World Business Council for Sustainable Development

WORLD RESOURCES INSTITUTE

The Greenhouse Gas Protocol Initiative

the foundation for sound and sustainable climate strategies

Product Accounting & Reporting Standard

DRAFT FOR STAKEHOLDER REVIEW

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Table of Contents

1 Introduction 1-3
2 Goal of the *Product Standard* 2-6
3 Business Goals 3-8
4 Principles of Product GHG Accounting & Reporting 4-11
5 Fundamentals of Product Life Cycle GHG Accounting 5-12
6 Establishing the Scope of a Product Inventory 6-16
7 Boundary Setting 7-21
8 Allocation 8-34
9 Collecting Data & Assessing Data Quality 9-50
10 Data Management Plan 10-62
11 Assessing Uncertainty 11-67
12 Calculating Inventory Results 12-73
13 Assurance 13-77
14 Reporting 14-90
15 Setting Reduction Targets and Tracking Inventory Changes over Time 15-97
Appendix A - Guidance on Product Comparison 16-101
Appendix B - Guidance for Program Designers and Policy Developers 17-103
Appendix C - Land Use Change Impacts 18-105
Appendix D - Supplier Engagement 19-115
Appendix E - Quantitative Inventory Uncertainty 20-118
Appendix F - Public Report Template 21-126
Appendix G - Glossary 22-131

1 Introduction

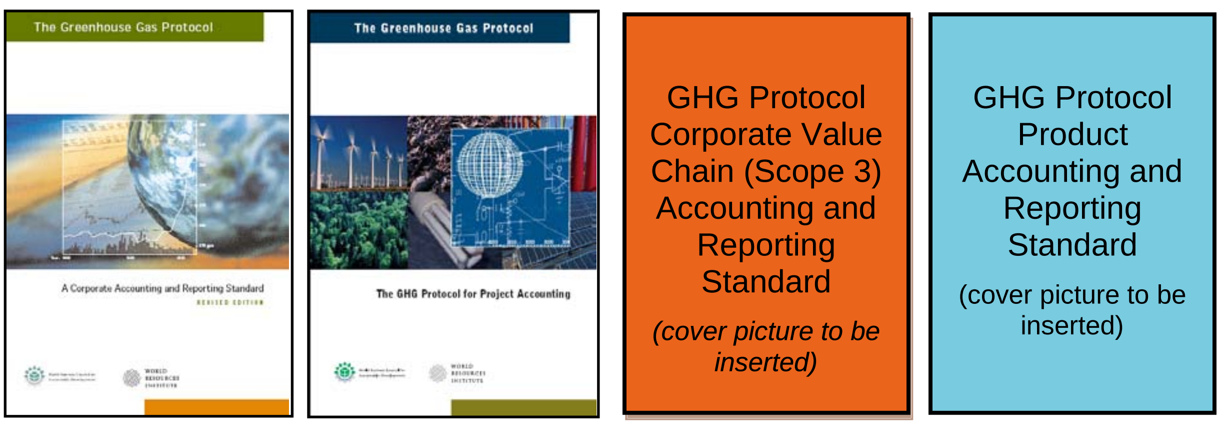
The Greenhouse Gas Protocol Initiative is a multi-stakeholder partnership of businesses, non-governmental organizations (NGOs), governments and others convened by the World Resources Institute (WRI), a U.S.-based environmental NGO and the World Business Council for Sustainable Development (WBCSD), a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

The GHG Protocol Initiative has produced the following separate but complementary standards:

- **GHG Protocol *Corporate Accounting and Reporting Standard*[1] (2004):** a standardized methodology for companies to quantify and report their corporate GHG emissions
- **GHG Protocol for *Project Accounting* (2005):** a guide for quantifying reductions from GHG mitigation projects

In 2008, the GHG Protocol launched an initiative to develop two new standards:

- **GHG Protocol *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*[2] (to be published in 2011):** a standardized methodology for companies to quantify and report their corporate value chain (Scope 3) GHG emissions, and is intended to be used in conjunction with the *GHG Protocol Corporate Accounting and Reporting Standard*
- **GHG Protocol *Product Accounting and Reporting Standard*[3] (to be published in 2011):** a standardized methodology to quantify and report the greenhouse gas emissions throughout a product's life cycle



The GHG Protocol Initiative has also published a number of sector-specific protocols and guidance, including:

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[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.

[2] This is referred to in short as the "Scope 3 Standard".

[3] This is referred to in short as the "Product Standard".

- **GHG Protocol for the U.S. Public Sector (2010):** provides a step-by-step approach to measuring and reporting emissions from public sector organizations, and complementary to the GHG Corporate Protocol
- **GHG Protocol Guidelines for Quantifying GHG Reductions from Grid-Connected Electricity Projects (2007):** explains how to quantify reductions in emissions that either generate or reduce the consumption of electricity transmitted over power grids, and used in conjunction with the Project Protocol
- **GHG Protocol Land Use, Land-Use Change and Forestry Guidance for GHG Project Accounting (2006):** explains how to quantify and report reductions from land use, land-use change and forestry, and used in conjunction with the Project Protocol
- **Measuring to Manage: A Guide to Designing GHG Accounting and Reporting Programs (2007):** provides guidance to program developers on designing and implementing effective GHG programs based on accepted standards and methodologies

1.1 Standard Development Process

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

The standard development process for the GHG Protocol *Product Standard* is occurring in parallel with the process to develop the GHG Protocol *Scope 3 Standard*. This joint process includes active participation from a large and diverse set of stakeholders and organizations. The process has a number of diverse stakeholder groups that oversee and direct the overall development of the standards. The 25-member Steering Committee provides strategic and technical direction to the process. Seven Technical Working Groups, consisting of over 160 members, developed the first draft of the standards through frequent consultations. A Stakeholder Advisory Group, comprised of more than 1,400 participants, has provided comments and feedback on the draft standards. A Road Testing group of over 60 companies piloted one or both standards within their organizations and provided feedback based on their experiences.

This second draft of the *Product Standard* was developed between July 2010 and October 2010. Revisions from the first draft (November 2009) were based on:

- Written comment from over 60 organizations in the stakeholder advisory group
- Stakeholder comments received during five in-person stakeholder workshops, attended by over 350 participants (November – December 2009)
- Feedback from approximately 40 road testing companies during an in-person road testing workshop (May 2010)
- Written feedback from approximately 40 road testing companies on the *Draft for Road Testing* (July 2010)
- Feedback from the Steering Committee (June 2010)
- Feedback received from Technical Working Group members during two webinars (April 2010 and August 2010)

The next steps to complete the *Product Standard* include:

- 30 day public comment period on the second draft of the *Product Standard*
- Revise the second draft based on feedback received
- Finalize text of the standard by Winter 2011
- Publish the final standard in Spring/Summer 2011

Figure 1-1: Standard Development Process Structure

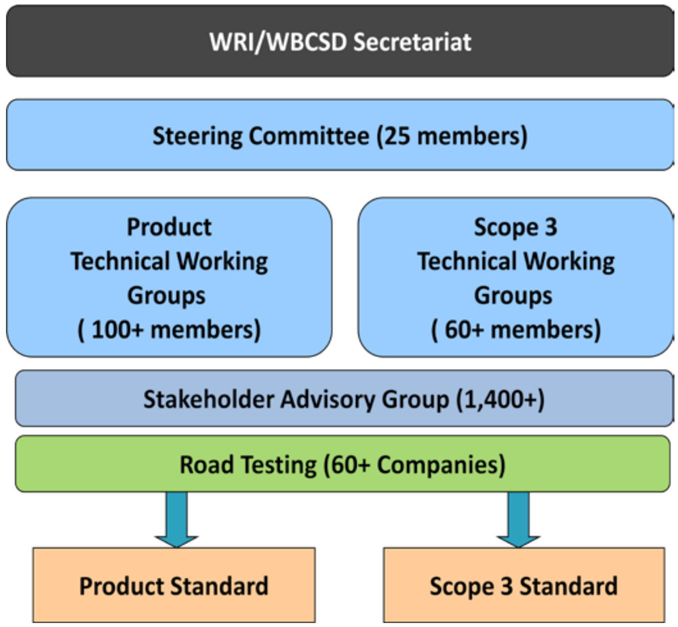

Figure 1-2: Product Standard Development Timeline

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)
Summer 2009	✓ Technical Working Group Meeting #2 (Washington DC) ✓ Stakeholder webinar and comment period
October 2009	✓ Steering Committee Meeting #3 (Washington DC)
November - December 2009	✓ First draft of standard released for stakeholder review ✓ Five stakeholder workshops (in Berlin, Germany; Guangzhou, China; Beijing, China; London, UK; Washington, DC, USA) ✓ Stakeholder comment period on first draft
January - June 2010	✓ Road testing by 40+ companies ✓ Steering Committee Meeting #4 (Oslo)
November 2010	▪ Public comment period on second draft
Winter 2011*	▪ Release final requirements and key guidance
Spring/Summer 2011	▪ Publication of final standard

*This data is subject to change based on the feedback received during the public comment period

2 Goal of the *Product Standard*

> *Product* – any good 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 GHG inventory* – Compilation and evaluation of the inputs, outputs and the potential GHG impacts of a product system throughout its life cycle.

The *GHG Protocol Product Accounting and Reporting Standard* (referred to as the *Product Standard*) provides requirements and guidance for companies and other organizations to prepare and publicly report an inventory of emissions associated with a product. This standard provides a general framework to support GHG quantification and reporting for many different types of products. The primary goal of the standard is to support companies to 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 are increasingly receiving demands from stakeholders to measure and disclose their corporate GHG inventories, and more and more, this demand also includes a company's products and supply chain emissions. Public reporting serves to satisfy stakeholder demands for greater disclosure around GHG inventory of products.

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 mitigate released emissions.

2.1 Use of the Standard for Product Comparison

The *Product Standard* is intended to support performance tracking of a product over time. For product labeling, performance claims by third parties, consumer and business decision making based on comparison of two products, and other types of product comparison, additional specifications are needed. Comparative assertions are not supported by the GHG Protocol *Product Standard*. (See Appendix A for more guidance on additional specifications needed for comparison).

> *Comparative assertion* – an environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same as function (ISO 14044:2006)

2.2 Who should use this Standard

This standard is designed for companies and organizations[4] of all sizes in all economic sectors. Companies seeking a better understanding of the GHG impacts of products they design, manufacture, sell, purchase or use can benefit from the use of this standard. Interested users of product inventories within companies could include staff from product design, procurement, marketing, energy, environment, and corporate sustainability departments.

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

2.3 Relationship between the Scope 3 and Product Standards

The GHG Protocol *Scope 3 Standard* and GHG Protocol *Product Standard* both take a full value chain or life cycle approach to GHG accounting. The *Scope 3 Standard* accounts for emissions at the corporate level, while the *Product Standard* accounts for emissions at the individual product level.

Together, both standards provide a comprehensive approach to value chain GHG management based on a company's business goals. They allow a company to focus on emissions related to its operations and its products, at both a corporate level and a product level. Companies should use both standards as part of a comprehensive approach to GHG measurement and management.

Figure 2-1 illustrates a simplified example of how the standards work together for a company that manufactures two products.

While each standard can be implemented without using the other, both standards are mutually supportive. Before implementing the *Product Standard*, companies may find it useful to account for Scope 3 emissions in order to identify the individual product categories that contribute most to total value chain emissions. Companies can conduct life cycle inventories for targeted products using the *Product Standard*, which can inform more detailed GHG reduction strategies. Conversely, companies conducting Scope 3 inventories may use product level GHG data based on the GHG Protocol *Product Standard* to calculate upstream and downstream Scope 3 emissions of associated products.

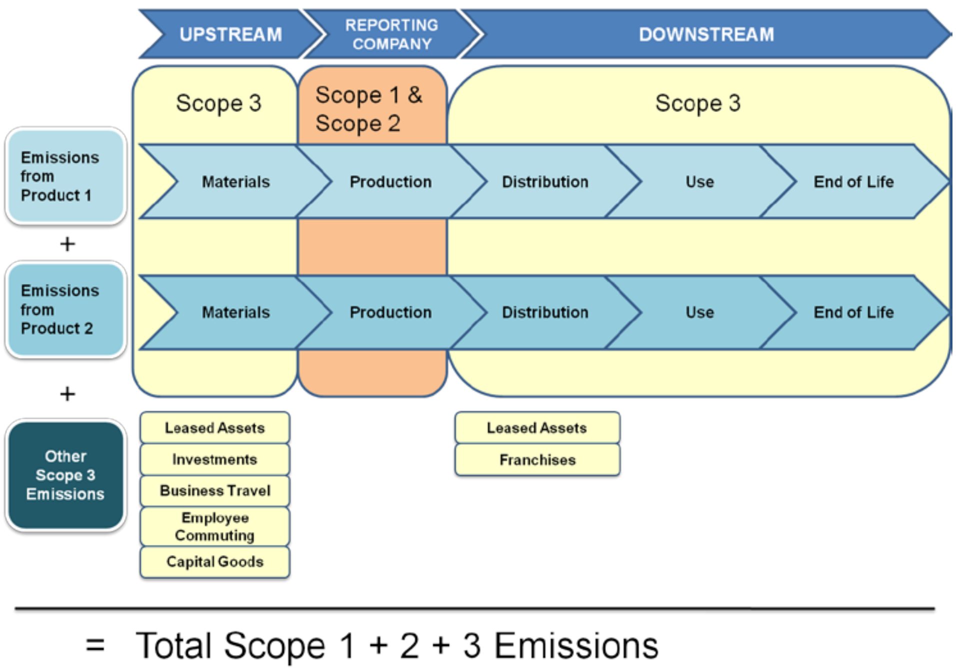

Figure 2-1: Example of a Scope 3 Inventory for a Manufacturing Company

2.4 Standard Terminology

The following chapters outline the requirements and guidance for completing a GHG inventory. 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. Within the guidance sections, the term "***required***" is used to refer to requirements in the standard. Also within the guidance sections, "***needs***", "***can***", or "***cannot***" are sometimes used to provide guidance on implementing a requirement or to indicate when an action is or is not possible.

3 Business Goals

Companies conducting product GHG inventories and undertaking public reporting may find that the process creates business value through:

- Identifying opportunities in a product's life cycle;
- Assessing GHG risks in a product's life cycle;
- Tracking performance;
- Differentiating products; and
- Engaging suppliers.

Companies should identify the business goals driving their decision to undertake a product level inventory. Doing so should bring clarity and help in selecting the right methodology and data to develop the inventory. Companies are required to report business goals in the public GHG inventory report (see Chapter 14, Reporting).

Identifying GHG reduction opportunities in the product life cycle

Business Goal	Description
Identifying GHG reduction opportunities in the product life cycle	A company uses a product GHG inventory to investigate new GHG reduction and cost-saving opportunities throughout the life cycle of a product

Product 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 life cycle. 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 life cycle.

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

Assessing GHG risks in a product's life cycle

Business Goal	Description
Identifying GHG risk in the life cycle	A company uses a product GHG inventory to assess risks from GHG regulations and from fluctuations in energy costs and availability

GHG regulations are already in place in a number of countries and may be enacted in a growing number of countries in the future. Energy is becoming a scarcer resource which creates price volatility and reduced reliability. Understanding the location and amount of GHGs embedded in a product is valuable information when assessing a company's risk exposure from that product.

This business goal has both internal and external uses. A company may use a product inventory to evaluate the GHG "hot spots" in a life cycle to model potential future costs of regulations. The "hot spots" may also be an indication of where there are energy intensive operations in the life cycle and provide incentive to develop a strategy to reduce dependency on fossil fuels such as switching to a less energy intensive product material or increasing the use of intermodal transportation to distribute products. An increasing number of stakeholders (e.g., investors) would also like to see this risk assessment publicly reported and there is growing demand for disclosure to become mandatory in some countries.

Performance tracking

Business Goal	Description
Performance tracking	A company utilizes a product GHG inventory to establish performance metrics and targets for tracking continual improvement of a product over time

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	A company conducts a product level GHG inventory and pursues reduction opportunities or design changes 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 inventories that may help a company distinguish its products in the marketplace. Comparisons 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 the ability for companies to communicate with these consumers about their efforts to measure and reduce their product impacts.

Supply chain engagement

Business Goal	Description
Supply chain engagement	A company engages stakeholders (including suppliers and customers) throughout its life cycle to reduce emissions and strengthen connections

Product GHG accounting requires communication with multiple stakeholders (including suppliers and customers) along the product life cycle. From raw material vendors to final consumers, product inventories provide an opportunity for firms to engage with stakeholders throughout a product's life cycle towards the common goal of reducing GHG emissions. Product inventories should support engagement with suppliers to reduce product life cycle GHG emissions. The inventory process may require soliciting measurements that suppliers have never taken before. In accordance with the axiom "what gets measured gets managed", this process may encourage emissions reductions. A product 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.

4 Principles of Product GHG Accounting & Reporting

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 inventory constitutes a true and fair representation of the company's product-level GHG emissions and removals[5]. Their primary function is to guide users in the implementation of this standard, in particular when facing decisions that are not specified in the standard.

Relevance

Ensure the product GHG inventory quantification methodologies and 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

Completeness

Ensure that the inventory report covers all product life cycle GHG emissions and removals within the specified boundaries, document and disclose any life cycle stages or significant non-GHG environmental impacts that have been excluded, and justify these exclusions.

Consistency

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

Transparency

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

Accuracy

Ensure that reported GHG emissions and removals are not systematically greater than or less than actual emissions and removals, and 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.

[5] In this standard, both emissions to the atmosphere and removals from the atmosphere are accounted for to calculate the total GHG impact of a product. Removals generally occur when biogenic carbon is used within the product's life cycle, as CO_2 is removed from the atmosphere during photosynthesis.

5 Fundamentals of Product Life Cycle GHG Accounting

5.1 Introduction to Life Cycle Assessment

The *Product Standard* provides a framework for companies to perform product life cycle GHG inventories. Product life cycle GHG accounting is a subset of life cycle assessment (LCA), which seeks to quantify and address the environmental aspects and potential environmental impacts throughout a product's life cycle from raw material extraction through to end-of-life waste treatment (ISO 14044:2006)[6]. LCA emerged as a multi-criteria environmental assessment method in the 1960s, and then resurfaced in the late 1980s as a way to identify holistic solutions to the growing amount of solid waste worldwide. LCA became internationally standardized by the International Standards Organization (ISO) with the publication of the 14040 series of life cycle assessment standards, an important step to consolidate procedures and methods of LCA.[7]

The *Product Standard* builds on the framework and requirements established in the ISO LCA standards (*14040:2006, Life Cycle Assessment: Principles and Framework* and *14044:2006, Life Cycle Assessment: Requirements and Guidelines),* with the intent of providing additional prescriptiveness and guidance to facilitate the consistent quantification and public reporting of product life cycle GHG inventories. In addition to the ISO standards, other standards and publications such as *PAS 2050*[8] and the *ILCD Handbook*[9] were used as reference during the development of this standard. The following sections clarify the relationship between the ISO LCA standards and the *Product Standard* while identifying two fundamentals on which the *Product Standard* is based: the life cycle and attributional approaches to GHG accounting. The last section defines the terminology used to identify requirements and guidance throughout this standard.

5.2 Life Cycle Approach

Product GHG inventories[10], also commonly known as product carbon footprints, are a subset of LCA because they focus only on the climate change impact category (the limitations of which are discussed in section 5.5). However, the accounting methodologies, and requirements presented in this standard follow the life cycle approach as established by ISO LCA standards.

The ISO LCA standards define four phases of a LCA study: the goal and scope definition, inventory analysis, impact assessment, and interpretation. To report the results of an LCA study, ISO also defines critical review and reporting as additional steps beyond these phases. **Figure 5-1** shows the relationship between the phases of an LCA study defined by ISO and the steps to completing a GHG inventory in conformance with this standard.

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[6] (ISO 14044:2006), International Organization of Standardization, 2006, Life Cycle Assessment: Requirements and Guidelines

[7] Finkbeiner, M. *et al*., The New International Standards for Life Cycle Assessment: ISO 14040 and ISO 14044. International Journal of Life Cycle Assessment, 11 (2) 80-85, 2006.

[8] BSI *et al.*, PAS 2050:2008: Specification for the assessment of life cycle greenhouse gas emissions of goods and services.

[9] (ILCD, 2010) Joint Research Commission, 2010, ILCD Handbook: General Guide for Life Cycle Assessment

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

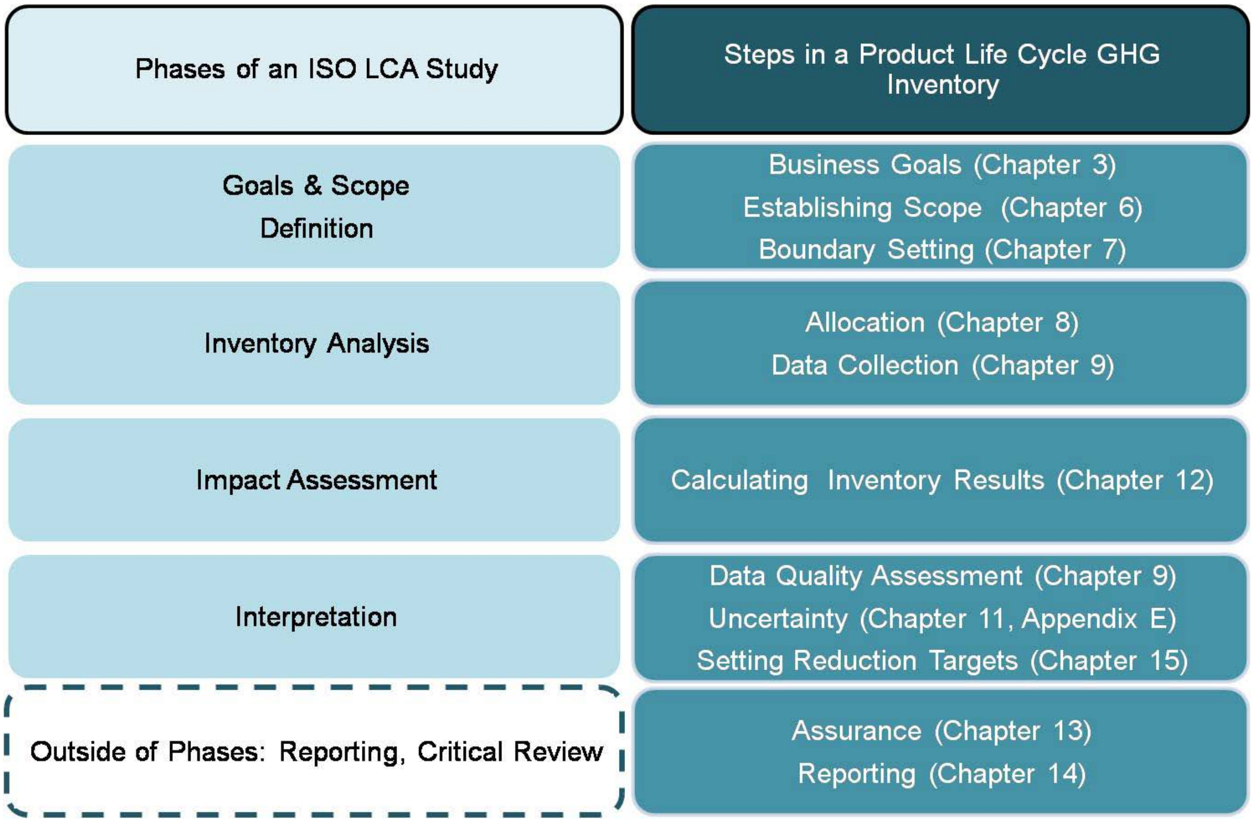

Figure 5-1: The Relationship between the Stages of an ISO LCA Study and the Steps to Performing a *Product Standard* GHG Inventory

LCA is by nature an iterative technique, where each phase or step is dependent on the results or methodologies used in another (previous or subsequent) phase or step. For example, defining the unit of analysis is a step that directly impacts the subsequent steps of boundary setting, data collection, and allocation. However, a company may find that to avoid allocation (as defined in Chapter 8) they need to redefine the unit of analysis. Boundary setting, data collection, and data quality are dependent on one another; setting the boundary (Chapter 7) is the first step in identifying what data are needed by determining attributable processes, but data collection limitations (as defined in Chapter 9) may result in the exclusion of some processes from the inventory results. The business goals of the company completing the inventory should be considered during each step to ensure that the final inventory results achieve those goals.

Box 5-1: ISO Principles of LCA

ISO defines seven general principles of LCA to use as guidance during the planning and conducting of an LCA: life cycle perspective; environmental focus; relative approach and functional unit; iterative approach; transparency; comprehensiveness; and a priority of scientific approach. Besides comprehensiveness[11], all of these principles are embedded within the requirements of the *Product Standard*. In this standard, companies are required to define a unit of analysis (functional unit), define the boundary in terms of interconnected life cycle stages, and transparently justify and report results, exclusions, and methodology choices. When possible, natural science (e.g. chemistry, physics, biology) should be the basis for all choices that influence how emissions are accounted for or allocated during the inventory process.

5.3 Attributional Approach

The requirements and guidance in this standard follow the attributional approach to life cycle accounting. Applied to this standard, the attributional approach accounts for the GHG impacts of a product over its lifecycle, making use of historical, fact-based, and measurable data and including all processes that are identified to relevantly contribute (i.e., be attributable as defined in Chapter 7) to the studied product's life cycle [12]. The attributional approach is most commonly used when accounting for life cycle emissions.

The consequential method is another approach for performing LCA. The consequential method, also known as a decision or market-based method is used to identify consequences that a decision to change a process or input in a product's life cycle has on other processes and life cycles. Results from the consequential method do not reflect the actual or average life cycle of a product, but rather a hypothetic life cycle based on market changes or other external factors such as policies and consumer behaviors[13]. While the consequential method can provide valuable insight, particularly when evaluating projects for reductions along the life cycle or when making policy decisions, an attributional inventory is needed to first accurately account and measure the GHG impacts of a product.

5.4 Use of Sector Guidance and Product Rules

As mentioned in Section 2.1, product comparisons, beyond tracking product performance over time, need additional specifications to this standard to be performed correctly. More details on what those additional specifications may include are available in Appendix A but in general these specifications come in the form of sector guidance or product rules. Sector guidance is typically created by a group of stakeholders and sector representatives convened to build consensus within the group on guidance for performing a GHG inventory within their sector. This guidance is typically less specific than product rules and often provides assistance on accounting issues specific to the sector. Product rules are typically created when a group of stakeholders with interest in a particular product or product category build consensus around rules to enable comparison or declarations about the product. An example of a product rule is a product category rule (PCR) defined by ISO as a mechanism to create environmental product declarations (EPD) (ISO 14025:2006).

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[11] The comprehensiveness principle states that the LCA consider all attributes or aspects of natural environment, resources, and human health (ISO 14040). The principle is not followed by the Product Standard because only one environmental impact, climate change, is considered.

[12] (ILCD, 2010) Joint Research Commission, 2010, ILCD Handbook: General Guide for Life Cycle Assessment

[13](ILCD, 2010) Joint Research Commission, 2010, ILCD Handbook: General Guide for Life Cycle Assessment

While not required for use with this standard, both sector guidance and product rules can provide additional guidance that companies may find helpful when performing product inventories. Additional guidance may be helpful in defining a unit of analysis, identifying attributable processes during boundary setting, choosing the most appropriate allocation method, or collecting activity data and emission factors to ensure consistency within a product category or sector. Throughout the guidance in this standard, a note is given when a product rule of sector guidance may be helpful during a certain inventory step.

Companies should use product rules or sector guidance documents that are created in conformance with the *Product Standard*. If existing product rules or guidance documents are not in conformance with the entire *Product Standard*, companies may use specific guidance sections within the guidance documents that are in conformance with the standard while following the *Product Standard* for general guidance on the remaining sections.

For example, companies may use a product rule to help choose an allocation method as long as the method is in conformance with the allocation principles in Chapter 8 and performed using the attributional approach. However, companies may not use guidance on boundary setting if the product rule excludes attributable processes without justification. Any sector guidance or product rules used during the inventory process are required to be referenced in the inventory report.

5.5 Limitations of GHG Inventories

The limitation of single-impact LCA is that potential trade-offs or co-benefits between environmental impacts can be missed. Non-GHG environmental impacts that occur during the life cycle of a product should be considered before making any decisions to reduce environmental impacts based on the inventory results. Examples of potentially significant non-GHG impacts for some products include ecosystem degradation, resource depletion, ozone depletion, and negative human health impacts.

While this standard focuses solely on climate change impacts, the accounting requirements and guidance provided in this standard can be used to collect life cycle data for any environmental impact. Companies wishing to include non-GHG impacts along with their GHG inventory should determine which impact assessment methodology to use following the requirements for life cycle impact assessment (LCIA) in the ISO LCA standards (14044:2006).

6 Establishing the Scope of a Product Inventory

Taking time to make sure the product inventory scope[14] is in line with the company's business goals can help ensure the final inventory provides the information and tools the company needs to meet their goals. Establishing the scope of a product GHG inventory includes three important steps: choosing a product, defining the unit of analysis, and identifying the reference flow. The requirements and guidance for establishing the scope of a product inventory are detailed below.

Studied Product – the product for which the GHG inventory is performed

Functional Unit – The quantified performance of the studied product

Reference Flow – the amount of studied product needed to fulfill the function defined in the unit of analysis

Intermediate Products – goods that are used as inputs to the production of other goods or services and require further processing, transformation, or inclusion in another product before use by the end consumer.

Final Product – goods and services that are consumed by the end user in their current form, without further processing, transformation, or inclusion in another product.

6.1 Requirements

A GHG inventory performed in conformance with the *Product Standard* shall abide by the life cycle and attributional approaches of product life cycle GHG accounting (see Chapter 5 for definitions of the life cycle and attributional approaches).

To establish the scope of the GHG inventory, companies shall identify the studied product, and then define the unit of analysis and reference flow.

The unit of analysis shall be the same in future inventories to enable the company to make comparisons and track performance over time.

For all final products, the unit of analysis shall be defined as a functional unit, which is the quantified performance of the studied product.

For intermediate products where the eventual function is unknown the unit of analysis shall be defined as the reference flow.

Companies shall disclose the studied product, unit of analysis, and reference flow in the inventory report.

6.2 Guidance

Companies should carefully plan their investment in product GHG accounting by selecting a studied product with the greatest potential to achieve their business goals. As defined in **Chapter 3**, companies may find business value in engaging with suppliers and identifying GHG reduction opportunities along the product's life cycle, assessing GHG risks in the product's life cycle, tracking the performance of GHG reduction targets over time, and creating opportunities for product differentiation in the marketplace.

Companies should read the entire standard before establishing the scope to understand how all the standard requirements fit together and recognize how decisions made when establishing the scope may influence other requirements.

[14] The product inventory scope is different from the scopes concept in the Corporate Standard or Corporate Value Chain (Scope 3) Standard.

6.2.1 Choosing the Studied Product

The studied product is defined as the product on which the GHG inventory is performed. Therefore, the results of the GHG inventory represent the life cycle GHG impacts of the studied product. The chosen studied product should satisfy the company's business goals for completing a product GHG inventory.

A cursory review or screening exercise of all the products a company produces, distributes, buys, or sells[15] is the first step to identifying the studied product. If a company has completed a corporate-wide Scope 3 GHG inventory following the *GHG Protocol Corporate Value Chain (Scope 3) Standard*, the results of the Scope 3 inventory can be used to quickly identify products or product categories with the greatest GHG impact. If a Scope 3 inventory is not available, companies may look to environmentally extended input-output tables to estimate the GHG intensity of products based on economic transactions. If neither is available, companies may use physical or economic factors to rank products by mass, volume, or spend. This option is least preferred because physical or economic factors alone may not correlate with GHG intensity.

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

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

For service-oriented companies, the method for choosing the studied service may vary depending on the company structure. For example, companies that provide one service can focus their inventory on that particular service. If a company provides multiple services, screening using a Scope 3 inventory or money received for services rendered may provide some guidance on choosing the best service for a GHG inventory.

6.2.2 Defining the Unit of Analysis

Companies are required to define the unit of analysis for the GHG inventory. The unit of analysis defines the performance characteristics and services delivered by the product being studied. The unit of analysis includes information about the product, such as the function or service a product fulfills, the duration or service life (amount of time needed to fulfill the function), and the expected level of quality. Based on the unit of analysis, the reference flow (amount of product needed to fulfill the function) is determined.

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

- The duration and service life of the function are the basis for the product's use profile during boundary setting

[15] Whether the studied product is produced, distributed, or sold by the reporting company depends on the company's position in the product's life cycle. For example, a manufacturing company should screen products they produce, while a retail company would screen products they buy and sell. More guidance is available in Chapter 6.

- The reference flow is the basis for all data collection as it defines the magnitude of material or energy inputs and outputs
- A well-defined unit of analysis can avoid allocation by defining a function that includes products and co-products
- The unit of analysis is the basis on which the inventory results are presented, and therefore a clear and easy to understand unit of analysis is important to insure inventory results are interpreted and used correctly

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

Identifying the Function

In most cases, the unit of analysis is the functional unit. The first step to defining a functional unit is to identify the function or functions of the studied product (ISO 14049:2010)[16]. Some questions a company may ask to help identify a product's function include:

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

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

Selecting the Function

The second step is to select the function that serves as the basis of the functional unit. Like the studied product, a carefully chosen function and functional unit provides companies with the greatest potential to achieve their business goals. Most importantly, comparing inventories and tracking GHG reductions over time requires that the inventories are based on the same function and functional unit. Therefore, selecting the right function(s) of the studied product is crucial to track emissions reductions over time.

If multiple functions are identified, companies should base the functional unit on the function that best reflects the GHG impact of the studied product. For example, if one of the functions uses energy or creates GHG emissions, that function best reflects the GHG impact of the product and should be the basis of the functional unit. Another way to choose a function is based on which function best serves a company's business goals. For example, paint fulfills the function of providing wall color and surface protection. If the goal of the company is to reduce GHG emissions by making paint with longer-lasting color that doesn't have to be reapplied as frequently, that is the function on which the functional unit should be based.

In some cases when multiple functions are dependent on each other, choosing one function for the functional unit may result in the need to allocate emissions (more details on allocation are provided in Chapter 8). To avoid allocation, companies should broaden the functional unit to account for each dependent function. For example, the functions of a plastic bottle may be identified as providing storage or providing a container to safely transport a product. If the functional unit only includes providing

[16] (ISO 14049:2010) Environmental management — Life cycle assessment — Examples of application of ISO 14044 to goal and scope definition and inventory analysis

storage, the company may need to allocate emissions associated with filling the bottle and transporting the filled bottle to a retail location between the bottle and the product. Selecting the functional unit basis that incorporates both functions (storage and safe transport of a product), would include both the bottle and the product and therefore avoid allocation.

Defining the Functional Unit

The third step is defining the functional unit and reference flow. A well defined functional unit consists of three general parameters: the magnitude of the function or service; the duration or service life of that function or service; and the expected level of quality. Using the light bulb example, the following three elements define the functional unit:

- The magnitude: lighting 10 square meters
- The duration: 50000 hours
- The quality: with 300 luminance lx and a daylight spectrum at 5600 K

In this example the final functional unit reads as follows: lighting 10 square meters with 300 lx for 50000 hours with daylight spectrum at 5600 K (ISO 14049:2010).

6.2.3 Identifying the Reference Flow

The magnitude, quality and duration parameters are all based on the technical performance characteristics and service life of the studied product; are the basis for the reference flow definition; and can be determined in two general ways. The first is to base these parameters on product rules, sector guidance, or industry average use-profiles and then determine the number of products needed to fulfill the functional unit (i.e., the reference flow). Companies that want inventory results to be comparable to other similar products should use this method to ensure that a consistent functional unit is used, then define the reference flow for their particularly product. For the light bulb example, assuming the parameters were based on a product rule for a light bulb, and the company's own light bulbs have a service life of 10000 hours and quality of 100 lx, the reference flow of the studied product would be defined as 15 bulbs (ISO 14049:2010).

In other cases, companies may define the functional unit parameters to fit a particular reference flow. The reference flow in this case may be based on individual or bulk packaging of a product, or government or industry regulated product specifications (e.g., government recommended serving sizes for food products). It may also be helpful to consider which reference flow would be most meaningful to the user of the report (e.g., the amount of product that a customer usually purchases). For example, to perform an inventory on one light bulb, the functional unit should have parameters of 10000 hours and 100 lx. To report efficiency improvements of a product over time, a company may want to define the parameters so as improvements are made, the reference flow needed to fulfill the same functional unit decreases.

Regardless of how and in what order the functional unit and reference flow are defined, both are required to be disclosed in the inventory report.

Box 6-1: Using Sector Guidance or Product Rules to Define the Functional Unit

Product rules or sector specific guidance can be a useful source of functional unit definitions within product categories, assuming they meet the specifications of this standard. Product- or sector-specific guidelines may be used as the source of the functional unit if they: 1) exist for the product being evaluated; 2) meet the requirements of this standard for the unit of analysis definition as stated above; and 3) meet the goal of the study. In the absence of sector guidance or product rules, industry groups, in consultation with appropriate stakeholders, may want to establish common definitions.

Box 6-2: Case Study: Defining the Unit of Analysis (to be completed)

6.2.4 Defining the Unit of Analysis for Intermediate Products

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 and therefore require further processing or transformation before the use stage. For example, a plastic resin that is eventually transformed into plastic car parts is an intermediate product. 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 and therefore enter the use stage in their current form without further processing or transformation. In general, an intermediate product is a good that eventually becomes a material input into the life cycle of a final product.

Because an intermediate product eventually becomes a material input into a final product, the service an intermediate product fulfills is usually dependent on the function of the final product. Companies that produce intermediate products may not know the function of the final product the intermediate product becomes an input to. When the function is unknown, it is not possible to define the unit of analysis as the functional unit.

In this case, companies are required to define the unit of analysis for an intermediate product as the reference flow. The specific value of the reference flow may vary depending on the type and GHG intensity of the product. A general rule of thumb is to use the amount or weight of a typical shipment of product (for example, a box of 50 units or a slab of 100 kilograms). If the amount of product results in inventory results that are very small, companies should scale up the unit of analysis to more meaningfully report the results.

For intermediate products where the function cannot be defined, companies may perform a cradle-to-gate inventory as defined in Chapter 7. If the function of the final product for which the intermediate product is an input is known, companies should define the functional unit and complete a cradle-to-grave inventory. In this case, companies may find it beneficial to work with the final product producer to develop an inventory on the final product, which avoids allocation and increases primary data collection.

6.2.5 Defining the Unit of Analysis for Services

Defining the unit of analysis for a service should follow the same general procedure outlined in this chapter, but without need to define the function because the studied service is the same as the selected function. As with a good, the magnitude, duration, and quality parameters may be based on sector or product rules, industry average data, or defined by a company to reflect a specific reference flow. For example, a home insurance company may define their functional unit as the provision of premium home insurance coverage for one year. The magnitude and quality of the insurance is specific to the definition of premium.

7 Boundary Setting

Once the scope of the inventory has been established, the next step is to define the boundary of the inventory. During boundary setting, companies identify the processes along the life cycle that are included to collect data and calculate the GHG impact of the studied product.

7.1 Requirements

All attributable processes shall be included in the boundary of the product GHG inventory. Attributable processes shall be disclosed in the inventory report in the form of a process map, mapped through the product's life cycle.

Any exclusion of attributable processes in the inventory results shall be disclosed and justified in the inventory report.

Any non-attributable processes included in the boundary shall be disclosed in the inventory report.

Companies shall disclose the life cycle stage definitions and descriptions in the inventory report.

The boundary for final products shall include the complete life cycle, from material acquisition through end-of-life (i.e., from cradle-to-grave). The boundary of a cradle-to-gate assessment shall not include product use or end-of-life processes in the inventory results. Companies shall disclose and justify when a cradle-to-gate boundary is used in the inventory report.

Attributable Processes – Processes that are directly connected to the studied product and its ability to perform its function by material and energy flows[14]

Life Cycle – Consecutive and interlinked stages, beginning with the extraction of natural resources and ending when the product's material components are returned to nature

Time Boundary – The period of time when attributable processes occur during the product's life cycle

Cradle-to-Gate – An assessment that includes part of the product's life cycle, including material acquisition through the production of the studied product and excluding the use or end-of-life stages

Cradle-to-Grave – An assessment that includes all of the product's life cycle, from material acquisition through end-of-life

The time boundary for the total product's life cycle shall be reported, and the time boundary for individual life cycle stages should be reported when applicable.

7.2 Guidance

7.2.1 Defining Life Cycle Stages & Identifying Attributable Processes

Before mapping out processes that are attributable to the studied product, companies should define the interconnected life cycle stages that make up the product's life cycle. Life cycle stages are useful tools for organizing processes, data collection, and inventory results. The standard identifies five general life cycle stages, which are illustrated in **Figure 7-1** and referred to throughout the standard.

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[17] Examples of material and energy flows into attributable processes include the studied product's components and packaging, materials used to improve the quality of the product (e.g. fertilizers, lubricants) and energy used to move, create, or store the product.

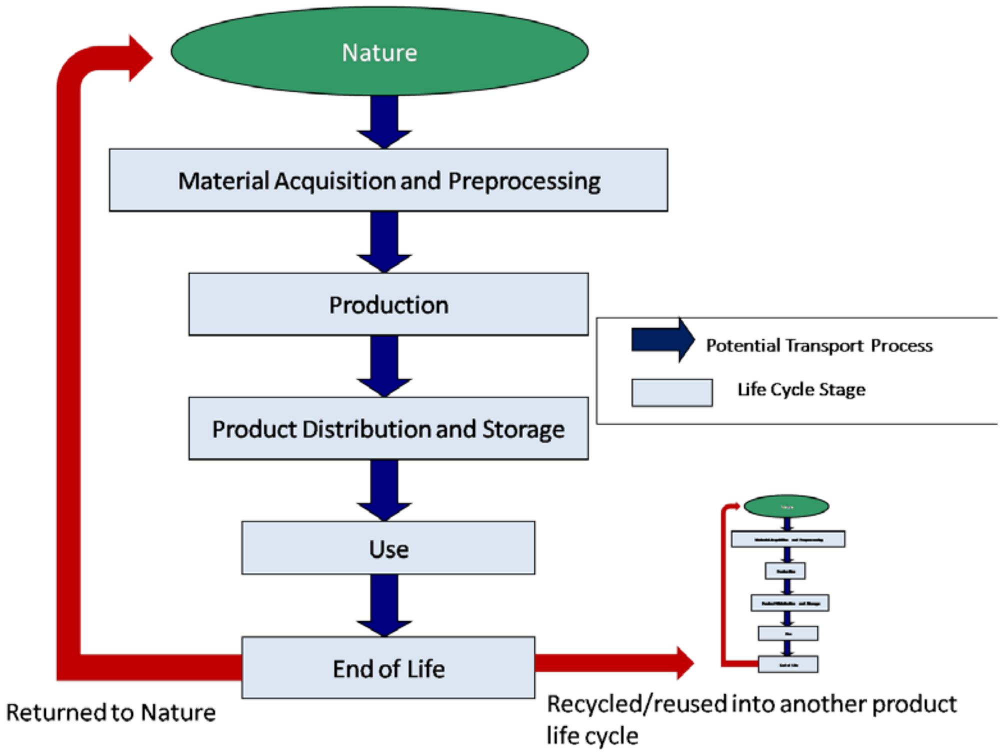

Figure 7-1: The Five Stages of a Product Life Cycle (Simplified for Illustrative Purposes)

Companies should use the stages defined in **Figure 7-1** for consistency, but they may classify the stages differently to better reflect a specific product's life cycle. For example, a company may want to disaggregate into more stages or use a term that better describes the processes taking place within the stage, such as service delivery when the studied product is a service. Regardless, the first stage is required to start with material extraction from nature. All stages should have clear and logical boundaries, and be consecutive and interlinked throughout the life cycle. The following sections give guidance on general boundaries and attributable processes that may be associated with a particular life cycle stage. Life cycle stage definitions and descriptions are required for inclusion in the inventory report.

It is important to note that the perspective of a company influences the life cycle stage that specific processes are reported in. The following guidance is given from the perspective of a company that is performing an inventory on a final product they produce or sell. For companies performing an inventory on an intermediate product, many of the processes termed preprocessing in a final product inventory would occur in the production stage. Additionally, a company using data from an intermediate product inventory for a material input into a final product would include the intermediate product's cradle-to-gate processes as part of the material acquisition and preprocessing stage. As a result, transparency is critical when defining the boundaries and mapping the processes included in each stage.

Box 7-1: 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 has a different perspective along the life cycle of a given product. Depending on an entity's position in the life cycle, a portion of the product's life cycle emissions occurs prior to their involvement, while the remainder of the life cycle emissions occurs subsequently. **Figure 7-2** is an example of a company that sells a final good called a widget. In this example, all material acquisition and material processing occurs prior to the company's involvement in the product's life cycle. **Figure 7-3** is an example of a company that produces an intermediate product to be used in the production of the widget. In this example, widget production occurs subsequent to the company's involvement in the product's life cycle. Understanding a company's perspective within the life cycle of the studied product is important as it influences the definition of life cycle stages, data collection requirements, and supplier engagement opportunities.

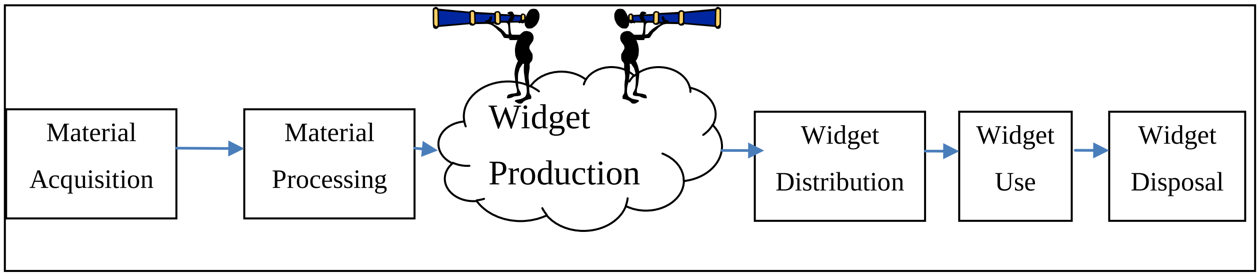

Figure 7-2: Perspective of a Company Producing a Final Product

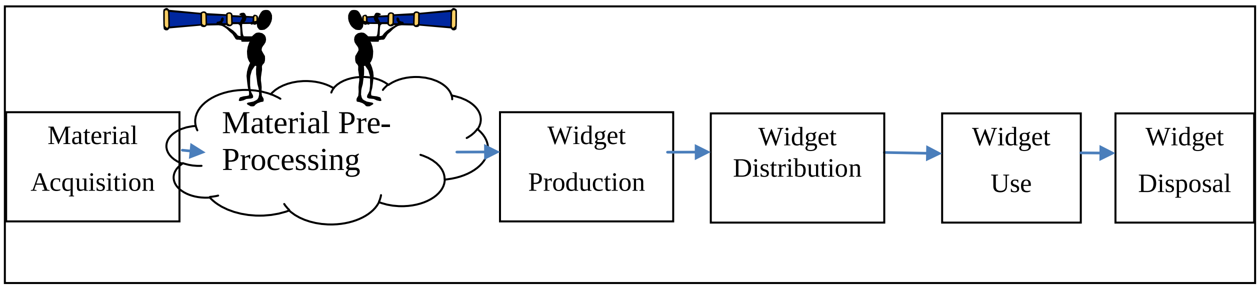

Figure 7-3: Perspective of a Company Producing an Intermediate Product

Material Acquisition and Preprocessing

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

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

- Transportation to the production facility and within extraction and pre-processing facilities

When land use impacts are attributable to a studied product, these processes are also considered in the material acquisition and preprocessing stage. Guidance on determining if land use impacts are attributable is given in Appendix C. Studied products made of biogenic materials may have unique cultivation and harvesting impacts that should be included as attributable processes in the material acquisition stage. For example, rice cultivation produces methane emissions that would be included as a material acquisition impact in the inventory of a rice product.

Box 7-2: GHG Removals

In this standard, both emissions to the atmosphere and removals from the atmosphere are accounted for to determine the GHG impact of a product over its lifecycle. The most common case of GHG removals is when a product is of biogenic origin and CO_2 is absorbed from the atmosphere during photosynthesis. However, removals may also occur when a product absorbs CO_2 during use, or when CO_2 from the atmosphere is used during a processing step along the product's life cycle. During boundary setting, it is important to include where removals may occur along the product's life cycle to make sure removal data are collected later in the inventory process.

The amount of removal calculated for materials of biogenic origin should only reflect the amount of carbon embedded in that material. For example, if a product requires 50 tons of wood input that is 40 percent carbon, 20 tons of CO_2 removal can be assumed. All other removals and emissions due to land use change or other stock changes associated with the use of biogenic materials are accounting for as land use change impacts and are defined in Appendix C.

Production

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

- Chemical processing
- Manufacturing
- Transport of semi-finished products between manufacturing processes
- Assembly of material components
- Preparation for distribution, e.g. packaging
- Treatment of waste
- Storage of GHG emissions[18]

[18] If a process within the production stage (or any other stage where GHGs are emitted) includes storage of emissions, the processes associated with storage (e.g. purification, pipeline transport) are included as attributable processes. The emissions are not required to be reported as emissions, but the amount storage should be noted separately in the inventory report

If scrap material exits the production stage and enters a recycling process that is eventually allocated, this is required to be noted in the production stage description. For more information on what qualifies as a recycling process see Chapter 8.

Product Distribution and Storage

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

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

Use

The use stage begins when the consumer takes possession of the product and ends when the used product is discarded for transport to a waste treatment location. The type and duration of attributable processes in the use stage depends heavily on the function of the product as defined by the functional unit, and the service life required to meet that function. For products that consume energy to fulfill their function, attributable processes in the use stage and their corresponding emissions may account for the largest fraction of impacts over the complete life cycle. Examples of attributable processes may include:

- Transportation to the use location (e.g., consumers driving to their residences)
- Refrigeration at the use location
- Preparation for use (e.g., microwaving)
- Use (e.g., power consumption)
- Repair and maintenance occurring during the usage time[19];

End-of-Life

The end-of-life stage begins when the used product is discarded by the consumer and ends when the product is returned to nature or allocated to another product's life cycle. Because the main attributable process in the end-of-life stage is the method used to treat the product (land filling, recycling, incineration, etc.), companies need to know or assume the fate of the product to map this stage. For products where the use stage and end-of-life stage occur simultaneously because they are fully consumed

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

(e.g., food products, energy), a company should still consider attributable processes associated with the end-of-life of packaging materials if applicable. Examples of attributable processes may include:

- Collection and transport of end-of-life products and packages
- Dismantling of components from end-of-life products
- Shredding and sorting
- Incineration and sorting of bottom ash
- Land filling and landfill maintenance
- Transformation into recycled material, e.g. remelting

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

If the product or some material component of the product exits the use or end-of-life stage and enters a recycling process that is eventually allocated, this is required to be noted in the stage description. Whether this is considered part of the end-of-life or use stage depends on when the recycled material is separated from the studied product; for example, if the product is sent together to disposal and the recycled materials are separated at that facility, the transport to that facility is part of the end-of-life and the separation occurs in the end-of-life stage. If the consumer separates the material themselves (or if the entire product is recycled by the consumer), this occurs at the end of the use stage. For more information on recycling see Chapter 8.

7.2.2 Developing a Process Map

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

1. Identify the defined life cycle stages at the top of the map, from material extraction through to end-of-life (or production for cradle-to-gate inventories).
2. Identify the position on the map where the studied product is finished, and exits the reporting company's gate.
3. Identify component inputs and upstream processing steps necessary to create and transport the finished product, aligning the processes below the appropriate life cycle stage.
4. Identify the energy and material flows associated with each upstream process, including inputs that directly impact the product's ability to perform its function (e.g., fertilizers, lubricants) and outputs such as waste and co-products.
5. For cradle-to-grave inventories, identify the downstream processing steps and energy and material flows needed to distribute, store, and use the studied product.
6. For cradle-to-grave inventories, identify the energy and material inputs needed for the end-of-life of the studied product.

Figure 7-4 illustrates the steps to develop a process map with a generic, simplified cradle-to-grave inventory.

The boundary for intermediate products may include part of the life cycle, from material acquisition through the intermediate product production gate (i.e., from cradle-to-gate). For a cradle-to-gate inventory, the process map ends when the studied product is a finished intermediate product as defined by the reference flow. Companies choosing to report the end-of-life impacts of an intermediate product separately[20] from the inventory results may do so in the inventory report; however, a company may not include a cradle-to-grave process map excluding the use stage to represent a cradle-to-gate inventory in the inventory report, as this may mislead users of the report to think that the end-of-life impacts are included in the results.

[20] There may be a case where the use of a product is unknown, but some end-of-life characteristics of the product would be useful for stakeholders (e.g. degradation processes). In this case companies may include this information in the inventory report as long as it is clearly separated from the inventory results and the process map.

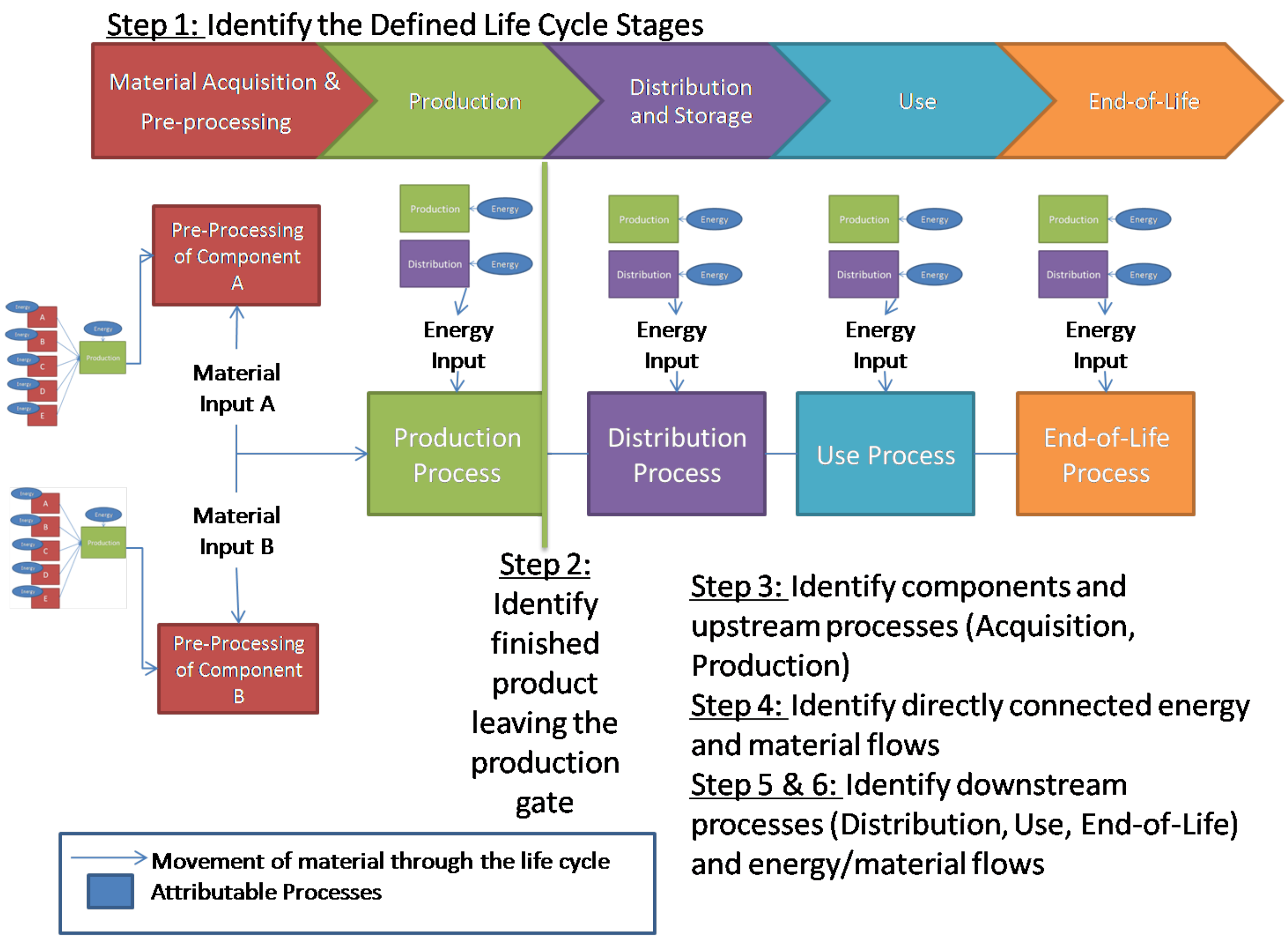

Figure 7-4: Illustrative Steps to Developing a Process Map for a Company that Produces a Final Product

Companies are required to include a process map in their inventory report. If specific details about processes, material, or energy flows are considered confidential, a company may create a simplified version of the process map for the inventory report. At a minimum, the reported process map should make clear:

- The defined life cycle stages
- The generalized attributional processes in each stage
- The flow of the studied product through its life cycle
- Any processes, material, or energy flow excluded from the inventory (see Section 7.2.4 on justified exclusions)

A company should create a detailed process map for internal use and assurance.

An example of a minimal process map to be reported for the cradle-to-grave inventory of a car is given in **Figure 7-5**.

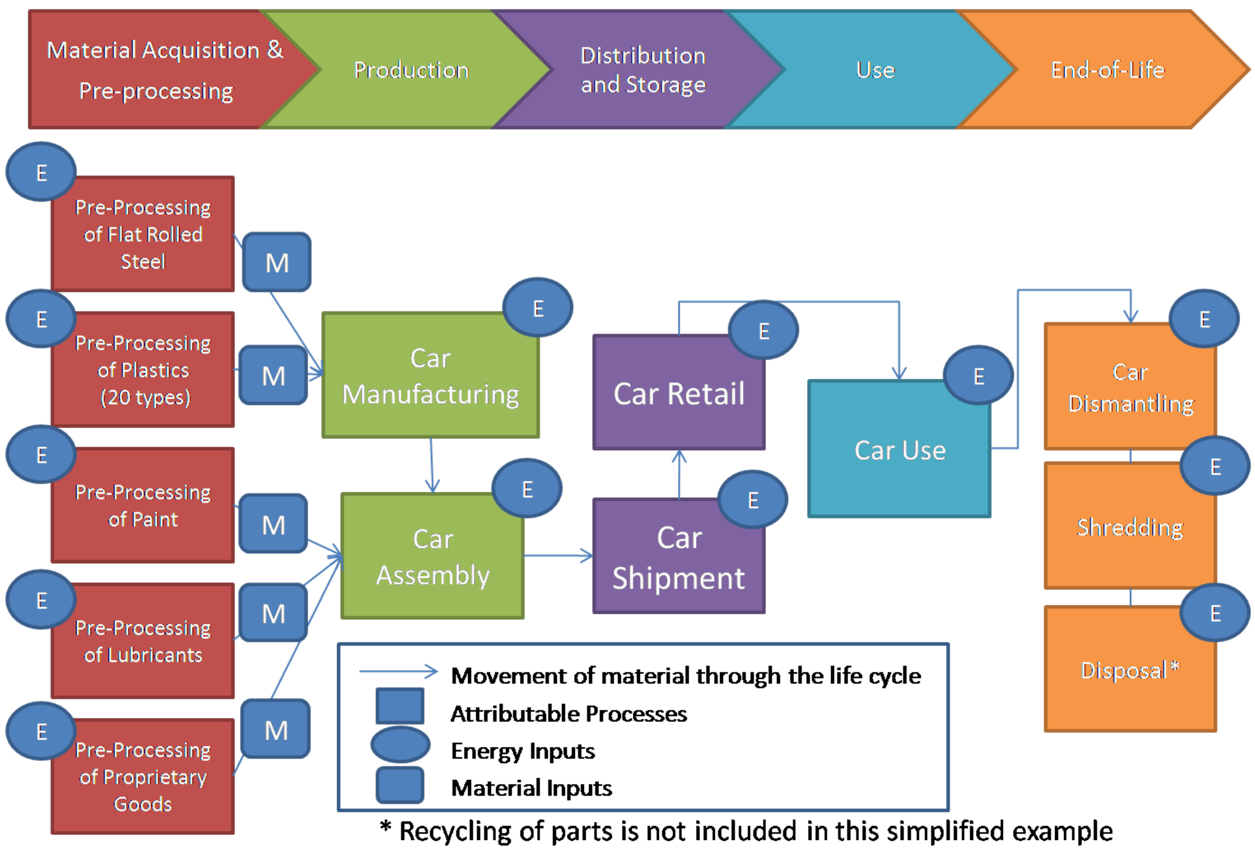

Figure 7-5: Example Process Map for a Car (Cradle-to-Grave Inventory)

7.2.3 Identifying Attributable Processes in the Use and End-of-Life Stages

Companies need to make assumptions about the specific attributable processes used to create, distribute, and sell the studied product as they develop their process map. Because the way a product is used (often referred to as the use profile) can vary significantly between users, companies often find it difficult to determine attributable processes for the use stage. The first step to identifying attributable processes in the use stage is to look to the functional unit definition for the product. The defined function, as well as the duration and quality of service provided by the product, should help identify the use profile processes. Because the service life does not always correspond directly to the use profile, companies should assume a profile that most accurately represents the use of their product while abiding by the attributional approach of the standard as well as the data collection requirement that specific data be used whenever possible. This could be data collected from customer surveys when available, or data based on industry average values for the average product use.

Attributable processes in both the use and end-of-life stage can vary significantly between geographical locations, and companies are required to disclose in the inventory report the geographic location where a product is consumed. While companies can use global averages, they may find that focusing on a specific region or country provides greater insight into the GHG impacts of the product's use and end-of-life stages. Data collection requirements and guidance are available in Chapter 9 to help companies determine the most appropriate use and waste treatment profile.

In the case where more than one use or end-of-life profile is possible, companies may assess the scenario uncertainty (i.e. sensitivity analysis, see Chapter 11 for additional guidance) to understand the impact each potential profile may have on the total inventory results. For example, a company may want users of the report to know the impact of storing food in the freezer for three months versus one year has on the inventory results. More information on scenario uncertainty is available in Chapter 11.

7.2.4 Justified Exclusions

All attributable process material and energy flows are required to be identified in the process map, which satisfies the requirement for boundary setting. However, the iterative nature of life cycle accounting dictates that a product's boundary may be revisited due to data collection limitations.

In this standard, material and energy inputs to an attributable process may be excluded from the inventory results if all of the following are true:

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

Definitions of data types and guidance on filling data gaps are included in Chapter 9.

Estimating to Determine Insignificance

To determine insignificance, a company should estimate the process's emissions using data with upper limit assumptions to determine whether, in the most conservative case, the process is insignificant based on either:

- Mass;
- Energy;
- Volume;

and environmental relevance criteria.

For example, consider a process for which there is no primary or secondary data (including proxy and extrapolated) available on material input X other than it contributes 0.5 g to a 100 g product. A company should estimate the input's emissions using data for the most GHG intensity impact.

To determine whether an estimate is insignificant or not, a company needs to establish a definition of insignificance which may include a rule of thumb threshold. For example, a rule of thumb for insignificance may be material or energy flows that contribute less than one percent of the mass, energy, or volume and estimated environmental significance over a process, life cycle stage, or total inventory[21]. In the above example, the company estimates that the most GHG intensive material input does not exceed one percent of the mass or environmental impact for material input X; therefore, the material input is a justified exclusion. The definition of insignificance should reflect the company's business goals for conducting the inventory.

All exclusions are required to be justified and disclosed in the inventory report. This should include a description of the estimation technique used and the insignificance threshold defined.

7.2.5 Non-Attributable Processes

Attributable processes are directly connected to the studied product by material and energy flows, but other processes, materials, and energy may be indirectly connected to the studied product. These are referred to as non-attributable processes, and examples include:

- Material flows due to capital goods (e.g., machinery, trucks, infrastructure)
- Material and energy flows due to overhead operations (e.g., facility lighting)
- Material and energy flows due to corporate activities and services (e.g. research and development, administrative functions, company picnics)
- Energy used to transport the product user to the retail location
- Energy used to transport employees to and from work

Companies are not required to include non-attributable processes in the inventory, but should include them if relevant. Relevance is determined by the company and may be based on many different factors including business goals and reduction potentials; literature sources; and relative impact in relation to the rest of the inventory. For example, renewable energy generation like hydroelectric and wind power require capital infrastructure that may have a large impact relative to the rest of the inventory. On the other hand, a company may see corporate activities as a key area of reduction potential and therefore feel they are relevant to include in the product inventory. As a rule of thumb, processes should be included when primary or secondary data is available to ensure completeness. Primary and secondary data are defined in Chapter 9.

Any non-attributable processes included in the boundary are required to be disclosed in the inventory report, and companies may also want to disclose any non-attributable processes that were deemed irrelevant for transparency. If, during data collection, a company is unable to separate GHG emissions associated with attributable processes from GHG emissions associated with non-attributable processes (e.g., a facility whose lighting electricity and process-specific electricity data are combined), this should also be noted in the inventory report.

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

Box 7-3: Relevance and Significance

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

Significance is defined as the size of impact and is used quantitatively throughout the standard. Significance is used in data quality reporting (Chapter 9) to describe data that has a large impact on the inventory results. Insignificance is also used in boundary setting and base inventory recalculation (Chapter 15) to describe a threshold under which a process or change can be assumed insignificant to the inventory results.

Relevance is a qualitative term used to describe how decisions made during the inventory process impact a company's business goals. Examples of decisions that consider relevance include establishing the scope (Chapter 6), including non-attributable processes, and screening during data collection (Chapter 9). When making decisions based on relevance, it is usually recommended that companies also consider significance.

7.2.6 Time Boundary

The time boundary is the amount of time from when a product and its components are extracted from nature until they are returned to nature at the end-of-life. Companies are required to disclose the time boundary of a product's life cycle. The time boundary for each life cycle stage should also be disclosed separately for transparency, especially when product's life cycle extends over many years. The use stage time boundary is based on the service life of the product, which is the time needed to fulfill the product's function. For example, if the function of a laptop computer is to provide 5,000 computing hours, eight hours a day, five days a week, the use stage time boundary would be 2.4 years. The end-of-life time boundary is based on the average waste treatment profile of the studied product in the assumed geographic location.

The end-of-life time boundary can vary significantly depending on the type of waste treatment assumed and how long it takes for the product's carbon to return to nature. For example, waste that is incinerated has a very short time boundary compared to waste that is disposed of in a landfill. Additionally, not all waste treatment methods result in the release of the product's embedded[22] carbon to the atmosphere. When a company knows that either all or a portion of a product's carbon does not return to the atmosphere during waste treatment, a company is required to disclose and justify this in the inventory report. For example, lignin is carbon-based component of wood that does not degrade under anaerobic conditions[23]. A company performing an inventory on a wood-based product that is disposed of under these conditions would disclose the amount of carbon from lignin that is not released in the inventory report.

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

For cradle-to-gate inventories, companies are required to report the amount of embedded carbon in the product as it leaves the inventory boundary. This is to provide transparency to companies that may use the data from the cradle-to-gate inventory to account for an input into their final product. If the amount of

[22] Embedded carbon is defined as carbon molecules that exist as part of the product, not the upstream life cycle emissions associated with the product.

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

embedded carbon is unknown, a company should note this in the inventory report. See Chapter 12 and Chapter 14 for additional information on the reporting requirements for carbon storage.

Box 7-4: Using Sector Guidance or Product Rules for Boundary Setting

Sector guidance and product rules and help companies set their inventory boundary by:

- Defining product-specific life cycle stages
- Providing sector specific guidance on the attributable process for a specific product or product category
- Providing a list of non-attributable processes
- Identifying typical use and end-of-life profiles
- Identifying time boundaries

Sector guidance and product rules can be a helpful tool, but companies need to be cautious to ensure that the guidance follows the requirements of the standard.

8 Allocation

During boundary setting, companies may identify attributable processes that have multiple valuable products as inputs and/or outputs. In these situations, the emissions and removals data collected for the process needs to be partitioned between the studied product and the other products in the same life cycle. This portioning is referred to as allocation, and is often considered one of the more challenging issues in product life cycle accounting. Perhaps even more challenging than general allocation is allocation due to recycling, which occurs when processes need to be allocated between two different product life cycles. This chapter provides requirements and guidance to help companies choose the most appropriate method to address allocation and recycling in their product inventory.

8.1 Requirements for General Allocation

When faced with allocation, companies shall follow these principles[24]:

- Emissions and removals shall be allocated[25] in a manner that accurately reflects the studied product and co-product(s) contributions to the common process's emissions, whether allocation is avoided or an allocation method is applied.
- When possible, companies should avoid or minimize the use of allocation by using process subdivision, redefining the functional unit, or using system expansion (see methods below).
- If allocation is not avoided, the allocation method chosen should be based on the underlying physical relationships between the studied product and co-product(s) when possible.
- When physical relationships alone cannot be established or used as the basis for allocation, companies should select another allocation method that reflects other relationships between the studied product and co-product(s).
- The sum of the allocated studied product and co-product(s)'s emissions from the common process shall be equal to the common process's total emissions.
- The same allocation method shall be used to allocate emissions for all co-products from a common process.
- If a co-product does not have value as an input into another product's life cycle, the co-product is considered waste and no allocation shall be applied.

Common Process - A process where the process outputs includes the studied product and co-product(s)

Co-Product - A product exiting the common process that has value as an input into another product's life cycle

The following methods shall be used to avoid or minimize the use of allocation:

[24] Adapted from ISO 14044 (2006)

[25] Allocation is used generally throughout this chapter to represent anytime allocation is required, even if the problem is solved by avoiding allocation.

Method	Definition
Process Subdivision	Dividing the common process into sub-processes in order to eliminate the need for allocation.
Redefining the Unit of Analysis	Inclusion of the co-products (additional functions) in the functional unit.
System Expansion	Using the emissions from an alternative product that comprises the same functional unit as a co-product to estimate the emissions of the co-product and allocating the remaining emissions to the subject product and remaining co-product(s). Only applicable when companies have direct knowledge of the function and eventual use of the co-product.[26]

The following methods shall be used to perform allocation if allocation cannot be avoided or minimized:

Method	Definition
Physical Allocation	Allocating the inputs and emissions of the system based on an underlying physical relationship between the quantity of product and co-product and the quantity of emissions generated.
Economic Allocation	Allocating the inputs and emissions to the subject product and co-product(s) based on the market value of each when they exit the process.
Other Relationships	Dividing the process emissions among the outputs using a factor based on established and justifiable relationships between the product and co-product other than physical or economic

The methods used to either perform or avoid allocation shall be disclosed and justified in the inventory report.

8.2 Requirements for Allocation due to Recycling

When allocation is necessary due to recycling, the method used shall be disclosed and justified in the inventory report.

[26] The system expansion method is applicable when a single alternative product is identified as the substitute to avoid arbitrary choices between potential substitute products. This requirement to know and document the use of the co-product(s) is included to maintain the attributional approach to the standard. Making co-product assumptions based on market changes is a consequential approach to product inventories and is not in conformance with the Product Standard. The data and methods used in calculating emissions from the co-product's life cycle shall be in conformance with the attributional approach and other requirements of the Product Standard.

Companies shall use one of the following methods to allocate recycling processes:

- the 100/0 input method;
- the 0/100 output method to avoid allocation.

The 0/100 output method shall not be used when the recycled material does not maintain the same inherent properties as its virgin material input.

If neither the input nor output method is most appropriate for a given recycling situation, companies shall reference, disclose, and justify the other method used in the inventory report.

The method[27] used shall account for all recycling process impacts (by applying an allocation factor between zero and 100 percent) and conform to the general allocation requirements of this standard.

Allocation or avoidance of allocation shall not occur if the material input or output is classified as a waste.

All data used to determine the recycling rate shall be in conformance with the data collection and quality requirements of the standard.

When using the 0/100 method, displaced emissions shall be disclosed separately when reporting inventory results by stage (see Chapter 12 for calculating inventory results requirements).

Recycling - When a product or material exits the life cycle of the studied product to be reused or recycled as a material input into another product's life cycle.

Recycling Processes - Processes that occur as a result of a product or material being reused or recycled as a material input into another product's life cycle. Recycling processes need to be allocated between the product life cycles.

100/0 Input Method - When 100 percent of the recycling process impacts are allocated to the recycled material input, and 0 percent is allocated to the recycled material output.

0/100 Output Method - When 100 percent of the recycling process impacts are attributed to the recycled material leaving the product's life cycle, but instead of allocating to the recycled input, a fraction of virgin material input is displaced based on the amount of recycled material output. This method is appropriate only when the recycled and virgin material have the same inherent properties.

Same Inherent Properties – When the recycled material has maintained its properties (e.g. chemical, physical) such that it can be used as a direct replacement of virgin material

[27] The method may also follow the guidance given in ISO 14044:2006, sub clause 4.3.4.3.

8.3 Guidance for General Allocation

8.3.1 When is Allocation Required?

In most product life cycles, companies discover during boundary setting or data collection at least one process that has multiple valuable products as inputs and/or outputs. This is known as a common process, and in these situations the total emissions or removals from the common process need to be allocated among the inputs and/or outputs in the studied product's life cycle and those in other product inventories.

Typically, there are two types of products produced from common processes:

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

Inputs to the common process may be intermediate products or energy inputs. Outputs may be intermediate or final products, or energy outputs (such as electricity or district heat) or waste. **Figure 8-1** illustrates a common process where emissions and removals need to be allocated between the studied product and co-product A.

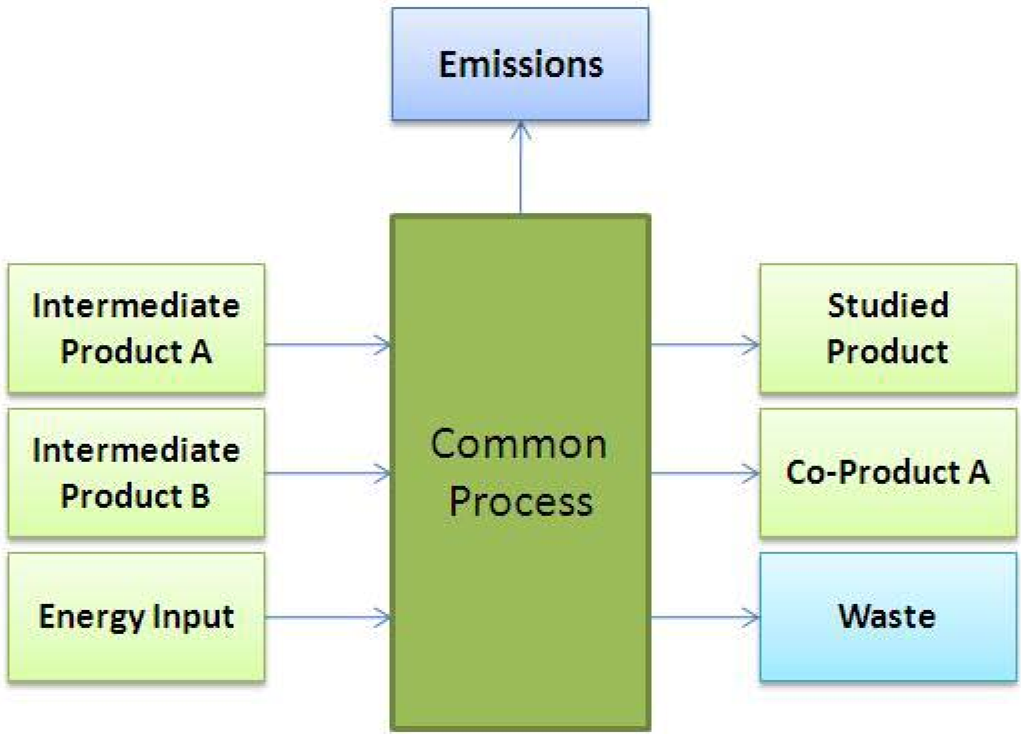

Figure 8-1: Illustration of a Generic Common Process that Requires Allocation[28]

Allocating GHG impacts is an important element of a product inventory process, as accurately attributing emissions or removals to the studied product is essential to maintaining the quality of a GHG inventory. The following sections provide definitions and examples of the methods available to avoid and perform allocation, as well as guidance on choosing the most appropriate method for a given common process. For simplicity, the methods and examples below focus only on emissions, but removals are also subject to allocation using the same methods.

[28] The term "common process" can be one or more processes that require allocation.

8.3.2 Methods for Avoiding Allocation

Process subdivision

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

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

Example of Process Subdivision

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

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

Redefining the Unit of Analysis

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

Example of Redefining the Unit of Analysis

A company produces a PET bottle designed to contain beverages. The company defines the functional unit (unit of analysis) and system boundary to include only the processes attributable to producing, using, and disposing of the bottle; the production, use, and disposal processes of the beverage are excluded. However, many processes in the system boundary process both the bottle and the beverage. To avoid allocation the company decides to redefine the functional unit to include the function of the beverage (to be consumed by customers). The functional unit is now defined as 1 bottle containing 1 liter of beverage consumed by a customer.

System Expansion

The system expansion method estimates the emissions contribution of the co-products to the common process by substituting the emissions of a similar product or the same product produced through a different product system[29].

To avoid arbitrary choices between potential substitute products, system expansion is only appropriate when companies know, and are able to, document the exact use of the co-product(s). Making co-product assumptions or using data based on market changes is a consequential approach to product inventories and is not in conformance with the attributional approach of this standard. When using system expansion companies are required to justify and report on how the selected substitute is a reasonable replacement for the co-product and accurately approximates the emissions attributable to the co-product. It is important to note that the system expansion method is only applicable when, a) the company knows the exact use of the co-product; and, b) quality data are available to use as a substitution factor.

One situation where system expansion may be particularly useful is in allocating waste incineration emissions between multiple inputs (including the studied product) and an energy co-product.

System Expansion Example: Substituting Power Generation Emissions

At a pulp mill, wood is converted into pulp that is used for valuable products and black liquor that is combusted for internal power generation. In some cases excess power is created as a co-product and sold to the grid. To account for the electricity co-product, system expansion 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.

Box 8-1: Allocating Removals

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

8.3.3 Methods for Performing Allocation

Physical Allocation

When a physical relationship between the studied product and the co-product(s) can be established, companies should allocate emissions based on the physical relationship. The physical allocation factor should describe the usefulness of the product in a meaningful way. Examples of physical allocation factors include:

Factor	Examples
Mass	• Mass of co-product outputs
Volume	• Volume of cargo transported

[29] In some LCA literature this method is known as the substitution or avoided burden method

Energy	• Energy content of heat and electricity co-products
Units	• Number of units produced
Other	• Protein content of food co-products • Chemical composition, for chemical co-products

Box 8-2: Transportation: Using Physical Relationships to Allocate Emissions

Allocating emissions from transportation is necessary when a company knows the total emissions for a truck, train, aircraft or vessel, and needs to partition those emissions to one or more of the products transported.

Transportation Example

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

In **Figure 8-2**, the amount of fruits and vegetables the truck transports are limited by the mass of the products.

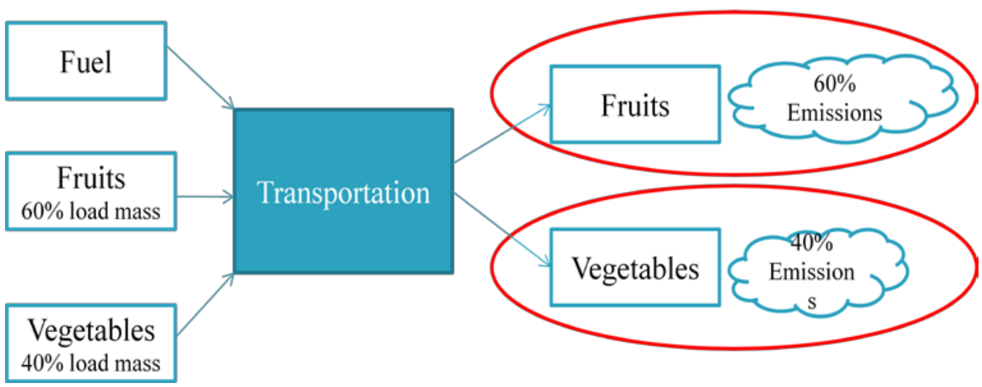

Figure 8-2: Allocating Emissions Based on a Mass Physical Factor

However, if the fruits and vegetables are transported by rail, and the limiting factor is the volume of products, the most appropriate allocation factor would be volume.

Figure 8-3 shows how the emissions would be allocated using a volume allocation factor.

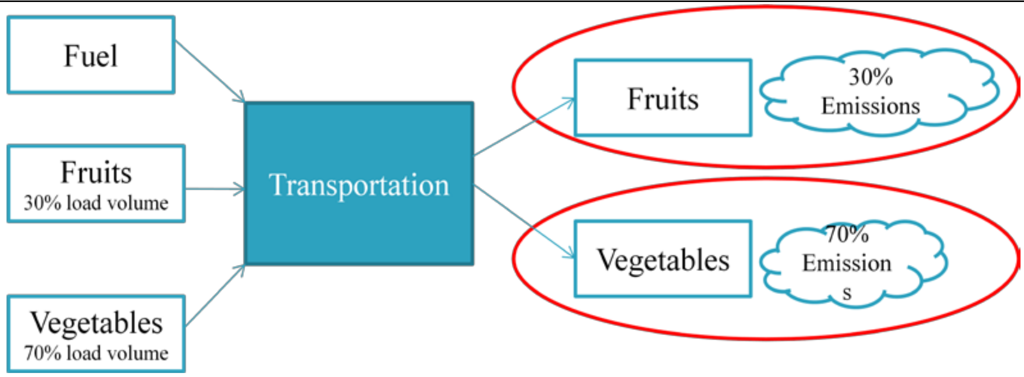

Figure 8-3: Allocating Emissions Based on a Volume Physical Factor

As with other processes companies should avoid allocation if possible. For transportation this could be done by obtaining a ton – kilometer emission factor that does not require allocation among co-products. For guidance on selecting appropriate emission factors see Chapter 9.

Economic Allocation

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

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

Other Relationships

The "Other Relationships" allocation method uses established sector, company, academic, or other sources of conventions and norms for allocating emissions. When no established conventions are available, and the other allocation methods are not applicable to the common process, a company may make assumptions on the common process in order to select an allocation method. When using assumptions companies should assess the scenario uncertainty or perform sensitivity analysis to determine how the assumptions may impact the inventory results (see Chapter 11 for more guidance on assessing uncertainty).

8.3.4 Choosing an Appropriate Method to Address Allocation

This standard identifies six valid methods for avoiding allocation or 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 method for avoiding or performing allocation for a given common process. Apart from the requirements listed above, this standard does not prescribe the use of any single allocation method due to the wide variety of circumstances companies are likely to encounter when calculating product emissions. Instead, this chapter provides guidance on determining the most appropriate allocation method to use for various situations. By following this decision process, users should select the most applicable method for their specific allocation.

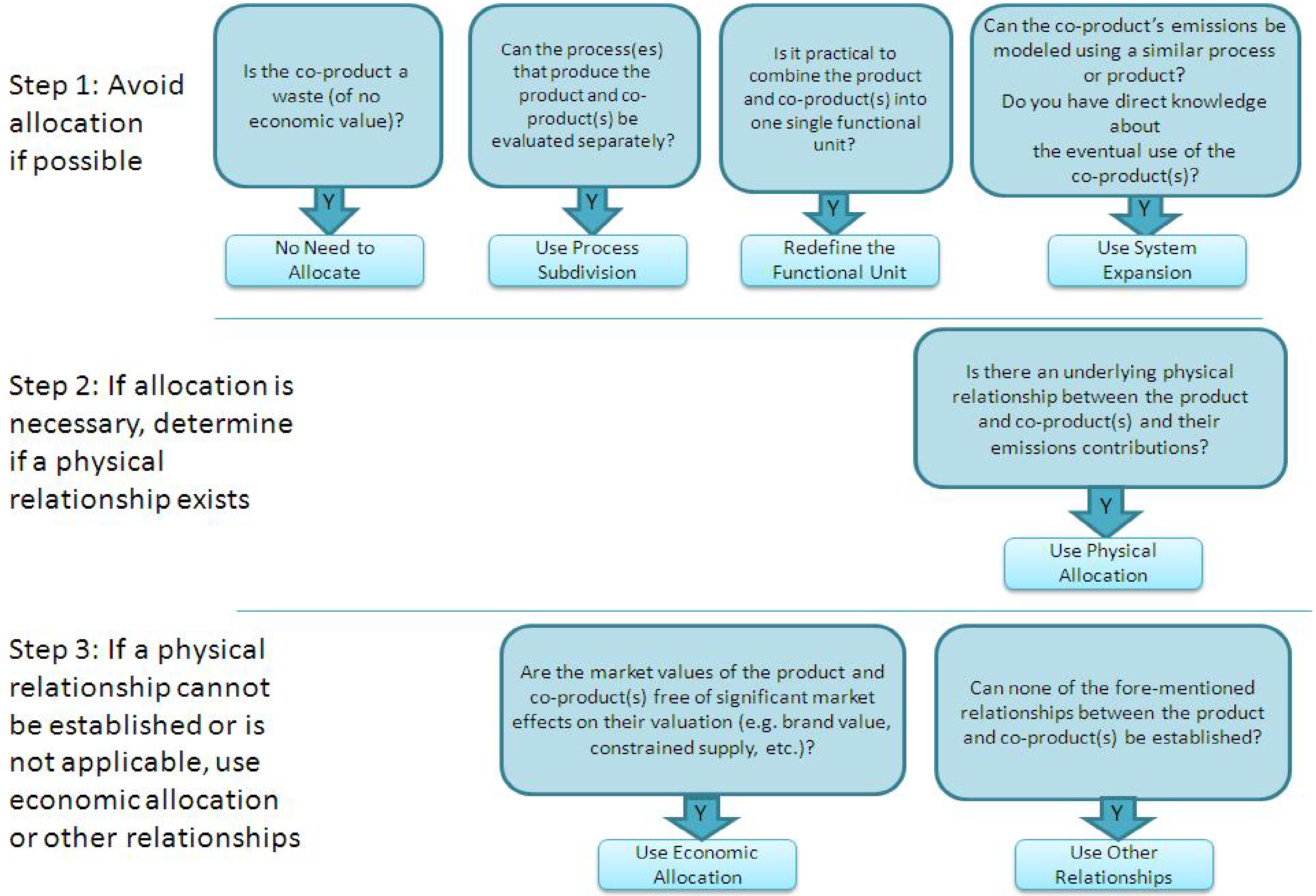

Figure 8-4: Steps to Select an Allocation Method[30]

[30] Steps adapted from ISO 14044 (2006), section 4.3.4.2 Allocation Procedure

Choosing between Physical and Economic Allocation

Step 3 in **Figure 8-4** states that if a physical relationship is not applicable or cannot be established, then companies should use economic or other relationships. Physical relationships cannot be established when:

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

However, in many cases both a physical and economic relationship can be established, and companies often struggle to determine when economic is more applicable. In general, physical allocation is preferred when:

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

Economic allocation is preferred when:

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

Example: Allocating Emissions between Lobster and By-Catch

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

8.3.5 Comparing Allocation Results

When one allocation method is not clearly more suitable than another, companies should perform multiple allocations with different methods and compare the results. This is particularly important when companies are deciding whether physical or economic allocation is more appropriate. If both methods are performed and similar results are obtained, the choice between the two methods should not impact the inventory results and the company should note this in the inventory report. However, if two allocation methods result in large differences in the total allocated emissions, companies should disclose and justify the method used to calculate inventory results. In this situation companies should select the more conservative allocation result (e.g. the method that allocates more emissions to the studied product as opposed to the co-products).

Company may also report a range of results as part of the qualitative uncertainty description in the inventory report. Guidance on reporting a range of values is included in Appendix E.

8.3.6 Reporting on Allocation

Regardless of which methods are used, companies are required to include in the inventory report a brief explanation of why the specific methods and factors (as applicable) were selected over others, including why those factors offer the most accurate allocation of emissions (see Chapter 14 for more information on reporting requirements).

Box 8-3: Using Sector Guidance or Product Rules to Determine Allocation Methods

Sector guidance or product rules can be a useful source of information when companies are trying to determine which allocation method to use (for general allocation and recycling). It is particularly important to consult product rules for the approved allocation methods when a company wants to use their inventory results to make comparisons to other products in the same product category. Companies should be cautious when using sector guidance or product rules to ensure that the suggested allocation methods abide by the requirements of this standard.

8.4 Guidance for Recycling Allocation

When a product or material exits the studied product's life cycle to be used as a recycled or reused input into another product's life cycle, common recycling processes occur that need to be allocated. **Figure 8-5** is a simplified and general example of these processes; however, as a rule of thumb recycling processes begin when the recycled material becomes separated[31] from the remainder of the studied product being sent for disposal or sent for use (in the case of recycled scraps). This type of recycling is defined as open-loop in ISO 14044:2006. Another type of recycling is closed-loop, where the material is recycling or reused in the same studied product's life cycle. In this situation allocation is not needed because the material does not leave the life cycle, and therefore the closed loop recycling type is not discussed in this chapter.

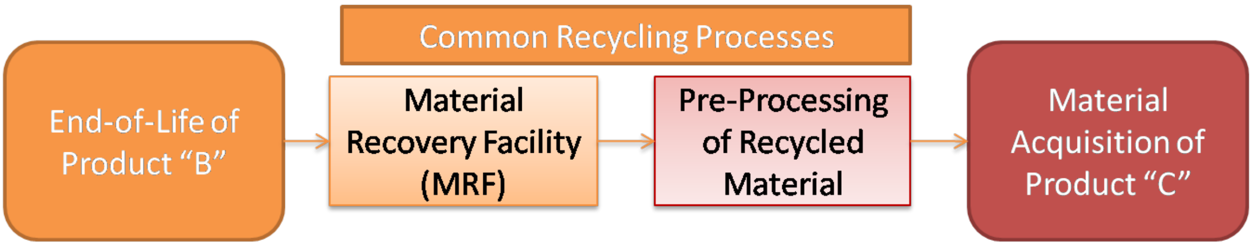

Figure 8-5: Example of Recycling Processes

Companies that create recycled outputs or use recycled inputs need to know how to account for these processes, and this standard provides two general methods: the 100/0 input method to allocate emissions and the 0/100 output method to avoid allocation. The definitions of these methods as well as guidance on choosing which method is appropriate are included in this section. This standard focuses on two methods in an effort to narrow down the different methods available and provide a simplified approach to improve the standard's usability. However, because different products may have specific recycling issues that cannot be solved with these methods, guidance is also given on using other methods when appropriate. Regardless of which method is used, companies are required to disclose and justify the method in the inventory report.

8.4.1 100/0 Input Method

The 100/0 input method allocates the emissions of the common processes as illustrated in **Figure 8-6**: 100 percent of the attributable recycling process emissions are allocated to recycled material input, and 0 percent of the impact of recycling at end-of-life is included in the studied product's inventory (Product "B" in **Figure 8-6**).

[31] Recycling material most likely separates from the studied product's life cycle boundary in the use stage, end-of-life stage, or in the production stage in the case of scrap materials. More guidance on which stage the recycling processes begin is available in **Chapter 7**.

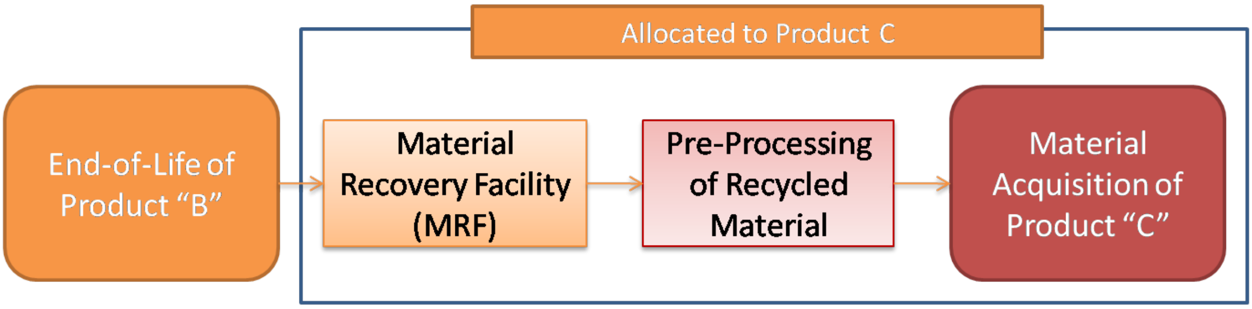

Figure 8-6: Recycling Process Allocation using the 100/0 Input Method

This method can be used by companies that have recycling material outputs, recycled material inputs, or both. For example, consider a studied product that is composed of 75 percent virgin material and 25 recycled material input. The attributable processes for the 25 percent recycled material input would include the material recovery facility (MRF) and the recycling process (e.g. melting)[32] in the material acquisition stage. If at the end-of-life 10 percent of that product is recycled, the attributable processes associated with recycling or other waste treatment processes for the 10 percent recycled output are not included in the end-of-life stage of the studied product, but would be allocated to another product life cycle that uses the recycled material input. **Figure 8-7** illustrates a simplified process map for a product that utilizes the 100/0 input method[33].

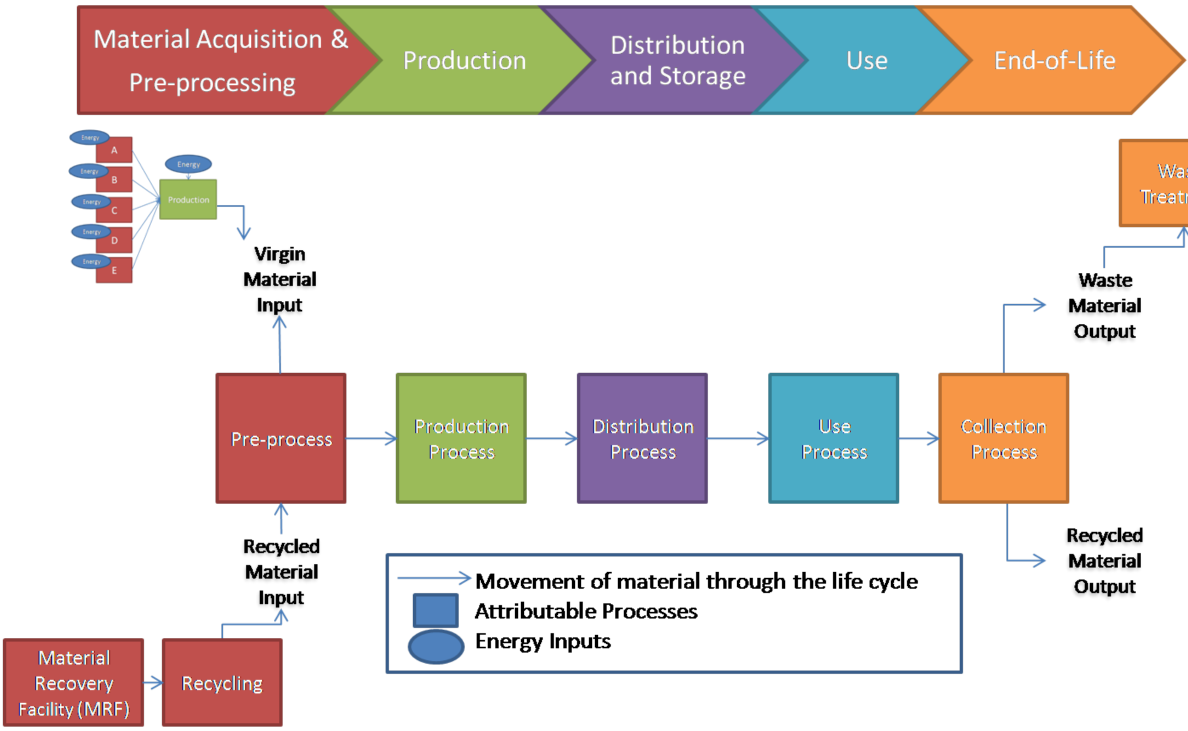

Figure 8-7: Example Process Map Illustrating the 100/0 Input Method

While the impact of avoided emissions from recycling at the end of the product's life is not included in this method, **Figure 8-7** does illustrate two potential benefits due to recycling in the studied product's inventory: the reduction in the amount of waste entering waste treatment and the reduction of upstream virgin material acquisition. The former reduces the GHG impacts of waste treatment in the end-of-life stage, and the latter

[32] This is consistent with the carbon intensity of secondary or recycled materials in many life cycle databases.
[33] The collection process is listed as an attributable end-of-life process; however, the location of this process depends on how the recycled material is collected, as discussed above and in **Chapter 7**.

may do the same for material acquisition if the recycling processes are less GHG intensive than virgin extraction. If the later scenario is not the case (e.g. recycling processes are more GHG intensive than virgin inputs), it is possible that using virgin inputs would result in a lower total product inventory than using recycled inputs. This unintended consequence, is an example of when focusing on one impact category may drive companies to make product decisions that are desirable for one impact (e.g. GHG emissions) but unfavorable to another (e.g. material depletion). Companies are encouraged to consider all applicable environmental metrics before making reduction decisions, as discussed in Chapter 15.

8.4.2 0/100 Output Method

The 0/100 output method accounts for the impact end-of-life recycling has on the net virgin acquisition of a material. It does this by including 100 percent of the common recycling processes in the end-of-life stage and then subtracts emissions equivalent to the virgin material acquisition and preprocessing for the amount of material recycled. **Figure 8-8** illustrates this and identifies the equation used to calculate net virgin material:

Net virgin material (N) = virgin material input (V) – recycled material (R)

In this equation R can be recycled material exiting the end-of-life stage (as illustrated in **Figure 8-8**) or scrap material exiting the production stage. If both of these exist in a product's life cycle and both met the qualifications to use the 0/100 method (e.g. same inherent properties as the virgin input), both can be included in R. This method is similar to the end-of-life approach defined and supported by many in the metal industry[34], recyclability substitution in the *ILCD Handbook*[35], and the closed loop[36] method in ISO 14044:2006.

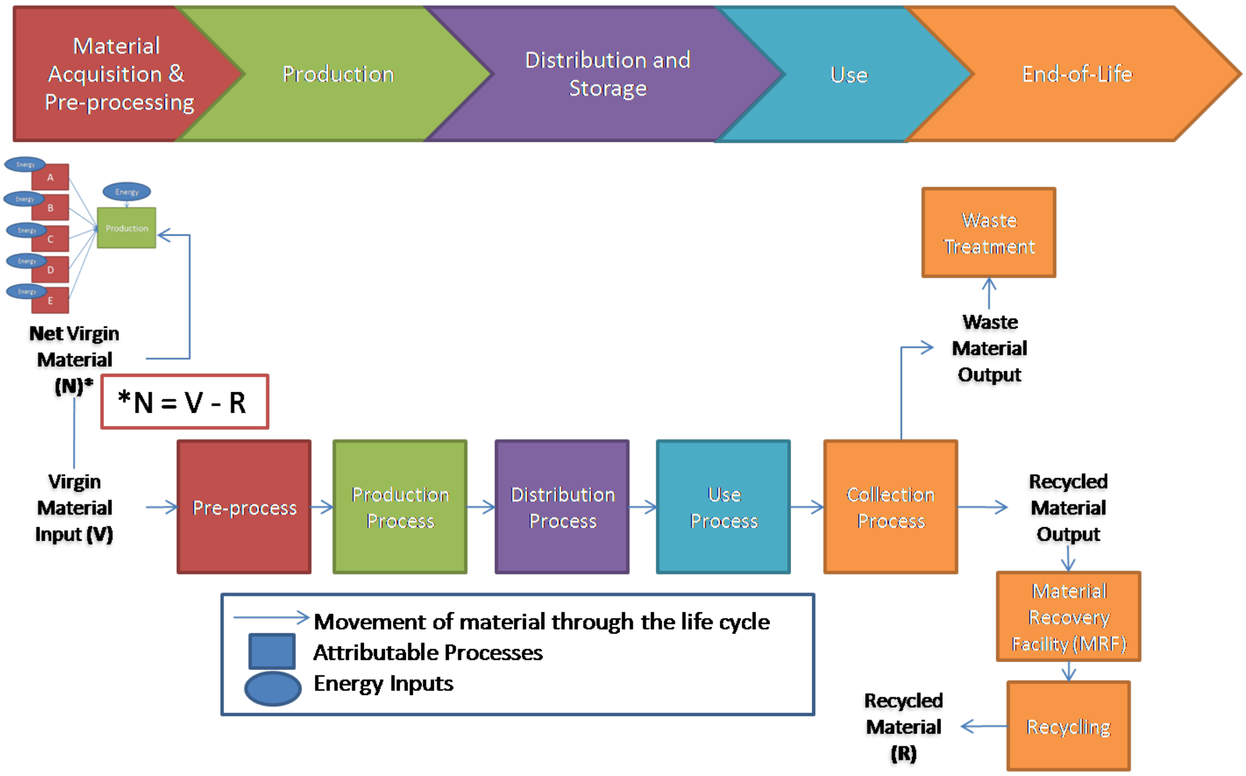

Figure 8-8: Example Process Map Illustrating the 0/100 Output Method

[34] Atherton, John. Declaration by the Metals Industry on Recycling Principles, International Journal of Life Cycle Assessment, 12 (1), 59-60, 2007.
[35] (ILCD, 2010) Joint Research Commission, 2010, ILCD Handbook: General Guide for Life Cycle Assessment
[36] ISO 14044:2006 defines open and closed loop recycling as well as open and closed loop allocation procedures. In ISO 14044, an open loop recycling situation where there is no change in the inherent properties of the material is treated using a closed loop allocation procedure.

To use the 0/100 output method, the recycled material, R, is required to have the same inherent properties as the virgin material input, V. This means that the properties (e.g. chemical, physical) of R leaving pre-processing have to be similar enough to the properties of V to be used interchangeably without any additional changes to the product's life cycle. For example, if a product with recycled input C needs additional additives to achieve the same function and a product with only virgin input D, C and D do not have the same inherent properties as C was down-cycled[37] in some way during its previous use. If some or all of the recycled material output is down-cycled, the 0/100 method cannot be used to assess this down-cycled material[38]. Instead, companies should either use the 100/0 method for all the recycled material output, or use both methods within the same life cycle: the 0/100 method for the recycling material R and the 100/0 method for the down-cycled material. While the latter is permitted, the former is recommended as the simpler option.

The 0/100 output method is most appropriate to use when the company has a material input for which they don't know how much is virgin versus recycled (e.g. a metal input where the amount of recycled metal is indistinguishable from the virgin metal in the market). In this case they assume all the input is virgin and then account for the unknown recycled content by applying the 0/100 method. It becomes more difficult to use the 0/100 method if the studied product also has known recycled content (e.g. the company buys 75 percent of their material input where the virgin and recycled content is indistinguishable and 25 percent as known secondary material). To use the 0/100 method correctly in this situation, the company would need to use the 100/0 input method for the 25 percent recycled content and the 0/100 output method for the remaining 75 percent only. If the company is unclear whether the product's material input is recycled or not, the company should err on the conservative side and assume all the input is virgin to ensure the 0/100 method is being used correctly.

8.4.3 Choosing Between the 100/0 Input and 0/100 Output Methods

Some limitations of the 0/100 output method are included above, but if both methods seem equally applicable to a company's product, a choice between the methods is necessary. The following guidance provides some insight as to which method is most appropriate in certain situations.

In general, the 100/0 input should be used in the following situations:

- When the product contains recycled input independent of whether the material is recycled downstream
- When the market for the recycled material is not saturated (e.g., not all material that is recycled is used as a recycled input) and therefore the creation of recycled material may not displace the extraction of virgin material
- When the material is down-cycled and therefore the creation of recycled material does not displace the extraction of virgin material within the studied product's life cycle[39]
- When the content of recycled material in the product is directly affected by the company's activities alone and therefore the company has control over how much recycled material input to procure (which could potentially be used as a reduction mechanism)

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[37] Down-cycling occurs when a recycled material loses quality during the recycling process and no longer possesses the same properties as the original virgin material. Paper is an example of a commonly down-cycled product.
[38] While the 0/100 method can technically be used for down-cycled material if the system is expanded to include the product that the material is down-cycled into, this is not recommended in this standard due to the difficulty in performing this in conformance with the standard. Companies wishing to perform this method would need to disclose and justify why the 0/100 method was not appropriate for their product and ensure that the data used to calculate the down-cycled rate and material use is in conformance with the attributional approach to product life cycle GHG accounting.
[39] If the down-cycled material is equivalent to another virgin material input within the studied product system, the 0/100 method could technically be used as long as the calculations were made separately.

- The time boundary of the product's use stage is long or uncertain and therefore the amount of material recycled at the end-of-life has increased uncertainty

In general, the 0/100 output method should be used in the following situations:

- When the recycled content of the material on the market is unknown and therefore the content of the recycling material in the product is not directly affected by the company's activities alone
- When the market for the recycled material is saturated (e.g. all material that is recycled is used as a recycled input) and therefore creating more recycled material is likely to increase the amount of recycled material used
- When the material is not down-cycled and therefore can be assumed to directly displace virgin material extraction
- When the time boundary of the product's use stage is short or well known.

It is important to note that in some cases both of these methods may be used in one inventory if different recycling occurs for different material components.

It is also important to note that while the 0/100 output method can be considered a type of system expansion and therefore a method to avoid allocation, for recycling (unlike general allocation) this is not given clear preference over the 100/0 input allocation method. This is because each method is appropriate in given situations (as described above) and companies should evaluate which method is most appropriate for their product before deciding which method to use.

8.4.4 Other Methods to Allocate Recycling Process Emissions

When neither the 100/0 nor the 0/100 methods are appropriate, companies may use another method to allocate the common processes if the following are true:

- The method accounts for all recycling processes (i.e., applies an allocation factor between 0 and 100 percent consistently between inputs and outputs to avoid double-counted or under-counted emissions)
- The method conforms to the general allocation requirements of this standard
- The method conforms to the life cycle and attributional accounting approaches of this standard
- The method uses as the basis for allocation (in the following order if feasible) physical properties, economic value, or the number of subsequent uses[40]
- The method is disclosed, justified, and referenced in the inventory report

The method used should be referenced from available sector guidance, product rules, technical reports, journal articles, or other standards. For example, companies with paper products that undergo down-cycling may want to use the "number of subsequent uses" method recommended by the American Forest & Paper Association for recycling cellulosic fiber in paper products[41]. If a company is using a method for a new recycling situation that may not be published, the company is strongly encouraged to include details on the method approach either in the inventory report or as a supplementary document and to have the approach externally verified to ensure it is in conformance with this standard.

Companies are required to justify why the particular method was chosen over the 100/0 and 0/100 methods. This transparency is useful for stakeholders to understand how and why the recycling processes were allocated using the chosen method. If more than one allocation method is appropriate, companies should include this in the inventory report as part of their scenario uncertainty (as defined in Chapter 11).

[40] As defined in the guidance of ISO 14044:2006, sub clause 4.3.4.3.

[41] American Forest and Paper Association. Life Cycle Inventory Analysis: Enhanced Methods and Applications for the Products of the Forest Industry. The International Working Group, 2006.

8.4.5 Collecting & Reporting Recycling Data

To abide by the attributional approach of the standard, data used to determine the amount of recycled material output must be based either on specific primary data about the recycling of a product, or on average recycling data for the product in the geographic location where the product is consumed (as defined by the use profile).

Companies using the 0/100 output method should ensure that the average recycling data used to determine recycled material R excludes down-cycled materials. Where the only data available aggregates recycled and down-cycled materials, companies should assume a down-cycled rate based on other available data. For example, if the average aggregate recycling rate (including down-cycle) for bottles made of plastic X in region Y is 35 percent but a company has another source indicating that 10 percent of plastic X is down-cycled, then R should equal 25 percent of the collected waste material. Where it is not possible to disaggregate the data but some portion of the material is known to be down-cycled, it should be clearly noted as a limitation in the inventory report that the down-cycling rate is unknown. Since the 100/0 input method can be used for recycled or down-cycled materials it is not necessary to have disaggregated data.

Companies using the 0/100 method are required to report displaced emissions separately from the inventory results by stage (see Chapter 12 for calculating inventory results requirements). This is to prevent the reporting of negative impacts in the end-of-life stage. It is also important to note that if removals occur during virgin material acquisition, a portion of the removals relative to the amount of material recycled also need to be allocated to the recycled material output.

Box 8-4: Recycling in a Cradle-to-Gate Inventory

As defined in Chapter 7, the boundary of a cradle-to-gate inventory does not include the use or end-of-life stages. If an intermediate product has recycled inputs, companies can use the 100/0 input method and account for the MRF and recycling process emissions for that input. If an intermediate product is known to be recycled at its end-of-life regardless of its function during use, companies may report this separately in the inventory report along with any other end-of-life information that may be useful to a stakeholder. Companies may include end-of-life recycling in the inventory results for an intermediate product only if the company knows the function of the final product and performs a cradle-to-grave inventory.

9 Collecting Data & Assessing Data Quality

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

9.1 Requirements

Data shall be collected for all attributable processes identified during boundary setting. Any exclusion of attributable processes shall be justified and reported in the inventory report. Primary data shall be collected for all processes under the control of the reporting company.

Data shall be collected for the following GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs). Data collection shall include removals of GHGs from the atmosphere and emissions of GHGs to the atmosphere.

Activity data, emission factors, and/or direct emissions data shall be assessed by the data quality indicators during the data collection process. For significant processes, companies shall report a descriptive statement on the data sources, the data quality, and any efforts taken to improve data quality.

The percentage of total GHG emissions and removals quantified using the following data types shall be included in the inventory report:

- Primary data;
- Secondary process data; and
- Secondary financial data.

Primary Data – Process data from specific processes in the product's life cycle.

Secondary Data – Data that are not from specific processes in the product's life cycle.

Activity Data – The quantified measure of a level of activity that results in GHG emissions or removals

Emission Factors – GHG emissions per unit of activity data

Direct Emissions Data – Emissions released from a process (or removals absorbed from the atmosphere) determined through direct monitoring, stoichiometry, mass balances, or similar methods

Financial Data – Monetary measures of a process that result in GHG emissions or removals

9.2 Guidance

9.2.1 General Steps for Data Collection

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

Step 1: Develop a Data Management Plan and document the data collection and assessment processes as they are completed

Step 2: Using the product's process map, identify all data needs and perform a screening of the processes to help focus your company's data collection efforts

Step 3: Collect primary data for all processes under the control of the reporting company

Step 4: For all other processes, collect primary or secondary data. Assess and document the data quality of the direct emissions data, activity data, and emission factors as the data are collected.

Step 5: To improve data quality, collect higher quality data, especially if the processes were found to be significant in Step 2.

The following sections provide guidance on completing each of these steps in conformance with this standard.

9.2.2 Data Management Plan

Documenting the data collection process is useful for improving the data quality over time, preparing for assurance, and revising future product inventories to reflect changes in the product's life cycle. To ensure that all the relevant information is documented a data management plan should be established early in the inventory process. Detailed guidance on how to create and implement a data management plan is located in Chapter 10.

9.2.3 Screening for Significant and Relevant Emission Sources

Screening emission sources at the beginning of the data collection process may help companies focus their data collection efforts to collecting high quality data for the most significant sources. Screening emission sources is not required, but it may deliver surprising findings and help companies use data collection resources more effectively.

Companies should first screen for significant processes that are:

- Likely to be a large source of emissions or removals
  - Companies should use secondary data and initial estimates to identify these sources.
- Consume large amounts of energy or material inputs relative to other processes in the product's life cycle
  - If companies choose not to collect secondary data for screening, companies should identify processes that are known to consume large amounts of energy or material inputs. These processes may also produce large amounts of emissions.
- Produce large amounts of energy, material, or waste outputs relative to other system processes
  - Similar to screening step 2, processes that produce large amounts of co-products (energy or materials) or waste outputs may also produce large amounts of emissions.

Companies are required to collect data on the six Kyoto GHGs. Data should be collected for other GHGs that may be significant or relevant to the studied product.

Processes may be relevant for non-emissions related reasons for some companies. Companies may want to use the following criteria, in addition to the ones above, to prioritize processes in the data collection process:

- Processes that are significant by spend relative to other processes in the product's life cycle
- Processes with potential emissions reductions that could be undertaken or influenced by the company

- Processes are controlled by suppliers with strategic importance to the company's core business
- Processes that meet additional criteria developed by the company or industry sector

Box 9-1: Case Study: Screening for Significant Processes (to be developed)

For descriptions of relevance and significance see **Box 7-3**.

9.2.4 Data Types Available for Product Inventories

Typically, data can be gathered in one of two ways:

1. Directly measuring or modeling the emissions release from a process.
2. Collecting activity data and emissions factor for a process and multiplying the activity data with an emission factor.

The following types of data have been defined in this standard.

Direct Emissions Data

Direct emissions data are emissions released from a process, determined through direct monitoring, stoichiometry, mass balance, or similar methods. Direct emissions data do not require the use of emission factors.

Examples of direct emissions data include:

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

To calculate the CO_2-eqivalent (CO_2e) emissions using direct emissions data, only the corresponding global warming potential (GWP) needs to be applied.

Activity Data

When direct emissions data are unavailable, companies should collect activity data on the inputs, outputs, and other metrics[42] for processes in the product's life cycle to calculate emissions or removals. Activity data are the quantitative measure of a level of activity that results in GHG emissions. Activity data can be measured, modelled, or calculated.

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

Process Activity Data

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

Process activity data includes:

- energy (e.g. joules of energy consumed)
- mass (e.g. kilograms of a material)
- volume (e.g. volume of chemicals used)
- area (e.g. area of a production facility)
- distance (e.g. kilometers travelled)
- time (e.g. hours of operation)

Direct emissions data and process activity data are both considered **process data** for the primary data collection requirement and reporting requirements (see section 9.1).

Financial Activity Data

Financial activity data are monetary measures of a process that results in GHG emissions. Financial activity data, when combined with a financial emission factor (e.g. Environmentally Extended Input-Output [EEIO] emission factor), result in GHG emissions.

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

However, if a company initially collects financial activity data on a process input then determines the amount of energy or material inputs using a conversion factor, the resulting activity data used in the emissions calculation is considered process data. For example, a company that knows the cost of the fuel consumed in a process and the cost per liter of fuel can easily convert the fuel cost into the physical amount of liters consumed in the process.

For any given process, one or more types of activity data may be available. Companies should collect activity data that is the accurately measured or modelled and, when combined with an emission factor, is closest to the actual release of emissions in the product's life cycle. Activity data shall also be assessed using the data quality indicators in **Table 9-1**. **Figure 9-1** illustrates the multiple types of activity data available.

[42] Other metrics may include distance travelled, time of operation, and other activity data used to calculate emissions or removals.

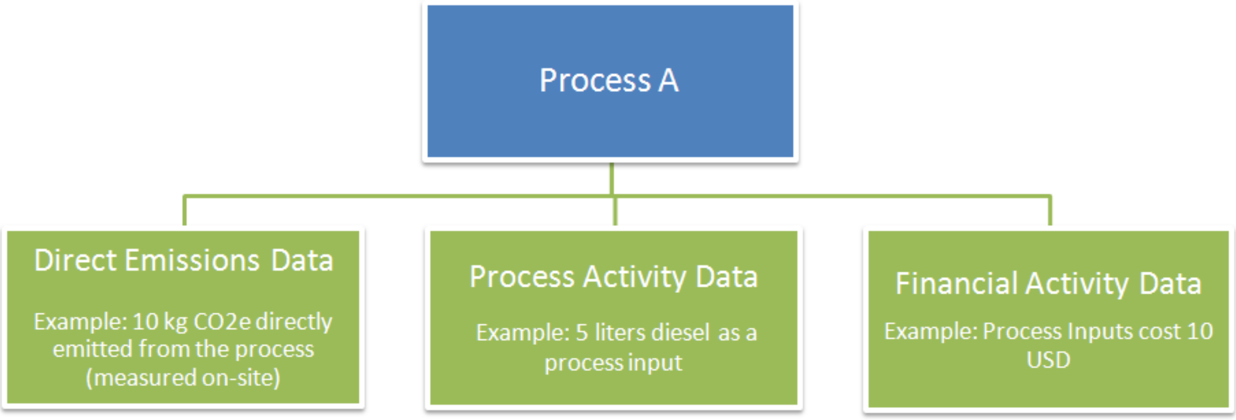

Figure 9-1: Examples of Data Types Available for a Process

Emission Factors

Emission factors are the GHG emissions per unit of activity data. Emission factors can include a single process in a product life cycle, or they can include multiple aggregated processes. Companies should understand which processes are included in the inventory's emission factors to ensure that all processes in the product's life cycle are accounted for in the data collection process.

The types of emission factors companies collect depend on the types of activity data collected. For example, if companies collect financial activity data on a material input to a process they can select an EEIO emission factor to calculate the upstream emissions (see **Box 9-2** for more information on EEIO emission factors). Sources of emission factors include life cycle databases, published product inventory reports, government agencies, industry associations, company-developed factors, and other data initiatives. Conversely, if few emission factors exist for a process a company may first collect available emission factors and then decide which type(s) of activity data to collect.

Companies should choose activity data and emission factors using the data quality indicators in Section 9.2.8. Emission factors and not included in the definitions of primary and secondary data. Emission factors are multiplied by activity data or financial data to calculate GHG emissions. More information on calculating emissions and inventory results is available in Chapter 12.

Many nations create economic input-output (IO) tables, developed through the analysis of economic flows between final production sectors. These IO tables summarize inter-industry purchases needed to make goods and services, and the tables exist at varying degrees of specificity (i.e., number of economic sectors provided) and frequency (i.e., how often the tables are updated). Input-output models use this information to estimate not just the economic flows of direct production, but also all upstream production as well.

Environmentally Extended Input-Output (EEIO) models estimate energy or emissions that result from production from direct and upstream supply chain activities. The resulting emissions factors can be used to estimate what the inventory and boundaries might look like for a given industry or product.

EEIO data are often very comprehensive, including many upstream sectors (e.g., in the case of the US, over 400 industries). However, the detail provided by process data is often not provided by EEIO data. As with process data companies are required to assess the data quality of financial activity data and EEIO emission factor data used in the product inventory.

Box 9-2: Using Environmentally Extended Input-Output Emission Factors

9.2.5 Collecting Primary Data

Primary data are required to be collected for all attributable processes under the financial control or operational control (as defined by the GHG Protocol *Corporate Standard*) of the company undertaking the product inventory.

Primary data are process data from specific processes in the product's life cycle. Primary data can be process activity data or direct emissions data from a specific site, or can be averaged across all sites that contain the product's given process. Primary data can be measured or modeled, as long as the result is specific to the given process in the product's life cycle. It is important to note that using the reference flow of the studied product (e.g. mass of finished product) as process activity data are not considered primary data.

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

Examples of primary data include:

- Liters of fuel consumed by a process in the product's life cycle, either from a specific site or averaged across all the sites that produce the product.
- Kilowatt-hours consumed by a process from an individual site or averaged across sites
- Kilograms of material input into a process
- GHG emissions from a process's chemical reaction

There are several reasons for collecting quality primary data in a product inventory:

- Collecting primary data from suppliers throughout the product's life cycle can expand GHG transparency, accountability, and data management.
- Primary data can reflect operational changes from actions taken to reduce emissions, whereas secondary data sources may not reflect operational changes undertaken by companies.
- Observed data provides transparency and accountability to the companies that have direct control over emissions sources and have the greatest ability to achieve reductions through operational changes.

In general, primary data should be collected for all sources and activities the company targets for GHG emission reductions. Collecting primary data allows companies to more effectively track progress toward its GHG reduction goals.

Box 9-3: Types of Control

The GHG Protocol *Corporate Accounting and Reporting Standard* defines two types of control: Financial Control and Operational Control.

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

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

For more information on control refer to the GHG Protocol *Corporate Accounting and Reporting Standard*

Box 9-4: Collecting Supplier Data

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

- Based on process-specific information and not disaggregated site information from a corporate inventory
- Provides sufficient supporting information to enable users to understand how the data was gathered, calculation methodologies, and inventory quality.

For guidance on how to collect supplier data and device a data collection strategy see Appendix D: Supplier Guidance.

Case Study: Collecting and Using Supplier Data – to be developed

9.2.6 Collecting Secondary Data

Secondary data are process data that are not from specific processes in the product's life cycle. Financial activity data, whether specific or generic to the given process, are also secondary data.

Examples of secondary data include:

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

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

For information on using secondary data to fill data gaps see section 9.2.11.

Lifecycle databases

Secondary data can be sourced from lifecycle databases. Many databases exist and they vary in their sector or geographic focuses, cost, update frequency, and review processes. Some questions to use in the selection of a database are listed in **Box 9-5**. While these questions can be used to evaluate entire databases companies are required to assess the quality (both in representativeness and data collection methods) of the individual data points chosen from databases using the data quality indicators in Section 9.2.8. The sources of emission factors used in the inventory should be documented in the data management plan.

Box 9-5: Questions to Assist with Selecting a Lifecycle Database to Use with the Product Standard

1. Are the process data from a collection of actual processes or estimated/ calculated from other data sources?
2. Were the data developed using a consistent methodology?
3. For agricultural & forest products are land use impacts included in the LCA emissions data? If yes, what impacts are included?
4. How long has the database existed, and how extensively has the database been used?

5. How frequently is the database updated?
6. How current are the data sources used for developing the LCA emissions data in the database?
7. Can uncertainties be estimated for the data and are the meta-data available?

9.2.7 Reporting Data Types

Companies are required to report the percentage of the inventory emissions calculated with:

- Primary Data
- Secondary Process Data
- Secondary Financial Data

If the company does not know the data type used in an emission calculation they can report this data in an unspecified data category. For more information on reporting see chapter 14.

9.2.8 Assessing Data Quality

Data quality indicators address how well the data fits the given process in the product inventory. Generally, data quality can be broken into how representative the data are (in time, technology, and geography), and the quality of the data measurement (completeness of data collection, and the precision of the data).

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

- Improving the inventory's data quality. The results of a data quality assessment can identify which data sources are of low quality, allowing companies to improve the overall inventory quality by collecting different data of higher quality.
- Assisting the assurance process. An assurance provider may request information on the quality of the data used in the product inventory.
- Demonstrating to stakeholders the quality of the data used in the product inventory. For requirements for reporting data quality, see section 9.2.9.

Companies are required to assess and document activity data, emission factors, and/or direct emissions data using the data quality indicators during the data collection process.

Data Quality Indicators & Methods

All data quality assessments are based on data quality indicators; it is how these indicators are used that may vary. The five data quality indicators used to assess individual data points for processes in the product inventory.

Table 9-1: Data Quality Indicators[43]

Indicator	Explanation
Technological representativeness	Degree to which the data reflects the actual technology (ies) used in the given process. Companies should select data that are technologically specific to the given process.
Temporal representativeness	Degree to which the data reflects the actual time (e.g., year) or age of the given process. Companies should select data that are time-specific to the given process.
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. Companies should select data that are geographically specific to the given process.

[43] Adapted from Weidema and Wesnaes (1996)

Completeness	Degree to which the data are statistically representative of the process sites. Completeness includes the percentage of locations for which the data are available and used out of the total number that relate to the given process. Completeness also addresses seasonal and other normal fluctuations in data (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). Companies should select data that are complete to the given process.
Precision	Measure of the variability of the data values used to derive the data for the given process (e.g. low variance = high precision). Companies should select data that are the most precise.

There is no one particular method for applying the data quality indicators. One method for assessing data is outlined below (the qualitative data quality assessment method); however, companies may use other available methods. Regardless of the data quality assessment method used, companies should document the method and results to support the assurance process, internal inventory quality controls, and for tracking data quality improvements over time.

Improving the quality of data that has a large influence on the inventory results in a large improvement in the overall inventory quality; therefore, if there are resource constraints companies should focus the assessment and collection of new data (if applicable), on data for the largest sources of emissions. Although it is a requirement to assess the data quality of all sources, both small and large, improving the data quality of small emission sources may be a lower priority for companies.

Qualitative data quality assessment

Qualitative data quality assessment approach uses rating criteria for each of the data quality indicators on direct emissions data, activity data, and emission factors as applicable.

This rating system has elements of subjectivity. For example, some fuel emission factors have not changed significantly in many years. Therefore, a fuel emission factor that is over 10 years old, which would be assigned a temporal score of poor with the data quality in **Table 9-2**, may not be different than a factor less than 6 years old (a temporal rating of good). Companies should consider the individual circumstances of the data when using the data quality criteria results as a basis for collecting new data or when using the results in an uncertainty assessment (see chapter 11 for requirements and guidance on uncertainty).

Table 9-2: Criteria to Evaluate the Data Quality Indicators (Adapted from Weidema and Wesnaes, 1996)

Score	Representativeness to the process in terms of:				
	Technology	Time	Geography	Completeness	Precision
Very Good	Data generated using the same technology	Data with less than 3 years of difference	Data from the same area	Data from all relevant process sites over an adequate time period to even out normal fluctuations	Data has less than ±5 percent standard deviation
Good	Data generated using a similar by different technology	Data with less than 6 years of difference	Data from a similar area	Data from more than 50 percent of sites for an adequate time period to even out normal fluctuations	Data has less than ±20 percent standard deviation

Fair	Data generated using a different technology	Data with less than 10 years of difference	Data from a different area	Data from less than 50 percent of sites for an adequate time period to even out normal fluctuations OR more than 50 percent of site but for shorter time period	Data has less than ±50 percent standard deviation
Poor	Data where technology is unknown	Data with more than 10 years of difference OR the age of the data are unknown	Data from an area that is unknown	Data from less than 50 percent of sites for shorter time period OR representativeness is unknown	Data has more than ±50 percent standard deviation

9.2.9 Reporting on Data Quality for Significant Processes

Companies are required to report on the data sources, data quality, and efforts to improve data quality for processes deemed significant by the reporting company. Companies need to determine which processes are significant to report the data sources, quality concerns, and quality improvement efforts. The criteria included in the screening steps (see section 9.2.3) may be helpful to identify significant processes.

Significant Process Name	Data Sources	Data Quality	Efforts to Improve Data Quality
Example: Fruit product transport from Distribution Center to Retail Store in Germany	*Activity Data: Average miles traveled for produce in Germany* *Source: Trucking Association.* *Emission Factor: U.K. DEFRA's Freight Transport*	*Activity data does not reflect our company's actual transport kilometer to take into account shipping efficiencies (good technology score). Emission Factor is for UK transport, not specific to Germany (poor geographic indicator score).*	*[We are working to improve our internal data collection efforts on kilometers driven. We are also working with our trade association to obtain country-specific emission factors for truck transport.]*

9.2.10 Additional Data Quality Considerations

In addition to the data quality indicators in **Table 9-1**, companies should consider the following quality considerations:

Allocated Data

Data that has not been allocated is preferable to allocated data. For example, with other data quality indicators being roughly equal, data gathered at the process-level for a product that does not need to be allocated is preferable to facility-level data that needs to be allocated between the studied product and other facility outputs. For requirements and guidance on performing allocation see Chapter 8.

Data Transparency

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

Uncertainty

Data with high uncertainty can negatively impact the overall quality of the inventory. For guidance on assessing data uncertainty see Chapter 11.

9.2.11 Data Gaps

Data gaps exist when there is no primary or secondary data that is sufficiently representative to the given process in the product's life cycle. For most processes where data may be 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. Data gaps may exist when:

- Emissions factors or activity data may not exist for a specific input/product, or
- Emissions factors or activity data may exist for a similar process but:
    - The data has been generated in a different region
    - The data has been generated using a different technology
    - The data has been generated in a different time period

Data gaps should be filled using:

- Extrapolated data, e.g., data specific to another process or product that has been adapted or customized to more-closely resemble the conditions of the given process in the studied product's life cycle
- Proxy data, e.g., data specific to another process or product that has not been adapted or customized to more-closely resemble the conditions of the given process in the studied product's life cycle.

If it is not possible to fill data gaps with extrapolated or proxy data, companies should estimate the data to determine significance. If the estimated data are significant and no other options are available (e.g. use additional resources to collect primary data), the estimated data should be used to fill data gaps. Extrapolated, proxy, and estimated data are all considered secondary data. The following sections give additional guidance on proxy, extrapolated, and estimated data.

Proxy Data

Proxy data can 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 a proxy to fill these gaps. The choices of proxy data are usually based on the knowledge and past experience of the person undertaking the product inventory, without having the possibility to validate such choices. Examples of proxy data include:

- Using data on apples as a proxy for all fruit
- Using data on PET plastic processes when data on the specific plastic input is unknown

Extrapolated Data

Extrapolated data refers to data that has been adapted or customized to more-closely resemble the conditions of the given process in the studied product's life cycle. Extrapolation may occur in many dimensions around the product, technology or geography. Extrapolating data requires knowledge of both the given process (es) and the process the data are being extrapolated from.

Extrapolation may vary in the degree of customisation applied. Identifying the critical inputs, outputs, and other metrics should be based on other relevant product inventories or other considerations (e.g. stakeholder consultant) when product inventories do not exist. Examples of extrapolated data include:

- Adapting an electricity grid emission factor for one region to another region with a different generation mix
- Customizing the amount of material consumed by a process in another product's life cycle to match a similar process in the studied product

Estimated Data

When a company cannot collect extrapolated or proxy data to fill a data gap, companies should estimate the data to determine significance. Estimated data refers to data generated using simple assumptions and data sources other than process, financial activity, extrapolated, or proxy data. If processes are determined to be insignificant based on estimated data, and no primary or secondary data exists, the process may be excluded from the inventory results. Criteria for determining insignificance are included in Chapter 7.

For an example of estimated data, consider a process for which there is no primary or secondary data (including proxy and extrapolated) available on material input X other than it contributes 0.5 g to a 100 g to the mass of the product. A company chooses an emission factor for the highest GHG intensity material they know to perform a conservative estimate.

If the emissions are estimated to be significant then a justified exclusion cannot be made. Process emissions quantified using estimated data and included in the inventory are reported as secondary data (either secondary process or secondary financial data) as detailed in the reporting requirements in Chapter 14.

To assist with the data quality assessment, any assumptions made in filling data gaps, along with the anticipated effect on the product inventory final results, should be documented. **Figure 9-2** illustrates the above-mentioned guidance for filling data gaps.

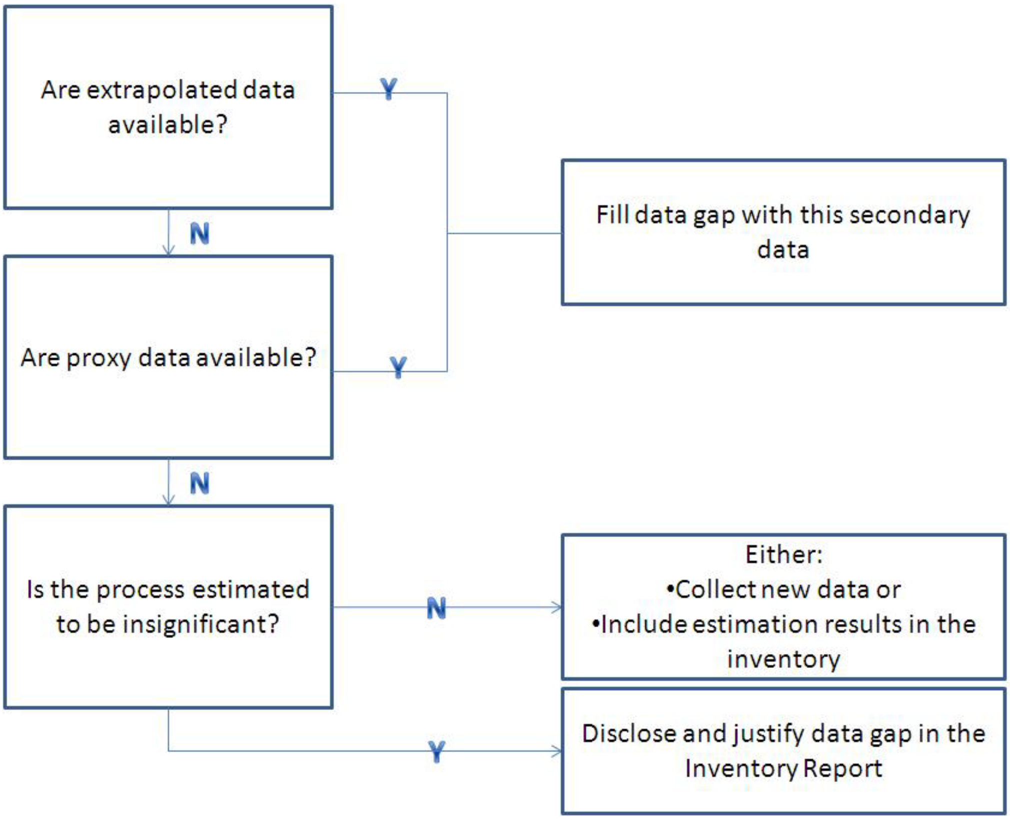

Figure 9-2: Guidance for Filling Data Gaps

9.2.12 Improving data quality

Collecting data and assessing its quality is an iterative process to improving the overall data quality of the product inventory. If data sources are identified as low quality using the data quality indicators, companies should re-collect data for the particular process, especially if that process was found to be significant in the screening process.

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

Using the data quality assessment results, identify any data of low quality.

Step 2: Collect new data for the low quality data sources.

Sources with low quality data that have also been identified as significant through the screening process should be given priority.

Step 3: Evaluate the data quality of the new data. If it is of higher quality than the original data, replace the original data with the new data. If the data are not of higher quality, either:

- Use the existing data
- Collect new data

Step 4: Repeat as necessary and as resources allow.

Step 5: Update and adjust data sources.

Box 9-6: Case Study Using Data Quality Assessment Results - To be developed

10 Data Management Plan

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

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

10.1 Overview of the Data Management Plan

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

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

At a minimum the data management plans should contain:

- Description of the product (and functional unit)
- Information on the 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 the results of any data quality assessment performed
- Calculation methodologies
- Length of time the data should be archived
- Data transmission, storage and backup procedures
- All QA/QC procedures for data collection, input and handling activities, data documentation and emissions calculations

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

10.2 Creating a Data Management Plan

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

1. *Establish a product accounting quality person/team.* This person/team should be responsible for implementing and maintaining the data management plan, continually improving the quality of product inventories, and coordinating internal data exchanges and any external interactions (such as

with relevant product accounting programs and assurance providers). The person/team may be responsible for all product inventories undertaken by a company or for an individual product inventory.

2. *Develop Data Management Plan.* For publicly-disclosed product inventories, the plan should cover the components outlined in the section above (also see Table 10-1). Documenting this information should assist with completing repeat product inventories and assessing and improving the quality of the current product inventory.

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

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

4. *Perform specific data quality checks.* 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 Chapter 11 on assessing uncertainty).

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

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

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

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

The data management plan checklist outlines what components should be included in a data management plan and can be used as a guide for creating a plan or for pulling together existing documents to constitute the plan.

Table 10-1: Data Management Plan Checklist

Component	Information	Rationale
1. Responsibilities	Name and contact details of persons responsible for: • Management of product inventory • Data collection for each process • Internal audit procedures • External audit procedures	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.
2. Product Description	Description of the product and	To provide internal auditors, assurance providers, and those doing future product

	functional unit	inventories, information on the product/functional unit
3. System boundary	• System boundary description (e.g. cradle to grave or cradle to gate) • How the boundary was derived • Attributable processes included in the inventory • Attributable processes excluded from the inventory (including rationale for exclusion) • Information on how the product use and end-of-life profile was determined	To provide internal auditors, assurance providers, and those doing future product inventories sufficient information to understand and replicate boundary decisions.
4. Allocation	• Allocation methodologies used and where they were used	To provide internal auditors, assurance providers, and those doing future product inventories sufficient information to understand and replicate allocation decisions.
5. Data Summary	• Data collection procedures, including data sources for each process	Records all data sources and allows others to locate data sources (for audit or future product inventories). Also provides information on what suppliers have been approached for data.
	• Quality of data collected for each process and if and how a data quality assessment was undertaken	• Enables data quality to be tracked over time and improved
	• Data sources where better quality data is preferable and plan for how to improve that data	• Identifies where data sources should be improved over time (e.g., needed emissions for laptop computer but could only obtain desktop computer information), including those suppliers who were asked to provide data and those that were not
	• Criteria used to determine when an inventory is to be re-evaluated, including the relevant information and changes to the system to be tracked over time and how these changes should be tracked	• This allows data and information sources to be tracked and compared 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

	• Calculation methodologies used (and references). This include where the calculation methodology for any secondary data used was not available.	• Provides internal auditors, assurance providers, and those doing future product inventories details on how emissions were calculated
6. Emissions Calculations	• Changes in calculation methodologies over time	• Noting methodological changes allows for easier baseline recalculation when tracking inventory improvements
	• How and where data is stored	• Allows information to be easily located
7. Data Storage Procedures	• Length of time data is archived for	• Keeps a record of how long information is stored to prevent looking for information that is no longer kept
	• Backup procedures	• Ensures backup procedures are implemented
8. QA/QC Procedures	• QA/QC procedures used See Table 2 for detailed guidance	• Ensures that adequate processes are in place to check data collection, input and handling, data documentation, and emissions calculations.

Table 10-2: Quality Assurance/Quality Control Procedures

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 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, base inventory (if relevant), GHGs included, allocation methodology uses, data sources and any relevant assumptions are documented and archived • Check that all data quality indicators are described, documented and archived for each process • Check for consistency in emissions sources and data sources to similar product inventories
Recording parameter and unit information	• Check that all units are appropriately labeled in calculation sheets • Check 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 are documented
Database/calculation sheet integrity	• 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 data quality assessment, 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

11 Assessing Uncertainty

The term uncertainty assessment refers to a systematic procedure to quantify and/or qualify the uncertainty in product GHG inventories. Uncertainty is an important aspect of any analysis and can be crucial for properly interpreting inventory results. Additionally, documenting sources of uncertainty can assist companies in understanding the steps required to help improve the inventory quality and the level of confidence users have in the inventory results. Because the audience for a product inventory report is diverse, companies should make a thorough yet practical effort to communicate the level of confidence and key sources of uncertainty in the inventory results.

The following chapter provides guidance to help companies identify, assess, and report qualitative information on inventory uncertainty. Appendix E includes more detailed descriptions of quantitative approaches to assess uncertainty, as well as an example uncertainty report. While remaining current with leading science and practice in the area of life cycle assessment, this uncertainty guidance is intended to favor practicality and feasibility for companies with widely ranging levels of expertise.

11.1 Requirement

A qualitative statement on sources of inventory uncertainty and methodological choices shall be reported.

11.2 Guidance

11.2.1 Role of the Uncertainty Assessment Process

Figure 11-1 illustrates the role of uncertainty assessment within the GHG inventory process. It is recommended that companies keep a listing of areas of uncertainties throughout inventory development in order to facilitate the assessment, assurance, and reporting processes.

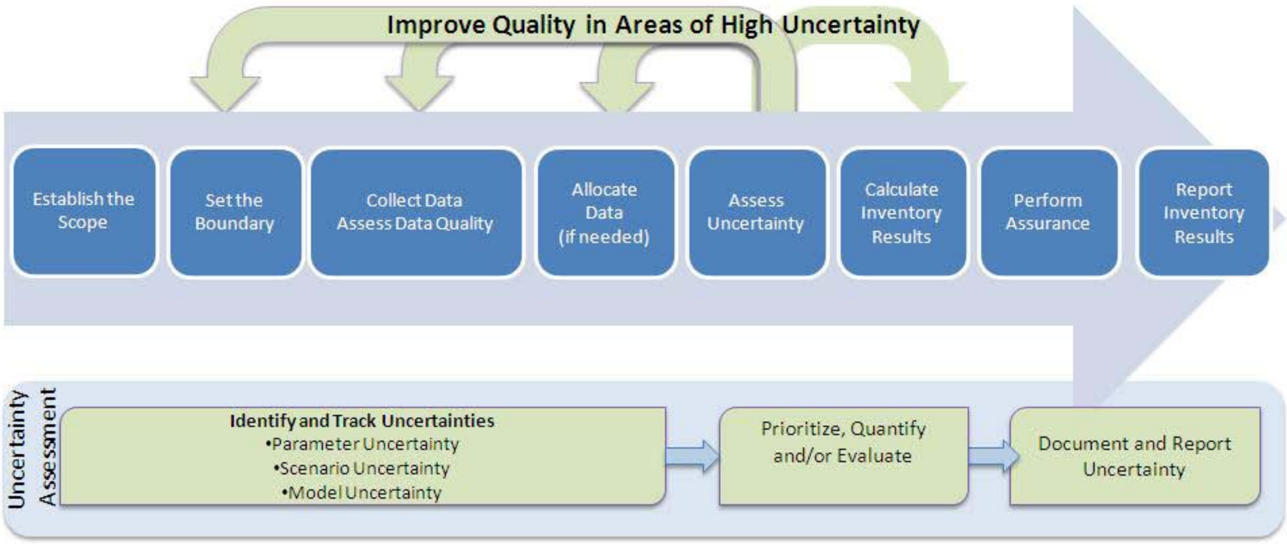

Figure 11-1: Iterative process of tracking and evaluating uncertainty with regard to project goals.

The following sections present a framework for classifications of uncertainty; definitions of the types of uncertainty encountered in a product GHG inventory; and categories of uncertainty and methodological choices companies are required to qualitatively report on in the inventory report.

While the reporting requirements are focused on qualitative descriptions, quantitative assessments of uncertainty can assist companies in prioritizing data improvement efforts on the sources that contribute most to uncertainty and in understanding the influence methodological choices have on the overall product inventory; a quantitative approach can also add clarity and transparency in reporting on uncertainty to inventory report readers. Appendix E includes additional guidance on quantifying and reporting uncertainty. Companies may report quantitative uncertainty results in the inventory report.

The procedure recommended here is intended to assist companies in tracking, evaluating and reporting on the sources of uncertainty in their analysis. Regardless of whether companies choose a qualitative and/or quantitative approach, the same general concept and flow of work shown below applies. Assessment of uncertainty is most useful when companies identify and track key uncertainty sources throughout the inventory process and iteratively checks on whether the confidence level of the results is adequate to meet the intended business goals. Once a sufficient level of confidence in the results is achieved, a process of reporting the results and their uncertainty can be initiated.

11.2.2 Types of Uncertainty

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

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

As shown in **Figure 11-1**, these types of uncertainties arise throughout the stages of the GHG inventory compilation process. **Table 11-1** illustrates these various types of uncertainties and how each type can be represented.

Table 11-1: Types of uncertainties, corresponding sources and representation

<table>
<tr><th colspan="2">Types of Uncertainty</th><th>Representation</th></tr>
<tr><td rowspan="3">Parameter Uncertainty</td><td>Uncertainty in Activity Data</td><td rowspan="3">Represented as probability distributions/range and/or as qualifications</td></tr>
<tr><td>Uncertainty in Emission Factor Data or in Estimated/Measured Emissions Data</td></tr>
<tr><td>Uncertainty in Impact Assessment</td></tr>
<tr><td rowspan="2">Scenario Uncertainty</td><td>Uncertainty in Methodologies</td><td rowspan="2">Represented as multiple outcomes and/or as qualifications</td></tr>
<tr><td>Uncertainty in Situations</td></tr>
<tr><td>Model Uncertainty</td><td>Limitations of Models</td><td>Represented as qualifications</td></tr>
</table>

Parameter Uncertainty

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

Single Parameter Uncertainty

Single parameter uncertainty refers to incomplete knowledge about the true value of a parameter[44]. Parameter uncertainty addresses the question, how well do the data that is used to represent a parameter fit the given process? Measurement errors, inaccurate approximation, and how the data was modeled to fit the conditions of the process influence parameter uncertainty.

For example, two data points of similar measurement accuracy may result in very different levels of uncertainty depending on the points represent the given process’s context.

[44] Parameter refers to the processes, inputs, outputs, within the product’s life cycle.

EXAMPLE:

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

Single parameter uncertainty can arise in three data types: direct emissions data, activity data, and emission factors. Components of these data may have uncertainties associated with them; it is recommended that those uncertainties be considered in the overall parameter uncertainty of the data points than in their own regard. This provides a structured framework for assessing and reporting on uncertainty that aids both the company and stakeholders in understanding the sources of parameter uncertainty within the inventory calculations.

Propagated Parameter Uncertainty

Propagation of parameter uncertainty is the combined effect of each parameter's uncertainty on the uncertainty of the total computed result. Methods are available to propagate parameter uncertainty from single data points There are two prominent methods applied to propagation of parameter uncertainty: by random sampling (such as in the Monte Carlo method) and by analytical formulas (such as in the Taylor Series expansion method). These methods are described in Appendix E.

EXAMPLE:

The inventory total for the printer cartridge is 155 kg CO_2e per functional unit of printing of 50,000 pages. The activity data, emission factor data and GWPs applied in this calculation each have a level of parameter uncertainty. This uncertainty is determined based on the total effect of all of the single parameter uncertainties. The propagated parameter uncertainty assessment shows that there is a 95% confidence that the true value of the product inventory is between 140 and 170 kg CO_2e. This can also be presented as: the inventory total is 155 kg CO_2e (+/-15 kg CO_2e)[45] per functional unit.

Scenario Uncertainty

Whereas parameter uncertainty is the measure of how close the data and calculated emissions are to the true (though unknown) actual process data and emissions, scenario uncertainty can be thought of as how much variation there may be in the process's emissions based on methodological choices. To identify the influence of these selections on results, parameters (or combinations of parameters) are varied in an exercise known in LCA as scenario analysis.[46] Scenario analysis can reveal differences in the inventory results due to different modeling approaches, allocation procedures, and use or end-of-life modeling choices.[47]

Methodological Uncertainty

Methodological uncertainty stems from the various methodological choices made by the reporting company that can affect the inventory results. An example of a methodological choice is the selection of appropriate allocation methods. When there are multiple methodological choices available in the standard methodological uncertainty is created.

EXAMPLE:

A company may choose to allocate facility electricity consumption between the toner production and other production lines using the physical allocation factor of the number of units produced.

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

[46] This also referred to as sensitivity analysis in some literature and other sources.

[47] Mark A. J. Huijbregts, 1998. Application of uncertainty and variability in LCA. Part I: A General Framework for the Analysis of Uncertainty and Variability in Life Cycle Assessment. Int. J. LCA 3 (5) 273 - 280

Using this factor 30% of the electricity consumption is allocated to the toner production process. However, allocating the electricity by the mass of products results in 40% of the electricity consumption allocated to the toner production process.

It should be noted that the use of standards results in a reduction in methodological uncertainty by constraining choices the user may make in their methodology. For example, the attributional approach and boundary setting requirements standardize the inventory approach for all products. Therefore, the uncertainty associated with different methodological or boundary setting approaches can be excluded from the uncertainty assessment.[48]

Situational Uncertainty

Similar to methodological uncertainty, situational uncertainty assessment is a useful tool to understand how changes in the product's design, use, and disposal could impact inventory results. Rather than a measure of the confidence in the result within the scenarios defined in the product's inventory, situational uncertainty can be thought of as the impact of potential situations other than the conditions and assumptions made in the product's inventory results and report.

EXAMPLES:

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

The number of pages produced by one printer cartridge can vary, especially depending on the amount of ink required per page; therefore, there is a range in the number of cartridges required to print a certainty number of pages. A company could consider a reasonable upper and lower bound to illustrate the influence of this uncertainty, or they could show various results that are specific to a consumer's printing habits.

Model Uncertainty

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

In many cases, model uncertainties can be represented—at least in part—through the parameter or scenario approaches described above. However, some aspects of model uncertainty might not be captured by those classifications and are otherwise very difficult to quantify.[49]

EXAMPLE:

A model of soy production is involved in predicting emissions from the production of the cartridge's soy-based ink. The emission of N_2O due to application of nitrogen fertilizers is based on a linear modeling of interactions of the fertilizer with the soil and plant systems, which are in fact more complicated processes than represented, leading to uncertainty regarding the emissions information resulting from this model.

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[48] Although such methodological choices may be reduced in regard to reporting under this protocol, they might still be considered in regard to their contribution to uncertainty in whether the reported result reflects the intended "true" value.

[49] In some cases, a validation of modeling components may be possible, but it may not be feasible for the reporting company if the model assurance has not been performed by others already.

11.2.3 Reporting Qualitative Uncertainty

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

Table 11-2 includes the required qualitative uncertainty sources to report on; companies may provide additional detail to the qualitative statements if they choose to.

Table 11-2: Example disclosure of qualitative uncertainty information

Source of Uncertainty	Qualitative Description
Scenario Uncertainty	
Use Profile[50]	[Describe the use profile of the product. If more than one use profile was applicable, disclose which method was used and justify the choice]
End-of-Life Profile[51]	[Describe the end-of-life profile of the product. If more than one end-of-life profile was applicable, disclose which method was used and justify the choice]
Allocation Method(s)	[Describe any allocation problems in the inventory and which allocation method was used. If more than one allocation method was applicable, disclose which method was used and justify the choice]
Recycling Allocation Method(s)	[Disclose and reference which method was used (0/100 output method, 100/0 input method, or other method]
Parameter Uncertainty	
Data (Single Parameter Uncertainty)	Included in Data Quality Reporting requirements instead. See **Section 9.2.9**
Impact Assessment	[List the source of Global Warming Potential (GWP) factors used]
Propagated Parameter Uncertainty	N/A
Model Uncertainty	
Model Sources Not Included in Scenario or Parameter Uncertainty	[Describe the models, identify their published source, and identify areas where they may deviate from real world conditions]

11.2.4 Uncertainty in Comparisons

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

Whenever considering uncertainty in a comparison, it is important to recognize that the uncertainty ranges of each individual system or component should not be directly compared; rather, it is the uncertainty in the comparison itself that should be assessed. That is, rather than comparing the distribution of A and the distribution of B, one can assess the distribution of A divided by B (i.e. (A/B)). This can be done for both parameter uncertainty and scenario uncertainty.

An important result of assessing uncertainty at the level of a comparative result is that uncertainties with a similar contribution to both systems should be correlated and therefore not influence the comparative result. Because of this, a comparison of two relatively uncertain results may itself be of relatively high certainty.

[50] For Cradle-to-Grave Inventories.

[51] For Cradle-to-Grave Inventories.

EXAMPLE:

The manufacturer of the toner cartridge estimates the GHG inventory of the cartridge with a parameter uncertainty of +/- 20%. The company develops a lighter weight cartridge body, saving 30% of the weight of that component and 3% of the total product carbon footprint. Besides the difference in weight, the processes in the two inventories are the same and the data sources are consistent between the inventories. Therefore, while both the original and revised inventories each have a parameter uncertainty of +/- 20% and the difference in their results is 3%, we can be confident that the new design is less impacting than the old design because the only difference is in the weight of the housing and we are relatively certain in these masses.

12 Calculating Inventory Results

Once data has been collected, data quality has been assessed and improved as much as possible, the next step is to calculate the GHG impact of the studied product. This chapter outlines key requirements, steps, and procedures involved in quantifying the GHG impact.

12.1 Requirements

A 100 year global warming potential (GWP) metric shall be applied to all GHG emissions data to calculate the GHG impact in units of CO_2 equivalent (CO_2e). Companies shall reference the source and date of the GWP factors used in the inventory report.

A company shall quantify inventory results by:

- Total CO_2e per unit of analysis
- Biogenic and non-biogenic removals and emissions (when applicable)
- Land use impacts (when applicable)
- Percentage of total life cycle impacts by life cycle stage
- Percentage of primary data, secondary process data, and secondary financial data.

The following shall not be included when calculating the inventory results:

- Weighting factors for delayed emissions
- Offsets
- Avoided emissions

Definitions of these are included in the following guidance section.

12.2 Guidance

Once data collection and data quality assessments are complete, companies have direct emissions measurements, activity data, and emission factors, which are used to calculate inventory results. For consistency, all inventory results are reported as a GHG impact in the form of CO_2 equivalents (CO_2e). Once CO_2e is known, companies can calculate the inventory results as CO_2e/unit of analysis, which includes all emissions and removals that occur during the product's life cycle.

12.2.1 Calculating the GHG Impact of the Studied Product

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

1. Calculate GHG impacts using collected data

The following equations illustrate how to calculate GHG impacts based on activity data, emission factors, and Global Warming Potential (GWP).

When process or financial activity data is collected the basic calculation equation is:

$$GHG\ Impact\ (kg\ CO_2e) = Activity\ Data\ (unit) \times Emission\ Factor\ (\frac{kg\ GHG}{unit}) \times GWP\frac{kg\ CO_2e}{kg\ GHG}$$

When direct emissions data has been collected, an emission factor is not required and therefore the basic calculation equation is:

$$GHG\ Impact\ (kg\ CO_2e) = Direct\ Emissions\ Data\ (kg\ GHG) \times GWP\frac{kg\ CO_2e}{kg\ GHG}$$

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

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

The GWP is a metric used to calculate the cumulative radiative forcing impact of multiple GHGs in a comparable way. Each GHG has its own GWP, and because all GWPs are relative to CO_2, the GWP for CO_2 is 1.

Although GWP metrics are available for different time periods (e.g., 20 and 500 years), 100 years is used most often by programs and policies as the median metric and is therefore required by this standard for consistency. Companies may report results separately in the inventory report using 20 or 500 year GWP metrics or other impact assessment metrics such as global temperate potential (GTP) for comparison if they feel this would be useful information to their stakeholders.

Because radiative forcing is a function of the concentration of GHGs in the atmosphere, and because the methodology to calculate GWP continues to evolve, GWP values may be updated every few years. For consistency, companies should use the same GWP values throughout the inventory (and subsequent inventories if applicable). Companies are required to report the source and data of the metrics for transparency. Companies are referred to the IPCC publications and reports for more information on GWP and the most recent GWP values.

2. Calculate total CO_2e/unit of analysis

The CO_2e values for all emissions and removals during the life cycle of the product are summed together on the reference flow basis to calculate the total CO_2e/unit of analysis.

$$\frac{Total\ CO_2e}{unit\ of\ analysis} = \frac{CO_2e\ Emissions}{unit\ of\ analysis} - \frac{CO_2e\ Removals}{unit\ of\ analysis}$$

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

12.2.2 Quantifying Inventory Report Information

Along with the total CO_2e/unit of analysis, companies are required to report the inventory results listed in **Table 12-1**. The reporting chapter includes a template to help companies organize the inventory results in a consistent manner.

Table 12-1: Guidance for Quantifying Inventory Results

Inventory Result	Quantification Guidance
Percentage of Impact per Life Cycle Stage	The total impact (emissions and removals) for each life cycle stage on the reference flow basis is divided by the total CO_2e/unit of analysis to calculate the percentage of impact per life cycle stage. - If the removals in the material acquisition phase are large enough to create a negative percent impact from that stage (e.g. for biogenic products), this should be noted clearly in the inventory report - If the 0/100 output method was used to account for recycling, the displacement of virgin material should not be calculated as part of the percentage but should be noted separately
Percentage of primary, secondary process, and secondary financial data	The CO_2e/unit of analysis contribution to each data types is divided by the total CO_2e/unit of analysis to calculate the percentage of each data type used to determine the inventory results.
Biogenic and Non-Biogenic Removals and Emissions (when applicable)	The total CO_2e/unit of analysis is separated into biogenic and non-biogenic emissions and removals[52]. These are reported in units of CO_2e/unit of analysis and when summed together with land use impacts equal the total CO_2e/unit of analysis. - If a company does not have removals or biogenic emissions, they may report only the total CO_2e/unit of analysis, noting that no removals or biogenic emissions were present in the product's life cycle
Land Use Impacts (when applicable)	If land use impacts are attributable to the studied product, the emissions and removals are included in the total CO_2e/unit of analysis but also reported separately for transparency. Land use impacts are reported in units of CO_2e/unit of analysis and when summed together with biogenic and non-biogenic emissions equal the total CO_2e/unit of analysis. Guidance on calculating land use impacts is available in Appendix C.

The following cannot be included in the inventory results but can be reported separately in the inventory report (see Chapter 14):

- Weighting factors for delayed emissions
- Offsets
- Avoided emissions

In a life cycle, particularly for products that have long use and end-of-life time periods, emissions can occur at different points in time and therefore may have different impacts on the atmosphere. Some methodologies try to capture this in the life cycle results by applying a weighting factor to account for emissions delayed over time. This standard requires inventory results to be calculated without weighting factors. This is true for both biogenic and non-biogenic emissions and products. Companies wishing to show the impact of delayed emissions in the inventory report may do this separately from the inventory results, as long as the results are first published without a weighting factor in the report template. It is

[52] The biogenic and non-biogenic emissions and removals due to land use impacts are not included in these values due to the difficulty in identifying these separately when IPCC or other calculation methods are used. Land use impacts are reported separately as total biogenic and non-biogenic emissions and removals. Guidance on calculating land use impacts is available in Appendix B.

important to note that if a weighting factor applied to emissions in the end-of-life period, the same factor needs to be applied to end-of-life allocation of co-products and recycled materials.

Offset and avoided emissions can both be classified as actions that occur outside the attributional boundary of the product's life cycle and therefore are not included in the inventory results. Offsets are emission credits (in the form of emission trading or funding emission-reduction projects) that a company purchases to offset the impact of their own emissions. Purchased offsets shall not be deducted from the product's total GHG emissions, but instead may be reported separately.

In some cases the term avoided emissions is used interchangeably with offsets and therefore is reported separately as an offset in the inventory report. However, in LCA the term avoided emissions is also used to describe when the studied product (or a co-product that is created during the studied product's life cycle) displaces another product in the market that has greater GHG impacts. For example, an energy-efficient wood-fired boiler is created that reduces the market for coal-fired boilers. This is a situation where consequential modeling is needed to determine how and to what extent the creation of the wood-fired boiler impacts the market for coal-fired boilers. Additionally, this impact occurs outside of the product's life cycle. Therefore, the avoided emissions associated with the potential displacement of a high-impact product cannot be included in the inventory results. Companies wishing to report to their stakeholders on potential benefits that occur outside of the product's life cycle can do so separately in the inventory results but not as part of the inventory results. However, companies reporting potential benefits should also consider and report any potential burdens associated with the displacement.

12.2.3 Quantifying Carbon Storage

Carbon storage occurs in a product life cycle inventory when embedded carbon or process emissions are not released to the atmosphere as GHG emissions. Carbon storage can be a result of the disposal method, the inert nature of the product, or the capture and sequestration of GHGs before they are emitted.

Companies may quantify carbon storage in the following ways according to the requirements of this standard:

- If it is known that embedded[53] carbon within the product is not released to the atmosphere during waste treatment, a company is required to disclose and justify this in the inventory report (Chapter 7)
- In a cradle-to-gate inventory, the amount of embedded carbon within the product as it leaves the inventory boundary is required to be disclosed and justified in the inventory report (Chapter 6)
- If process emissions are not released to the atmosphere due to storage, the attributable processes associated with storing the emissions are required to be included in the inventory boundary (Chapter 7) and the amount of emissions stored is required to be noted in the inventory report (Chapter 14).

[53] Embedded carbon is defined here as carbon molecules that exist as part of the product, not the upstream life cycle emissions associated with the product.

13 Assurance

Having assurance over a product inventory provides confidence to users, including the reporting company, that the reported information represent a fair, reasonable, and accurate presentation of a product's GHG emissions.

13.1 Requirements

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

Data assurance shall be performed when possible. When data assurance is not possible, model assurance shall be performed. The type of assurance shall be determined during the pre-assurance check by the assurance provider.

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

Assurance providers, whether internal or external to the organization, 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.

When reporting a product GHG inventory, the assurance opinion shall also be presented, including or accompanied by a clear statement identifying the type of assurance performed and whether it was performed by a First or Third Party.

Where internal assurance providers are used the following shall be disclosed in the product GHG inventory report or assurance statement:

- their relevant competencies;
- the reason for selecting them as assurance providers; and
- how any potential conflict of interest was avoided.

13.2 Guidance

13.2.1 The Assurance Process

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*[54]. ***Assurance,*** as further defined chapter, provides a broad review of product inventories and is aligned with financial accounting processes and terminology. ***Verification*** is more narrowly defined as the assessment of the accuracy and completeness of reported GHG information against pre-established GHG accounting and reporting principles.

A company completing a product inventory should conduct internal assurance or have an independent third party conduct assurance. An assurance engagement, whether internal assurance performed within the company or third party assurance, has similar elements, including:

1. Planning and scoping (e.g., determine risks, materiality)
2. Identifying processes and emissions data , as applicable
3. Executing the assurance process (e.g., test of controls, test of details, re-perform data collection procedures, gathering evidence, performing analytics, testing of details, testing of controls, etc.)
4. Evaluating results

[54] This standard is based upon guidance from recognized and generally accepted international standards.

5. Determining conclusions and issuing reports.

Providing assurance on product emissions may be challenging. Emissions data relies on a mixture of data sources and assumptions. Inventory uncertainty, including data used to forecast downstream emissions, may affect the quality of the GHG inventory. It is important to consider the state of product data collection systems and the integrity of the underlying data and assumptions for the assurance process.

There may be situations when it is not appropriate to obtain assurance externally; this can be evaluated by performing a pre-assessment of the state of readiness for assurance. This assessment can be performed internally or by an external service provider.

Definition of Assurance

Assurance is an evidence-gathering process whereby an assurer obtains sufficient and appropriate evidence that is used to express a conclusion concerning an outcome of an evaluation or measurement. The nature and extent of assurance procedures can vary widely depending on whether the assurance engagement is designed to obtain reasonable or limited assurance (as described below in Section 13.2.6).

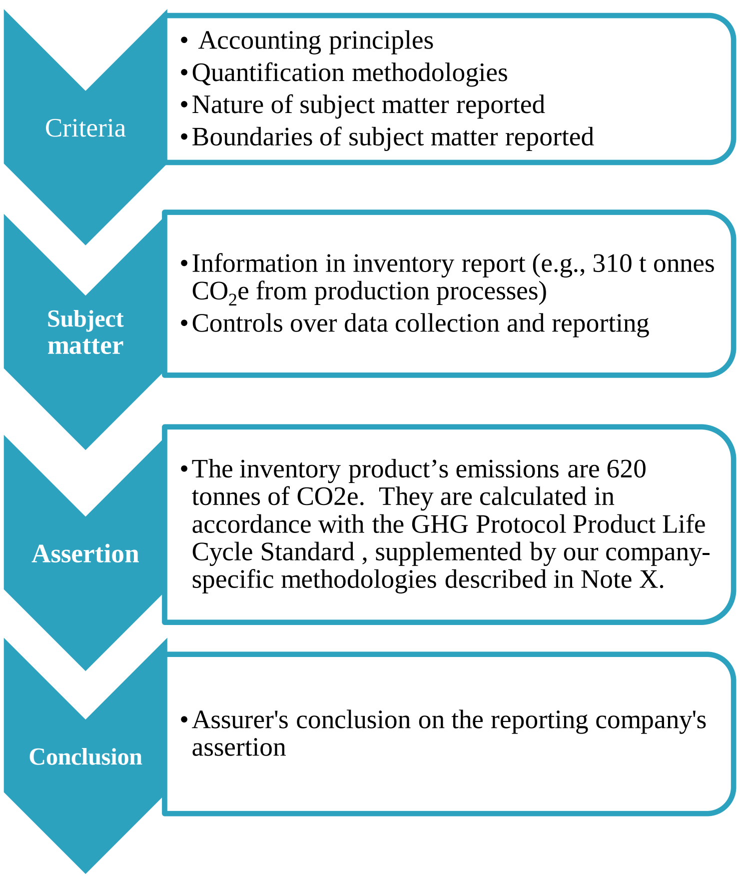

Figure 13-1: The Relationship of Assurance Concepts

The concepts above are explored throughout this chapter.

Assurer - A competent individual or body who is conducting the assurance process, whether internally within the company or externally.

Assertion – A written representation that evaluates or measures the subject matter against the criteria. An assertion examples is a statement about the GHG emissions of a product or organization.

Conclusion – An expression of the results of the assurer's evaluation of the company's written assertion or a statement that a conclusion cannot be expressed. In the event that the assurer determines that a conclusion cannot be expressed, the statement should cite the reason.

Criteria - The benchmarks used to evaluate or measure the subject matter, including how the subject matter is reported and prepared

Subject matter - The information supporting the inventory report and associated assertion(s).

Relationships of Parties in the Assurance Process

Three key parties are involved in the assurance process: 1) the company undergoing assurance that is making an assertion about its emissions (reporting company); 2) an intended user (stakeholders); and 3) an assurer. The key parties may assume multiple roles depending on the type of assurance being provided.

- When the company making the assertion also performs the assurance, this is known as *internal assurance*.
- When a party other than the company making the assertion or the intended user performs the assurance, the assurer is considered to be an external *third party* assurer.

Table 13-1: Types of Assurance

Type of Assurer	Description	Recommended independence mechanism
Internal assurance	Person(s) from within the company but independent of the GHG inventory determination process conducts internal assurance.	Different lines of reporting are key for ensuring independence
External assurance (Third Party)	Persons from an assurance body independent of the product GHG inventory determination process, conduct independent third party external assurance.	Different business entity than the reporting company or intended user

Assurance providers, whether internal or external to the company, are required to be sufficiently independent of any involvement in the determination of the product inventory or development of any declaration and have no conflicts of interests, such that they can exercise objective and impartial judgment. Inherently, assurance provided by a third-party offers a higher degree of objectivity and independence. Independence is required to be disclosed to the intended user in the inventory report. Some typical threats to independence may include financial and other conflicts of interest or lack of segregation between the reporting company and the assurer. These threats should be assessed throughout any assurance process. Assurers should perform an assessment based on their individual facts and circumstances to ensure independence has been maintained.

Preparing for Assurance

Preparing for assurance is a matter of ensuring that the evidence that the assurer requires is available or easily accessed. The type of evidence requested will depend on the subject matter, the industry and the type of assurance being sought. Maintaining documentation of the inventory process through the use of a data management plan (see Chapter 10) is helpful for ensuring the evidence needed for data or model assurance is available.

Evidence is:

- **Physical observations**, such as site tours to confirm the existence and completeness of the sources
- **Assurer's calculations**, such as recalculation of aggregated emissions across GHG inventory
- **Statements by independent parties**, such as an interview of a courier about the driving training received and routes taken to the reporting company

- **Statements by the reporting company**, such as interview of the production manager about production capacity and delivery in last period
- **Documents prepared by an independent party,** such as invoices
- **Documents prepared by the reporting company**, such as procedures used to check sales receipts
- **Data interrelationships,** such as the emissions generated by a supplier and the production rate

13.2.2 Timing of Assurance

Assurance is conducted before the public release of the written assertion and inventory report by the reporting company. This allows for material misstatements to be corrected prior to the release of the opinion and assertion. The work should be initiated far enough in advance of the inventory report release so that the assurance work is useful in improving the inventory when applicable. An example timeline is shown below. The period for assurance is dependent on the nature and complexity of the subject matter, level of assurance, and geographical spread of the evidence.

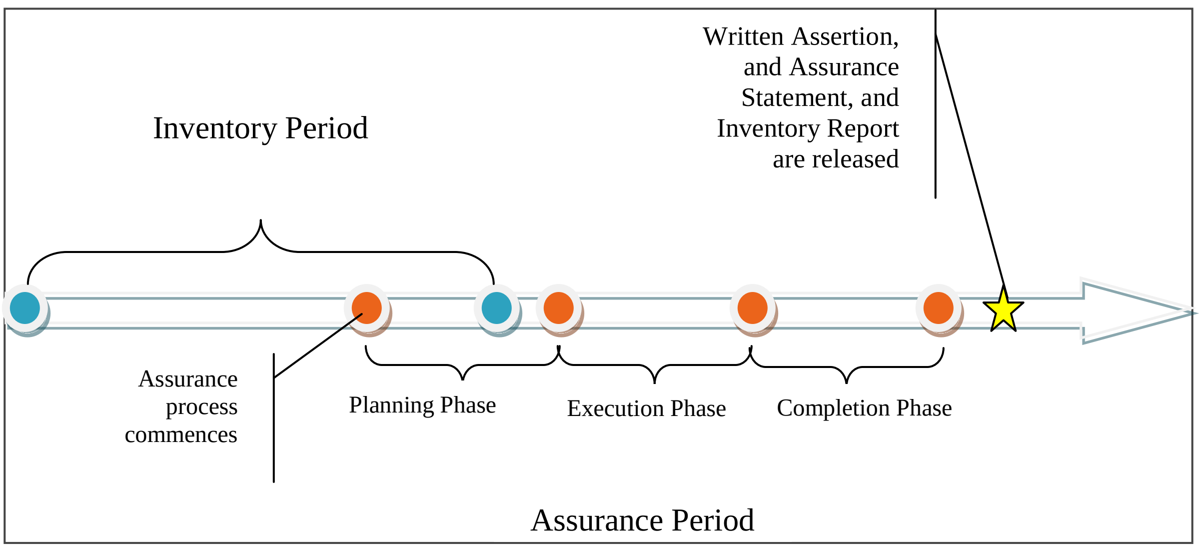

Figure 13-2: Timing of Assurance

13.2.3 Selecting an assurance provider

Selecting an appropriate assurance provider is critical in ensuring that the assurance statement has the credibility needed from the intended user. There are three key characteristics that a reporting company should look for in their assurance provider, whether internal or external:

1. Independence mechanisms: internal mechanisms in-place to communicate requirements for personnel, identify threats to independence and breaches of independence, and to monitor and report the independence status of personnel
2. Competence of the assurance team: knowledge of GHG issues, requirements of the standard, and the company's industry
3. Infrastructure of the assurer: appropriate training protocols, project management systems, and systems to document and retain results of the work performed

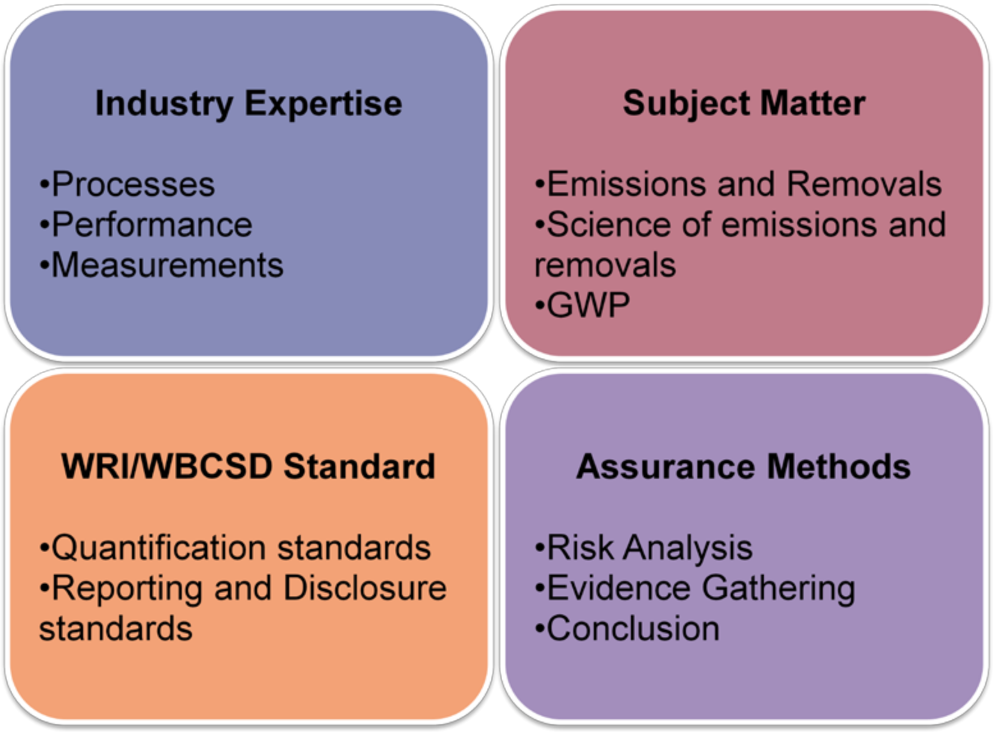

Figure 13-3: Competencies of the Assurance Team

For companies performing internal assurance, the personnel should be independent of those undertaking the GHG inventory accounting and reporting process. Both internal and external assurance should follow similar procedures and processes. For external stakeholders, third-party assurance is likely to increase the credibility of the GHG inventory. However, internal assurance can also provide valuable assurance over the reliability of information and can be a worthwhile learning experience for a company prior to commissioning external assurance. It can also provide third-party assurance providers with useful information.

A credible and competent GHG inventory assurance provider has:

- Deep assurance expertise and proven previous experience under recognized assurance frameworks
- Robust assurance methodologies
- Ability to assess the emission sources and the magnitude of potential errors, omissions and misrepresentations
- Knowledge of the company's activities, industry sector, suppliers and products and understanding of product requirements and guidance concepts and principles
- Objectivity, impartiality, credibility, independence and professional skepticism to challenge data and information.

When internal assurers are used companies are required to report their competencies in the assurance conclusion report.

13.2.4 Preconditions for assurance

Assurance requires certain conditions to be in place in order for a conclusion to be expressed. Illustrated below are the challenges in providing assurance over product emissions. In particular, Section 13.2.5 describes different forms of assurance that the reporting company may select in order to handle these challenges.

There are preconditions for assurance, which apply regardless of whether the assurance provided is internal or external to the company, including:

- The company's written assertion(s)
- An appropriate subject matter
- Suitable criteria that are sufficiently complete and measurable to permit assurance and available to the intended users
- Access to sufficient and appropriate evidence (i.e., invoices, bills of sale, etc.)

Reporting Company's Written Assertion(s)

The "reporting company" is responsible for the assertion, but the reporting company might not be responsible for the subject matter itself.

The reporting company prepares the written assertion and is thus is also responsible for:

- Designing, implementing and maintaining controls relevant to the preparation and presentation of the written assertion;
- Selecting and applying appropriate quantification methods; and
- Making reasonable emissions calculations

Table 13-2 provides examples of written assertions for different assurance types and levels.

Appropriate Subject Matter

Once a company determines the activities included in its product boundary, appropriate subject matter can be determined. The components of the inventory report (data, calculation methodologies, etc.) and inventory quality control mechanisms may be appropriate subject matter. The type of assurance performed will determine which subject matter(s) should be assessed. The data management plan (Chapter 10) contains information on subject matter assurers may review. The data management plan should be made available to assurers at the start of the assurance process.

If the subject matter is not capable of consistent measurement or does not have procedures designed to gather sufficient appropriate evidence, it would be inappropriate to render an assurance conclusion.

Suitable Assurance Criteria

Just as this standard follows GHG accounting and reporting principles (i.e., relevance, completeness, consistency, transparency and accuracy), assurance providers often rely on suitable assurance criteria that are measurable and based on similar principles (i.e., relevant, complete, reliable, neutral and understandable).[55]

[55] International Federation of Accountants

Appropriate Evidence

There needs to be sufficient appropriate evidence for the reporting company to make an assertion and for the assurer to support their conclusion.

Sufficiency is the measure of the quantity of evidence. Sufficient evidence is a question about how much evidence is necessary and how it is evaluated based on professional judgment. If another person could reach the same conclusion on the same evidence, then it is likely that the evidence is sufficient.

Appropriateness is the measure of the quality of evidence; that is, its relevance and its reliability. For evidence to be relevant, it needs to assist in achieving the objectives of the assurance. The reliability of evidence is influenced by its source and nature.

While recognizing that exceptions may exist, the following is an illustrative hierarchy of the reliability of suitable evidence which the company needs to consider as it compiles data for the inventory report:

- Evidence is more reliable when it is obtained from knowledgeable independent sources outside the company (e.g., actual utility invoices vs. internally estimated based on square footage).
- Evidence that is generated internally is more reliable when it is corroborated by other data generated from independent systems.
- Evidence that is generated internally is more reliable when there are effective related controls.
- Evidence obtained directly by the assurer (e.g., observation of the application of controls) is more reliable than evidence obtained indirectly (e.g., inquiry about the application of controls).
- Evidence is more reliable when it is based on standardized processes and controls, and documented at the same time it is generated (e.g. employee expense reports for miles traveled vs. asking employees to estimate mileage).

13.2.5 Types of assurance

This standard recognizes two main types of assurance: data assurance and model assurance. Each assurance type differs in their conclusions and in the level of assurance it provides.

Data assurance includes the inventory data, calculations, processes and other subject matter. Model assurance is only provided on the calculation methodology, data assumptions and standard requirements, not the inventory emissions results.

Data Assurance

Data assurance is expressed over historical data and the adherence to a specified quantification methodology and reporting standard (i.e. the product standard).

Typically, data assurance requires an in-depth understanding of the subject matter and the underlying systems that generate the assertion. This type of assurance is risked-based. Analytical procedures are a basic tool of providing data assurance. Analytics require independently measured parameters for processes with known relationships and continuous data. For example, a company’s monthly electrical utility bills are independently measured and continuous to undergo analytical procedures.

The internal control environment that supports the processes and systems around the emissions data is an important aspect of the company's internal reporting framework. A control environment is properly designed if it is sufficient to detect and prevent a material misstatement. The assurer may perform controls testing, as part of the data assurance process, to increase the efficiency of the assurance process. Control testing is only available to the assurer when a relatively robust data management system is in place. Control assessment offers more certainty about the environment in which the subject matter exists and the written assertion is generated.

Model Assurance

Model assurance reviews the boundaries, calculations and other assumptions used to generate a written assertion to ensure the standard requirements were followed and the assumptions are reasonable. Model assurance offers confidence over models, methodological decisions, and assumptions used to generate the assertion, but not assurance over the written assertion itself (i.e. inventory results). When a model calculates future emissions the assurer should evaluate the model's assumptions.

Model assurance is an option when data assurance is not practical due to limitations and uncertainty related to the data. Model assurance should be considered for use when an inventory contains a substantial amount of assertions relying on modeling.

Modular Approach to Assurance

Modular assurance framework is an implementation approach for both data and model assurance. It is available when a supplier or vendor obtains assurance on their operations or products they sell to or purchase from the reporting company. The assurer for the reporting company may be able to rely on the work of another assurer to increase the scope of their assurance but not necessarily to increase the level of their assurance (i.e., limited or reasonable).

The reporting company's assurer should consider the following before relying on the work of another assurer:

- Independence and competence of the assurer
- Design, nature and results of the component assurance procedures
- The risks of misstatement in the supplier's assertion
- The relative contribution of the supplier's assertion to the reporting company's assertion
- The boundaries of the modular opinion and written assertion

Box 13-1: Site/Supply Chain Visits

Site/supply chain visits are conducted when they are the most efficient and effective way to collect evidence. They are also commonly employed because evidence gathering procedures are very relevant (e.g., direct observation of the completeness and validity of the GHG inventory) and the quantity of evidence needed is less compared to other methods. However, site / supply chain visits can be challenging to conduct for product emissions because of access and location issues. Alternate assurance procedures can be applied; however, the objectives of the assurance procedures, and the sufficiency and appropriateness of the alternate evidence will need to be assessed. Site/supply chain visits are typically not used in assurance over models.

Table 7: Examples of Alternative Procedures to Site Visit Based Procedures

Assurance Procedure Objective	Typical site visit assurance procedure	Potential alternative procedures (not a comprehensive list)
Confirm sources in the inventory	Conduct site tour and compare visual inspection of sources and sinks to GHG inventory list	• Review "as-built" process flow diagrams with identified sources in the process • Review capital asset list or maintenance list • Identify sources based on interviews about the process and understanding of the industry • Identify sources based on third party sources such as aerial photographs, insurance records, leasing lists, etc.
Confirm calibration of measurement devices	Obtain a sample of calibration records	• Obtain a third party report on the calibration • Review operational data for changes in calibration • Obtain a third party measurement for the same measurement point (e.g., sales receipt volume and inventory acceptance volume)
Understand the operation practices and limits	Interview production manager in person Review operational records	• Interview production manager over the phone • Interview a specialist about the operational practices • Review engineering references (e.g., operation manual, product text books, etc) • Conduct analytical testing on the production

13.2.6 Levels of assurance - Limited and reasonable 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.

There are two levels of assurance: limited and reasonable. Both levels of assurance can be performed for data and model assurance types. Model assurance cannot achieve limited or reasonable or limited levels of assurance over an assertion, but it can achieve limited or reasonable assurance over the assumptions underlying the models used to generate the assertion.

The level of assurance requested will determine the amount of evidence required. The highest level of assurance that can be provided is a reasonable level of assurance. Absolute assurance is never provided as 100% of inputs to the GHG Inventory are not tested; testing at such a level by the assurer is neither feasible, practical nor cost efficient.

The thoroughness with which the assurance evidence is obtained is less rigorous and more circumscribed in limited assurance than with reasonable assurance. **Table 13-2** below provides examples of limited and reasonable assurance opinions for an assertion of product inventory emissions.

Table 13-2: Examples of Assurance Types, Criteria, Assertions, and Opinions

Assurance Type	Data Assurance	Model Assurance
Assurance Objective	• Assures the company conformed with the standard requirements • Assures the inventory total(s)	• Assures the methodologies and assumptions used to calculate emissions are reasonable • Assures that the company conformed with the standard requirements
Criteria	• Requirements of the Standard • Methodology Decisions and Assumptions • Data quality and uncertainty Others as specified by the reporting company and assurer	• Requirements of the Standard • Methodology Decisions and Assumptions Others as specified by the reporting company and assurer
Assertion Example	The inventory product's emissions are 620 tonnes of CO_2e. They are calculated in accordance with the GHG Protocol Product Life Cycle Standard as supplemented by our company-specific policies and methodologies described in the inventory report.	The inventory product's emissions are calculated in accordance with the GHG Protocol Product Life Cycle Standard as supplemented by our company-specific policies and methodologies described in the inventory report.
Limited Opinion Example	"Based on our review, we are not aware of any material modifications that should be made to the company's assertion that the inventory product's emissions are 620 tonnes of CO_2e and are in conformance with the requirements of the product standard."	"Based on our review, we are not aware of any material modifications that should be made to the company's assertion that the inventory product's emissions are in conformance with the requirements of the product standard."
Reasonable Opinion Example	"In our opinion the reporting company's assertion that the inventory product's emissions are 620 tonnes CO_2e is fairly stated, in all material respects, based on the criteria set forth in the assertion."	"In our opinion the reporting company's assertion that the inventory product's emissions are calculated in conformance with the product standard is fairly stated, in all material respects, based on the criteria set forth in the assertion."

13.2.7 Assurance Challenges and Choosing the Assurance Type

There are several challenges in assuring product inventories. These challenges have been grouped into themes and solutions. One of the primary challenges with product assurance is that the subject matter is removed from the reporting company's control and the assurer's ability to obtain sufficient appropriate evidence.

Two approaches to addressing this diminishing control are:

1. Change the level or type of assurance; or
2. Create a modular framework for the assurance that can be aggregated across the product sources in the reporting company's assertion.

Assurance challenges may be mitigated by selecting the correct assurance model. Common challenges with providing assurance on product inventories and potential solutions are listed in **Table 13-3** below.

Table 13-3: Common Assurance Challenges and Assurance Type Solutions

Theme	Challenges	Example	Possible Assurance Types
The subject matter may be removed from the reporting company's control	• Determining reasonable estimates over a subject matter when the reporting company does not have information (e.g., estimates for distances fuel is hauled to supplier companies) • Establishing whether the evidence originates from an adequate control environment (e.g., determining the data management system) • Accessing information and documentation from downstream activities (e.g., a television manufacturer may need to make assumptions about consumers' use of its products) • Accessing information and documentation from upstream activities information that is contractually restricted (e.g., a supplier may be unwilling or unable to provide the reporting company with reliable evidence)	Manufacture of silicon chips in Taiwan for televisions assembled and sold in North America	**Modular assurance** allows for a television company's assurer to rely on another assurer's conclusion on the emissions of the silicon chip supplier. **Model assurance** allows for an assessment of the assumptions that underlie the emissions calculations for the manufacturer of the silicon chips
Process may be diverse and dynamic, and consistent assurance criteria may be difficult to apply	• Identifying and consistently evaluating calculation models against the assurance criteria (e.g., the product boundary of LCA data) • Developing suitable criteria for all types of emissions	Distribution networks for materials to the reporting company change significantly over the reporting period due to economic conditions	**Model assurance** allows for an assessment of the assumptions that underlie the emissions for distribution networks

	• The calculations methods to determine emissions may be unknown or highly uncertain	A waste and recycling company uses incinerator to dispose of multiple waste stream, of which the composition changes on a daily basis	**Model assurance** allows for an assessment of the assumptions that underlie the emissions for the incinerator
Product inventories may include emissions based on estimations	• The calculations methods to determine emissions may be unknown or highly uncertain	Emissions from operating an automobile for a car manufacturer	**Model assurance** allows for assertions on future events
Confidentiality of the criteria needs to be maintained for competitive reasons	• The calculation methods may be proprietary or confidential (e.g., calculation of emissions for highly technical products (e.g., catalysts, electronic components, etc.) supplied to the reporting company).	Emissions from a supplier's operations	**Modular assurance** allows for the supplier's emissions to be assured by an assurer independent of the product inventory

Combining Types of Assurance

Companies should use one model of assurance for all of the reporting company's product emissions to ease reporting and the understanding of intended users; however, this may not be feasible in all situations. When a combination of models of assurance are used, it should be made clear in the assurance report the scope of application of the assurance models and the assurance provided.

In most cases, model assurance will be an appropriate type of assurance for product inventories.

13.6.8 The Concept of Materiality

Materiality refers to the risk that errors, omissions and misrepresentations can affect the accuracy or validity of an assertion.

Materiality has both quantitative and qualitative aspects and thresholds are typically set by the assurer. A misstatement may be quantitatively material in isolation or in aggregate. A material misstatement is a broader concept than that of a material discrepancy as a misstatement can occur as a result of qualitative disclosures in addition to the quantitatively disclosed subject matter.

Quantitative materiality is typically calculated as a percentage of the inventory (in total or on an individual line item basis). In determining the quantitative materiality benchmark, assurers should contemplate the risk (the likelihood and magnitude of a potential misstatement) and the history of previous restatements.

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

The assurer should also consider qualitative misstatements during the evaluation of the evidence and the decisions made about the assurance statement. The assurer should be alert throughout the assurance for qualitative misstatements.

The concept of uncertainty is not addressed here as it is not a known error, rather an indicator of how well the data represents the product emission sources.

Factors that could contribute to potential material misstatements include:

- A lack of a well controlled data management system for GHG emissions
- A non-disclosure of the reason behind emission changes (e.g., change in calculation methodologies vs. change in actual emissions)
- Disclosure of emissions but not the individual activities that comprise the emissions to the assurer.

The assurer and reporting company should determine an appropriate threshold or benchmark of materiality during the assurance process. This threshold or benchmark should be disclosed in the assurance conclusion.

13.6.9 Assurer's Written Conclusion

The assurer's conclusion conveys the assurance obtained about the subject matter and may take different forms depending on whether the company is conducting internal assurance and also depending on the third party assurance provider's professional standards and requirements. The written conclusion related to the assurance of the company's assertions should generally include the following:

Introduction

- An identification and description of the subject matter information and the period of time to which the evaluation or measurement of the subject matter relates
- A reference the reporting company's assertion that is available to the intended users
- Identification of the criteria

Description of Assurance Process

- Description of the reporting company's and assurer's responsibilities
- The standard to which the assurance was performed
- A summary of the work performed (including the type and level of assurance)

Conclusion Paragraph

- The assurer's conclusion regarding the results of the assurance over the company's assertion with any additional details regarding exceptions noted or issues encountered in performing the assurance.

The assurance criteria should be made available in the report. The main method of disclosure of the criteria is to cite a standard (e.g., the GHG Protocol Product Standard) or to provide the criteria in the assertion. The relative detail of the criteria will depend on the relative size or importance of the emissions associated with the criteria.

When there are material departures in the assertion from the criteria, the reporting company should disclose:

- That the assertion is presented fairly
- It has complied with the criteria with the exception those noted The specific criteria that it has departed from, the nature of the departure, including the treatment that the criteria would require, the reason why that treatment would be so misleading, and the treatment adopted; and
- The effect of the departure

14 Reporting

Reporting is essential to ensure accountability and effective engagement with stakeholders. The purpose of the reporting chapter is to summarize the various reporting requirements specified in other chapters and to identify additional reporting considerations that together provide a credible reporting framework and enable users of reported data to make informed decisions.

14.1 Requirements

A public GHG inventory report that is in accordance with the *GHG Protocol Product Standard* shall follow the key accounting principles (Relevance, Accuracy, Completeness, Consistency, and Transparency) and include the following information.

14.1.1 General Inventory Information

A company shall report the following as a general introduction to the report:

- Contact information
- Studied product name & description
- Type of inventory i.e. final product cradle-to-grave or intermediate product cradle-to-gate inventory
- Business goals of the inventory
- Sector specific guidance or product rules used to influence decisions around methodology, boundary setting, allocation procedures, data use, etc.
- Inventory date and version
- For subsequent inventories, a link to previous inventory reports and description of any methodological changes
- A process map identifying both attributable and non-attributable processes

14.1.2 Establishing the Scope

A company shall report the following:

- The studied product (included above in General Inventory Information)
- Unit of analysis
- Reference flow

14.1.3 Boundary Setting

A company shall report the following:

- All attributable process material and energy flows in the form of a process map
- Life cycle stages definitions and descriptions
- Excluded attributable processes, materials, or energy flows (including land use impacts): Document and justify all process , material, or energy flow exclusions
- Non-attributable processes included in the boundary
- Disclose and justify when a cradle-to-gate boundary is used in the inventory report.
- The time boundary, which represents the period of time when attributable processes occur during the product's life cycle (separately for each stage when applicable)

- If land use change impacts are attributable, the method used to calculate and allocate those impacts shall be disclosed

14.1.4 Allocation

A company shall report the following:

- A brief explanation of why the specific allocation method or method to avoid allocation and factor (as applicable) was selected over others, including why that factor offers the most accurate allocation of emissions

14.1.5 Recycling

A company shall report the following:

- When recycling occurs in a product's life cycle that requires allocation, the method used to allocate or avoid allocation of those processes shall be disclosed and justified
- If a method other than the 100/0 or 0/100 method is used, that shall be referenced, disclosed, and justified in the inventory report
- When using the 0/100 method , displaced emissions shall be reported separately when reporting inventory results by stage (see Chapter 12 for calculating inventory results requirements)

14.1.6 Data Information

A company shall report the following:

- For significant attributable processes, a descriptive statement on the data sources, the data quality aspects, and any efforts taken to improve data quality
- The percent of total GHG emissions and removals quantified using primary data, secondary process data, and secondary financial data. If the company does not know the data type used in an emission calculation they can report this data in an unspecified data category.
- A descriptive statement on sources of uncertainty and methodological choices

14.1.7 Inventory Results

A company shall report the following:

- Inventory results by:
  - Total CO_2e per unit of analysis
  - Biogenic and non-biogenic removals and emissions (when applicable)
  - Land use impacts (when applicable)
  - Percentage for each life cycle stage: 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.
- Reference the source and date of the GWP metric used in the inventory report
- 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. 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 report.

- The amount of embedded carbon not returned to nature (and therefore considered stored) shall be reported. For cradle-to-gate inventories, the amount of embedded carbon in the product as it leaves the inventory gate shall be reported.
- If process emissions are stored, the amount of stored emissions shall be noted in the inventory report.

The following shall not be included in the inventory results but can be reported separately in the inventory report:

- Weighting factors for delayed emissions
- Offsets
- Avoided emissions

14.1.8 Methodology Choices

- Cradle-to-Gate Inventory: Justify why a cradle-to-gate inventory was performed
- Use Profile: If more than one use profile was applicable, disclose which method was used and justify the choice
- End-of-Life Profile: If more than one end-of-life profile was applicable, disclose which method was used and justify the choice

14.1.9 Inventory Changes Overtime

A company tracking and reporting inventory changes overtime shall report the following:

- Both base inventory and current inventory results in the updated inventory report
- If the base inventory was recalculated, changes made to the inventory shall be reported
- If the base inventory was not recalculated, companies shall report the threshold used to determine that recalculation was not needed
- The change in inventory results as a percentage change over time between the two inventories on the unit of analysis basis.
- A company shall provide an explanation on what steps were taken to reduce emissions based on the inventory results.
- Companies shall not communicate predicted, planned or committed reductions. Reductions shall be reported retrospectively.

14.1.10 Assurance

A company shall report the following:

- Assurance type i.e. 3rd party or self-assurance
- If self-assurance, explain how required competence was ensured and any conflict of interest was avoided
- Assurance provider i.e. name and contact information
- Assurance opinion

14.1.11 Use of Results

- To avoid misuse of results, a company shall include:

- An evaluation of the inventory describing its significance and limitations
- A disclaimer to the audience (reader) identifying the difficulties in comparing results and referring the reader to additional information if needed.

14.2 Guidance

14.2.1 Goal of Public Reporting

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, and supporting information for product differentiation
- Changes to the reported inventory that have occurred over time
- How the inventory 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
- Any additional relevant and material information that ultimately have an impact on the results and the quality of the assessment.

The following sections provide guidance on understanding the audience and completing some of the reporting requirements not included elsewhere in the standard[56]. A list of optional reporting elements is provided in Section 14.2.5, and a reporting template is located in Appendix F to help companies organize their inventory report.

14.2.2 Identifying Audience

Keeping the audience in mind is important right from the start as companies are setting objectives and making decisions throughout the steps in developing an inventory. A key opportunity to make a meaningful connection with the audience is when a company prepares their inventory report. Helping stakeholders and readers understand the purpose, context, rationale behind various accounting decisions, and limitations and uses of the inventory results are some key objectives that a company should seek to address in the inventory report.

It is important to recognize that public disclosure does not mean there is one homogenous audience with a uniform set of requirements. **Table 14-1** 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 14-1: Potential Audiences of a Publicly Disclosed GHG Inventory Report

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

Audience category/role	Audience description
General public	Lay person. No understanding or prior visibility of LCA/GHG Inventories may be assumed.
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)
Assurance Provider	Assessor performing third-party independent assurance of report
Report stakeholders	Suppliers, product-owning organization, report-commissioning organization
Sustainability / environmental practitioner	General interested party seeking to understand more about a specific product, a product sector, an industry sector, or other aspects of life-cycle emissions
Green professional purchasing	Professional purchasing decision-maker seeking differentiation across products
Environmental/Carbon Labeling Organizations	GHG programs that may provide a platform to report, register, and disseminate your inventory results
Government Agencies	Government stakeholders that may use the inventory results to plan future programs and policies

14.2.3 Disclaimer

Providing a disclaimer is a requirement to ensure readers are aware about the limitations and understand the scope and intended purpose of the inventory results (See **Box 14-1** for an example).

Box 14-1: 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 the GHG Protocol Product Standard for a glossary and additional insight into the GHG inventory process.

14.2.4 Use of Results

The audience of the public report may be most interested in what the company is doing, or plans to do, to reduce 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 is required to inform its stakeholders the steps it plans to implement to reduce emissions based on the inventory results. If this is a subsequent report, a company must 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 plan to use the results to reduce emissions along the product life cycle.

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.

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

14.2.5 Optional Reporting

In addition to required elements a company should consider including elements that it may find necessary to report to meet the needs of its potential audience and/or its specific business goals. These elements may be added to the public report, depending on which audience may benefit from the additional information or be made available upon request.

A public GHG inventory report should include, when applicable, the following additional information:

- Additional business goals met by performing a GHG inventory
- A description of the estimation technique used and the significance threshold defined in deciding exclusions
- If more than one allocation method is appropriate, companies should include this in the inventory report as part of their scenario uncertainty (as defined in Chapter 11)
- 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
- Quantitative uncertainty assessments
- Data should be collected for other GHGs that may be relevant to the studied product.
- Additionally disaggregation of GHG impacts. Examples include:
    - CO_2e emissions reported as a fraction of all GHG components (i.e. grams of CO_2, N_2O, CH_4, etc.)
    - For specific foreground processes

    - Attributed to product packaging
- Any impacts calculated through consequential modeling (separate from 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
- In the case that GHG emissions have actually increased since the last inventory, companies should report these results, adding explanation to their stakeholders as to why the impact increased and what plans the company has to reduce this value in the future.

Box 14-2: Example Public Report (TBD)

15 Setting Reduction Targets and Tracking Inventory Changes over Time

The goal of this standard is to support public reporting of product GHG inventories and help companies reduce the GHG impacts of the products they design, manufacture, sell, purchase, or use. Additionally, companies have business goals they hope to achieve by performing a product life cycle GHG inventory. The following requirements and guidance are available for companies wishing to set reduction targets and track and report their progress.

15.1 Requirements

Companies planning to set reduction targets and track inventory changes over time shall:

- Complete and report a base inventory done in conformance with the requirements of this standard;
- Recalculate the base inventory as needed when significant changes in the inventory occur and disclose those changes in the inventory report; and
- Complete and disclose an updated inventory report including the updated results and the base inventory results.

15.2 Guidance

The following steps provide guidance for companies to track inventory changes overtime:

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

Companies are not required to track inventory results over time, and therefore this guidance is only applicable to those companies that have business goals which are met through performance tracking. The following sections describe each step in more detail.

15.2.1 Complete and Report a Base Inventory

> *Base inventory* - a historic inventory against which a company's GHG impact is tracked over time.

The first step is to ensure that a base inventory has been completed and publically reported in conformance with this standard. The base inventory does not have to be the first inventory a company performs on a product; in some cases, companies may want to improve data quality or spend more time deciding on the most appropriate allocation method before finalizing the base inventory. Once a company has identified the base inventory and has begun identifying improvements, any changes made that warrant a base inventory recalculation should be done following the guidance in Section15.2.2.

15.2.2 Identify Reduction Opportunities

Companies should begin identifying potential areas of improvement while creating the base inventory. Improvements include any changes made along a product's life cycle to reduce its GHG impact and meet business goals.

Companies should identify improvements based on the potential for reductions and their level of influence. In general, companies have the largest influence on the processes they control. Therefore, a first step may be to identify energy savings or fuel switching opportunities within the processes under the company's control. In many cases the largest potential for improvement comes from processes that are not under the control of the company but rather under the control of suppliers and customers along the product's supply chain. To address upstream and downstream emissions, companies should identify suppliers and customers to engage with based on both their level of influence and reduction potential. For example, a company may have a good relationship with a supplier but their process may have little impact on the overall inventory and therefore low potential for improvement. On the other hand, a supplier the company has not engaged with in the past may have such a large impact that the company decides to begin an engagement program. For downstream processes, the company may determine that improvements are influenced primarily by the design of a product and less by the behaviors of their customers. In this case, companies may want to identify engagement potential within the company, such as the product design or research and development team.

15.2.3 Set a Reduction Target

Any robust business strategy requires setting targets for revenues, sales, and other core business indicators, as well as tracking performance against those targets. Likewise, effective GHG management involves setting a GHG target.

Companies may set a reduction target for only the total product's life cycle, or the total product's life cycle as well as individual targets for stages or processes. A reduction target should include the following elements:

- Target boundary(ies)
- Target completion date (e.g. within 2 years)
- Target level, the numeric value of the reduction target per unit of analysis

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

15.2.4 Achieving and Accounting for Reductions

Companies may achieve reductions in different ways, such as working within the company to improve the processing or design of the product or engaging with suppliers. For the latter, the first step is to set up a strategy for supplier and customer engagement, guidance for which is available in Appendix D. Once engaged, companies should work with these partners to identify specific changes that can achieve improvements along a product's life cycle. Changes may include working with a supplier to help them manage and reduce their corporate level (Scope 1 and 2) emissions which should lower the impact intensity from that process in the life cycle. However the changes could also be more inventive, such as working together with a supplier to come up with a new material component that is less GHG intensive during its production and also reduces GHG impacts further upstream (e.g. a lighter car panel that reduces fuel use in the use stage).

To account for improvements, companies are referred to the data collection requirements of this standard (Chapter 9). Improvements that are expected to happen but have not yet happened should not be included in the inventory results. Any improvements need to be based on collected direct measurement or activity data that abide by the attributional approach of the standard (i.e. historical, fact-based, and measurable) and have occurred prior to the updated inventory. Additionally any improvements based on avoided emissions or purchased offsets are subject to the same reporting requirements as defined in Chapter 12 and therefore are reporting separately from the inventory results.

Box 15-1: Trade-offs between Environmental Impacts

One limitation of a GHG product inventory is the consideration of only one impact category. Before making a decision to reduce GHG emissions by making changes in the product life cycle, companies should consider whether any environmental trade-offs could occur as a result of that change. For example, switching from a GHG intensity processing step to one that uses more water resources would be an environmental trade-off. Because it is difficult to make a choice between environmental impacts, companies are encouraged to first consider reduction opportunities that don’t cause trade-offs. If this is not possible, companies need to decide whether the change has an overall positive or overall negative impact on the product’s life cycle.

15.2.5 Recalculate the Base Inventory

In many cases, changes along the product’s life cycle are also met with improvements in activity data, emission factors[57], data quality, and methodologies. When changes are made that impact the results of the base inventory, the base inventory should be recalculated to ensure that any reductions represent an actual change in GHGs attributable to a product and not methodological changes or data improvements made during the inventory process. These changes may include redefining attributable processes, collecting higher quality data, or changing allocation or recycling methodologies. Any changes made that warrant recalculation of the base inventory are required to be reported in the updated inventory report.

Before recalculating a base year inventory, companies should develop a recalculation policy to clearly articulate the basis and context for any recalculation. Companies are required to define and report a threshold for insignificance above which a change warrants recalculation. For example, if a new emission factor is published that when used has a 1 percent impact on the inventory results, a company may decide that is below the threshold and opt not to recalculate the base inventory. If a threshold for insignificance was already established for justified exclusions (see Chapter 7) then the same threshold should be used here.

As noted in Section 15.2.2, if a change is made that causes the unit of analysis to be redefined, the base inventory cannot be recalculated. In this case, companies need to perform a new base inventory and set a new reduction goal.

15.2.6 Update the Inventory Report

Once reductions have occurred, new data has been collected, and the base inventory has been recalculated (if needed), companies update the inventory report to include results from both the new and base inventories. The updated inventory report must be done in conformance with the reporting chapter and

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

therefore must include the same reporting elements as the base inventory. The introduction should be updated to reflect the purpose of the update including the reduction target, and any information that has changed since the base inventory should be clearly noted. The number of updated inventory reports for the studied product should be reported, with a link to previous reports as available. If the base inventory is recalculated, all changes are required to be listed in the inventory report. If the base inventory was not recalculated, companies are required to report the threshold under which no recalculation was warranted. Either case, both the base inventory results and the updated results are included in the updated inventory.

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

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

16 Appendix A - Guidance on Product Comparison

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

As stated in Chapter 2, the *Product Standard* is intended to support performance tracking (i.e., comparison of one product over time). For other types of product comparison – including product labeling, performance claims by third parties, consumer and business decision making based on comparison of two products – additional specifications are needed. Comparative assertions are not supported by the *GHG Protocol Product Standard*. **Table 16-1**illustrates the applicability of this standard for product comparisons.

Table 16-1: The Use of the Product Standard for Product Comparisons.

Comparison Type	Supported by the Product Standard as-is	Supported with GHG program specifications or product specific guidance	Not supported by the Product Standard
Performance tracking	X		
Consumer and business purchasing decisions		X	
Product labels		X	
Performance claims made by stakeholders		X	
Comparative assertion			X

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

Performance tracking of a product over time and performance tracking labels:

- The functional unit should be identical
- If the methodologies change, the previous inventory shall be adjusted to compare on the same basis

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

- The functional unit should be identical
- The system boundaries and temporal boundary should be equivalent
- The same allocation methods should be used for similar processes

- The data types used and the data quality and uncertainty of data should be reported and assessed to determine if a fair comparison can be made
- The temporal and geographical representativeness of the inventories should be assessed to determine if a fair comparison can be made
- Third party assurance should be performed

Comparative assertion:

- An LCA in conformance with ISO 14044, assessing all environmental impacts and including the additional requirements for comparative assertions, shall be performed

ISO Type 1, Type 2, and Type 3 labels and declarations:

- Should meet the communication requirements of the respective standards

16.1 Role of Product Rules

To facilitate the implementation of these additional specification that enable valid comparison, product rules are useful. Product rules may vary in quality. When developing a new product rule or evaluating the quality of an existing product rule before use, criteria to consider include whether:

Product rules - Rules that add additional specificity to general standards to enable valid product comparisons

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

17 Appendix B – Guidance for Program Designers and Policy Developers

17.1 Purpose of Guidance

The GHG Protocol Product Standard may be used as the basis for product related GHG programs and policies that facilitate product comparisons. While the GHG Protocol *Product Standard* supports the goal of performance tracking to compare a product over time, its use is not sufficient to enable other types of comparisons and users must supplement the GHG Protocol *Product Standard* with additional methodological steps. This guidance outlines the additional specificity recommended beyond the requirements of the GHG Protocol Product Standard to enable valid comparison and provide recommendations on the design and implementation of credible and effective programs and policies.

Numerous types of programs and policies could benefit from the adoption of the GHG Protocol *Product Standard*. This guidance focuses on recommendations for product labeling programs for consumers. Labeling programs include initiatives operated by an NGO, an independent private operator, a retailer, or a government agency. These recommendations could also be useful for a wider variety of programs and policies that create preferences for low carbon products, including government and corporate procurement programs and sector-level initiatives.

17.2 Guidance on Product Comparison

The GHG Protocol *Product Standard* is a general standard to be used for all goods and services. To meet these broad needs the standard offers flexibility and therefore the results can vary depending on methodological decisions. However, programs such as those designed for product labeling or procurement use product comparison as a decision making tool to drive preferences for low carbon products, low carbon technologies, or inputs to low carbon processes. To enable valid comparison, these programs need additional methodological prescriptiveness beyond the requirements included in the GHG Protocol *Product Standard* to ensure consistency and comparability of results. Details on the additional prescriptiveness needed is included in Appendix A (Chapter 16). The following sections provide specific guidance for the design of a product GHG labeling program and a product procurement product.

17.2.1 Design of Product GHG Labeling Programs

Product GHG labeling programs are designed to help consumers make purchasing decisions based on the GHG information communicated on the label. These programs may either be voluntary or mandate participation. Labels can use a variety of approaches to communicate information about a product's GHG impact, such as:

- A metric that aggregates multiple environmental impacts including climate change;
- A metric representing only the climate change impact of the product;
- A claim that a company is working to reduce its emissions; and
- A claim that a product has low GHG impacts compared to other products in its category.

When designing a program for product labeling, program designers should consider the following recommendations.

Product labeling programs for consumers should:

- Achieve consistency with the methodology and reporting requirements of other programs where possible to reduce barriers to participation and minimize consumer confusion.
- Be pilot tested with a select number of companies or product categories to get input on the draft program design and revise as needed before the program is launched.
- Be designed to drive GHG reductions. Sectors addressed by the program should have potential for significant reductions.
- Address all key environmental impacts to ensure consumers do not unknowingly increase the impact of one environmental impact (i.e. toxicity) when purchasing a product with a low GHG impact.

- Consider a phased implementation approach, possibly sector by sector. Programs may want to start as a voluntary program, with mandatory participation phased in over time. Mandatory programs should be of the highest quality since they have more cost and sales implications.
- Only be used for final products and not for intermediate products. In accordance with the GHG Protocol *Product Standard*, an inventory of an intermediate product may exclude the use and end of life stages. Without an understanding of a product's full life cycle, decisions based on the inventory results could lead to unintended consequences.
- Provide technical assistance to small and medium sized businesses and companies in developing countries to reduce barriers to participation.
- Metrics should be developed for measuring the success of the program. Possible metrics include:
    - Emissions reduction goal
    - Number of products labeled

Product GHG label design recommendations include:

- Research should be performed to determine the most appropriate label type for a program's target market to enable consumers to make valid purchasing decisions.
- When a quantitative emissions metric is on a label, the uncertainty of inventory results should also be provided. Uncertainty information can be provided on a company's website instead of on the label.

Helpful tools and resources that a program may provide to reduce the burden of participation include:

- Public database of inventories for stakeholders to monitor progress
- List of LCA emissions factors
- Web-based calculation tools with data collection templates
- Incentives for participation – recognition, training, technical assistance, peer exchange etc.

17.2.2 Design of a Product Procurement Program

Governments and companies may establish procurement requirements for products that minimize life cycle GHG emissions. Governments and businesses may create these programs to reduce their GHG impacts and the impacts of their suppliers. Another goal of these programs should be to encourage suppliers to develop low GHG-emitting products that meet larger market demand.

Recommendation for designers of procurement policies include:

- Maintaining consistency with the methodology and reporting requirements of other procurement programs to reduce burden and prevent barriers to participation.
- Implementing programs using a phased approach to minimize burden on suppliers (e.g., by increasing rigor over time, moving from a voluntary to a mandatory approach over time, and/or moving from qualitative to quantitative reporting over time).
- Provide incentives for participation, rather than penalizing suppliers, to encourage innovation and encourage participation.

18 Appendix C - Land Use Change Impacts

This appendix provides guidance on identifying when land use change impacts are attributable to the studied product. If they are attributable, guidance is also included for calculating and allocating those impacts[58]. These impacts include:

- CO_2 emissions and removals resulting from a carbon stock change occurring within or between land use categories;
- CO_2, N_2O, and CH_4 emissions resulting from land use change practices (biomass burning, liming and urea applications)

This appendix focuses only on the types of impacts presented above, however other processes associated with land use (e.g. harvesting, fertilizer application) also need to be considered in a product GHG inventory as part of the material acquisition stage when the studied product or its material components are of biogenic origin.

Box 18-1: Key Concepts in Land Use Impacts

Carbon Stock refers to the total amount of carbon stored on a plot of land at any given time in one or more of the following carbon pools: biomass (above and below ground), dead organic matter (dead wood and litter), and soil organic matter (IPCC, 2006)[59]. A change in carbon stock can refer to additional carbon storage within a pool, the removal of CO_2 from the atmosphere, or the emittance of CO_2 to the atmosphere.

Land use change occurs when the demand for a specific land use results in a change in carbon stocks on that land. A change in carbon stock can occur from one category to another (e.g. converting forest to crop land) or within a land use category (e.g. converting a natural forest to a managed forest, converting from till to no-till). Land use change does not include changes in crop cover or crop rotations that occur within the crop land category. Land use categories include forest land, cropland, grassland, wetlands, settlements, and other lands (IPCC, 2006).

Land use change practices are activities done during land use change to prepare the land for its new use. Examples of land use change practices include biomass burning, liming, fertilizer application, and soil preparation.

Land Use Change Impacts are the emissions and removals due to land use change and land use change practices.

Indirect Land Use Change occurs when the demand for a specific land use (e.g. bio-energy crops in the U.S) induces a carbon stock change on other land (e.g. deforestation in Brazil). This displacement is a result of market factors consistent with a consequential modeling approach and therefore is not required for considered within this standard (see Chapter 5 for more information on the consequential versus attributional approach to life cycle GHG inventories).

This appendix provides guidance for two situations: when the specific land that the product or product component originates from is known, and when it is not**.** However, the concepts of assessment period, allocation, and amortization period defined when the specific land is know (Section 17.1) are also used when the specific land is unknown (Section 17.2). It is important to note that while this appendix focuses on agricultural and forest products, not only biogenic products have the potential to have significant land use change impacts. Any company with a studied product that uses a large amount of land should use this

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

[59] (IPCC, 2006) IPCC, 2006, Guidelines for National GHG Inventories, Volume 4: Agriculture, Forestry, and Other Land Use

guidance to determine whether the land use changed within the assessment period and whether that had any impact on the carbon stocks of that land.

Companies choosing to assess land use impacts using a different method than the ones described here should reference that method in the inventory report.

18.1 When the Specific Land is Known

18.1.1 Determining Attributable Land Use Impacts

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

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

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 change impacts are attributable to the product.
2) A product is made from wood that is extracted from a naturally grown forest (extraction and production occur in the same year). If the extraction of above-ground biomass causes a change in carbon stock of the land, the impacts of the land use change are attributable to the product[60].
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 1982. Because the length of the harvest cycle is longer than 20 years, the company must consider any carbon stock changes that may have occurred up to 28 years ago (from 2010 to 1982). Therefore the impacts of the land use change 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 change impacts are not attributable to the product.

18.1.2 Calculating Land Use Change Impacts

When information about the specific land is available, collecting data for land use change impacts follow the same data collection and quality requirements given in Chapter 9 of this standard. If the reporting company owns the land from which a product is harvested, primary data are required (i.e. the company must know and use data from the land use changes and practices associated with that land). Primary data from a supplier is preferred for land not owned by the reporting company. These types of data are collected directly from the production site, with actual areas, 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 process data include:

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

[60] 2006 IPCC Guidelines give values for forest land above and below a certain density of biomass. If the removal of biomass does not cause a change in carbon stock value, then land use change impacts may be calculated as zero.

- 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, and usually includes carbon stock change impacts as well as land use change practice emissions within the default emission factor.

Figure18-1 is a simplified illustration to show how carbon stock information can be used to calculate land use change impacts. In this example, forest land is converted into crop land, creating a 150 ton release of carbon due to the change in carbon stock. If several carbon stock changes occur within the assessment period, then the overall impact of all changes must be considered. If wood is harvested from a forest that is not converted (forest remaining forest), a carbon stock change can be calculated based on the change in forest density. To complete the land use change impact calculation, companies need to consider what land use change practice emissions may have occurred as a result of the carbon stock or land use change unless these are already included in the default emission factors.

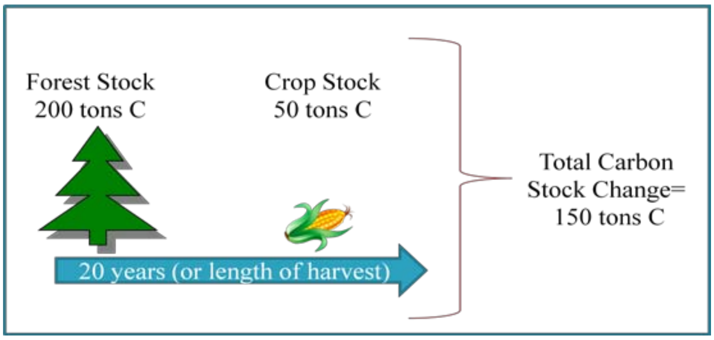

Figure18-1: Simplified Illustration of a Carbon Stock Change Calculation

18.1.3 Allocation of Land Use Change Impacts

Once land use change impacts are deemed attributable and impacts are identified, a company needs to allocate those impacts between the studied product and other co-products that are outputs of the land. This is because, in most cases, land use change occurs to create land that produces products over many years, and therefore it is not appropriate to allocate all the land use change impacts to the first products that are produced on the land. Using the example from Figure18-1above, a company has calculated a carbon stock change associated with the product (in this example, a crop) of 150 tons. The next question is how to allocate those emissions to the products that are harvested from that land. **Figure 18-2** illustrates three ways land use change impacts can be allocated over time; A) single year, B) 20 year constant, and C) 20 year decline.

Figure 18-2: Amortizing GHG emissions over a 20 year time period (Zaks et al. 2009)

In this standard, land use change impacts[61] should be allocated using option B: evenly over an amortization period of either 20 years or the length of one harvest (whichever is longer). This option was chosen as the most consistent way to 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 change impacts. It is recognized that applying any time period to amortize emissions creates an arbitrary cut off after which companies are free to grow products on the land without a land use change burden. However, identifying no time period would create additional uncertainties and inconsistent inventories.

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

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

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

Allocation of Co-products: Forestry and Wood Products

Forest products create unique examples when considering the allocation of land use change impacts. Some forest products are grown on managed forest plantations that are harvested over relatively short time frames, while others may be extracted from natural forests that take over 100 years to grow. Some forests are removed with the intent of producing annual crops, while others are removed for the stock of wood that can be extracted at the time of removal. Depending on the type of product or wood being studied and the location where that wood is cultivated, vastly different harvesting techniques occur which have large impacts on the amount and allocation of land use change impacts. Furthermore if the studied product is a crop but the land use change 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 of forest and wood products

Scenario A: A forest is harvested for wood but the land is not converted into another category or the future use of the land is unknown. In this scenario any stock change that is calculated based on the density change of the forest is attributable to the products created from the harvested wood. No allocation is needed because additional growth of the land is not planned, or is unknown.

Scenario B: A forest is harvested for wood then converted into another managed land category. In this scenario land use change impacts should be allocated to all products produced by the land within the amortization period. Consider an example where a stock change of 150 tons C is calculated with an initial harvest of 100 tons of wood and an annual harvest of 1 ton of crop for the remaining 19 years of the amortization period. This means that 150 tons C are allocated among 119 tons of products. The additional impacts of land use change (e.g. liming applications) and any practice emissions may also be allocated depending on which product is the studied product. For example, if the wood is the studied product, any liming used to prepare the crop land would not be included in the inventory (as it is only applicable to the crop). This scenario is only applicable when the converted land is managed and the production of that land is

[61] It is recognized that a change in carbon stock can result in either a removal or emission of carbon from or to the atmosphere. However, because this standard accounts for the GHG inventory of a product, it is most likely that the removal of biomass (and not the planting or re-growth of biomass) which results in carbon emissions 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) a company may see a slight net positive impact (more removal than emissions) associated with carbon stock and land use change.

known. In this context managed refers to land that is continuously maintained for the purpose of cultivating and harvesting a product from the land. Allocation is not applicable for forest land that has been harvested and replanted but is not maintained, or a plot that is replanted and managed but with an extensive harvest period (greater than 50 years). In both cases the uncertainty associated with the eventual production of the replanted product makes it most accurate to apply all land use change impacts to the first harvest of wood.

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

18.2 When the Specific Land Use is Unknown

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 impacts. This situation occurs 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 are not available and secondary data must be used not only to calculate stock changes but also to determine how much land use change impacts should be allocated to a product.

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

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

Land use imaging and/or agricultural demand-based models include using remote sensing[62] or GIS data to estimate land use change in a particular location or market-based models[63] to estimate land use change based on the market trends of a crop or wood product. For example, if the studied product is a crop assumed to be produced in Brazil, and satellite imagery shows that land use for that crop has remained constant in Brazil for the past 20 years, then the company can assume that not land use change impacts are attributable to their product. These methods may be the most accurate way to determine the amount of land use change impacts that should be allocated to a product when no specific data are available; however, these are often complex, time consuming, and not always freely available. Additionally, these methods 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 impacts as long as the modeled results are justified and transparent.

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

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

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

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

18.2.1 Example: Estimating Land Use Change Impacts without Specific Data

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

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

The first step is to determine the country profile for the most-planted crops. Because many agricultural products are harvested in Malaysia, only crops that on their own contribute more than 1 percent of the countries harvested area are considered. These crops include oil palm fruit, rice, natural rubber, and coconut. Oilseed nes is also more than 1 percent, but because this is a summation of all other oil baring crops it was not considered. If the studied crop is not within the top 1 percent of area harvested in the location, this is an indication that the assumed location is not appropriate. Companies should assume a location where a large amount, if not the largest amount, of the studied product is harvested from each year. Table 18-1 shows these statistics, with the largest producers highlighted in green.

Table 18-1: Area Harvested for Crops Grown in Malaysia in 2008, FAO Stat. Crops with harvested areas greater than 1 % are highlighted in green.

Crop	Area harvested 2008 [ha]	Area harvested in % of total area harvested
Arecanuts	1300	0.020
Bananas	26000	0.401
Cabbages and other brassicas	1750	0.027
Cashew nuts. with shell	7000	0.108
Cassava	41000	0.633
Chillies and peppers. Dry	1700	0.026
Citrus fruit. Nes	1100	0.017
Cloves	800	0.012
Cocoa beans	20622	0.318

Coconuts	174000	2.686
Coffee. Green	50000	0.772
Cucumbers and gherkins	3100	0.048
Fruit Fresh Nes	12400	0.191
Fruit. tropical fresh nes	32000	0.494
Ginger	890	0.014
Grapefruit (inc. pomelos)	1200	0.019
Groundnuts. with shell	260	0.004
Lemons and limes	800	0.012
Maize	26000	0.401
Mangoes. mangosteens. guavas	5660	0.087
Manila Fibre (Abaca)	0	0.000
Natural rubber	1247000	19.249
Nutmeg. mace and cardamoms	1400	0.022
Oil palm fruit	3900000	60.202
Oilseeds. Nes	150000	2.315
Oranges	2000	0.031
Papayas	7200	0.111
Pepper (Piper spp.)	13487	0.208
Pineapples	10900	0.168
Pumpkins. squash and gourds	500	0.008
Rice. Paddy	667656	10.306
Roots and Tubers. nes	8000	0.123
Soybeans	0	0.000
Sugar cane	14340	0.221
Sweet potatoes	2010	0.031
Tea	2770	0.043
Tobacco. unmanufactured	13000	0.201
Tomatoes	2200	0.034
Vegetables fresh nes	19000	0.293
Watermelons	9130	0.141
Total	6478175	100

2. Collect historic land use data for the studied product

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

In **Figure 18-3** the total change in the area harvested for rice (paddy) over the 20 years period remains fairly steady (e.g. does not exceed 1 percent increase). It can be assumed that land use change did not occur in Malaysia due to rice production over the assessment period. Assuming the GHG inventory is being assessed in 2010; companies should also consider whether any recent changes in land use in Malaysia may have caused an increase in rice production over the past two years that are not present in the data. If there is no reason to believe this is the case, the company can assume that no land use change impacts are attributable to the studied product rice.

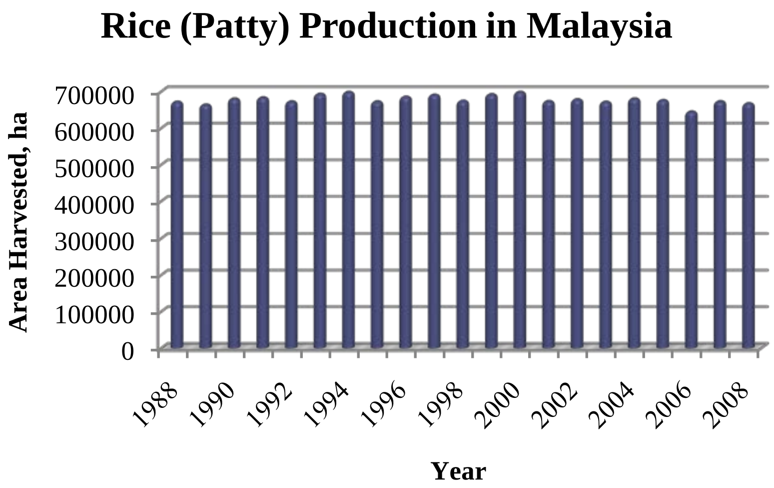

Figure 18-3: Area Harvested for Rice (patty) Production in Malaysia for the Period from 1988-2008.

Taking the same approach for Palm oil, it is obvious from **Figure 18-4** that there has been an increase in land used for palm production over the assessment period.

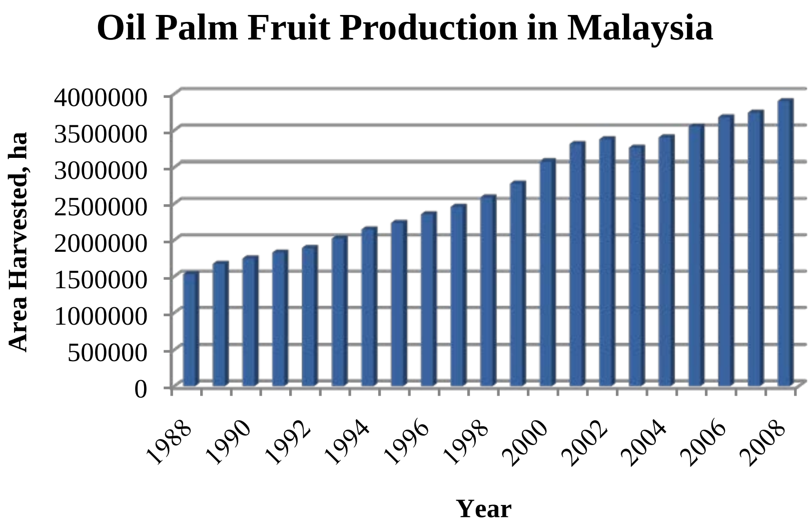

Figure 18-4: Area Harvested for Oil Palm Fruit Production in Malaysia for the Period from 1988-2008.

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

3. (Optional) Determine what percentage of land use change is due to converted crop land

Looking at the major crops dynamics in Malaysia over the past 20 years, **Figure 18-5** shows that the growth of Malaysia harvested area is driven by the growth in palm oil production. However, some crops did decrease in area harvested over the analyzed period, as is shown in **Table 18-2**.

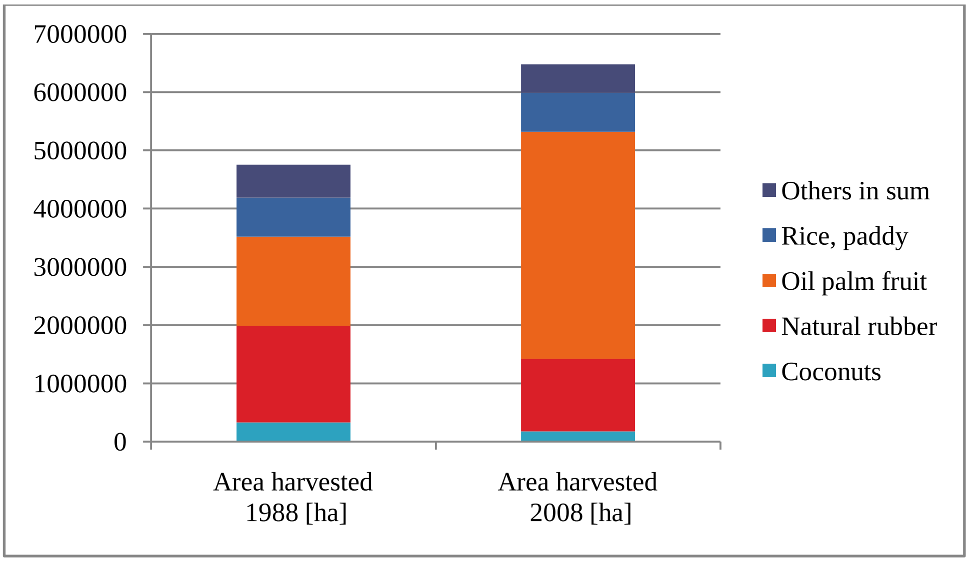

Figure 18-5: Top Crops in Malaysia by Area Harvested (ha), 1998 and 2008

Table 18-2: Top Crops and the Difference in Areas Harvested (ha) from 1988 to 2010 in Malaysia

product	Area harvested 1988 [ha]	Area harvested 2008 [ha]	Difference [ha]
Coconuts	327812	174000	-153812
Natural rubber	1660000	1247000	-413000
Oil palm fruit	1530905	3900000	2369095
Rice. paddy	671755	667656	-4099
Others in sum	566686	489519	-77167
Total growth			2369095
Total decrease			648078
% growth that can be covered by crop to crop conversion			27.4

As **Table 18-2** suggests, around 27percent of the overall land use growth could potentially come from the conversion of other crop land. Therefore the company may assume that 72 percent of the palm oil produced in Malaysia comes from area which was converted from a different land category. This assumption should not be made if the total area of crop land is decreasing, or if the country has specific efforts to convert degraded crop land to pasture land or another type of land category; in these cases, the decrease in other crop land may be due to those efforts and conversion to the studied product.

4. Determine type of land converted

Malaysia has a tropical climate, and according to statistics the majority of land is forest (66 percent) or cropland (31 percent) (Earthtrends, 2006). Therefore, it should be assume that the land use change occurred from tropical forest to cropland to meet the increased demand for palm oil fruit. Companies can use IPCC or other default values to determine what the carbon stock change associated with this land use change would be. The company also needs to assume what the land use change practices would be typical when forest land is converted to crop land in Malaysia; for example, whether the forest biomass is burned during conversion and what fertilizers are applied to prepare the land for crop production.

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

5. Allocation land use impact emissions

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

18.3 Estimating Significance for Land Use Impacts

When specific land data are not available, companies may also chose to estimate the potential significance of land use impacts on their products to determine if a justifiable exclusion is appropriate. For example, a product that uses a bio-based polymer as an input could estimate the impact of land use change assuming the worst case scenario (e.g. all comes from land that was converted from natural forest) and determine whether this is significant, applying the same rules for significance as described in Section 7.2.4. If land use impacts are deemed significant using this estimation the company can either include the worse-case values in the report or go back and try to estimate the potential impact using statistical data. If land use impacts are insignificant then this should be included as a justifiable exclusion in the inventory report.

19 Appendix D - Supplier Engagement

Collecting greenhouse gas (GHG) inventory data along the life cycle of a product can be a major undertaking, particularly when collecting primary data from suppliers or customers alone the product's life cycle. Having a plan in place before contacting suppliers[64] can significantly improve supplier response. This appendix highlights the key decisions companies should make to have a successful supplier engagement program and a positive experience working with suppliers.

An initial step in the planning process is to determine if the company is currently surveying its supply chain on other environmental or social responsibility aspects of their business. If an assessment program is already in place, it is helpful to coordinate the GHG inventory collection program with existing activities to ensure a consistent, coordinated approach throughout and to minimize the burden on suppliers.

19.1 Developing a Supplier Engagement Program

Companies should develop an internal strategy for collecting GHG emissions data from its value chain partners. The internal strategy should address the following key components:

1) Identification of the Departments Responsible for Data Collection
2) Identification and Categorization of Suppliers
3) Supplier Selection Process
4) Engagement of the Procurement Staff

Each step is described in more detail below.

19.1.1 Identification of the Responsible Organizations

Typically, environmental survey activities originate in the Environmental Affairs, Environmental Health and Safety or Social Responsibility group within a company. While one of these groups may originate the program, the program itself may be best executed through and with the support of the procurement organization, as they typically have the responsibility for managing the supply chain. In some companies, the procurement organization has assigned an individual or department to manage environmental and material issues in the supply chain. This individual or group could be valuable to the success of the effort.

There are two possible organizational approaches by which companies can execute this program:

- Place responsibility for coordinating the program with the environmental or social responsibility staff and have them manage and coordinate the program through the procurement staff.
- Assign a program manager in the procurement organization with responsibility to interface with the environmental team and manage the program across the procurement organization.

There may also be other project management approaches that are more suitable for an organization. Regardless of the approach chosen to execute this effort, it is essential to get a strong executive sponsor within the procurement organization to secure and maintain organizational support for the process to collect GHG inventories from a company's suppliers.

19.1.2 Identification and Categorization of Suppliers

A company may only know their direct suppliers (those that supply the company directly – called tier 1 suppliers) or, in some cases, the direct suppliers to those direct suppliers (i.e. tier 2). Depending on the complexity of the product and the position of the company along the product's lifecycle, the number of suppliers may vary significantly. Therefore, once the number of known suppliers is identified, companies should determine whether to engage with all suppliers (for a small supplier network) or categorize and select only a subset of suppliers to contact (for a large supplier network).

[64] In this appendix, the term supplier is meant to represent suppliers upstream and customers downstream of the reporting companies operations. The same guidance should be applicable to both.

A comprehensive supplier list that details the supplier name, address, procurement contact, supplier type (production or service), commodity or service type, and the annual spend with that supplier is needed. Ideally, the full ranges of data are available, but it may be that only subsets of the listed data are available. Consulting with the procurement agents responsible for the suppliers may allow for filling in some or all of the missing data. The less data that is available the more difficult it may be to develop a supplier selection process. For some companies, depending on the number of suppliers and availability of supplier information, creating a comprehensive list may be feasible. If the task becomes time- or cost-prohibitive, companies should list suppliers by function and collect information for the top suppliers according to spend within each function.

19.1.3 Supplier Selection Process

If supplier selection is necessary, the preferred approach is to rank them according to their expected contribution to emissions, i.e., to select suppliers of the highest emitting goods and services. If a company has trouble screening its value chain by emissions, the simplest selection process is to rank direct suppliers according to spend and select those suppliers that make up a designated percentage of the company's total supplier spend. This procedure is identical to the one used to screen data collection efforts in Chapter 9. The number of suppliers to engage is at the company's discretion; however, the more suppliers that are surveyed the more likely a company is to obtain completeness. As a general rule of thumb, companies should request data from the top 80% of known suppliers based on the preliminary evaluation of emissions contribution. Overtime, it is expected that the number of suppliers a company requests data from will increase in an effort to continue improving data quality.

As a company gathers data over time, it will gain an understanding of the GHG inventories of different commodity and service types and the ability of different parts of the supply chain to provide GHG inventory data. This information allows companies to determine what parts of the supply chain need assistance in compiling their GHG inventories and direct them to appropriate resources to assist them in their efforts.

19.1.4 Engage Procurement Staff

Once the preliminary supplier selection is completed, the procurement staff responsible for the chosen commodity types should assess the chosen list of suppliers for appropriateness and applicability. They should be aware of plans to add or remove specific suppliers or modify supply agreements. In addition, this allows the procurement team to have input in the supplier selection process and ensure their buy-in to the process.

As part of this engagement process, it is important to educate the procurement team on the program, explaining the reasons the survey is important, the mechanics of the data collection process, tips for dealing with suppliers (including a list of frequently asked questions), and the importance of clearly explaining the program to the supplier. Companies should also communicate that there is executive support for the program. Having the understanding and support of the procurement team is important to achieving a successful data collection program.

19.2 Working with Suppliers

Now that the supplier engagement program is in place, a critical aspect of working with suppliers is communicating the importance and requirements of the program to the supply chain. These communications should take place throughout the data collection process. There are several key steps:

1) Announce the program to the supply chain before sending any survey forms.
2) Provide a training or information session on the data collection methodology.
3) Check-in periodically with suppliers regarding their progress on completing the survey.
4) Determine the consequences for suppliers that choose not to respond.
5) Assess data quality and follow up with suppliers to resolve data questions and thank them for participating.

Each step is described in more detail below.

19.2.1 Announce the Program

Prior to sending the survey or data collection form, it is advisable for the procurement team to send a letter to their supplier counterparts explaining the program, its importance and any consequences associated with not participating, how the data are collected and used, and reassurance that data are kept confidential, available resources to assist in the response to the survey, and the survey schedule. The letter should request the name of the individual responsible for preparing and disclosing the supplier's emissions data. Identification of this individual at the beginning of the process enables the company to direct the survey to the responsible person at the supplier, avoiding delays in the survey process. The letter should also offer a phone call with the appropriate member(s) of the company's environmental staff if the supplier wishes to further discuss the program details.

Companies should send a letter from the appropriate procurement executive to their executive counterpart at the supplier. This should provide an explanation of the program, its importance, and a request for the supplier's participation in the survey effort.

When the company holds supplier forums, it is advisable to present a module on the GHG inventory program, explaining the reasons for the program and the mechanics of the survey process.

19.2.2 Provide training or information sessions

A letter and information packet should be sent to the person identified as the GHG inventory contact for each supplier with a copy to the supplier contact.Companies should schedule one or more training or information sessions on the reporting spreadsheet or software tool. This session should be designed to familiarize the supplier's representative with the data collection process and provide them the information they need to undertake the data reporting. Suppliers vary widely in knowledge of GHG emissions data. Some suppliers are unfamiliar with GHG emissions data while other suppliers have already been tracking this type of data. Additional guidance may be required for suppliers who are reporting for the first time. It is best to schedule sessions that align with the working hours of the supplier's representative.

Maintain a "Help Desk" or Help Person to whom inquiries about the system can be directed. Having a contact that is responsive and knowledgeable about the company's data collection tool and process can be critical to the success of the program.

19.2.3 Check-in Periodically

This part of the process is simplified if the company is using a web-based or online reporting system where you can track supplier progress. Regular follow-up underlines the importance getting survey response is to the company, and allow suppliers the opportunity to ask questions and further develop the relationship.

19.2.4 Handling Delinquent Responses

Companies should determine the consequences and related follow-up actions for suppliers that do not respond to survey requests, even after follow-up engagement. Failure to communicate clear consequences for not participating may dilute the value of the data collection process and make it more difficult to get data collected in subsequent years.

19.2.5 Data Quality and Follow Up

Following up with the supply to resolve questions, send the supplier a note indicating that you have reviewed the data, and thanking them for their efforts are just a few ways companies can cultivate a lasting relationship. In addition, it is advisable to send a follow-up letter from the procurement executive.

Clear, concise and regular communication with the supplier is integral to a company's success in gathering a meaningful inventory. If a company does not show committed interest in the program, their suppliers may not take the program seriously. Even with a committed effort to drive the program, it is likely to take several years to get the completeness and quality of the overall inventory to a high level of confidence. Regular communications with and feedback to your suppliers on the process and its results should help accelerate the relevance and quality of the company's inventory.

20 Appendix E - Quantitative Inventory Uncertainty

Single parameter uncertainty arises from four types of parameters used in calculating product inventories: direct emissions data, activity data, emission factors, and GWP parameters. Any uncertainties from others parameters used to quantify any of these three should be considered in the context of their influence on these parameters. An important exception to this classification is those cases where emissions are directly measured, in which case uncertainty in that measurement replaces the need to consider activity and emission factor uncertainty.

Parameter uncertainty can be represented by a probability distribution or as a range. Common distributions include the normal distribution, lognormal distribution, uniform distribution and triangular distribution, among others[65]. For representation of the natural and industrial processes that are represented by activity and emission factor data, the log-normal distribution is often determined to be a reasonable fit. Guidance on quantifying parameter uncertainty from direct emissions data are available in the GHG Protocol's *Measurement and Estimation Uncertainty of GHG Emissions tool*. For direct emissions data used in the inventory, guidance on quantifying uncertainty has been developed by ISO[66] and in the GHG Protocol online calculation tools. This appendix focuses on quantifying parameter uncertainty from activity data and emission factors; however, the pedigree matrix approach and many of the propagation techniques discussed below may apply for direct emissions data.

Different approaches of quantifying single parameter uncertainty include:

- Measured uncertainty (represented by standard deviations),
- The pedigree matrix approach, based on data quality indicators (DQIs)67 can be applied If measured uncertainty is not either known or available68 (expert judgment involved),
- Default uncertainties for specific activities or sector data (reported in various literature69)
- Some commercial databases contain probability distributions for data they contain,
- Uncertainty factors reported in literatures, and
- Other approaches reported by literature

20.1 Pedigree Matrix

If single parameter uncertainties are unknown, a pedigree matrix approach can be used to calculate uncertainties. Once the single parameter uncertainty values have been determined using this approach, the values can be propagated using techniques such as Monte Carlo simulation or Taylor Series expansion (discussed below).

In the pedigree matrix approach, the qualitative data quality assessment results (see section 9.2.8) are used to relate the data quality indicators to uncertainty ranges for individual parameters[70,71,72]. Data quality assessment results from activity data and emission factors should be translated separately; they are considered together in the propagating parameter uncertainty section.

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[65] For further discussion or the use of these distributions in LCA, see Heijungs, 2004, *A Review of Approaches to Treat Uncertainty in LCA* and for detail of additional distributions, see Lloyd, SM, 2007, *Characterizing, Propagating, and Analyzing Uncertainty in Life-Cycle Assessment*
[66] Guide to the Expression of Uncertainty in Measurement
[67] See prior section on data quality, Chapter 9
[68] Weidema, BP, 1996, Data quality management of life cycle inventories-an example of using data quality indicators Assessment
[69] Shannon M. Lloyd and Robert Ries, 2007.Characterizing, propagating, and analyzing uncertainty in Life-Cycle Assessment: a survey of quantitative approaches. Journal of Industrial Ecology 11 (1) :161-179
[70] Bo Pedersen Weidema, B.P. and Wesnaes, M.S., 1996. Data quality management of life cycle inventories-an example of using data quality indicators. J. Cleaner Prod. Vol. 4, No. 3-1, pp. 167-174
[71] Weidema, B.P., 1998. Multi-user test of the data quality matrix for product life cycle inventory data. Int. J. LCA3 (5) 259-265
[72] Data quality guidelines for the ecoinvent database version 3.0

In the pedigree matrix an uncertainty factor is assigned to each of the five data quality indicators and four data quality criteria (very good, good, fair, and poor). The uncertainty factors are used to compute the GSD^2 (the square of the geometric standard deviation). These uncertainty factors, shown in **Table 20-1**, are ultimately based on expert judgment, as represented in the scientific literature on this topic (see Section 9.2.8).

Table 20-1: Suggested pedigree matrix for determining uncertainty scaling factors based on data quality ratings

Indicator score	Very Good	Good	Fair	Poor
Precision	1.00	1.10	1.20	1.50
Completeness	1.00	1.05	1.10	1.20
Temporal representativeness	1.00	1.10	1.20	1.50
Geographical representativeness	1.00	1.02	1.05	1.10
Technological representativeness	1.00	1.20	1.50	2.00

The total uncertainty, expressed as a 95% confidence interval, SD_{g95} (the square of the geometric standard deviation), is calculated using the formula shown below[73]:

$$SD_{g95} = \sigma_g{}^2 = \exp^{\sqrt{[\ln(U_1)]^2+[\ln(U_2)]^2+[\ln(U_3)]^2+[\ln(U_4)]^2+[\ln(U_5)]^2+[\ln(U_b)]^2}}$$

where:

U_1= uncertainty factor of precision[74]
U_2= uncertainty factor of completeness
U_3= uncertainty factor of temporal representativeness
U_4= uncertainty factor of geographic representativeness
U_5= uncertainty factor of other technological representativeness
U_b= basic uncertainty factor

When not enough information is available for a particular data point to apply the data quality criteria companies should assign a default low scores (i.e. “poor”) in order to make a conservative estimate of uncertainty. Furthermore, all scores should be disclosed along with the results in order to promote transparency and ensure accountability of uncertainty analysis results. Single parameter uncertainties based on the pedigree matrix approach can be supplemented and used in combination with distributions determined thru other methods.

The formula above includes a component of a “basic uncertainty factor.” This is a minimal uncertainty rating for specific process categories. It is important to note that this basic uncertainty factor may vary by process type or other factors. The following categories and factors are suggested for use as the basic uncertainty factors based on available information in literature sources:

Table 20-2: Suggested Basic Uncertainty Factors[75]

Category of activity or emission	Suggested Basic Uncertainty Factor
Thermal energy	1.05
Electricity	1.05
Semi-finished products	1.05
Raw materials	1.05
Transport services	2.00

[73] Weidema, B.P., 1998. Multi-user test of the data quality matrix for product life cycle inventory data. Int. J. LCA3 (5) 259-265

[74] These terms are defined in the data quality section above.

[75] Adapted from Ecoinvent report No.1 Overview And Methodology (Data v2.0, 2007)

Waste treatment services	1.05
Infrastructure	3.00
CO_2 emissions	1.05
Methane emissions from combustion	1.50
Methane emissions from agriculture	1.20
N_2O emissions from combustion	1.50
N_2O emissions from agriculture	1.40

Quantifying Uncertainty of Global Warming Potentials

The uncertainty of the direct Global Warming Potential (GWP) for the six GHG Protocol gasses is estimated to be ± 35% for the 90% confidence interval (5% to 95% of the distribution). This is based on information provided in the IPCC's Fourth Assessment Report, and the range to reflect the uncertainty in converting individual GHG emissions into units of CO_2e. Companies may include GWP uncertainty in a total propagated parameter uncertainty if they choose to.

20.1 Propagating Parameter Uncertainty

Various methods exist for propagating single parameter uncertainties in a product inventory to determine the overall parameter uncertainty. Some of these methods include Monte Carlo simulation[76,77,78], Bayesian statistics, analytical uncertainty propagation methods, calculation with intervals and fuzzy logic[79], and Taylor Series expansion. This appendix does not go into the details of these various methods but only provides a brief description of two popular methods: Taylor Series expansion and Monte Carlo simulation. Consult referenced literature for further details regarding uncertainty analysis tools and techniques **(to be determined).**

20.1.1 Taylor Series Expansion

Taylor Series Expansion is an analytical method used to analyze the combined uncertainty from the associated with individual parameters. The squared geometric standard deviation (GSD^2) of the total product inventory result is determined as a function of the inventory result's sensitivity to each input parameter (i.e., each parameter's relative impact/influence on the total inventory result[80]) and the squared geometric standard deviation of each parameter. The Taylor Series expansion method requires the assumption that the uncertainty distribution for each input parameter is log-normally distributed.

The single parameter uncertainties can be used to determine the uncertainty in the total inventory result based on the equation below.

$$(\ln GSD_y)^2 = S_1^2(\ln GSD_1)^2 + S_2^2(\ln GSD_2)^2 + \ldots + S_n^2(\ln GSD_n)^2$$

Where GSD_y is the geometric standard deviation of the total inventory result. GSD_1 is the geometric standard deviation of the first input (e.g., activity data or emission factor data) and S_1 is the sensitivity of the result to that factor.

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[76] Ibid.

[77] Lo, S.-C.; Ma, H.-W.; Lo, S.-L., (2005) Quantifying and reducing uncertainty in life cycle assessment using the Bayesian Monte Carlo method, Science of Total Environment 340 (1-3) 23-33

[78] Sonneman, G.W., M. Schuhmacher, and F. Castells. Uncertainty assessment by a Monte Carlo simulation in a life cycle inventory of electricity produced by a waste incinerator. *Journal of Cleaner Production* 11 (2003), 279-292.

[79] Tan, R.R., 2008. Using fuzzy numbers to propagate uncertainty in matrix-based LCI. Int. J Life Cycle Assess (2008) 13:585–592

[80] The sensitivities are defined as the percent response in the output to modification to the input and are identical to the percent contributions of the process in question to the overall result. For example, if a given process is responsible for 10% of the total GWP of the product system, its sensitivity (*S*) is 0.1.

20.1.2 Monte Carlo Simulation

Monte Carlo simulation is a well-known form of random sampling used for uncertainty analysis and is a commonly used tool in commercial Life Cycle Assessment software. In order to perform Monte Carlo simulation, input parameters (e.g. direct emissions data, activity data, or emission factors) must be specified as uncertainty distributions. The input parameters are varied at random, but restricted by the given uncertainty distributions. The randomly selected values from all the parameter uncertainty distributions are inserted into the emission calculations. Repeated calculations produce a distribution of the predicted result values, reflecting the combined uncertainty of the individual parameters.[81]

20.2 Reporting Quantitative Uncertainty

Quantitative uncertainty can be reported in many ways, including qualitative descriptions of uncertainty sources, as well as quantitative depictions, such as error bars, histograms, etc. Although various methods and tools exist to address individual types of uncertainty, it is impossible to represent a true measure of total combined uncertainty in a single, consistent way. Nonetheless, it is useful to provide as complete a disclosure of uncertainty information as is possible. Users of the information may then weigh the total set of information provided in judging their confidence in the information.

20.2.1 Example Uncertainty Assessment Reporting

A product inventory has been created for a toner cartridge. The functional unit is the printing of 50,000 black-and-white pages, and the inventory result is 155 kg CO_2e per functional unit. The following sections describe an uncertainty assessment associated with this inventory.

Summary of Sources of Uncertainty

Table 20-3 lists (1) sources of uncertainty identified in compiling the product inventory and (2) a qualitative description of the anticipated importance of each area of uncertainty. Uncertainties chosen for scenario analysis (included below) are shown in italics.

Table 20-3: Sources and descriptions of uncertainty compiled throughout GHG inventory

Uncertainty Type	Uncertainty Source	Description	Importance
Parameter uncertainty	Toner cartridge resin production emission factor	Poor temporal and geographical representativeness	Moderate; cartridge resin is not a large emissions contributor
	Printer electricity activity data	Source: Electricity use is taken from an older model	Moderate; electricity use is important, but difference in models is expected to be small
Methodological Uncertainty	*Choice of grid mix*	Choice has been made to use a the US national electricity grid mix	High; electricity use is important in the result and variation among and within countries is large
	Functional unit choice	Number of pages printed is chosen as the functional unit rather than area of ink printed	Low; within the assumption made for ink/page, little difference would be expected
Situational Uncertainty	*User recycling behavior*	Some users may recycle more or less cartridges than the average	Moderate; influence of recycling is a small but not insignificant contributor
	Page yield variation[82]	Some users experience more or less pages printed per cartridge	Moderate; could affect electricity use or paper use, which are important factors

[81] Huijbregts, M.A.J. (1998), Application of uncertainty and variability in LCA. Part 1: a general framework for the analysis of uncertainty and variability in life cycle assessment. Int. J. LCA 3(5):273-280

[82] This falls under situational uncertainty because the page yield may vary depending on the usage variations of the printer. For example, User A may use the printer to print pictures, and User B may use it for reports. The page yield for these different functions can vary significantly.

Model Uncertainty	Electricity production	It is difficult or impossible to know the exact mix of production technologies supplying electricity to the printers	Moderate; electricity production is important, but the variation from the assumed production is expected to be relatively minor.

Summary of GHG Inventory Components and Contributions

Table 20-4 summarizes the components of the GHG inventory, the activity and emission factor data used, and the percent of the total result contributed by each of the listed materials or processes.

Table 20-4: Summary of GHG inventory

Inventory Category Name	Emission Factor Geographic Representativeness	Emission Factor Temporal Representativeness	Unit	Technology Type	Total GHG factor (kg CO2e/unit)	Activity Data	GHG Total	Percent of total inventory
Electricity, Manufacturing	US	Within 2 years	kWh	Electricity	0.84	30.0	25	16%
Electricity, Assembly	US	Within 2 years	kWh	Electricity	0.84	10.0	8.4	5%
Electricity, Use	US	Within 2 years	kWh	Electricity	0.84	63	53	34%
Heavy Truck	RER	Within 2 years	tkm	Transport Services	0.13	2.8	0.35	<1%
Aluminum	RER	Within 10 years	kg	Industrial Products	12	0.077	0.94	1%
Copper	GLO	Within 10 years	kg	Industrial Products	3.5	0.001	0.002	<1%
Steel	RER	Within 10 years	kg	Industrial Products	5.2	0.39	2.0	1%
Polystyrene	RER	Within 10 years	kg	Industrial Products	3.5	0.45	1.6	1%
Nylon	RER	Within 10 years	kg	Industrial Products	9.2	0.028	0.26	<1%
PVC	RER	Within 10 years	kg	Industrial Products	4.6	0.006	0.029	<1%
Polyurethane	RER	Within 10 years	kg	Industrial Products	4.8	0.020	0.095	<1%
Corrugated Board	RER	Within 10 years	kg	Agricultural Products	1.4	0.48	0.66	<1%
Paper, packaging	RER	Within 10 years	kg	Agricultural Products	1.3	0.024	0.031	<1%
LDPE	RER	Within 10 years	kg	Industrial Products	2.1	0.026	0.055	<1%
Paper, Use	RER	Within 10 years	kg	Agricultural Products	1.3	50	63	41%
Total							**155**	

Data Quality Ratings and Quantification of Parameter Uncertainty

The data sources listed in the above table are assessed for their data quality based on the criteria recommended in section 9.2.8. These data quality ratings are used to approximate an uncertainty range with the methods recommended in the appendix to the standard. The chosen data quality ratings and the resulting standard deviations are shown in **Table 20-5**.[83]

[83] Note that the uncertainty of the global warming potential (GWP) for the six GHG Protocol gasses is assumed to be ± 35% for the 90% confidence interval (see Section 7.2).

Table 20-5: Summary of Data Quality Indicators and

Inventory Category Name	Activity Data Precision	Activity Data Completeness	Activity Data Temporal Representativeness	Activity Data Geographic Representativeness	Activity Data Technological Representativeness	Activity Data GSD	Emission Factor Data Precision	Emission Factor Data Completeness	Emission Factor Data Temporal Representativeness	Emission Factor Data Geographic Representativeness	Emission Factor Data Technological Representativeness	Emission Factor GSD	GWP GSD	Contribution to uncertainty of GSD of result	Percent of total uncertainty contributed
Electricity, Manufacturing	Fair	Poor	Good	Poor	Fair	1.16	Fair	Good	Poor	Fair	Fair	1.26	1.16	0.003	4%
1Electricity, Assembly	Poor	Poor	Good	Fair	Very Good	1.26	Fair	Fair	Poor	Fair	Fair	1.26	1.16	<0.001	1%
Electricity, Use	Fair	Very Good	Fair	Poor	Poor	1.16	Fair	Good	Poor	Good	Poor	1.26	1.16	0.011	16%
Heavy Truck	Fair	Poor	Good	Poor	Poor	1.46	Very Good	Good	Poor	Poor	Very Good	1.50	1.16	<0.001	<1%
Aluminum	Poor	Poor	Good	Poor	Poor	1.27	Poor	Poor	Poor	Poor	Good	1.36	1.16	<0.001	<1%
Copper	Good	Good	Good	Poor	Very Good	1.09	Fair	Fair	Fair	Good	Fair	1.15	1.16	<0.001	<1%
Steel	Poor	Poor	Good	Fair	Fair	1.26	Fair	Fair	Fair	Fair	Fair	1.15	1.16	<0.001	<1%
Polystyrene	Fair	Very Good	Good	Poor	Poor	1.13	Very Good	Poor	Fair	Good	Fair	1.14	1.16	<0.001	<1%
Nylon	Poor	Poor	Good	Poor	Poor	1.27	Fair	Good	Fair	Good	Very Good	1.14	1.16	<0.001	<1%
PVC	Fair	Good	Fair	Good	Very Good	1.14	Good	Poor	Fair	Fair	Good	1.15	1.16	<0.001	<1%
Polyurethane	Poor	Poor	Fair	Fair	Fair	1.28	Poor	Good	Poor	Good	Fair	1.34	1.16	<0.001	<1%
Corrugated Board	Fair	Poor	Fair	Good	Fair	1.46	Poor	Poor	Poor	Fair	Good	1.58	1.16	<0.001	<1%
Paper, packaging	Poor	Poor	Fair	Fair	Fair	1.53	Fair	Fair	Good	Fair	Very Good	1.44	1.16	<0.001	<1%
LDPE	Fair	Poor	Good	Poor	Poor	1.17	Fair	Fair	Poor	Poor	Poor	1.27	1.16	<0.001	<1%
Paper, Use	Fair	Good	Good	Fair	Poor	1.44	Fair	Fair	Poor	Good	Very Good	1.51	1.16	0.054	79%

Using the calculated GSDs and the sensitivities/contributions of each inventory category to the total results, the Taylor Series Expansion Method (see Section 20.1.1) is applied to estimate the propagated parameter uncertainty of the product inventory result.

Reporting Parameter Uncertainty

Parameter uncertainty can be presented as a probability density function, such as the familiar normal curve (or with one of many other distributions that might be chosen). The shape of the representation depends upon the distribution type used to represent it, and the width of the distribution reflects the relative magnitude of the uncertainty. A distribution example is shown below in **Figure 20-1**.

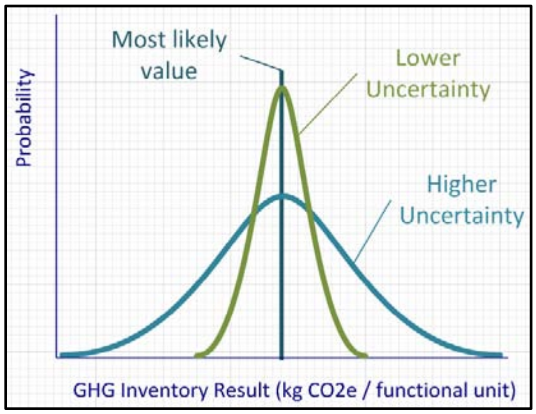

Figure 20-1: Example of Parameter Uncertainty Distribution

Another convenient means of representing parameter uncertainty is with the use of "error bars," which can be used to depict, for example, the 95 percent confidence limit of the value in question. It is important when using error bars to identify the confidence interval that is represented.

Using the toner cartridge example, the inventory results are presented in **Figure 20-2**. The column (blue bar) is the inventory result of 155 kg CO_2e per functional unit, and the uncertainty is represented by the error bar (-15 and +15 kg CO_2e). Combined, these result in a range of inventory result values of 141 to 170 kg CO_2e.

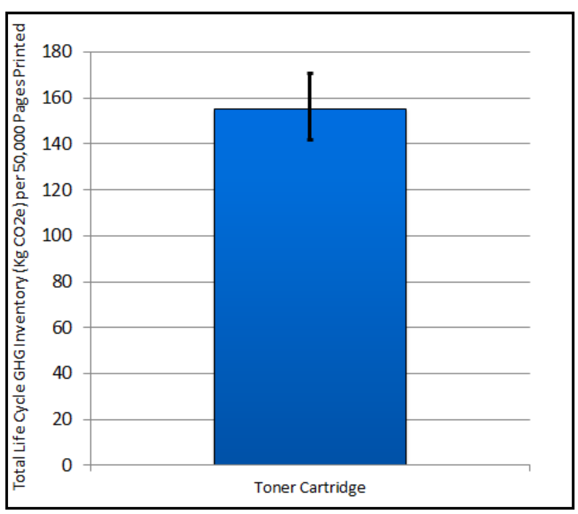

Figure 20-2: Impact assessment results of toner cartridge GHG inventory study

Scenario Uncertainty Assessment and Reporting

In this example scenario assessment is performed on two of the areas identified as potentially important sources of scenario uncertainty. These include the choice of electrical grid mix (where both a more localized grid mix and a continental grid mix have been tested as replacements for the national grid mix assumed in the initial inventory) and the use of the national average of 40 percent plastic recycling (where both the case of no recycling and 100 percent recycling have been tested as the extreme cases of toner cartridge use by an individual).

Scenario uncertainty is most appropriate to show as separate values on a chart. A variety of chart types could be used for such a purpose; one example, a histogram, is shown in **Figure 20-3**.

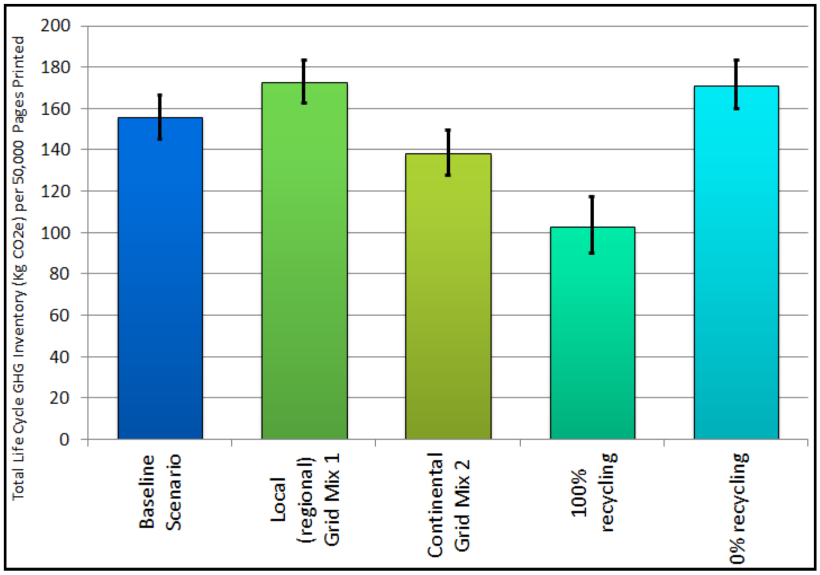

Figure 20-3: Scenario Uncertainty Assessment Shown with Parameter Uncertainty

Conclusion

The uncertainty assessment provides a perspective on the relative confidence report readers can have in the inventory results. In this example, parameter uncertainties combine to provide an interval of approximately +/- 15 CO2e surrounding the inventory results value of 155 $kgCO_2e$ per functional unit. The impact of the user's recycling behavior is shown to be important for the toner cartridge, with users who do recycle most or all materials (cartridge and paper) having a substantially lesser impact than those that recycle very little. Due to these variations, individual users of the cartridge may produce very different emission totals than that shown in the inventory results. This example shows the importance of providing uncertainty information with the product inventory results to inform report readers of how to interpret the results.

1 # 21 Appendix F - Public Report Template

General Inventory Information	
Parameter	Description [Template Notes]
Company Name and Contact Information	
Studied Product Name	[Material Product or Service, Brand Name if applicable]
Studied Product Description	[Brief product description including whether it is a final or intermediate product]
Type of Inventory	[Final Product Cradle-to-Grave Inventory OR Intermediate Product Cradle-to-Gate Inventory]
Goal of Public Disclosure	[See Chapter 3 for business goals]
Sector Guidance or Product Rules	[Include reference to sector guidance or Product Rules used when applicable[84]]
Inventory Date and Version	[Year inventory was finalized]
	[1 if first inventory, 2,3 etc. for future versions]
Link to previous inventory reports and description of any methodological changes (when applicable)	
Establishing the Scope & Boundary Information	
Unit of Analysis	[Functional unit for cradle-to-grave inventories, reference flow for cradle-to-gate inventories, see Chapter 6]
Reference Flow	[see Chapter 6]
Time Boundary	[see Chapter 7]
Country/Region of Product Consumption	[for cradle-to-grave inventories]
Process Map	[see Chapter 7]
Life Cycle Stages	
Stage Definition[85]	Stage Description

[84] Companies are not required to use sector guidance or product rules, but if guidance was used then it is referenced here.

[85] Stage definition should be the general stages defined in the standard or disaggregated or specific stages defined by the company. Guidance on life cycle stage definitions is given in Chapter 7.

Material Acquisition & Preprocessing	[Brief description the life cycle stage, including the start and end point and the time boundary of each stage when applicable [86]. Non-attributable processes included in the boundary can be reported here or in the process map.]
Production	
Distribution & Storage	
Use	
End-of-Life	

Data Information	
GWP metric	[Source and date of GWP metric used, see Chapter 12]
Data Type	Percent of Emissions Calculated with the Data Type
Primary Data	[See Chapter 9]
Secondary Process Data	
Secondary Financial Data	
Unspecified	

Data Quality Information
[For significant attributable processes, a descriptive statement on the data sources, the data quality aspects, and any efforts taken to improve data quality , see Chapter 9]

Inventory Results: g[87] CO_2e /Unit of Analysis					
Total Inventory Results	Biogenic Inventory Results (when applicable[88])		Non-Biogenic Inventory Results (when applicable)		Land Use Impact (when applicable[89])
Current inventory	Removals	Emissions	Removals	Emissions	

[86] If carbon storage is assumed in the end-of-life stage, this should be included in the stage description along with the time boundary.

[87] Inventory results may be reported grams, kilograms, milligrams, etc.

[88] Biogenic and non-biogenic inventory results do not need to be reported separately if the studied product does not remove or emit biogenic carbon.

[89] Land use impacts do not need to be report if no land use impact are attributable to studied product

results					
Base inventory results (if tracking performance)					

Inventory Results: Carbon Storage (when applicable), g CO_2e/unit of analysis	
Embedded product carbon not released at the end of life	[only when applicable, see Chapter 7]
Embedded product carbon leaving the gate of a cradle-to-gate inventory	[only when applicable, see Chapter 7]
Amount of process emissions stored as a result of emission storage	only when applicable, see Chapter 12]

Inventory Results: Percent of Total Inventory Results per Life Cycle Stage		
Stage Definition[90]	Value (Percent of Total CO_2e)	Displaced Emissions due to 0/100 Output Method Recycling (Percent of Total CO_2e)
Material Acquisition & Preprocessing	[Value, see Chapter 12]	[Only applicable when the 0/100 method is used, see Chapter 8]
Production		
Distribution & Storage		
Use		
End-of-Life		

Inventory Results: Inventory Results per Cradle-to-Gate and Gate-to-Gate	
Definition	Results (g CO_2e /Unit of Analysis)

[90] Stages may be combined due to confidentially issues, if this is clearly noted in the inventory results.

Cradle-to-Gate	[Value]
Gate-to-Gate	[Value, or justification as to why the data is confidential]

Assurance	
Assurance Type	[3rd Party or Self-Assurance, see Chapter 13]
Assurance Process	[If Self-Assurance, explain how any potential conflict of interest was avoided]
Assurance Provider	[Name, affiliation]
Assurance Opinion	[Limited or Reasonable]

Uncertainty		
Parameter (data) Uncertainty	[Descriptive statement on qualitative uncertainty, See Chapter 11]	Quantitative Uncertainty (Optional[91])
Methodological Choice & Assumptions[92]	Disclosure & Justification[93]	Quantitative Uncertainty (Optional)
Cradle-to-Gate Inventory	[Justify why a cradle-to-gate inventory was performed, See Chapter 7]	
Use Profile	[If more than one use profile was applicable, disclose which method was used and justify the choice, see Chapter 7]	[e.g., range of inventory results assuming different use profiles]
End-of-Life Profile	[If more than one end-of-life profile was applicable, disclose which method was used and justify the choice, see Chapter 7]	[e.g., range of inventory results assuming different end-of-life profiles]
Allocation Method (s)	[Disclose which allocation methods were used. If more than one allocation method was applicable, disclose which method was used	[e.g., range of inventory results assuming different

[91]Companies may include an optional quantitative uncertainty range based on a specific choice, but this is not required and may not be applicable for all choices. See Appendix E for more information on quantitative uncertainty.

[92] Companies may add to this list if they feel other choices or assumptions have an impact of the certainty of the inventory results. Companies may also remove choices that are not applicable to their inventory, such as end-of-life stage assumptions for a cradle-to-gate inventory.

[93] Companies are required to disclose justifications. When applicable, this may include a qualitative description of how the methodological choice impacts the certainty of the inventory results.

	and justify the choice. See Chapter 8]	allocation methods]
Recycling Allocation Method(s)	[Disclose which recycling allocation methods were used. Justify the use of a method besides 100/0 and 0/100. See Chapter 8]	[e.g., range of inventory results assuming different recycling allocation methods]
Land Use Change Impacts Method(s)	[Disclose which methods were used to calculate and allocate land use change impacts. Justify the exclusion of land use change impacts if applicable, see Appendix C]	
Excluded attributable Processes, Materials, or Energy Flows	[Document and justify all[94] attributable process, material, or energy flow exclusions, including the threshold used for insignificance. See Chapter 7]	

Inventory Changes Overtime (when applicable)	
Changes made to the base inventory, or if no change was made, the threshold used to determine that recalculation was not needed	[See Chapter 15]
The change in inventory results	[percentage change overtime, g CO_2e/unit of analysis]
Explanation of steps taken to reduce emissions	

Use of the Inventory Results
[Brief description on how the results were interpreted, see Chapter 14]
[Disclaimer on the use of results, see Chapter 14]

[94] Companies may group together a type of process, material, or energy to reduce reporting burden, when logical

1 # 22 Appendix G – Glossary

Term	Definition
0/100 Output Method (Recycling Allocation)	A method for allocating recycling processes in a product's life cycle where recycled material output is assigned 100 percent of the recycling process emissions and virgin material input is displaced by recycling material with the same properties.
100/0 Input Method (Recycling Allocation)	A method for allocating recycling processes in a product's life cycle where recycled material input is assigned 100 percent of the recycling process emissions, and recycled material output is assigned zero percent of the recycling process emissions.
Accuracy (Principle)	Ensure that reported GHG emissions and removals are not consistently greater than or less than actual emissions and removals, 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.
Activity Data	The quantified measure of a level of activity that results in GHG emissions or removals.
Allocation	Occurs when emissions and removals data collected for a common process needs to be partitioned between the studied product's life cycle and the life cycle of the other products.
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.
Assurance Conclusion	An expression of the results of the assurer's evaluation of the company's written assertion or a statement that a conclusion cannot be expressed. In the event that the assurer determines that a conclusion cannot be expressed, the statement should cite the reason.
Assurer	Competent individual or body who is conducting the assurance process, whether internally within the company or externally.
Attributable Processes	Processes that are directly connected to the studied product and its ability to perform its function by material and energy flows, including the studied product's components and packaging, materials used to improve the quality of the product (e.g. fertilizers, lubricants) and energy used to move, create, or store the product.
Attributional Approach	Accounts for the GHG impacts of a product over its lifecycle, making use of historical, fact-based, and measurable data and including all processes that are identified to be attributable to the studied product's life cycle.(ILCD, 2010) [95]

[95] (ILCD, 2010) Joint Research Commission, 2010, ILCD Handbook: General Guide for Life Cycle Assessment

Audit Trail	Well organized and transparent historical records documenting how the GHG inventory was compiled.
Biogenic	An emission, removal or product that is produced by living organisms or biological processes.
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)[96]. A change in carbon stock can refer to additional carbon storage within a pool, the removal of CO_2 from the atmosphere, or the emittance of CO_2 to the atmosphere.
Common Process	A process where the process outputs includes the studied product and co-product(s).
Comparative Assertion	An environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function. (ISO 14040:2006)[97]
Completeness (principle)	Ensure that the inventory report covers all product life cycle GHG emissions and removals 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.
Consequential Approach	Accounts for the consequences a decision to change a process or input in a product's life cycle has on other processes and life cycles due to market changes or other external factors such as policies and consumer behaviors.
Consistency (principle)	Use of methodologies, data, and assumptions to allow for meaningful comparisons of a GHG inventory over time.
Consumer	An individual that purchases and uses a product.
Co-Products	A product exiting the common process that has value as an input into another product's life cycle.
Cradle-to-Gate Assessment	An assessment that includes part of the product's life cycle, including material acquisition through the production of the studied product and excluding the use or end-of-life stages.

[96] (IPCC) IPCC, 2006, Guidelines for National GHG Inventories, Volume 4: Agriculture, Forestry, and Other Land Use

[97] (ISO 14044:2006), International Organization of Standardization, 2006, Life Cycle Assessment: Requirements and Guidelines

Cradle-to-Grave Assessment	An assessment that includes all of the product's life cycle, from material acquisition through end-of-life.
Customer	An entity that purchases, rents, or uses the products of another entity (i.e., a supplier).
Embedded Product Carbon	Carbon molecules that exist as part of the product.
Emission Factors	The GHG emissions per unit of activity data.
Direct Emissions Data	Emissions released from a process (or removals absorbed from the atmosphere) determined through direct monitoring, stoichiometry, mass balances, or similar methods
End-of-Life Stage	A life cycle stage that begins when the used product is discarded by the consumer and ends when the product's components are returned to nature or allocated to another product's life cycle.
Environmentally Extended Input-Output (EEIO)	Emission factors developed through the analysis of economic flows and used to estimate emissions arising from sectors within an economy.
Extrapolated Data	Data specific to another process or product that has been adapted or customized to more-closely resemble the conditions of the given process in the studied product's life cycle.
Final Product	Goods and services that are consumed by the end user in their current form, without further processing, transformation, or inclusion in another product.
Financial Data	Monetary measures of a process that result in GHG emissions or removals
First Party ("Self" or "Internal") Assurance	Assurance provided by persons from within the organization but independent of the product GHG inventory determination process.
Functional Unit	The quantified performance of the studied product.
Gate-to-Gate	The emissions and removals attributable to a studied product while it is under the control of the reporting company.
GHG Emission Source	Any process which releases GHG into the atmosphere.
GHG Impact	The results calculated when GHG emissions and removals are multiplied by the Global Warming Potential (GWP).
Global Warming Potential (GWP)	A metric used to calculate the cumulative radiative forcing impact of multiple GHGs in a comparable way.

Indirect Land Use Change	Occurs when the demand for a specific land use induces a carbon stock change on other lands.
Intermediate Products	Goods that are used as inputs to the production of other goods or services and require further processing, transformation, or inclusion in another product before use by the end consumer.
Inventory Report	The full reporting requirements, plus any optional information, reported publicly in conformance with the *Product Standard*.
Inventory Results	The GHG impact of the studied product per unit of analysis as required by the reporting requirements.
Land Use Categories	Forest land, crop land, grass land, wetlands, settlements and other lands (IPCC, 2006)[98].
Land Use Change	Occurs when the demand for a specific land use results in a change in carbon stocks on that land due to conversion from one land use category to another or conversion within a land use category.
Land Use Change Impacts	Emissions and removals due to land use change and land use change practices.
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.
Life Cycle	Consecutive and interlinked stages of a product system, from material acquisition or generation of natural resources to end of life
Life Cycle Stage	A useful tool for organizing processes, data collection, and inventory results, life cycle stages are defined as interconnected steps along a product's life cycle.
Material Acquisition and Preprocessing Stage	A life cycle stage that begins when resources are extracted from nature and ends when the product components enter the gate of the studied product's production facility.

[98] (IPCC, 2006) IPCC, 2006, Guidelines for National GHG Inventories, Volume 4: Agriculture, Forestry, and Other Land Use

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.
Materiality	Concept that individual or the aggregation of errors, omissions and misrepresentations could affect the GHG inventory and could influence the intended users' decisions.
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.
Non-attributable Processes	Processes that are not directly connected to the studied product by material and/or energy flows, such as capital equipment and corporate operations.
Primary Data	Process data specific to the given process in a product's life cycle.
Product	Any good or service.
Product Distribution and Storage Stage	A life cycle stage that begins when the finished studied product leaves the gate of the production facility and ends when the consumer takes possession of the product.
Product GHG Inventory	Compilation of the GHG impacts of a studied product throughout its life cycle.
Production Stage	A life cycle stage that begins when the product components enter the production site for the studied product and ends when the finished studied product leaves the production gate.
Proxy Data	Data specific to another process or product that has not been adapted or customized to more-closely resemble the conditions of the given process in the studied product's life cycle.
Recycling	When a product or material exits the life cycle of the studied product to be reused or recycled as a material input into another product's life cycle.
Recycling Processes	Processes that occur as a result of a product or material being reused or recycled as a material input into another product's life cycle. Recycling processes need to be allocated between the product life cycles.
Reference Flow	The amount of studied product needed to fulfill the function defined in the unit of analysis.

Relevance (principle)	Ensure the product GHG inventory quantification methodologies and 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.
Removal	The sequestration or absorption of GHG emissions from the atmosphere, which most typically occurs when CO_2 is absorbed by biogenic materials during photosynthesis.
Reporting Company	The company performing the product GHG inventory in conformance with the *Product Standard*.
Same Inherent Properties (recycling)	When a recycled material has maintained its properties (e.g. chemical, physical) such that it can be used as a direct replacement of virgin material.
Scope 3 Inventory	A reporting organization's indirect emissions other than those covered in scope 2. A company's scope 3 inventory includes the upstream and downstream emissions of the reporting company.
Secondary Process Data	Data generic to the given process in a product's life cycle.
Service Life	The amount of time needed for a product to fulfill the function defined in the unit of analysis.
Studied Product	The product for which the GHG inventory is performed.
Time Boundary	The period of time when attributable processes occur during the product's life cycle.
Third Party ("External") Assurance	Assurance provided by persons from a certification or assurance body independent of the product GHG inventory determination process.
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. Clearly explain any estimates and avoid bias so that the report faithfully represents what it purports to represent.
Uncertainty	Quantitative Definition: measurement that characterizes the dispersion of values that could reasonably be attributed to a parameter (adapted from ISO 1995)[99] Qualitative definition: A general and imprecise term which refers to the lack of certainty in data and methodology choices, such as the application of non-

[99] (ISO, 1995) International Organization for Standardization. ISO/IEC Guide 98:1995. Guide to the expression of uncertainty in measurement (GUM)

	representative factors or methods, incomplete data on sources and sinks, lack of transparency etc.
Unit of Analysis	The basis on which the inventory results are calculated; the unit of analysis is defined as the functional unit for final products and the reference flow for intermediate products.
Use Stage	A life cycle stage that begins when the consumer takes possession of the product and ends when the used product is discarded for transport to a waste treatment location.