Report

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Improving EPD Data Quality

COLLEGE OF BUILT ENVIRONMENTS
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CLF Carbon Leadership Forum

This report addresses the following requirement from RCW 39.116.050:

> *(6)(b)(iii) Make recommendations for improving **environmental** [**product**] **declaration data quality** including, but not limited to, integrating reporting on variability in facility, product, and upstream data for key processes…"*

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Executive Summary

Environmental product declaration (EPD) data quality is an important topic because EPDs serve as the basis for procurement policies like Buy Clean Buy Fair (BCBF). EPDs provide transparency about a product's environmental impacts, support product-to-product comparisons for specification and procurement, and serve as data sources for downstream EPDs and whole-building assessments. Their data quality is critical for all of these functions. This report provides background information and recommendations on how to improve EPD data quality.

"EPD data" encompasses the following types of data:

1. the data that feeds into a life cycle assessment (LCA) model for an EPD, and
2. the data that is published in an EPD.

For the purposes of this report, ***EPD data quality*** is defined as the extent to which the EPD data supports the **reliability, comparability,** and **user-friendliness** (including accessibility and transparency) of EPDs.

The heart of this report presents 14 strategies for how to improve EPD data quality. The strategies are grouped into the following categories:

1. **LCA modeling**. These strategies are aimed at improving accuracy and consistency in the data and methods used in the LCA models behind the EPDs. The more that EPDs align in how they model the same real-world process, the more confidence we have that differences in EPD results are due to real-world differences rather than differences in modeling and data selection.
2. **Data stewardship**. These strategies are aimed at maintaining and improving the quality of data used in EPDs. Input data should be accessible, comprehensive, and up to date to support high-quality EPDs.
3. **EPD reporting**. These strategies are focused on clarifying how EPDs report environmental impact data. Clear and consistent reporting provides users with better insight into what the numbers mean, how to use them, and how reliable they are.
4. **EPD verification and publication**. These strategies are about improving the verification and digitization of EPDs in order to improve their reliability and user-friendliness.

These strategies can be undertaken by any entity that has control or influence over the strategy, such as:

- Product category rules (PCRs), their program operators, and PCR committees
- Project owners, including governments and private companies
- Policymakers and government agencies
- LCA professionals
- LCA tool developers
- Manufacturers or material suppliers
- Industry associations
- Funders

In the last section of the report, we tailored a list of recommendations specifically for the State of Washington and its BCBF Program. These recommendations are summarized in the two lists below: (1) near-term strategies for the BCBF Program, and (2) long-term strategies for the broader ecosystem.

Near-term strategies for the BCBF Program: To improve the quality of EPD data submitted to the BCBF Program, the State could adopt the following strategies for BCBF:

1. Specify which PCRs should be followed.
2. Require suppliers to report supply-chain specificity (SCS) scores to BCBF.
3. Encourage suppliers to meet target SCS scores.
4. Encourage suppliers to submit EPDs with up-to-date primary data (i.e., EPDs whose primary data was collected not more than five years before submission to BCBF).
5. Encourage suppliers to report energy attribute certificate (EAC)-based impacts separately.
6. Encourage suppliers to separately report global warming potential (GWP) impacts from biogenic vs. fossil emissions.

Long-term strategies for the broader ecosystem: To improve the quality of EPD data more generally, the State could adopt the following strategies. These strategies would take place outside of the BCBF Program but can help improve the quality of EPDs submitted to BCBF in the long run.

7. Support efforts to update and improve federal LCA data repositories, such as filling data gaps for upstream processes or ingredients in many EPDs.
8. Engage in the PCR development process. Advocate for key positions to improve EPDs by participating in PCR committees, issuing public comments, and writing letters to program operators and PCR committees.

Table of Contents

Executive Summary **2**
1. Introduction **6**
2. What is EPD Data Quality? **7**
What is EPD data? 7
Data used in the LCA model for the EPD 7
Data reported in the EPD 8
What is data quality? 9
Use cases for EPDs 10
Key EPD data quality characteristics 11
3. PCR Review **13**
4. Current Strengths and Limitations of EPD Data Quality **15**
Current strengths 15
Current challenges and limitations 16
5. Strategies to Improve Data Quality **18**
A. LCA modeling strategies 19
A1. Prioritize the use of specific data for upstream processes 19
A2. Require or encourage EPDs to use more recent primary data 20
A3. Specify upstream data for key materials and processes (within a PCR) 20
A4. Specify common electricity, fuels, and transportation LCI datasets across PCRs 21
A5. Specify LCA methods: data collection, cut-off criteria, allocation approach, etc 21
B. Data stewardship strategies 22
B1. Maintain and improve public LCA data repositories (such as USLCI) 22
B2. Collect industry data to fill significant gaps in data used for EPDs 22
C. EPD reporting strategies 23
C1. Require or facilitate product characteristics to be reported consistently in EPDs 23
C2. Require EPDs to calculate and report supply-chain specificity scores 24
C3. Require EPDs to report EAC-based impacts separately 24
C4. Require or encourage EPDs to report GWP from fossil and biogenic carbon sources separately 25
C5. Require or encourage EPDs to calculate and report variability and uncertainty of their results 25
D. EPD verification and publication strategies 26
D1. Strengthen EPD verification 26
D2. Facilitate digitized (or digitizable) EPDs 26
6. Recommendations for Washington State **29**
Near-term strategies for the BCBF Program 29
Long-term strategies for the broader ecosystem 31
7. Acknowledgments **33**

Appendices **34**
Appendix A: LCA data quality 34
ISO definition of LCA data quality 34
Pedigree matrices 35
Variability and uncertainty 37

1. Introduction

This report provides **background information and recommendations on how to improve EPD data quality**. EPD data quality is important because EPDs serve as the basis for procurement policies like Buy Clean Buy Fair (BCBF), and the data in EPDs should be high-quality in order to support the goals of BCBF and other EPD use cases.

However, before we can discuss EPD data quality, we must first define what is "EPD data quality." Section 2 provides a working definition of "EPD data quality." We also introduce the various types of EPD data—the data that go into an EPD, and the data that come out of EPDs. These terms will later be used to describe the strategies and recommendations for improvement.

Section 3 provides an overview of how Product Category Rules (PCRs) affect EPD data quality, since PCRs specify data requirements in EPDs.

Section 4 discusses the current strengths and weaknesses of EPD data quality as they exist today.

Section 5 presents a list of strategies to address the current shortcomings of data quality in EPDs, and also identifies which kind of entities (including government agencies) can support which strategies.

Section 6 pulls out the recommendations from Section 5 that can be adopted by the Department of Commerce. In other words, how can the State of Washington help improve EPD data quality, both for the BCBF program in the near-term and for the EPD ecosystem in the long-term?

2. What is EPD Data Quality?

Currently, there is no single universal definition for EPD data quality. For the purpose of this report, we use the following working definition:

> ***EPD data quality**: the extent to which the EPD data supports the reliability, comparability, and user-friendliness of EPDs.*

This working definition comes from how we consider the following questions in relation to BCBF, discussed below:

- *What is EPD data?*
- *What is data quality, generally?*
- *What are EPD use cases?*
- *What are key EPD data quality characteristics — i.e., what qualities make EPDs fit for purpose?*

What is EPD data?

In this report, we mean "EPD data" to be broadly inclusive of:

1. the data used in the LCA model for the EPD (the EPD's *input data*), and
2. the data reported in the EPD (the EPD's *output data*).

Data used in the LCA model for the EPD

We can consider two types of data used in the **LCA model for the EPD**:

1. **Supply chain–specific data**, which is data from the actual product's supply chain. This could be either of the following types of data:
    a. The **manufacturer's own collected data:** often called "foreground" or "primary" data. Examples of this include:
        i. *X* kWh of electricity consumed at the plant;
        ii. *Y* kg of ingredient *A* used;
        iii. *Z* direct emissions measured from the plant.
    b. Data from **upstream suppliers**. This is called by various names: sometimes "foreground" or "primary" data, and sometimes "specific background" data.
2. **Average or generic data**: often called "background" or "secondary" data. This predominantly consists of:
    a. Data from **life cycle inventory (LCI) databases**: typically, average or generic datasets representing various processes and materials. Examples of this include:
        i. emissions per kWh of electricity consumed in a given location;
        ii. emissions per kg of an ingredient.

b. **Life cycle impact assessment (LCIA) datasets**, which convert emissions (such as CO_2 or CH_4) to impact assessment indicators (such as CO_2e).

Figure 1 provides more information about the possible types of data (and who could provide this data) in the LCA model of an EPD, separated by the life cycle stage of a typical process/product.

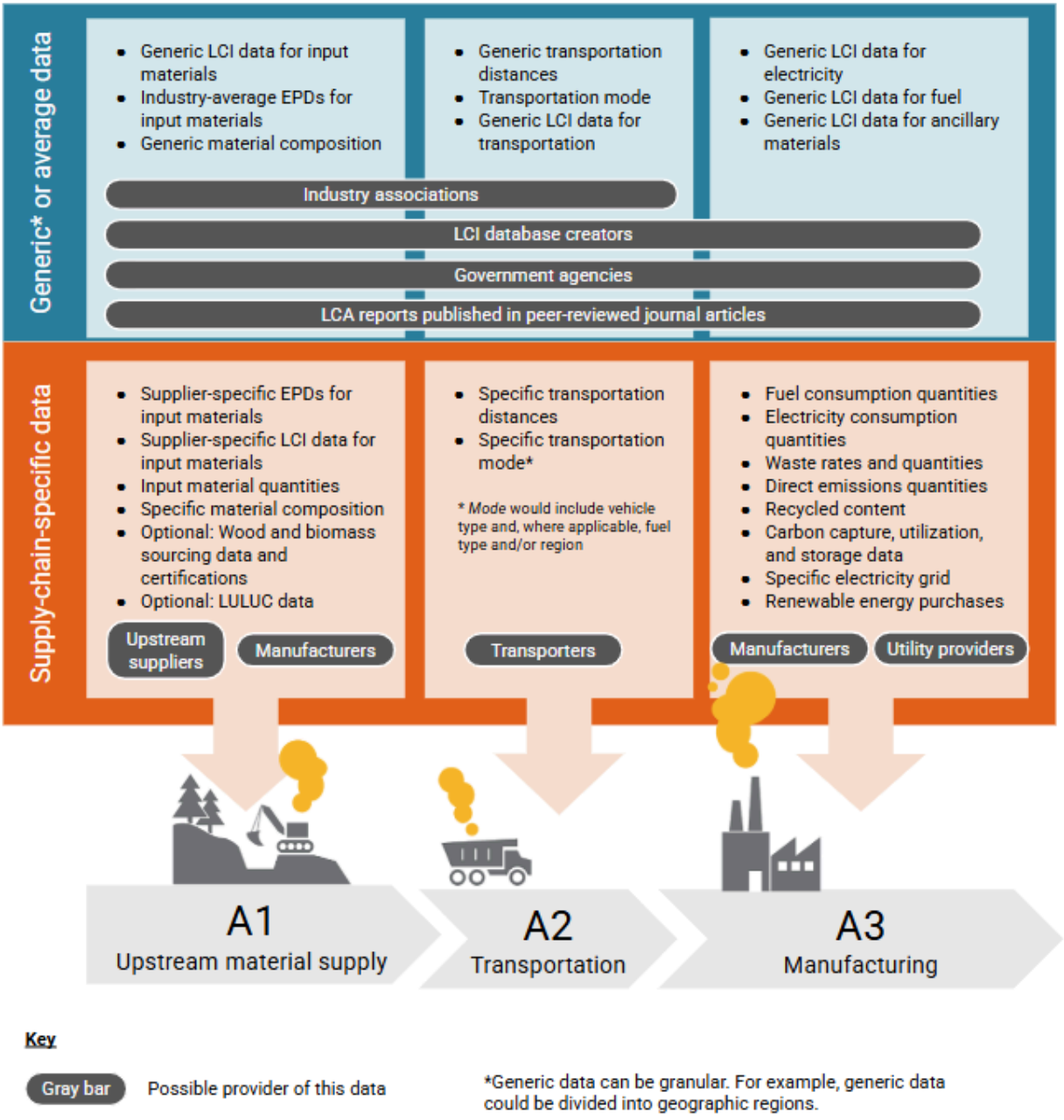


Figure 1. Types of data used in an LCA model, separated by life cycle stages A1–A3.

Data reported in the EPD

The **data reported in the EPD** includes:

1. The **LCA results**: the impact category results (e.g., GWP result) and other indicator results
2. **Additional** reporting and disclosures, such as:
    a. product characteristics
    b. facility location
    c. data quality assessment
    d. supply chain specificity (SCS) score
    e. verification information

These data types are diagrammed in Figure 2.



Figure 2. Types of EPD data. EPD input data is a combination of both (a) average or generic data and (b) supply-chain-specific data (which itself is often partly based on average or generic data for further upstream processes).

What is data quality?

A conceptual look at data quality…

If we asked ourselves, "What is chair quality?" we might quickly realize that we can't describe it with a single metric. We'd come up with a list of attributes related to our use of chairs: comfort, durability, aesthetics, ergonomics, etc. And we would likely decide that the way we assessed those different attributes, and the way we might weigh the importance of one attribute versus another, wouldn't be universal—they would depend on the chair type and its use case. We may have different criteria for office chairs vs. dining chairs vs. recliners, etc. It is similar for data quality.

Currently, there is no single universal definition for EPD data quality.

Definitions for "data quality" vary, but they generally focus on the extent to which the data is fit for its purpose or use cases. Additionally, data quality tends to be:

- Multi-attributed, meaning that it includes a constellation of attributes that have different types of assessment and may or may not always align with each other; and
- Context-specific, meaning that data quality is not universally applicable, but depends on the particular use case(s) of the data in question.

This leads us to the question, "What are the use cases for EPDs?"

Use cases for EPDs

According to the American Center for Life Cycle Assessment (ACLCA) PCR Open Standard,[1] the primary use cases for EPDs are:

- **Transparency**: EPDs should clearly report the underlying processes in the product's supply chain that are included in the LCA and document the data sources and methods used to quantify the EPD's environmental impact results.
    - The ACLCA describes EPD use cases as cumulative levels, where transparency is the "baseline use case" for EPDs. And the following two use cases build on this baseline.
    - BCBF's current program focuses on the transparency use case of EPDs.
- **Procurement**: If a consumer (such as a government agency) wants to purchase a product based on its environmental impact, EPDs can support procurement decisions by informing the consumer of the environmental impacts of different products available on the market.
    - ACLCA's "procurement" use case builds on the baseline transparency case and focuses on EPD comparability — comparing the results of different EPDs for the same product type, or comparing an EPD result against a threshold or limit. Compared to the transparency use case, "EPDs used to support procurement decisions require a higher level of prescriptiveness."
    - BCBF may evolve in the future to use EPDs for procurement decisions. Many public procurement policies, private owner requirements, and green building rating systems do this already.
- **Data source**: EPDs can also be used as building blocks for downstream EPDs or in LCAs of whole buildings (WBLCA), projects, or assemblies.

[1] Bhat, C. G., Adhikari, T., Mellentine, J., Feraldi, R., Lasso, A., Swack, T., Mukherjee, A., Dylla, H., & Rangelov, M. (2022). *2022 ACLCA PCR Guidance – Process and Methods Toolkit*. American Center for Life Cycle Assessment (ACLCA). https://cdn.prod.website-files.com/685abecf52079050b589877d/685abecf52079050b5898974_2022-ACLCA-PCR-Guidance_v1_Introduction_05252022.pdf Accessed May 7, 2026

- The "data source" use case builds on the previous two levels and "requires harmonization with products and co-products up and down the supply chain, prescribing common public background datasets, and a rigorous assurance of data quality and completeness."
- While this is not BCBF's current or likely use case for EPDs, it is an important function of EPDs to consider, such as in the context of whole-building LCA.[2]

Next, we need to consider: *what are the key characteristics of EPDs to effectively serve these use cases?*

Key EPD data quality characteristics

EPDs that are fit to effectively serve the use cases above are:

- **Reliable**. EPD results should accurately and completely represent the intended product(s) (as much as possible) so that they can serve their intended purpose as effectively as possible.
- **Comparable**. EPDs should use consistent methods, data, and reporting so that they can be compared with or used equivalently as EPDs of other products, especially within the same product category.
- **User-friendly**. EPDs should be accessible and transparent. The consumer of the EPD should be able to find the EPD and understand it, and software tools should be able to read and import the EPD. The EPD's reporting should support a user's understanding of where the results come from and how to use them.

When we combine the general concept of data quality (*the extent to which the data is fit for its purpose or use cases*) with the characteristics of effective EPDs that are fit for serving their use cases (*reliable, comparable,* and *user-friendly*), this leads us to our working definition for *EPD data quality*:

> ***EPD data quality**: the extent to which the EPD data supports the reliability, comparability, and user-friendliness of EPDs.*

The development of this definition is illustrated in Figure 3.

[2] See BCBF Brief #5 *Design Strategies for Lower Embodied Carbon State Buildings* for more discussion of WBLCA.

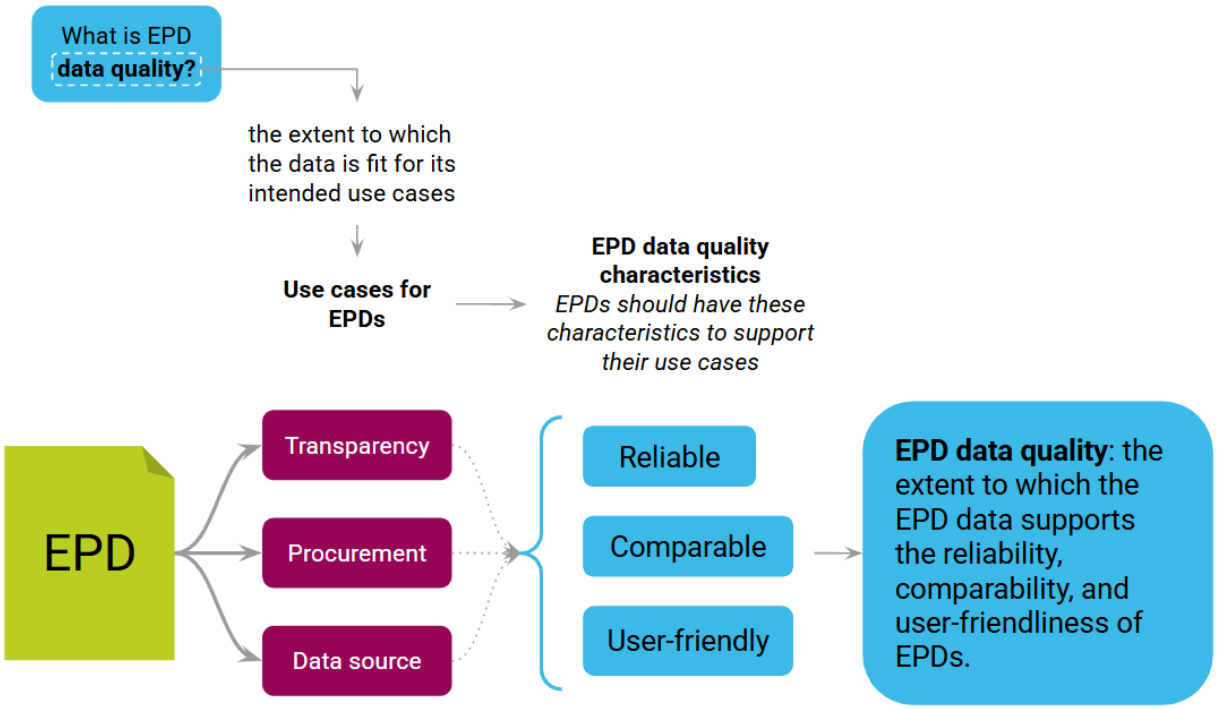


Figure 3. Development of the definition for *EPD data quality*.

Note that data quality for *LCA* (the input data for an LCA model) has traditionally been defined and assessed based on ISO 14044 and pedigree matrices. For more information about this topic, see Appendix A.

3. PCR Review

Since PCRs are so critical to many of the items listed above, it is helpful to see how PCRs currently treat these various contributors to EPD data quality. See Table 1 for a summary table on how the PCRs of covered products in BCBF treat EPD data quality.

Table 1. Review of how PCRs (of covered products in BCBF) treat data quality. ✓ = true, ✗ = false. The references for the reviewed PCRs are listed below the table.

Data quality element		Concrete [a]	Precast [b]	CMU [c]	Wood [d]	Steel [e]
LCA modeling	PCR prescribes electricity impacts data source?	✓	✓	✓	✗	✗
	PCR prescribes transport impacts data source?	✓	✗	✓	✗	✓
	PCR prescribes fuel combustion impacts data source?	✓	✗	✓	✗	✗
	PCR provides background data selection hierarchy?	✓	✗	✓	✓	✓
	PCR specifies impact data for key GWP contributors (hotspots)?	✓	✗	✓	✗	✓
	Maximum age of secondary data at EPD publication (years)[f]	none	none	10	10	10
	Maximum age of primary data at EPD publication (years)[f]	3	3	5	5	5[g]
Reporting requirements for EPDs	Report SCS scores?	✗	✗	✗	✗	✓
	Report GWP-biogenic and GWP-fossil separately?	✓	✗	✗	✗	✗
	Report reference service life?	✗	✗	✗	✗	✗
	Report key product performance characteristics?	✓	✗	✓	✓	✓
	Report variability or uncertainty of EPD results?	Ind-avg. EPDs only	✗	✗	Ind-avg. EPDs only	Ind-avg. EPDs only
Verification an	Are there basic verification requirements/rules per ISO 14025?	✓	✓	✓	✓	✓
	Are there additional PCR-specific verification requirements?	✓	✓	✗	✗	✗

Data quality element		Concrete [a]	Precast [b]	CMU [c]	Wood [d]	Steel [e]
d pu bli ca ti on	Require digitized EPD format?	⊗	⊗	⊗	⊗	✓

[a] **Concrete** (including ready-mixed concrete and shotcrete): NSF International. (2026). *NSF Product Category Rule for Environmental Product Declarations: Concrete, version 3.* https://d2evkimvhatqav.cloudfront.net/documents/PCR-Product-Category-Rules/NSF-1112-26.pdf?v=1779365153. *Version 3 recently replaced the previous version 2.3.*

[b] **Precast concrete**: NSF International. (2021). *Product Category Rule for Environmental Product Declarations: PCR for Precast Concrete v3.0*. https://www.nsf.org/nsf-standards/product-category-rules
NSF is currently developing a new version of the precast PCR.

[c] **Concrete masonry units (CMU)**: UL. (2022). *PCR Part B: Concrete Masonry and Segmental Concrete Paving Product EPD Requirements v1.1*. https://www.shopulstandards.com/ProductDetail.aspx?productId=ULE10010-29_2_S_20220301. *Smart EPD is currently developing a new version of the concrete masonry PCR.* (https://smartepd.com/pcr-library/)

[d] **Wood** (including sawn lumber and engineered wood products): UL Environment. (2020). *Product Category Rules for Building-Related Products and Services – Part B: Structural and Architectural Wood Products EPD Requirements*. UL. https://www.shopulstandards.com/ProductDetail.aspx?UniqueKey=36412.
UL is currently developing a new version of the wood PCR.

[e] **Steel** (including reinforcing, prestressing, and structural steel products): Smart EPD. (2025). *Smart EPD Part B PCR for Designated Steel Construction Products (1000-008) v3*. https://smartepd.com/pcr-library

[f] Primary and secondary data age requirements for these PCRs are specified in the corresponding Part A PCRs. (Part B PCRs can provide additional specifications.)

[g] The steel PCR says that EPDs should use primary data that is under 2 years old, or else provide justification.

4. Current Strengths and Limitations of EPD Data Quality

This section describes the current strengths and limitations of EPD data quality in the industry today before diving into strategies for improvement in the next section.

Current strengths

Before diving into the challenges and limitations of EPD data quality, this section briefly highlights the current strengths of EPD data quality. Currently, some positive aspects of EPD data quality are:

1. **The existence of PCRs**. LCAs used to be based on company-specific, private methodologies. PCRs provide standard guidance across assessments, helping ensure that LCAs for EPDs are performed in a more rigorous, consistent way. Also, since PCRs are publicly available documents, users of EPDs now have more insight and confidence in the reliability and consistency of EPDs.
2. **Independent verification**. Having a third party review the LCA calculations enhances confidence in the EPD results.
3. **PCRs are becoming more detailed**. PCRs have become more prescriptive, which is helpful because it makes many of the decisions for the LCA model ahead of time, typically leading to greater comparability. This also helps guide the development of EPD generation tools, which will lead to lower production costs for EPDs.
4. **The life cycle perspective is captured**. Other environmental reporting schemes for products often include only the manufacturer's direct operations (Scopes 1 and 2 in GHG accounting terms; module A3 in EPD terms). EPDs include the upstream impacts from raw material extraction and the production and transport of input materials (a subset of Scope 3 emissions in GHG accounting; modules A1 and A2 in EPD terms).
5. **EPDs can be product specific**. It is notable that product-specific EPDs even exist, considering that just a few years ago, many manufacturers expressed concerns about sharing internal company data.
6. **EPDs include other environmental impact indicators, not just carbon**. This gives users a more holistic picture and allows them to assess tradeoffs.
7. **TRACI is starting to include regionally specific characterization factors**, like those for eutrophication.
8. **PCRs in the construction sector are far ahead of other sectors** in terms of quantity, coverage of the market, alignment with each other, and detail.

9. **The common "building-block" processes, such as transportation and energy, are available in the US Federal LCA Commons.** This **free and publicly available secondary LCI data** gives all manufacturers and EPD developers access to the same background data sources. Thus, all US-based LCAs could potentially use the exact same LCI processes for these common activities, providing better alignment in the background data of the LCAs and better comparability of results.
10. **The community of leaders in the world of LCA and EPDs cares about improving the quality and veracity of EPDs, and they are driving the charge.** This means that EPD data quality is expected to improve over time.

Current challenges and limitations

In addition to the many positive aspects of EPD data quality described above, there are also challenges, organized below by the three key EPD data quality characteristics defined above: reliability, comparability, and user-friendliness.

The current key limitations to EPD **reliability** are:

A. **Limited representativeness (temporal, geographical, and technological) of the input data. Currently, there are the following issues:**
    a. **Not using supply chain–specific data**. Sometimes, EPDs use generic or average data where supply-chain-specific data would be more appropriate.
    b. **Input data is too old**. Sometimes, the age of the input data is too old to accurately represent the current product.
    c. **Average or generic secondary data is not representative**. Sometimes, when average or generic data is used, it does not accurately represent the supply chain or the manufacturing process.

B. **LCI data gaps.** In some cases, publicly available secondary LCI data sources may not be available or prescribed for all materials and processes within the system boundary. Further, there may be materials or processes within a supply chain that have no available secondary LCA data in any database or other data source. In this case, EPD creators face the challenge of handling the data gap (e.g., by choosing a proxy dataset or ignoring the process) if not addressed by the PCR. The National Institute of Standards and Technology (NIST) recently published two thorough reports on LCI data gaps for construction product EPDs.[3]

The current key limitations to the **comparability** of EPDs are:

[3] Ranganath, S., Rodriguez-Garcia, G., Kneifel, J., & Parekh, P. (2025). *NIST TN 2353: Environmental Product Declaration (EPD) Database Creation and Public Life Cycle Inventory (LCI) Data Gap Assessment*. NIST. https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.2353.pdf and Kneifel, J., Rodriguez-Garcia, G., & Ranganath, S. (2025). *NIST TN 2338: Public Life Cycle Inventory Data Gap Analysis through Process Modeling*. NIST. https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.2338.pdf

A. **Different secondary data to model the same processes**. If EPDs use different secondary data sources to model the same process, differences in EPD results are more likely to be due to differences in data selection rather than differences in the real world.

B. **Different LCA methods.** Currently, the LCA methods used in EPDs vary in their data collection procedures, allocation procedures, cut-off criteria, scenario assumptions, consideration of biogenic carbon, and consideration of energy attribute certificates (EACs) in the EPD results.

C. **Different scopes/reporting stages.** For similar product types (such as unfabricated rebar vs fabricated rebar), EPDs will sometimes report results in different life cycle scopes.

D. **Inconsistent or unclear functional properties of products**. Currently, it can be difficult to determine if the products covered by different EPDs are functionally equivalent. Declared units do not always account for relevant functional performance characteristics (such as different weight classes of CMU). And EPDs for similar products may not consistently report functional performance attributes or other relevant product characteristics, which makes it difficult to appropriately compare EPDs with each other, or against a target value.

E. **Different degrees of variability.** There may be differences in the results due to different degrees of aggregation of data (for example, the variability of data from one facility versus the variability of data from many facilities) or differences in the use of specific versus generic data.

The current key limitations to EPD **user-friendliness** (accessibility and transparency) are:

A. **Lack of EPD coverage**. There are still many products for which there are no EPDs. This is partly because it is expensive and time-consuming for manufacturers to create EPDs. This lack of EPD coverage in the market limits users' ability to understand products, make informed decisions, or accurately represent a product in a WBLCA model or downstream EPD.

B. **Limited reporting or transparency related to the EPD results, scope, or data**. Sometimes, EPDs do not report enough information to ensure transparency of what the EPD covers or how to understand the results. For example, there can be a lack of transparency where EPD results are based on combined data: e.g., only results that include RECs, biogenic carbon, carbonation, etc.

C. **Difficult to sort, filter, or extract data from EPDs**. Sometimes it is difficult for EPD users to read or interpret EPDs because they are usually published in PDF files (rather than a digital format) with different layouts, terminology, etc. This makes it hard for humans as well as machines to accurately and consistently understand the information in the PDF document.

D. **Not published in a central location**. EPDs are typically published by the EPD owner (i.e., on their company website) instead of a central location. This makes it difficult to find EPDs or sort by product type or performance characteristics. Note that EC3, which is an online database of EPDs, currently serves this function by collecting and digitizing EPDs.

5. Strategies to Improve Data Quality

In this section, we will present various strategies to address the current challenges and limitations of EPD data quality. This section is organized by topic:

A. LCA modeling
B. Data stewardship
C. EPD reporting
D. EPD verification and publication

The strategies are previewed in Table 2 below, which also summarizes the EPD data quality characteristics that these strategies aim to improve.

Table 2. List of strategies to improve EPD data quality.

Category	Strategy for improvement	Target EPD data quality characteristic(s)		
A. LCA modeling	A1. Prioritize the use of specific data for upstream processes	reliable		
	A2. Require or encourage EPDs to use more recent primary data	reliable		
	A3. Specify upstream data for key materials/processes (within a PCR)	reliable	comparable	
	A4. Specify common electricity, fuels, and transportation LCI datasets across PCRs	reliable	comparable	
	A5. Specify LCA methods: data collection, cut-off criteria, allocation approach, etc.	reliable	comparable	
B. Data stewardship	B1. Maintain and improve public LCA data repositories (such as USLCI)	reliable	comparable	
	B2. Collect industry data to fill significant gaps in data used for EPDs	reliable		
C. EPD reporting	C1. Require product characteristics to be reported consistently in EPDs		comparable	
	C2. Require EPDs to calculate and report supply-chain specificity scores		comparable	user-friendly
	C3. Require EPDs to report EAC-based impacts separately	reliable	comparable	user-friendly
	C4. Require EPDs to report GWP from fossil and biogenic carbon sources separately	reliable	comparable	user-friendly
	C5. Require EPDs to calculate and report variability and uncertainty in their results	reliable	comparable	user-friendly
D. EPD verification and publication	D1. Strengthen EPD verification	reliable		
	D2. Facilitate digitized (or digitizable) EPDs		comparable	user-friendly

A. LCA modeling strategies

These strategies relate to how the LCA modeling is done for the EPD, including LCA data selection (strategies A1–A4) and LCA methods (strategy A5).

A1. Prioritize the use of specific data for upstream processes

Description: Using more specific data makes EPDs more representative of the actual product system. This strategy would require or otherwise prioritize the use of specific data reflecting the actual supply chain to represent activities or emissions outside of the EPD owner's control (such as the production of input materials). Specific data that represents the actual suppliers of input ingredients or processes (rather than generic or average data for those ingredients or processes) increases the representativeness of the input data and the **reliability** of the EPD result. This strategy could be implemented in various ways:

- **Require the use of specific data for designated key processes**. For example:
    - For steel decking EPDs, use facility-specific data for upstream steel coil production (the main contributor to steel decking impacts)
    - For concrete EPDs, use facility-specific data for upstream cement production (the main contributor to concrete impacts).
- **Incentivize EPDs to meet a target supply-chain-specific (SCS) data score.** For example, PCRs or policies could require that EPDs for a given product type use at least 70% supply-chain-specific data, and the EPD developer could choose which processes to represent with specific data to meet that threshold. Note that different product types should have different thresholds or targets. This is because (i) for some product types, the manufacturer controls the processes that contribute the most emissions, and for other product types, they don't; and (ii) some product types have major ingredients with readily available EPDs to use as data inputs, and some do not.
- **Otherwise prioritize the use of specific data**. Some PCRs provide a data selection hierarchy. For example, the steel PCR (section 7.1.9) directs EPDs to use, in the following order of preference: (1) specific data, where available; (2) default data prescribed by the PCR; (3) datasets that are pre-approved by the PCR (for processes with PCR-prescribed data); and finally (4) another data source, with justification.

Who has control or influence:

- PCR committees and program operators creating and publishing PCRs.
- Project owners who set design or procurement criteria for their construction projects. (This includes Washington State and other state, local, and federal government agencies, and private companies that build projects, particularly those with large portfolios.)

A2. Require or encourage EPDs to use more recent primary data

Description: "Primary data" here refers to data covering processes under the manufacturer's control or measured by the manufacturer (such as quantities of input ingredients consumed, the distance of transport from upstream supplier to manufacturer, the quantity of electricity consumed at the manufacturing plant, or the total quantity of product produced). PCRs, policies, or programs can specify that the EPD uses data that is no older than a certain number of years. This ensures more temporally representative input data, which supports the **reliability** of the EPD result.

PCRs generally have some requirement for this (as well as for secondary data) already, typically related to the amount of time from the data collection period to when the EPD is published. (See Table 1.) EPDs are typically valid for five years after publication. Other approaches, such as one proposed by the California Air Resources Board's (CARB) embodied carbon policy, provide a requirement around the timeline from the data collection period to the time of submitting the EPD for a project. This second approach could effectively reduce an EPD's validity period (from the standard five years to something smaller) in the context of the given policy or program.

A variant of either approach is to provide a default expectation for a shorter data vintage (e.g., two years before EPD publication), and provide the option for EPDs to deviate from that expectation and use older data if they can justify that it is still sufficiently representative of their current manufacturing practices. (It would still need to be under some maximum age requirement, e.g., five years before publication.)

Who has control or influence:

- PCR committees and program operators creating and publishing PCRs
- Project owners, including Washington State

A3. Specify upstream data for key materials and processes (within a PCR)

Description: In cases where EPDs use secondary average or generic data to represent a given upstream process, the PCR should specify which secondary dataset to use to represent the given process.

If EPDs use the same data source to model the same real-world process, this promotes EPD **comparability** *within a given product category*. Users can have more confidence that differences in EPD results are due to real-world emissions differences rather than differences in modeling and data selection.[4]

Who has control or influence: PCR committees and program operators creating and publishing PCRs.

[4] The EPA's Secondary Data Improvement Plan identified "the need for specification of [relevant and representative] data in PCRs as required for developing associated EPDs." U.S. EPA. (2024). *A Vision and Plan to Improve Secondary Life Cycle Assessment Data Used in Environmental Product Declarations.* https://www.epa.gov/system/files/documents/2024-08/secondary-data-improvement-plan_08062024_final.pdf

A4. Specify common electricity, fuels, and transportation LCI datasets across PCRs

Description: Virtually all construction products use electricity, fuels, and transport in their production process. This means that all EPDs depend on emissions data, or LCI datasets, for these inputs. However, there are multiple LCI datasets, including datasets that are public and private, at different levels of aggregation or granularity, older and newer, etc.

In many cases, EPD developers and manufacturers can select the dataset of their choice. This means that Company A and Company B might use different emission factors to represent the same real-world processes in their EPDs. This leads to differences in EPD results due to data selection rather than to actual real-world emissions.

If PCRs specify which LCI datasets to use for common electricity, fuel, and transportation data, EPDs become more **comparable**, and users can have more confidence that differences in EPD results are due to real-world emissions differences rather than differences in data selection.

Note that this strategy would support *harmonization across product categories* and *better comparability of different materials and assemblies in WBLCA*. While it is generally inappropriate to directly compare EPDs across categories, these comparisons happen indirectly anyway when EPDs are used as inputs to WBLCA models. Additionally, people compare the results of different WBLCA models that incorporate different material types.

Who has control or influence: Entities engaged with the development of multiple PCRs, such as:

- Program operators or PCR committees that are developing PCRs, especially a PCR Part A that applies across all construction product categories
- The ACLCA, which is developing the PCR Open Standard (that applies across PCRs of different categories)

A5. Specify LCA methods: data collection, cut-off criteria, allocation approach, etc.

Description: LCA methods such as data collection procedures, cut-off criteria, and allocation approaches can vary widely across LCAs. This strategy proposes specifying a single approach for each type of method in order to promote consistency in the underlying LCA models, and thus **comparability** between EPDs.

It should be noted that there are no right or wrong LCA methods from a scientific perspective. Often, they are based on different modeling assumptions or human values, which are subjective.

Who has control or influence:

- PCR committees and program operators creating and publishing PCRs
- Project owners, including Washington State
- ACLCA

B. Data stewardship strategies

The following strategies relate to the development, maintenance, and curation of data that EPDs and other LCAs use. There is an emphasis on free and publicly available LCA data.

B1. Maintain and improve public LCA data repositories (such as USLCI)

Description: Public LCA data repositories such as the U.S. Life Cycle Inventory (USLCI) database and others in the Federal LCA Commons provide free, publicly accessible LCA data. The value of these databases depends on how well and how often they are maintained and updated. Maintenance and updates are valuable because they address bugs, expand scope, and improve timeliness (i.e., data based on more recent studies).[5]

Maintenance and updates support more reliable, more timely, comprehensive, and accessible LCA data to practitioners for EPD inputs. If EPD developers have access to consistent, well-maintained, timely, and freely accessible data, then the resulting EPDs are more likely to be **reliable** and **comparable**. Additionally, PCRs are more likely to prescribe or prefer these public datasets. (See *Specify common electricity, fuels, and transportation LCI datasets across PCRs*.)

Who has control or influence:

- The federal government, including its various agencies and national laboratories, currently supports public LCA data repositories through funding and carrying out and/or commissioning the data work.
- Industry can support this effort by collecting and aggregating manufacturer data and submitting it to USLCI (the public repository that accepts private industry data).[6] See more on this in the next strategy.

B2. Collect industry data to fill significant gaps in data used for EPDs

Description: LCA data gaps, especially for significant processes in an LCA model, impede the development of complete and representative models, which limits the accuracy and reliability of EPDs. To help address this, industry and LCA practitioners can collaborate to collect and aggregate primary data, and then integrate that data into LCA data repositories such as USLCI, where it can be available as inputs for downstream EPDs and other LCA studies.

Well-funded data collection and creation efforts can help fill these gaps, leading to more complete and representative input data to EPDs, leading to more **reliable** EPD results. With further research, a list of priority LCA processes could be identified that would support BCBF materials. This could include items such as local aggregate production, iron ore mining, etc.

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[5] The EPA's Secondary Data Improvement Plan identified the "need for the usability of the specified data so that LCA practitioners can use the data to generate EPDs…" Usability of the data depends on its availability (preferably free and publicly accessible) and if its format can be used in relevant software (U.S. EPA., 2024).
[6] The Federal LCA Commons provides this data submission toolkit: https://flcac-admin.github.io/FLCAC-docs/datasubmissiontoolkit/

Who has control or influence:

- Manufacturers can provide their own primary data.
- LCA practitioners at (or contracted to) federal agencies, national labs, etc., could do the gap analysis (building upon NIST's recent work[7]) and data aggregation.
- Funding can be provided by:
    - the federal government
    - industry associations
    - grant-making organizations
    - state government agencies, if they already subsidize or are involved in certain industries, they could support primary data collection in these industries.

C. EPD reporting strategies

These strategies relate to the reporting that occurs in EPDs. Separate from the issue of how the LCA was performed (LCA modeling strategies above), EPDs should communicate their results and related information in such a way that supports their effective use.

C1. Require or facilitate product characteristics to be reported consistently in EPDs

Description: To the extent possible, EPDs should clearly and consistently report product characteristics that support appropriate sorting, filtering, and comparing of EPDs.[8] For example, gypsum panels are produced in different thicknesses, with different types of facers, fire ratings, and other performance qualities such as moisture and mold resistance. Ideally, all gypsum panel EPDs would use the same format to consistently report the relevant values for each of these fields (thickness, facer type, etc.).

Clear and consistent reporting of relevant product characteristics supports **user-friendliness** (particularly transparency) and **comparability**. It allows EPD users to understand what type of products are represented in the EPD, and allows tools to incorporate that information so that tool users can effectively sort, filter, and compare EPDs based on desired functional or physical criteria.

[7] NIST technical notes NIST TN 2338 and NIST TN 2353. (Section 4 of this report provides full citations.)
[8] ERG. (2026). ERG's Environmental Product Declaration Requirements v1.0. Requirement 4: "The EPD shall include a description of each product that clearly outlines material and performance characteristics…"

Who has control or influence:

- PCR committees and program operators creating and publishing PCRs. (The PCR can require this reporting, including requirements for what to report and how to report it — e.g., units; numeric values vs. drop-down of options, etc.)[9]
- EPD generator tools can support this by building fields for reporting product characteristics into their tools, facilitating easier uptake by manufacturers and more consistent reporting to support user-friendliness.
- Project owners can ask for this information to be reported in a clear and consistent manner.

C2. Require EPDs to calculate and report supply-chain specificity scores

Description: This strategy would require EPDs to calculate and report their supply-chain-specificity score according to the ACLCA guidance.[10] This improves an EPD's transparency about the representativeness and specificity of its input data, which can in turn support decision-making that considers EPD reliability. It also lays the groundwork to indirectly support more reliable EPDs (that use more specific input data) — manufacturers may push for more specific data to increase their supply-chain specificity scores.

Who has control or influence:

- PCR committees and program operators creating and publishing PCRs
- Project owners, including Washington State. For example, WA BCBF can require this for the EPDs they accept — either within the EPD itself or separately.[11]

C3. Require EPDs to report EAC-based impacts separately

Description: If an EPD includes purchased attributes from energy attribute certificates (EACs), such as renewable energy certificates (RECs), in the LCA model, this strategy would require the manufacturer to provide separate reporting of the EPD results with and without those attributes.[12]

Separate reporting supports **transparency (a component of user-friendliness)**, as well as accuracy, **reliability**, and **comparability**. Purchased RECs and other EACs often represent energy generated in a different location and/or time period from the manufacturer's actual consumption. And they may not lead to reduced emissions that wouldn't have otherwise occurred. Separate reporting allows EPD users the option to consider either impact result, depending on the user's goals and the nature of the EACs.

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[9] The latest North American steel PCR (Smart EPD, 2025), Section 9.3.2, Table 8 "Steel product specifications" provides an example of various attributes (system boundary option, form factor, etc.) and instructions for EPDs ("pick one," "pick all that apply," "true/false," etc.).

[10] ACLCA. (2025). Guidance for Determining EPD Types and Calculating and Communicating Data Specificity Through the Supply Chain. https://www.aclca.org/initiatives#PCR-Open-Standard

[11] See the UW/CLF BCBF Brief #4 on consistent treatment of reporting for more on this topic.

[12] See the UW/CLF BCBF Brief #3 on scope 2 emissions for more on this topic.

Who has control or influence:

- PCR committees and program operators. PCRs can require this in EPDs.
- Project owners, including Washington State. For example, WA BCBF can require this for the EPDs they accept — either within the EPD itself or separately.
- ACLCA can revise its guidance on this topic (which many PCRs reference) to require separate reporting of impacts with and without EACs.

C4. Require or encourage EPDs to report GWP from fossil and biogenic carbon sources separately

Description: Separate fossil and biogenic carbon reporting means providing separate results for GWP due to fossil and biogenic GHG emissions, in addition to total GWP.

Separate reporting supports **transparency** (a component of **user-friendliness**), as well as accuracy, **reliability**, and **comparability**, by helping avoid counting only the benefits of biogenic carbon (the sequestration counted in A1 as a negative GWP value) while omitting the corresponding emissions (positive GWP value) at the end-of-life and/or manufacturing stages.

This separate reporting also aligns with EN15804+A2[13] (the core rules for construction product EPDs generally used outside of North America), which supports better global alignment of EPDs.

Who has control or influence:

- PCR committees and program operators. PCRs can require EPDs to do separate reporting. EPDs can also do this independently of the PCR, as long as they don't conflict with it. For example, EPDs could follow the PCR for their main results, and provide separate results as additional environmental information)that differentiate fossil carbon from biogenic carbon.
- Project owners, including Washington State. For example, WA BCBF can require this for the EPDs they accept — either within the EPD itself or separately.

C5. Require or encourage EPDs to calculate and report variability and uncertainty of their results

Description: This strategy would require or encourage EPDs to calculate and report the variability and/or uncertainty in their EPD results. This promotes more **transparency** in the results, and could also support **comparisons** based on uncertainty-adjusted GWP results, similar to the approach in the Embodied Carbon in Construction Calculator (EC3) tool.[14]

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[13] European Committee for Standardization (CEN). (2019). *EN 15804:2012+A2:2019: Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products*. https://www.en-standard.eu/bs-en-15804-2012-a2-2019-sustainability-of-construction-works-environmental-product-declarations-core-rules-for-the-product-category-of-construction-products/

[14] Building Transparency provides documentation for the EC3 tool's methodology around calculating EPD uncertainty and incorporating it into results here: https://docs.buildingtransparency.org/methodology/uncertainty-and-statistics

We anticipate the ACLCA to publish a report very soon on calculating and incorporating uncertainty into EPD results. We recommend reviewing this forthcoming publication for the most up-to-date approaches and thinking on this topic. If appropriate, WA Commerce may consider incorporating its methods into BCBF reporting and/or advocating for PCRs to incorporate its methods.

Who has control or influence:

- Independent groups like ACLCA can publish methods for calculating and reporting variability/uncertainty in EPDs.
- PCRs can adopt the above methods and require EPDs to calculate and report the variability and uncertainty of results.
- Project owners, including Washington State. For example, WA BCBF can require this for the EPDs they accept — either within the EPD itself or separately.
- EPD database tools like EC3 can provide uncertainty (in some format) along with results. By providing conservative uncertainty values using their own methods, this might push manufacturers to publish their own more accurate uncertainty results for tools to use.

See “Variability and uncertainty” in Appendix A for further discussion.

D. EPD verification and publication strategies

These strategies relate to what happens after the manufacturer and EPD developer have done their work of developing the LCA model (strategies A1–A5) and compiling and communicating the results in the EPD report (strategies C1–C5) — external verification and review of the LCA and EPD, and final EPD publication, making it available to the public.

D1. Strengthen EPD verification

Description: This strategy aims to make EPD verification more robust and more efficient. Each of these aspects is discussed more below:

- **Why verification needs to be more robust**: Current EPD verification focuses mostly on the alignment of the EPD’s methods with the governing PCR and related standards (ISO 14025, ISO 21930, etc.). However, it typically does not cover data values (e.g., quantities of materials or electricity used). This means that verification may not catch mistakes or prevent the publication of inaccurate or inconsistent results. More robust EPD verification, including verification of the primary data inputs, would improve **EPD reliability** — both in terms of the effects on the accuracy of the actual numbers and the public’s perception of the robustness of EPDs and the extent that they are appropriate for comparative or regulatory use cases. For ideas on how to make verification more robust, see the suggestions below under “Who has control of influence.”

- **Why verification needs to be more efficient**: Verification is currently a major bottleneck in EPD development. If verification were more efficient, it would be easier for manufacturers to

publish EPDs and thus make EPDs more available to end-users (an aspect of **user-friendliness**). It could also indirectly support more robust verification by freeing up verifiers to provide a more thorough and comprehensive review. For ideas on how to make verification more efficient, see the suggestions below under "Who has control or influence."

Who has control or influence:

For more robust verification:

- Program operators could increase the verification requirements for EPDs they publish. (They could, for example, require facility site visits and verification of the primary data.[15])
- ACLCA or similar entities could develop step-by-step guidance on how to verify data and results.
- Project owners or government agencies could require more robust verification in the EPDs they accept.

For more efficient verification:

- Funders can support the expansion of the pool of EPD verifiers through workforce development efforts, which would help alleviate the bottleneck problem.
- ACLCA and similar entities could develop trainings and other support measures to increase the capacity of verifiers.
- PCR committees and program operators can make PCRs clearer and more prescriptive, to support streamlined verification.
- Organizations that develop EPD generator tools can continue to improve those tools to also support streamlined verification.
- Program operators can invest in automating more of the rote or complex tasks of verification, perhaps with the help of artificial intelligence (AI).

D2. Facilitate digitized (or digitizable) EPDs

Description: This strategy would support publishing EPDs in a digital format (such as openEPD[16]) or in a form that supports straightforward post-publication digitization. Currently, EPDs (and their publishing program operators) have inconsistencies in data structures, scopes, units, version management, etc.[17]

Digital EPDs allow for more **accessibility** (a component of **user-friendliness**): digitization makes it easier to search for and **compare** EPD results, or to use EPD results as inputs to whole-project assessments. The best case is for manufacturers to publish their EPDs digitally. This allows them to

[15] Facility verification visits are more common in other certification schemes and regulatory programs, such as the International Living Futures Institute (https://living-future.org/lpc/certification/) and the U.S. EPA (https://www.epa.gov/compliance/monitoring-compliance).
[16] https://www.open-epd-forum.org/
[17] Building Transparency. (2026). "Behind the Data: What It Takes to Keep Up EC3's EPD Database." https://www.buildingtransparency.org/behind-the-data-what-it-takes-to-keep-up-ec3s-epd-database/

ensure that the digitized data is correct and complete. The currently common scenario is that third parties digitize previously published PDFs, which tends to lead to many omissions and errors due to the range of EPD PDF formats and the multiple potential interpretations of reporting requirements for EPDs.

Who has control or influence:

- PCR committees and program operators. PCRs can support digitization by providing consistent and discrete fields that EPDs must report values for, with clear data format options.
- Manufacturers and EPD developers can choose to publish EPDs digitally.
- Developers of EPD generator tools can streamline this process by building tools that support direct publication of digitized EPDs.

6. Recommendations for Washington State

This section presents a list of recommendations that Washington State could adopt to help improve EPD data quality, built on the strategies described in the previous section. The first subsection contains recommendations specifically for the WA BCBF Program, and the second subsection contains recommendations that the State could adopt outside BCBF to improve the broader ecosystem around EPD data quality.

Near-term strategies for the BCBF Program

Washington State could adopt the following strategies in BCBF to help improve the quality of EPD data submitted to the program.

1. **Specify which PCRs should be followed.** To improve clarity, it would be beneficial for Commerce to specify which PCR (name, program operator, and version) to follow for each covered product category, especially if/when BCBF implements GWP limits.
    - Pros: This strategy promotes consistency and comparability across the submitted EPDs for a given product type.
    - Cons: This strategy would exclude EPDs that follow less common PCRs (such as European-focused PCRs). There would be the logistical challenge of how to treat still-valid EPDs from recently expired PCRs.
    - Notes: Where many existing EPDs use a recently outdated PCR, it is likely appropriate to provide a "sunset" period for how long it is still acceptable to submit EPDs under the old PCR. For categories with EPD generator tools (such as ready-mixed concrete), it may be appropriate to specify shorter sunset periods, since it is much easier to create and publish new EPDs in those cases compared to categories where EPD generator tools are not readily available.
2. **Require suppliers to report supply-chain-specificity (SCS) scores to BCBF** (Strategy C2). The SCS score would ideally be in the EPD itself, but it could also be provided as a separate attachment. (See the UW/CLF BCBF Brief #4 for more discussion on this recommendation.)
    - Pros: This strategy supports transparency; provides a mechanism for determining if an EPD meets BCBF's current definition of "supply-chain specific;" and supports implementation of Recommendation #3 below.
    - Cons: This strategy could be burdensome to the supplier if their EPD does not already have the SCS score.

3. **Encourage[18] suppliers to meet target SCS scores** (option in Strategy A1). To implement this strategy, Commerce would have to develop targets per product type[19] that are robust, yet achievable. These could be optional initially, supported by incentives. And BCBF could eventually require threshold SCS scores by product type.
    - Pros: More specific data generally means more accurate, reliable results.
    - Cons: This strategy would require additional BCBF administrative effort and more work/time/cost to develop appropriate targets that acknowledge the different current conditions between various product types. (A certain SCS score may be easy to achieve for one product type, difficult for another product type, and impossible for a third product type.)
    - Notes: The assessment of the "current conditions" would look at how much of the product's GWP is typically due to A1 activities (which are generally outside of the manufacturer's control), and the availability of EPDs for the product type's significant upstream ingredients or processes.
4. **Encourage suppliers to submit EPDs with up-to-date primary data** (Strategy A2). For this strategy, Commerce would ask for EPDs whose primary data was collected not more than five years before submission to BCBF. If the primary data is older than 5 years, BCBF would require suppliers to provide justification for why the EPD's primary data is still sufficiently representative of their manufacturing practices.
    - Pros: This strategy promotes confidence in EPD results based on more recent and representative primary data.
    - Cons: This strategy puts more burden on manufacturers, as it effectively shortens an EPD's validity period for BCBF. (A typical EPD may involve a year of data collection, and another year before publication during development and verification. This would mean such an EPD would be applicable, without requiring further justification, to BCBF for three years after publication.)
    - Notes: If BCBF considers such an approach, we recommend further research to determine an appropriate data age window. We consider the five-year recommendation here as preliminary — it may be feasible to ask for EPDs with even more recent data.
5. **Require suppliers to report energy attribute certificate (EAC)-based impacts separately** (Strategy C3).

[18] For the strategies that use the word "encourage," this could include financial support (such as funding for EPD development); bid incentives; free technical support and training; or other approaches as described in the strategy.

[19] "Product type" here refers to the level of aggregation of products typically covered in an EPD, such as "softwood lumber" or "steel decking." This is in contrast to a broader "product category" such as "wood" or "steel."

- Pros: This strategy supports transparency around the EPD results; provides the option for BCBF to assess the appropriateness of the EACs used and determine which impact result (with or without EACs) to consider in its accounting; may assuage some potential industry concerns about RECs.
- Cons: This strategy would require additional effort by BCBF program administrators to understand and account for more information; and this strategy may be perceived as unfair to electricity-intensive industries.
- Notes: The separate reporting could be in the EPD if already required by the PCR, or submitted separately to BCBF. See the UW/CLF BCBF Brief #3 on Scope 2 emissions for further information and recommendations on this topic.

6. **Encourage suppliers to separately report global warming potential (GWP) impacts from biogenic vs. fossil emissions** (Strategy C4).
    - Pros: This strategy improves EPD transparency (and thus user-friendliness); GWP-biogenic and GWP-fossil may be easier to understand than the other biogenic carbon indicators typically found in EPDs; may assuage potential concerns, especially from the steel and concrete industries, about the carbon storage benefits of wood, which is a controversial topic; supports global EPD alignment, since EPDs conforming to EN 15804[20] report these impacts separately.
    - Cons: For BCBF covered products, separate reporting of biogenic and fossil emissions is currently only required in the concrete PCR and may be perceived as unnecessary or burdensome for other covered products.

Long-term strategies for the broader ecosystem

To improve the quality of EPD data more generally, the State could adopt the following strategies. These strategies would take place outside of the BCBF Program but can help improve the quality of EPDs submitted to BCBF in the long run.

7. **Support efforts to update and improve federal LCA data repositories** (Strategies B1 and B2). Supporting the federal LCA data repositories helps improve the accessibility of freely available, representative secondary data to support more reliable and comparable EPDs. The BCBF program could fund, incentivize, or administratively support the collection, aggregation, preparation, and submission of supplier primary data to the Federal LCA Commons. Such efforts would ideally focus on processes which are common inputs to construction product EPDs, such as aggregate production.[21]

[20] EN 15804 serves as the core standard for construction product EPDs in most programs outside of North America. (ISO 21930 serves that purpose in North America.)

[21] If the State is already supporting a certain industry (for example, the Department of Commerce contributes funding to the Washington Mass Timber Accelerator (MASSTAC)), this relationship could be leveraged to support primary data collection in that industry.

- Pros: This supports the accessibility of secondary data and the reliability of EPDs; and it supports engagement of Washington State agencies and industry with broader LCA data efforts.
- Cons: This strategy has additional administrative burdens and financial costs; and funding efforts may not be evenly distributed across covered industries, resulting in inconsistent data collection efforts and potential perception of bias.

8. **Engage in the PCR development process.** Agency staff can help improve PCRs and resulting EPDs by participating in PCR committees, issuing public comments, and writing letters to program operators and PCR committees. Recommended positions include the strategies listed in this report where the PCR (program operator and PCR committee) has influence or control — all strategies listed in *A. LCA modeling strategies*, *C. EPD reporting strategies*, and *D. EPD verification and publication strategies*.
    - Pros: This strategy supports a broader approach to PCR and EPD improvement. These effects could extend far beyond the BCBF program. It also signals the State's interest in LCA topics, even if the agency staffer is not an expert on the topic. State agency staffers have the public good in mind, which can help balance industry interests that tend to dominate PCR development.
    - Cons: This strategy would require the time and effort of State agency staff.

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Appendices

Appendix A: LCA data quality

This appendix contains early-stage research on LCA data quality. The subsections cover:

- The ISO definition of LCA data quality
- Pedigree matrices
- Variability and uncertainty

ISO definition of LCA data quality

ISO 14044:2006 outlines various characteristics of the data that an LCA (including an LCA for an EPD) should evaluate for quality. The LCA's scope should describe the data quality requirements that determine what the LCA modeler should evaluate in terms of the quality of the data used. Section 4.2.3.6.2 provides a list of data quality characteristics to address for input data:

Data quality requirements should address the following:

a. *time-related coverage: age of data and the minimum length of time over which data should be collected;*
b. *geographical coverage: geographical area from which data for unit processes should be collected to satisfy the goal of the study;*
c. *technology coverage: specific technology or technology mix;*
d. *precision: measure of the variability of the data values for each data expressed (e.g. variance);*
e. *completeness: percentage of flow that is measured or estimated;*
f. *representativeness: qualitative assessment of the degree to which the data set reflects the true population of interest (i.e. geographical coverage, time period and technology coverage);*
g. *consistency: qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis;*
h. *reproducibility: qualitative assessment of the extent to which information about the methodology and data values would allow an independent practitioner to reproduce the results reported in the study;*
i. *sources of the data;*
j. *uncertainty of the information (e.g. data, models and assumptions).*

One could perform a qualitative evaluation of ISO 14044's listed data quality characteristics.

ISO 14044 also mentions that quantitative methods should be used and that the methods by which the data were collected should also be evaluated, but it does not provide guidance on how this can be done. This leaves the actual method of data quality assessment open to interpretation. Fortunately, others have developed more structured ways of evaluating LCA data quality, which are presented in the next section.[22]

Pedigree matrices

Pedigree matrices build on ISO 14044's foundation and function as tools to quantitatively assess and score LCA data quality characteristics.[23] The U.S. EPA's *Data Quality Assessment Method to Support the Label Program for Low Embodied Carbon Construction Materials (Version 1)* from 2024 is a recent example.[24] The original pedigree matrix for LCA data quality was developed by Weidema and Wesnaes in 1996, shown in Figure A1. The pedigree matrix is laid out as follows:

- The first column lists the data quality indicators that the authors believe are important to evaluate data quality.
- The top row lists all of the possible scores for the indicators. Each data quality indicator is scored on a scale of 1–5, where 1 represents the best or highest data quality, and 5 represents the lowest data quality.
- The remaining cells describe the criteria for determining which score should be selected for each indicator.

The result of using the pedigree matrix is a set of numbers called the data quality index. An example of a resulting data quality index is "(1,3,4,5,3)".

[22] There are other methods that assess data quality, but they are less well-known, less commonly used, and some are blended with uncertainty assessment, so we will not cover them here. These methods include:

1. EC3's uncertainty assessment method (2020)
2. Wang & Shen's hybrid approach (2013)
3. Q metadata by Erlandsson (2018) (link no longer available)
4. EN 15804:2012+A2:2019: Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products, Annex E.
5. ecoinvent's data quality guidelines (2013)

[23] The name "pedigree matrix" is from Funtowicz & Ravetz 1990. The name "pedigree matrix" was chosen because "the data quality indicators refer to the history or origin of the data, like a genealogical table reports the pedigree of an individual" (ecoinvent 2013).

[24] The U.S. EPA link to this document is no longer available.

Indicator score	1	2	3	4	5
Reliability	Verified[a] data based on measurements[b]	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on assumptions	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate
Completeness	Representative data from a sufficient sample of sites over an adequate period to even out normal fluctuations	Representative data from a smaller number of sites but for adequate periods	Representative data from an adequate number of sites but from shorter periods	Representative data but from a smaller number of sites and shorter periods or incomplete data from an adequate number of sites and periods	Representativeness unknown or incomplete data from a smaller number of sites and/or from shorter periods
Temporal correlation	Less than three years of difference to year of study	Less than six years difference	Less than 10 years difference	Less than 15 years difference	Age of data unknown or more than 15 years of difference
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar production conditions	Data from area with slightly similar production conditions	Data from unknown area or area with very different production conditions
Further technological correlation	Data from enterprises, processes and materials under study	Data from processes and materials under study but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials but same technology	Data on related processes or materials but different technology

[a]Verification may take place in several ways, e.g. by on-site checking, by recalculation, through mass balances or cross-checks with other sources. [b]Includes calculated data (e.g. emissions calculated from inputs to a process), when the basis for calculation is measurements (e.g. measured inputs). If the calculation is based partly on assumptions, the score should be two or three.

Figure A1. Original pedigree matrix from Weidema and Wesnaes, 1996.[25]

Other pedigree matrices have been developed since the original in 1996, including: Weidema (1998)[26]; EPA's updated pedigree matrix[27]; EN 15804+A2, Annex E[28]; ACLCA's enhanced pedigree matrix (2024)[29]; and EPA's *Data Quality Assessment Method to Support the Label Program for Low Embodied Carbon Construction Materials (Version 1)* from 2024.

Figure A2 shows how these pedigree matrices (specifically, their data quality indicators) have changed over time. It shows how the names of the indicators have changed slightly with each iteration, how the number of indicators has grown, and how new categories have been added, as indicated by the different colors.

[25] https://doi.org/10.1016/S0959-6526(96)00043-1

[26] Weidema, B.P. (1998). Multi-user test of the data quality matrix for product life cycle inventory data. *Int. J. LCA 3, 259–265*. https://doi.org/10.1007/BF02979832

[27] Edelen, A., & Ingwersen, W. (2016). *Guidance on Data Quality Assessment for Life Cycle Inventory Data, v1* (The International Journal of Life Cycle Assessment, pp. 3–9). EPA Life Cycle Assessment Research Center, National Risk Management Research Laboratory. ww.epa.gov/research

[28] European Committee for Standardization (CEN). (2019). *EN 15804:2012+A2:2019: Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products*. https://www.en-standard.eu/bs-en-15804-2012-a2-2019-sustainability-of-construction-works-environmental-product-declarations-core-rules-for-the-product-category-of-construction-products/

[29] Mukherjee, A., & Bhat, C. G. (2022). *Guidance for Assessing Data Quality of Background Life Cycle Inventory (LCI) Datasets*. ACLCA. https://aclca.org/wp-content/uploads/2022-ACLCA-PCR-Guidance_Addendum_Assessing_LCI_Quality_05252022-1.pdf

We believe that the EPA 2024 version of the pedigree matrix is the most robust and up-to-date version of an LCA data quality pedigree matrix.

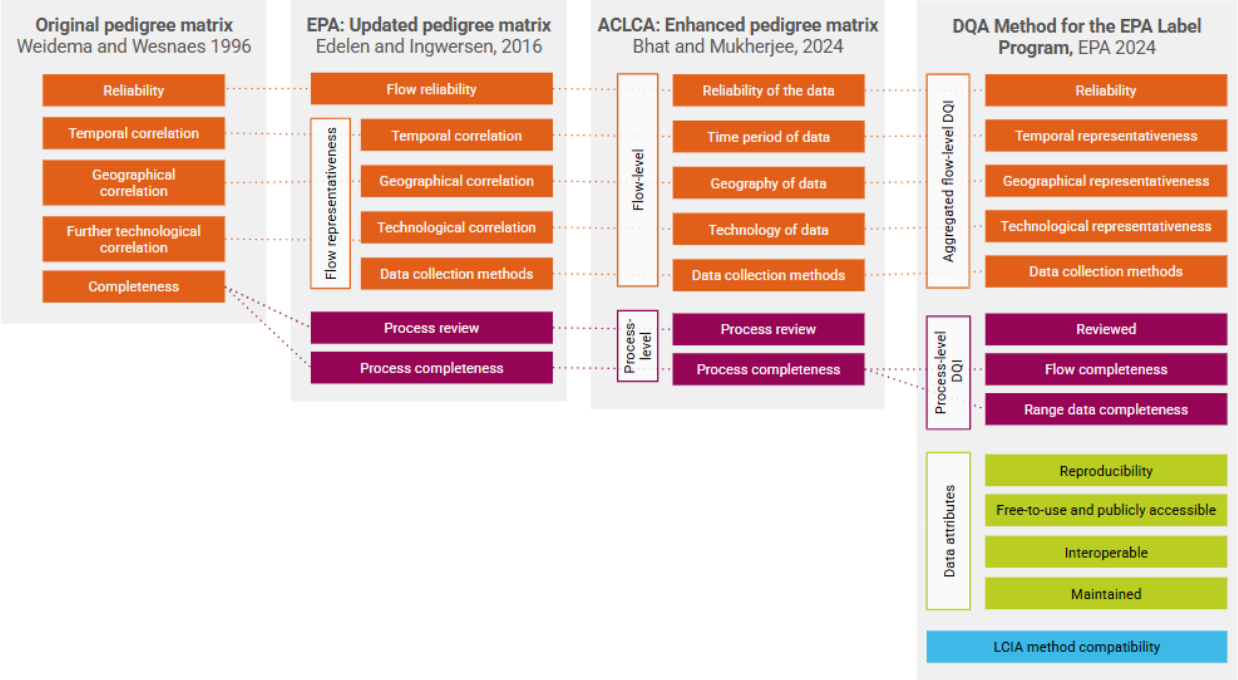


Figure A2. Evolution of the data quality indicators in LCA data quality pedigree matrices over time.

Variability and uncertainty

Variability and uncertainty are often discussed in conjunction with data quality. This section explains what variability and uncertainty are, how they relate to data quality, and how these metrics could be published alongside a data quality evaluation in an EPD.

What is variability and why is it important?

Variability refers to variation stemming from the real world.[30] Variability is important to consider in an LCA model because it is needed to represent the real world as accurately as possible. However, this does add complexity, which complicates the interpretation of the LCA results, but it also adds nuance.

An example of variability is *temporal variability.* For example, the amount of energy consumed in a certain manufacturing process may vary seasonally. Another example of variability is that a manufacturer might use multiple suppliers for a given ingredient, and the impacts for producing and transporting that ingredient vary by supplier, depending on the supplier's production processes and location. Average data representing the production of that ingredient likely doesn't capture the range in that real-world variation.

[30] Huijbregts, M. A. J. (1998). Application of uncertainty and variability in LCA. The International Journal of Life Cycle Assessment, 3(5), Article 273. https://doi.org/10.1007/BF02979835

Variability of impact results can be quantified through sensitivity analyses. There are numerous parameters in an LCA model that contribute to variability and may be analyzed in a sensitivity analysis. Of particular interest is how much the EPD results vary with different sources of secondary (background) data. CEN/TR15941:2010 recommends creating an estimation of the variance in EPD results using different choices for generic data.[31]

What is uncertainty and why is it important?

Uncertainty comes from inaccurate measurements, lack of data, model assumptions, etc., that are used to "convert" the real world into LCA outcomes.[6] Uncertainty is important to consider because no data or model is perfect, and the user needs to understand how large the uncertainty is in order to understand how reliable or accurate the LCA results are. If the uncertainty is high, then the results are more unreliable. If the uncertainty is low, then the results are more reliable.

An example of uncertainty is the source of electricity. Since electricity is typically traded between balancing authorities (mixing electrons produced by different grids), it is virtually impossible (in most places in the US) to trace electricity from the actual grid where it was produced. Thus, with electricity impacts, there is always a certain amount of uncertainty due to the uncertainty about its origin.

One approach to quantifying data quality uncertainty in EPD results involves assigning uncertainty factors to the data quality scores for each flow in a product system, then calculating the overall uncertainty of the product system, as in the work by AzariJafari et al.[32] However, these methods require the same data quality assessment method to be applied to all background data, and thus cannot be employed in EPDs that use proprietary background data. Quantitative methods such as this could be employed in the future if standard data quality assessment methods were applied to all EPDs and generic LCA data used in evaluation of EPD results. Uncertainty can also be quantified using Monte Carlo simulations, which are commonly employed in LCA literature to assess various types of uncertainty.[33]

How do variability and uncertainty relate to data quality in LCA/EPDs?

In the world of LCA, variability and uncertainty are sometimes used interchangeably. For example, in the EC3 tool, variability (expressed as the percentage variation in an upstream supply chain) is used to adjust GWP results to account for “uncertainty.” In other fields, variability is categorized as a subtype of uncertainty. However, in this document, we distinguish variability and uncertainty using the following definitions from Huijbregts 1998, as defined earlier:

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[31] CEN. (2010). *EN 15941:2010 Sustainability of construction works — Environmental product declarations — Methodology for selection and use of generic data*.

[32] AzariJafari, H., Guest, G., Kirchain, R., Gregory, J. & Amor, B. (2021). Towards comparable environmental product declarations of construction materials: Insights from a probabilistic comparative LCA approach. *Build Environ 190*, 107542. https://doi.org/10.1016/j.buildenv.2020.107542

[33] Thaneya et al. (2024). *Assessing uncertainty in building material emissions using scenario-aware Monte Carlo simulation*. https://doi.org/10.1088/2634-4505/ad40ce

- ***Variability*** *covers variation stemming from the real world*
- ***Uncertainty*** *covers inaccurate measurements, lack of data, modeling assumptions, etc.*

This difference between variability and uncertainty is illustrated in Figure A3. Figure A3 also shows that:

- Certain aspects of variability and uncertainty both affect the quality of the input data of an LCA.
- The quality of the input data and modeling assumptions affect the quality of the output data (the LCA results in an EPD).

In the end, we defer to ACLCA's forthcoming report on uncertainty.

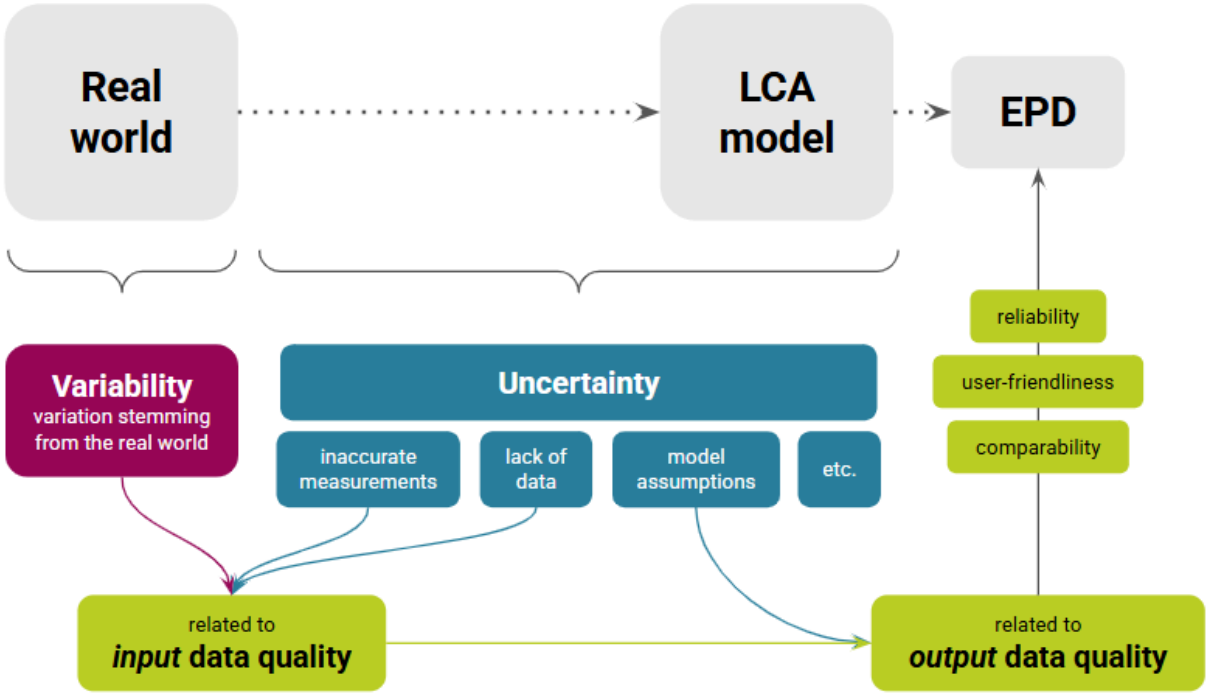


Figure A3. Conceptual illustration of how variability, uncertainty, and data quality are related in LCA models and EPDs.