Sector Supplement for Measuring and Accounting for Embodied Emissions in the Built Environment

Sector Supplement for Measuring and Accounting for Embodied Emissions in the Built Environment

A Guide for measuring and reporting embodied emissions using the Greenhouse Gas Protocol
version 1.1 - November 2021

Authored by
Brightworks Sustainability
WAP Sustainability

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About this Sector Supplement
The following measurement protocol has been developed by a stakeholder consortium identified as the Total Carbon Coalition to provide guidance on how an organization can measure and report greenhouse gas (GHG) emissions embodied in the materials that make up a built environment project. This document was developed as a supplement to the GHG Protocol's Scope 3 Standard with references to the Corporate and Product Life Cycle Standards. The protocol sets out minimum requirements for measuring and reporting embodied emissions in order to meet best practices. Users should also follow the Greenhouse Gas Protocol Scope 3 Standard to claim conformance with the Scope 3 Standard.

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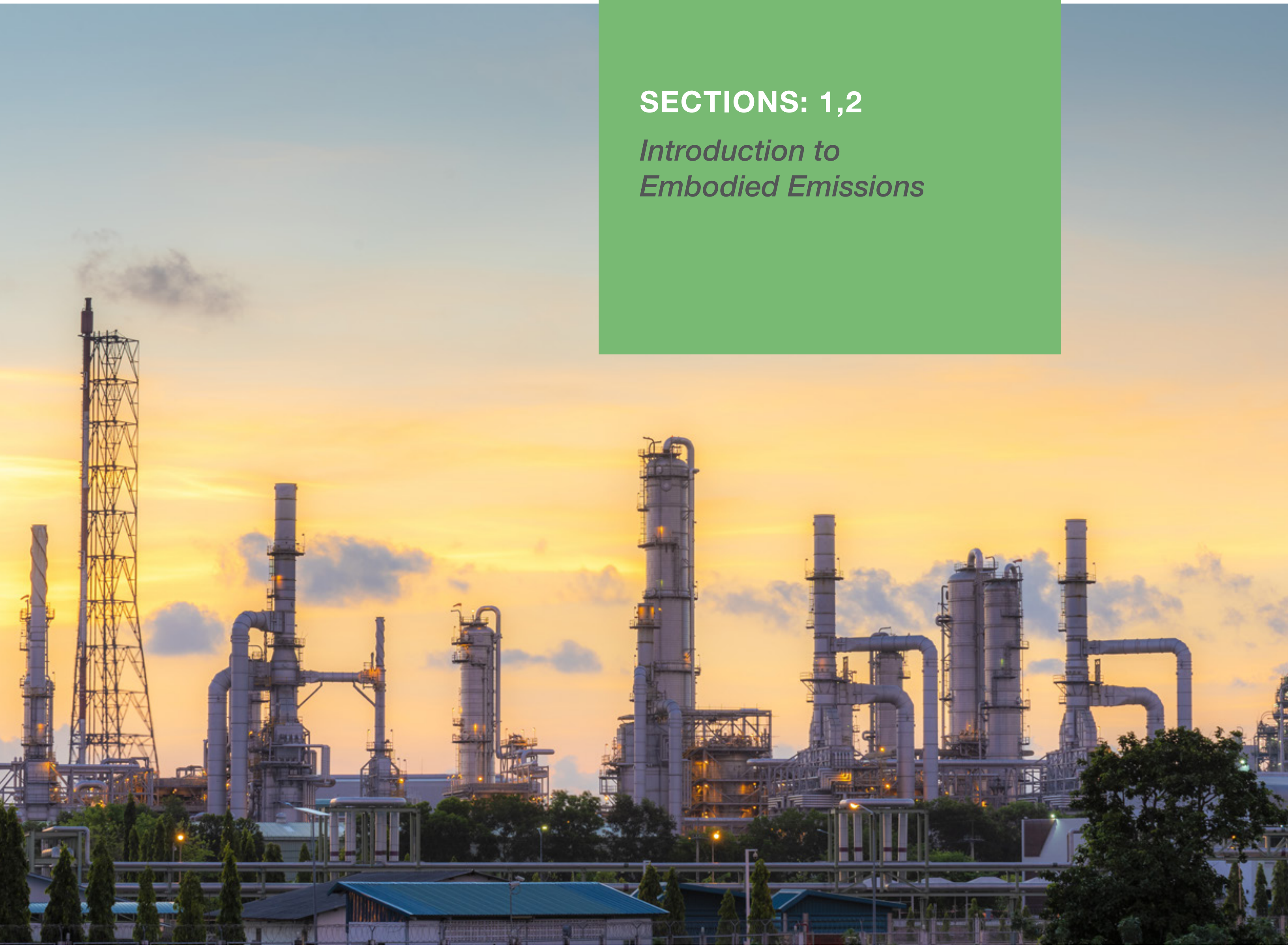


SECTIONS: 1,2

Introduction to Embodied Emissions

1 Introduction

The Built Environment is responsible for 40% of direct and indirect carbon emissions. Roughly half of the carbon impact of a built environment project originates from sourcing, construction and transportation of the building materials. Measuring, accounting and reducing embodied emissions of building materials is an essential decarbonization strategy for the building sector.

This Sector Supplement seeks to propel accounting for embodied emissions in corporate GHG accounting efforts by providing clarity on how to measure, account and report for embodied emissions as Scope 3 emissions under the GHG Protocol Scope 3 Standard.

Global warming and climate change are key sustainable development issues. Organizations must be able to understand and manage their GHG risks if they are to ensure long-term success in a competitive business environment. A well-designed and maintained corporate GHG inventory, which aligns with business specific issues, is an essential business tool and is increasingly seen as a marker for good management practice.

Well-designed GHG inventories must be complete to maximize business value. Completeness is one of the five GHG Accounting Principles and relates to the practice of accounting for all material and relevant GHG emissions sources. These sources are divided across three Scopes: Scope 1, Scope 2, and Scope 3 emissions. ***Figure 1.1*** below illustrates these different Scopes.

If not designed properly, a GHG inventory could neglect a significant portion of GHG emissions. Some organizations may report on Scope 1 and Scope 2 but

EXAMPLE:

Nancy is the Carbon Accounting Expert at a large technology company, Tech-X based in San Francisco. As a publicly traded company, Nancy helps measure, account and report on the GHG emissions of Tech-X. In the past year, Tech-X has spent $5B on real estate projects, specifically three large data centers and a new company headquarters. In reviewing business activity for the past year, Nancy recognized that the $5B spend in building projects was not accounted for in the Tech-X GHG Inventory. The impact of the concrete, steel, glass, furniture and flooring did not show up in her purchased goods data she received from her purchasing and procurement team. Nancy is concerned she is not accounting for a significant amount of GHG emissions, specifically Scope 3 emissions. Calculating embodied carbon will allow Nancy to update her scope 3 GHG inventory, particularly upstream categories including categories 1,2,4,5 and 8

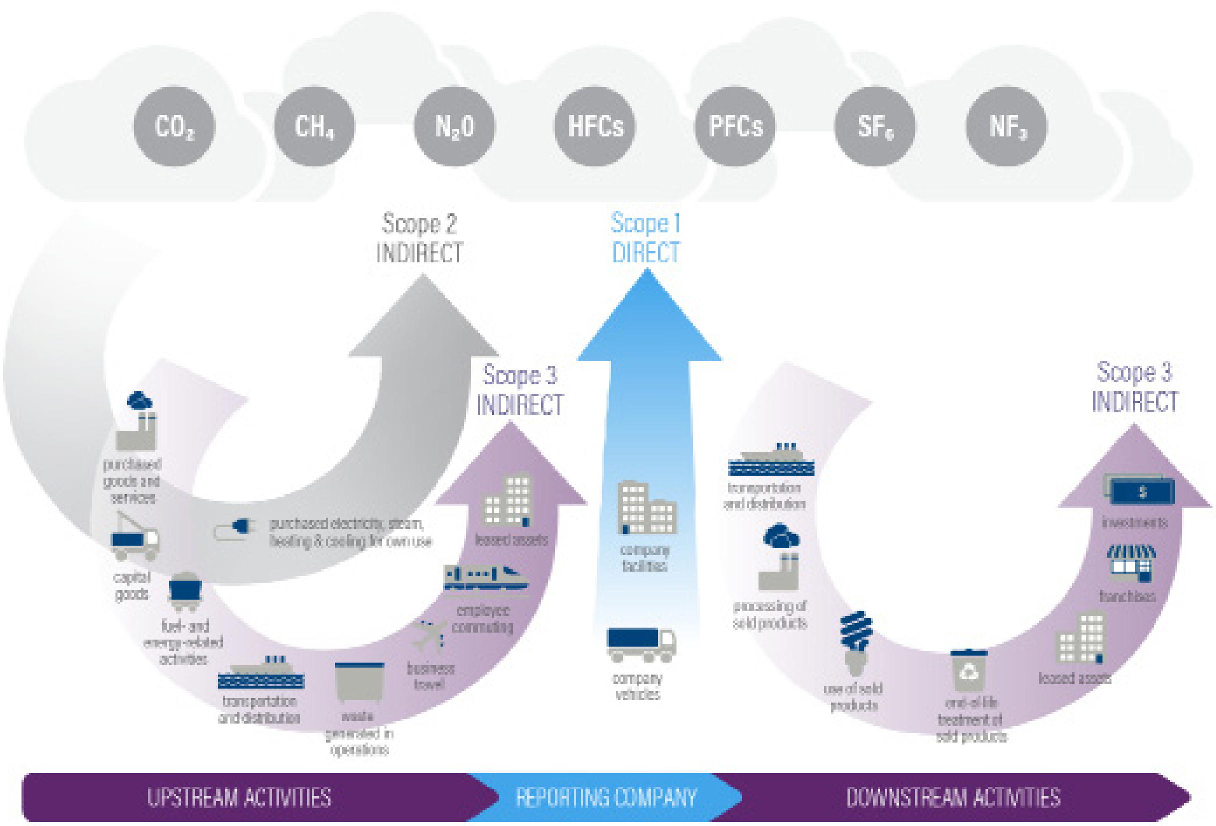


Figure 1.1 *Overview of the GHG Protocol scopes and emissions across the value chain (Source: GHG Protocol Scope 3 Standard)*

may ignore important Scope 3 emissions. Within the built environment sector, many organizations fail to account for the impacts of the purchased goods, capital goods, and associated upstream and downstream transportation with the manufacturing of the products used to construct a built environment project itself. As you will learn, these unaccounted emissions are a significant percentage of a buildings total GHG emissions over the buildings projected service life.

Within the built environment, there are two main components to the GHG emissions from the built environment that must be understood: *Operational Emissions and Embodied Emissions.*

Operational Emissions are the calculated environmental impacts of the operational energy use of a building during its operations. This includes energy consumption such as HVAC systems, lighting, appliances and electronics. These are most commonly accounted for as Scope 1 and Scope 2 emission sources by companies that own or operate buildings.

Embodied Emissions (often referred to as Embodied Carbon) are the calculated environmental impacts (including the 7 GHG emissions defined by the Kyoto Protocol) consumed during the life cycle of products used to construct a built environment project - from raw material extraction through product end-of-life. Embodied Emissions are almost always Scope 3 emissions sources reported as Purchased Goods and Services or Capital Goods and Upstream and Downstream transportation.

Combined, the sum of embodied emissions plus the sum of the operational emissions constitutes 'total emissions in the built environment'.

Over time and as buildings have become more energy efficient, the ratio of operational emissions to embodied emissions has changed. Embodied emissions are now outpacing operational emissions as the significant contributor of emissions in the built environment. The relationship between embodied and operational emissions is also illustrated in Figure 1.2 by the business-as-usual projection chart by Architecture 2030 where embodied carbon emissions are almost half the total impact for a new construction scenario

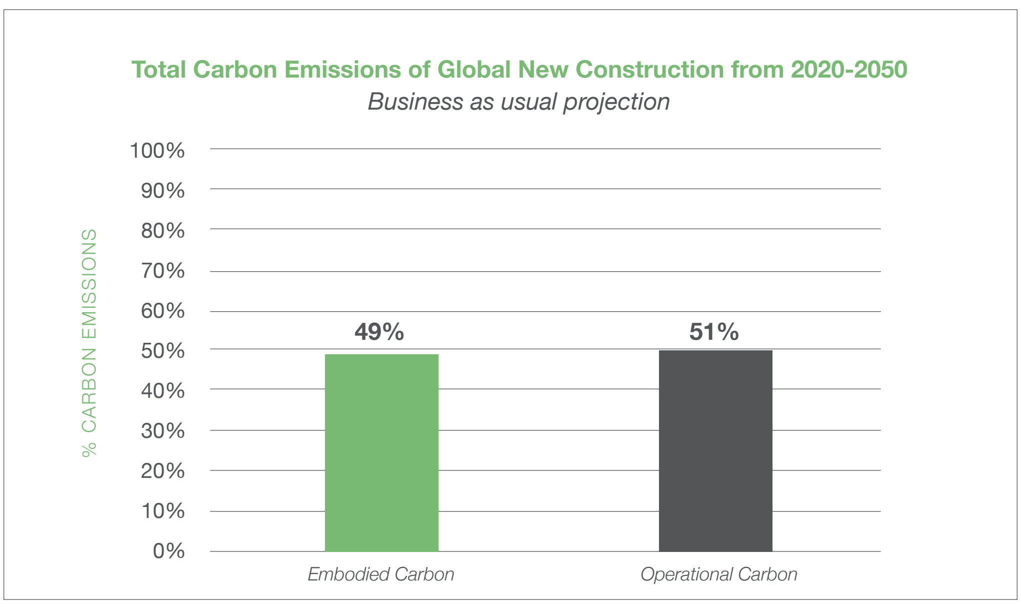


Figure 1.2: *Total carbon emissions of global new construction from 2020-2050; Source: 2018 2030. Inc/ Architecture 2030. All Rights Reserved. Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017*

compared to the operational carbon emissions of the building over its projected service life. In the UN Environment, Global Status Report 2017, it was stated that between now and 2060, over 2.5 trillion square feet of new buildings will be constructed, equal to one New York City every 34 days, and between now and 2050, embodied emissions would amount to 49% of the total lifetime emissions from those building projects. It is projected that by 2060, building sector floor area will almost double to that of the current values resulting in significant GHG emissions.

Currently, most organizations in the built environment sector are only tracking emissions associated with Scope 1 and Scope 2 Operational Emissions, leaving an estimated >40% of a buildings total carbon unaccounted for (as embodied emissions). Organizations responsible for built environment projects need to account for those emissions in their corporate inventory. This includes real estate developers, home builders, hospitality companies, healthcare and corporations. Embodied emissions generated during the same boundary year as a corporate inventory should be accounted for as Scope 3, purchased or capital goods (See Figure 1.3).

Success in decarbonizing the built environment will depend on organizations exercising their power of decision to set requirements on embodied emissions while also taking accountability for embodied emissions. This is important because a decision made related to the embodied emissions impact of materials in buildings is irreversible once a product is made, purchased and delivered. The products lifetime emissions are essentially spent at installation showcasing that embodied emissions are highly influenceable if understood and prioritized before purchase.

Life Cycle Assessment (LCA) is a scientific methodology used to determine potential environmental impacts of products or services from sourcing and extraction of raw materials (cradle) to disposal of the product at the end of its useful life (grave). Life Cycle Assessment results can be published in ISO compliant LCA Reports or in simplified LCA Reports known as Environmental Product Declarations (EPDs). This practice has functioned as the source of data for embodied emissions data of products which empowers embodied emissions decision making.

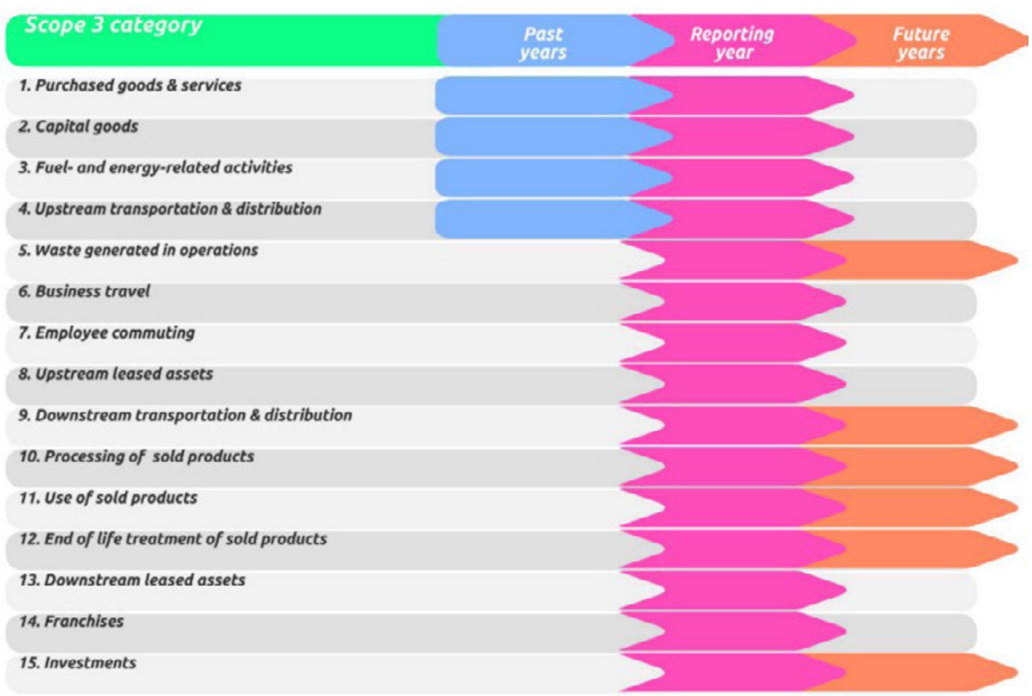


Figure 1.3: *Scope 3 Emissions Time Boundary, Source: GHG Protocol Scope 3 Standard*

Over the last decade, manufacturers of building products have been incentivized through market mechanisms to conduct life cycle assessments of their products. Green building certification schemes such as LEED, incentivized manufacturers who conducted LCAs and created ISO compliant Environmental Product Declarations (EPDs). With these incentives, EPDs have become the primary market mechanism for disclosure of product impacts, containing environmental impact data beyond embodied emissions: depletion of stratospheric ozone layer, acidification of land and water sources, eutrophication, formation of tropospheric ozone (smog) and depletion of nonrenewable energy sources. EPD data and the push to measure all aspects of GHG emissions presents a unique opportunity to give purchasers data to make decisions related to low carbon/emission materials.

Additionally, emerging regulations such as Buy Clean that focus on embodied emissions accounting and reductions have been implemented or are currently under consideration. The result of these activities is a data pool of over 25,000+ publicly available EPDs.

This sector supplement, named the ***Sector Supplement for Measuring and Accounting for Embodied Emissions in the Built Environment*** was developed to complement the methodology of the The Corporate Value Chain (Scope 3) Accounting and Reporting Standard (from here on referred to as the Scope 3 Standard) developed by the World Resources Institute (WRI). Additionally, the Greenhouse Gas Protocol Corporate Accounting and Reporting Standard, (from here on referred to as the Corporate Standard), and the GHG Protocol Product Life Cycle Accounting and Reporting Standard (from here on referred to as the Product Standard) were used to inform this sector supplement. This sector guidance has been reviewed by the GHG Protocol and is in conformance with the Scope 3 Standard including alignment with the Corporate Standard and Product Standard.

The purpose of this sector supplement is to provide guidance for how to account for embodied emissions of buildings using life cycle assessment (LCA) and environmental product declarations (EPDs) of building products. This sector supplement was not designed for Operational Emissions accounting as that practice is better understood. Through this Sector Supplement, we endeavor to fill the gaps between the Scope 3 Standard, Product Standard and Corporate Standard to make accounting for embodied emissions more approachable, consistent, and relevant with current industry tools.

In accordance with page 4 of the Corporate Standard, the GHG Protocol Initiative encourages the use of the GHG Protocol Corporate Standard by all companies regardless of their experience in preparing a GHG inventory. The term “shall” is used in the chapters containing standards to clarify what is required to prepare and report a GHG inventory in accordance with the GHG Protocol Corporate Standard. This is intended to improve the consistency with which the standard is applied and the resulting information that is publicly reported, without departing from the initial intent of the first edition. It also has the advantage of providing a verifiable standard for companies interested in taking this additional step.

When measuring and reporting an organization’s GHGs, the GHG Protocol and this Sector Supplement shall be consulted when embodied emissions are being considered. References are made to the Corporate, Scope 3 and Product Standards published by the GHG Protocol throughout this document to assist those not familiar with the Protocol. The Sector Supplement for Measuring and Accounting for Embodied Emissions in the Built Environment shall be followed to report embodied emissions, where an organization wishes to follow best practice.

This document will be updated over time to take account of any new standards or changes to current methodologies and guidance.

1.1 The Sector Supplement for Measuring and Accounting for Embodied Emissions in the Built Environment and its relationship to the Corporate Standard, Scope 3 Standard and Product Standard

One of the challenges with accounting for embodied emissions is that there is a wide range of approaches that reflect different stages in data maturity of emissions data. The current versions of the Scope 3 Standard and Product Standard take a value chain or life cycle approach to GHG accounting and were developed simultaneously.

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

In the context of a building, the building project value chain is long and complex. Manufacturers produce products that are used to construct a building, that has been commissioned by the building owner, designed by a team of architects, engineers and designers, and constructed by a team of contractors and subcontractors. These projects can also take multiple years to construct, traversing multiple years of GHG inventories. Once constructed, the building becomes operational and generates operational emissions each year until the building commences its service life. Embodied Emissions can also re-appear over the life of the building as renovations, retrofits, and replacements for items like furniture, paint, and flooring. At end of life, embodied emissions also re-appear with end-of-life programs, demolition, landfilling and recycling of building products and materials.

Due to this complex value chain, clarifying how embodied emissions can be calculated within the construct of a building over the course of its life, using common industry tools and the GHG Protocols was an important step to increasing accountability of embodied emissions. Understanding how to use each of the respective standards for calculating embodied emissions was also important in driving adoption.

Description of each of the standards and its relationship to Embodied Emissions

The GHG Protocol Corporate Accounting and Reporting Standard (referred to as the Corporate Standard) provides the requirements and guidance for companies and other organizations preparing a corporate-level GHG emissions inventory which would encompass building projects.

The Corporate Value Chain (Scope 3) Accounting and Reporting Standard (referred to as the Scope 3 Standard) defines the accounting of emissions across the value chain, including emissions from purchased and sold products, like those purchased for use in a building. Depending on the entity using this methodology, Scope 3 emissions could be categorized as upstream scope 3 emissions - such as purchased goods & services, capital goods, upstream leased assets - or as downstream scope 3 emissions, such as use of sold products, or end-of-life treatment of sold products.

The GHG Protocol Product Life Cycle Accounting and Reporting Standard (referred to as the Product Standard) provides requirements and guidance for companies and other organizations to quantify and publicly report an inventory of GHG emissions and removals associated with a specific product. The product standard aligns with many of the requirements used to complete LCAs and generate construction product related Environmental Product Declarations (EPDs).

All three standards provide guidance that is useful for embodied emissions accounting, but additional guidance is needed on applying them together in the context of accounting for embodied emissions in the built environment. Additionally, how to use each to account for and report the embodied emissions associated with a finished building project has historically been left undefined.

FOR EXAMPLE:

Noah is attempting to understand the embodied emission impact for a new LEED Certified hotel recently constructed. Each year, Noah's company builds dozens of new hotels using the same materials and design. They refer to their design as a "sustainable materials palette". As part of their design, Noah's company requests Environmental Product Declarations for all building products. Most manufacturers have complied, while other categories of products have not. As such, Noah feels he understands the life cycle impacts of 80% of the building products used to construct his hotels and relies on industry wide tools for the other 20% of products. This year, Noah wants to include the embodied emissions impact of the products he purchases in his annual GHG inventory. When consulting the Scope 3 Standard, Noah feels he can use a combination of a supplier specific method, average-product method and average spend-based method to calculate the embodied emissions but is unsure if the data sources he is using is credible. Noah consults a variety of stakeholders who provide mixed opinions ranging from "embodied emissions are not material", to "make sure to account for uncertainty within each LCA and EPD". In reviewing the Product Standard, Noah is concerned much of the data included within the EPDs may not comply with the Product Standard.

As such, the primary goal of the Sector Supplement is to provide a more specific framework to guide organizations on applying the Product Standard and Scope 3 Standard to measure, total, and report the embodied emissions of products in corporate level GHG Reporting. This includes further defining embodied emissions, guidance on how to use LCAs and EPDs and apply uncertainty for embodied emissions accounting, how to address products without product specific LCA or EPD Data, and how to total products for building level embodied emissions reporting.

A significant component to this Sector Supplement is the guidance provided for how to aggregate Life Cycle Assessment (LCA) and Environmental Product Declarations (EPDs) for the purposes of measuring the embodied emissions of a building. This sector supplement provides clarity and definition on estimation methods for products without supplier specific data, aggregation techniques, boundary setting guidance, reporting instructions and more.

Further, this sector supplement draws its approach from the GHG Protocol's Quantitative Inventory Uncertainty Guidance (referred to as Uncertainty Guidance) document which has been incorporated and adapted to embodied emissions accounting in the Methodology outlined within this document. Incorporating the GHG Protocol's Uncertainty Guidance into this methodology includes the expanded use of the Pedigree Matrix to measure and adjust stated values to account for variations in Life Cycle Assessment techniques, software and datasets. The uncertainty indicators used in this methodology align with the required reporting content under ISO 14040:2006 and ISO 21930:2017.

Even with ISO standards, regulation and market driven incentives, there remains variability in EPDs which requires trained practitioners to evaluate the data within EPDs to determine which product has a lower embodied emissions. Examples of how EPDs may not align include:

- Inconsistent data quality
- EPD practitioner decisions
- Optional reported life cycle phases
- Misaligned time boundaries
- Product LCA software variations
- Product category rules - assumptions and exclusions

Due to these factors, data quality and uncertaintiy must be considered when using EPDs for embodied emissions calculations.

The methodology within this Sector Supplement for Measuring and Accounting for Embodied Emissions in the Built Environment has been developed to help ensure that a consistent approach is taken to measuring and reporting embodied emissions in the built environment when using LCAs and EPDs. In general, our process can be described through the following stepwise structure which will be explained in the following sections.:

Lastly, this Sector Supplement seeks to help organizations make informed choices by quantifying the embodied emissions from the products it specifies, purchases, or uses in built environment assets. In the context of this guidance, public reporting refers to product specific carbon-related information reported publicly via disclosure documents like LCAs and EPDs.

As awareness increases regarding the significance embodied emissions has on a company's total emissions, it is anticipated that the demand for product level carbon emissions data will increase. Many Product Manufacturers are already seeing increased demand for these disclosures and the benefits of measuring and managing their product-related embodied emissions risks if they are to ensure long-term success in a competitive business environment and be prepared for any future product-related programs and policies.

1.2 Who should use this Sector Supplement

This methodology is designed for organizations of all sizes in all economic sectors and in all countries actively engaged in building, managing, manufacturing, or occupying the built environment or organizations involved with products used in the built environment. Organizations seeking a better understanding of the embodied emissions impact of products specified, designed, manufactured, sold, purchased, or used can benefit from the use of this methodology.

Interested users of this Sector Supplement could include staff from product design, building design, procurement, architects, contractors, research and development, specification, sales, marketing, energy, environment, logistics, and corporate sustainability departments. Policymakers, green building standards organizations and other GHG programs may also be interested in incorporating the methodology in this Sector Supplement into policy or program requirements.

1.3 Use of this Sector Supplement

The methodology within this Sector Supplement shall be used by organizations seeking to measure, track and report the total embodied emission impacts of products used in the built environment. Further guidance is provided within this methodology on how to use the resources and disclosure documents available to the built environment market to demonstrate complete and accurate embodied emissions accounting.

To accomplish more accurate embodied emissions accounting, this methodology provides additional prescriptiveness on embodied emissions accounting methodologies, including selection of data sources, relevance of product disclosures, estimation methods, use of performance claims, embodied emissions decision making, and other types of product level accountability based on product GHG impacts.

Exclusions from this methodology are:

- evaluating claims regarding the overall environmental superiority or equivalence of one product versus a competing product, referred to in ISO 14044 as comparative assertions
- avoided emissions or actions taken to mitigate released emissions
- GHG reductions from offsets or claims of carbon neutrality

1.4 Why use this Sector Supplement

The term embodied emissions (also referred to as embodied carbon) is significant because it consolidates product lifecycle impacts into a single unit, framing a product in the context of impacts per one unit purchased and sold in a market driven economy.

This framing empowers institutional buyers and consumers to influence emissions sources that they previously had no way to influence. For example, in the past a buyer would have no way to influence the energy procurement decisions of a factory or the fuel choices of a shipping provider.

With expanded accountability of embodied emissions, a buyer can set a standard for a product's carbon footprint and draw a line in the sand by stating that goods will only be purchased if embodied emissions-based thresholds or product specific reductions over time have been met. This is a powerful signal and one that has the potential to send economic ripples through supply chains by influencing manufacturing, distribution and use towards products that curb carbon emissions and therefore climate change impacts.

For this to happen there needs to be a way for purchasing influencers to define, calculate and monitor embodied emissions throughout their organization's value chain. As such, the practice of embodied emissions accounting empowers organizations to work towards several forward-thinking goals that include:

- Setting GHG emissions / carbon-based purchasing criteria,
- influencing their supply chain,
- and developing a pathway towards zero carbon & net zero buildings.

The methodology within this **Sector Supplement for Measuring and Accounting for Embodied Emissions in the Built Environment** has been developed to help ensure that a consistent approach is taken to measuring and reporting embodied emissions in the built environment when using LCAs and EPDs. In general, the process can be described through the following stepwise structure which will be explained in the following sections.:

Product Selection -> Data Extraction from EPDs -> Data Cleansing -> Data Quality Assessment -> Uncertainty Analysis -> Calculation of Product Embodied Emissions -> Estimation of Supplemental Data Points -> Embodied Emissions Calculation.

2.0 Defining Embodied Emissions in the Building Sector

While the principals of GHG accounting can be applied to any building project, this guidance is primarily aimed at the use of product level life cycle assessment (LCA) and environmental product declarations (EPD) as source data for embodied emissions information used to account for a building or occupied space such as tenant improvement (TI) project. These product level assessments serve as standardized transparency documents that disclose the environmental impacts of a specific product or range of products.

Several existing standards within the building sector are currently used to provide quantified environmental information of a product via LCA. This is done using a harmonized and scientific basis. These standards include EN15804 and EN 15978 developed by the European market and ISO 21930:2017 which standardized the reporting of product environmental impacts through Environmental Product Declarations (EPDs). EPDs are public documents that summarize the findings of an LCA. To maintain consistency in the assessment and reporting of environmental impacts, EN15804 and ISO 21930:2017 define a modular approach to various phases of the life cycle assessment of a construction product. The modules as defined by ISO 21930 and EN15804 are:

- A1-A3 – Product Stage (includes raw material sourcing, transport to facility and manufacturing)
- A4-A5 – Construction Stage (includes transport to site and installation at site)
- B1-B7 – Use Stage (includes use, maintenance, repair, replacement, refurbishment, operational energy use and operational water use or scenarios for these life cycle stages)
- C1-C4 – End of Life Stage (includes demolition of building, transport to end of life, waste processing and final disposal or scenarios for these life cycle stages)
- D – Benefits and loads beyond the system boundary (supplementary information beyond the building life cycle or scenario for this life cycle stage)

These modules are also described in Figure 2.0 below.

Figure 2.0: Common life cycle stages and the optional supplementary module D Source: ISO 21930

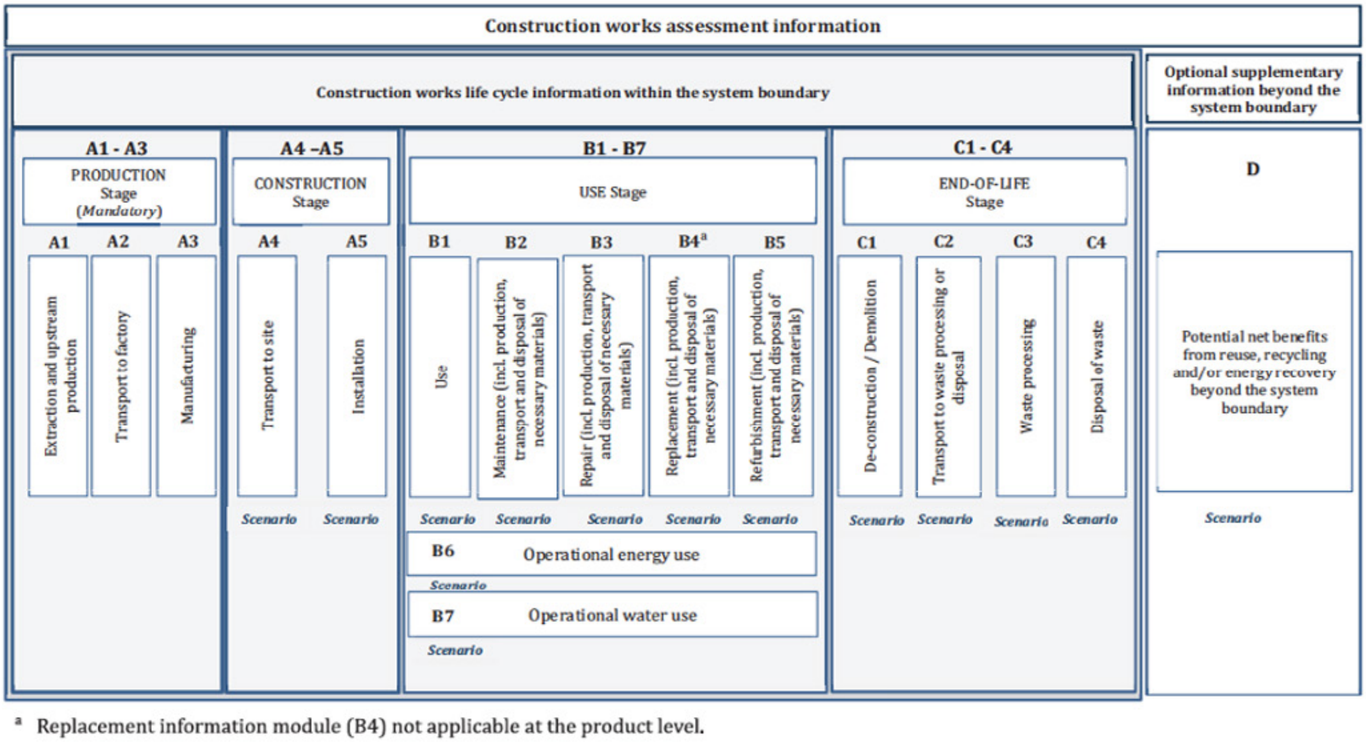


Figure 2.1: Life Cycle Stages and relevant scopes as Embodied or Operational Emissions

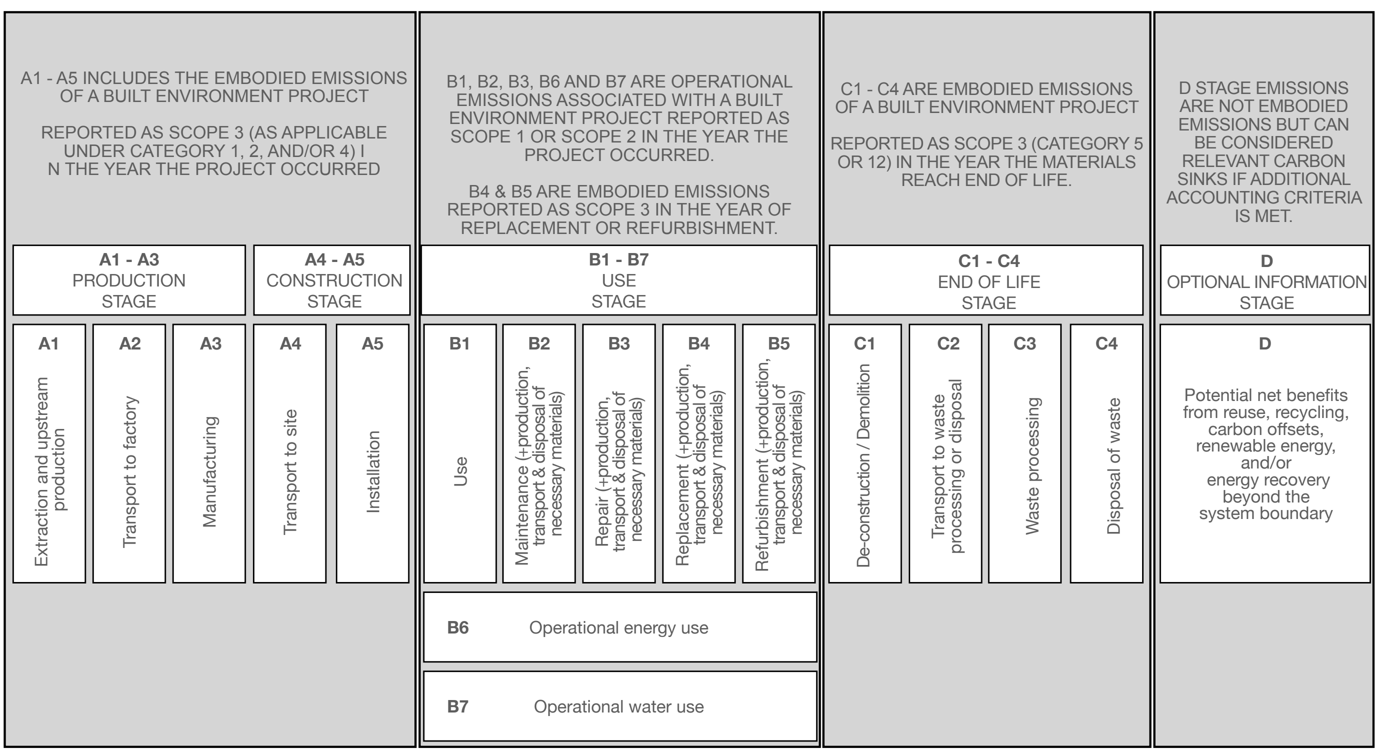
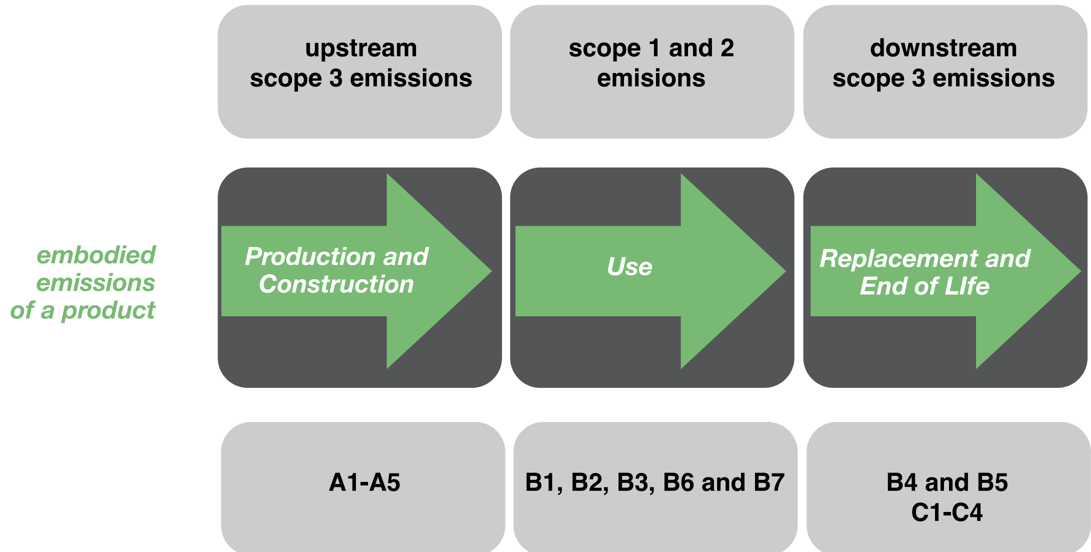


Figure 2.2: Relationship between Embodied Emissions and a GHG Inventory by Life Cycle Stage



These modules were considered when developing this Sector Supplement to define the boundary of embodied emissions when functioning as a building product. With this context in place, embodied emissions of a building are defined as the emissions inherent in the building as ready for occupancy based on the total of each individual building product used in the building. This includes emissions from sourcing materials for all products in the building, manufacturing them into finished products, and transporting them to the building site. Said another way, embodied emissions are defined as A1-A5.

Within the context of a building project, embodied emissions can originate in a variety of ways.

- **Complete:** Project design and construction (building, including new construction, demolition and refurbishment, renovation, off-site production, infrastructure, and transport of materials used for construction and on-site materials manufacture) of a complete building.
- **Partial:** Project design and construction (building, renovation, retrofit, or refresh including but not limited to demolition and refurbishment, off-site production, infrastructure, and transport of materials used for construction and on-site materials manufacture) of a subset of space within a building project.
- **Portfolio:** a combination of complete and partial building projects as part of an owner's real estate holding portfolio.

The outputs (i.e., reported emissions) are intended to be used by regulatory bodies and governments, clients, standards bodies and any other organization/individual that have an interest in the embodied emissions of a built environment project. By adopting a standard approach to measurement and reporting, the industry will have the greatest opportunity to work with stakeholders to reduce embodied emissions. Robust measurement will also allow companies to identify sources of excessive embodied emissions in their design and construction practices and develo solutions which will lead to reduced emissions. Collectively, this activity set enables the reporting of embodied emissions of buildings and seeks to create higher levels of accountability from businesses with large built environment footprints.

SECTIONS: 3, 4 ,5, 6

Defining Embodied Emissions and how they can be identified in the Built Environment

3 Principles of Embodied Emissions Accounting

As outlined within the **Corporate Standard** (Page 7), companies seeking to report their emissions shall ensure that GHG accounting is based on the following principles.

Relevance
Ensure the GHG inventory appropriately reflects the GHG emissions of the company and serves the decision-making needs of users of the data – both internal and external to the company.

For embodied emissions accounting, projects must account for all relevant sources of embodied emissions within the stated boundary.

Completeness
Account for and report on all GHG emission sources and activities within the chosen boundaries. Disclose And justify any key exclusions.

For embodied emissions accounting, building product materials and components shall be included and accounted for. Any gaps or exclusions shall be reported in the boundary.

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

For embodied emission accounting, the methods of LCA and EPD use along with calculation of LCA and EPD uncertainty shall be consistent. Methodologies for boundary setting shall also be consistent throughout the building project.

Transparency
Address 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 accounting and calculation methodologies and data sources used.

For Embodied emission accounting, methods and calculations shall be made transparent. Where possible uncertainty methods shall be well documented. Source EPDs and LCAs shall also be reported by EPD number along with methods for product estimations. Documentation of project take offs or building product unit volumes shall also be included in Reporting.

Accuracy
Ensure that the quantification of GHG emissions is systematically neither over nor under actual emissions, and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the integrity of the reported information.

For embodied emission accounting, the accuracy principle applies as written. Further guidance is provided in the GHG Protocol, Chapter 1 (pages 6 - 9).

4 Embodied Emissions Accounting Steps

This Embodied Emissions Accounting Methodology applies to the measurement of embodied emissions in a built environment project by accounting for the GHG impacts of the all the products used in the project. This methodology aligns with the guidance provided in the Scope 3 Standard and Product Standard but provides additional guidance on how to use LCA and EPD data for embodied emissions accounting in the Built Environment using the
Uncertainty Guidance.

4.1 Phases and steps of an Embodied Emissions Inventory

When accounting for embodied emissions of a build environment project the inventory must use an attributional approach as described in the Corporate and Product Standards. Similar to the steps identified in the Corporate Standard, accounting teams shall follow the steps below when collecting data and assessing data quality:

Step 1. Determine the built environment project type, establish an embodied emission accounting team, and define project purpose.

Step 2. Determine the built environment project boundary and develop a data management plan to manage the collection of products used in the built environment project. Boundary must include all attributable processes.

Step 3. Identify all built environment (ex. building, infrastructure, mechanical, plumbing, etc.) and related products within the building project boundary. Document the building product use, unit of analysis, and data collection and assessment processes as they are completed as part of a built environment product inventory.

Step 4. Identify product specific data sources (such as product specific LCAs, EPDs or EC Emission Factors) for building product life cycle emissions. Collect data for all building products included within the project boundary. Identify reference flows and determine embodied emission conversion factors. Document whether product specific data will be used or if estimations were required.

Step 5. Assess and document the data quality of the product level emissions data, activity data, and emission factors as the data are collected. Perform Allocation if necessary.

Step 6. Assess data quality and define data quality uncertainty scores using the pedigree matrix approach defined in this document. Conduct work to improve the data quality, focusing on processes that have a significant impact on the inventory results.

Step 7. **Calculate embodied emissions.**
Step 8. **Perform verification.**
Step 9. **Report embodied emissions.**
Step 10. **Set embodied emission reduction targets.**

5 Built Environment Project Types & Key Areas of Operation

Guidance on Step 1. Determine the built environment project type, establish an embodied emission accounting team, and define project purpose.

5.1 Defining Project Type

Each product used within a built environment project has the potential to be a significant source of embodied emissions. However, built environment projects can range from tenant improvement, partial renovations, new construction, and so forth. To take these different project types into account, it is necessary to differentiate between the project types and purpose to allow better targeting of embodied emissions accounting and emission reduction measures.

In this section we set out guidance to identify the activities to be included within the embodied emission project boundary.

This guidance shall be read in conjunction with the Corporate Standard chapters 3 and 4 (pages 16 – 33) on organizational and operational boundaries.

This guidance is intended to identify the emissions from key built environment project types (see Corporate Standard Section 3 for guidance on setting organizational boundaries). Built environment project types can be split between three broad areas of operation:

- **Complete:** Project design and construction (building, including new construction, demolition and refurbishment, renovation, off-site production, infrastructure, and transport of materials used for construction and on-site materials manufacture) of a complete built environment project.
- **Partial:** Project design and construction (building, renovation, retrofit, or refresh including but not limited to demolition and refurbishment, off-site production, infrastructure, and transport of materials used for construction and on-site materials manufacture) of a subset of space within a built environment project.

- **Portfolio:** a combination of complete and partial built environment projects as part of an owner's real estate holding portfolio.

A 'built environment project' reporting under this protocol may be involved in just one or all of these areas of operation.

The Corporate Standard outlines (in Chapter 7) requirements for the information that shall be included in a GHG emissions inventory, including the disaggregation of emissions by scope. The Scope 3 Standard also defines how emissions should be reported in each scope 3 category. The boundary of each scope 3 category is defined in table 5.4 (page 35) of the Corporate Value Chain (Scope 3) Accounting and Reporting Standard For the purpose of this methodology, embodied emissions accounting will include the A1-A3 life cycle stages of a product life cycle assessment, the estimated A4 for the specific project location and the A5 installation impacts. This is also called "cradle to gate". It currently excludes the B-D phases of the product life cycle where data availability is much more limited. Embodied emissions are classified as a Scope 3 emissions (i.e., purchased goods and services, upstream T&D, capital goods) for the owner or occupant of the built environment project. More than one owner may lay claim to the embodied emissions of a building, but no more than one organization shall lay claim to the embodied emissions of a building product (i.e., a chair).

In addition to these requirements, it is recommended that when a built environment project chooses to benchmark between its different project types or use activities, the defined boundary and uses are explained. The aim of disaggregating impacts using this approach is to provide clarity and consistency for embodied emissions reporting. A built environment project and building project type has a significant impact on emissions and therefore the results shall be benchmarked within the same sector and project types.

In a typical corporate scope 1+2+3 inventory, emissions from different projects are aggregated and reported as scope 1, scope 2 and then 15 scope 3 categories. This methodology recommends that companies should be able to disaggregate by project type and by embodied/operational carbon.

6 Determining the Project Boundary

Guidance on Step 2. Determine the built environment project boundary and develop a data management plan to manage the collection of products used in the built environment project. Boundary must include all attributable processes.

6.1 Organizational Boundaries

Business operations and structures can vary significantly between organizations. In order to consolidate embodied emissions across its operations, an organization must identify the boundaries it will work within and be consistent in its approach over time. The GHG Protocol defines three distinct approaches which shall be used to define organizational boundaries when accounting for embodied emissions, the equity share and the control approach. The control approach is split into financial and operational control.

A brief description of each approach is provided below. *For further guidance, companies should consult the Corporate Standard, Chapter 3 (pages 16 – 23).*

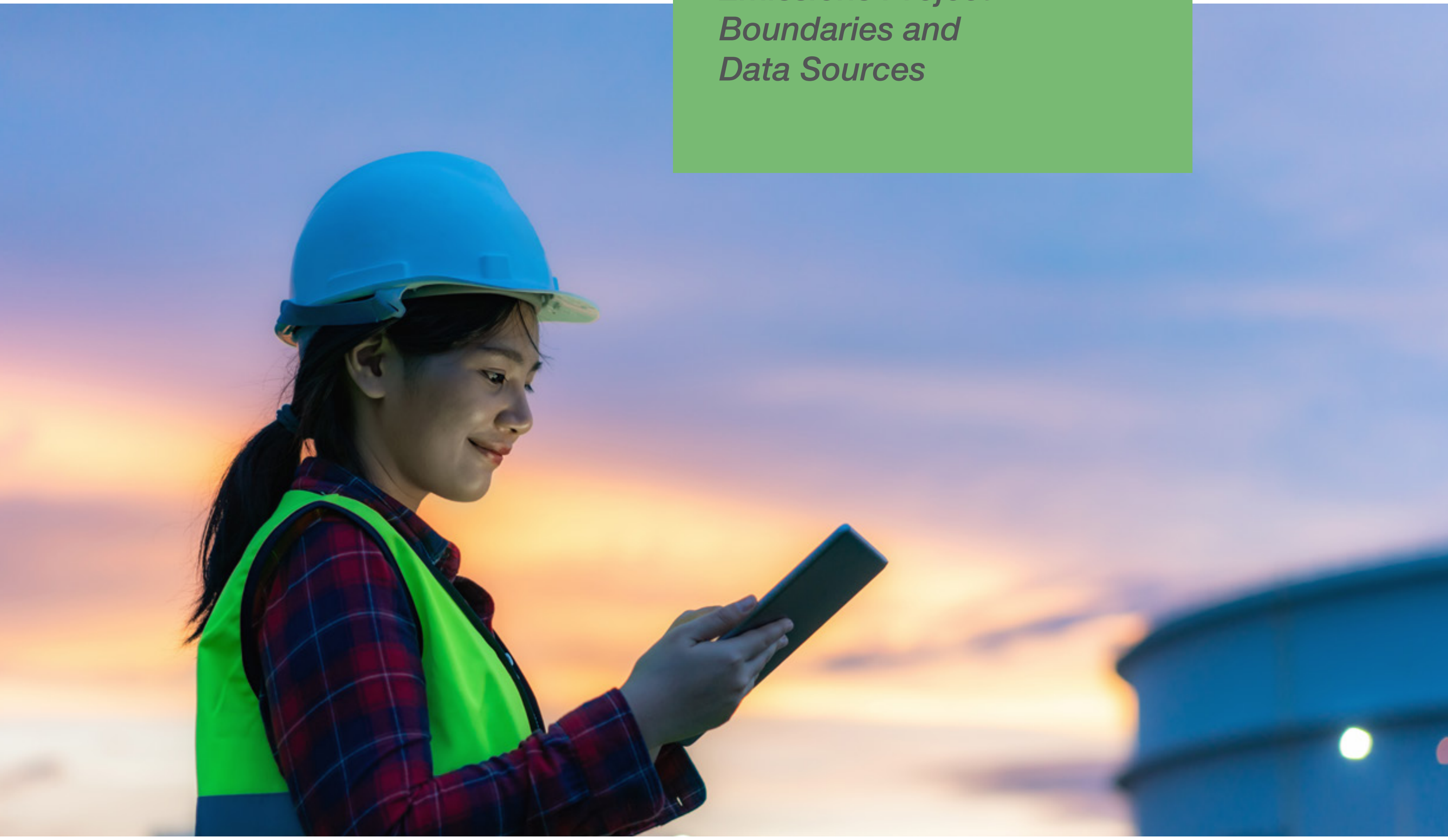
Equity share approach - Under this approach, a company would record its emissions according to (pro rata) the equity share it holds in each built environment project. This is based on the assumption that the economic risks and rewards for a company are comparable to its ownership share. There may be cases where equity share differs from ownership, in which case the economic share a company has in a building would override its share of ownership, to better reflect the risks and rewards at stake.

Financial control approach - Under this approach a company would record emissions from a built environment project over which it has financial control, i.e., it has the ability to direct the financial and operating policies with a view to gaining economic benefits from its activities. A company accounts for 100% of the embodied emissions of those operations over which they have financial control.

Operational control approach - Under this approach, a company would record emissions from a built environment project over which it or one of its subsidiaries, has operational control, i.e., the authority to introduce and implement changes to its embodied emissions profile. A company accounts for 100% of embodied emissions from operations over which it or one of its subsidiaries has operational control.

SECTIONS: 7, 8

Defining Embodied Emissions Project Boundaries and Data Sources



7 Identifying Products within Project Boundary

Step 3. Identify all built environment (ex. building, infrastructure, mechanical, plumbing etc) and related products within the building project boundary. Document the building product use, unit of analysis, and data collection and assessment processes as they are completed as part of a built environment product inventory.

7.1 Identifying the product inventory

A review or screening exercise of all the products consumed by a built environment project is the first step to identifying an individual product to study. This effort can be a large step as a built environment project may have various stakeholders who have contributed to the selection of products used in a built environment project. Architects, Contractors Structural Engineers, Sub-Contractors, Finishers, and so forth may al possess product consumption data. Collecting bill of materials, specifications, project take-offs for the associated project boundary is an important step in identifying the products for which embodied emissions will be calculated from.

It is important to remember that embodied emissions can be calculated for an entire building or specific components of a building.

The determination of the product inventory is dependent on the boundary of the study, but is often organized into the following categories based on the sources of product inventory data:

1. **MEP:** Mechanical, Electrical and Plumbing Systems
2. **TI:** Tenant Improvement (interior) – includes flooring, ceiling, walls, insulation, furniture and fittings
3. **C&S:** Core & Shell Embodied Emissions includes foundation, structure, enclosure and roof.
4. **Total Embodied Emissions:** including all products and all materials used in the complete building project.

Total embodied emissions for a building project must include all C&S, MEP and TI components installed in the building. If this is not the case and embodied emissions are being calculated for either MEP or TI or for a sub-group of products, this must be made clear when reporting the final embodied emission values.

The following information is to be collected as part of the product inventory.

- Goal and scope for project
- Product List (list of products used)
- Product take-off (quantities of products used)
- Unit of Analysis (unit for which the product is defined)
- Period of evaluation (date or timeframe for purchase of the product)
- Optional) Replacement cycle of products

Once the above information has been obtained, the next step is collecting and recording relevant information necessary to complete the analysis of embodied emissions.

8 Identifying Data Sources and Collecting Data

Guidance to Step 4. Identify product specific data sources (such as product specific LCAs, EPDs or EC Emission Factors) for building product life cycle emissions. Collect data for all building products included within the project boundary. Identify reference flows and determine embodied emission conversion factors. Document whether product specific data will be used or if estimations were required. **Document data sources used in accordance with the Scope 3 Standard Guidance, Chapter 7.3 and 11 and in the Corporate Standard at the end of Chapter 6.**

8.1 Data Sources

Identifying embodied emission data on products included in the product inventory requires the identification of product specific or generic data for each product type. The preferred data source for this methodology is an Environmental Product Declaration (EPD).

As described earlier, EPDs are generally third-party verified summaries of a product's environmental impacts. These documents are verified against standards such as ISO 21930, EN 15804 and/or ISO 14025, a standard that establishes the principles and specifies the procedures for developing Type III environmental declaration programs and Type III environmental declarations. EPDs follow the modular approach described in Section 2.1 whereby A1-A4 embodied emissions can be derived. EPDs and their underlying LCAs follow Program Category Rules (PCR) developed by Program Operators that define certain underlying assumptions and rules to carry out an LCA and the subsequent disclosure of impacts. Despite attempts to harmonize EPDs within a product category and between geographical regions, there still exist certain inconsistencies in the reporting of environmental impacts. Product manufacturers are allowed to use a variety of methods to disclose their impacts. For instance, EPDs can disclose cradle to gate (A1-A3), cradle to gate with options (A1-A3, A4 – optional, A5 – optional, B1-B7 – optional, C1-C4 – optional) and cradle to grave (A1-A3, A4, A5, B1-B7, C1-C4).
EPDs and other forms of product level emissions accounting and reporting provide the data necessary to determine the Unit of Analysis and the multiplier for which product take-offs can be multiplied against to determine the embodied emissions impact of a select set of products. Repeating this process for all products included in the product inventory will result in the calculation of total embodied emissions.

Generally, there are two main types of EPDs.

1. **Product specific EPDs:** These are intended to disclose impacts for a particular product or group of products within a product family and/ or collection produced by a particular manufacturer.
2. **Industry wide EPDs:** These are typically industry / trade association efforts to create a single EPD for an average or representative product determined by a group of manufacturers. The results are not product specific, rather they represent average impacts for the industry in a particular region.

Manufacturers often report cradle to gate impacts only or a cradle to grave single total value for all modules. These discrepancies lead to confusion among EPD readers as to the actual value to be considered for any sort of assessment or analysis of various product options.

Other forms of life cycle impact reporting may also be used to report embodied emissions values for products. The following are potential surrogates that could be considered with higher uncertainty values depending on the quality of the data used.

-Life Cycle Assessment Reports - ISO 14044/14040 compliant LCA Reports on specific products including the USGBC LEED approved LCA format.

-PEP EcoPassport is the international reference program for the environmental products declarations (EPDs) for the electric, electronic and heating & cooling industries. The resulting declarations are in åconformance with ISO 14025 and 14040 as well as in alignment with EN 15804.

-Inventory of Carbon and Energy (ICE) Database[5] is a publicly available database that contains generic embodied emissions values for commonly used materials in the building and construction sector. This was specifically used in the calculation of impacts from installation materials whose impacts were not available in the corresponding product EPDs.

-Generic Life Cycle Assessment, Proxy Products, or Product Estimates, are licensed or publicly available datasets that contain life cycle or embodied emission values for product families or materials in the building and construction sector. Most of these were created specifically to fill data gaps in product categories lacking corresponding product specific EPDs.

8.2 Extracting Data from LCAs and EPDs

Once the products included in the product inventory have been determined, EPDs or related LCA documentation for each products shall be obtained by collecting documentation from a manufacturer's website or through various EPD databases. Using the documents defined in Section 8.1, accounting teams will need to identify the appropriate life cycle stage data (A1-A4) and determine embodied emissions conversion factors (ex. GWP Values) for each of those stages. If data for a specific product does not exist, non-product specific data (generic data) will need to be utilized.

The following data points must be extracted from each EPD or related LCA document. Depending on documentation format, select data may be less accessible.

- Product name matches Product Inventory
- Manufacturer name matches Product Inventory
- Manufacturer address
- Product type / category
- EPD Expiration Date
- Verification of LCA and EPD – external or internal
- Product Category Rules
- Functional/ Declared unit
- Weight of the product per functional/ declared unit
- Global warming potential (GWP) values per functional/ declared unit;
  - Cradle to gate (mandatory)
  - Transportation (if available)
  - Installation (if available)
- LCA Modules included
- Other information as described in Section 9 to assess data quality

Most EPDs will be available in PDF format which is inconvenient to automate the extraction of information. Movement towards digital EPDs (such as the OpenEPD) will add further ease to this process. Validation of digital EPD data from sources such as Digital Disclosures and InData will also aide in quicker extraction of relevant LCA and EPD data.

8.3 Extracting Data for Products without LCAs or EPDs

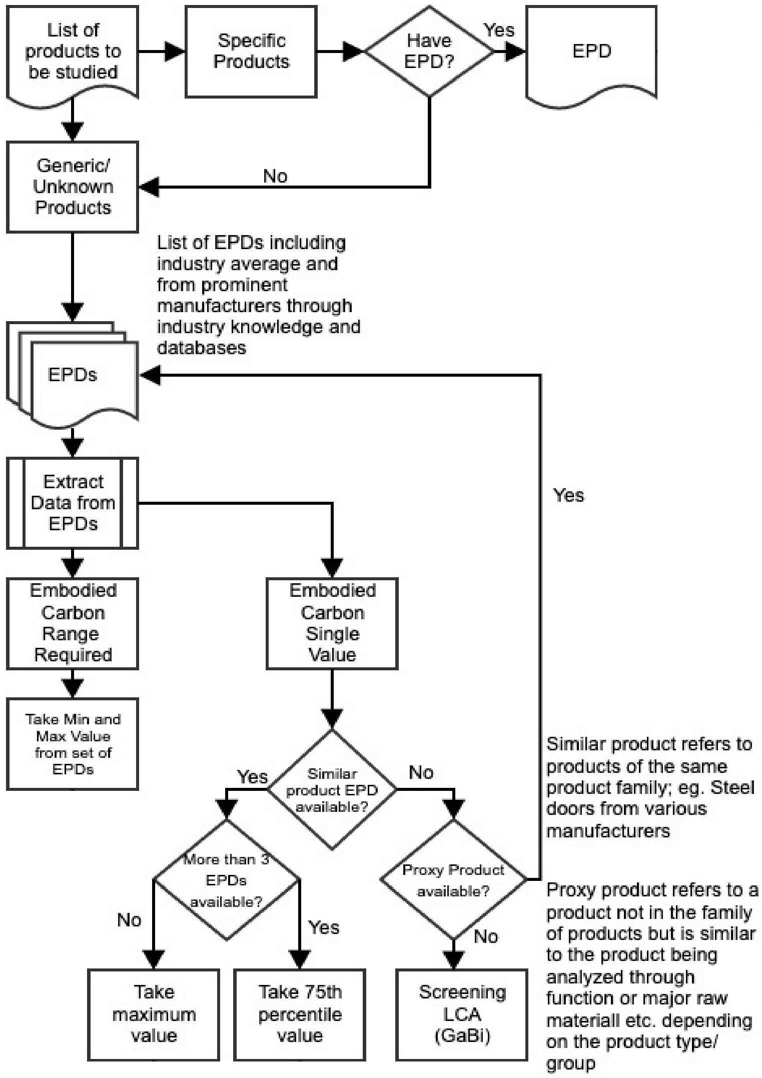
Even with 25,000+ EPDs available, there are still products that neither have product specific EPDs nor an industry wide EPD. For these products, EPDs from other manufacturers, industry average datasets or proxy daya can be utilized for same or similar product types. The following scenarios are illustrated in Figure 3.0 for selecting data without LCAs or EPDs.

To utilize EPDs from other manufacturers or industries, the following step-by-step process was created and is outlined below.

Step 1: Collect all available EPDs within a product category or, if no EPDs within the target product category exist, collect all available EPDs within a proxy product category. Note: A “proxy product” or a “proxy product category” refers to a product not in the family of products but which is similar to the product being analyzed through function or major raw material. For example, utilizing a set of aluminum door EPDs for a steel door would be an example of utilizing a proxy product category. Note: In the data quality assessment this product would receive a low score for product specificity and thus would have a high range of uncertainty (see Section 9 in this document). If a proxy product is unavailable, a screening level LCA must be conducted by an LCA practitioner using an LCA software.

Step 2: Record the overall minimum and maximum values from the collected EPDs. This provides the potential high/low range for the product without EPD information.

Figure 8.0: Flowchart to determine A1-A3 impacts from products without EPDs or generic products



Step 3: From the group of EPDs collected, take the 75th percentile (as calculated by the excel "percentile" function) as the final value. The 75th percentile is selected as conservative estimate of the potential single value of the product without the EPD. Note: if the group of collected EPDs is less than three, then the maximum value (not the 75th percentile) shall be used.

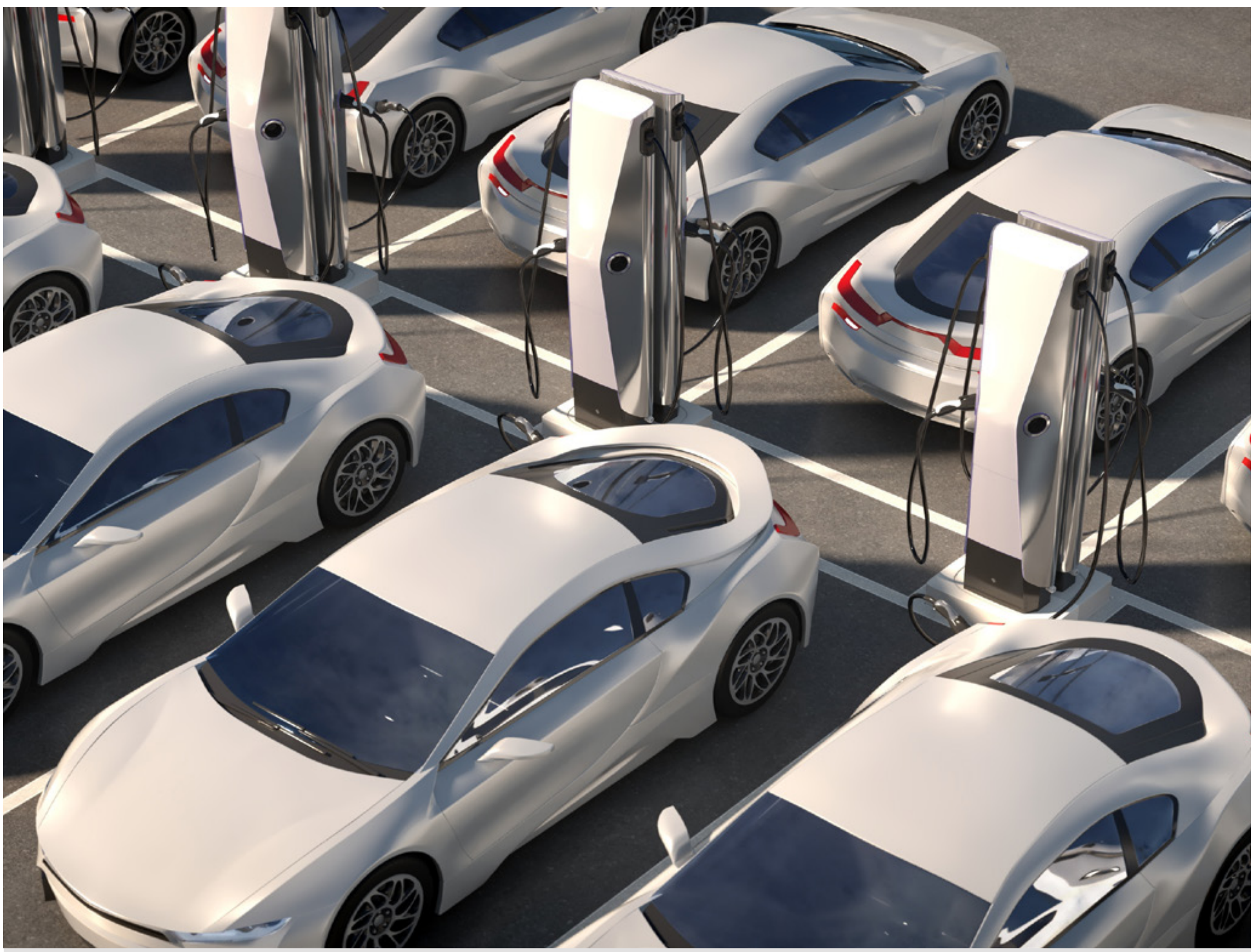
This method may also be applied to generic products. Generic products are those products listed in the product inventory that are not manufacturer specific.

The purpose of this step is to establish traceability and transparency in the data source used to determine the embodied emission impact of a product regardless of whether it has an EPD or not. Documentation of data sources within the Product Inventory is critical to reporting and embodied emission performance over time (i.e., demonstrating embodied emission reductions over time because of procurement and design-based decisions).

8.3 Data Sanitizing

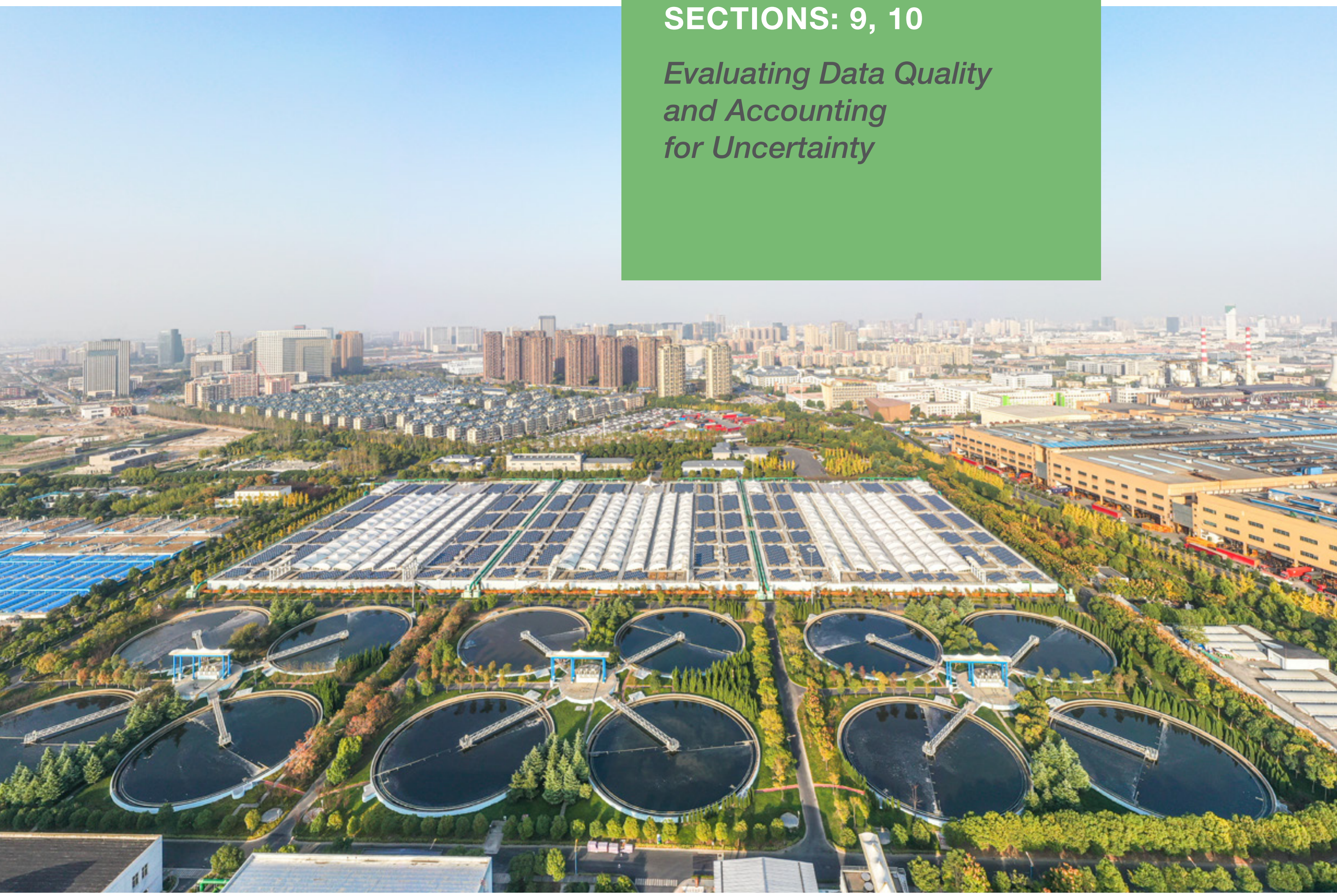
Once the GWP impacts have been extracted, the values need to be evaluated to determine if the values are applicable to the correct unit provided in the product take-offs. Some values may need to be converted. For instance, if the GWP values extracted from the EPDs are in emissions per square meter, but the purchased values provided in the take-off sheet are in square feet, then the emissions data will need to be converted to emissions per square feet.

This stage confirms the Unit of Analysis and the Product Take-Off Values as part of the Product Inventory. At the end of this step, we have a quantitative GWP value for cradle to gate impacts (or other defined boundary) for all products included in the analysis. The next step is to look at the data quality aspects of this data before proceeding with the rest of the calculation.



SECTIONS: 9, 10

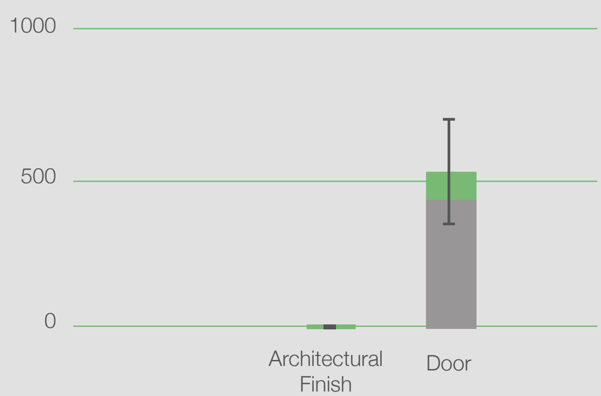
Evaluating Data Quality and Accounting for Uncertainty



9 Assessing Data Quality

Guidance to Step 5. Assess and document the data quality of the product level emissions data, activity data, and emission factors as the data are collected. Perform Allocation if necessary.

Figure 9.0: Example of embodied GWP emissions of doors (stacked bar) and associated uncertainty ranges (vertical black line)



9.1 Data Quality

To assess LCA and EPD Data Quality, this methodology uses a data quality pedigree matrix and qualitative uncertainty analysis harmonized with the Uncertainty Guidance introduced earlier. The primary reason to quantify uncertainty is to account for the underlying assumptions and value choices that were used by LCA practitioners and that could have a significant impact on the results of the LCA and EPD. It is advisable to use a conservative estimate rather than underestimating carbon impacts for products.

9.1.1 Assessment of Data Quality through a Pedigree Matrix

To address EPD data quality uncertainty, it is important to present not just a single embodied GWP number, but also a range of the potential GWP values. This range is developed from an estimate of the quality of individual data points and supports the use of conservative values in decision making. This methodology is preferable to putting one's trust in a single, potentially underestimated carbon value. To address this, the Uncertainty Guidance was adopted and modified to include a data quality assessment methodology that is recommended in the Product Standard. This method is referred to as a pedigree matrix and defines data quality indicators and a scoring rubric to estimate an empirically understood value of uncertainty.

The WRI Uncertainty Guidance was adopted and modified to include a data quality assessment methodology for embodied emissions. This method is referred to as a pedigree matrix and defines the data quality indicators used to measure embodied emissions with a transparent scoring rubric that helps manufacturers of building products and users of the methodology understand how uncertainty can be controlled and reduced.

Figure 9.1: Data quality matrix

Data Indicator Score	***Representatives to the process in terms of:***							
	Product Specificity	**Installation Specificity**	**Supply Chain Data**	**Technology Rep.**	**Temporal Rep.**	**Geo Rep.**	**Completeness**	**Reliability**
Very Good (Achieves 3 pts)	Exact product	Exact product	100% of material suppliers provided supplier-specific life cycle data or a verified LCA.	Data represents specific technology and equipment owned and operated by client for the specific product. Data collected at process level.	Data collected within one year of study completion. Collected for a minimum one-year period.	All data collected from specific Geography. Includes all energy, waste processing and other dataset used.	Data includes all relevant proces ses, inputs, and locations.	Verified data based on measurements
Good								
(Achieves 2 pts)	Product from a group of similar products from same manufacturer.	Product from a group of similar products from same manufacturer.	>50% of material suppliers provided supplier-specific life cycle data or a verified LCA. The remaining material proxies have been validated.	Data represents technology mix owned and operated by company. For instance, data may include machinery that produces product other than the one in the LCA/EPD. Data collected at plant level.	Data collected within 1-3 years of study completion. Collected over a minimum one-year period.	>75% data collected from specific geography. Includes all energy, waste processing and other dataset used.	Data includes >50% of the relevant processes, inputs, and locations.	Verified data partly based on assumptions or non-verified data based on measurements
Fair								
(Achieves 1 pt.)	Industry Average	Industry Average	Supply Chain accounted for with validated supply chain proxy datasets from a reputable LCA database	Data represents specific technology from source outside of company.	Data collected within 1-3 years of study completion. Collected over a period of less than 6 months.	50-75% data collected from specific geography. Includes all energy, waste processing and other dataset used.	Data includes <50% of the relevant processes, inputs, and locations.	Non-verified data partly based on assumptions or a qualified estimate (e.g., by sector expert)
Unknown (Achieves 0.5 pt.)	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Poor (Achieves 0 pt.)	Proxy	Proxy	Supply Chain accounted for with no validated supply chain proxy datasets.	Data represents similar technology from source outside of company or the data represents antiquated version of technology from inside the company.	Data collected within 3+ years of study completion. Collected over a period of less than one year.	< 50% data collected from specific geography. Includes all energy, waste processing and other dataset used.	Data utilizes proxies for processes, inputs, and locations.	Non-qualified estimate
**** Adopted from GHG Product Life Cycle Accounting Protocol***								

Figure 9.1 below represents the adapted version of the Uncertainty Guidance pedigree matrix to determine the quality of data applied in a LCA and/or EPD. The qualitative method to determine data quality called the pedigree matrix has been developed by Weidema et al. 2013. There are several parameters through which data quality is required to be assessed, namely:

- Technological representativeness of background data
- Temporal representative of background data
- Geographical representativeness of background data
- Completeness of data
- Reliability of data

Additionally, using guidance from the Product Standard, three additional indicators are also required to be assessed, which are:

- Product specificity
- Installation specificity
- Supply chain data

Each parameter is scored on a scale that includes data quality of very good (3 points) to poor (0 points). Products scored lower are meant to serve as an incentive for publishing higher quality EPDs with as much product specific data as possible or sourcing higher quality data. A description of each indicator and the scores for each of them is described in the section 9.2 below.

9.2 Data Quality Indicators and Scores

9.2.1 Product Specificity

Scores for this indicator are provided based on whether the LCA or EPD selected is an exact match for a particular product identified in the Product Inventory via the Material take-off. Points are awarded to the product based on the following criteria:

- **Very good (3 points):** The LCA/EPD is solely applicable to the product under study and owned by the manufacturer of the product. No other types of products from the same manufacturer are included in the EPD and the LCA results represent impacts of the product under study only.
- **Good (2 points):** The LCA/EPD is applicable to products within the same family or collection of products as the product under study and owned by the manufacturer of the product. Results of similar products are included in the EPD as a range, average of various products or as a representative product. For EPDs that provide results for average or representative products, these usually do not differ by more than 10% as prescribed in ISO 21930 (Section 5.3). A lower score is given to account for the variation in results.
- **Fair (1 point):** Manufacturer has not declared its product's environmental impacts but has participated in an industry-wide effort to disclose impacts. The industry-wide average value may be used to calculate embodied emissions. Variations here could arise from different manufacturing processes used, raw materials and sources of energy = used to manufacture the product.
- **Alternative Manufacturer / Unknown (0.5 points):** The selected LCA/EPD is declared by a different manufacturer from that of the product under study. However, the products are similar in major raw materials and function. This reflects the case for a "similar" product as described in Section 5. These are usually EPDs from competing manufacturers in the same industry and can be used if product specific (same manufacturer), product group specific (same manufacturer) or industry-wide EPDs are unavailable.
- **Poor (0 points):** No EPDs for the product category are available and a screening level LCA must be performed or generic values must be taken from an existing database, such as the ICE Database. The extracted values are referred to as a proxy value.

9.2.2 Installation Specificity

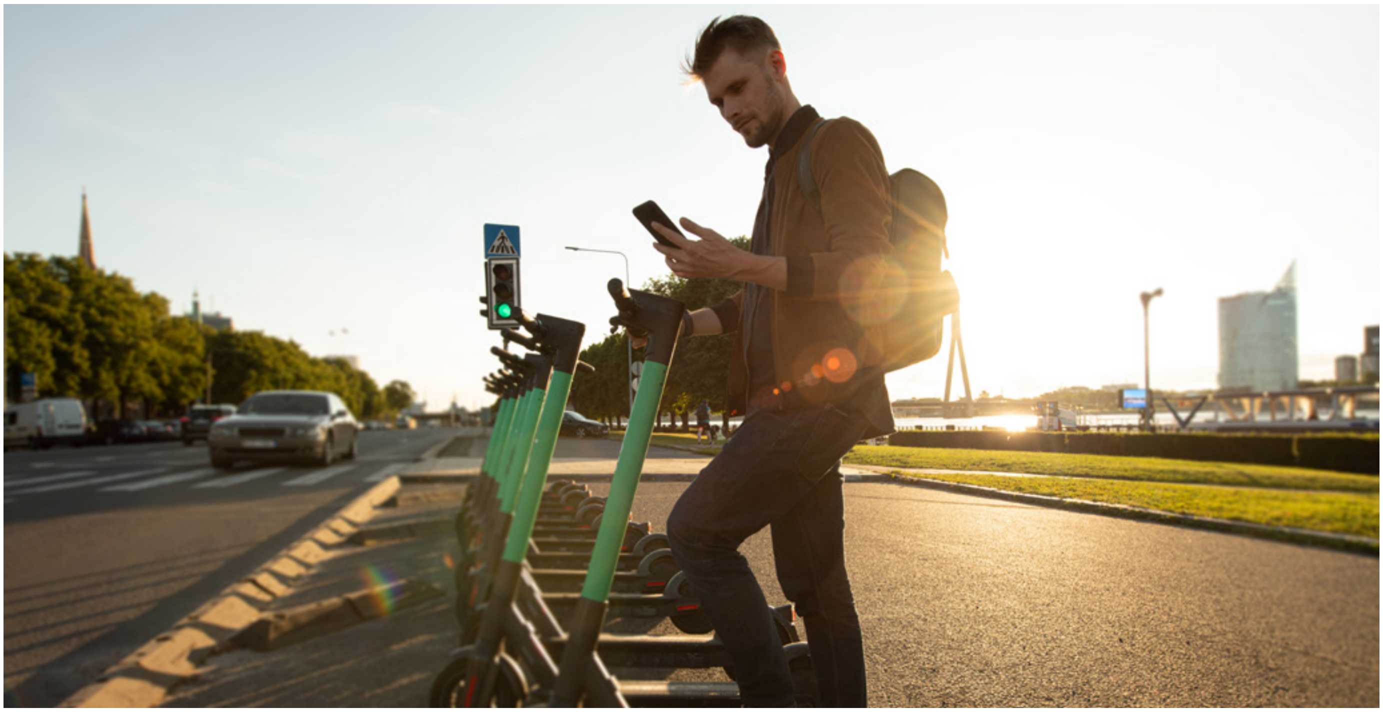
Scores for this indicator are provided based on product specific installation impacts (A5) provided in the EPD. Points are awarded to the product based on the following criteria:

- **Very good (3 points):** Installation GWP impact is available in the LCA/EPD and is solely applicable to the product under study. Additionally, the LCA/EPD is owned by the manufacturer of the product. No other types of products from the same manufacturer are included in the EPD and the LCA results in the accurate representation of the GWP impacts of the product under study only.
- **Good (2 points):** The installation impacts in the LCA/EPD are applicable to products within the same family or collection of products as the product under study and the LCA/EPD is owned by the manufacturer of the product. Results from the installation of similar products are included in the LCA/EPD as a range, average of various products or as a representative product. For EPDs that provide installation impact results for average or representative products, these usually do not differ by more than 10% as prescribed in ISO 21930 (Section 5.3). A lower score is given to account for the variation in results.
- **Fair (1 point):** Manufacturer has not declared their product's specific environmental impacts from installation, but has participated in an industry-wide effort to disclose impacts that include installation phase impacts.
- **Alternative Manufacturer / Unknown (0.5 points):** The LCA/EPD in which installation impacts are pulled from is declared by a different manufacturer from that of the product under study. However, the products are similar enough to expect that installation requirements would be similar. For major raw materials and functions include impacts from the installation stage. This reflects the case for a "similar" product as described in Section 5.
- **Poor (0 points):** No EPDs for the product category are available and a screening level LCA must be performed or generic values must be taken from an existing database for installation impacts. The extracted values are referred to as a proxy value.

9.2.3 Supply Chain Data

Scores for this indicator are provided based on product specific supply chain data provided in the LCA or within the underlying LCA in the EPD. Points are awarded to the product based on the following criteria:

- **Very good (3 points):** All suppliers of the product have provided supplier-specific life cycle data, or a third party verified LCA that shows the GWP impacts of the material or product being supplied to the manufacturer of the product under study.
- **Good (2 points):** More than half of the suppliers of the product have provided supplier-specific life cycle data or a third party verified LCA that shows the GWP impacts of the material or product being supplied to the manufacturer of the product under study. Apart from this, the remaining material choices must be validated by the manufacturer as the most appropriate available dataset choice.
- **Fair (1 point):** The LCA does not apply supply chain specific data to the assessment. All proxy datasets chosen for supplier specific data must be validated from a reputable LCA database.
- **Alternative Manufacturer / Unknown (0.5 points):** The EPD has no indication as to how datasets were chosen and no indication of supplier-specific data or sources for data. There are two cases in which this score can be assigned.
    1. An EPD from the specific product and company has not been published. Therefore, a proxy EPD from a different manufacturer was used; or,
    2. Evaluator was unable to determine the final score for this indicator based on the EPD, additional information that was provided or research. Gaps exist but these gaps do not clearly indicate a poor score.



- **Poor (0 points):** Datasets chosen for the assessment of GWP impacts are not supplier-specific and proxy datasets chosen are not from validated reputable LCA databases.

9.2.4 Technological Representativeness

Scores for this indicator are provided based on the technological representativeness of the data used in the underlying LCA. Points are awarded to the product based on the following criteria:

- **Very good (3 points):** Data used in the LCA represents specific technology and equipment owned and operated by the manufacturer for the product under study. All data collected by the manufacturer for the LCA is at the process level and is specific to the product under study.
- **Good (2 points):** Data used in the LCA represents a mix of technology owned and operated by the manufacturer. Data encompasses equipment used to manufacture products other than the product under study. All data is collected at the plant level.
- **Fair (1 point):** Data represents product specific technology from sources outside the company.
- For example, manufacturing energy is taken from validated, reputable LCA databases or from literature and is not provided by the manufacturer of the product.
- **Alternative Manufacturer / Unknown (0.5 points):** The EPD has no indication as to how datasets were chosen and no indication of technological specificity of data processes used related to the product under study. There are two cases in which this score can be assigned.

    1. An EPD from the specific product and company has not been published. Therefore, a proxy EPD from a different manufacturer was used; or,
    2. Evaluator was unable to determine the final score for this indicator based on the EPD, additional information that was provided or research. Gaps exist but these gaps do not clearly indicate a poor score.

- **Poor (0 points):** LCA process data represents similar technology from sources outside of the manufacturer or data represents antiquated version of technology from the manufacturer.

9.2.5 Temporal Representativeness

Scores for this indicator are provided based on the year in which data was collected relative to the year in which the LCA was conducted. Points are awarded to the product based on the following criteria:

- **Very good (3 points):** Process and manufacturing data is collected within one year of study completion. The data is also collected over a minimum one-year period to account for seasonal changes as well as various production rates within the year.
- **Good (2 points):** Process and manufacturing data is collected within 1-3 years of study completion. The data is also collected over a minimum one-year period to account for seasonal changes as well as various production rates within the year.
- **Fair (1 point):** Process and manufacturing data is collected within 1-3 years of study completion. The data is also collected over a period of less than six months.
- **Alternative Manufacturer / Unknown (0.5 points):** No references to temporal representativeness provided in the EPD. There are two cases in which this score can be assigned.
    1. An EPD from the specific product and company has not been published. Therefore, a proxy EPD from a different manufacturer was used; or,
    2. Evaluator was unable to determine the final score for this indicator based on the EPD, additional information that was provided or research. Gaps exist but these gaps do not clearly indicate a poor score.
- **Poor (0 points):** Process and manufacturing data is collected three or more years from date of study completion. The data is also collected over a period of less than one year.

9.2.6 Geographical Representativeness

Scores for this indicator are provided based on the regionality of data used within the LCA in relationship to the manufacturing. Points are awarded to the product based on the following criteria:

- **Very good (3 points):** All data used in the LCA are collected for appropriate geography. This includes all energy, waste, processing and other datasets used. For example, for a flooring product that is produced in the UK and installed in North America, all datasets used for sourcing and manufacturing and transport to customer sites must be UK specific. While datasets representing the installation phase are North America specific, thus reflecting the appropriate geographical region and its effects on carbon impacts.
- **Good (2 points):** More than 75% of data used in the LCA are collected from the appropriate geography. This includes all energy, waste, processing and other datasets used.
- **Fair (1 point):** Between 50-75% of data used in the LCA are collected from the appropriate geography. This includes all energy, waste, processing and other datasets used.
- **Alternative Manufacturer / Unknown (0.5 points):** No references to geographical representativeness provided in the EPD. There are two cases in which this score can be assigned.
    1. An EPD from the specific product and company has not been published. Therefore, a proxy EPD from a different manufacturer was used; or,
    2. Evaluator was unable to determine the final score for this indicator based on the EPD, additional information that was provided or research. Gaps exist but these gaps do not clearly indicate a poor score.

- **Poor (0 points):** The EPD specifically mentions that less than 75% of data used in the LCA are collected from the appropriate geography. This includes all energy, waste, processing and other datasets used.

9.2.7 Completeness

Scores for this indicator are provided based on the level of data gaps within the reference LCA. Points are awarded to the product based on the following criteria:

- **Very good (3 points):** The data used in the LCA includes all relevant processes, inputs, and locations. No known data point is missing from the study.
- Good (2 points): Data used in LCA modeling includes more than 50% of relevant processes, inputs, and locations.
- **Fair (1 point):** Data used in LCA modeling includes less than 50% of relevant processes, inputs, and locations.
- **Alternative Manufacturer / Unknown (0.5 points):** No reference to completeness is provided in the EPD. There are two cases in which this score can be assigned.
    1. An EPD from the specific product and company has not been published. Therefore, a proxy EPD from a different manufacturer was used; or,
    2. Evaluator was unable to determine the final score for this indicator based on the EPD, additional information that was provided or research. Gaps exist but these gaps do not clearly indicate a poor score.
- **Poor (0 points):** All data in the LCA utilizes proxies for relevant processes, inputs, and locations.

"The theory of change behind this methodology is how critical supply chain engagement is.. If we really want to compare products based on embodied carbon, we can't just rely on generic material values, we must also consider the supply chain."

William Paddock, Managing Director, WAP Sustainability

9.2.8 Reliability

Scores for this indicator are provided based on the reliability of data used in the LCA. Points are awarded to the product based on the following criteria:

- **Very good (3 points):** All data used in assessment is primary data based on verified measurements. They represent data as close to reality as possible.
- **Good (2 points):** Data used for the assessment is verified data partly based on assumptions or non-verified data based on measurements. This represents data that is as close to reality as possible but also has a few well-educated estimates.
- **Fair (1 point):** Data used in the assessment is non-verified data partly based on assumption or a qualified estimate by a sector expert. There are no verified or non-verified direct measurements or primary data available.
- **Alternative Manufacturer / Unknown (0.5 points):** No reference to reliability provided in the EPD. There are two cases in which this score can be assigned.
    1. An EPD from the specific product and company has not been published. Therefore, a proxy EPD from a different manufacturer was used; or,

2. Evaluator was unable to determine the final score for this indicator based on the EPD, additional information that was provided or research. Gaps exist but these gaps do not clearly indicate a poor score.

- **Poor (0 points):** Data gathered here is based on non-qualified estimates. These have a greater chance to be farther away from real-time scenarios. Estimates are non-verified and not suggested by a sector expert.

10 Estimating Uncertainty

Guidance to Step 6. Assess data quality and define data quality uncertainty scores using the pedigree matrix approach defined in this document. Conduct work to improve the data quality, focusing on processes that have a significant impact on the inventory results.

10.1 Uncertainty Analysis

The primary reason to quantify uncertainty is to account for the underlying assumptions and value choices that were used by LCA practitioners and that could have a significant impact on the results of the LCA and EPD.

After qualitatively analyzing uncertainty in the EPD data, the next step is to utilize the scoring in each data indicator to assess overall uncertainty. At the end of the previous step, every product has a score for each parameter in the data quality matrix that ranges from poor to very good. A common rule estimates that the best achievable uncertainty in LCA to be around 10%. This was supported by Kupfer, 2005 on the example of the forecast of environmental impacts in the design of chemical equipment. The actual degree of uncertainty can vary significantly from study to study7. As 10% is the best achievable uncertainty, the highest score of 3 or “very good”, translates to 10% relative uncertainty following which there is a 5% increase in uncertainty for subsequently lower scores. The highest uncertainty possible is 40%. Relative uncertainties for each data quality score are provided in Table 2.

Table 10.1: *Uncertainty and Data quality scores*

Overall Score	Data Quality Assessment Score	GWP Relative Uncertainty	
Very good	3	+-	10%
	2.5	+-	15%
Good	2	+-	20%
	1.5	+-	25%
Fair	1	+-	30%
	0.5	+-	35%
Poor	0	+-	40%

These data quality scores are then weighted based on the relevance of the parameter to the over GWP impacts. Weighting factors for each data quality indicator is provided in Table 10.2.

The sum of the weighted scores gives us the final data quality assessment score. This final score is then used to obtain a final relative uncertainty from Table 10.2. Again, here a conservative approach is taken to round down the final score and the corresponding relative uncertainty becomes the final relative uncertainty.

Table 10.2: *Weighting factors for data quality indicators*

Weighting	
Product Specificity	25%
Installation Specificity	5%
Supply Chain Data	25%
Technological Representativeness	10%
Temporal Representativeness	5%
Geographical Representativeness	5%
Completeness	10%
Reliability	15%

The absolute uncertainty is calculated by multiplying the final relative uncertainty with the cradle to gate embodied emissions GWP value obtained from a previous step. The result of this calculation is the absolute uncertainty in the positive (+) and negative (-) direction and is reported for each product.

Relative Uncertainty (A1-A3) a product x cradle to gate Embodied Emission value

The resulting output of this step is an embodied emission value per EPD functional unit and an estimated higher and lower limit due to potential data quality uncertainty. In Step 7, this value will be applied to the purchased amounts provided on the material take-offs.

Example: Using Pedigree Matrix Approach in EC3

EPD evaluation can be supported by the use of the Embodied Carbon in Construction Calculator (EC3) tool. The EC3 tool is a free and easy to use tool that allows benchmarking, assessment and reductions in embodied carbon per material category. The data is open and transparent and discloses key data quality indicators that can be used to assess EPD quality using the **Sector Supplement for Measuring and Accounting for Embodied Emissions in the Built Environment.**

The following guidance will allow users to source information from EC3 to better evaluate data quality using the Sector Supplement for Measuring and Accounting for Embodied Emissions in the Built Environment's pedigree matrix approach. Currently not all data quality indicators are able to be sourced from EC3 since EPD is often missing key information, however this example provides ways to align data in EC3 for use with this approach.

Step 1: *Begin the process by searching for an Environmental Product Declaration in EC3.*

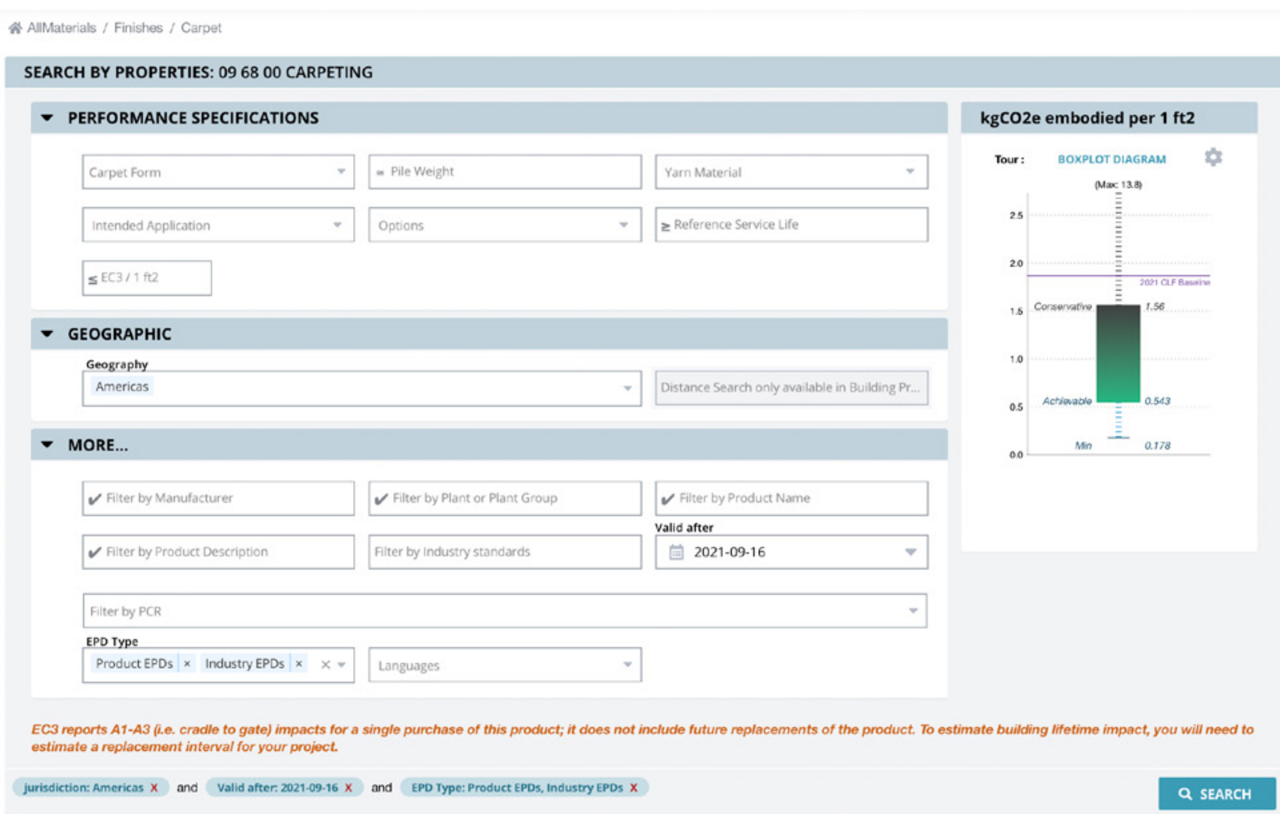


Figure 10.3: EPD Data View

Step 2: *Click "View" to view the specific EPD's data input fields.*

ct EPDs: 271 Achievable: 0.543 kgCO2e Average: 1.29 kgCO2e ± 131% Conservative: 1.56 kgCO2e Converted per Unit: 1 ft2

UCT EPDS

tegory	Manufacturer	Plant or Plant Gr...	Product	Description	Pile Weight	Yarn Material	≤ EC3 / 1 ft2	Details
	Shaw Flooring	Dalton, GA	EcoWorx® Performa...	The product is a com...		Nylon 6	1.8 kgCO2e	Details Open -S-
	Shaw Flooring	Dalton, GA	EcoWorx® Performa...	The product is a com...		Nylon 6	1.5 kgCO2e	Details Open -S-
	Shaw Flooring	Dalton, GA	EcoLogix® Carpet Tile...	The product is a com...		Olefin	1.94 kgCO2e	Details Open -S-
	J+J Flooring	Dalton, GA	Kinetex Textile Comp...	Kinetex® is an advan...	7.17 oz / yd2	Recycled PET	0.582 kgCO2e	Details Open -S-
	J+J Flooring	Dalton, GA	Standard Back Carpet	As part of EF Contract...	19.3 oz / yd2	Nylon 6	1.04 kgCO2e	Details Open -S-
	J+J Flooring	Dalton, GA	Nexus Modular Carpe...	J+J Flooring Group's c...	15 oz / yd2	Nylon 6	1.51 kgCO2e	Details Open -S-
	J+J Flooring	Dalton, GA	PremierBac Plus Broa...	As part of J+J Flooring ...	19300 oz / yd2	Nylon 6	1.09 kgCO2e	Details Open -S-
	J+J Flooring	Dalton, GA	TitanBac Plus Broadlo...	The problems that ca...	19.3 oz / yd2	Nylon 6	1.5 kgCO2e	Details Open -S-
	J+J Flooring	North Tazewell, VA	and Functional Unit	J+J Flooring Group's c...		Nylon 6	1.58 kgCO2e	Details Open -S-
	Shaw Flooring	Shaw, GA (2 Plants)	ClassicBac® Broadloo...	The product is a com...	50 oz / yd2	Nylon 6,6	1.76 kgCO2e	Details Open -S-
	Shaw Flooring	Shaw, GA (2 Plants)	ClassicBac® Broadloo...	The product is a com...	50 oz / yd2	Nylon 6	1.66 kgCO2e	Details Open -S-
	Shaw Flooring	Shaw, GA (2 Plants)	StrataWorx® Carpet ...	The product is a resid...	60 oz / yd2	Polyester (PET)	1.16 kgCO2e	Details Open -S-
	Shaw Flooring	Shaw, GA (2 Plants)	StrataWorx® Carpet ...	The product is a resid...	35 oz / yd2	Nylon 6	2.09 kgCO2e	Details Open -S-

Figure 10.4: EPD Data Input View

Step 3: Evaluate the data quality indicators

Product Specificity - To evaluate the Product Specificity data quality indicator, follow the guidance below:

- If the boxes in EC3 are checked for both "Manufacturer Specific" and "Product Specific" then the EPD is eligible for either a "Very Good" or a "Good" Score.

  To determine if the final score is "Very Good" or "Good", review the "Product Description" field. If the product description field indicates that the EPD is specific to a model or SKU then the final score will be "Very Good". If the "Product Description" indicates that the EPD is for a group of similar products represented by a product with an average characteristic (such as weight, thickness and/or performance) then the final score is "Good"

- If neither the Manufacturer Specific nor the Product Specific boxes are checked then the final score will either be "Fair", "Unknown" or "Poor". To determine if the final score is "Fair" evaluate the product description again. If the description references that an industry-wide EPD was used, then the final score is Fair.

- If you have sourced a different company's EPD to account for a product that you are evaluating, then the final score will be "Poor".

- It is unlikely that if you are using EC3 you will score an EPD for "Product Specificity" as "Unknown".

Installation Specificity – Currently installation specific data quality assessments are not supported by EC3. If using EC3 for this indicator, mark data quality of "Unknown" or refer back to the actual EPD.

Supply Chain Data - To evaluate the Supply Chain data quality indicator, follow the below guidance:

- On the details view of the EC3 entry for the EPD, note the percentage in the "Supply Chain Specific" field.

- If this number is 100% then the "Very Good" score shall be applied.

- If this number is between 50% and 99%, then the "Good" score shall be applied.

- If this number is 0%-49% AND the EPD is verified and has an appropriate and valid Product Category Rule listed in the "Product Category Rules" field, then the final score is "Fair"

- **Note:** If you are using EC3 to source data quality indicator information, it is unlikely that the final data quality score under Supply Chain specificity will be "Unknown" or "Poor". This is because EPDs without third party verification to an appropriate PCR are not eligible for listing in EC3.

Technology Representation

To evaluate the Plant Specific data quality indicator, follow the below guidance:

- On the details view of the EC3 entry for the EPD, note if the "Plant Specific" box is checked.
- If the "Plant Specific" box is checked and the source data notes section indicate that process level data was collected and used, then the indicator score will be "Very Good"
- If the "Plant Specific" box is checked and the source data notes section does not indicate that process level data was collected and used, then the indicator score will be "Good"
- If the "Plant Specific" box is not checked and the Source Data Notes section indicates that the source of the data was from a company source at a level greater than the plant level (i.e., average from multiple plants) then the score shall be indicated as "Fair"
- If the "Plant Specific" box is not checked and the Source Data Notes section does not indicate the source of the data, then the score shall be indicated as "Unknown"
- If the "Plant Specific" box is not checked and the Source Data Notes section indicates that the source of the data is from a source outside the company then the data quality indicator shall be indicated as "Poor".

Temporal Representation

To evaluate the Temporal Representation data quality indicator, follow the below guidance:

- On the details view of the EC3 entry for the EPD, note if the "Just in Time" box is checked.
- If the "Just in Time" Box is checked then the data quality indicator is "Very Good"
- If the "Just in Time" Box is not checked then it is not possible to use EC3 to evaluate the temporal representation data quality indicator. In this case, the actual EPD should be evaluated.

Geographical Representation - Currently the geographical representation specific data quality assessment is not supported by EC3. If using EC3 for this indicator you shall mark the data quality as "Unknown" or refer back to the actual EPD.

Completeness – Currently data quality assessments for completeness are not supported by EC3. If using EC3 for this indicator, mark the data quality as "Unknown" or refer back to the actual EPD.

Reliability - Currently Reliability specific data quality assessments are not supported by EC3. If using EC3 for this indicator, mark the data quality as "Unknown" or refer back to the actual EPD.

Verified Data - within EC3, data quality can be evaluated based on verification of the data into the EC3 tool. This includes Program Operator and Digitally Verified Tags within the System. Data with Verification is assumed to be a higher quality than non-verified data.

EPD data located within EC3 can be used with no further analysis by simply selecting unknown for each data indicator category. Figure 10.5 demonstrates the alignment between EC3 and this Methodology for each data quality indicator category.

FIGURE 10.5

EC3 to Pedigree Matrix Quick Chart

Identifying uncertainity critieria available in the EC3 Tool

Figure 10.5: EC3 to Pedigree Matrix Quick Chart

Data Indicator Score	Representatives to the process in terms of:							
	Product Specificity	*Installation Specificity*	*Supply Chain Data*	*Technology Rep.*	*Temporal Rep.*	*Geographical Rep.*	*Completeness*	*Reliability*
VERY GOOD (Achieves 3 pts)	*Exact product*	*Not Available*	*100% of material suppliers provided supplier-specific life cycle data or a verified LCA.*	*Data represents specific technology and equipment owned and operated by client for the specific product. Data collected at process level.*	*Data collected within one year of study completion. Collected for a minimum one year period.*	*Not Available*	*Not Available*	*Not Available*
GOOD (Achieves 2 pts)	*Product from a group of similar products from same manufacturer.*	*Not Available*	*>50% of material suppliers provided supplier-specific life cycle data or a verified LCA. The remaining material proxies have been validated.*	*Data represents technology mix owned and operated by company. For instance, data may include machinery that produces product other than the one in the LCA/ EPD. Data collected at plant level.*	*Not Available*	*Not Available*	*Not Available*	*Not Available*
FAIR (Achieves 1 pt.)”	*Industry Average*	*Not Available*	*Supply Chain accounted for with validated supply chain proxy datasets from a reputable LCA database*	*Data represents specific technology from source outside of company.*	*Not Available*	*Not Available*	*Not Available*	*Not Available*
UNKNOWN (Achieves 0.5 pt.)”	*Unknown*	*Not Available*	*Unknown*	*Unknown*	*Not Available*	*Not Available*	*Not Available*	*Not Available*
POOR (Achieves 0 pt.)	*Proxy*	*Not Available*	*Supply Chain accounted for with no validated supply chain proxy datasets.*	*Data represents similar technology from source outside of company or the data represents antiquated version of technology from inside the company.*	*Not Available*	*Not Available*	*Not Available*	*Not Available*

** Adopted from GHG Product Life Cycle Accounting Protocol*

SECTIONS: 11

Calculating Total Embodied Emissions across the product life cycle

11 Calculating Embodied Emissions

Guidance to Step 7. Calculate embodied emissions.

11.1 Product Embodied Emissions

As described in section 2, embodied emissions encompass impacts from sourcing and manufacturing to the installation of the products in the built environment. These emissions occur as the project is being completed under the same boundary as the GHG Emissions Inventory. For a built environment project owner, embodied emissions are also relevant Scope 3 emissions which shall be included in existing inventory efforts when determined to be material. The following sections describe calculation methodologies and formulas to determine embodied emissions by life cycle module for products under the goal and scope of the project.

11.1.1 Sourcing and Manufacturing (A1-A3)

Sourcing and Manufacturing Emissions meet the scope 3 Category 1 definition for Purchased Goods and Services and Capital Goods. Thus A1-A3 emissions are considered scope 3 emissions. Product level cradle to gate impacts can be extracted from EPDs of various products or extrapolating impacts from competitor EPDs, industry-wide EPDs or generic databases has been described in detail in Section 5. Once a built environment product inventory is complete (including product take-offs) and that inventory has been normalized to the correct functional units and the impacts from product EPDs with varying functional units (due to different PCRs or having a declared unit) have been normalized to uniform units, impacts need to be scaled to the amount of each product being used in the system under review. Scaling can be completed by applying the formula below for each product:

GWP impact (A1-A3) of specified quantity of Product A = GWP impacts (A1 to A3) per functional unit × Product take-off amount (number of products used)

This equation is then applied to every product under consideration.

11.1.2 Transport to Site (A4)

EPDs currently report transport to site (A4) impacts for a production weighted average of annual product deliveries or assume a customer transport distance value prescribed by the PCR. These upstream transportation emissions are considered Scope 3 Category 4 Upstream Transportation emissions. This methodology aims to eliminate variation in results due to this difference from the actual scenario being evaluated. Through this methodology, variation due to the above-mentioned factors are eliminated by considering the site of installation (i.e., the building location) vs the annual product deliveries from a manufacturer address.

Figure 11.1: *CO2 emission factors for transport to site*

CO2 emissions factors for transport to site (A4)	
Mode of transport	kg CO2/ kg.km
Ship	0.00000503
Plane	0.19
Train	0.0000267
Truck	0.000153

The address of the installation site can be obtained from the commissioner of the embodied emissions study. Manufacturer addresses have already been extracted from the EPD or LCA (see Section 5) and distance between these can be calculated using any distance mapping software and stored within the product database. The mode of transportation depends on the location of the supplier. The weight of the product per functional unit and product take-offs are also extracted from EPDs. Figure 11.1 details the carbon emissions from transporting one kilogram of a product over a distance of 1 kilometer from transporting products from the manufacturing facility to the site of installation can be calculated using the formula below:

GWP impacts from A4 = Distance (manufacturing facility to installation site (km)) × Total Weight of product take-off(kg) × emission factor for mode of transport

Where total weight of product take-off is:
Weight of functional unit (kg) × Product take-off amount

11.1.3 Installation at Site (A5)

Installation impacts can be reported as Scope 3 category 1 and 2 if reporting company is paying construction company to install building materials or Scope 1 and 2 if company is building themselves. To determine installation impacts, the following process was established:

1. The first step is to determine if the installation impacts are available in the EPD for the product in question.

   a. If yes, use the impacts available and scale the entire purchased amount (see section 8.1) of the associated product used in the building.

   b. If the installation impacts are not available in the EPD, check to see if the total impacts provided in the EPD include a contribution chart.

      i. If a contribution chart is available, then extract the impacts for A5 per the functional unit and then scale to include the entire amount of product used in the building.

      ii. If a contribution chart is not available in the EPD, then determine if there are any EPDs for similar products or any industry wide EPDs that have installation impacts included.

1. If there are similar EPDs then take the 75th percentile value per functional unit and scale to required quantity of product.

2. If there are not, gather data on tools and installation materials required for installation from manufacturer guidelines and collect, if available, EPDs for the installation materials.

   a. If EPDs are available use A1-A3 impacts from EPD for appropriate functional unit and then scale to required quantities of product.

   b. If EPDs are not available, then estimate the amount of installation materials required from manufacturer guidelines and use LCA software or ICE database to determine impacts per functional unit and then scale to required quantity of product.

11.2 Supplemental Data Points

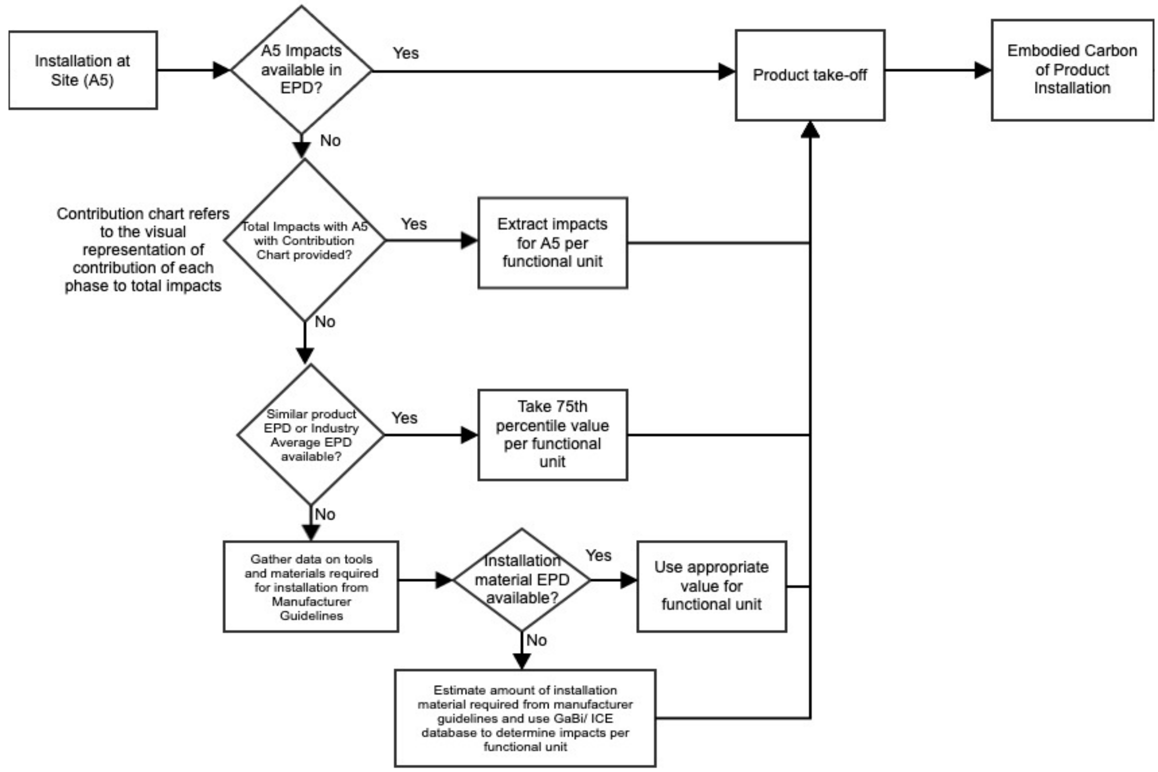
Accounting for the downstream impacts after the installation phase of the product life cycle includes additional GHG emissions associated with the product and can therefore be considered as part of the product's total life cycle emissions and to the overall lifetime GHG emissions of a building or interior space.

Apart from embodied emissions, this methodology also aims to calculate and disclose downstream GHG emissions not covered as embodied emissions. This includes all modules other than the use phase (operational energy) of the building which would be covered under Scope 1 and Scope 2 Emissions Categories for the Building Owner and/or Occupant. If the building owner leases or sells the built environment project, then these emissions are reported in scope 3 category 11 (use of sold products) or category 13 (downstream leased assets).

The downstream impacts that can be calculated using this methodology are impacts associated with the replacement of products during the period of occupancy in the building and the impacts associated with the final disposal of products. In line with the Scope 3 Standard, if emissions from projected material replacement are reported, they shall be separated out to avoid confusion with end-of-life treatment of building products.

These are not part of embodied emissions calculations as per the definition in Section 2 however are important considerations since user decision can drastically change the amount of carbon associated with a building during its occupancy.

Figure 11.2: *Flowchart to determine installation phase impacts*



11.2.1 Replacements (B4)

For purposes of this Sector Supplement, there is also a method to calculate replacement cycles for products as it applies to their overall space refresh cycles. Often the service life of a product can inform the amount of emissions the product type would generate over the lifetime of a built environment project. Understanding Replacement emissions can inform lower built environment emissions at design or procurement. Replacement values included in EPDs in B4 are often reported as projections based on an estimated service life of the product. These projections are often estimated and the degree to which products are replaced is unknown as they are occurring in the future. These emissions from refurbishment and replacement generated at the time of implementation should not be included in Scope 3, Category 1 or 2 in the GHG Inventory year the replacement occurred.

It is also recommended that projects calculate the end-of-life emissions as defined in section 11.2.2 End of Life (and consult Page 49 of the Scope 3 Standard for best practices on estimating Scope 3 Category 12 emissions) for products being replaced in the inventory year the replacement occurs.

Should there be a desire to factor replacement values into evaluation efforts for other strategic or comparison purposes, this section will identify how that is done. A product installed during initial construction is not always used for the entire duration of the building. Some products like ceiling panels and ceramic tiles last for a long time and are typically used for the entire duration of occupancy. Alternatively, some products like flooring or wall paint may be changed more frequently. This can be due to functional efficiency or for aesthetic reasons and is at the discretion of the architect or building owner/occupant. These replacements, if carried out often over the duration of occupancy, can quickly and significantly increase total life cycle impacts as they require the manufacturing, transporting and installation of a new product to replace the old one. These values are important as they provide a holistic view of impacts apart from initial construction. They also provide incentive to manufacture longer

lasting products and builders to invest in higher quality durable products with long lasting aesthetics.
To calculate impacts from replacement for each product, the following equation can be applied:

Replacement EE = (GWP(A1+A2+A3) + GWP(A4) + GWP(A5) + GWP(C1+C2+C3+C4)) X take-off units x number of replacements

Where occupancy period and replacement cycle are in years and GWP values are in kg CO2e.

Another consideration in this calculation is accounting for uncertainty. The uncertainty value calculated earlier for A1-A3 can be used for replacements. The following equation can be applied to calculate uncertainty for replacements and added to the result.

The uncertainty due to replacements of a product over the duration of occupancy is:

Uncertainty for Replacements = Replacement EE x Uncertainty (A1+A2+A3) for product

Adding both equations gives the total downstream impacts from replacement for each product. Similar to uncertainty from A1-A3 there is a lower and upper limit for the above impacts.

11.2.2 End of Life (C2, C4)

At the end of each product's useful life, a conservative approach is to assume that all products are landfilled. While some markets may have recycling opportunities for certain material types and some manufactures may have Extended Producer Responsibility (EPR) programs, these programs are often not used. Furthermore, different material types use varied amounts of energy to be landfilled and degrade at different rates and it is important to account for this difference. Transportation of materials to landfill must also be accounted and additional guidance is available on page 49 of the Scope 3 Standard for best practices on estimating category 12.

Figure 11.3: *Emission factors for End-of-life GWP impacts*

Material Type	GWP (kg CO2e/ kg)
Biodegradable waste on landfill	0.487
Ferro metals on landfill	0.0439
Glass/inert on landfill	0.0439
Municipal Solid Waste on landfill	0.452
Paper waste on landfill	0.781
Plastic waste on landfill	0.0439
Textiles on landfill	0.801
Untreated wood on landfill	1.16
Wood products (OSB, particle board) on landfill	1.18

Since different materials deteriorate at different rates, the GWP impacts for different materials is different. GWP impacts for common raw materials in the building and construction sector are given in Figure 11.3. These values have been taken from GaBi Software (version 9.2.0.58, service pack 39). Each product under study is classified under one of the materials mentioned in Table 5 and overall GWP emissions from end-of-life phase are calculated as follows:

Impacts from end of life emissions = (Weight of product take_off x GWP emissions from landfilling product) + (distance to landfill x GWP emissions from transport X weight of product take-off)

Where distance to the landfill is provided by the commissioner of the study. For more details on calculation of transport impacts, see section 8.2.

11.3 Total Embodied Emissions

Finally, total embodied emissions is the summation of all impacts from all products under analysis of A1-A3 sourcing through manufacturing, transport of finished product to installation site (A4) and installation (A5) life cycle modules. This can be summarized by the equation below.

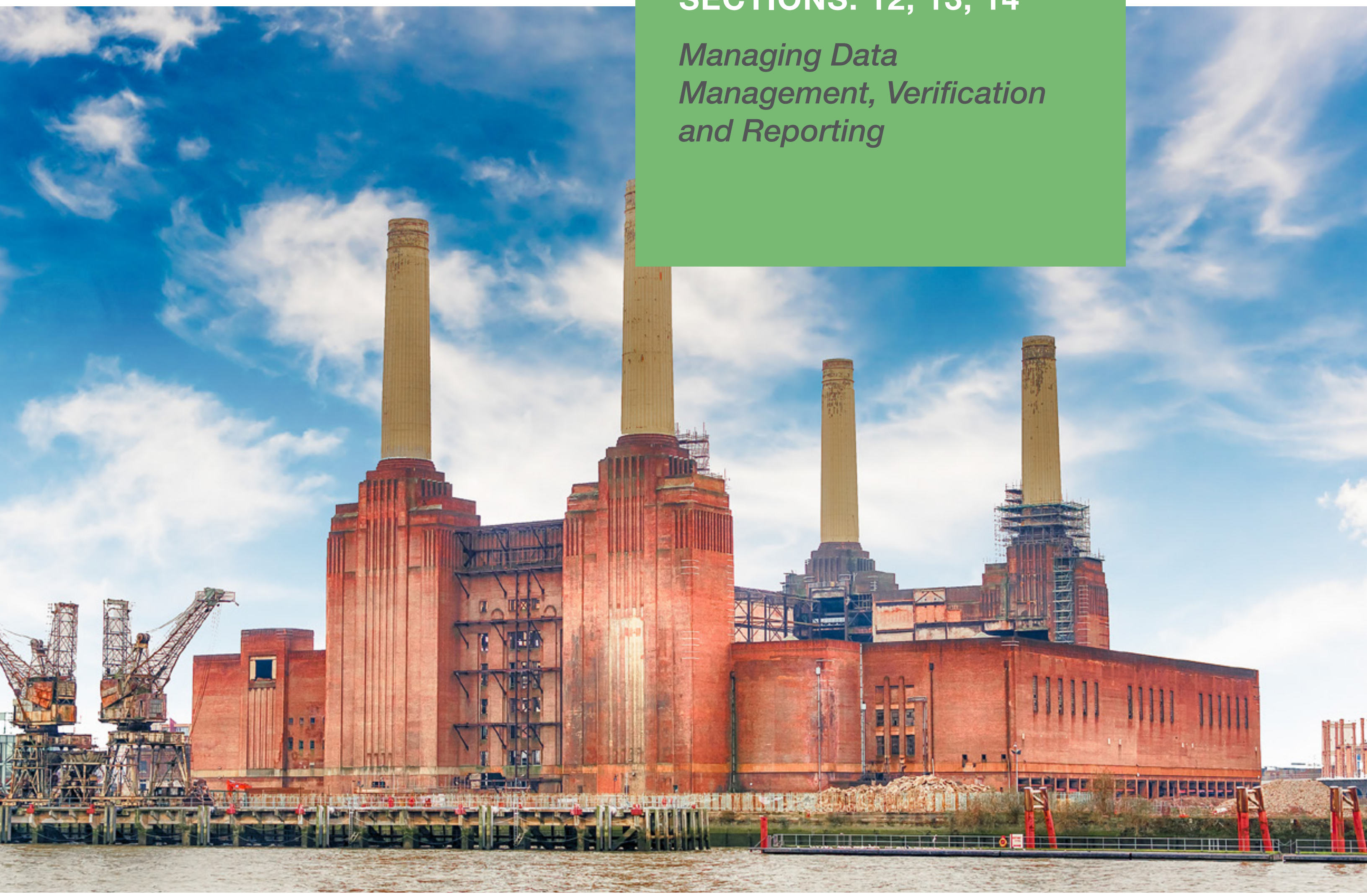
$$\sum_{i=1}^{n} \left(GWP(A1\text{-}A3 \text{ for } i) + GWP(A4 \text{ for } i) + GWP(A5 \text{ for } i)\right)$$

Where,
n = number of products under review
i = list of products under review

It is important to note that when disclosing embodied emissions impacts publicly, the scope of the study must also be declared, especially if impacts from modules other than A1-A5 or cradle to installation (i.e. embodied emissions scope for buildings) are also declared. Along with embodied emissions values, data sources, and uncertainties shall also be declared. This is so that the quality of data from the source EPDs are available for a user of the analysis. Disclosing scope along with impacts also enables transparency and facilitates comparisons to be drawn on equivalent units. Any comparisons between products or buildings are to be completed by an LCA practitioner.

SECTIONS: 12, 13, 14

Managing Data Management, Verification and Reporting



12 Managing Data Over Time

12.1 Inventory Data Management Plan

The inventory shall also include a data management plan that shall be divided into two portions, quality control (QC) and quality assurance (QA). Additional guidance can be found in the Corporate Standard, Chapter 5, Tracking Emissions Over Time.

At a minimum the data management plan shall contain:

- Description of the embodied emissions boundaries and building products included in the inventory
- Information on the entity(ies) or person(s) responsible for measurement and data collection procedures
- Data collection procedures
- Data sources, including LCA and EPD data, estimation data, emission factors and other data, and the results of any data quality assessment performed
- Calculation methodologies including unit conversions and data aggregation
- Length of time the data will 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 shall involve establishing standard procedures to address all of the data management activities, including the quality control and quality assurance aspects of an embodied emissions accounting project.

The data management plan documents the embodied emissions accounting process and ensures the internal quality assurance and quality control (QA/QC) procedures are 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 quality and future project performance.

> ***The embodied emissions data management plan documents the embodied emissions accounting process and ensures the internal quality assurance and quality control (QA/QC) procedures are 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 quality and future project performance.***

Building Project Teams may already have similar procedures in place for other data collection efforts to guide this process to meet the accounting requirements of other carbon or energy reporting, such as the GHG Protocol, and ISO standards. Where possible, these processes should be aligned to reduce data management burdens.

12.1.1 Creating a Data Management Plan

According to the Product Standard (page 126, Appendix C) and the Corporate Standard (Chapter 7), a successful data management plan includes the following steps:

1. Establish an Embodied Emissions Accounting quality person/ team. This person/team should be responsible for implementing and maintaining the data management plan, continually improving the quality of the embodied emissions accounting, and coordinating internal data exchanges and external interactions (such as with manufacturers, certification programs and assurance providers).

2. Develop data management plan. The data management plan shall cover the components outlined at each stage of the embodied emissions accounting process. 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 shall be applied to all aspects of the embodied emissions accounting process, focusing on data quality, data handling, documentation, and calculation / uncertainty procedures.

4. Perform specific data quality checks. More in-depth checks shall be made for those products and/or activities that are significant to the inventory and/or have high levels of uncertainty.

5. Review final inventory and report. Review procedures shall be established that match the purpose of the inventory and the type of assurance that may be performed. Internal reviews shall be undertaken in preparation for the assurance process by the appropriate team within a building project team, such as a certification review, internal audit or GHG Verification.

6. Establish formal feedback loops to improve data collection, handling and documentation processes. Feedback loops can improve the quality of the 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 information shall be documented to support data collection and calculation methodologies, and how the data shall be stored over time. 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 can be updated as data sources change, data handling procedures are refined, or calculation methodologies improve.

The data management plan can also be useful as an assurance readiness measure as it contains much of the data that a certification body or verifier provider may need. The plan should be made available to those providers (internal or external to the reporting company), as a helpful tool to guide the certification/verification process.

12.1.2 Quality Control within 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 embodied emissions accounting source data and the data management processes. More information on this can be found in Chapter 7 of the Corporate Standard. The purpose is to ensure that the inventory does not contain misstatements, including identifying and reducing errors and omissions; providing routine checks to maximize consistency in the accounting process; and facilitating internal and external inventory review and assurance.

12.1.3 Quality Assurance of the Data Management Plan

The quality assurance portion of the data management plan involves a peer review to assess the quality of the inventory. Peer review involves reviewing the documentation of the embodied emissions accounting process but does not rigorously review the data used as source data. This review aims to reduce or eliminate any inherent error or bias in the process used and assess the effectiveness of the quality control procedures. The peer review evaluates whether the embodied emissions accounting effort complies with the quality control specifications outlined in the data management plan. Peer review shall be conducted by someone not involved in the development of the building projects inventory as described in Chapter 5 of the Corporate Standard.

> ***"So few companies are taking accountability and responsibility for embodied carbon emissions and that needs to change. We see a world emerging where building owners and investors will expect superior embodied carbon performance in every built environment project and this methodology will help make that possible."***
>
> *Jeff Frost, Project Manager and Materials Specialist, Brightworks Sustainability*

13 Verification

Guidance to Step 8. Perform Verification.
Embodied Emissions Verification involves an assessment of the risks of material discrepancies in measured and reported data. Discrepancies relate to differences between reported data and data generated from the proper application of the relevant GHG standards and methodologies. In practice, assurance involves the prioritization of effort by the assurance provider towards the data and associated systems that have the greatest impact on overall data quality.

13.1 Verification

The primary aim of verification is to provide confidence to users that the reported information and associated statements represent a faithful, true, and fair accoun of a company's embodied emissions. Ensuring transparency and verifiability of the inventory data is crucial for verification. The more transparent, well controlled and well documented a company's emissions dat and systems are, the more efficient it will be to verify. As outlined in Section 3, there are a number of GHG accounting and reporting principles that need to be adhered to when compiling a GHG inventory. Adherence to these principles and the presence of a transparent, well-documented system (sometimes referred to as an audit trail) is the basis of a successful verification.

While verification is often undertaken by an independent, external third party, this may not always be the case. Many companies interested in improving their GHG inventories may subject their information to internal verification by personnel who are independent of the GHG accounting and reporting process. Both internal and external assurance efforts shall follow similar procedures and processes. For external stakeholders, external third-party assurance is likely to significantly increase the credibility of the inventory. However, independent internal assurance providers can also provide valuable assurance over the reliability of information.

As embodied emissions are a subset of total emissions, this methodology defaults to the guidance for Assurance in Chapter 10 of the Corporate Standard and Scope 3 Standard. The Product Standard offers guidance for Assurance in Section 12.1. Building projects that seek to verify the embodied emissions of a single project shall adhere to the same principles and guidance for assurance & verification as defined in the other protocols.

14 Reporting and Disclosure

Guidance to Step 9. Report Embodied Emissions.
Measuring and Reporting Embodied Emissions in the built environment is a best practice for companies aspiring to measure relevant Scope 3 emissions sources, however Embodied Emissions classified as Scope 3 emissions identified in this protocol (and described below and in Chapter 9 of the Corporate Standard and relevant chapters in the Scope 3 and Product Standards), are considered to be the highly relevant and significant emissions impacting the built environment where there are large opportunities and points of influence for reducing.

14.1 Embodied Emissions Reporting Required information

Companies shall publicly report the following information while also following the reporting requirements detailed in the Scope 3 Standard:

- Total embodied emissions shall be reported separately as a subset of scope 3 categories, such as Purchased Good and Services, Capital Goods or other categories as relevant occuring in the reporting year of the emission activity (as described in Figure 1.3)
- Embodied emissions can be reported as a subset of an existing scope 3 category, given that embodied emissions overlap with many scope 3 categories (e.g. purchased goods and services, upstream transportation and distribution, end of life treatment)
- For embodied emissions, total embodied emissions shall be reported in metric tons of CO2e
- A description of the embodied emissions
- A list of embodied emissions sources excluded from the inventory with justification of their exclusion
- Quantitative assessments of data quality
- Information on inventory uncertainty (e.g., information on the causes and magnitude of uncertainties in emission estimates) and an outline of policies in place to improve inventory quality
- Include an emissions recalculation policy for built environment and appropriate context for any significant emissions changes that triggered initial base year recalculation (e.g., estimations replaced with primary data)
- A description of the types and sources of embodied emissions data, including LCAs, EPDs, LCI Datasets, other activity data, product specific emission factors and GWP values, used to calculate emissions, and a description of the data quality of reported emissions data
- Include a description of the methodologies, allocation methods, and assumptions used to calculate embodied emissions
- For embodied emissions totals, the percentage of emissions calculated using data obtained directly from manufacturers vs. other value chain partners

14.2 Embodied Emissions Reporting Optional information

Embodied Emissions Accounting reporting should also include, when applicable, the following additional information:

14.2.1 Optional Reporting: General

- Emissions data further subdivided where this adds relevance and transparency (e.g., by floor, function, product type, CSI division, etc.)
- Qualitative information about emission sources not quantified
- Information on avoided emissions, reported separately from scope 1, scope 2, and scope 3 emissions
- The type of assurance performed (first or third party), the relevant competencies of the assurance provider(s), and the opinion issued by the assurance provider
- Relevant embodied emissions performance indicators and intensity ratios
- Information on the company's GHG management and reduction activities, including embodied emissions reduction targets, manufacturer engagement strategies, product GHG reduction initiatives, etc.
- Information on manufacturer/partner engagement and performance
- Information on product performance
- A description of performance measured against internal and external benchmarks
- Information on purchases of GHG reduction

instruments, such as emissions allowances and offsets, from outside the inventory boundary

- Information on reductions inside the inventory boundary that were a result of design stage changes that resulted in avoided emissions from purchased products should be reported separately as Embodied Emissions Procurement and Design Reductions. The GHGP does not provide guidance on reporting for avoided emissions.
- Information on any contractual provisions addressing embodied emissions-related risks or obligations
- Information on the causes of emissions changes that did not trigger a scope 3 base year emissions recalculation
- GHG emissions data for all years between the scope 3 base year and the reporting year (including details of and reasons for recalculations, if appropriate)
- Additional explanations to provide context to the data

14.2.2 Optional Reporting: Information on Manufacturer Engagement

Embodied emissions accounting is focused on tracking the emissions associated with specific activities in the built environment value chain, such as the production of purchased products, transportation of purchased products, and use of sold products. Because embodied emissions include the scope 1 and scope 2 emissions of a building product manufacturer in the value chain (including tiered suppliers, service providers, etc.), reporting on a building project teams efforts to engage building product manufacturers provides additional transparency on a building project teams embodied emissions management and reduction activities.

Embodied emissions reporting should include, when applicable, the following additional information:

- Manufacturer/partner engagement metrics, such as the number and percentage of suppliers and other partners that have:
- Received a request from the building project team to provide primary GHG emissions data in the form of LCAs or EPDs.
- Provided GHG emissions data to the reporting company in the form of LCAs and EPDs
- Established a publicly available product-level GHG reduction target via an EPD Action Plan or other documentation
- Building Product Manufacturer performance metrics, including the GHG emissions performance of their own suppliers over time
- Other relevant information

14.2.3 Optional reporting: Information on Product Performance

To provide appropriate product related performance context related to Scope 3, Category 11 (Use of sold products), an embodied emissions report should include, when applicable, the following additional information:

- Product performance indicators and functional metrics
- Average lifetime/durability of purchased products
- The methodologies and assumptions used to calculate product performance indicators and intensity metrics
- The percentage of sold products that are compliant with standards, regulations, and certifications, where applicable
- Any purchased products not included in the inventory, with justification for their exclusion
- Other relevant information

14.3 Reporting Information on Uncertainty

Companies shall describe the level of uncertainty of reported data, qualitatively or quantitatively, to ensure transparency and avoid misinterpretation of data. In cases where data uncertainty is high, companies shall also describe efforts to address uncertainty.

SECTIONS: 15

Setting Embodied Emission Reduction Targets

15 Embodied Emissions Reduction Targets

Guidance on Step 10. **Set Embodied Emissions Reduction Targets**

Guidance for setting embodied emissions reduction targets and tracking changes involves the following steps which were modified from Chapter 11 of the GHG Protocol and Chapter 14 of the Product Standard.

1. Complete and report on embodied emissions for the specified project or project phase.
2. Identify reduction opportunities.
3. Set a reduction target(s)
4. Achieve reductions and account for these by performing an updated embodied emissions 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; or source of data.
6. Complete and disclose an updated inventory report including the updated results and the base inventory results. Companies should report the inventory results as a percentage change over time on the unit of analysis basis.

15.1 Reporting on Embodied Emissions

Using the steps defined in Step 9 (Section 14) complete and report on the embodied emissions for the specified project or project phase. As noted earlier in this methodology, the built environment project boundary may be a partial or whole building and be segmented by design stage (such as embodied emissions associated with the structure and enclosure systems of a building project).

15.1.1 Reduction Opportunities

Project Teams can begin identifying potential emissions reduction opportunities along the building projects life cycle while evaluating and calculating embodied emissions as part of a baseline inventory. The baseline can then be compared or re-calculated based on embodied emissions reduction opportunities associated with the specific building life cycle stage. These comparisons can then be assessed to determine the magnitude of the reductions and how those reductions may be achieved. In general, built environment project teams have the largest influence on building stage they control and therefore, a first step may be to identify embodied emissions reductions or alternative material specification opportunities within those building stages. In many cases the largest potential for improvement comes from processes that are under the control of suppliers along the product's life cycle. Asking suppliers of building products for life cycle assessments and environmental product declarations (EPDs) are ideal documents for evaluating the embodied emissions impacts of their products.

To address embodied emissions, building project teams should identify suppliers to engage with, based on both their level of influence and embodied emissions reduction potential. For use and end-of-life processes, the building project team may determine that improvements are influenced primarily by the design of a product and less by the behaviors of customers. In this case, the building project team should engage their product design or research and development team.

15.2 Setting a Reduction Target

Reduction targets should be set for the total built environment project's life cycle to avoid the perception of cherry-picking. In addition, building project teams may also set individual targets for stages or processes of a building project. Companies can either set absolute or intensity reduction targets. Target should include both a completion date and a target level - the numeric value of the reduction target per unit of analysis (e.g.,20 percent reduction per sq ft.). In general, building project team should set an ambitious target that reaches significantly beyond business-as-usual. "Stretch goals" (such as Net Zero) tend to drive greater innovation and are seen as most credible by stakeholders.

15.3 Accounting for Reductions

Built environment projects may achieve embodied emissions reductions in different ways, such as working within the design stage to reduce embodied emissions of core materials or by specifying and purchasing products with the lowest embodied emissions.

To account for embodied emissions reductions in a building project, building project teams are referred to the data collection requirements of the Product Standard (Chapter 8). Any embodied emissions reductions shall be assessed using collected direct measurement data, activity data, or emission factors that abide by the attributional approach of the standard (i.e., historical, fact-based, and measurable) and have occurred prior to the updated inventory.

15.4 Use of offsets

Built environment project teams should strive to achieve their reduction targets entirely from emission sources within the inventory boundary (i.e., those directly related to the built environment project) without the use of offsets.

If the building project team is unable to meet the target through those reductions, it can use offsets that are generated from sources external to its inventory boundary.

Any purchased, sold, or banked offsets relevant to the inventory results are subject to the same reporting requirements as defined in the GHG Protocol Corporate Standard in Chapter 13 and therefore are reported separately from the inventory results.

For products communicating a carbon neutral product, these products are subject to the same reporting requirements as defined in the GHG Protocol Corporate Standard in Chapter 13. Stated GWP must be accounted for as part of the total emissions of the building project, and then separately the GWP reductions associated with carbon neutral products can be reported separately from the inventory results.

Any building product manufacturer reporting or sharing information on carbon offsets related to the product should also disclose information on the credibility of the offset, including:

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

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

Appendix 1: References

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Appendix 2: Acronyms and Terms

AIA American Institute of Architects

AISC American Institute of Steel Construction

ANSI American National Standards Institute

APA Engineered Wood Association

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASTM American Society for Testing and Materials

BPDO Building Product Disclosure and Optimization

BREEAM Building Research Establishment Environmental Assessment Method (UK)

CA Canada

CaGBC Canada Green Building Council

CLF Carbon Leadership Forum

EC3 Embodied Carbon Construction Calculator

EE Embodied Emissions

ECN Embodied Carbon Network

EN European Standard

EPD Environmental product declaration

GHG Greenhouse gas

GWP Global warming potential

IgCC International Green Construction Code

IPCC Intergovernmental Panel on Climate Change

ISO International Standards Organization

LCA Life cycle assessment

LCI Life cycle inventory

LEED Leadership in Energy and Environmental Design

N/A Not applicable

NA North America

NGO non-governmental organization

PCR Product category rule

PEP Product Environmental Profiles (PEP)

RFP Request for proposal

RFQ Request for proposal

SE2050 Structural Engineers 2050 Initiative

UK United Kingdom

UKGBC UK Green Building Council

UL Underwriters Laboratories Inc.

ULe UL Environment

US United States

USGBC United States Green Building Council

WAP WAP Sustainability Consulting

WBLCA Whole building life cycle assessment

WSEC Washington State Energy Code

ZNC Zero net carbon