February 16, 2023

Introduction to EC3 Uncertainty

Environmental Product Declarations (EPDs) are useful tools for quantifying environmental impacts, including global warming potential (GWP), of materials and products. However, there are many uncertainties inherent in the calculations and reporting of EPDs.

Consider the example EPD scenarios below:

EPD A:

- A window EPD that reports environmental impacts for an entire product line of windows (as a weighted average).

EPD B:

- A window EPD that reports the environmental impacts for a single product

It is clear that the range of impacts for a specific product covered by EPD A is more uncertain than that of the single product represented in EPD B.

Building Transparency (BT) aims to support data transparency and data specificity in EPDs. Thus, EPD uncertainty is addressed in BT's Embodied Carbon in Construction Calculator (EC3) tool through the use of uncertainty factors. BT has defined a set of uncertainty categories, as described below, commonly found in EPDs that can be quantitatively assessed. These factors are then applied by EC3 to an EPD within its database depending on the EPD scenario. BT acknowledges that there are other sources of uncertainty in the EPD process, but these may be better captured as qualitative (rather than quantitative) uncertainties.

The uncertainty approach used by EC3 is based on peer reviewed publication by the Carbon Leadership Forum Embodied carbon in construction materials: a framework for quantifying data quality in EPDs. Similar methodology approach was also presented in Q Metadata For EPD Quality - Assured Environmental Product Declarations (EPD) For Healthy Competition And Increased Transparency. Uncertainty and specificity of Greenhouse Gas (GHG) calculations is also covered in IPCC Calculation Methodology (Volume 1, Chapter 3). Building Transparency continues to refine the EC3 methods and welcomes feedback and data that makes its uncertainty factors more accurate and representative of specific product categories.

Types of uncertainty captured in EC3

Manufacturer Uncertainty

Definition
Manufacturer uncertainty arises when an EPD is industry-wide rather than manufacturer-specific since it is typically the result of a weighted average of inputs from contributing manufacturers.

Method for removing uncertainty
This uncertainty is removed when an EPD is manufacturer-specific. Industry or sector EPDs are not manufacturer-specific.

Product Uncertainty

Definition
Product uncertainty arises when an EPD reports impacts for an entire product line (or set of products) and the impacts reported are an average of multiple products.

Method for removing uncertainty
This uncertainty is removed when an EPD is shown to be for a single product (i.e., as opposed to covering a range of products whose GWP per unit may vary by more than 3%). Product variation under 3% is covered under Residual Uncertainty, below.

The EC3 team works with industry to develop heuristics for product differences that tend to reflect a significant variation in GWP, including having different names, SKUs, material compositions, or physical differences that affect the GWP per declared unit. However, any EPD that can be shown, using independently verified evidence, to cover products that vary by less than 3% in GWP per declared unit can also be considered product-specific.

Plant Uncertainty

Definition
Plant uncertainty arises when an EPD reports impacts for a product as an average of multiple production facilities (typically as a weighted average).

Method for removing uncertainty
This uncertainty is removed when an EPD is shown to be plant-specific, meaning primary data is from a specific production facility. Equivalent terms are "Facility-Specific" or (for steel) "Mill-Specific".

Supply Chain Uncertainty

Supply chain uncertainty arises from using average background life cycle inventory (LCI) data for impactful upstream inputs that are highly variable in terms of global warming potential[1].

Method for removing uncertainty

This uncertainty is removed to the degree that an EPD's upstream inputs are evaluated based on EPDs or third-party verified data for the specific products used, rather than average (generic) background LCI data. The degree of supply chain specificity must be based on the GWP contribution of each input in a generic product.

Batch Uncertainty (Just in Time)

Definition

Batch uncertainty arises from small batch-to-batch variations in environmental impacts and changes over the EPD's period of validity.

Method for removing uncertainty

This uncertainty is removed when an EPD is batch-specific, meaning it is based on data for the specific manufacturing batch of no more than 90 days to which it applies. Also called a Just In Time or On-Demand EPD.

Residual Uncertainty

Definition

A basic residual uncertainty of 3% is applied to all EPDs, which aims to capture any remaining uncertainties in the LCA calculations and underlying measurements for a product.

Method for removing uncertainty

This uncertainty is never removed.

LCIA Uncertainty

Definition

When sourcing products globally, the EPDs for products under consideration may use different life cycle impact assessment (LCIA) methods including different factors for specific GHGs in the common unit kgCO2e. Construction-material impacts are dominated by CO2, so LCIA differences are usually minor, but this uncertainty can be large when non-CO2 GHGs are involved.

Method for removing uncertainty

LCIA uncertainty is removed if the EPD declares a result in the user's preferred LCIA method.

[1]Example: Cement is a highly impactful material input to concrete production. Its GWP impact can be highly variable; thus, using average or generic LCI data for cement would be associated with supply chain uncertainty.

Development of uncertainty factors

When each type of uncertainty described above is applied to an EPD, a range (i.e., statistical distribution) of possible GWP impacts (rather than a single, exact GWP impact value) is created for that EPD. BT aims to quantify the most representative distribution of GWP that is possible for each uncertainty type for a product category. The calculations for these distributions are discussed in more detail in the EC3 General Uncertainty Methodology Document. BT has conducted uncertainty assessments for priority product categories (e.g., ready-mix concrete, steel, flat glass) and uses default uncertainty values for material categories not yet addressed. Thus, the uncertainty values for each product category can be significantly different based on the realities of the product category's supply chain and associated environmental impacts. See the individual category-specific default uncertainty factors documentation for more detail.

Example 1
Ready Mix Concrete: The major contributing factor to a ready mix concrete's GWP is the cement, which is known to have a wide range of GWP impact. Thus, the supply chain uncertainty is high for ready mix concrete, with cement as the major contributing factor.

Example 2
Flat glass: The main source of GWP variability is the energy used in the production facility for flat glass. Contributions from the upstream supply chain to the GWP are both low and not highly variable. Therefore, flat glass has relatively low supply chain uncertainty but more significant plant uncertainty.

An illustration of the calculations, and a listing of all factors used, is maintained in web calculator and spreadsheet format.

For improved comparability within the same category, BT has selected the 80th percentile of the range of possible GWP impact as the *uncertainty-adjusted GWP (uaGWP)*. This value was selected because the 80th percentile is a reasonable conservative estimate that incentivizes higher EPD data quality and specificity versus comparing the reported value in the EPD (i.e., an average value).

Applying uncertainty to EPDs

Product EPDs

Application of each type of uncertainty is applied based on the information found in the EPD. This information can be found in the uncertainty checklist for a digitized EPD as shown below.

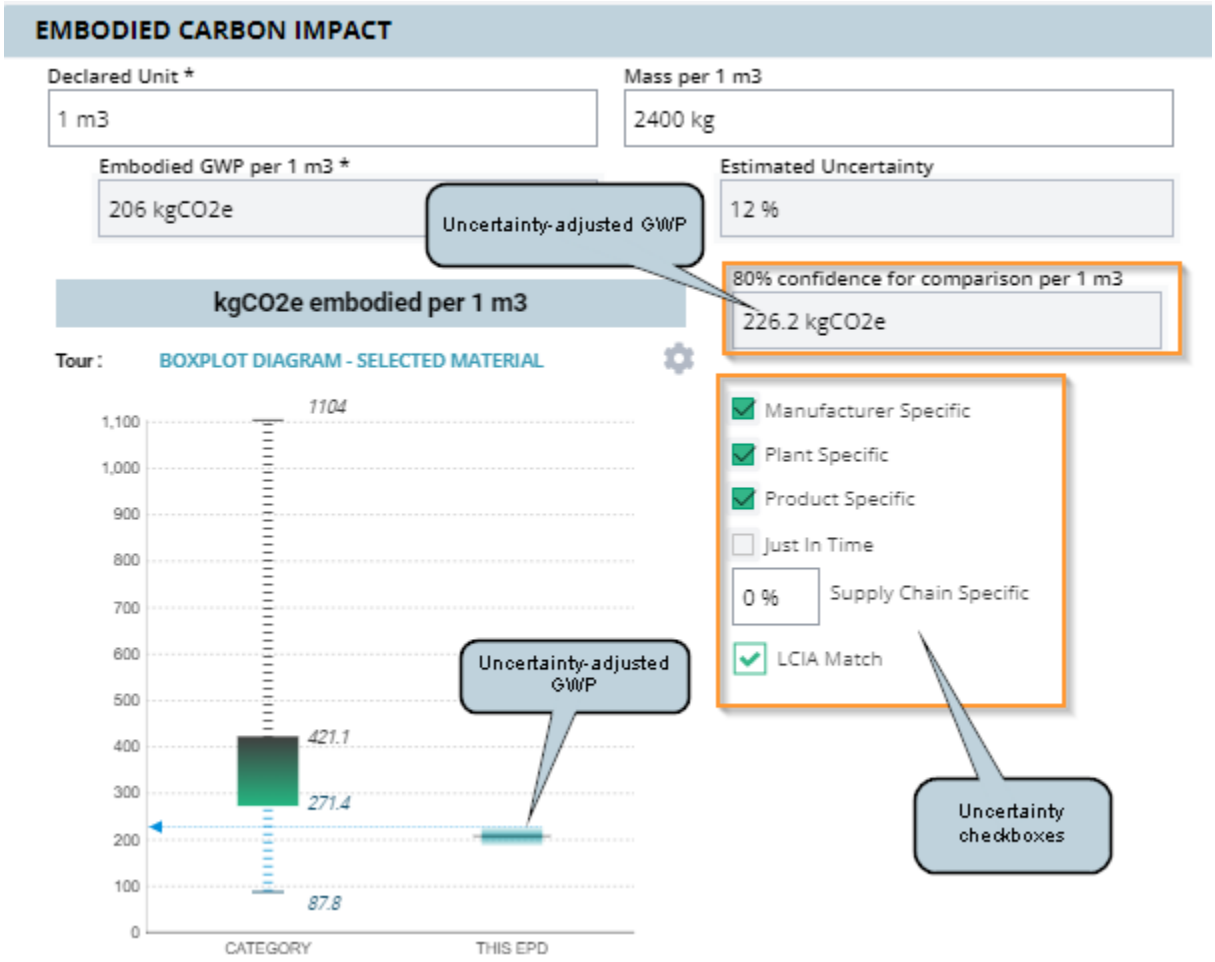

Figure 1 - Uncertainty represented in the EC3 tool.

When boxes in the uncertainty checklist are checked, the associated uncertainty is removed. For instance, the EPD shown above is manufacturer-specific, plant-specific, and product-specific. However the data uses no supply chain-specific data and is not batch-specific.

Alternatively, compare Figure 1 to Figure 2. The EPD in Figure 2 is supply chain-, manufacturer-, plant-, product-, AND supply chain-specific. Thus, the uncertainty associated with this EPD is less than that shown in Figure 1.

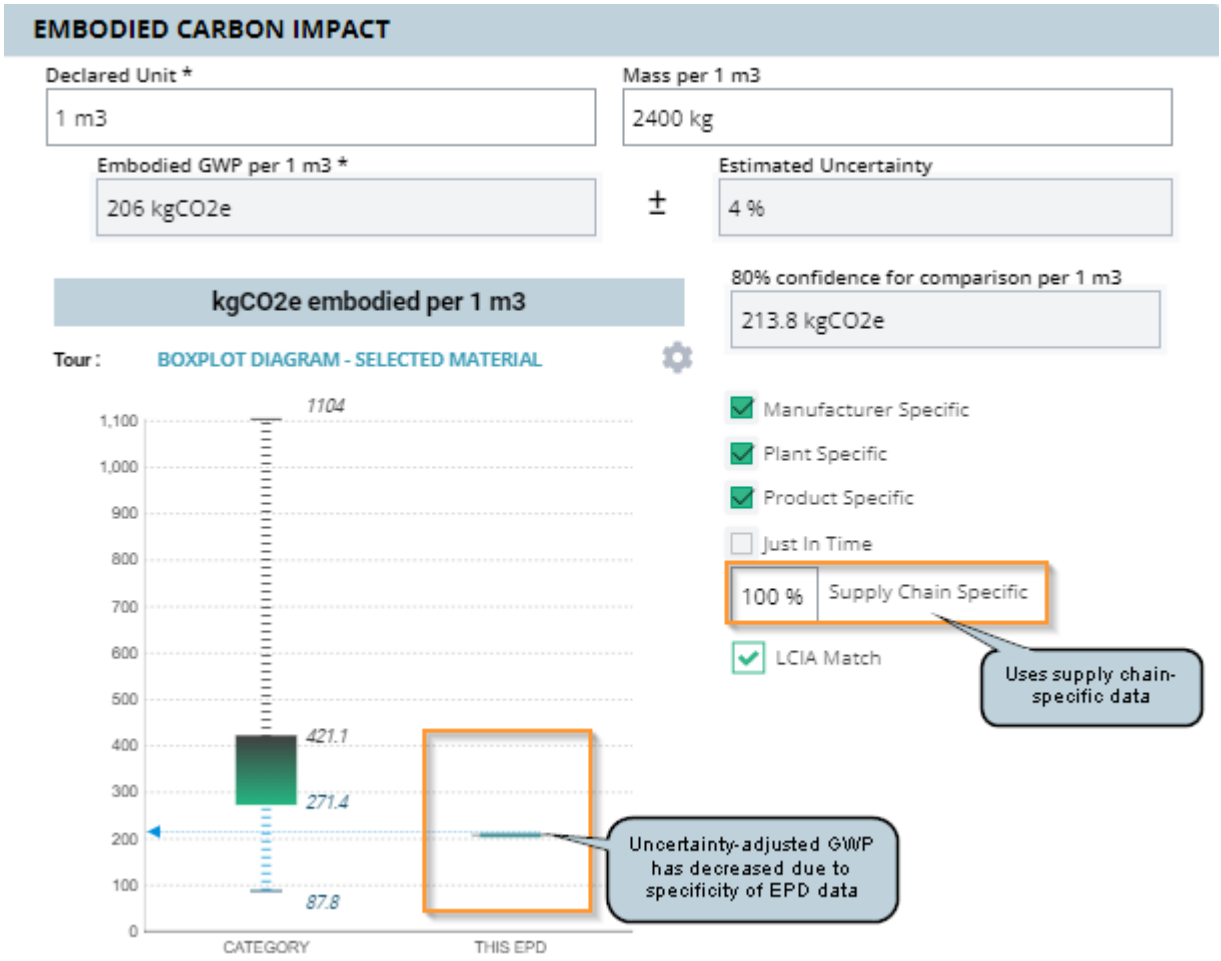

Figure 2 - Example EPD with supply chain-specific background data.
(The EPD is also manufacturer-, plant-, and product-specific)

The uncertainty-adjusted GWP is used in EC3's statistics such as the comparison boxplot on the left side of Figures 1 and 2, and in EC3's Building Planner in order to incentivize the use of EPDs that use highly specific background and foreground data.

Industry EPDs

Each industry EPD has all uncertainty factors (e.g., manufacturer, facility, product, etc.) applied by default, except for a few exceptions shown below.

Exceptions

1. When an Industry EPD is for a specific product type or thickness, then the product uncertainty may be removed. For example, a gypsum board Industry EPD covering ½ inch Type X gypsum board is considered a product-specific Industry EPD in EC3.
2. When the EC3 user's LCIA method matches EPD's LCIA method, then the LCIA uncertainty is removed.

Statistical explanation of uncertainty-adjusted GWP

When a building is under construction, we can imagine a truckload of some product arriving at the site. There is some actual climate impact (GWPa) associated with that truckload, which (if we were tracking perfectly) could be known at that point. The purpose of an EPD is to predict GWPa with sufficient precision to allow climate-aware decision-making before delivery, and to approximate GWPa closely enough to enable reporting after delivery in the absence of universal tracking.

The GWP value reported in the EPD, then, is the *expected value* of GWPa, E(GWPa). Ideally E(GWPa) would be a point estimate from the population of previous deliveries, but often it's based on a population of SIMULATED previous deliveries. So there is a substantial distribution of possible values around the expected value. We are only 50% confident that if E(GWPa) is less than some limit L, that GWPa is actually less than L.

What EC3 does is to set an 80% confidence test that GWPa is really less than L. We do this by calculating the uncertainty-adjusted GWP (uaGWP), which we are 80% confident is above GWPa, and determining if uaGWP < L. uaGWP is calculated as E(GWPa) + 0.8416*σ(GWPa). The 0.8416 factor is the conversion factor from standard deviation (84th percentile) to the 80th percentile of a normal distribution.

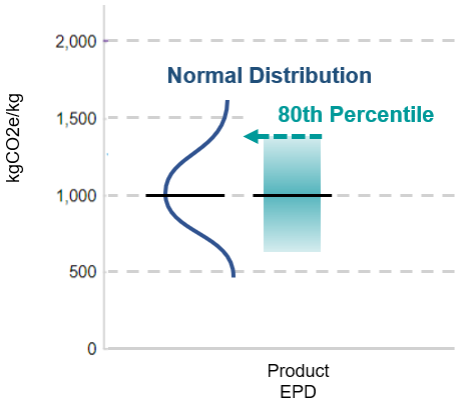

Figure 3 - Illustration of uncertainty-adjusted GWP calculation according to normal distribution.

Unfortunately, published EPDs rarely if ever disclose the variance of the population, so EC3 estimates the variance based on a generic model of each category, breaking it down into the uncertainty types listed. We assume each of the types represents an independent source of error, and so we combine them on a root-sum-square basis to estimate σ(GWPa).

The data and calculations are illustrated in this web calculator, which also contains a link to a spreadsheet containing all the equations and constants.

Calculation of statistics for a search

When an EC3 user defines performance specification, geographical or other filters in EC3 and searches for EPDs matching the search criteria, EC3 returns the statistics for that specific search. The set of matching EPDs counts toward the generated boxplot and statics as follows:

1. For each product EPD, use the [Uncertainty Adjusted GWP value]
2. For each industry EPD, use the uncertainty factor for industry EPDs to generate a range of 13 data points based on a lognormal distribution with the 15% top and bottom deleted.[2]
3. Combine (1) and (2) into an ordered list, and find quintiles, interpolating linearly between the closest two data points when necessary.

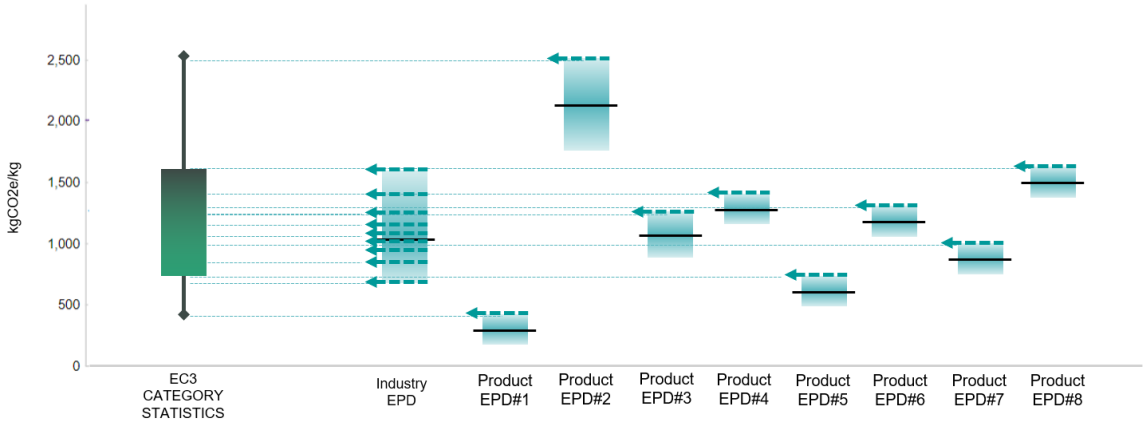

Figure 4 - Combining Industry and Product EPDs in search statistics. (for illustration only)

This approach ensures that categories with only a few Product EPDs show a range of potential GWPs that reflect the industry, and not just a small subset of manufacturers with EPDs that may be anywhere in the range of impacts for that industry as a whole. In categories with no Industry EPDs, or many more product EPDs than Industry EPDs, the Product EPDs start to hold more weight. Note that this approach is necessary because of the diverse nature of categories that EC3 holds (some categories have no Industry EPDs and others have multiple) and the global nature of some categories (i.e., products in categories that are globally traded) where multi-regional searches may include Industry and Product EPDs from many regions.

[2] Points are generated for percentiles spaced 5% apart, totaling 21 points. We trim any datapoints above 80th or below 20th percentiles (i.e., 0, 5, 10, 15, 85, 90, 95, 100th percentile points), ending with 13 datapoints that contribute to the search statistics for each Industry EPD.