave inventory is required for products (e.g., consumer products) sold to retailers, because they are final products that are not processed or transformed before the use stage.

Companies may not selectively include either the use stage or the end-of-life stage. If the use stage is included in an inventory, the end-of-life stage shall also be included, and vice versa. For example, a company shall not include any end-of-life recycling of an intermediate product in a cradle-to-gate assessment. To include recycling of an intermediate product in the GHG inventory, a cradle-to-grave assessment is required.

Producers of intermediate products should optionally choose one representative end use application for their product and conduct a full cradle-to-grave assessment for a representative product. For example, if a manufacturer of plastic resin knows that the majority of its resin is used as an input to manufacture plastic bottles, the company should choose plastic bottles as its representative product for conducting a cradle-to-grave assessment. The company should then report emissions on both a cradle-to-gate basis (for plastic resin) and cradle-to-grave basis (for plastic bottles).

Box 6-1: Cradle-to-Grave and Cradle-to-Gate GHG Inventories

Products are divided into two categories:

Intermediate products are goods that are used as inputs in the production of other goods and services rather than entering the use stage in their current form. Intermediate products require further processing, transformation within the system, or inclusion in another product system before the use stage. Examples include steel bars, microchips, electrical motors, metals, resins, plastics, and machinery components (i.e. ball bearings).

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. Final products enter the use stage in their current form without further processing, transformation within the system, or inclusion in another product system before the use stage. Examples include a car, laptop computer, or vacuum cleaner.

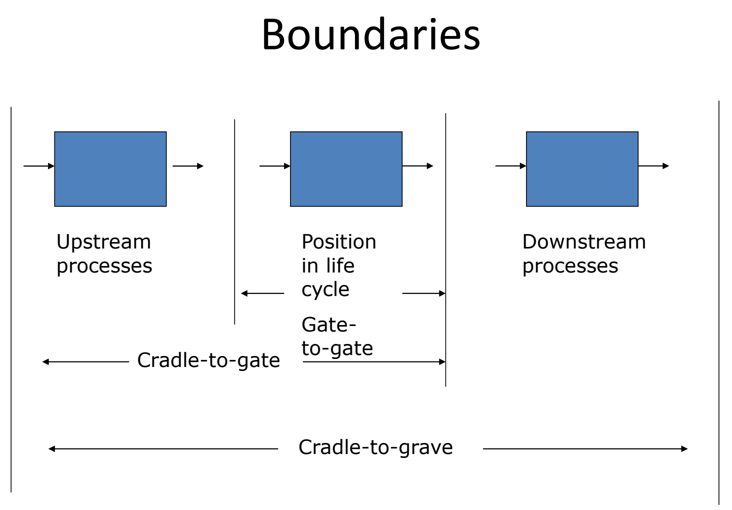
(Note: In some cases, the end user is a company producing other goods. These products are considered final goods rather than intermediate goods. Examples include catalysts, turbines, fuels, etc.)

Product GHG inventory assessments are divided into two categories:

Cradle-to-gate: This inventory includes all GHG emissions in the life cycle of a product from the beginning of the life cycle (e.g. raw material acquisition) up through the point of sale to the customer, including the emissions from processes owned or controlled by the reporting company. From the perspective of the reporting company, a cradle-to-gate assessment includes data on historic emissions but excludes estimates of future emissions after the product is sold to the customer. A cradle-to-gate assessment is a subset of a cradle-to-grave assessment. These are sometimes referred to as Business-to-Business (B2B) inventories.

Cradle-to-grave: This inventory includes all GHG emissions in the complete life cycle of a product from the beginning of the life cycle (e.g. raw material acquisition) through final disposal or end use by the end consumer. From the perspective of the reporting company, a cradle-to-gate assessment includes both data on historic emissions and estimates of future emissions. These are sometimes referred to as Business-to-Customer (B2C) inventories.

Figure 6-2: Illustration of Cradle to Gate and Cradle to Grave Boundaries



6.3.4. Process Mapping

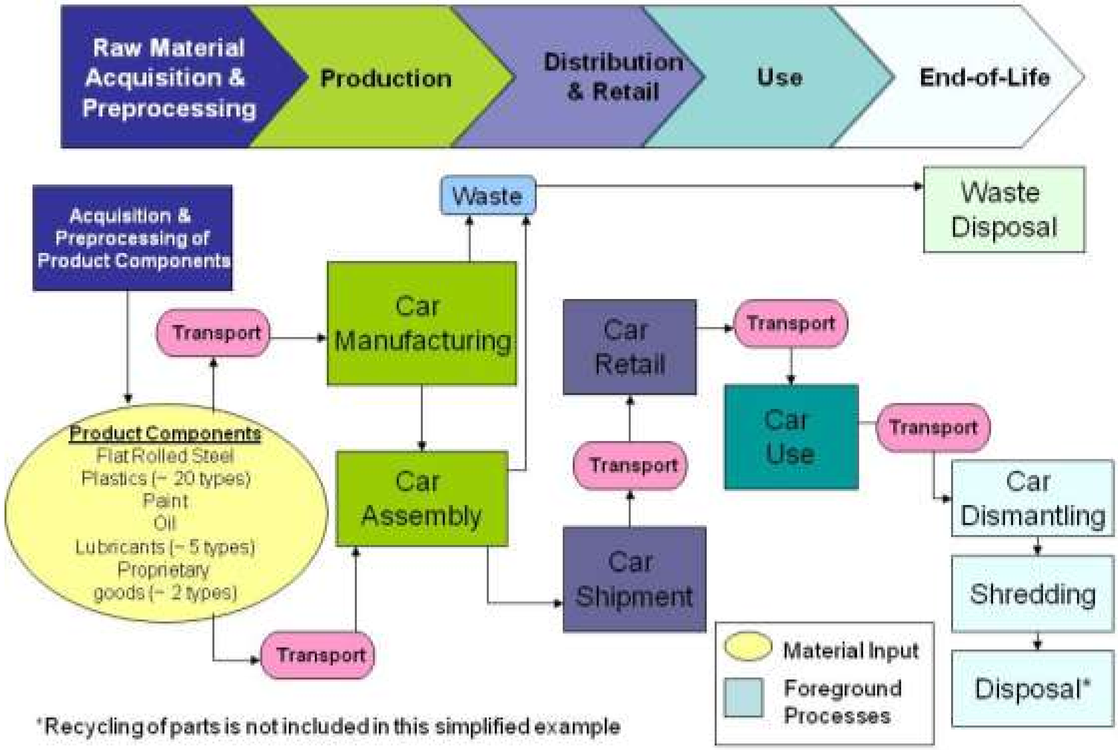
A process map identifies stages and foreground processes throughout the product life cycle. A company should track wastes, co-products, and component inputs within the process map. However, as specifics about the processes and inputs of a product may be considered confidential, a company may report a generic version of the process map. At a minimum, the reported process map should make clear:

- The flow of a product (and its components) through its life cycle
- The life cycle stages considered in the study
- The general processing steps of a product

An example of a minimal process map to be reported for the production of a car is given in

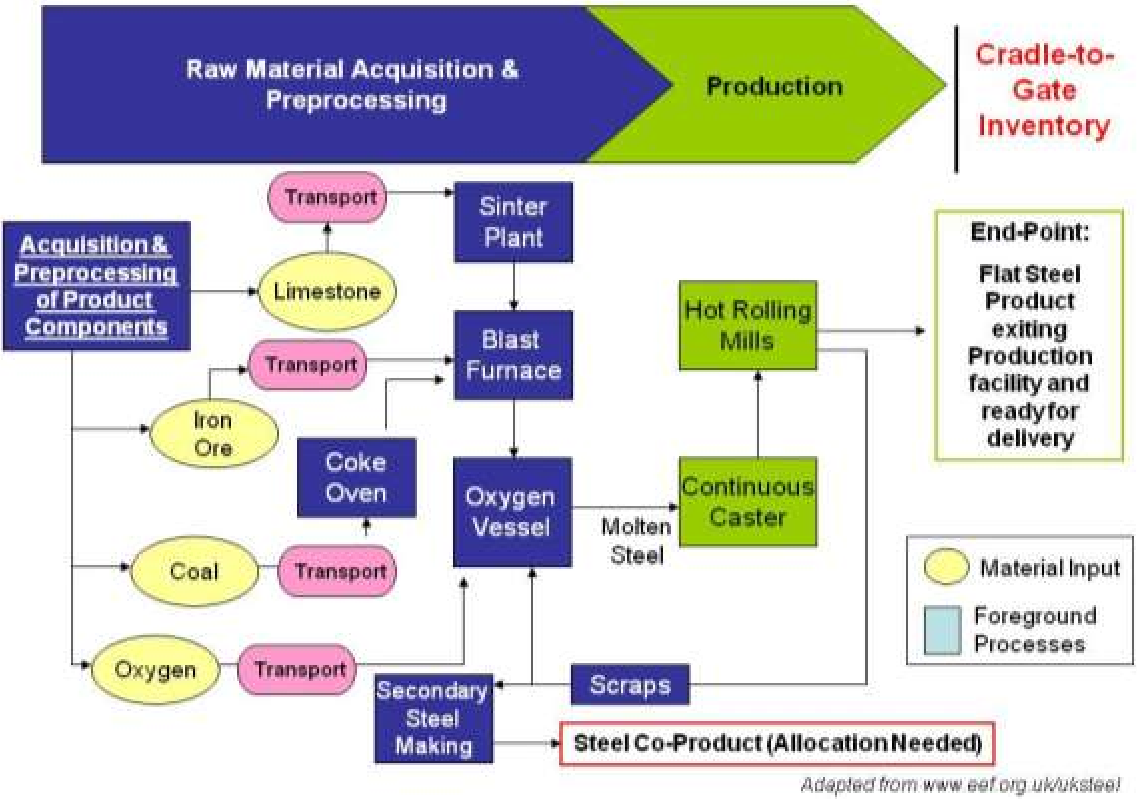
Figure 6-3. A company is encouraged to prepare a detailed process map for internal use, as process maps help to visualize data needs and should inform assurance providers of the scope of the product system.

Figure 6-3: Example Process Map for a Car (Cradle-to-Gate Inventory)



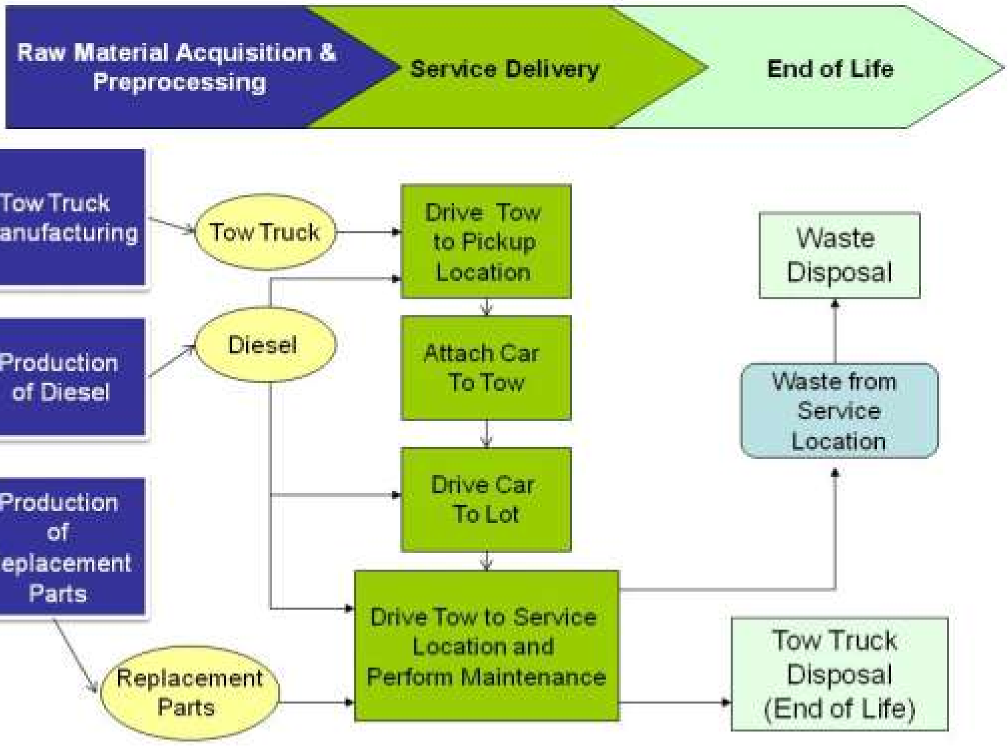
The general stage definitions are provided as guidance, and depending on the particular product a company may find that disaggregating the stages provides more insight into the emissions of the product. This could include separating raw material extraction from preprocessing and component transport, or separating the production process into many stages. Further separation of stages may provide a company with additional insight into areas for potential GHG reductions. This is particularly true for an intermediate product where only some of the five stages are included in the inventory. **Figure 6-4** illustrates a process map for a cradle-to-gate inventory of an intermediate product. In this example, some recycling is shown as it occurs within the extraction and fabrication stages; however, if the company wanted to include recycling of the flat steel product after its use, a cradle-to-grave assessment is required. For an intermediate product, a company should clearly state the end-point of the inventory. For this example, the end point is a flat steel product exiting the production gate and ready for delivery.

Figure 6-4: Example Process Map for Flat Steel Product (Cradle-to-Gate Inventory)



Process maps should also be created for a service, as illustrated in **Figure 6-5**. Because a service may not follow the same life cycle stages as a good, the assurance provider should assure that all relevant processes for a service are included in the inventory.

Figure 6-5: Process Map for a Tow Truck Service



6.3.5. Background Processes

Background processes are not directly attributable to the function of a product. In general, three types of background processes exist:

- Facility Operations
  - Facility utilities to run day-to-day activities (electricity, water use)
  - Capital good management (on-site transport, maintenance)
  - General facility supplies (paper, cleaners)
  - Treatment of emissions (water or air)
- Corporate Activities and Services
  - Personnel
  - Financial Accounting
  - Information Systems Management
  - Marketing
  - Research and Development
  - “Headquarters” activities
  - EH&S
  - Travel
- Capital Goods

Facility operations and corporate activities should be included in the product system boundary, where relevant. Companies that do have corporate inventories are encouraged to account for the portion of the corporate inventory allocated to their product, even if this accounting is done internally and not publicly reported. This allocation should be done by physical relationship or economic factors, and should give the company an idea of the magnitude of these processes compared to emissions along the life cycle of a product (more information on allocation is located in **Chapter 8**). Furthermore, when a company reduces its GHG emissions on a corporate and/or product level, the positive impacts and synergies may be felt in both inventories. Additionally, including facility operations (which typically include electricity use for utilities) in a product GHG inventory would allow a company to pursue energy saving strategies are part of their product GHG reduction plan.

Capital goods are included in the product system boundary if deemed significant to the product. Before testing significance, best practice is for a company to collect data for these activities and include these within the boundary as this would provide the most complete account of the GHG inventory (see **Chapter 7** for data collection requirements). If data cannot be collected, a company may look to approved[9] sector or product-specific standards and literature to determine if capital goods may be excluded. One example[10] of this is a paper published by Rolf Frieschknecht et al. which summarizes the significance of capital goods, as shown in **Table 6-1**. From this example a company may conclude that any sectors with minor impacts from capital goods could claim insignificance.

[9] The process for which the publications will be approved has not been determined yet. Alternatively their use could be assured on a case-by-case basis.

[10] It has not been determined whether this example is an “approved” source. Subject to change.

Table 6-1: The influence of Capital Goods on Specific Sectors (Frieschknecht *et al.*, 2007)

Sector	Capital Goods Impact on Climate Change
fossil energy	minor
nuclear energy	substantial
biomass energy	substantial
renewable energy, not else covered (hydro, wind, solar)	major
metals	minor
mineral construction materials	minor
wood products	minor
agricultural products	minor
transport services	substantial
waste incineration	minor
landfilling	substantial
wastewater treatment	major

If qualitative data is not available, a company may choose to estimate capital goods, or continue with the quantitative significance test. A company is encouraged to engage in estimation before moving forward with the significance test, which in itself may require considerable effort to determine insignificance[11].

Quantitative significance involves estimating the environmental impact of an input; for the case of capital goods, if the type or quantity of goods is such that it has a negligible GHG impact on the inventory results, then capital goods may be excluded. Negligible is defined here as less than 1% of the total process or life cycle stage. Therefore, one would need to provide evidence of the following:

- The material input for capital goods has no known GHG hot-spots along its life cycle (i.e. the material GHG profile is similar to other typical capital goods inputs such as concrete and cold rolled steel).
- The material input is negligible when compared to other inputs within a process or stage

[11] Guidance on estimating data for capital goods will be included in the Standard (to be developed)

7. Collecting Data

Undertaking a product inventory involves collecting emissions factors, activity data and/or GHG emissions for the various processes associated with a given product. The following requirements focus on the types of data, while the guidance provides steps to help a company collect data effectively and efficiently.

7.1. Requirements

Primary data shall be collected for all foreground processes and significant background processes under the financial control or operational control (as defined by the GHG Protocol *Corporate Standard*) of the company undertaking the product inventory.

For all other processes, data of the highest practical quality shall be collected. Quality is based on how well the data represents the actual process, and is defined in detail in **Chapter 9**. For processes where a company may engage suppliers to meet data collection needs, high quality primary data is preferred. For all other data needs, the best quality secondary data is preferred. Any remaining data gaps shall be filled using proxy or extrapolated data.

Box 7-1: Types of Data

Primary data: Direct emissions measurements or activity data collected from specific processes within a product's life cycle or specific sources within a company's operations or its supply chain.

Activity data: A quantitative measure of a level of activity that results in GHG emissions or removals. Examples of activity data include kilowatt-hours of electricity used, volume of fuel used, output of a process, hours a piece of equipment is operated, distance travelled, and area of a building.

Activity data are multiplied by an emissions factor to derive the GHG emissions associated with a process or an operation.

Secondary data: Data that are not collected from specific processes within a product's life cycle or specific sources within a company's operations or its supply chain. Secondary data include industry-average data, data from literature studies, and data from published databases.

Process data: Data measured in physical units relating to a life cycle process or a company's operations.

Input-Output data: Non-process data derived from an environmentally extended input-output analysis (IOA), which is the method of allocating GHG emissions (or other environmental impacts) associated with upstream production processes to groups of finished products by means of inter-industry transactions. The main data sources for IOA are sectoral economic and environmental accounts. Economic accounts are compiled by a survey of facilities on economic inputs and outputs and tax data from individual establishments. Environmental accounts are derived from (surveyed) fossil fuel consumption by industry and other GHG sources compiled in national emission inventories

Extrapolated data: Primary or secondary data related to a similar (but not representative) input, process, or activity to the one in the inventory, which are adapted or customized to a new situation to make more representative (for example, by customizing the data to the relevant region, technology, process, temporal period and/or product).

Proxy data: Primary or secondary data related to a similar (but not representative) input, process, or activity to the one in the inventory, which are directly transferred or generalized to the input, process, or activity of interest without being adapted or customized to make more representative.

7.2. Guidance

Data collection may be a time consuming and expensive exercise, potentially involving a number of people within the company and outside the company. While the highest quality data is preferable, there may be times where cost, time and availability of data are limiting. Where possible there is a preference for verifiable, good quality primary data.

To ensure that a company exerts an appropriate level of effort in terms of collecting data related to the largest emissions sources, the following steps are recommended.

Step 1: Establish a data management process

Documenting the data collection process is useful for internally revising the product inventory, for any external reviewers of the product inventory (e.g., assurance provider), for taking steps to improve the quality of data in the inventory, and for any future development of product inventories of the same or similar products. To ensure that all the relevant information is documented a data management plan should be established early in the product inventory and data collection process. Detailed guidance on how to create and implement a data management plan is located in **Appendix A**.

Step 2: Identify all sources

Once the system boundary has been defined, a list of all relevant individual emissions sources and processes should be determined.

Step 3: Screen all sources

A rapid emissions screening process should be undertaken for all individual emissions sources and processes. This involves using readily available information (e.g., from a lifecycle database, previous studies, input-output tables, corporate inventory) to compile a rough estimate of emissions from the various sources associated with each process.

Step 4: Identify the large emissions sources

Using the estimate of emissions in the screening step, identify the large emissions sources. The definition of large may vary between inventories as the company only uses it as a guide for where to focus their data collection efforts. The large emissions sources should also be split into those the company controls and those they do not.

Step 5: Focus data collection on the large emissions sources

For any emission source that the company controls, primary data is collected. This may involve liaising with personnel within the company to collect the required information. Greater efforts should be made to improve the accuracy and quality of the primary data for the larger emissions sources. For sources that are not controlled by the company, secondary data should be used. However, to improve the accuracy of the product inventory, every effort should be made to collect good quality primary from suppliers (see **Box 8-1**). Again, more efforts should be placed on improving the accuracy and quality of data for the larger emissions sources.

For the remaining emissions sources, list all possible data sources and identify the highest quality data possible given the remaining resources.

Step 6: Fill any remaining data gaps

There should be no data gaps for any foreground or significant background processes. Therefore, any remaining data gaps should be filled using extrapolated, proxy data.

The data collection process is an iterative process where additional data is constantly being sought and improved until the data is of desired quality, no further improvements are possible, or until financial or other resource constraints are reached.

Box 7-1: Importance of Primary Supplier Data

Good quality primary data from a supplier should improve not only the accuracy of the product inventory but enable a company to better manage reductions in GHG emissions along their supply chain. For many product inventories, a majority of GHG emissions may come from the inputs used to produce a product. Therefore, an effective way for a company to reduce their product-level emissions is by procuring inputs with lower GHG emissions or working with their suppliers to reduce the emissions associated with the products they produce.

Good quality data is key to being able to effectively reduce emissions. Therefore, the best type of information from the supply chain is:

- Based on process-specific information and not disaggregated site information from a corporate inventory
- Provides sufficient supporting information to enable the user to understand how the data was gathered and emissions were estimated and the overall quality of the information.

7.2.1. Guidance on Choosing Data

The data collection process should always be guided by data quality considerations. In practice, the data used in a product inventory may be a mix of measured, calculated and estimated data from both primary and secondary data sources. However, the type of data does not provide an indication of the data's quality, so the appropriateness of each data source should be independently judged based on its quality. The subsequent text summarizes the types of data available for a product inventory:

Site specific process data (primary data): These data come from the production sites associated with the processes within the system boundary. They include direct emission measurements and/or activity data. The challenge with site specific process data is disaggregating data for an entire production site to a single product / process. For example, allocating annual average electricity consumption from one production site to the specific processes used in the production of a specific product(s). Allocation procedures are described in **Chapter 8**.

Activity data: These data are *a* quantitative measure of the level of activity that results in GHG emissions or removals. Activity data is multiplied by an emissions factor to derive the GHG emissions associated with a process.

Example 1:

Royal Gala apples are grown on a 6-hectare block. A 120-HP tractor is used to apply herbicide and it takes 3 hours to apply the herbicide to the 6 hectares. To calculate emissions from a given activity (i.e. herbicide application), the activity data (i.e. hours to apply herbicide) are multiplied by an emission factor that gives the GHGs emitted per unit of activity. Emission factors are activity specific. In this example the emission factor is specific to the size (horse power) of the tractor, i.e. the emissions factor for a 120-HP tractor which is 23.56 kg CO_2-e/hr. The calculation would be:

GHG emissions = hours taken to apply herbicide × emission factor

= 3 hours × 23.56 kg CO_2-e/hr

= 70.68 kg CO_2-e

The activity data is this example is the time taken to apply the herbicide. Alternatively, the amount of fuel used to apply the fungicide could also be used.

Example 2:

The Sauvignon Blanc grapes for a wine were grown on 6 hectares. A small, 120-HP tractor is used to apply fungicide and it takes about 1 hour to apply the fungicide to the 6 hectares. The emission factor for a 120-HP tractor is 23.56 kg CO_2-e/hr. The calculation would be:

GHG emissions = hours taken to apply fungicide x emission factor

= 1 hour x 23.56 kg CO_2-e/hr

= 23.56 kg CO_2-e

The activity data is this example is the time taken to apply the fungicide. Alternatively, the amount of fuel used to apply the fungicide could also be used.

Generic/average process data (secondary data): These data are secondary process data which represent averages of site-specific process data collected from organizations or associations which run the same type of processes or from multiple facilities within the one company (e.g., emission factors supplied by industry associations).

To provide high quality generic/average process data, site specific process data are collected and aggregated to determine average data for a specific type of process. This is useful, for example, where confidentiality concerns preclude obtaining site specific process data or where it is not possible to identify the specific supply source(s) of an input.

Process data from literature studies and expert estimates (secondary data)**:** These data are secondary process data that come from literature studies, lifecycle databases and expert estimates. The quality of these data is likely to be highly variable depending on the source and/or product for which the inventory is being undertaken.

Impact Assessment results (secondary data): For example, GHG figures for ingredients from literature sources.

Input-Output data (secondary data): are non-process secondary data derived from environmentally extended input-output analysis (IOA) which is the method of allocating GHG emissions (or other environmental impacts) associated with upstream production processes to groups of finished products by means of inter-industry transactions. The main data sources for IOA are sectoral economic and environmental accounts. Economic accounts are compiled by a survey of facilities on economic inputs and outputs and tax data from individual establishments. Environmental accounts are derived from (surveyed) fossil fuel consumption by industry and other GHG sources compiled in national emission inventories.

Extrapolated data: Primary or secondary data related to a similar (but not representative) input, processor activity to the one in the inventory that are adapted or customized to a new situation to make more representative. For example, using data from the same or a similar activity type and customizing the data to the relevant region, technology, process, temporal period and/or product.

Proxy data: Primary or secondary data related to a similar (but not representative) input, process, or activity to the one in the inventory, which should be used in lieu of representative data if unavailable. These existing data are directly transferred or generalized to the input/process of interest without adaptation.

The most representative, reliable and highest quality data should be used when compiling a product inventory. Any reviewer of the product inventory should be able to determine the quality of the data and be assured that they reasonably represent the relevant aspects of the foreground and background process(es). The quality of the data used should match the purpose of the product account. For example, screening assessments might use data that are not geographically specific nor include any site specific process data, while publicly disclosed accounts would aim to use as much site specific or generic process data as possible.

7.2.2. Guidance on Collecting Data

The following considerations should guide the data collection process:

- Data collection should follow the GHG Protocol principles of accuracy, completeness, relevance, and transparency to ensure a true and fair account of a product GHG inventory.
- The system boundary defines the processes and inputs that data is collected for.
- Primary data is collected for all foreground processes and significant background processes under the financial or operational control of the company undertaking the product inventory.
- Every effort should be made to collect good quality primary data from suppliers.

- Comparing primary data to secondary data may be used to check the validity of the collected primary data.
- Data should represent as closely as possible to the time, geography and technology of the relevant inputs/processes.
- Time, expense and accuracy may need to be considered when collecting information. Therefore, more effort should be put in improving the accuracy of larger emission sources.

Collecting primary data

Primary data includes:

- GHG emissions that have been directly measured from the production sites associated with the processes, e.g., GHG emissions from a fermentation process
- Activity data from inputs used to produce the specific product at the production sites, e.g., kilograms of fertilizer used, liters of fuel used.
- Emissions factors that have been derived from direct measurements at the production sites or actual inputs used in the product, e.g., GHG emissions per hour generated from operating a piece of equipment or the GHG emissions per unit should be determined specifically for the fuel to be used to fire a boiler.

Where activity data are collected directly by the company for the relevant processes (primary data) but the emissions factor used is derived from a secondary, external source (e.g., LCA database), then the emissions from this calculation would still be considered primary data. As required, there should be no instances where secondary data are used instead of primary activity data for the processes a company controls.

When collecting primary data there is a preference for the way the data is collected and used to calculate GHG emissions:

1. Measured data, e.g., direct GHG emissions measurements for the process at the production site.
2. Calculated data, e.g., where activity data are collected at the production site and emissions factors are used to determine the GHG emissions.
3. Estimated data, e.g., where GHG emissions are available, but cover the whole production site and need to be disaggregated to a specific process/product

Collecting Secondary Data

Lifecycle databases
Secondary data are typically sourced from existing lifecycle databases. Many such databases exist and they vary in their sector or geographic focus, their cost, frequency of update and review processes. To identify the appropriate database(s) to use, additional information should be sourced about the database. This information should be obtained directly from the database supplier. Some questions to use in assisting with the selection of a database are listed in **Box 7-2.**

Box 7-2: Questions to Assist with Selecting a Lifecycle Database to Use

1. Are the listed process-based LCA emissions data from a collection of actual processes or estimated/ calculated from other data sources?
2. Are the sector-based LCA emissions data developed using Input-Output techniques or other methods?
3. Were the LCA emissions data developed using a consistent methodology and were the data developed in compliance with ISO and other quality standards (add which ones we want to specify)? If yes, what standards were used?
4. For agri-products, are direct and/or indirect land use impacts included in the LCA emissions data? If yes, what indirect impacts are included?
5. How long has the database existed, how long has its developer been in business and how extensively has the database been used?

6. How frequently is the database updated?
7. Are the data sources consistent with the scope, geography, product use and product manufacturing characteristics (e.g., processes) for the GHG account being performed?
8. How current are the data sources used for developing the LCA emissions data in the database?
9. Can uncertainties be estimated for the data and are the meta-data available?

Emission Factors

Emission factors may be derived from any of the secondary process data sources. An emission factor is the GHG emissions per unit of activity. There are two types of emissions factors commonly available. The first relates only to the activity causing the emissions (e.g., combustion of fuel) – activity emission factor. The other relates to the production of the inputs used in an activity as well as any emissions associated with the activity itself – lifecycle emission factor. Using a fuel example, the lifecycle emission factor would include not only the combustion of the fuel itself but emissions associated with the extraction, transport to refinery, manufacture of the fuel, and often the transport of this fuel from the refinery to the retailer.

The activity emission factor is commonly used in corporate accounting and is the most likely emissions factor to be updated regularly; however, it should not be used in a product inventory unless the additional lifecycle emissions are included. There may also be variability in what is included in the lifecycle of the factor. For instance, a fuel lifecycle emission factor may include the refining of oil to produce fuel, transport of fuel to a wholesaler, and combustion of the fuel, but exclude emissions from the extraction of oil and transport of oil to the refinery. Where possible, the lifecycle emissions factors used should be consistent with the system boundary defined by this standard. It is good practice to document the system boundary of any emissions factors used. There may be some instances when an emissions factor may correspond to the lifecycle analysis of a specific input within the system boundary.

Box 7-2: Tips for Using Emission Factors

- Process-specific emissions factors (either from direct measurement or from other studies) are preferable to more generic emissions factors; and should be as high a quality as possible. Some sources include national factors published by a government authority, industry factors published by industry associations, and lifecycle databases.
- Lifecycle emissions factors should be used. If they are not, this should be documented.
- Where possible, use emissions factors that correspond to
  - The year(s) covered in the product inventory. This especially important for electricity emissions factors which vary over time.
  - The country(ies) where the product and its inputs are being extracted, produced and consumed.
  - The technologies used to produce the product and its inputs.
- Document the source of all emissions factors and what is included in their system boundary.

Input-Output Data

Input-output (IO) data is another form of secondary data. This data is typically based on national IO tables which are frequently updated 5-yearly. They are based on industry data and depending on the country, product or sector categories are more or less disaggregated. For example, the US, Japan and Korea have over 400 products or sectors in their IO table, while most European countries have 60-120 categories. Most IO data are in monetary units that likely need to be converted to physical units using price information before being used in product inventories. Some IO tables are being developed that do contain physical information and/or GHG information[12].

Box 8-3: Using input-output data

IO data is used in a similar manner to process data – applying GHG emissions per unit of input to data derived from an IO table. The steps for using IO data are:

1. Obtain GHG emission factors derived from environmentally extended input-output analysis. These factors represent the total upstream production GHG emissions per monetary unit of a product, product category or sector. Such factors can be obtained from publicly available data sources or proprietary LCI databases. For example, the Guideline to Defra/DECC's GHG Conversion Factors for Company Reporting has a section on supply chain conversion factors based on IO analyses (http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm).
2. Identify the product, product category or sector relevant to the data gap. The products found within a category may be more or less homogenous depending on the level of aggregation. For instance, an IO table may distinguish between copper, aluminum and precious metals or cover all or some of these categories under a larger generic classification of "non-ferrous metals, not elsewhere classified."
3. Determine the monetary value of the inputs where a data gaps exists. In some cases, this value will have to be converted from actual (purchasers') prices to basic prices by subtracting taxes and distributors' trading margins. For example, ceramic pots are one of the inputs in the system boundary, and no suitable process data can be located. The company knows they purchased £1000 of ceramic pots during the production process.
4. Multiply the monetary value of the input by the IO-based emission factors (from 1 above) for each GHG to obtain the total emissions associated with all upstream production processes. Using the ceramic pot example, the IO-based emissions factor for 'ceramic goods' is 1.309 kg CO_2e/£.
5. Include this information into overall GHG product inventory.

[12] A list of IO data sources will be included as in the Standard Appendix (to be developed)

Use and Management of Confidential and Proprietary Data

There are any number of situations when collecting and using data in a product inventory where the data are considered confidential and/or proprietary to the provider of these data. Such information may take several forms, from direct emission measurement data to indirect data sources from which emission data may be calculated or deduced.

Some organizations may provide data needed to perform GHG calculations without any use restrictions. Other organizations require that the data provided be protected from disclosure and use for any purpose other than that which is specified by the data provider. Frequently, use and disclosure of data considered to be confidential and proprietary is governed by some form of "confidentiality" or "non-disclosure" agreement. If so, specific terms of data use and disclosure are defined within the agreement. Violating breach of use and disclosure provisions in legally binding documents may have serious legal consequences, particularly if harm to the data source provider may be demonstrated as a result of unauthorized disclosure.

Whenever data that represent a specific organization are to be used for a product inventory, it is generally good practice to check with the data provider to determine if there are any restrictions regarding data use and disclosure, regardless of how the data were obtained. It is also good practice to inform the data provider concerning how the data are to be used and ask for written permission to use them for that purpose. Any restrictions on use of data or further disclosure need to be respected.

8.2.3 Addressing Data Gaps

In most instances where data are missing, it should be possible to obtain sufficient information to provide a reasonable estimate of the missing data. Therefore, there should be few, if any, data gaps. Again, the highest quality data should be used given resource constraints.

Identifying data gaps

Data gaps exist when there is no primary or secondary data that is specifically relevant to the product inventory being undertaken. For example,

- Emissions factors or activity data may not exist for a specific input/product
- Emissions factors or activity data may exist for a specific input/product but has been generated in a different region
- Emissions factors or activity data may exist for a specific input/product but has been generated using a different technology

Filling data gaps

Data gaps should be filled using:

- Extrapolated data, e.g., GHG emissions from the same or similar products that have been customized to a new situation, e.g., region.
- Proxy data, e.g., GHG emissions from the same product but from a different locality or produced using different technology or GHG emissions of a similar product. This data is not modified in anyway.

Using proxy data

Proxy data could come in the form of any data type but relates to a 'similar' input or process. Where data gaps exist, data relating to 'similar' products/ingredients may be used as 'proxy' or 'surrogate' data to fill these gaps. This approach has been used extensively to deal with lack of primary data in lifecycle analysis. The choice of proxy data is usually based on the knowledge and past experience of the person undertaking the product inventory, without having the possibility to validate such choices. There are two ways to generate proxy data:

- Data transfer which is the application of data obtained in one situation to a different but similar situation. The key issue is how to define "similar," e.g., use of GHG emissions data from apple production for pears (see examples below).
- Data generalization which is generalizing specific product datasets to more generic product types, e.g., generalizing apples and oranges data to fruit.

The accuracy or representativeness of data in data generalization is possibly lower than data transfer. However, transferring data may also suggest a false level of certainty as data generalization results may be more robust where proper consideration of embedded variability in the data is made.

Identifying similar inputs/products
There are many things to consider when identifying similar inputs/products, including type of input/product, where the input/product is produced, type of technology (ies) used, and a distinguishing characteristic(s) of an input/product. The following examples for food and chemicals list some variables to consider when deciding if an input/product may be considered 'similar' to the one for which data are missing:

i) Food/bio-based materials

- Country of production (indicative of fuel mix/technology type/infrastructure/climatic conditions etc)
- Yield
- Technology type (extraction, processing, transportation, etc.)
- Taxonomy/biological properties/harvested crop or animal parts for bio-based materials – e.g. top fruit, soft fruit, legumes (nitrogen fixers), red meat, poultry, eggs, dairy etc.

ii) Chemicals

- Chemical Structure – data from a material which are structurally similar
- Technology/process type – materials which are produced by similar chemical reactions (e.g., sulphonation of surfactants, mining and purification of minerals or distillation) or number of stages in a reaction process or synthesis
- Starting materials or feedstock – e.g., petrochemical, mined materials, clays, oleochemicals
- Scale of production – high volume materials tend to be more efficiently produced than small scale manufacture

Extrapolation
Extrapolation refers to the adaptation or customization of an existing dataset to the conditions of the product inventory being undertaken. Data could come in the form of any data types and extrapolation may occur in many dimensions around the product, technology or geography. Extrapolating data requires knowledge of both the existing situation and those for the current product inventory such as detailed lifecycle information on the existing data and the general characteristics of the product being assessed. It is likely that extrapolation is likely to yield more accurate results than the use of proxy data.

Extrapolation may vary in the degree of customisation applied. For example, adaptation of an existing dataset may be limited to changing the electricity mix to match the country in which the input/product is being manufactured. Alternatively more extensive adaptation may be applied where the key emissions attributes of the product impact are identified (e.g. for a laptop, these may include weight, area of printed circuit board, screen size, hard drive size, etc). An algorithm may subsequently be developed to apportion impacts related to those attributes. Identifying the key emissions attributes and the subsequent algorithm developed should be based on other relevant product inventories or LCA studies for similar products or stakeholder input where inventories or LCAs don't exist.

Where data gaps have been filled, e.g., using one of the above options, it is worth noting the procedure(s) taken to fill the data gap. This should enable others (either for the current product inventory or for future product accounts) to understand the steps taken to identify other avenues to find the new sources of data.

To assist with the data quality assessment, any assumptions made to obtain missing data along with the anticipated effect on the final product GHG emissions should be documented. For example, if an emissions factor based on a different technology was used, is this expected to over- or under- estimate GHG emissions. If such effects cannot be anticipated then this should be stated, e.g., the likely effect of the GHG emissions estimate is unknown.

8.2.4 Data for the Use and End-of-Life Stages

The use and end-of-life stages for a product are where there is likely to be greatest uncertainty in a product inventory, primarily because of the potentially large variation in how a product is used and disposed of. For some products, the use and end-of-life stages may comprise a significant portion of the product's total GHG emissions, and decisions around the use and end-of-life stages may have a significant impact on a product inventory. Therefore, when defining service life information, it should be verifiable and should refer to the intended use conditions of the product and be related to its functional performance.
(Examples to be added if needed)

It is also good practice to undertake sensitivity analyses to assess the influence of use and end-of-life profile assumptions on the product's GHG emissions. Any deviations to use and end-of-life profiles taken from sector-specific guidance and published guidelines should also be assessed using sensitivity analysis, especially where the use and end-of-life stages comprises a significant portion of the product inventory. **Box 8-4** outlines an example of a sensitivity analysis, including how the emissions from the use and end-of-life stages may vary depending on the assumptions made.

Box 8-4: Sensitivity analysis for the use and end-of-life stage for a bottle of wine

The total GHG emissions for the bottle of Sauvignon Blanc in this example were 1243 g CO_2e/750 ml glass bottle.

General Assumptions:
Distance from home to retailer = 5.5 km
Wt of goods purchased at retailer = 11kg
Mode of transport = petrol passenger car
Total refrigeration = 48 hours
Wt of 750m1 bottle of wine = 1.2862 kg

Sensitivity Analysis
Scenario 1: Consumer drives to retailer and refrigerate wine for 48 hours before consumption, bottle is recycled, screw cap goes to domestic waste

Assumptions	GHG Emissions (g CO_2e/750 ml glass bottle)
Transport from home to retailer and back (km)	307.40
Refrigeration (48 hours)	1.77
Recycling glass bottle	-282.00
Domestic waste to landfill (screw cap)	0.10
Total	**27.27**

Scenario 2: Consumer drives to retailer and refrigerate wine for 48 hours before consumption, both bottle and screw cap are recycled

Assumptions	GHG Emissions (g CO_2e/750 ml glass bottle)
Transport from home to retailer and back (km)	307.40
Refrigeration (48 hours)	1.77
Recycling glass bottle	-282.00
Recycling screw cap	-47.70
Total	**-20.53**

Scenario 3: Consumer drives to retailer and consume wine without refrigeration, bottle is recycled, screw cap goes to domestic waste

Assumptions	GHG Emissions (g CO_2e/750 ml glass bottle)
Transport from home to retailer and back (km)	307.40
Recycling glass bottle	-282.00
Domestic waste to landfill (screw cap)	0.10
Total	**25.50**

Scenario 4: Consumer walk/cycle to retailer and refrigerate wine for 48 hours before consumption, bottle is recycled, screw cap goes to domestic waste

Assumptions	GHG Emissions (g CO_2e/750 ml glass bottle)
Refrigeration (48 hours)	1.77
Recycling glass bottle	-282.00
Domestic waste to landfill (screw cap)	0.10
Total	**-280.13**

End-of-life issues – methane releases from landfills

How products are disposed of may substantially impact their product inventory, e.g., what happens to a product in municipal solid waste streams. The typical end-of-life scenarios include disposal to landfills, incineration with energy recovery, and incineration without energy recovery. When products decompose in landfills under anaerobic conditions they produce methane, giving rise to even greater GHG emissions. There are some published studies about the fate of some products in landfills, particularly paper products, but often assumptions are made. There are also some published data on the energy value and emissions from combustion of different types of materials, inefficiencies of converting heat to electricity, etc. in landfills. This information may be used to either derive or inform the end-of-life profile.

Because of the uncertainty of the end-of-life GHG emissions, it is especially important to transparently document all relevant assumptions. The type of information that should be provided for typical end-of-life scenarios are:

- Landfill
    - Amount of product sent to landfill
    - Portion of product that decomposes to methane and portion that decomposes to biomass or fossil carbon dioxide
    - Amount of carbon in product that is sequestered in the landfill
    - Amount of methane and fossil or biomass carbon dioxide emitted from decomposition of the specified quantity of product in a landfill
    - Sources for the above estimates

- Waste-to-Energy Incineration
    - Amount of product sent to WTE incineration
    - Heat of combustion for the product
    - Amount of fossil fuel replaced by the energy from the incineration of the product
    - Net effect on GHG emissions for the specified quantity of product sent to WTE incineration
    - Sources for the above estimates

- Incineration without energy recovery
    - Amount of product incinerated without energy recovery
    - Amount of fossil or biomass carbon dioxide emitted from incineration of the specified quantity of product
    - Sources for the above estimates

7.2.3. Accounting for Losses (to be completed)

8.2.5 Complex and Complicated Products

Complicated products are products with many (probably thousands) of physical or service components and processes as part of their lifecycle. They are also likely to have product systems that are highly complicated, in that it is difficult to gain a detailed understanding of the full product system. For example, it is difficult to comprehensively map a product lifecycle for a product or service with thousands of components, multiple suppliers and supply chains that has multiple stages and/or a product system with many (variably sourced) commodity components. Some examples of highly complicated products include some kinds of IT-based goods (e.g. computer equipment) and automotive products.

Complex products are those where there are many inter-related (often non-linearly related) factors in the product system that may, individually or collectively, have significant impacts on the properties of the system as a whole. That complexity means that such systems are problematic to model or simulate effectively or meaningfully. It is likely to be the case that *highly* complicated products are also complex, i.e. their product systems as a whole are large with many inter-dependant processes and are problematic to model effectively. An example of a non-linear relationship might be a service which contains a delivery component – the required delivery time may be variable with options available to the customer, a relatively small change in required delivery time may require a transition from ground to air fright with a potentially large change in GHG emissions. Some examples of complex products include many types of services, such as those where demand for a service is highly variable, where customers or service provision is widely geographically distributed, or where a service contains customized elements

The complicated and/or complex natures of such systems may originate from a number of underlying causes, beyond just having a large number of components, for example:

- supply chains may be wide (many suppliers of sub-components)
- supply chains may be deep (each sub-component may itself be complex)
- supply chains and some life cycle stages may be highly variable (e.g. in cases where commodity components are a significant part of a product system, in the use stage of some kinds of products and where products have fast innovation cycles)
- products may be customized or bespoke (in the case of services they may be dynamically configured, the particular configuration used depending on multiple variables)
- product systems may be widely geographically distributed (especially likely in the case of some kinds of services)

It may also be the case that no single company or organization is directly responsible for a large proportion of life cycle emissions or removals of such products (because of the breadth and depth of the supply chain). This further complicates the task of ensuring that the processes in the product's system boundary and data are accurate or complete. Because of the number of life cycle components and processes within a complicated product system it is possible that no particular component or process contributes more than a small fraction of overall GHG emissions.

Until product inventories are more universally implemented (so that the components parts themselves also have their own product inventories), complex and complicated products are likely to require special consideration and it is likely that a number of general requirements of this standard may be especially challenging to meet for these types of products. Depending on the specific context of a particular complicated and/or complex product it is likely that simplified approaches may need to be taken to overcome these and other issues in order to make an assessment practical.

Box 7-3: Undertaking a product inventory for complex and/or complicated products

The following approach is recommended for undertaking a product inventory for complex and/or complicated products:

1. If relevant and approved *sector specific guidance* exists for a particular product then that guidance should be followed.

2. If relevant and approved *sector specific guidance* is *not* followed for any reason, (e.g. because a particular product has features that are not covered in the generic sector specific guidance), then the reasons should be stated, justified and documented. If this approach is used then it may not conform to the public reporting requirements of this standard. However, there are many other uses such as product procurement where this information would still be useful.

3. State on what basis the product is particularly complicated or complex as defined above.

4. State any decisions and assumptions taken to simplify the process of modeling and collecting data for complex and complicated products and list any known limitations of the study.

In the longer term it is preferable for industry sector organizations and stakeholders to work collaboratively to develop appropriate sector specific guidance for complex and complicated products. This could specifically address many of the issues for specific product groups. The development of such guidance, however, may take time and, in the interim, guidelines are needed for those undertaking product inventories for complicated and/or complex products.

In the case of a complicated and/or complex product where there is *no* appropriate approved *sector specific guidance* and where it may not be possible to meet all the requirements of this standard, simplifying assumptions, decisions and approaches may be taken. However, it should be clearly stated that the standard requirements have not been met and therefore the reporting GHG inventory is not in compliance with the GHG Protocol Product Standard.

Box 7-4: Example of Simplifying Approach to Complex Modeling

An example of one simplifying approach that may be generically used is hot spot based modeling and estimation. It may be possible to use existing product inventories or LCAs or to conduct internal studies to identify GHG relevant 'hot spots' in the life cycle of a representative sample of products, along with means of estimating overall emissions/removals. A hot spot assessment would enable the development of a generic product group process model and this could be used as the basis for undertaking a product inventory.

If a hot spot assessment indicates that the majority of emissions/removals are located in a small number of components or processes, then more detailed assessments may be conducted on those key components or processes. More generic data from secondary data sources could then be used for the other processes in the system boundary. The validity of the approach could be tested by comparing the results against more detailed product inventories or LCA studies of similar or the same products.

(further development expected)

8. Allocation

8.1. Introduction: What is an Allocation Problem?

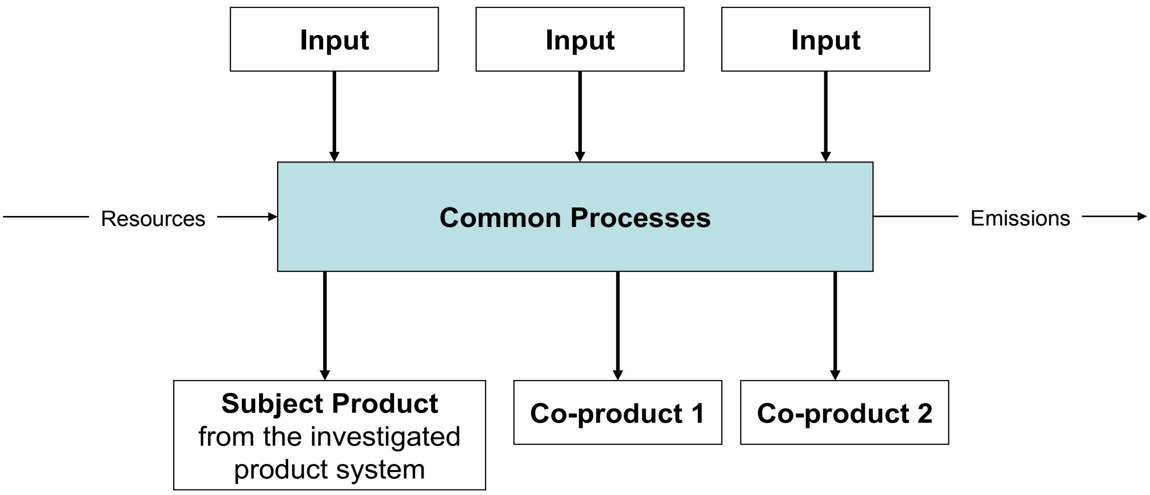
Once a company begins collecting data, they may find processes along the product's life cycle that have multiple valuable products as inputs and/or outputs. In these situations, the total emissions from the process need to be allocated between the product system under study and other product systems). Typically there are two types of products from these multifunctional processes: the **subject products** for which the GHG inventory is being prepared and the **co-products** that are used in other product systems. In these cases, the emissions from the common process shall be allocated to the subject products and co-products in a manner that accurately reflects each products contribution to the common processes emissions. Note that products and co-products shall have an economic value to apply allocation to the process; emissions should not be allocated to waste streams. There are three general cases when allocation problems are encountered:

- Multi-output processes
- Multi-input processes
- Recycling and reuse

A **multi-output process** occurs when a common process has multiple outputs of which only the subject product output is included in the studied product system (and the other outputs belong to other product systems). In such cases it typically would be not appropriate to charge the total emissions from this common process only to the product system under study since a portion of those emissions are attributable to the other product systems(s).

Inputs to the common process may be intermediate products, product components, or energy inputs. Outputs may be intermediate or final products or energy outputs (such as electricity or district heat). In Figure 8-1, the "subject product" is the product output of the common process which is used for the product system under study; "co-products" are the products outputs of the common process which are used by other product systems.

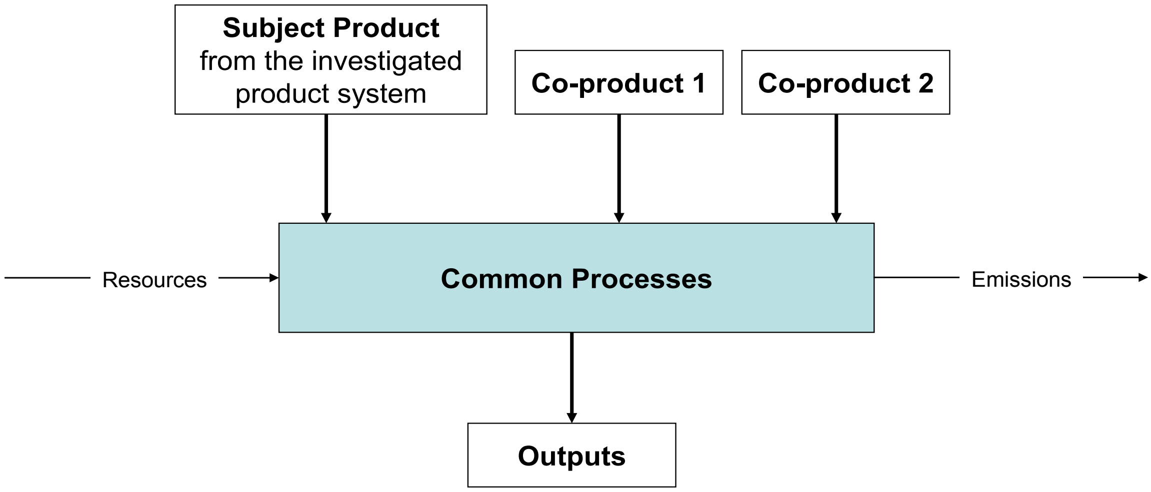
Figure 8-1: Multi-Output Allocation Problem



A **multi-input process** occurs when a number of different products (including the subject product) are treated in the same process. As with the multi-output process, only a part of the GHG inventory of the common process are attributable to the product system under study.

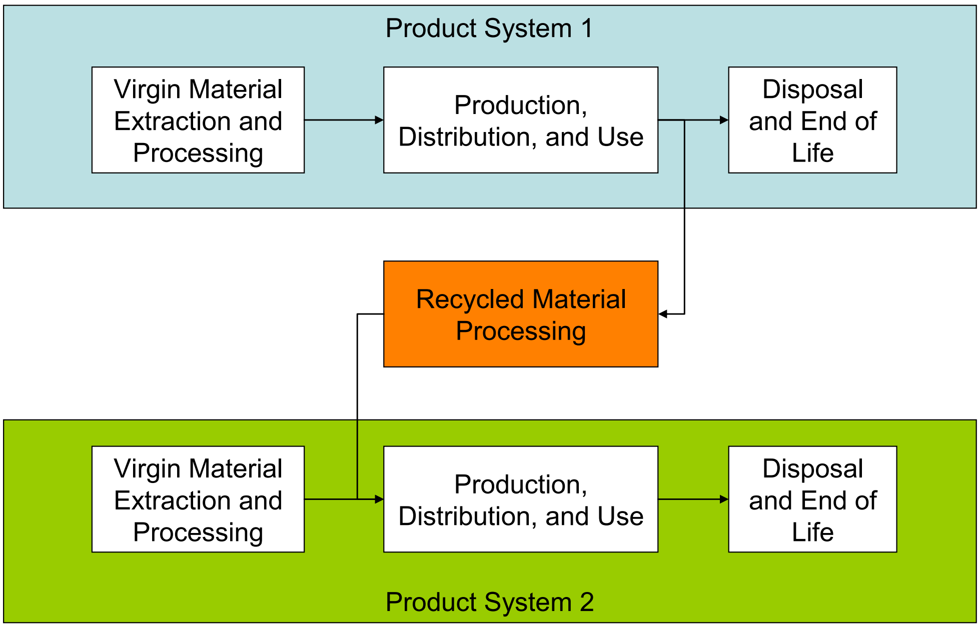
Figure 8-2 gives an example of a multi-input process.

Figure 8-2: Multi-Input Allocation Problem



Recycling and reuse occurs when recycled or reused material enters the product system under study as a system input or leaves it as a product output. In this case, the recycled material does not have a raw material lifecycle stage and only a partial final disposal stage. The recycling loop is, in essence, a common process across several product systems, as shown in **Figure 8-3**.

Figure 8-3: Example Recycling Process



Solving allocation problems is an important element of a product accounting system as it is a mechanism for accurately attributing emissions to various outputs including the subject product.

Table 8-1 lists all the procedures to solve allocation problems recommended for use in this standard.

Table 8-1: Procedures for Emission Accounting in Multi-Output/Input Product Systems

Method	Definition
Process Subdivision	**Dividing the common process into sub-processes in order to eliminate the need for allocation.**
System Expansion	**Inclusion of the co-products (additional functions) in the functional unit**
Physical Allocation	**Allocating the inputs and emissions of the system based on an**

Factors	**underlying physical relationship between the quantity of product and co-product and the quantity of emissions generated. This is relevant if the production volume of the co-products can be varied independently**
Substitution	**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 with the remaining emissions being allocated to the subject product and remaining co-product(s).**
Market Value	**Allocating the inputs and emissions to the subject product and co-product(s) based on the market value of each product at the exit of the process.**
Other Relationships	**Dividing the process emissions among the outputs using a factor based on other scientific approaches than natural science (e.g. from social and economic sciences) or international conventions**
Value Choice/ Arbitrary	**Use of allocation factors (e.g., mass, energy, volume, etc.) based on value choice or arbitrary factors**

8.2. Requirements

General principles for solving allocation problems

When faced with an allocation problem, a company shall consider the following general principles:

- When addressing common processes, users should avoid allocation, i. e. partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems.
- The allocation process shall adhere to the general accounting principles of completeness (all emissions accounted for), transparency (clear documentation of how emissions are calculated), accuracy (a true accounting of the product's GHG inventory, and consistency (a process that is applied similarly to multiple outputs).
- The allocation process has a preference for decisions based on natural science, followed by those based on other scientific approaches (e.g., social or economic science). Value choices are the least preferred basis for allocation decisions.

Requirements for multi-output and multi-input allocation problems

If possible, an organization shall avoid allocation by using one of the following methods:

Process subdivision

Process subdivision is applicable for different products whose manufacturing processes are not intrinsically linked. For those cases, allocation may be avoided by increasing the level of details of the modeling. The common process is disaggregated into sub-processes which each produce one of the subject product and co-products. The process needs only to be sub-divided to the point that a distinct process is identified and emissions calculated for the subject product. There is not a need to subdivide the process to the point that every co-product has a unique and distinct process.

Direct system expansion

Another method to avoid allocation is to expand the product system under study in a way that includes both the subject product and the co-product(s) together as a functional unit.[13]

[13] There are two primary methods for applying system expansion. The first, direct system expansion, involves expanding the product system through a redefinition of the functional unit so that the functional unit includes all of the shared process outputs. The second, avoided burden, involves expanding the product system and then estimating the emissions contribution of one or more co-products(s) by equating those emissions to the emissions of the alternative product the co-product replaces in the market. Because this standard is based on an attributional approach, only direct system expansion can be used to solve allocation problems. System expansion shall be done in accordance with the functional unit requirements defined in the Chapter 5.

If allocation is necessary, the company shall use one of the following methods selected in accordance with the general principles for solving allocation problems. A decision tree is provided in **Figure 8-1** to help users select the best allocation method for their process. In all cases, the method used to solve the allocation problem shall be justified and documented. The documentation shall include a brief explanation of why the specific method and factor (as applicable) was selected over others including why that factor offers the most accurate allocation of emissions.

Allocating based on physical relationship

Allocating based on physical relationships of the products may be used e.g. by applying energy content, energy, mass, content of chemical elements, etc. as allocation factors. When applying physical relationship allocation, all co-products need to be characterized by the same physical indicator. The physical indicator needs to describe the usefulness of the product in a meaningful way, e.g. energy or energy content in case of energy processes that produce heat and electricity, chemical composition in case of chemical reactions, protein content in case of use as feed and food, etc. Selection of the factor needs to be based on science and verifiable.

Substitution allocation approach

The substitution approach estimated the emissions contribution of the co-products to the common process by using the emissions of a similar product or the same product produced through a different method. The product substitution method is most applicable if a single alternative product is identified as the substitute to avoid arbitrary choices between potential substitutes. For the substitution method to be valid, users should be able to demonstrate and document that the selected substitute is a reasonable replacement for the co-product and accurately approximates the emissions attributable to the co-product.

Value based allocation

Value based allocation is the division of emissions from the common process to the subject product and co-product(s) according to the economic values of the products when leaving the multi-output process Market prices or prices at a later point of the life cycle should only be used if direct prices are not available or cannot be evaluated. Known downstream costs should be subtracted as far as possible. The direct price of the product is the price of the product directly after leaving the process. The market price is the value of the product in a commercial market.

Allocation methods based on value choices or arbitrary assumptions

Allocation methods based on factors (e.g., mass, energy, volume) selected using value choices or arbitrary assumptions represents the position of one person, e. g. the practitioner of the study. However, such an approach is sometimes necessary in cases where all other allocation methods cannot be applied due to a lack of required data. When value or arbitrary choices are used, the influence of the choice of the allocation factor on the outcome of the study needs to be determined in a sensitivity study.

Requirements for allocation of recycling process emissions

Recycling, although different from a multi-output or multi-input process, is accounted for in product GHG inventories using similar procedures to the ones defined above for allocation. A company shall consider the general principles for allocation when assessing recycling in a GHG inventory. There are three general recycling applications:

- *Closed loop recycling:* Closed loop recycling occurs when specific material is recycled and used again within the same product system.
- *De-facto closed loop recycling:* De-facto closed loop recycling occurs when the recycled material at the end-of-life is functionally equivalent to a material input of the product (i.e. the same inherent properties)
- *Open loop recycling:* Open loop recycling occurs when the material recycled at the end-of-life has inherent properties which are different from those of the virgin material it is derived from or when the recycled material is used in other product systems and cannot be modeled as a closed loop system.

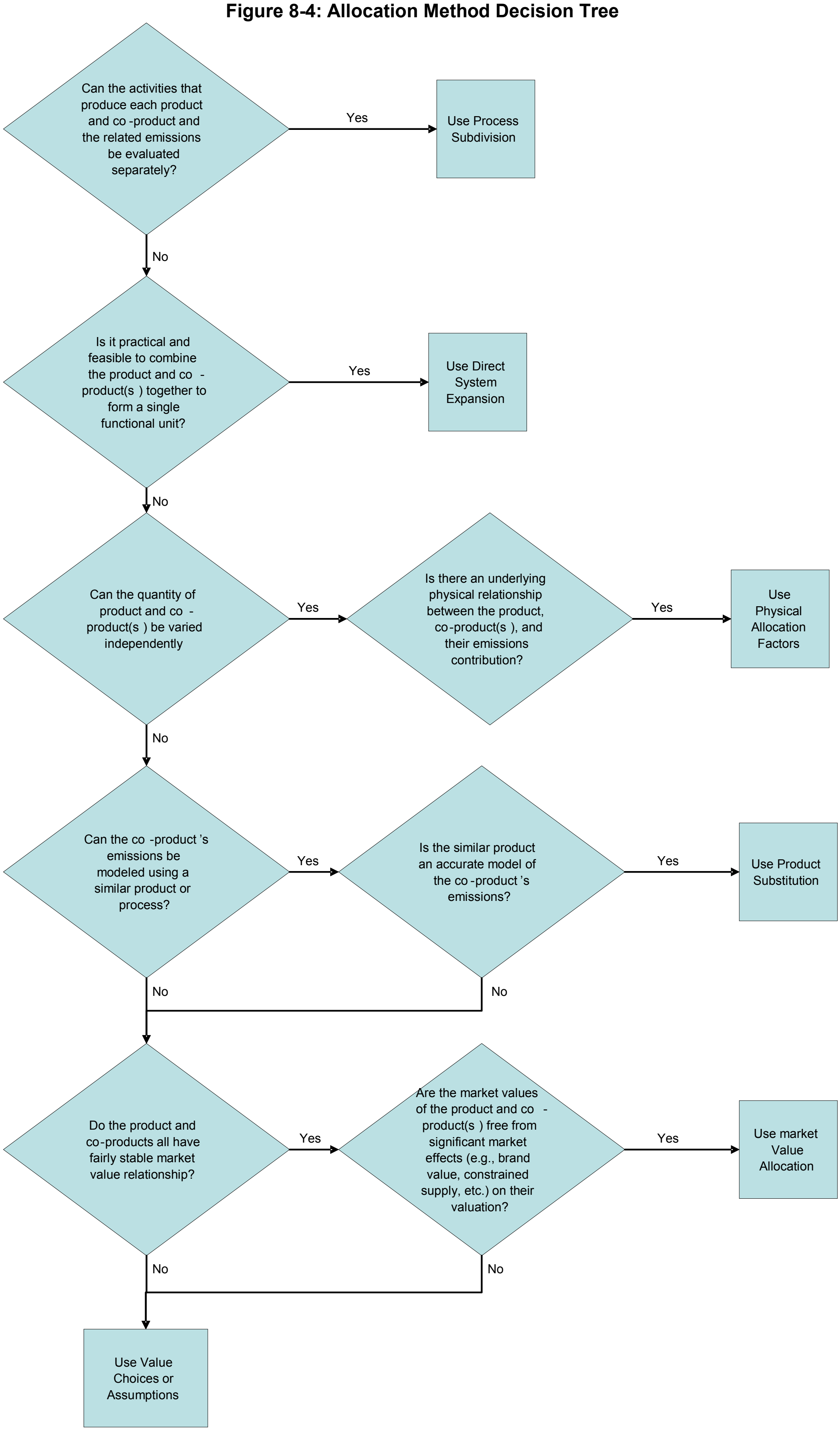
Data used to determine recycling rates shall be justifiable and reported.

8.3. Guidance

8.3.1. Selecting an Allocation Approach

This standard identifies six valid methods for allocating emissions from a common process. Each of these methods is a valid approach; however, each is suited to different scenarios. **Figure 8-4** presents a decision process for selecting the best allocation method for a given situation.

Figure 8-4: Allocation Method Decision Tree



The decision process in **Figure 8-4** is based on the order of preference for the allocation methods, from those that tend to produce the most accurate results to those that are less accurate. This preference is combined with the data requirements and applicable conditions for each method to determine if it should be used. By following this decision process, users select the most applicable method for their specific allocation problem. In any case, the allocation method selected should be documented as required by the standard. Users should consider practicality (i.e., the effort involved in calculating emissions using the allocations method, availability of data, etc.) in selecting an allocation method. In general, the effort involved in calculating the allocation of emissions should be somewhat proportional to the process's overall contribution to the total inventory.

8.3.2. Examples of Allocation Methods

Process Subdivision
A petroleum refinery produces many outputs, including but not limited to gasoline, diesel, heavy oil petrol coke and bitumen. If the GHG inventory of diesel is needed for a GHG inventory study, then only a part of the GHG inventory of the refinery process has to be taken into account. Therefore, the refinery process should be subdivided as much as possible to considered processes that include only diesel fuel. However, it is not possible to solve the allocation problem at a refinery by only process subdivision; after considering process subdivision and simplifying the allocation problem as much as possible, a company should allocate using one of the recommended allocation procedures.

System Expansion
The filling and sealing operation of a beverage container is a common process, both for the container and the beverage. In this case, allocation may be avoided if the product system "beverage container" is expanded to include the beverage, as well. Before the system expansion, the product system "beverage container" may have included the product systems of the components "glass bottle", "lid" and "label"; after the system expansion it includes the product system "beverage" as fourth component. It is evident that the systems expansion, in addition, adds new functions with the new component.

Another example is where the initial product system is a metal conductor in a cable, and the cable production process and some of the end-of-life operations have to be shared with the other components of the cable. In this case, it may be decided to include the other components of the cable into the product system and to determine the GHG inventory of the whole product. Again, the additional functions of the new product system have to be considered.

Underlying Physical Relationships
If a truck transports the subject product P1 and a co-product P2 for a given distance D, then the diesel consumption M of the truck has to be shared between P1 and P2. The solution of the allocation problem depends if the payload of the truck transporting these two products is limited by mass or by volume. If the payload is limited by mass and the relation between P1 and P2 is 25 and 75 percent respectively, then four times more mass of subject product could be carried with the same diesel consumption if the co-product would not exist. It is evident that in this case the diesel consumption is shared by the mass relation of the products: the subject product carries only 25 % of diesel consumption M.

If, on the other hand, the payload of the truck is limited by volume and the subject product needs 50 % of the space of the truck, then, without the co-product, only two times more of the subject product may be transported by given quantity of diesel. In this case, the diesel consumption is shared by the volume relation of the products: the subject product carries now 50 % of diesel consumption M.

The example shows that it needs a justification, which physical size has to be used for allocation. The decision to use allocation by mass in any case without further justification would have received the lowest priority, according to the principle of the priority of the scientific approach.

Substitution
At a pulp mill, waste wood and lignin products are combusted for internal power generation. In some cases that waste is gasified and excess power is created as a co-product and sold to the grid. To allocation for the electricity co product, the substitution method should be used to identify the emissions associated with electricity (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, that the mill emissions allocated to the pulp product would be 950 kg. It is important to note that the substitution method is only applicable when a) the co-product has one distinct used and b) good quality data is available to use as a substitution factor. Otherwise, the company should default to value-based or arbitrary assumptions.

Value-based
(to be developed)

Arbitrary Assumption
When copper is extracted and refined, trace amounts of other valuable metals are often also extracted and therefore considered valuable co-products. If copper is the subject product, and process subdivision has been used to simplify the allocation, then a company would look to underlying physical relationship to calculate the allocated emissions. However, it is not clear if the mass or the value of the products is the true underlying relationship (i.e., depending on the use of the copper, either the valuable product needs to be removed to obtain pure copper, or the valuable product is removed because of its value). Therefore the company should chose an allocation procedure based on their own assumptions. In the case of arbitrary assumption, a company is encouraged to before a sensitivity analysis on all possible allocation methods to determine how the assumption may impact the final inventory results.

8.3.3. Recycling

When a product's life cycle includes recycling, additional consideration may be necessary to insure that the inventory is as accurate as possible. Accuracy here includes consideration that 1) all applicable GHG emissions are accounted for, and 2) no GHG emissions are leaked or double counted into a subsequent product inventory as a result of recycling. A company shall only include recycling within a GHG inventory using factual and science-based knowledge. For example, if a company purchases and inputs 30% recycled material to create the subject product, the company should accurately assess the GHG inventory of the recycled material. It would be incorrect to assume that the material had either the same inventory as virgin material or no GHG impact because it was recycled. Additionally, a company should not simply assume that their product is recycled and therefore end-of-life impacts are zero; recycling, just like any other material processing, uses energy and therefore creates emissions.

Closed-loop recycling

A closed loop recycling system is one where a material A is recycled and reused as material A during the production of subject product B. Closed-loop systems are most common within a single process or facility, and therefore the net consumption of material A (at steady state) is dependent on the rate of recycling. A company should include any additional processing steps needed to recycling material A in the GHG inventory (e.g., cleaning, separating, etc.).

De-facto Closed Loop Recycling

Accounting for recycling in a GHG inventory becomes more challenging when you move away from closed loop systems and into open loop systems. The variety of recycling rates, recycled material properties, and recycled material uses makes it difficult to assign a single allocation procedure to address all recycling problems accurately.

For a de-facto closed loop system, the recycled material has the same inherent properties as a material input into the product. For example, a product may require 100 kg of primary material, e. g. in form of granules or ingots. Then the GHG inventory of the acquisition of 100 kg raw material is charged to the product under study. However, after the end-of-life operations, 90 kg of recycled material with the same inherent properties as primary material are obtained and 10 kg of material are lost. By approximating this as a closed loop system, 90 kg of the input material is recycled; therefore, the GHG inventory for the product includes the production of 10 kg of virgin material and the emissions associated with recycling 90 kg of material. The following should be true for a company to use the de-facto closed loop approach:

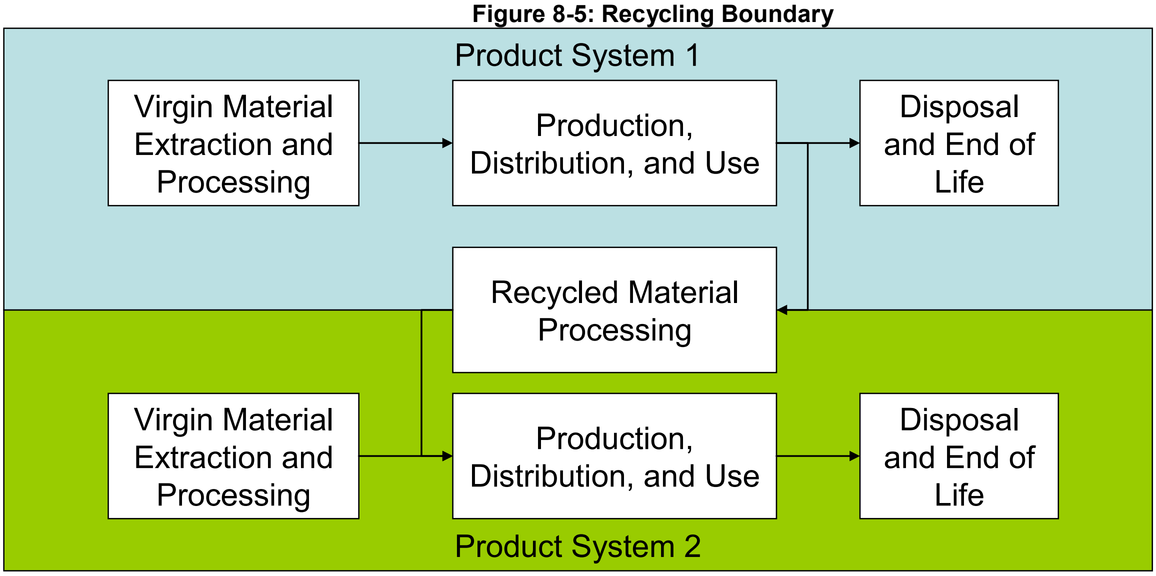
- The recycled material has the same inherent properties as in the original material input
- The rate of recycling assumed

A company may not use the de-facto closed loop approach when the recycled material does not have the same inherent properties as the material inputs. For example, if a high-grade metal is the input and a low-grade metal is the output, then that recycling is considered open loop.

Open-loop recycling

Most recycling situations are open-loop recycling. Open loop recycling occurs when the material recycled at the end of life has inherent properties which are different from those of the virgin material it is derived from or when the recycled material is used in other product. The allocation between the first product and the second (or subsequent) product should be performed such that all GHG emissions are accounted for (i.e. the end –of-life of one is the material extraction of the other). The recycled material processing activities are shared between the two product systems according to the ratio of value between the collected material and the re-processed material. Therefore, if the collected material has no value, then the second product system accounts for the recycling process. If there is equal value, then the emissions from the recycling process are equally shared between the two product systems. A company is required to report the value used to determine the allocation factor, along with the recycling rates assumed.

Figure 8-5: Recycling Boundary



In all recycling cases, if the portion of recycled and virgin material used in the product is known, then that ratio should be used to directly calculate the emissions from the virgin material extraction and processing and the portion of the recycling process attributable to the product. Likewise, if the portion of end of life product that is recycled, then that figure should be used as the basis for emissions calculation.

8.3.4. Other Recycling Issues

If a material is only recyclable a finite number of times, the company should consider the number of subsequent uses when allocating the emissions of the product[14]. The number of subsequent uses of the recycled material should be used for the allocation if this number is determined and justified. If the number of subsequent uses is five, then the common processes are shared equally between the five cycles and only 20 % of the GHG inventory of the common process need to be charged to the product under study. In certain cases it is not easy to explain the selected number of cycles without estimates and arbitrary assumptions.

Reuse of products

Reuse of an item occurs when an item that leaves a product system during the end of life stage is then incorporated into a new product. Note that routine maintenance of a product or its components is considered

[14] The reader is referred to ISO 14049 and PAS 2050 for more information on calculating the number of subsequent uses.

part of the use stage for that product and is not reuse. It is only when those items are incorporated into a new product that this is considered reuse.

The cycle of a reused item follows that of recycled material in an open loop system. At the processing center a reused item is refurbished (compared to reprocessing of recycled material) and then introduced to the new product system. Since reused items follow the same pattern as recycled items, the emissions associated with them are managed in the same way. Therefore reused items should follow the same procedures outlined for open-loop recycling.

8.3.5. Examples of Recycling Allocation Methods (to be completed)

9. Assessing Data Quality and Uncertainty

9.1. Requirements

The percent of total GHG emissions derived using different quantification methods shall be clearly stated and reported. The quantification methods to use are:

- derived from directly measured process-specific GHG emissions
- estimated from aggregated directly measured site information
- calculated using site and process specific activity data and an emissions factor derived from secondary process data
- calculated using site and process specific activity data and an emissions factor derived from input-output data
- estimated using only secondary data sources (either process or input-output data)

A data quality assessment shall be undertaken for all GHG emissions sources that cumulatively sum to 75% of total product emissions, beginning with the largest emissions source.

For all processes quantified using *any* primary data, a qualitative data quality assessment shall be undertaken based on technological, temporal and geographical representativeness, completeness, and precision. For processes that only used secondary data, the data quality assessment shall be undertaken based on technological, temporal and geographical representativeness.

A statement regarding the overall methodology appropriateness and consistency of the inventory shall be made *(to be further developed)*.

9.2. Guidance

Data quality refers to the characteristics of data for satisfying stated requirements. Generally data quality characteristics address how well the data corresponds to the time, geography and technology represented in the product inventory, the precision of any direct measurements, the completeness of processes represented in the inventory and the consistency of data across processes in the inventory.

9.2.1. Why undertake a data quality assessment

Data quality assessments are undertaken for a number of reasons including,

- Improving data quality. A data quality assessment may be used internally by an organization to identify areas within the product inventory that could be improved either for the current inventory or for future inventories.
- Assisting any assurance process. A verifier may request various pieces of information surrounding the quality of the data used in the product inventory.
- Demonstrate to an external audience the quality of the data used in the product inventory. Customers or consumers may request information pertaining to the quality of the data used in the product inventory, e.g., to inform procurement choices.

9.2.2. Assessing Data quality

There is no one definitive process for assessing data quality. However, in most instances data quality indicators are used as the basis of any assessment. This section outlines some procedures that could be used to assess data quality. Regardless, of the data quality assessment procedure used, the procedure should be documented for future reference.

Data Quality Indicators

The common data quality indicators used to describe individual process data in the system boundary are outlined in **Table 9-1**. All data quality indicators should be used to describe primary data, while technological, temporal and geographic representativeness are the most relevant for secondary data.

Table 9-1: Data Quality Indicators

Indicator	Explanation
Technological representativeness	Degree to which the data set reflects the actual technology(ies) used in the processes within system boundary, including any background data sets used.
Temporal representativeness	Degree to which the data set reflects the actual time (e.g., year) or age of the processes within the system boundary, including any background data sets used or whether an appropriate time period is used (e.g., for food products annual/seasonal averages or average of several seasons may be appropriate to smooth out data variability due to factors such as weather conditions).
Geographical representativeness	Degree to which the data set reflects actual geographic location of the processes within the system boundary such as, e.g., country or site, including any background data sets used.
Completeness	The degree to which the data represents the relevant process. The percentage of locations for which site specific or generic process data are available and used out of the total number that relate to a specific product or process. Generally, a percent target is identified for the number of sites from which data is collected for each process.
Precision	Measure of the variability of the data points used to derive the GHG emissions from a process (e.g., low variance = high precision). Relates mostly to where direct measurements have been used.

Methodological appropriateness and consistency

Methodological appropriateness and consistency are important for the quality and robustness of the final GHG emissions value for a product inventory. It is especially important where product comparisons are being made.

Any assessment of methodological appropriateness and consistency determines whether the applied methods and methodological choices (e.g., allocation, substitution, etc.) are in line with the goal and scope of the data set, especially its intended applications and decision support context (e.g., monitoring, product-specific decision support, strategic long-term decision support). The methods also have been consistently applied across all data including background data sets for included processes, if any.

Consistency becomes an issue where secondary data is used as the data may be derived using different assumptions (e.g., allocation approach). At a minimum, the database or data source and relevant study should be documented for any secondary data used. Where possible, the methodological decisions should be documented. The areas where consistency may be an issue includes allocation approach, system boundary, temporal scope of data and geographical scope of data.

Procedures to Assess Data Quality

All data quality assessments are based on data quality indicators; it is how these indicators are used that may vary. There are two procedures outlined which could be used. Primary data assessments use the qualitative approach while either a descriptive or qualitative approach should be used for secondary data.

Consolidating processes for data quality assessments

Undertaking a data quality assessment may be a time consuming task especially where there are many small emission sources. The following guidelines may be used to reduce this burden:

- Separate large individual emissions sources from other sources and conduct individual data quality assessments on these larger sources. The definition of large is likely to vary between product inventories. For example with a bottle of wine, the bottle itself, electricity use in the winery and international shipping emissions may be relatively large individual emissions sources in the product inventory, and separate data quality assessments would be conducted for each of these sources.

- Aggregate processes based on similarities between emissions sources. For the remaining smaller emissions sources, identify ways to aggregate emissions sources. For example, with producing a bottle of wine there are a number of emissions related to the production of agri-chemicals. The individual emissions related to each agri-chemical is relatively small but in aggregate they are quite large. In all likelihood the type of data and its quality may be similar or the same between each individual source and could be aggregated. The data quality assessment is carried out on this aggregated set of sources.
- Aggregate emissions within a given larger process. In some instances it may be possible to aggregate a number of smaller emissions within one larger process. For example, in Figure 10-1 and 10-2 the data sources and quantification of GHG emissions are relatively similar between for all the process within the machining and assembly processing. Therefore, the data quality assessment assesses these emissions in aggregate.

Descriptive Data Quality Assessment

A descriptive data quality assessment will outline data sources; address the technological, temporal and geographical representativeness of the data and overall methodological appropriateness and consistency of the inventory. It may also assess the precision and completeness of the data. A descriptive assessment should include:

- Indication of the largest emissions sources
- Outline of data sources and how decisions, such as those around allocation, were made.
- Statement of the overall methodological appropriateness and consistency of the product inventory
- Who, if anyone has reviewed the data
- Summary of the data quality and how the data quality was assessed

Box 9-1 provides an example of how this type of data quality assessment could be undertaken.

Box 9-1: Example of a Descriptive Data Quality Assessment

The largest sources of energy use and GHG emissions have been derived directly from the life cycle supply chain for the product. Numerous company representatives have assisted in obtaining accurate, relevant, and current data for the product inventory. They have also assisted with co-product allocation issues to accurately and fairly represent the life cycle data for the product. In addition, data has been reviewed by ABC Consulting Ltd for reasonableness, and calculations have been reviewed internally. To the best of our knowledge there is consistency in all allocation decisions and the setting of system boundaries throughout the inventory. Directly measured process-specific emissions comprised 75% of GHG emissions, 20% of GHG emissions were derived using activity data and emissions factors derived from secondary process data and 5% was estimated only using secondary data.

Data quality is summarized in Table 1. The highest quality data (A) represents about 75% of the total energy results and about 75% of the total GHG emissions (carbon dioxide equivalents).

Table 1: Data Quality Summary

Product Step	Source of Data	Data Quality
Product Manufacture	Actual data from client facility	A
Components made from recycled material	Actual component supplier in life cycle product chain	A
Processing	Actual processor in life cycle product chain	A
Chemicals, coatings, ancillary materials	Franklin Associates LCI database	B-C
Product Transportation by path A	Peer reviewed LCI study- detailed tables	B
Product Transportation by path B	Estimates based on actual distances	C
Pallets and Packaging	Public LCI data sources	B
Disposal Practices in U.S.	EPA MSW 2007 Facts and Figures	B
Disposal Practices in Other Countries	Literature search for this study	D
Landfill Operations in U.S.	Estimates based on Research Triangle Institute's Municipal Solid Waste Decision Support Tool	C
Landfill emissions from decomposition	Best estimates available based on most recent landfill research results	D

A = Appropriate and best possible data, reviewed for accuracy
B = Typical LCA data sets, reviewed for appropriateness to study
C = Estimates made using limited, but high quality data
D = Estimates made using data known to be uncertain

Modified example provided by Harmony Environmental, LLC

Qualitative data quality assessment

Qualitative data quality assessments can be based on data quality indicators – technological, temporal and geographical representativeness, completeness, and precision. One approach to use is a scoring criteria for each of these indicators (see **Table 9-2**). For the relevant emissions sources, the quality of the data is given a dating of 1 through 4. A score of 1 indicates poor quality data while a score of 4 indicates high quality data. The data quality assessment is carried out on aggregated categories of GHG emissions sources, rather than each individual emissions source.

This scoring system may still have elements of subjectivity as there may be some variability between the individual processes within a foreground process, foreground input and output flow and significant background process. For instance, one score is used to describe the data quality of all data collected for a foreground process. As a general guide, the data associated with high GHG emitting processes should influence scores for a foreground process more than lower GHG emitting processes.

In some instances, it may make sense to slightly modify the scoring criteria. For example, the technology and time scores for electronic equipment may need to be modified to reflect the rapid development of technology within that sector. Where modifications for specific products or categories of products are made, they should be transparently documented and provided with the data quality assessment.

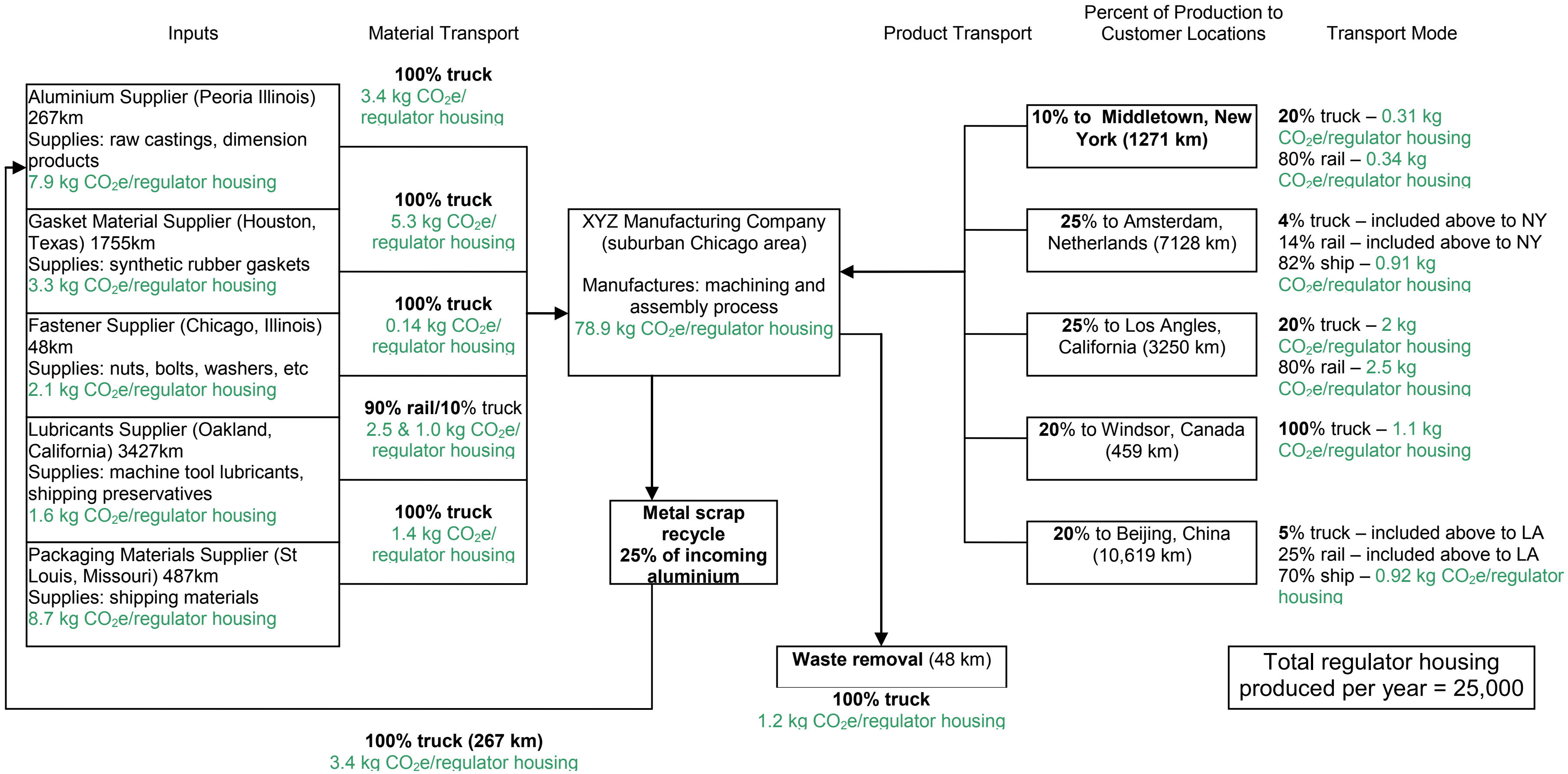
An example of how this approach may be applied is outlined in **Figure 9-1** and **Figure 9-2.**

Table 9-2: Criteria to Evaluate the Data Quality Indicators

Score	Representiveness to the process in terms of:				
	Technology	**Time**	**Geography**	**Completeness**	**Precision (used for direct measurement data only)**
4 (Very Good)	Data from enterprises, processes and materials that are part of the product account	Data with less than 3 years of difference to the product account	Data from the area relevant to the product account	Representative data from all relevant sites over an adequate time period to even out normal fluctuations	Data has less than ±5 percent standard deviation for large emissions sources
3 (Good)	Data on processes and materials from the product account but from different enterprise	Data with less than 6 years of difference to the product account	Average data from a larger area but includes the area relevant to the product account	Representative data from more than 50 percent of sites for an adequate time period to even out normal fluctuations	Data has less than ±20 percent standard deviation for large emissions sources
2 (Fair)	Data on processes and materials from the product account but with different technology OR related processes and materials and same technology	Data with less than 10 years of difference to the product account	Data from an area smaller that that relevant to a product account	Representative data from less than 50 percent of sites for an adequate time period to even out normal fluctuations OR more than 50 percent of site but for shorter time period	Data has less than ±50 percent standard deviation for large emissions sources
1 (Poor)	Data on related processes and materials to those in the product account but different technology OR data where technology is unknown	Data with more than 10 years of difference to the product account OR the age of the data is unknown	Data from an area that has slightly similar production conditions to that relevant to the product account OR area that data relates to is unknown	Representative data from less than 50 percent of sites for shorter time period OR representativeness is unknown	Data has more than ±50 percent standard deviation for large emissions sources

Adapted from Weidema and Wesnaes (1996).

Figure 9-1: Applying a qualitative data quality assessment for the manufacture of aluminum and cast iron regulator housings for use with natural gas combustion equipment



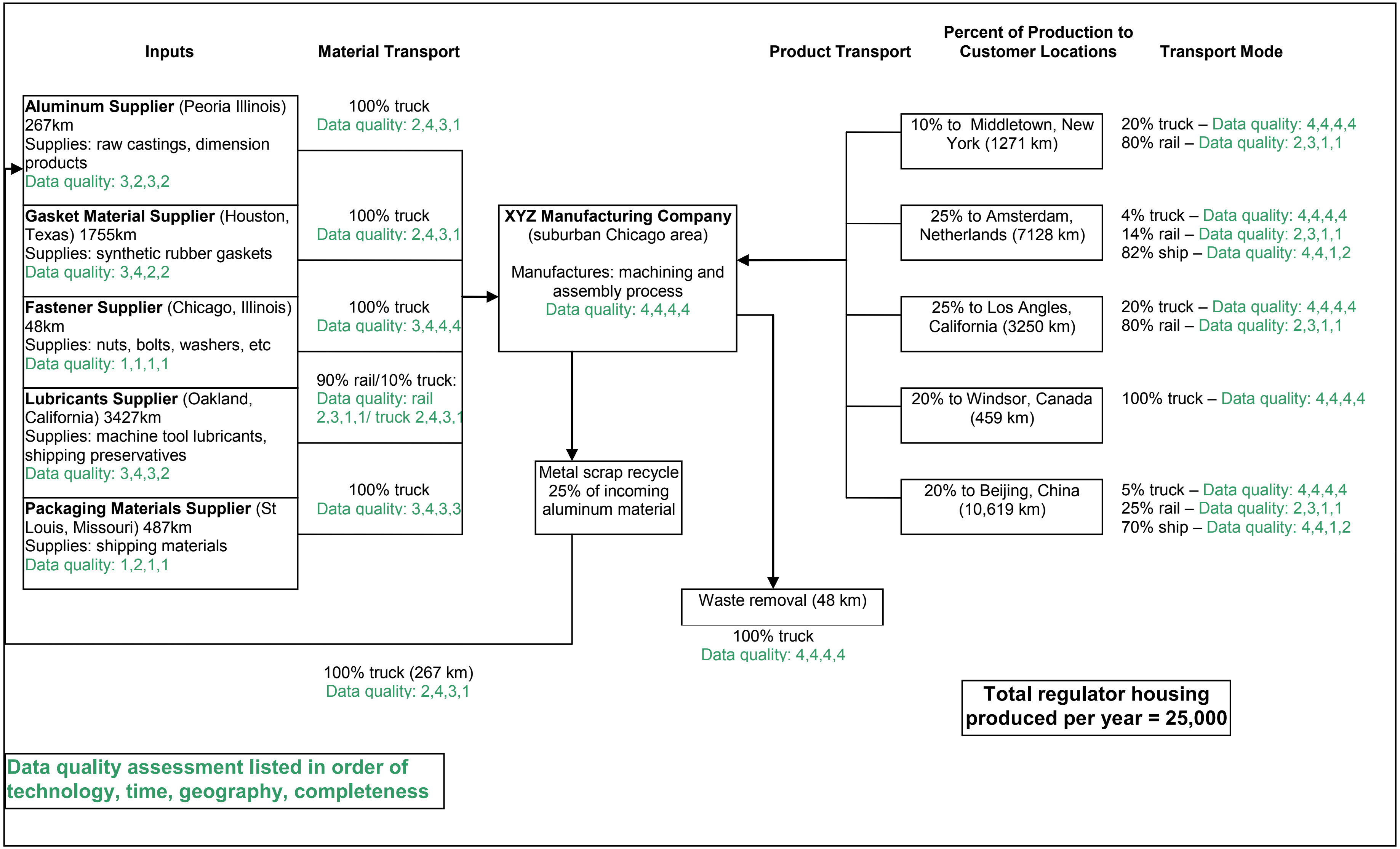
GHG emissions from aggregated sources:

Total supplier GHG emissions = 23.6 kg CO2e/regulator housing
Total supply chain transport GHG emissions = 13.74 kg CO2e/regulator housing
Total manufacturing GHG emissions = 78.9 kg CO2e/regulator housing
Total waste GHG emissions = 4.6 kg CO2e/regulator housing
Total distribution GHG emissions = 8.08 kg CO2e/regulator housing
Total GHG emissions/regulator housing produced = 128.92 kg CO2e/regulator housing

Percent of data derived from data quantification methods:

Directly measured process specific GHG emissions = 18%
Activity data * emissions factors from secondary process data = 82%

Figure 9-2: Applying a qualitative data quality assessment for the manufacture of aluminum and cast iron regulator housings for use with natural gas combustion equipment.



9.2.3. Assessing Uncertainty *(to be further developed)*

Uncertainty is a measure of the knowledge of the magnitude of a parameter. Uncertainty may be reduced by research, i.e., the parameter value is refined. Uncertainty is quantified as a distribution. For example the volume of a lake may be estimated from its surface area and an average depth. This estimate can be refined by measurement. For example, conversion factors used to calculate CO_2e emissions may be uncertain (modeling uncertainty).

Sources of uncertainty

Approaches to assess uncertainty

Variance, a term often confused with uncertainty, is a measure of the heterogeneity of a landscape parameter or the inherent variability in a chemical property. Variance cannot be reduced by further research. It is quantified as a distribution. For example, the organic carbon content of the soil in a region may vary, even over short distances. The soil is not homogenous and thus the organic carbon content is described with a distribution of values. For example, the energy inputs needed to produce wheat may vary depending on soil type, climate etc.

9.2.4. Interpreting data quality and uncertainty *(to be further developed)*

Evaluating data quality and uncertainty is useful to both the generators and users of data. Opportunities for improvement may be identified for those foreground processes and corresponding input and output flows and significant background process where all or some data are assigned low data quality scores.

For example, the data from the packaging suppliers in **Figure 9-1** and **Figure 9-2** scored poorly in terms of temporal and geographic representativeness and completeness. This indicates to the data generator where they should focus efforts to improve the data. Any steps to improve data quality should focus on the larger emissions sources first. For the data user, it indicates where they may use data with confidence and where they may like to undertake sensitivity or scenario analysis to assess the impact of poor quality or uncertain data on the final product inventory.

9.2.5. Improving data quality

Data quality indicators should be used in an iterative fashion to improve the overall quality of a product account.

Step 1: Identify the appropriate time period, geography and technology for the data to be collected.

> Identifying the time, area and technology should be the first consideration when developing and collecting data for a product inventory. If data comes from governmental agencies any delay in publishing data should be considered.

Step 2: Assess data quality, uncertainty and variability

> For the data collected, assess the quality and level of uncertainty and variability of the data of foreground processes, foreground input and output flows and significant background processes that correspond to the outlined standards.

Step 3: Assess impact of low quality and/or uncertain data

Using the data quality and uncertainty assessment, highlight any data whose quality could be improved and where this may have a material impact on the product inventory. Sensitivity or scenario analysis should be used to establish likely materiality (see section below – *under development*). The thresholds used to determine a material threshold should be documented.

Step 4: Update and adjust data sources

Either document the use of low quality or highly uncertain data for improvements in future product inventories or try to source better data for the current product inventory. Improved data may come from different secondary data sources or from improved internal data collection procedures for those processes controlled by the reporting company.

Sensitivity Analysis (to be completed)

10. Calculating GHG Emissions

10.1. Requirements

To calculate carbon dioxide equivalents (CO_2e) of all non-CO_2 gases (CH_4, N_2O, SF_6, HFCs, CFCs) the company shall use and report the most recent 100-year IPCC global warming potentials (GWP). The 100–year GWP is a metric used to describe the time-integrated radiative characteristics of well mixed greenhouse gases over a 100-year time horizon. GWPs represent the combined effect of the differing times GHGs remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation (IPCC). Although other time horizons are available (IPCC publishes 20 and 500-year GWPs), 100 years is the widely accepted time horizon adopted by UNFCCC in the Kyoto Protocol.

The total GHG emissions for a product inventory shall be calculated as the sum of GHG emissions, in CO_2e, of all foreground processes and significant background processes within the system boundary.

10.2. Guidance

10.2.1. Converting non-CO_2 gases to CO_2e

Total product emissions are calculated by summing the GHG emissions from each process in the foreground, foreground input and output flow and significant background process. The emissions from the individual process are likely to be a mix of measured emissions and emissions derived from multiplying activity data by an emissions factor, and may have different metrics (e.g., kilograms and tones of CO_2e, kilograms of CO2, N_2O or CH_4).

The emissions from each process should be converted to a common unit before they are summed (i.e. kilograms of CO_2e per defined functional unit).

10.2.2. Quantifying emissions

For each process the GHG emissions are quantified by either:

a) directly measuring emissions from specific processes
b) disaggregating site-specific aggregated data to the product level
c) multiplying site and process specific activity data by an emissions factor
d) using secondary data only (e.g. for use phase emissions)

Once the GHG emissions for each process have been quantified, it is generally more straightforward to then convert all non-CO_2 emissions to CO_2e before calculating total product inventory GHG emissions. If there are any differences in the unit used to quantity GHG emissions, then emissions should be converted to a consistent per unit basis or metric. For example, in the product inventory for a bottle of wine some processes may have been quantified on a 'per tonne of grapes' basis or 'a per bottle of wine' basis. Therefore, all metrics would be converted to a bottle of wine basis. The common basis or metric should reflect the functional unit/product identified for the product inventory.

Once emissions from all foreground processes and significant background process are in CO_2e and are based on a common metric, then the total GHG emissions are then calculated by adding the emissions from all GHG sources together.

The following emission sources should not be included in the quantification of emissions:

- Emission credits due to the storage of carbon in a product
- Biogenic carbon emissions due to the combustion of renewable bio-based materials
- Purchased Offsets

- Avoided emissions due to consequential modeling assumptions
- Allocation of emissions due to recycling that cannot be justified or proved (i.e. assuming a product may be recycled when no recycling data exists)

Carbon storage and biogenic carbon emissions due to combustion should be reported separately from the inventory results in the summary report (as defined in **Chapter 12**). All other sources may be reported in the detailed report as optional information if it is clearly stated that the calculation of these emissions were not in conformance with the GHG Protocol Standard.

10.2.3. Additional Guidance on Collecting and Calculating Data

Guidance on collecting and calculating data for land use and land use change, capital goods, and electricity emissions are include in **Appendix B**.

11. Assurance

11.1. Introduction

Performing assurance around the calculation of a product GHG inventory supports the goals of providing confidence to users that the reported information is fairly stated and the business goals outlined in **Chapter 1.** In this standard, the term assurance is used in place of the term verification, which is used in Chapter 10 of the GHG Protocol Corporate Accounting and Reporting Standard. It is the recommendation of experts in the area that assurance is a more accurate representation of this activity.

The purpose of this chapter is to:

1. Establish requirements for the type of assurance that shall be performed and presented alongside the product GHG inventory in order for a company to demonstrate compliance with this standard; and
2. Provide guidance on the key aspects of obtaining such assurance.

Assurance is when an assurance provider expresses a conclusion designed to enhance the degree of confidence of the intended users (other than the preparer of the product GHG inventory report) over the measurement of the product GHG inventory against defined criteria. The defined criteria should include all required elements of this Standard and the relevant optional elements.

Assurance is an objective assessment of the accuracy, completeness and presentation of a reported product GHG inventory and the conformity of the product GHG inventory to the Standard[15]. Although assurance of product GHG inventory is still evolving, the emergence of reporting and assurance standards, such as ISO14064, Part 3; ISO14065; PAS 2050: 2008 and this Standard[16], should help product GHG inventory reporting become more consistent and credible, with assurance becoming more accessible and widely understood.

Assurance involves an assessment of the risks of material discrepancies in reported data. Such discrepancies relate to differences between reported data and data generated from the proper application of the Standard. In practice, assurance involves the prioritization of effort by the assurance provider towards the higher risk areas that have the greatest impact on overall accuracy, completeness and presentation. However, an assurance provider cannot provide *absolute* assurance because there are inherent limitations that affect the assurance provider's ability to detect material discrepancies. These limitations result from factors such as the assurance provider testing less than 100% of inputs to the product GHG inventory, and the fact that most assurance evidence is persuasive, rather than conclusive. Rather, the assurance provider provides 'reasonable assurance' or 'limited assurance', depending on the nature and extent of the assurance provider's work.

The categories of risks related to potential errors, omissions and misrepresentation that are considered by assurance providers are:

- Inherent Risk: susceptibility of data to material misstatement, assuming there are no related internal controls

[15] Assurance is based on an assertion by management that their report is prepared in line with applicable criteria (refer to section 1.3.4 for further information on criteria). In representing that their product GHG inventory is in accordance with applicable criteria, management implicitly or explicitly make an assertion regarding the quantification, presentation and disclosure of the inventory. Assertions provide the assurance provider with a framework that can be used when identifying the risks of material misstatement and gathering engagement evidence in response to identified risks.
[16] Refer to the Appendix for more information on these standards

- Control Risk: the risk that a material misstatement could occur and not be prevented or detected on a timely basis by the entity's internal controls. This risk is a function of the effectiveness of the design and operation of internal control in achieving the entity's objectives relevant to the product GHG inventory. Some control risk may always exist because of the inherent limitations of internal controls.
- Detection Risk: the risk that the assurance provider may not detect a material misstatement that exists in a product GHG inventory. This risk is a function of the effectiveness of the procedures performed. It arises partly from uncertainties that exist when less than 100% of the data is examined.

The process of developing an assurable product GHG inventory is largely the same as that for obtaining reliable and defensible data; i.e., designing and implementing adequate processes and controls to support the obtaining of reliable data and documenting the approach and methodologies used to allow appropriate interpretation of the product GHG inventory. Therefore, whilst this chapter should provide insight to the assurance process and where an assurance provider is likely to focus their procedures, it does not negate the need for companies to make a good faith effort to provide a complete and accurate product GHG inventory.

Level of assurance

The level of assurance refers to the degree of confidence the intended user of the assurance conclusion may gain from the outcome of the assurance evaluation. The level of confidence that may be gained is provided in the wording of the assurance conclusion, which reflects the conclusion the assurance provider reaches based on the reduction of the assurance risk. Assurance engagement risk is the risk that the practitioner expresses an inappropriate conclusion when the subject matter information is materially misstated.

There are 2 levels of assurance:

Assurance opinion	Limited	Reasonable
Nature of opinion	Negative opinion given – moderate assurance	Positive opinion given - high assurance
Example of report wording	'Based on the results of our procedures nothing has come to our attention that indicates that management's product GHG inventory report/ assertion is not fairly stated, in all material respects is accordance with the defined criteria.'	'In our opinion, management's product GHG inventory report/ assertion is fairly stated, in all material respects, in accordance with the defined criteria.'

The level of assurance required should dictate the amount of evidence required. An assurance provider should only provide confirmation to a reasonable assurance level, never absolute as 100% of inputs to the product GHG inventory are not tested.

The objective of a limited assurance engagement is a reduction in assurance engagement risk to a level that is acceptable in the circumstances of the engagement, but where the risk is greater than for a reasonable assurance engagement. The assurance provider expresses their opinion in a negative form – "From what we have looked at, nothing has come to our attention". The opinion is negative as it is restricted to the specific areas assured and doesn't state that the information is free from material misstatement but that the assurance procedures performed have highlighted no errors.

The objective of a reasonable assurance engagement is a reduction in assurance engagement risk to an acceptably low level in the circumstances of the engagement. The assurance provider expresses their opinion in a positive form – 'is free from material misstatement'. Reasonable assurance gives a high, but not absolute, level of assurance, expressed positively in the assurance report as reasonable assurance, that the product GHG inventory is free from material misstatement.

11.2. Requirements

In order to state compliance with the Standard, the product GHG inventory shall be assured.

The following types of assurance are permissible:

- First Party ("Self" or "Internal") assurance – Persons from within the organization but independent of the product GHG inventory determination process, conduct first party internal assurance;

- Third Party ("External") assurance – Persons from a certification or assurance body independent of the product GHG inventory determination process, conduct independent third party external assurance.

Assurance providers, whether internal or external to the organization[17], shall be sufficiently independent of any involvement in the determination of the product GHG inventory or development of any declaration and have no conflicts of interests resulting from their position in the organization, such that they exercise objective and impartial judgment.

The assurance opinion shall be expressed in the form of either reasonable assurance or limited assurance[18].

When reporting a product GHG inventory, the assurance opinion shall also be presented, including or accompanied by a clear statement identifying whether First or Third Party assurance has been obtained.

Where internal assurance providers are used, their relevant competencies and reasons for selecting them as assurance providers shall be disclosed in the product GHG inventory report or assurance statement.

11.3. Guidance

11.3.1. Objectives of assurance

For the company seeking assurance

Before commissioning assurance, a company should clearly define its objectives and decide whether they are best met by internal or external assurance. Common reasons for undertaking assurance include:

- Increased credibility of a publicly reported product GHG inventory and progress towards reduction targets, leading to enhanced stakeholder trust, particularly for consumers
- Increased senior management confidence in reported information on which to base investment and target setting decisions
- Improvement of internal accounting and reporting practices (e.g., calculation, recording and internal reporting systems, and the application of product GHG inventory accounting and reporting principles), and facilitating learning and knowledge transfer within the company
- Preparation for mandatory assurance requirements of product GHG inventory programs.

For the assurance providers

[17] Although either of the above types of assurance are permitted, benefits of external assurance are outlined in the guidance section.

[18] At the time of writing, reasonable assurance is not widely provided for GHG reporting (this is the case for both corporate and product GHG inventories). This is largely due to immature controls around GHG data that often results in the time requirement and hence cost of a reasonable assurance engagement being prohibitive. However, over time and as controls improve, it is expected that reasonable assurance will become more, commonplace.

When conducting an assurance engagement over a product GHG inventory the objective of the assurance provider is:

- To obtain reasonable assurance about whether the product GHG inventory as a whole is free from material misstatement; or
- To obtain limited assurance that nothing has come to their attention that causes them to believe that the product GHG inventory is materially misstated; and
- To report on the product GHG inventory in the form of an assurance opinion, in accordance with their findings and the level of assurance they have been engaged to provide.

11.3.2. Timing of the assurance

The engagement of an assurance provider may occur at various points during the product GHG inventory preparation and reporting process. Some companies may establish a semi-permanent internal assurance team to facilitate that product GHG inventory data standards are being met and improved on an on-going basis.

Assurance procedures that occur during a reporting period allows for any reporting deficiencies or data issues to be addressed before the final fieldwork is carried out. This may be particularly useful for companies preparing high profile public reports. However, companies should be aware that:

- some procedures may only be performed when the final product GHG inventory has been prepared; and
- the related assurance on the final product GHG inventory shall be completed before conformity with the Standard is confirmed.

11.3.3. Selecting an assurance provider

An assurance provider, whether internal or external, should apply the principles listed in

Box 11-1. While assurance is often undertaken by an independent, external assurance provider this need not be the case. Many companies interested in improving their product GHG inventory may subject their information to internal assurance. In this case, the personnel should at least be independent of those undertaking the product GHG inventory accounting and reporting process. Both internal and external assurance should follow similar procedures and processes. For external stakeholders, external assurance is likely to significantly increase the credibility of the product GHG inventory. However, internal assurance may also provide valuable assurance over the reliability of information and may be a worthwhile learning experience for a company prior to commissioning external assurance. It may also provide external assurance providers with useful information. Consequently, the use of external assurance as a final step is a decision at the discretion of the company.

A credible and competent product GHG inventory assurance provider has:

- Deep assurance expertise and proven previous experience and competence in undertaking assurance engagements under recognized assurance frameworks. This includes making objective judgments on fact based material issues, assessing the quality of data and the application of product GHG inventory methodology rules;
- Robust assurance methodologies including the ability to assure data and information systems;
- Ability to assess the sources and the magnitude of potential errors, omissions and misrepresentations for further assurance activities;
- Knowledge of the company's activities, industry sector and products and understanding of product GHG inventory principles, methodologies and limitations, including (but not limited to) knowledge of product life cycle, scope, unit of analysis (functional unit), system boundary, allocation, and calculation methodologies including LCA software (e.g. databases and modeling software); and
- Objectivity, impartiality, credibility, independence and professional skepticism to challenge data and information.

External assurance

There are several standards, accreditation schemes and frameworks in place to assist companies in selecting a credible and competent external assurance provider. For example:

- Various accreditation schemes are currently available to GHG assurance providers world-wide, particularly for regulated schemes, for example UKETS, EUETS, CDM/JI. Typically, these accreditations are against the requirements established in ISO 14065. Accreditation to ISO 14065 indicates that the organization performing the assurance has been independently tested against specified criteria (including competence) by a recognized and authorized body (although the company engaging the assurance provider may wish to ensure that the scope accreditation covers their specific requirements).
- Professional, registered auditors in public practice are required to comply with ISAE 3000, the International Framework for Assurance Engagements, the Quality Control Standard ISQC1 and other ethical requirements. Assurance provided under these standards also gives high credibility to the assurance provider.

This standard does not require assurance providers to be accredited under any scheme and it is left to the discretion of the organization intending to obtain assurance over their product GHG inventory to identify the most appropriate assurance provider for their circumstances. All credible assurance practitioners should follow the principles established in recognized standards, such as ISAE 3000 or ISO 14065, and be able to demonstrate this to their clients.

When choosing their assurance provider, companies should consider the knowledge and qualifications of the individual(s) conducting the assurance as well as broader experience and/or accreditation of the organization they represent. Effective assurance of product GHG inventories often requires a mix of specialized skills, not only at a technical level (e.g., engineering expertise and product life cycle specialists) but also at a business level (e.g., assurance, industrial sector and information system specialists). This includes at least one member of the assurance team having sufficient knowledge, understanding and experience of life cycle analysis sufficient to be able to objectively assess the suitability of the criteria.

Companies may also wish to ensure that the lead assurance provider assigned to them is appropriately qualified and experienced. The lead assurance provider should have the ability and experience to manage an engagement including planning, managing risk, assurance execution, objective judgment and drawing appropriate conclusions.

Advantages to a company of engaging an external credible and competent assurance provider include:

- Confidence that the independence, impartiality, integrity, management and competence of personnel employed by the assurance provider are scrutinized by an independent body against established standards or requirements;
- Increased credibility over reported product GHG inventories;
- Improved management confidence in reported information on which to base strategic, investment and reduction target decisions; and
- Enhanced stakeholder confidence when making investment and/or purchasing decisions.

Internal assurance

If using an internal assurance provider, companies should seek a suitable independent team who demonstrate the most relevant experience for the task. The guidance above relating to external assurance providers should be a useful aid in identifying the appropriate skills. For example, employees within internal audit who have a scientific background and/or experience with corporate GHG inventories may be considered suitable or site engineers experienced with environmental site assessment audits.

Box 11-1: Principles for Assurance Providers

Competency and due care
Personnel have the necessary skills, experience, supporting infrastructure and capacity to effectively complete validation or assurance activities.

Confidentiality
Confidential information obtained or created during assurance activities is safeguarded and not inappropriately disclosed.

Impartiality
Decisions are based on objective evidence obtained through the assurance process and not influenced by other interests or parties.

Integrity
Integrity is a prerequisite for all those who act in the public interest. It is essential that assurance providers act, and are seen to act, with integrity, which requires not only honesty but a broad range of related qualities such as fairness, candor, courage, intellectual honesty and confidentiality. Integrity includes assessing and, if appropriate, disclosing whether any conflicts of interest arise should an assurance provider take on a product GHG inventory engagement.

Objectivity
Objectivity is the state of mind which has regard to all considerations relevant to the task in hand but no other. It is sometimes described as 'independence of mind'. The assurance opinion is based on evidence collected through an objective assessment of the product GHG inventory.

11.3.4. Establishing assurance parameters

The scope of assurance and the level of assurance it provides may be influenced by the company's wider goals and/or any specific jurisdictional requirements. It is possible to assure the entire product GHG inventory or specific parts of it, although the assurance providers should need to satisfy themselves that assurance over a part of a product GHG inventory is meaningful to the user, e.g. assurance over a cradle-to-gate assessment would be meaningful to a business customer. The assurance process may also examine more general managerial issues, such as quality management procedures, managerial oversight, data processes and controls, knowledge and experience of personnel, clearly defined responsibilities, segregation of duties and internal review procedures.

The company and assurance provider should reach agreement on the level of assurance required: reasonable assurance, or limited assurance.

Where an assurance provider external to the company is used, the terms of the engagement should be agreed in a contract in advance (before the commencement of the assurance procedures). This contract confirms the intended use of the assurance opinion. It is also important that the respective responsibilities of management of the company and the assurance provider are clearly defined and understood.

The company is responsible for determining the assurance criteria, and for establishing policies and procedures to measure, record and report the product GHG inventory in accordance with those criteria. The assurance provider's responsibility is to form an independent opinion, based on their assurance procedures, on whether the product GHG inventory is fairly stated in accordance with the criteria, to the extent of the level of assurance sought. Because the assurance provider is required to be independent, they should have no involvement in setting the criteria, establishing processes in relation to, or executing any part of, the product GHG inventory.

Clearly defined criteria are not only important to the company and assurance provider, but also for external stakeholders to be able to make informed and appropriate decisions. Criteria communicate the basis of preparation used to measure the product GHG inventory, similar to the general information and study information given in Summary Reporting template (**Table 12-1**) in **Chapter 12**. Criteria are required as a frame of reference to achieve consistency in interpretation and understanding of the assurance opinion. It is for this reason that criteria need to be made available to all users of the assurance report.

Assurance providers should assess the suitability of the criteria and in doing so should assess whether:

- all Standard requirements are included
- the product system, boundaries and functional unit are clearly defined
- assumptions and estimations made are appropriate in the circumstances
- selection of primary and secondary data is appropriate and methodologies used are adequately disclosed (with references to external sources where applicable)
- the attributional approach is used (unless sector-specific guidance is sited)
- exclusions are reasonable in the context of the whole.

11.3.5. The concept of materiality

Information is considered to be material if, by its inclusion or exclusion, it may be seen to influence decisions or actions taken by users of it. A **material discrepancy** is an error (for example, from an oversight, omission, miscalculation or fraud) that results in a reported quantity or statement being sufficiently different from the true value or meaning to influence a user's decisions. In order to express an opinion on management's report/ assertion over the data or information, an assurance provider needs to form a view on the materiality of identified errors or uncertainties, individually and in aggregate. While the concept of materiality involves professional judgment and includes consideration of both quantitative and qualitative aspects, the point at which a discrepancy becomes material (**materiality threshold**) is usually pre-defined. As a rule of thumb, it may be considered that an error is materially misleading if its value exceeds 5% of the total product GHG inventory being assured. However, such a threshold does not negate the principle of completeness and companies need to make a good faith effort to report a complete and accurate product GHG inventory. For cases where emissions have not been estimated, or estimated at an insufficient level of quality, it is important that this is transparently documented and justified.

Consequently, assurance providers may adjust this materiality threshold during the course of their procedures if, for example, omissions are identified. Note - A materiality threshold is not the same as "de minimus" emissions, or a permissible quantity of emissions that a company may leave out of a product GHG inventory.

Materiality is used by the assurance provider during the planning process and then again in evaluating the evidence obtained:

Planning: The concept of materiality is used when designing the assurance approach and sampling plans. A materiality threshold provides guidance to assurance providers on what may be an immaterial discrepancy so that they concentrate their work on areas that are more likely to lead to materially misleading errors.

Evaluation: The concept of materiality is also used to assess whether errors and omissions identified during the course of the assurance process that, if uncorrected or omitted, would significantly misrepresent a product GHG inventory to intended users, thereby inappropriately influencing their conclusions or decisions.

Understanding how assurance providers apply a materiality threshold should enable companies to more readily establish whether any errors in their product GHG inventory are likely to raise questions of materiality. Materiality thresholds may also be outlined in the requirements of a specific product GHG inventory program or determined by an assurance standard, depending on who requires the assurance and for what reason.

Box 11-2: Understanding Qualitative Aspects of Materiality

An assurance provider can be expected to assess errors within the full context of what is being assured and what a user may consider material, for example:

- where a company has a reduction target to reduce a product's GHG inventory by a set amount or percentage. Clearly, if the company's target is a 5% reduction, then the materiality threshold should be set at such a level to enable them to conclude whether or not this has been achieved; or
- where a regulatory environment requires reduction by a certain amount. A material error would include those that may be small in isolation but would mean the difference between compliance and non-compliance.

Assessing the risk of material discrepancy

Assurance providers need to assess the risk of material discrepancy for each component of the product GHG inventory information collection, calculation and reporting process. This assessment is used to plan and direct the assurance process. In assessing this risk, they should consider a number of factors, including:

- Complexity and nature of the product GHG inventory
- The technical knowledge and expertise of the person(s) compiling the product GHG inventory
- The structure of the organization and the approach used to assign responsibility for the collection, calculation and reporting processes associated with product GHG inventories
- The approach and commitment of management to the collection, calculation and reporting processes associated with product GHG inventories
- Development and implementation of policies, processes, controls and procedures for collection, calculation and reporting (including documented methods explaining how data is generated and evaluated)
- Processes, controls and procedures used to check and review calculation methodologies
- Complexity and reliability of the computer information system used to process the information
- The state of calibration and maintenance of meters, and the types of meters used
- The defined system boundary for the product or supply chain
- The allocation methodology and assumptions made
- Reliability and availability of input data, including primary and secondary
- The nature of assumptions and estimations used
- Aggregation of data from different sources
- The extent to which reduction and/or competitive claims are made over the product GHG inventory
- Other assurance processes to which the systems and data are subjected (e.g., internal audit, external reviews and certifications).

11.3.6. Preparing for Product GHG Inventory assurance

General preparation

Irrespective of whether the assurance provider is internal or external, assurance providers' needs are similar. The presence of a transparent, well-documented system (referred to as an audit trail) is crucial for the achievement of assurance. Assurance providers should require access to significantly more detailed information than that established for the minimum reporting requirements (**Chapter 12**). Sufficient and appropriate evidence needs to be available to support the product GHG inventory subject to assurance, i.e. the assurance provider should need to see evidence that supports the inputs to the calculation, supporting justification for assumptions made etc. The evidence should be sufficient to demonstrate consistent application of the criteria. Information required by the assurance provider may include (but not be limited to) the following:

- Information about the company, its structure, geographic location main activities and controls culture and environment
- Details of the product system and criteria
- Documented processes or procedures for identifying sources of GHG emissions for the product GHG inventory within the company and along the supply chain
- Changes since any previous assurance to the system boundaries, processes, assumptions, data sources or other elements that affect the product GHG inventory
- Information on other assurance processes to which the systems and data are subjected (e.g. internal audit, external reviews, assurance over part of the supply chain and/or certifications)
- Both primary and secondary data and evidence used for calculating product GHG inventory emissions. This might, for example, include:
    - Energy consumption data (e.g. invoices, meter readings: electricity, natural gas , steam, and hot water.)
    - Production data (e.g. grams of material produced, kWh of electricity produced)
    - Raw material consumption data for mass balance calculations (e.g. invoices, delivery notes, weighbridge tickets)
    - Emission factors used and their respective sources
- Description of how product GHG inventory emissions data has been calculated:
    - Emission factors and other parameters used and their justification
    - Assumptions on which estimations are based
    - Information on the measurement accuracy of meters and weighbridges etc., (e.g., calibration records), and other measurement techniques
    - Documentation on what, if any, product GHG inventory sources or activities are excluded due to, for example, technical or cost reasons
- Information gathering process:
    - Description of the procedures, systems and controls used in collecting, documenting, processing and collating product GHG inventory emissions data
    - Description of quality control procedures applied (e.g. internal audits, comparison with previous years' data, peer calculation or review)
- Other information:
    - List of (and access to) persons responsible for collecting product GHG inventory emissions data at each site, at corporate level and suppliers
    - Information on uncertainties, qualitative and if available, quantitative.

A company, particularly where they have not yet implemented systems and controls for routinely accounting and recording product GHG inventory emissions data, may wish to obtain a pre-assurance assessment from the assurance provider as to whether their processes and controls are sufficiently robust for assurance. Under these circumstances, assurance providers may make recommendations on how current measurement, data collection and collation procedures and controls can be improved to enable an assurance engagement to commence.

Companies are responsible for ensuring the existence, quality and retention of documentation so as to create an audit trail of how the product GHG inventory was compiled. Companies should be mindful of this when designing and implementing product GHG inventory data processes and procedures.

Site / supply chain visits

Assurance providers may need to visit a number of sites/supply chain organizations to enable them to obtain sufficient, appropriate evidence in order to form a conclusion over the product GHG inventory. The sites / supply chain organizations visited may be selected on the basis of their proportional importance in the context of the whole product GHG inventory. The selection of sites / supply chain organizations to be visited should be based on consideration of a number of factors, which may include the:

- nature of the product/service
- nature of the life cycle and product GHG inventory emission sources at each site/supply chain organization
- complexity of the emissions data collection and calculation procedures
- percentage contribution to total product GHG inventory emissions from each site / supply chain organization
- risk that the data from sites / supply chain organizations may be materially misstated
- competencies and training of key personnel
- adequacy and quality of evidence supplied remotely (e.g. electronically or by post); and
- results of previous reviews, assurance, and uncertainty analyses.

It is in the interests of the company to retain evidence used in calculating their product GHG inventory, whether relating to their own operations or those of others in their supply chain, for inspection by the assurance providers. Companies should ensure they obtain and retain sufficient evidence to support the accuracy of data and reasonableness of assumptions, judgments and estimations. Where visits to other sites in the supply chain may be necessary, companies may wish to include a clause allowing access for assurance providers in their contracts. The retention of adequate supply chain documentation may help to minimize visits required by assurance providers to other organizations' sites. However, it would be unusual, regardless of the level of assurance sought, for site visits to the reporting company not to be made.

Automated processes
LCA software is often used in supply chain and product GHG inventory calculations and may be the only realistic option available to the company on the basis of, for example, cost, data availability, and time. Depending on inherent risk and the level of assurance sought, assurance providers may deem it appropriate to perform some procedures on the LCA software itself. Indeed, this may be the most efficient way of obtaining sufficient comfort for the level of assurance sought.

In addition to procedures over the data analysis tools within the system, an assurance provider may perform procedures over the existence and operating effectiveness of system controls such as:

- Access controls: The system should be password protected and allow users to have different levels of access depending on their role.
- Segregation of duties: In a strong control environment, the system may be used to ensure segregation of duties is maintained.
- User log and edit tracking: The system should record when data changes have been made and by whom.
- Data protection and back-up: Sufficient controls should be in place over data protection and data back-up.
- Change management: any updates (bespoke or otherwise) to the system should be tracked, tested and approved prior to introduction into the live system.
- System interfaces: if data is moving between the LCA software and other systems, controls should be in place to validate the completeness and accuracy of the transfer.

11.3.7. Using the assurance findings

Before assurance providers issue their opinion, they are expected to share their significant findings with the company. This should include any material discrepancies they have identified, both discrepancies that are individually material and those that are material when considered in aggregate. This provides an opportunity to adjust the product GHG inventory to eliminate the material discrepancies. If the assurance providers and the company do not come to an agreement regarding adjustments, then an unqualified ("clean") assurance opinion may not be appropriate. In these circumstances a qualified opinion, expressing the nature of the material discrepancy may be issued.

As well as issuing an assurance opinion the assurance providers may, depending on the terms of their engagement, also issue a report to management containing recommendations for future improvements, e.g. where their measurement methodologies may be refined and/or their procedures and controls relating to the measurement methodologies may be improved. The process of assurance may therefore be viewed as a valuable input to the process of continual improvement in GHG emission measurement and reduction. Whether assurance is undertaken for the purposes of internal review, public reporting or to certify conformance with a particular product GHG inventory program, it should likely contain useful information and guidance on how to improve and enhance a company's product GHG inventory accounting and reporting system.

Similar to the process of selecting an assurance provider, those selected to be responsible for assessing and implementing responses to the assurance findings should also have the appropriate skills and understanding of product GHG inventory accounting and reporting issues.

12. Reporting

12.1. Requirements

A company shall publicly disclose the GHG inventory in the form of both a summary and detailed report. Both reports shall be disclosed together and be easily accessible by the public. Neither report shall be disclosed separately without reference to the other report. The summary report identifies key information and results, while the detailed report contains more information about the methodological assumptions and data used to calculate the inventory.

12.1.1. Summary Report

A company shall publicly disclose a summary report that includes an introduction to the inventory, the process map of the studied product, a summary report template (as shown in **Table 12-1**), and a brief description on how the results should be used (i.e. to facilitate emission reductions). The introduction should give an overview of the inventory and state the goal of public disclosure. To avoid misuse of results, a company shall include a disclaimer to the audience (reader) identifying the difficulties in comparing results and referring the reader to additional information if needed.

Box 12-1: 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 functional unit, use and end-of-life stage assumptions, and data quality may produce incomparable results. The reader is referred to the detailed report for more information on this study, and the GHG Protocol Product Standard for a glossary and additional insight into the GHG inventory process.

Developing a process map is a requirement when a company is setting the boundary for the product system. At a minimum, the reported process map should make clear:

- The flow of a product (and product components) through its life cycle
- The life cycle stages considered in the study
- The general processing steps of a product

Table 12-1: Summary Report Template

Type of Inventory		
Final Product Full GHG Inventory (Cradle to Grave) OR Intermediate Product Partial GHG Inventory (Cradle to Gate)		
General Information		
Parameter	*Description [Template Notes]*	
Company Name and Contact Information		
Product Name	[Material Product or Service, Brand Name if applicable]	
Product Description	[Brief product description including whether it is a final or intermediate product]	
Functional Unit (study basis)	[For Cradle-to-gate assessments, the boundary of the functional unit should be clearly stated – see Chapter 4]	
Temporal Boundary	[time span of the product life cycle – see Chapter 6]	
Country/Region of Product Consumption	[for Cradle to Grave assessments]	
Inventory Date and Version	[Year inventory was finalized] [1 if first inventory, 2,3 etc. for future versions]	
Study Results: Total Product GHG Inventory		
Parameter	*Value*	*Unit*
Total GHG Inventory	[Value]	[gram base unit[1] CO_2e per Functional Unit]
Study Results: Percent of Life Cycle Stage		
Stage Name	*Value (Percent of Total CO_2e)*	*Comments*
Raw Material Acquisition & Preprocessing	[Value]	*[Brief description of inclusions and end points for each stage]*
Production		
Distribution & Retail		
Use [2]		
End-of-Life		
Quality Assessment Information		
Assurance Type	[External or Internal, Performed by Whom]	
Assurance Opinion	[Limited or Reasonable]	
Data Quality Assessment	[Percent of total GHG emissions derived using the different quantification methods: • derived from directly measured process-specific GHG emissions • estimated from aggregated directly measured site information • calculated using site and process specific activity data and an emissions factor derived from secondary process data • calculated using site and process specific activity data and an emissions factor derived from input-	

		output data • estimated using only secondary data sources (either process or input-output data)]

[1] Gram shall be the base unit reported with a logical prefix (kg, mg, etc,), as applicable.

The audience of the summary report may be most interested in what the company is doing, or plans to do, to reduce GHG emissions as a result of the inventory. Additionally, the 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 shall provide some explanation on what steps will be taken to reduce emissions based on the inventory results. If this is a subsequent report, a company shall provide an overview of any reductions achieved. This should be brief and highlight key initiatives or results. Examples include:

- An overall reduction target based on the GHG inventory results
- A plan to focus reductions around a few key emission sources
- Information on how users/consumers can reduce key emission sources (i.e., reuse, following manufacturer use instructions, purchasing green power, etc.)
- Overview of reductions based on a previous inventory, highlighting the most effective initiatives

At a minimum, if the company has not determined specific initiatives at the time the report is published, a company should simply report that they will use the results to reduce emissions along the product life cycle and supply chain.

In the following cases additional information may be required in the summary report/template:

- If the use or end-of-life stage includes carbon storage, that shall be reported separately (i.e., should not be included as a credit to either stage)
- If biogenic emissions associated with the combustion of renewable biomass materials occur during the product life cycle, these emissions shall be reported separately from the inventory results
- If a company cannot separate the raw material acquisition & preprocessing stage from the production stage without facing confidentiality issues, they may combine the study results for those stages only. It shall be clearly stated that confidentially issues could not be avoided.
- A company who performs only internal assurance shall include a disclaimer in the summary report stating the following: "The results presented in this report were assured internally and may carry a lower degree of confidence than an independent assurance performed by an external assurance provider".
- If a company performs inventories on several products in the same product class or family using the same functional unit, those results may be presented in a single report. It is important to note that this does not mean several products are considered during one inventory, rather that several inventories may be included in one report. An example includes a manufacturer who produces the same quality of product in different packaging. For this case, the summary template shall include additional comparisons of the included products; **Table 12-2** gives an example of these results.

Table 12-2: Example of Additional Results for a Report Including Several Similar Products

Studied Product	Total Emissions [gram CO_2e per Functional Unit]	Percent impact from Packaging
A	100	5%
B	75	3%
C	150	10%
D	85	4%

A case study, highlighting the use of the summary data template and the other elements of the summary report, is included as guidance in **Section 12.4**).

12.1.2. Detailed Report

A company shall publicly disclose a detailed report that includes the following required elements. The required reporting elements for the detailed report were chosen as a balance between facilitating proper use of inventory results and achieving a practical level of reporting.

Introduction
Following the summary report, a company shall report the following as an introduction to the detailed report:

- Disclosure of any sector specific sources used to influence decisions around methodology, boundary setting, allocation procedures, data use, etc.
- For subsequent inventories, a link to previous inventory reports and description of any methodological changes

Boundary:
The boundary section shall include:

- A more detailed description of the process steps included and excluded than in the summary report (by way of a more detailed process map for example)
- Justification of the temporal boundary assumed (if the 100-year default value is not used)
- For cradle-to-gate inventories, justification as to why a cradle-to-grave inventory was not possible.
- Indication on whether capital goods were included in the product system and if excluded, details on how insignificance was determined

Data and Quantification:
A transparent report of data quality and quantification shall include:

- An overview of the data collection process
    - A data quality summary
    - Databases used and the corresponding processes where this data was used
    - Other data sources used (e.g. literature) and the processes where this data was used
    - A statement on completeness of data (i.e., percentage of proxy and extrapolations used to fill data gaps)
- Key drivers/emission sources that had the largest impact on the inventory

- For all cradle-to-grave inventories, the use profile and end-of-life profile assumptions including the emission factors and their source of each type of energy used during the use and end-of-life stage. The documentation shall include justification for why the selected approach was chosen to define the use and end-of-life profile.

The objective of this section is not to provide a complete list of all data origin and assumptions made (which should be assured and included in the company's data management plan) but rather to provide a summary of most relevant and material information that ultimately have an impact of the results and the quality of the assessment.

Data Allocation and Recycling:
If allocation is necessary as part of data calculations performed under the ownership of the company (i.e. for processes where primary data was required), the company shall report:

- Why allocation could not be avoided
- The allocation method used
- Brief justification as to why that method was most accurate (i.e. based on natural science, following the general accounting principles)

If recycling is included in the end-of-life profile of a product, the company shall report:

- The type of recycling (closed-loop, de-facto closed-loop, open loop)
- Data used to determine recycling rates
- Method used to allocate recycling emissions and a brief justification as to why that method was most accurate

Results

To encourage the communication of results and use of inventory data from business-to-business, cradle-to-grave inventories shall also report the cradle-to-gate and gate-to-gate inventory values. Cradle-to-gate refers to the extraction of the raw materials through to the point of sale to the customer, and gate-to-gate is the emissions of the product when it is under control of the reporting entity, as shown in **Figure 6-2**. If only a cradle-to-gate inventory is performed, a company shall also report a gate-to-gate value. Companies shall clearly define the gates around their own operations. If a company feels they cannot report the emissions of their own operations (gate-to-gate) without jeopardizing confidentiality, a company shall clearly state this limitation in the detailed report.

12.2. Guidance

The overarching goal of producing a GHG inventory in conformance with the GHG Protocol Product Standard is to promote GHG emission reductions through increased public disclosure of product level GHG emissions. Reporting is central to achieving this goal, as well as any specific business goals a company may have for completing a GHG inventory. The specific goals of reporting under the standard are met by communicating the following:

- The absolute inventory of a product, information on the related break-down of the footprint, explicit identification of the product and the scope of the assessment, as supporting information for product differentiation
- Changes to the reported footprint that have occurred over time
- How the footprint might be reduced by organizations responsible for formation and end-of-life processing for the product, and how consumers of the product might reduce the footprint of the product through their actions
- Key points on methodological considerations for a report, and indication of the reliability of the reported figures for consideration by report users and decision makers

When reporting a GHG inventory, it is important to recognize that public disclosure does not mean there is one homogenous audience with a uniform set of requirements. **Table 12-3** lists some distinct audiences of the report, and also identifies the extent to which the needs of these audience types are intended to be addressed by the reporting requirements. This is not an inclusive list as audience types not identified here may still find value in reports produced following the reporting requirements in the Standard.

Table 12-3: Audiences of a Publicly Disclosed GHG Inventory Report

Audience category/role	Audience description	Extent to which audiences needs should be met by the reporting requirements
General public	Lay person. No understanding or prior visibility of LCA/GHG Inventories may be assumed.	Fully
GHG Inventory / LCA practitioner	Practitioner wishing to use the footprint information as input to another study (e.g. direct cradle to gate or B2B, or proxy footprint for similar product)	Fully
Assurance Provider	Assessor performing third-party independent assurance of report	Partial
Report stakeholders	Suppliers, product-owning organization, report-commissioning organization	Partial
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	Partial
Green professional purchasing	Professional purchasing decision-maker seeking differentiation across products	Partial
Environmental/Carbon Labeling Organizations	*(to be developed)*	Partial
Government Agencies	*(to be developed)*	Partial

Considering this, two reports are defined; a summary report to meet the needs of the general public, and a detailed report to meet the needs of a GHG inventory/LCA practitioner. In addition, optional reported elements are included as guidance that a company may find necessary to report to meets the needs of their potential audience type and/or their specific business goals. These elements may be added to the summary or detailed report, depending on which audience may benefit from the additional information. The following list outlines some reporting elements a company may find useful:

- Additional business goals met by performing a GHG inventory (see **Chapter 1**)
- Additional background information on GHG inventories and how they are calculated
- Additional disclaimers around proper use of results
- SKU, NASIC code, UNSPSC code or other unique product/service identifier
- Additional details around why a particular functional unit was chosen
- The country (ies) where the raw material acquisition, production, and distribution stages occur
- A more detailed process map including product components, waste streams, energy flows, co-products, etc.

- Information on data collected from suppliers, including:
    - Percent engagement from supply surveys
    - Data collection techniques and sources
    - Allocation procedures
    - Data gaps
- Description of any known data variability or data uncertainty
- Additionally disaggregation of CO_2e emissions. 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 foreground processes
    - Attributed to product packaging
- If a company purchases offsets, these offsets may be reported **separately** from the inventory results in the detailed report, with a clear statement that offset emissions are not calculated in conformance with the Standard. It is important to note that emission credits from offsets should not be applied directly to the inventory results.
- Additional guidance on how the results should be used (by both the company and the user)
- Detailed reduction plans for future inventories

12.3. GHG assessment as an enabler for GHG reduction (section under development)

A fundamental objective of the GHG Product Protocol is to provide a methodology for calculating emissions in the life cycle of a product not as an end itself, but as an essential step towards enabling carbon reduction. A robust GHG assessment is an essential platform from which a company can identify hotspots and formulate an informed action plan towards mitigation of emissions in the product life cycle.

There are many ways to achieve reduction in product life cycle emissions. The most effective route is determined by a number of different factors particular to the product, the businesses involved in its life cycle and the actions of the consumer or user of the product. The list below presents some of the common options to be explored; there are often synergies or linkages between these options:

– Redesign product to dematerialize content or reduce emissions resulting from use-phase of product
– Redesign processes to be more efficient – fewer material used, less energy used, or less waste generated per unit of product
– Catalyze changes in waste activities towards increased reuse transformation
– Increase service life of our product
– Switch materials consumed in the formation, use and end of life of the product
– Switch to different suppliers – for materials consumed and for energy sources
– Increase content of recyclate for consumed materials
– Made it easier to recycle waste materials or product itself
– Relocate activities to be closer to markets, raw materials, energy sources
– Develop more efficient distribution channels
– Reduced packaging
– Work with our suppliers to implement collaborative emissions reduction

12.3.1. Calculation of GHG reductions

The GHG Product Protocol will ultimately incorporate specific requirements and guidance for the calculation of GHG reductions in product life cycles; this is not complete for this draft version, instead the content below provides as set of essential points to consider for the reduction calculation.

Comparison basis

The GHG Product Protocol provides a framework for calculation of emissions reduction that can be used in many ways – either retrospectively to assess reductions achieved over a period of time, or prospectively to estimate emissions reductions that may be achieved in the future. The reduction calculation framework may also be used in scenario analysis to examine the potential reductions through a variety of mitigations actions.

When to calculate and communicate reduction

To remain in compliance with the GHG Product Protocol a company must - within a two-year period from the last communicated product life cycle emissions - recalculate and report the new emissions inventory.

When reporting a revised GHG emissions inventory companies must also report the reduction achieved in emissions over the time period since the earlier reported inventory; this rule applies in all cases except for those listed below.

- A new emissions result is reported early to correct errors in the previous emissions inventory
- Force majeure – see notes below

How to calculate and communicate reduction – core principles

- For products with annual seasonality in emissions intensity the reduction must be calculated across a period of complete years (1 or 2)
- Where new products replace older obsolete products in the reduction reporting period an emissions reduction can only be communicated when in compliance with "product replacement rules (TBD)"
- Reduction calculations are made by comparing a more recent GHG emissions inventory with a previously published inventory as the baseline
- A previously published inventory may be "re-baselined" in the following situations
    - Errors in the earlier GHG inventory are corrected -> errors must be corrected in both old and new inventory models
    - Improvements have been made in the modeling -> new techniques must be applied retrospectively to old product GHG inventory model
    - Improvement have been made in primary data collection -> new techniques must be applied retrospectively to old product GHG inventory model
    - Improvements have been made in the reference data used within the model -> new reference data must be applied retrospectively to old product GHG inventory model
    - Force majeure – see notes below
- Special notes for changes in supplier/downstream emissions
    - Any reduction within the product life cycle emissions shall be counted towards the overall reduction, even where the reduction is achieved through no influence from the reporting company e.g. reductions from embodied emissions intensity of supplied materials, or reductions in emissions intensity of grid delivered electricity
    - The reverse to the above also applies, increases in GHG emissions for the product life cycle must be incorporated regardless of the cause or source of emissions

12.3.2. Reporting emissions increases

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 may not be used as this may confuse.

What should be reported

The reduction must be reported as a percentage of reduction from the previously reported value, or the new baseline value.

Calculation basis => (Year 2 – Year 1) change as a percentage of Year 1

e.g. Year 1 GHG emissions = 50 kgCO2e per functional unit, Year 2 GHG emissions = 48kgCO2e per functional unit. Reduction = 4%

100 * ((50-48) / 50))

Notes to the reduction may also be included to provide additional explanation of cause of reduction or increase.

Explanation must always be provided for rebaselined inventories; the reasons for rebaselining and the new baseline amount must be reported.

What should not be reported

Companies shall not communicate predicted, planned or committed reductions. Reductions are always reported retrospectively.

Force majeure

Force majeure events may have material impact on a product GHG emissions for the time period they occur within. Where a product's life cycle emissions for a reduction-reporting period have been deleteriously impacted the company can decline to report reduction, but must clearly indicate that reduction has not been calculated and provide explanatory notes on the details of the force-majeure event.

Where force-majeure applies, the company must provide a new emissions inventory and reduction calculation within one year of the report.

12.4. Example Summary Report

The objective of this case study is to provide an illustrative example of a summary report based on a real GHG inventory. This example is meant to illustrate a) the usefulness of fulfilling the reporting requirements and b) the level of effort required. The reported results are derived from the Life Cycle Carbon footprint National Geographic Magazine study conducted for National Geographic Society (NGS) in 2009 prior to the development of this standard. Therefore, the following case study is based on factual information with some fabrications added to conform to the specific requirements of the standard. Optional information is included here to highlight how optional information may be used by incorporating additional information that NGS found useful to report.

Introduction

This GHG inventory was conducted for National Geographic Society following the GHG Protocol Product Standard. It evaluates the amount of greenhouse gas (GHG) emissions generated during the life cycle of a National Geographic magazine from the creation of the content, forestry operations and papermaking, printing and binding manufacturing, mailing and distribution to the recycling or disposal phase of the magazine. The goal of this report is to publicly disclose GHG inventory results in conformance with the GHG Protocol product standard.

Disclaimer: The study is specific to the National Geographic Magazine, the magazine supply chain, and distribution of the magazine. The study does not make comparative assertions about other magazines or products. The results presented here are not meant to be compared to other companies and/or products. Even for similar products, differences in functional unit, use and end-of-life stage assumptions, and data collection and quality may produce incomparable results. The reader is referred to the detailed report for more information on this study, and the Greenhouse Gas Protocol Product Standard for a glossary and additional insight into the GHG inventory process.

Box 12-2: Optional Information Included in the Summary

Background on GHG inventories:
Product life cycle carbon footprints or greenhouse gas (GHG) inventories are increasingly being used to convey to customers and the public the potential contribution of a product to climate change, a global concern. Additionally, companies are using results of these studies to make operating, manufacturing, and supply chain decisions, as well as decisions for purchasing renewable energy certificates (RECs) or carbon offsets. To calculate a carbon footprint, emission quantities of individual greenhouse gases (GHG) are converted to the measurement of carbon dioxide equivalents (CO_2 equivalents) using the Intergovernmental Panel on Climate Change (IPCC) 100-year Global Warming Potential (GWP) 1996 factors. This allows the potential effect on climate change from different activities to be evaluated on a common basis.

Additional Goals of NGS:
The results of this study will aid NGS in making decisions to reduce and/or offset GHG emissions associated with the life cycle of the magazine, as well as provide information that NGS may share with subscribers or other interested persons.

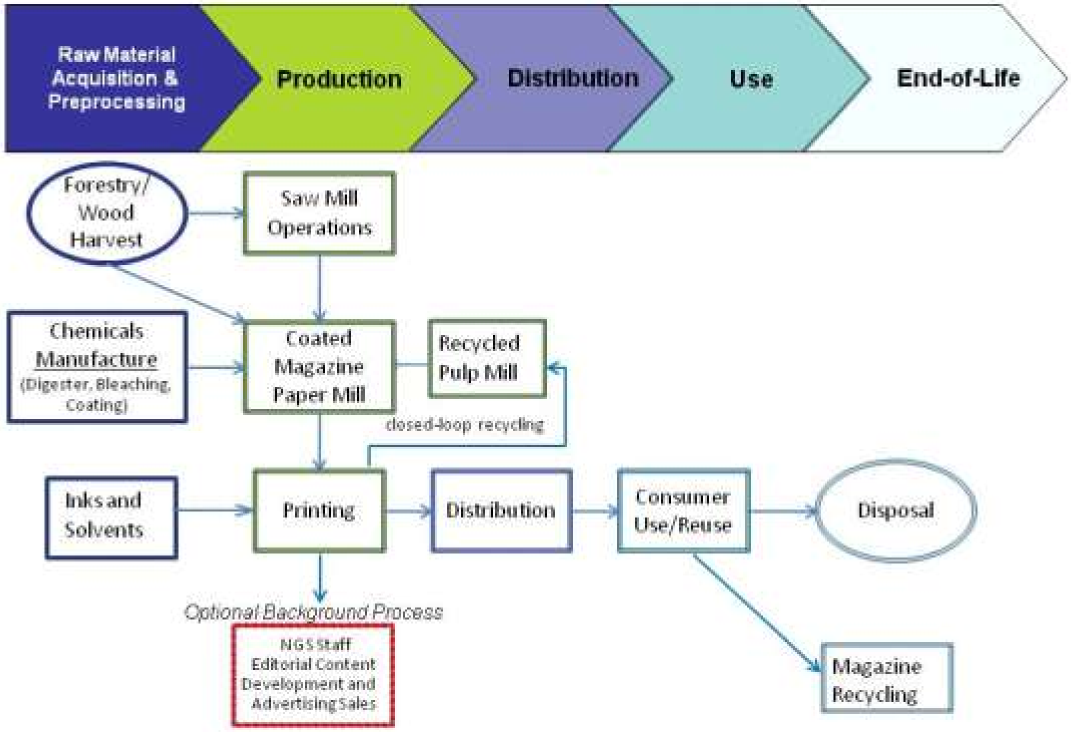
Additional Disclaimers around Presented Results/Data Quality:
The conclusions presented in this report are professional opinions, based solely upon information obtained from others and interpretation of documents prepared by others. Total GWP results have an estimated uncertainty of plus or minus 25%. This means that it is likely that other LCI practitioners, using the same data sources to do the same study, would find that the life cycle of the National Geographic magazine produces between 0.6 to 1.0 kg of carbon dioxide equivalents per magazine.

Neither NGS, nor any employee of NGS : (a) makes any warranty or representation whatsoever, express or implied, (i) with respect to the use of any information, method, process, or similar item disclosed in this document, including merchantability and fitness for a particular purpose or (ii) that this document is suitable to any particular user's circumstance; or (b) assumes responsibility for any damages or other liability whatsoever resulting from your selection or use of this document or any information, method, process, or similar item disclosed in this document.

Product Process Map

The product system modeled is the life cycle of National Geographic magazines, beginning with forestry operations and waste paper acquisition and ending with final disposal of magazines. **Figure 12-1** is a simplified illustration of the boundaries and material flows for the system.

1
2 **Figure 12-1: NGS Process Map**



3
4

Summary

Type of Inventory		
Cradle to Grave Full Inventory of National Geographic Magazines (Final Product)		
General Information		
Parameter	*Description*	
Company Name and Contact Information	National Geographic Society (NGS) Contact: Jane Doe, JaneDoe123@ngs.org	
Product Name	National Geographic (NG) magazines	
Product Description	NG magazines (English version) produced in the US and sold globally (average weight of 0.35 kg per magazine and 5% of recycled fibers content in 2008). NG magazines are a final product.	
Functional Unit (study basis)	1000 kg of NG magazines delivered to consumers globally equivalent to 2860 copies	
Temporal Boundary	1 year	
Country/Region of Product Consumption	Production and printing of NG magazines in the US and delivery in the US/Canada and to the rest of the word	
Inventory Date and Version	First Inventory completed in 2009 (Note: date reflects inventory completion, not the date of all collected data. The most recent data available were used, mainly 2008 and 2007)	
Study Results: Total Product GHG Inventory		
Parameter	*Value [Template Notes]*	*Unit*
Total GHG Inventory	2 370	kg CO_2e per 1000 kg magazines (functional unit)
Study Results: Percent of Life Cycle Stage		
Stage Name	*Value (Percent of Total CO_2e)*	*Comments*
Raw Material Acquisition & Preprocessing	70%	Includes forestry operations, harvesting trees, producing coated paper, chemicals production and use, as well as use of recycled fibers
Production	27%	Includes printing operations, solvents and ink manufacturing as well as NGS staff activities
Distribution & Retail	5%	Includes packaging production, transport by USPS and other carriers
Use	0%	Assumes no emissions due to the use of the magazine
End-of-Life	-2%	Includes waste collection emissions and the production of energy (co-product) at incinerators
Quality Assessment Information		
Parameter	*Description*	
Assurance Type	External review at Assurance Firm X	
Assurance Opinion	Limited review	
Data Quality Assessment	*(to be completed)*	

* Definition of "satisfactory" still under development in the Standard

Use of results

The GHG inventory showed that 96 % of the emissions from 1000 kg of NG magazines were from suppliers, with 70% being from paper manufacturing and 26 % from printing and binding. NGS found that only 4 % of the emissions were caused by their own operations. To reduce emissions created by NGS, they have implemented the following:

- Switching to wind-powered electricity to power office buildings
- Made a commitment to reduce energy consumption by 10 % over the next five years

Additionally, NGS is engaging with their suppliers to encourage:

- Switching to some renewable energy in their operations
- Investing in the renewable energy capacity
- Efficient shipping.

Finally the overall goal of NGS is to use the carbon emissions data identified through the GHG inventory to find ways to take carbon emissions out of the system. They are confident that it is not only possible, but that it should reduce costs in the long term.

13. Accounting for GHG Emission Reductions *(to be completed)*

This chapter will include guidance on how a company can use the GHG inventory results to set reduction goals, account for reduction activities, and track reduction performance. Some text related to this is included in Chapter 12.

Appendix A: Data Management Plan

A data management plan outlines the relevant information for a specific product GHG inventory and the internal quality assurance and quality control (QA/QC) processes established to oversee the preparation of an inventory from its inception through to final reporting. 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.

The quality control aspect of the data management plan outlines a system of routine technical activities to determine and control the quality of the product GHG inventory development. The purpose is to ensure that the product GHG account does not contain misstatements and conforms to relevant standards or guidelines, including 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 aspect of the data management plan contains the review of procedures conducted by personnel not directly involved in developing the product GHG inventory. This review is to determine the quality of the data; 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.

As part of best-practice, data management plans are established and made available to assurance providers (whether internal or external) for any publicly-disclosed product GHG inventory.

At a minimum the data management plans should contain:

- Description of the relevant product (and/or functional unit) for the GHG account.
- Entity(ies) or person(s) responsible for measurement and data collection procedures.
- All information that describes the product's system boundary
- Criteria used to determine when a product inventory is re-evaluated
- Data collection procedures
- Data sources and their quality for each process where a data quality assessment was undertaken.
- Calculation methodologies for each process where a data quality assessment was undertaken. Where secondary data was used and the corresponding methodology used to derive the data is not available, this shall also be stated.
- 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 protocols to address all the data management activities, including the quality control and quality assurance aspects of developing a GHG product inventory.

Implementing a Data Management Plan

To implement a data management plan, the following steps should be undertaken.

1. *Establish a product accounting quality person/team.* This person/team should be responsible for implementing 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 verifiers). The person/team may be newly established or an existing quality control team that is given additional responsibilities. The person/team may be responsible for all product inventories undertaken by a company or for an individual product inventory.

2. *Develop Data Management Plan.* For publicly-disclosed product accounts the plan should cover the components outlined in the standards section above (see **Table A-1**). Other components that should be outlined in the data management plan but are not required to be made available for assurance include data storage and QA/QC procedures for data collection, input and handling activities, data documentation and emissions calculations. Recording this information should assist with repeat product inventories and the quality of the current product inventory. It is also good-practice for all inventories developed for internal company purposes (e.g., performance tracking) to specify a data management plan with similar content and rigor as publicly-disclosed product inventories.

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

3. *Perform generic data quality checks based on data management plan.* Checks should be applied to all aspects in the inventory, focusing on data quality, data handling, documentation, and calculation procedures (see **Table A-2** for data control activities).

4. *Perform specific data quality checks.* More in-depth checks should be made for those sources, process and/or activities that are major contributors to the product inventory and/or have high levels of uncertainty (see Collecting Data chapter section on assessing uncertainty).

5. *Review final product GHG inventory and reports.* Review procedures should be established that match the purpose of the inventory and the type of assurance the inventory may be exposed to. Internal review processes (self-assurance), independent third-party or accredited third-party assurance may be used for both internal uses or publicly disclosed product inventory (see **Chapter 11** for what these reviews entail). Internal reviews should be undertaken 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.* This establishes the record-keeping processes for what and how data should be stored over time; what data should be reported as part of an internal inventory report; how data should be reported to conform with a publicly-disclosed inventory; and what should be documented to support data collection and calculation methodologies. It may also involve aligning or developing any 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 quality improves, internal data collection and handling procedures are refined, calculation methodologies improve, product inventory responsibilities change within a company or the purpose of the product inventory changes (e.g., from an internally used account to a publicly disclosed account).

Table A-1: Components of a Data Management Plan

Component	Information	Rationale
Responsibilities	Name and contact details of persons responsible for: • overall management of product inventory • data collection for each process	This ensures institutional knowledge is maintained and allows relevant person(s) to be identified for: • confirming and checking information during any internal or external audit procedures • producing consistent future product inventory.

	• internal audit procedures • external audit procedures	
Product	Description of the product and/or functional unit	To provide auditors and those doing future product inventories information on the product/functional unit, which puts the rest of the information in context.
System boundary	• System boundary description • How the boundary was derived • Emissions sources included in the inventory (including those sources considered but not included and the rationale for exclusion) • Allocation methodologies use and where they were used	To provide auditors and those doing future product inventories sufficient information to understand and replicate boundary decisions.
Data	• Data collection procedures, including data sources for each process (including any relevant references) and procedure used to fill any data gaps • Quality of data collected for each process and how the data quality assessment was undertaken • Data sources where better quality data is preferable and plan for how to improve that data • Information on how the product use profile was obtained • Criteria used to determine when an inventory is to be re-evaluated, including the relevant information and changes to the system to be tracked over time and how these changes should be tracked	• 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. • Enables data quality to be tracked over time and improved • 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 • Allows auditor and those doing future inventories sufficient information on how the use profile was developed, and identifies how this information may be improved • This allows data and information sources to be tracked and compared overtime. 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
Calculating emissions	• Calculation methodologies used (and references). This include where the calculation methodology for any secondary data used was not available. • Changes in calculation methodologies over time	• Provides auditors and those doing future product inventories details on how emissions were calculated • Noting methodological changes should allow discrepancies between product inventory to be

		checked and ensure that recorded methodologies are kept current
Data Storage	• How and where data is stored • Length of time data is archived for • Backup procedures	• allows information to be easily located • keeps a record of how long information is stored so don't expend energy looking for information that is no longer kept • ensures backup procedures are implemented
QA/QC	See Table 2 for more details	Ensures that adequate processes are in place to check data collection, input and handling, data documentation, and emissions calculations.

Table A-2: Data Control Activities

Activity	Procedure
Data collection, input and handling activities	
Transcription errors in primary activity data and secondary data	• Check a sample of input data in each process (both direct measures and calculated estimations) for transcription errors
Uncertainty estimates	• Check qualification of individuals providing expert judgment or uncertainty estimates are appropriate and are recorded • Check that the calculated uncertainties are complete and calculated correctly
Data Documentation	
Transcription errors in references and storage of all references used	• Confirm bibliographical data references are properly cited • Ensure all relevant references are archived
Storing information on data and data quality	• Check that system boundary, product base year (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 and the overall product account • Check for consistency in the use of the same or similar data sources between different processes • 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 all units are correctly transferred through all calculations and aggregation of emissions in all processes • Check 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 between product inventories are documented
Database/calculation sheet integrity	• Check that the appropriate processing steps are correctly represented in database or calculation sheets • Ensure all fields and their units are labeled in

	database/calculation sheet • Ensure 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 uncertainty estimations • Check all data, supporting data and records are archived and stored to facilitate a detailed review • Check that the archive is securely stored
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 methodology(ies)	• Reproduce a sample set of emissions and removals calculations to cross-check application of calculation methodologies • Where possible, cross-check calculation methodologies used against more or less complex methodologies to ensure similar results are achieved

The quality assurance aspect of the data management plan involves peer review and audits to assess the quality of the inventory. Peer review involves reviewing the documentation of the product accounting methodology and results but does not rigorously review the data used or the references. Peer review is conducted by someone not involved in the development of the product account. The audit evaluates whether the inventory complies with the quality control specifications outlined in the data management plan. More information on the assurance process is found in **Chapter 11**.

Appendix B: Additional Guidance on Collecting and Calculating Data

Accounting for GHG Emissions due to Land Use and Land Use Change

This section provides guidance on calculating and allocating GHG emissions due to land use and land use change. These emissions include[19]:

- CO_2 emissions and removals resulting from a carbon stock change
- CO_2, N_2O, and CH_4 emissions resulting from the removal of biomass (logging, mowing, burning), preparation of the soil (tilling, disking, subsoiling) and the application and impacts of inputs such as liming and fertilizer applications
- CO_2, N_2O, and CH_4 emissions and removals of CO_2 from managed land practices (managed soil emissions, rice cultivation, manure management, livestock rearing, peat extractions)

These emissions are only considered in a product level GHG inventory if the land use and/or land use change is directly attributable to the studied product; guidance is provided to help a company determine what impacts are attributable. This chapter focuses only on the types of emissions presented above, however other emissions associated with land use during harvest and cultivation (i.e. fuel use of farm equipment, material inputs of fertilizers and pesticides) also need to be considered in a product life cycle GHG inventory as part of the boundary setting process outline in **Chapter 6**. 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. Companies are 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, its focus is guidelines for national inventories and therefore some details are not applicable to a product-level inventory.

Key Concepts

Land use is defined as the specific type of activity occurring on the land, based on certain land categories. Land categories include forestland, cropland, grassland, wetlands, settlements and others (unmanaged lands that do not fall into the other five categories such as bare soil or rock) (IPCC).[20] The type of GHG emissions due to land use practices differ depending on the category of land used.

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[21]), dead organic matter (dead wood and litter), and soil organic matter (IPCC). A change in carbon stock can refer to additional carbon storage within a pool or a release of CO_2 to the atmosphere. Carbon stock changes can occur between land categories (forestland to cropland) or within a land category (natural forestland to managed forestland).

Land use change is defined as a change from one land use category to another**.**

[19] This list was adapted from the 2006 IPCC Guidelines for National GHG Inventories, Volume 4: Agriculture, Forestry, and Other Land Use. http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html
[20] Appendix to this document contains detail definition of these land categories.
[21] Above ground biomass refers to any biomass above the soil such as trees, plants, stumps, and brush. Below ground biomass refers to live biomass under the soil such as roots.

Land use impacts are GHG emissions that occur as a result of land use change, a change in carbon stock, or the preparation of land for future land use. Land use impacts do not include changes in crop cover or crop rotations that occur within the cropland category.

Indirect land use change occurs when the demand for a specific land use (e.g. bio-energy crops in the U.S) induces land use change on other lands (e.g. deforestation in Brazil). This displacement is a result of market forces and marginal impacts. This is consistent with a consequential modeling approach and not considered within this standard (although may be applicable for certain products based on category or sector specific guidance – see **Box 4-2**).

Assessment period is the period of time before harvest that must be considered in order to identify land use impacts that may be attributable to a product.

Amortization period is the period of time after a land use impact that must be considered in determining the products to which a land use impact is attributable.

What is Attributable to a Product?

Land use impacts are attributable to a product if they occurred within the assessment period and one or both of the following conditions are true:

- A land use impact is the direct result of extraction or production of material to produce the product (e.g. a forest is cut down for use of the product wood without planting a crop or regenerating and maintaining[22] the land to produce additional products), or
- The land use impact was caused by human intervention with the intent of creating a product from plants grown on the land after the intervention (e.g. a forest is cut down to produce a crop).

The assessment period is defined as the period of time before harvest that must be considered in order to identify land use impacts that may be attributable to a product. Figure B-1 illustrates an assessment period. For biomass with a harvest period less than or equal to 10 years, the assessment period is 20 years. For biomass with a harvest periods greater than 10 years, the assessment period is the length of a harvest plus 10 years[23]. To implement this, a company begins at the time of harvest (of the studied product) and looks back onto the use of the land over the assessment period. This is considered a moving assessment period because the references year from which land use impacts are attributable to a product will change depending on the harvest year. For example, an annual harvest completed in 2010 will have an assessment period of 20 years and a reference year of 1990. The same harvest in 2020 would have a reference year of 2000. If a tree, which takes 40 years to cultivate, is harvested in 2010, the assessment period is 50 years and the reference year is 1960. A moving assessment period was chosen instead of a set reference year to improve equality in accounting among products and regions.

[22] For the carbon stock change to be attributable to a product after stock is removed from a forest, the land must be regenerated and maintained. This means that if wood is extracted from the forest, and the extraction company plants new trees for every tree that is removed (either voluntarily or due to regulations in the area), the products created from the regenerated wood is only allocated some of the land use change impacts is that wood is maintained for a future product, i.e. not left to grow with none or very minimal maintenance. Minimal maintenance is defined as maintenance only in the first few years of the trees life. Additionally, as a rule of thumb, trees that are regenerated with a harvest life of greater than 50 years should not be allocated any of the land use impacts due to uncertainty.

[23] This provision was added to avoid a loophole where plants with a harvest period of greater than 20 years could avoid attributing land use impacts based on a 20-year assessment period.

Figure B-1: Illustration of the Assessment Period

Examples:

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 impacts are attributable to the product.
2) A product is made from wood that is extracted from a naturally grown forest where there is no intention to grow another product, included either land that is left to naturally regenerate or land that is regenerated but not maintained. If the extraction of above ground biomass causes a change in carbon stock of the land the land use impacts are attributable to the product[24].
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 to a plantation from a natural growth forest in 1980. The assessment period for this wood is 38 years, and therefore the land use impacts 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. Because the carbon stock change was not caused by human intervention with the intent of creating a product, the land use impacts are not attributable to the product.

If a company is not able to determine what land use emissions are attributable to a product because they do not know the specific land from which the product was harvested, the company should refer to the procedure and example given in the following section: **Assessing Land Use Impacts with Limited Data.** The type of land use practice emissions that are attributable to a product depend heavily on the type of land category used and the product itself. For example, a product made from rice would need to consider methane emissions due to rice cultivation. A product that relies on wetlands will need to consider additional emissions due to peat management. Even if land use change impacts are not attributable to a product, land use practice emissions must be considered. Detailed information on the specific GHG emissions associated with each land category is available in the IPCC guidelines.

Calculating Land Use Impacts

Collecting data for land use impacts follow the same data collection and quality requirements given in **Chapter 7** and **Chapter 9** of this standard. If the reporting company owns the land from which a product is harvested, primary data is required (i.e. the company must know and use data from the land use impacts associated with that land). Primary data from a supplier is preferred for land not owned by the reporting company. This type of data is collected directly from the production site, with actual areas, mass or volume of inputs used. It includes measured biomass, carbon stocks, and emissions from soils using approved, peer reviewed methodologies. Common sources for secondary data include:

- Sector-specific activity data/emission factors: This data is usually provided by associations, cooperatives, and institutes representing a particular sector, and it can include aggregate activity data/emissions from site-specific sources.

[24] 2006 IPCC Guidelines give values for forestland 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.

- 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 persons with expertise in the region.
- Generic activity data/emission factors: These are default values provided by the IPCC, FAOSTAT, etc. This data refers to broad categories, such as high activity clay soils and tropical rain forest.

Companies are referred to IPCC guidelines for detailed equations to calculate GHG emissions due to land practices. The remained of this chapter focuses on calculating and allocating land use change (LUC) impacts.

Figure B-2 is a simplified illustration to show how LUC emissions are calculated using carbon stock information. In general, when a stock change is attributable to a product, the stock change is equal to the difference between the average carbon stocks before the activities which caused the land use impact and the average carbon stocks over one growing cycle beginning at the end of the assessment period. If there is no intent to grow product on the land after the land use impact, the stock change is the average stocks on the land before the activities that caused the land use impacts minus the stocks on the land after the activities that caused the land use impacts (forest density). In this example, forestland with an average carbon stock of 200 tons is converted into cropland with an average carbon stock of 50 tons, creating a 150-ton release of carbon due to the change in carbon stock. A company shall provide a transparent report of which stock changes occurred and how LUC emissions were calculated. Carbon stock data can be collected based on primary data, or secondary data sources such as IPCC default stock factors.

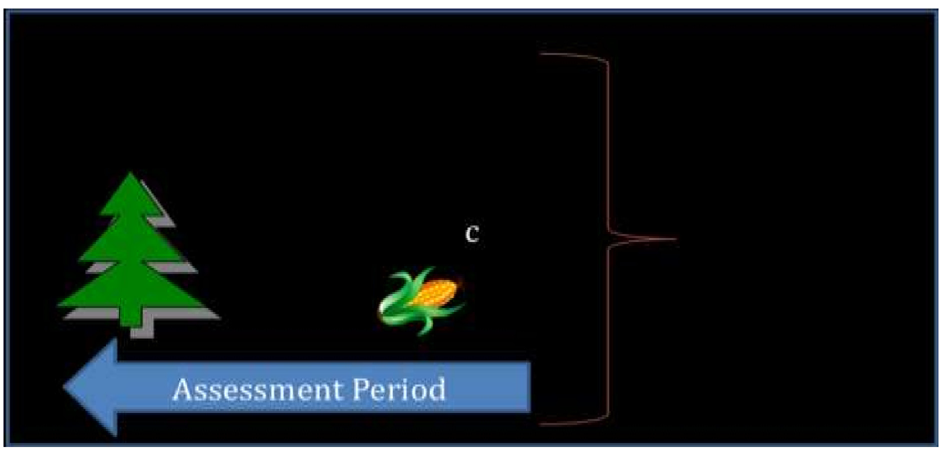


Figure B-2: Simplified Illustration of Carbon Stock Change Calculation

Once it is clear that land use impacts are attributable to a product, and carbon stock changes and other impacts are calculated, the next question is how to allocate emissions among the products that may be produced on the land.

Allocation of Land Use Impacts

Figure B-3 illustrates three ways land use change emissions can be allocated over time; A) single year, B) 20 year constant, and C) 20 year decline.

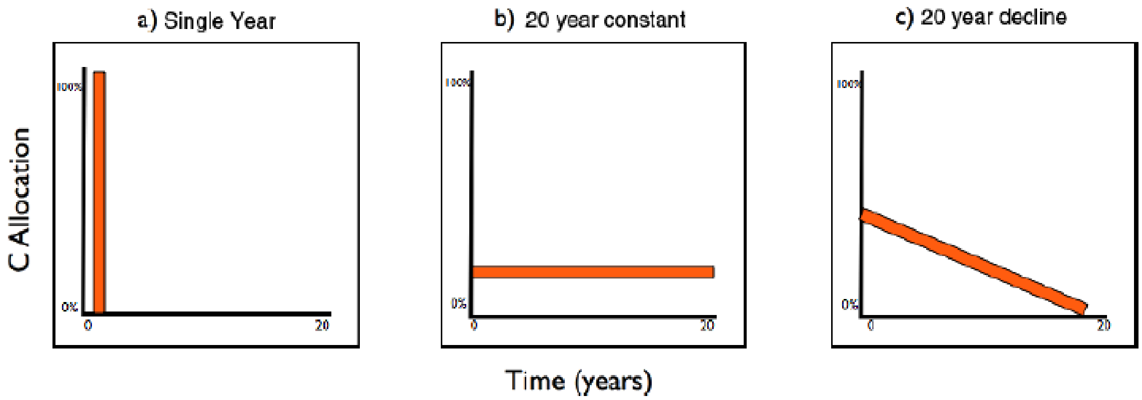


Figure B-3: Amortizing GHG emissions over a 20 year time period (Zaks et al. 2009)

In this standard, land use impacts[25] should be allocated using option B: evenly over the amortization period. This option was chosen as the most consistent way to allocate emissions for use in a GHG inventory, as both option A and C create some incentive for companies to delay inventory reporting in an effort to reduce land use 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.

The amortization period is defined as the period of time after a land use impact that must be considered in determining the products to which a land use impact is attributable. As with the assessment period, biomass with a harvest period less than or equal to 10 years has an amortization period of 20 years and biomass with a harvest periods greater than 10 years has an amortization period the length of a harvest plus 10 years. The difference between the two is that the assessment period looks back from the studied harvest to determine if land use impacts are attributable, while the amortization period looks forward from the land use impact to determine how much of the impact is allocated to the studied product. Figure B-4 shows the relationship between amortization and assessment periods.

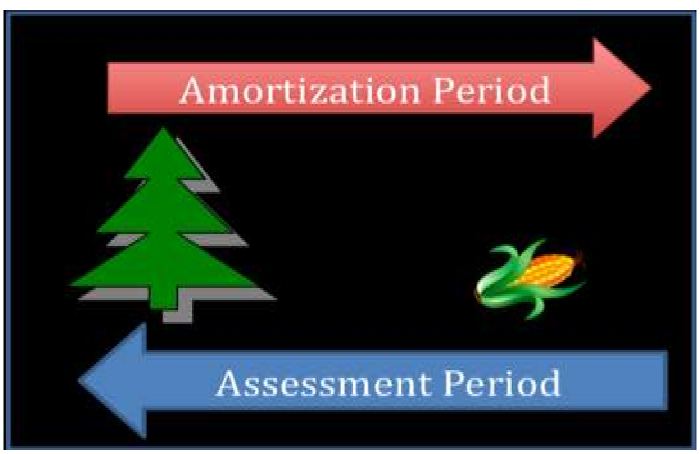


Figure B-4: Illustration Comparing Assessment Period with Amortization Period

[25] It is recognized that a change in carbon stock can result in either a release or storage of carbon, and therefore not all changes result in GHG emissions. However, because this standard accounts for the GHG inventory of a product, it is most likely that the removal of biomass (and not the planting or re-growth of biomass) is the attributable carbon stock impact. Growing biomass to create a GHG credit is not attributable to a product following this standard methodology. However in some specific cases, such as a carbon stock change from till to no-till crop rotation or a change from cropland to grassland, a company may see storage of carbon due to land use. This does not mean that the final value for the land use impacts will be positive, since other factors such as preparing the land and land use practice emissions also contribute to the final emissions value.

For annual or semi-annual crops, herbaceous plants, or short-rotation woody crops, a company allocates x/y of the emissions to the studied product, where x is the harvest period of the studied product and y is the amortization period. If the company can account for all products produced[26] from extracted biomass over the assessment period, they may estimate the total production of the land and then allocates the emissions to each ton of harvested biomass.

A company must clearly state and justify the allocation methodology used.

Example:

Figure B-5 illustrates a land use change from forestland to annual cropland within the assessment period (20 years for an annual crop). Corn is grown annually throughout the amortization period, so each harvest of corn receives 1/20th of the land use impacts. Corn grown on year 21 would not be burdened with the land use impact emissions, as they have already been fully amortized. However, that corn would still be burdened with emissions associated with cultivating and harvesting corn.

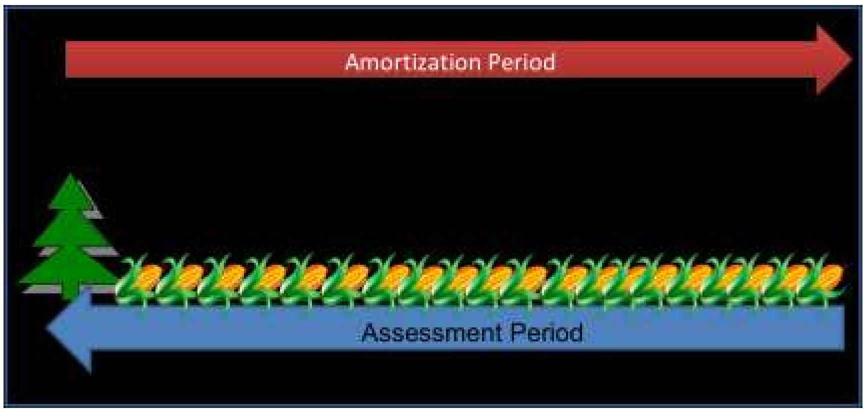


Figure B-5: Illustration of a Carbon Stock Change from Forestland to Cropland

Examples involving forest products

Forest products (most often wood and paper products) examples differ from non-forest products when considering the allocation of land use impacts. Some forest products are made from wood grown on managed plantations that are harvested every 10 years, while others may be extracted from natural forests that have been growing for many decades or even centuries. Some forests are cut with the intent of producing annual crops on the land, while others are cut for the stock of wood that can be extracted and used for making forest products. Depending on the type of product being studied and the location where the trees are cultivated, vastly different harvesting techniques occur which have large impacts on the amount and allocation of land use impacts. Furthermore, if the studied product is an agricultural crop but the land use event created a co-product of wood, a company needs to accurately allocation those emissions. The following scenarios provide some insight into the correct allocation to forest products; however, a company is required to report and justify the allocation method chosen[27].

[26] The company must have either owned the land and been responsible for all the products produced, or have clear and justifiable data proving the biomass was extracted and used to create a product including the production yield.
[27] If a company is creating an inventory for a forest product where primary data is not available, the company may not make assumptions about the allocation of co-products or the nature of the wood extraction unless sector or country specific data suggests that the majority of wood is harvested in a particularly way. Even in this case, a sensitivity analysis should be performed before to determine the impact of any large data assumptions on the final inventory.

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 will be attributable to the products created from the harvested wood. No allocation is needed because additional growth of the land is not planned, or is unknown.

Scenario B: A forest is converted into annual cropland and the wood is sold or otherwise used to create a co-product. From the perspective of the crop product, the wood is considered a co-product and land use impacts should be allocated between all products produced during the amortization period. In this case it may be easiest for a company to consider all the products produced during the assessment period, calculate the total amount of biomass, and allocate the impacts per mass or volume of biomass. However, this approach is only applicable if the company can account for all products produced over the assessment period, which in this case includes the wood co-products. If the use of the wood for co-products is not justified then the allocation of emissions to the co-product is not appropriate. The additional impacts (e.g. liming applications) and any practice emissions associated with preparing the cropland will be allocated solely to the corn.

From the perspective of the wood product, a company can only allocate based future use of the land within the amortization period **if** the main purpose of converting the land was to create a new land category. To report this, a company must have clear and justifiable data to support the intent of the land to be cultivated over the amortization period. If the land is only intended to be cultivated for 10 years (i.e the land is leased for 10 years), then the allocation will be based on that time period.

Scenario C: Wood is extracted from a forest that is not converted to a new land category, but new trees are planted to regenerate the forest over time. In this case, even thought new trees are planted to replace the old trees, no allocation can be made to future harvests that may occur as a result of the regeneration and all of the land use impacts are attributable to the extracted wood. This is because the purpose of removing the wood was not to plant new trees but to create a product and the choice to plant new trees was either a requirement of the government or the good practice of the company to ensure resources for future generations.

Assessing Land Use Impacts with Limited Data

When a company has limited information on the specific land from which the product is extracted or harvested, it can be difficult to determine how to attribute or allocation emissions. This situation will exist when a company buys crops/biomass from a supplier who receives indistinguishable shipments from a wide range of land-based sources; therefore, primary and/or site-specific data is not available and secondary data must be used not only to calculate stock changes but also to determine how much LUC impacts should be allocated to a product. In these cases where it is not known whether, when and to which extent, land use change has taken place, the following sources should be used to determine land use impacts:

- Land use and/or agricultural demand-based models
- Average data, including
    - international statistics
    - country / regional specific statistical databases / satellite images?
    - statistical year books

Land use and/or agricultural demand-based models may be the most accurate way to determine the amount of land use change emissions that should be allocated to a product; however, these are often very complex and still may not provide an accurate representation for many countries. If a company has access to these tools they are encouraged to use them to determine land use change allocation as long as the modeled results are justified and transparent.

In many cases, a company will not have access to models and will need to look to average data sources. These sources give information about the country profiles, especially the agricultural sector of a given country (i.e. they show the land occupation of the main crops planted in a specific country for different years). Therefore information about the total land allocation of a country and its change during the years may be deduced.

Using average data sources, a company can proceed step by step using the following guidance in order to estimate the land use change of a product (i.e., a specific crop):

1. Use a global/country profile to determine the total agricultural and forest statistics over a 20 year time period
2. Using the statistics located in step 1, a company should identify:
    - The change in land occupation of the studied product
    - The change in natural forest land (deforestation rate)
    - The change in land occupation of agricultural activities (i.e. crops, ranching)
3. Using the above data, a company may decide whether they need to account for land use impacts by using the following guidelines:
    - For a forest/wood product:
        a. If the deforestation rate is increasing and agricultural activities are decreasing or remaining constant, then a carbon stock change (and corresponding impacts) from forest to managed land must be considered.
        b. If no deforestation is occurring, but agricultural land is decreasing, the company must determine if a carbon stock change has occurred (i.e. from pastureland to wood plantation) based on the type of agricultural changes.
        c. If no deforestation is occurring and agricultural lands are remaining constant, and the demand for the product is increasing, then it must be assumed that wood is being harvested directly from the forest. A company will need to use the IPCC default values to determine if the density change results in a carbon stock change.
    - For an agricultural product:
        a. If land use for the product has remained constant or decreased over the 20 year assessment period, then no land use impacts must be considered.
        b. If land use for the product has increased, deforestation has increased, and other agricultural land has remained constant then a carbon stock change (and corresponding impacts) from forest to agricultural land must be considered
        c. If land use for the product has increased, but deforestation has not increased, the company must determine if a carbon stock change has occurred (i.e. from pastureland to wood plantation) based on the type of agricultural changes.
4. If a carbon stock change has occurred, a company can either assume all the land was converted (worst case scenario) or use the statistics to determine the change in land and a percentage of impacts. For example, if the data shows a 50 % increase in a product over the 20 year time period, a company can assume that 50 % of the product they use comes from land with a carbon stock change impact. Emissions will be allocated to the crop following the allocation procedures defined above.
5. To calculate the land use impacts, companies are referred to the list of data sources in the section: Calculating Land Use Impacts

A company using this process must make clear the following in the report:

- The data source for agriculture and forestry statistics used

- A graph, table, or other explanation of the decision made in regards to attributable land use impacts (i.e. showing a increase or decreasing in crop and/or forest land)
- If land use impacts are attributable, a graph, table, or other explanations as to the choice of carbon stock change (i.e. forest-to-crop versus grassland-to-crop). If several changes are possible, or the data is not clear, a company is expected to justify their choice using general *land use trends in the region and sensitivity analysis.*

To be completed: An example calculating land use impact emissions based on the above methodology

Definitions of different land categories (from the UNFCCC):

- Forest is a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 1030 per cent with trees with the potential to reach a minimum height of 25 meters at maturity in situ. A forest may consist of either closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 1030 per cent or tree height of 25 meters are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest;
- Forest land includes all land with woody vegetation which falls under the definition of forest;
- Cropland includes all arable and tillage land as well as agroforestry systems which do not fall under the category of forest land;
- Grassland includes [all] rangeland and pasture land as well as agroforestry systems which do not fall under the categories of forest land and cropland;
- Wetlands includes land that is covered or saturated by water for all or part of the year, such as peatland, and which does not fall under the forest land, cropland, grassland or settlements categories;
- Settlements includes all developed land, including transportation infrastructure and human settlements of any size, which does not fall under the forest land, cropland, grassland or wetlands categories;
- Other land includes bare soil, rock, ice and all land areas which do not fall under the forest land, cropland, grassland, wetlands or settlements categories.

Electricity Emission Factors (to be completed)

Capital Goods (to be completed)

Appendix C: Product Comparisons *(to be completed)*

This section will include guidance on how programs, developers, and organizations should apply additional constraints to the Standard requirements so that valid assertions and claims can be made.

Appendix D: Life Cycle Databases *(to be completed)*

Appendix E: Glossary

Term	Definition
Accuracy (principle)	Ensure that reported GHG emissions are not consistently greater than or less than actual emissions and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the reliability of the reported information. Clearly explain any estimates and avoid bias so that the report faithfully represents what it purports to represent. (2)
Activity Data	A quantitative measure of a level of activity that results in GHG emissions or removals. Examples of activity data include kilowatt-hours of electricity used, volume of fuel used, output of a process, hours a piece of equipment is operated, distance travelled, and area of a building. (Box 7-1)
Amortization Period (Land Use Impacts)	The period of time after a land use impact that must be considered in determining the products to which the land use impact is attributable. (Appendix B)
Assessment Period (Land Use Impacts)	The period of time before harvest that must be considered in order to indentify land use impacts that may be attributable to a product. (Appendix B)
Assurance	An objective assessment of the accuracy, completeness and presentation of a reported product GHG inventory and the conformity of the product GHG inventory to the Standard designed to enhance the degree of confidence of the intended users. (11.1)
Assurance Opinion/Conclusion	A formal written declaration prepared by the assurance provider addressed to the intended user(s) which concludes, based on their assurance procedures on whether, in their opinion, the GHG inventory is fairly stated in accordance with the criteria, to the extent of the level of assurance sought. (11)
Assurance Providers	Competent and independent person, or persons, with responsibility for performing and reporting on the assurance process. (11)
Attributional Approach to GHG Accounting	Accounting approach that provides information about the GHG emitted directly by a product and its life cycle. (4.1)
Audit Trail	Well organized and transparent historical records documenting how the GHG inventory was compiled. (11.3.6)
Avoided Burden	Type of system expansion that avoids allocation by including in the product system the emissions associated with the co-product produced by a similar process. (8.2)
Background Processes	Processes that are not directly connected to the product or its components. Background processes include facility operations, corporate activities, and capital goods. (6.2)
Business Goal	Refers to the high level purpose that a product GHG inventory serves. (1.3.1)

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 (IPCC). A change in carbon stock can refer to additional carbon storage within a pool or a release of CO_2 to the atmosphere. Carbon stock changes can occur between land categories (forestland to cropland) or within a land category (natural forestland to managed forestland). (Appendix B)
Calculated Data	When activity data are collected at the production site and an emissions factors are used to determine the GHG emissions. (7.2.2)
Closed-loop recycling	Recycling system where all of the recycled material returns to the system under study. (8.3.4)
Comparative Assertion	An environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function. This standard does not directly enable comparative assertion. (1.2) Source: ISO 14040
Completeness (principle)	Ensure that the GHG report covers all product life cycle emissions within the specified boundaries (including temporal), state clearly any life cycle stages or significant non-GHG environmental impacts that have been excluded and justify these exclusions. (2)
Completeness (data quality indicator)	The degree to which the data represents the relevant process. The percentage of locations for which site specific or generic process data are available and used out of the total number that relate to a specific product or process. Generally, a percent target is identified for the number of sites from which data that is collected for each process. (9.2.2)
Complex Products	Products with many and/or complicated physical or service components and processes, as part of their lifecycle. They are also likely to have both highly complicated and complex product systems. (8.2.5)
Consequential Approach to GHG Accounting	Accounting approach that provides information about the GHG emitted, directly or indirectly, as a consequence of changes in demand for the product. This approach typically describes changes in GHG emissions levels from affected processes, which are identified by linking causes with effects. (4.1)
Consistency (principle)	Use methodologies to allow for meaningful comparisons of emissions over time. Transparently document any changes to the data, inventory boundary, methods, or other relevant factors in the time series. (2)
Co-Products	Products produced in the product system under study but are used in other product systems. (8.1)
Corporate Activities	Activities that are done by a company to better both the company branding and the products they sell. (6.3.6)
Cradle-to-Gate Assessment	This inventory includes all GHG emissions in the life cycle of a product from the beginning of the life cycle (e.g. raw material acquisition) up through the point of sale to the customer, including the emissions from processes owned or controlled by the reporting company. From the perspective of the reporting company, a cradle-to-gate assessment includes data on historic emissions but excludes estimates of future emissions after the product is sold to the customer. A cradle-to-gate assessment is a subset of a cradle-to-grave

	assessment. These are sometimes referred to as Business-to-Business (B2B) inventories. (Box 6-2, 12.1.2)
Cradle-to-Grave Assessment	An assessment that includes all GHG emissions in the complete life cycle of a product from the beginning of the life cycle (e.g. raw material extraction) through final disposal or end use by the end consumer. (6.3.4)
Customer	An entity that purchases, rents, or uses the products of another entity (i.e., a supplier).
Data Quality	The characteristics of data for satisfying stated requirements. Generally data quality characteristics address how well the data corresponds to the time, geography and technology represented in the product inventory, the precision of any direct measurements, the completeness of processes represented in the inventory and the consistency of data across processes in the inventory. (9.2)
Direct Land Use Change	Refers to the conversion of unmanaged to managed land to directly produce a land-based product. (6.3.1)
Emission Factors	An emission factor is the GHG emissions per unit of activity. (7.2.2)
End-of-Life Stage	Stage from when the used product is ready for disposal, recycling, reuse, etc. to when the product is buried, returns to nature (combustion, deterioration), or transformed to be recycled or reused. (6.3)
Estimated Data	Where GHG emissions are available, but cover the whole production site and need to be disaggregated to a specific process/product. (7.2.2)
Extrapolated Data	Primary or secondary data related to a similar (but not representative) input, process, or activity to the one in the inventory, which are adapted or customized to a new situation to make more representative (for example, by customizing the data to the relevant region, technology, process, temporal period and/or product). (7.2.1)
Final Product	Goods and services that are ultimately consumed by the end user rather than used in the production of another good or service. Final products enter the use stage in their current form without further processing, transformation within the system, or inclusion in another product system before the use stage. (6.3.3)
First Party ("Self" or "Internal") Assurance	Assurance provided by persons from within the organization but independent of the product GHG inventory determination process. (11.2)
Foreground Processes	Processes that are directly connected over the product's life cycle by material or energy flows, from extraction and pre-processing of product components through to the product's end-of-life. (6.2)
Functional Unit	The quantified performance of a product system for use as a reference unit. (3.1) Source: ISO 14044:2006

Gate-to-Gate	An inventory of the GHG emissions associated with a product when it is owned or controlled by the reporting entity. (12.1.2)
Geographical representativeness (data quality indicator)	Degree to which the data set reflects the true population of interest regarding geography such as e.g. country or site, including any background data sets used. (9.2.2)
GHG Emission Source	Any physical unit or process which releases GHG into the atmosphere.
Global Warming Potentials	GWP is a metric used to describe the radiative characteristics of well mixed greenhouse gases which combine the effects of the differing times GHGs remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation. (10.1) Source: IPCC
Indirect Land Use Change	Occurs when the demand for a specific land use (e.g. bio-energy crops in the U.S) induces land use change on other lands (e.g. deforestation in Brazil). This displacement is a result of market forces and marginal impacts. This is consistent with a consequential modeling approach and not considered within this standard (although may be applicable for certain products based on category or sector specific guidance (Appendix B)
Input-Output Data	Non-process data derived from environmentally extended input-output analysis (IOA). (Box 7.1)
Input-Output Analysis (IOA)	The method of allocating GHG emissions (or other environmental impacts) associated with upstream production processes to groups of finished products by means of inter-industry transactions. The main data sources for IOA are sectoral economic and environmental accounts. Economic accounts are compiled by a survey of facilities on economic inputs and outputs and tax data from individual establishments. Environmental accounts are derived from (surveyed) fossil fuel consumption by industry and other GHG sources compiled in national emission inventories. (Box 7.1)
Intermediate Products	Goods that are used as inputs in the production of other goods and services rather than entering the use stage in their current form. Intermediate products require further processing, transformation within the system, or inclusion in another product system before the use stage. (6.3.3)
Land Use	The specific type of activity occurring on the land, based on certain land categories. Land categories include forest land, cropland, grassland, wetlands, settlements and others (unmanaged lands that do not fall into the other five categories such as bare soil or rock) (IPCC). For instance, if the land category is crop land, the land use may be crop production. Land use causes changes in the carbon stock of land which can result in GHG emissions. (Appendix B)

Land Use Change	Defined as a change from one land use category to another (Appendix B)
Land Use Impacts	GHG emissions that occur as a result of land use change, a change in carbon stock, or the preparation of land for future land use. Land use impacts do not include changes in crop cover or crop rotations that occur within the cropland category. (Appendix B)
Level of Assurance	The level of assurance refers to the degree of confidence the intended user of the assurance conclusion can gain from the outcome of the assurance evaluation. The level of confidence that can be gained is provided in the wording of the assurance conclusion, which reflects the conclusion the assurance provider can reach based on the reduction of the assurance risk. Assurance engagement risk is the risk that the practitioner expresses an inappropriate conclusion when the subject matter information is materially misstated. (11.1)
Life Cycle	Consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to end of life. (ISO 14044:2006)
Life Cycle Stage	Defined to aid in boundary definition and emission reporting along the life cycle of a product. Stages are defined in this standard as raw material acquisition and preprocessing, production, product distribution and storage, use, and end-of-life. (6.3)
Material Discrepancy	An error (for example, from an oversight, omission, miscalculation or fraud) that results in a reported quantity or statement being sufficiently different from the true value or meaning to influence a user's decision. (11.3.5)
Materiality	Concept that individual or the aggregation of errors, omissions and misrepresentations could affect the GHG inventory and could influence the intended users' decisions. (11.3.5)
Materiality Threshold	A concept employed in the process of assurance. It is often used to determine whether an error or omission is a material discrepancy or not. It should not be viewed as a de minimus for defining a complete GHG inventory. (11.3.5)
Measured Data	Direct GHG emissions measurements for a process at the production site. (7.2.2)
Multi-Input Process	Occurs when a number of different products (including the subject product) are treated in the same process. (8.1)
Multi-Output Process	Occurs when the product system under study includes a common process with multiple outputs from which only the subject product output is included in the studied product system (and the other outputs belong to other product systems). (8.1)
Open-loop recycling	Recycling system where the recycled material from a product system is used to make another product or cannot be recycled into a material with equivalent properties to virgin material. (8.3.4)

Precision (data quality indicator)	Measure of the variability of the data points used to derive the GHG emissions from a process (e.g., low variance = high precision). Relates mostly to where direct measurements have been used. (9.2.2)
Primary Data	Direct emissions measurements or activity data collected from specific processes within a product's life cycle or specific sources within a company's operations or its supply chain. (Box 7.1)
Process Approach	A method of product life cycle accounting that involves quantifying and aggregating the emissions from each specific unit process within the established boundary of the product system. (4.2)
Process Data	Physical flow data relating to the individual process within the defined system boundary, and may consist of site specific process data, generic/average process data, process data from literature studies and expert estimates, and results from impact assessments. (7.1)
Process Subdivision	Method of dividing the common process into sub-processes in order to eliminate the need for allocation. (8.1)
Product	Any good or service.
Product Differentiation	*A* broad term encompassing all the specific end uses of product level GHG inventory that can help a company distinguish their product in the market place. (1.3.1)
Product Distribution & Storage Stage	Stage from when the product leaves the gate of the fabrication facility to when the consumer purchases the product for use. Several legs of distribution and storage can occur for one product, with storage included storage at a distribution center and a retail location if applicable. (6.3)
Product level GHG inventory	Compilation and evaluation of the inputs, outputs and the potential GHG impacts of a product system throughout its life cycle. (1.1)
Product System	The collection of processes that make up the boundary of a product level GHG inventory.
Production Stage	Stage from when the product components enter the production site to when the final product leaving the production gate. (6.3)
Proxy Data	Primary or secondary data related to a similar (but not representative) input, process, or activity to the one in the inventory, which are directly transferred or generalized to the input, process, or activity of interest without being adapted or customized to make more representative. (Box 7.1)
Raw Material	Primary or secondary material that is used to produce a product (note: secondary includes recycled material). (6.3) Source: ISO 14044:2006

Raw Material Acquisition and Preprocessing Stage	Stage from when the material is extracted from nature, to when the product components reach the gate of the fabrication facility or service delivery operation. This stage includes the processes between the natural resources and the raw material which is supplied in the form of ingots, granules, powders, etc. as needed for the fabrication process. If several materials are used for the product, several raw material acquisition stages may be included within the boundary. (6.3)
Relevance (principle)	Ensure the product GHG report serves the decision-making needs of all users identified within the report. Present information in the report in a way that is readily understandable by the intended users with a reasonable knowledge of GHG accounting and who are willing to study the information. (2)
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	Data that are not collected from specific processes within a product's life cycle or specific sources within a company's operations or its supply chain. Secondary data include industry-average data, data from literature studies, and data from published databases. (Box 7.1)
Subject Products	Products used within the product system under study. (8.1)
System Expansion	A method of expanding the functional unit of a study to avoid allocation. (8.1)
Technological representativeness (data quality indicator)	Degree to which the data set reflects the true population of interest regarding technology, including any background data sets used. (9.2.2)
Temporal representativeness (data quality indicator)	Degree to which the data set reflects the true population of interest regarding time / age of the data, including any background data sets used or whether an appropriate time period is used (e.g., for food products annual/seasonal averages or average of several seasons may be appropriate to smooth out data variability due to factors such as weather conditions). (9.2.2)
Third Party ("External") Assurance	Assurance provided by persons from a certification or assurance body independent of the product GHG inventory determination process. (11.1)
Transparency (principle)	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. (2)
Uncertainty	Measure of the knowledge of the magnitude of a parameter. Uncertainty can be reduced by research, i.e., the parameter value can be refined. Uncertainty is quantified as a distribution. (9.2.3)

Use Stage	Stage from when a consumer purchases the product and to when the used product enters the end of life stage. (6.3)
Variance	A measure of the heterogeneity of a landscape parameter or the inherent variability in a chemical property. Variance cannot be reduced by further research. It is quantified as a distribution. (9.2.3)

Appendix F: References

The following documents provide further information to assist in the application of this standard.

- WRI/WBCSD GHG Protocol Corporate Accounting and Reporting Standard (Revised Edition) (http://www.ghgprotocol.org/standards/corporate-standard)
- WRI/WBCSD GHG Protocol for Project Accounting (http://www.ghgprotocol.org/standards/project-protocol)
- ISO 14040:2006: Life Cycle Assessment – Principles and Framework
- ISO 14044:2006: Life Cycle Assessment – Requirements and Guidelines
- BSI/Carbon Trust/BSI/Defra. PAS 2050:2008 – Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. (http://www.pas2050.com)
- BSI/Carbon Trust/Defra. Guide to PAS 2050: How to assess the GHG inventory of goods and services. (http://www.pas2050.com
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- ISO 14025 – Environmental labels and declarations - Type III environmental declarations -- Principles and procedures
- ISO 14065 – "Requirements for greenhouse gas validation and verification bodies for use in accreditation or other forms of recognition"
- ISAE 3000 – "International Standard on Assurance Engagements 3000 (Revised) – 'Assurance Engagements other than Audits and Reviews of Historical Financial Information' issued by the International Auditing and Assurance Standards Board.
- International Framework for Assurance Engagements, issued by the International Auditing and Assurance Standards Board.
- ISQC1 - International Standard on Quality Control 1, Quality Controls for Firms that Perform Audits and Reviews of Financial Statements, and Other Assurance and Related Services Engagements
- ISO 14064-3:2006, Greenhouse gases — Part 3: Specification with guidance for the validation and verification of greenhouse gas assertions

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Chapter 7: Collecting Data

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Appendix B: Land Use and Land Use Change Emissions

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