Biogenic Carbon Accounting in Wood Environmental Product Declarations

A comparison of methodologies in European and North American Wood Product EPDs

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CLF Carbon Leadership Forum

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The Carbon Leadership Forum is a nonprofit dedicated to accelerating the transformation of the building sector to radically reduce the greenhouse gas emissions attributed to materials (also known as embodied carbon) used in buildings and infrastructure. We research, educate, and foster cross-collaboration to bring the embodied carbon of buildings and infrastructure down to zero.

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The Life Cycle Lab at UW's College of Built Environments leads research to advance life cycle assessment (LCA) data, methods, and approaches to enable the optimization of materials, buildings, and infrastructure. Our work is structured to inform impactful policies and practices that support global decarbonization efforts. We envision a transformed, decarbonized building industry – better buildings for a better planet.

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Executive Summary

Environmental product declarations (EPDs) are a key mechanism for reporting the environmental impacts of construction materials – including wood products. EPDs are standardized, third-party-verified documents that aim to clearly and transparently report the environmental impacts associated with production, use, and disposal of a product calculated according to standard life cycle assessment (LCA) accounting rules.

Structural wood products are touted globally for their low environmental impacts relative to other fossil-intensive construction materials. EPDs are one mechanism – often used in combination with certifications, owners sourcing requirements, and others – used by the building industry to understand the relative impact of wood products. However, the environmental benefit of biogenic carbon sequestration and storage associated with forest growth and production and use of structural wood products is currently reported differently across regions according to varying accounting mechanisms for wood EPDs in different regions. As EPDs grow increasingly important in the context of global policy and trade, these differences in rules and accounting methods applied to structural wood product EPDs merit greater attention.

This report dives deep into the accounting and reporting standards for structural and architectural wood product EPDs in Europe and North America with the goal of (1) identifying key challenges in comparability based on current standards and (2) highlighting the largest opportunities to increase the comparability of product category rules (PCRs) and related international LCA standards moving forward.

The greatest differences between European and North American wood product EPDs stem from differences between these regional parent LCA standards for construction products: EN 15804:2012+A2:2019 (CEN, 2019) and ISO 21930 (ISO, 2017). Despite global agreement on the general framework of EPDs, inherent differences in the emissions and removals included in European and North American wood EPDs prevent direct comparison of products across markets due to their different approaches to quantification and reporting of biogenic carbon removals and emissions.

Critical aspects of wood product PCRs which currently lack global harmonization include:

- biogenic carbon removals accounting,
- treatment of biogenic carbon emissions and stocks at end-of-life,
- characterization of temporary and permanent carbon storage,
- source forest disclosure requirements,
- land use and land-use change (LULUC) accounting, and
- required environmental impacts and indicators to be reported.

Despite technical disagreements and temporal misalignment resulting in differences across current regional wood product PCRs, global consensus on the need to improve transparency and accuracy of EPDs is already contributing to international harmonization efforts. Due to the increasingly global nature of construction material supply chains, harmonization of PCRs is necessary to improve global comparability of EPDs. In the near future, current misalignments between regional LCA standards and wood product PCRs may feasibly be remedied leading to vast improvements in global comparability of wood product EPDs and whole building LCA (WBLCA) models for which they are a critical data source.

Table 1. Hierarchy of standards and PCRs governing structural wood product EPDs in Europe and North America, and key differences in biogenic carbon accounting requirements.

LCA Standards and PCRs Hierarchy and Key Differences		
	European Standards Core Standard: EN 15804:2012+A2:2019 PCR: EN 16485:2014 - Wood Construction Products Supporting Standard: EN 16449:2014 - Calculation of the Biogenic Carbon Content of Wood	**North American Standards** Core Standard: ISO 21930:2017 PCR(s): ULE 10010 Part A - Building-Related Products and Services, ULE 10010-9 Part B - Structural and Architectural Wood Products
Biogenic Carbon Accounting and Source-Forest Rules	▲ -1 / +1 biogenic carbon accounting ▼ -1 for all biomass except from **native** forests ▲ +1 for CO_2 emitted or exiting the product system	▲ -1 / +1 biogenic carbon accounting ▼ -1 only if from **sustainably managed** forests ▲ +1 for CO_2 emitted or exiting the product system
Land Use and Land-Use Change Accounting	▼ GWP-luluc accounts for any land use and land-use change, including any biogenic carbon emissions from native forests	▼ GWP (land-use change) declared separately when "significant", and assumed zero for wood from sustainably managed forests ▼ Land use emissions not addressed
Carbon storage (temporary and permanent)	▲ No discounting for temporary carbon storage ▼ No permanent carbon storage allowed. Degradation calculated without time limit	▲ No discounting for temporary carbon storage ▼ Permanent carbon storage allowed. Landfill emissions accumulated up to 100 years after disposal, remainder is considered permanently stored
Impact categories required	▲ GWP-total includes biogenic carbon ▼ GWP-biogenic, GWP-luluc, and GWP-fossil reported separately ▼ Biogenic carbon content in product and packaging at the factory gate required to be reported separately as additional information. See Table 2 for more details.	▲ GWP-total includes biogenic carbon ▼ Additional biogenic carbon inventory indicators required to be reported separately. See Table 3 for more details.
Life Cycle Stages required	▼ LCA stages A1–A3, C1–C4, and D required	▼ LCA stages A1–A3 required

▲ Aligned

▼ Not aligned

Note: In North America, different organizations may publish a PCR for any given product category. For example, while UL Environment published the current PCR for structural wood products, SmartEPD published a PCR for wood pallets (https://smartepd.com/pcr-library) requiring distinct reporting rules from the UL PCR considered herein. Another common publisher of North American PCRs is the National Sanitation Foundation (NSF).

1. Introduction

Structural wood products are touted globally for their low environmental impacts relative to other fossil-intensive construction materials. Environmental product declarations (EPDs) are a key mechanism for reporting the environmental impacts of construction materials, and are used – often in combination with certifications, owners sourcing requirements, and others – by the building industry to understand the relative impact of wood products.

However, the environmental benefit of biogenic carbon sequestration and storage associated with forest growth and production and use of structural wood products is currently reported differently across regions according to varying accounting mechanisms for wood EPDs in different regions. As EPDs grow increasingly important in the context of global policy and trade, these differences in rules and accounting methods applied to structural wood product EPDs merit greater attention.

This report dives deep into the accounting and reporting standards for structural and architectural wood product EPDs in Europe and North America with the goal of (1) identifying key challenges in comparability based on current standards and (2) highlighting the largest opportunities to increase the comparability of product category rules (PCRs) and related international LCA standards moving forward.

1.1 Background

Life Cycle Assessment and Environmental Product Declarations

Life cycle assessment (LCA) is a systematic set of procedures for compiling and evaluating the inputs and outputs of materials and energy and the associated environmental impacts from emissions to air, water, and land across the life cycle of a product, process, or entire project (e.g. building). Environmental product declarations (EPDs) are standardized, third-party-verified documents that aim to clearly and transparently report the environmental impacts, based on the results of a product LCA.

EPDs must meet requirements from a family of standards, including a product category rule (PCR) and a family of 'parent' PCR and LCA standards. A PCR is a set of specific rules, requirements, and guidelines for conducting an LCA and developing EPDs for one or more product categories. PCRs vary regionally, but a number of core LCA standards are similar across regions (see Appendix D). Both international standards and regional PCRs are developed through an open stakeholder development process, where a technical committee comprising experts from industry, academia, NGOs, and government uses a consensus-based approach to create the scope and content of the standard. PCRs are typically updated every 3-5 years. While similar principles are used in European and North American EPDs, key differences in regional PCRs and LCA standards result in significant differences in the calculated and reported impacts.

When performing an LCA, greenhouse gas emissions, including carbon dioxide, are tallied up over a product's life cycle to produce a value commonly referred to as global warming potential (GWP), an impact category reported in kilograms of carbon dioxide equivalents (kgCO2e). LCAs (and therefore EPDs) also disclose information on other impact categories, such as acidification, eutrophication, ozone depletion, and smog formation.

Environmental impacts are reported across four main stages: Product stage (A1-A3), Construction stage (A4-A5), Use (B), and End-of-life (C). Depending on the scope required by the standards followed by the EPD in each region, some stages are required, whereas others are optional, as discussed further in section 4.

Biogenic Carbon Accounting

Biogenic carbon refers to carbon that is derived from or contained in biomass (e.g. plants and trees) (EN 16485:2014). This is in contrast to fossil carbon, which comes from living matter that has died and been deposited on the ground, and is often emitted from burning of fossil fuels. It is commonly accepted that forests sequester (or "remove") atmospheric CO2 during growth and emit CO2 and other greenhouse gases during decay. Carbon removals – stocks of atmospheric carbon (CO2) sequestered into building materials – are therefore sometimes tracked in an LCA model as negative numbers. In contrast, emissions (whether from fossil fuels or biogenic emissions) are tracked as positive numbers.

This general accounting principle, often referred to as "-1/+1" accounting, is consistent across many LCA modeling and reporting frameworks. "-1/+1 accounting" describes a method by which biogenic carbon enters the system as stored carbon in biomass (-1) in the product stage (A1-A3), and exits the product system as emissions (+1) at end-of-life (C stage). Both North American and European standards limit the use of negative reporting (i.e. getting "credit" for biogenic carbon sequestration) in certain contexts, which is discussed further in section 3.

Biogenic carbon accounting has been a controversial topic because depending on the calculation methodology, negative numbers associated with biogenic carbon sequestration and storage may be used to offset the total embodied carbon of a project, making the difference between whether or not a project complies with voluntary or regulatory requirements reducing the total allowable emissions from a project or product.

This report focuses on the biogenic carbon accounting and reporting requirements for EPDs. However, there are also differences in methodologies in whole building life cycle assessment (WBLCA) tools that are outside the scope of this report.

2. Product Category Rules: Parallel Systems of Accounting

PCRs are a set of requirements and guidelines which apply to a specific product or group of products (e.g. "structural and architectural wood products") that LCA practitioners must follow when developing EPDs. PCRs are governed by overarching LCA standards which provide the core LCA rules applicable to all PCRs under that standard.

The greatest differences between European and North American wood product EPDs stem from differences between these regional parent LCA standards for construction products: EN 15804:2012+A2:2019 (CEN, 2019) **and ISO 21930** (ISO, 2017). Despite global agreement on the general framework of EPDs, inherent differences in the emissions and removals included in European and North American wood EPDs prevent direct comparison of products across markets due to their different approaches to quantification and reporting of biogenic carbon removals and emissions.

North American PCRs

In North America, wood construction products must follow UL PCR Part B: Structural and Architectural Wood Products EPD Requirements (UL Environment, 2020). This PCR supplements the core UL PCR for Building-Related Products and Services, Part A: Life Cycle Assessment Calculation Rules and Report Requirements UL Environment (UL Environment, 2022), in addition the parent LCA standard for construction products referenced in North America, ISO 21930. The UL PCR Part B for wood products complements UL's Part A by providing additional rules regarding functional unit details to be reported, additional information and statements to be included in the EPD, and guidance for modeling landfill emissions of biogenic carbon according to the US EPA WARM model (US EPA, 2019).

For a full discussion of normative and reference standards for North American wood EPDs, see Appendix D.

European PCRs

In Europe, wood construction products must follow EN 16485:2014 (CEN, 2014). EN 16485 provides specific rules for wood construction products and complements the core PCR for all construction products, EN 15804:2012+A2:2019.

The current version of EN 15804 +A2 includes several major updates that occurred in 2019 to comply with the EU's Product Environmental Footprint (PEF) standard, including:

- Requiring separate reporting of global warming potential (GWP) impacts from biogenic carbon, land use and land-use change, and fossil fuels, referred to as GWP-biogenic, GWP-luluc, and GWP-fossil.
- Requiring all product EPDs to report end-of-life (module C1–C4) and module D impacts in addition to the previously required manufacturing stages (A1–A3).
- Requiring the use of the 100-year time horizon GWP factors without climate-carbon feedback, as provided by the IPCC 2013 Fifth Assessment Report (AR5), for reporting climate change impacts. For further discussion of characterization factors, see section 4.3.

Although enacted in 2019, EN 15804+A2 standard has only been required for all European EPDs since 2022. Updating a product-EPD is time and resource-intensive and, currently, there remain many EPDs in circulation that have not yet been updated, though they are technically not yet expired.

The structure of the PCRs and LCA standards governing European and North American wood product EPDs and their key differences are discussed in depth in sections 3 and 4.

3. Accounting Differences: Biogenic Removals and Emissions

This section explains the fundamentals of biogenic carbon accounting and reporting differences between these two systems. While similar accounting principles are used in European and North American EPDs, key differences in regional PCRs and LCA standards result in significant differences in the calculated and reported impacts.

3.1 Biogenic Carbon Accounting Principles

-1/+1 accounting

European and North American LCA standards use a basic accounting principle commonly referred to as "-1/+1" accounting. While this basic principle is consistent across LCA modeling and reporting frameworks, how these positive and negative numbers are reported and interpreted differs and is the source of much of the confusion and differences across methods.

Under both European and North American LCA standards, biogenic carbon removals may be credited with -1 kgCO2eq/kgCO2 removed for biomass entering the product system as a raw material, however with unique language in each standard limiting when the negative credit may be applied. In both cases, the carbon contained in the dry mass of the wood product is converted into a CO2 eq.; this quantity is represented as a negative value, or credit, in life cycle module A1 — Raw Material Supply. This stock of carbon (represented as negative emissions) remains in the product system until it is emitted to the atmosphere through combustion or decay, or exits the product system at the end of the analysis period. If emissions and sequestration (positive and negative numbers) are summed within or across life cycle modules, these negative numbers may obscure the emissions to the atmosphere occurring during that life cycle stage.

Figure 1 illustrates the biogenic carbon accounting rules detailed in both European and North American LCA standards, with the -1/+1 accounting method starting at the -1 characterization factor applied in stage A1.

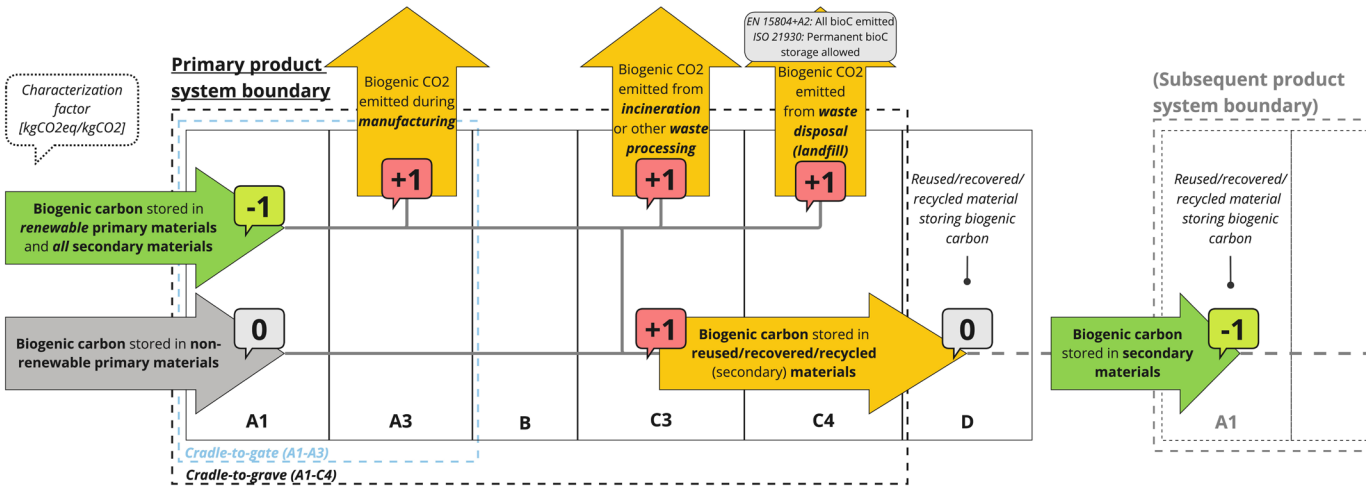

Figure 1: -1/+1 biogenic carbon accounting methodology for biogenic carbon stored in raw materials and biogenic CO2 emissions. Note: Characterization factors shown here align with both EN 15804+A2:2019 and ISO 21930:2017, however EN 15804+A2 requires end-of-life biogenic carbon emissions are calculated without time limit while ISO 21930:2017 only requires accounting for landfill emissions for 100 years after placement.

0/+1 accounting

Applying a negative characterization factor to biogenic carbon imported into the product system results in a negative GWP-biogenic impact in stage A1. For wood originating from native forests (per EN 15804+A2) or non-sustainably managed forests (per ISO 21930), the characterization factor for biogenic carbon entering the product system is 0 instead of -1, eliminating the negative GWP-biogenic impact in A1 and resulting in a net-positive impact across the product life cycle. The definitions for native forests and sustainably managed forests that define whether or not a "0" or "-1" applies are described below in section 3.2.

When biogenic carbon neutrality applies (-1/+1), the net GWP impact of biogenic carbon emitted as CO2 is zero because the negative GWP impact of CO2 removed exactly offsets the positive impact of CO2 emitted. When biogenic carbon neutrality does not apply (0/+1), the net GWP impact of biogenic carbon emitted is greater than zero because the emissions are not offset by any negative CO2 removals.

3.2 Wood Sourcing

Biogenic carbon neutrality (-1/+1 accounting) is only allowed if wood meets certain criteria. This criteria differs between EN 15804+A2 and ISO 21930.

North American Requirement: "Sustainably Managed Forests"

Biogenic carbon accounting rules in the North American PCR for wood products are dictated by ISO 21930:2017, which allows a -1 kgCO2eq/kgCO2 characterization factor to be applied to biogenic CO2 imported into the product system for wood originating from "sustainably managed forests" or as a secondary material. ISO 21930 (section 7.2.11) specifies that wood from "sustainably managed forests" may be identified through various certification schemes, or "other evidences such as national reporting under the United Nations Framework Convention on Climate Change (UNFCCC)." The forest certification schemes approved by ISO 21930 include Canadian Standards Association (CSA), Forest Stewardship Council (FSC), Sustainable Forestry initiative (SFI), and "other standards endorsed by the Programme for the Endorsement of Forest Certification International (PEFC International) and the FSC."

According to this methodology, all wood products produced in the United States, regardless of the forest of origin or specific forest management or harvest practices employed, can be considered "sustainably managed" because on average forest stocks across the United States are stable or increasing.

European Requirements: "Native Forests"

EN 15804+A2 (section C.2.4) instead applies a -1 kgCO2eq/kgCO2 characterization factor to any biomass entering the product system, excluding biomass from "native forests". Native forests contain "indigenous tree species not established by planting or/and seeding" (UN-REDD) and excludes "short-term forests, degraded forests, managed forests, and forests with short-term or long-term rotations" (CEN 2019, section C.2.4). The limitation for native forests does not apply to biomass transferred from a previous product system, so a -1 characterization factor applies to any reused, recovered, or recycled (secondary) biomass without exclusion.

Prior to being superseded by EN 15804+A2, EN 16485 allowed for biogenic carbon neutrality to be applied to wood complying with Article 3.4 of the Kyoto protocol or "established certification schemes for sustainable forest management" (CEN 2014, section 6.4.3.2). The currently applicable language in ISO 21930:2017 therefore plainly correlates with the now-outdated language in EN 16485:2014. In the future, ISO 21930 may be updated to align once again with the more recent EN language.

Source Forest Disclosure

Currently, neither European nor North American wood PCRs require source forest disclosure – sometimes referred to as supply chain specificity – for wood products. Companies may choose to include this information in the additional information section of the EPD to streamline compliance with private sector owner disclosure requirements. Europe has new regulations requiring increased disclosure about wood origin, but there are no similar regulations in North America.

Understanding the source forest from which a wood product is harvested helps to inform procurement decisions that support deforestation prevention and ecological preservation efforts, and monitoring forest harvests and stocks helps inform policy and decision-making in support of sustainable forest management (FAO, 2020). Tracking harvests and wood sources enables consumers of wood products to have confidence that they are helping to protect forest ecosystems which are critical to biodiversity and global environmental health.

The only disclosure-related language in the current PCRs focuses on certification. EN 16485 (sections 6.3.4.2 and 7.1) requires reporting of information on responsible sourcing and chain of custody certification. The UL PCR Part B for wood products (sections 2.21 and 7.5) suggests stating the source of wood products in the product identification if available, and further offers that sources of wood fiber may optionally be categorized according to ASTM D7612-10: Standard Practice for Categorizing Wood and Wood-Based Products According to Their Fiber Sources, which focuses on distinguishing legal, certified, and other wood. However, no additional language in the UL PCR (Part A or Part B) requires disclosure of wood source.

To ensure that European forest products are not sourced through unsustainable harvesting from protected forests globally, the European Union passed the Regulation on Deforestation Free Products (EUDR) which will go into effect December 30th, 2025 (after a one-year delay). The EUDR requires tracing of all forest products to the specific plot of land from which they were sourced (European Commission, n.d.). This requirement exceeds the specificity of source-forest tracing required by LCA standards, although standards or PCRs may be updated to require a similar level of wood source traceability on EPDs.

No similar law or regulation currently exists in North America requiring source forest disclosure or any chain of custody tracking for wood products, although any North American products exported to the EU will be subject to EUDR sourcing disclosure requirements.

3.4 End-of-Life Accounting Rules

Differences in end-of-life accounting rules are a key reason for the lack of comparability between North American and European EPDs that include biogenic carbon. Due to differences in end-of-life accounting rules in EN15804+A2 and ISO 21930, European EPDs have a net balance (i.e. no negative GWP-biogenic values at end of life) whereas North American EPDs may have a net negative. Additionally, because of the exclusion of C stage impacts from most North American EPDs, A1-A3 results typically count all biogenic carbon stored in the product as an emission in stage A3, further making A1-A3 results incomparable between regions.

End-of-life (EOL) impacts at the end of life are typically modeled in life cycle stages C1–C4, including deconstruction or demolition (C1), transport (C2), waste processing (C3), and disposal of waste (C4). Additional impacts beyond the system boundary are accounted for in module D. As shown in Figure 2, these stages are required to be reported in European EPDs, but most North American EPDs only include stages A1–A3, the minimum reporting requirement under ISO 21930.

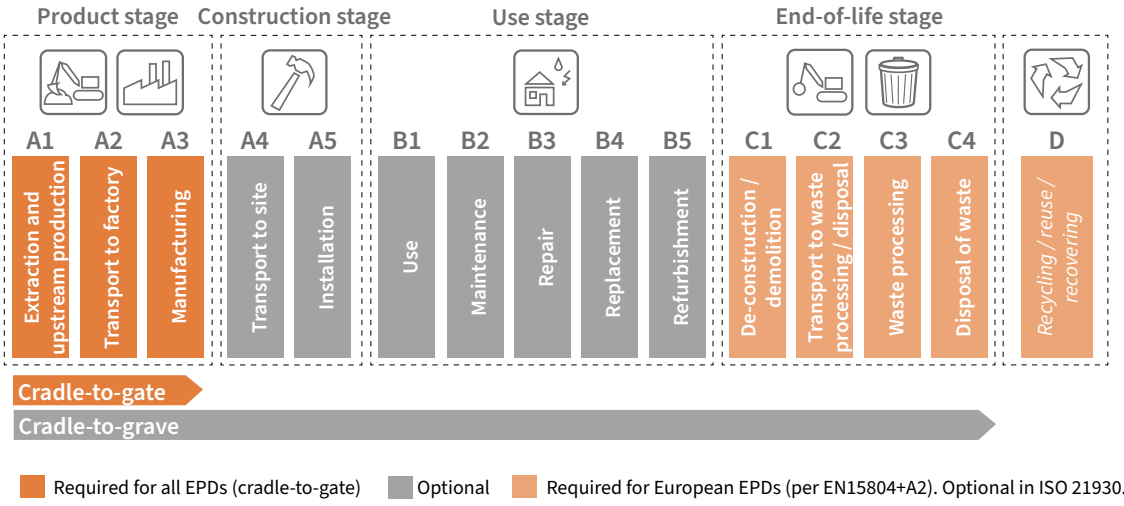

Figure 2. Life cycle stages and required reporting in European (EN 15804+A2) vs. North American (ISO 21930) EPDs. Image source: Carbon Leadership Forum.

Due to the lack of C and D stages in North American EPDs, some North American EPDs have adopted a convention where all biogenic carbon is shown as emitted in stage A3, resulting in a net zero accounting. In these EPDs biogenic carbon neutrality is maintained across modules A1–A3, however EOL biogenic carbon emissions are not accounted for in the "module where they occur". Other EPDs complying with ISO 21930 choose to omit biogenic carbon removals and emissions from GWP altogether, or report GWP both with and without biogenic carbon removals and emissions. This results in significant disharmony between the A1–A3 GWP values reported in EPDs complying with ISO 21930 and EN 15804+A2.

Additionally, the difference in accounting rules for biogenic carbon emissions from incineration and decomposition, and for secondary materials that are recovered, recycled, or reused in a subsequent product system, are of particular significance for wood products.

In European EPDs, the negative impacts reported in A1-A3 are offset in module C3, regardless of which disposal method (e.g. incineration, landfill) is used, resulting in a net balance (0) for A-C impacts of the product. EN 15804+A2 section 6.3.5.5 specifies that biogenic carbon emitted via degradation in a landfill "shall be calculated without time limit", meaning that all biogenic carbon contained in a material is characterized as an emission (+1) at EOL, rather than allowing for landfill carbon storage as is typical in EPDs created using ISO 21930:2017. This also ensures the positive GWP-biogenic impact for any EOL scenario is equal to or greater than the negative GWP-biogenic impact accounted for in A1–A3. Reflecting current regional practice, default EOL scenarios for European wood product EPDs typically assume wood is incinerated or recycled after use, though results for multiple EOL scenarios are sometimes reported separately to comply with national reporting guidance.

In North American EPDs with a limited cradle-to-gate (A1–A3) scope, biogenic carbon emissions at the end-of-life are either reported in stage A3 to maintain a carbon neutrality balance or omitted, starkly deviating from EN 15804+A2-compliant EPDs. Reflecting current regional practice, the default EOL scenario for North American wood products assumes all wood is landfilled after use. Permanent landfill carbon storage is not explicitly disallowed by ISO 21930:2017. Accordingly, the UL PCR Part B prescribes use of the US EPA WARM model to calculate landfill emissions, which assumes the majority (88%) of biogenic carbon in landfilled

structural wood products remains permanently stored.

This series of methodological decisions results in North American wood product EPDs producing GWP-total values that are net-negative due to permanent landfill carbon storage, or net-positive but with a large permanent landfill biogenic carbon storage value reported separately. On the other hand, European wood product EPDs "cancel out" all biogenic carbon removals with EOL emissions, producing GWP-total figures over the full product lifecycle that may be low-carbon but are not net-negative or carbon-neutral.

3.5 Carbon Storage in Wood Products

"Stored biogenic carbon" generally refers to the quantity of biogenic material contained within the building's durable materials and systems, contributing to long-term storage. The value of carbon storage rests on a premise that the built environment can act as a durable stock of carbon that would otherwise be emitted back to the atmosphere while enabling increased carbon sequestration in managed landscapes through regeneration. Quantification of stored carbon is relatively simple, with an equation provided in EN-16449:2014 and referenced by ISO-21930 and EN-15804 that estimates the carbon content per volume of product based on moisture content, dry density, carbon fraction, and bio-based content (for engineered products), and reports values in kg CO2 eq.

This value is reported separately as an inventory metric when included in EPDs (not summed up with emissions or removals accounting). While EPDs from all regions seek to reflect the environmental benefit of biogenic carbon sequestration and storage in wood products, this benefit is reflected through contrasting mechanisms. In European EPDs, stored carbon is the key parameter used to reflect the environmental benefit of biogenic carbon sequestration and storage in wood products. The key parameters of interest for European EPDs are the quantity and length of biogenic carbon storage during product use, which are reflected by the biogenic carbon content at the factory gate and the reference service life of the product, respectively.

This differs from North American EPDs, in which the environmental benefit of biogenic carbon sequestration and storage is reflected in the calculation of permanent landfill carbon storage at end-of-life. The example EPD results in Appendix B provide a clear example of the distinct results from these two accounting systems.

3.6 Land use and land-use change (LULUC) and forest carbon stocks

In addition to the carbon contained in products, changes to forest carbon stocks resulting from land management actions may contribute significantly to the life cycle impacts of wood harvests. Five distinct carbon stocks are typically defined for forests: above- and below-ground biomass, deadwood, litter, and soil organic matter (IPCC, 2003). European and North American LCA standards apply different language requiring accounting for changes to these forest carbon stocks under the category of land use and land-use change (LULUC).

EN 15804+A2 (section C.2.5) includes mandatory reporting of the impact category GWP-luluc. This impact accounts for GHG emissions caused by land use and land-use changes associated with the product system under study, including biogenic carbon emissions resulting from deforestation and soil carbon, and any emissions resulting from harvests of wood from native forests.

While land use and land-use change are not discussed in the UL PCR Part B for wood products, ISO 21930 (section 7.2.11) requires accounting for GHG emissions resulting from land-use change, or land conversion, in a separately declared "GWP (land-use change)" impact, when significant. ISO 21930 offers no methodology for quantifying or disclosing impacts or benefits that arise through land use or land management, and treats all forest management as exactly net-neutral regardless of ownership, forest type, harvest characteristics,

management planning, or silvicultural activities.

As a result, North American wood product EPDs do not typically report GWP (land-use change) impacts. In contrast, EN 15804+A2-compliant wood product EPDs typically report non-zero GWP-luluc impacts which contribute negligibly to GWP-total.

3.7 Lack of Comparability

The differences in accounting methods required by European and North American standards described in sections 3.1-3.6 result in EPDs that are incomparable across regions.

Figure 3 highlights the incomparable nature of the results from EPDs complying with ISO21930, EN15804+A1 and EN15804+A2 respectively. The differences shown in Figure 3 are solely due to differences in accounting

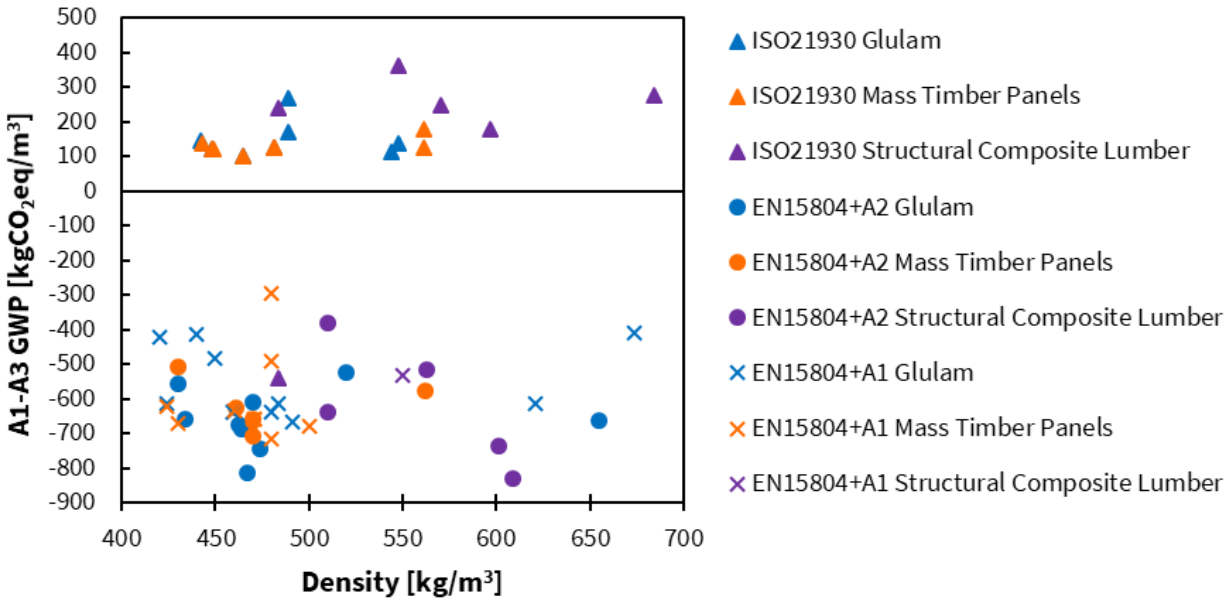

Figure 3: Scatterplot showing reported A1–A3 GWP impacts against reported density for European and North American EPDs. EN 15804-compliant EPDs report a negative A1–A3 GWP total because biogenic removals are included in A1, while biogenic emissions are reported in end-of-life stages (C1–C4). ISO 21930-compliant EPDs report a positive A1–A3 GWP total because end-of-life stages are not typically reported, so all biogenic carbon in the product is reported as an emission in stage A3 to maintain alignment with the principle of carbon neutrality. Some of the reviewed ISO 21930-compliant EPDs report GWP values with and without biogenic carbon, in which case the more conservative, positive value (not including biogenic carbon) is shown in this figure. For ISO 21930 EPDs reporting GWP values with and without biogenic carbon, the A1-A3 GWP values which include biogenic carbon may be negative, although not shown in this figure. One ISO 21930-compliant EPD reviewed in this study chose to report end-of-life stages similarly to EN 15804-compliant EPDs, thus also reporting a negative A1–A3 GWP. **This plot highlights the incomparable nature of results from most EPDs complying with EN 15804+A2 and ISO 21930.**

methods, rather than differences in the products themselves. See Appendix B for additional details on the example wood EPDs included.

Table 1 provides a summary of the hierarchy of LCA standards and PCRs that apply in Europe and North

Table 1. Hierarchy of standards and PCRs governing structural wood product EPDs in Europe and North America, and key differences in biogenic carbon accounting requirements.

LCA Standards and PCRs Hierarchy and Key Differences		
	European Standards Core Standard: EN 15804:2012+A2:2019 PCR: EN 16485:2014 - Wood Construction Products Supporting Standard: EN 16449:2014 - Calculation of the Biogenic Carbon Content of Wood	**North American Standards** Core Standard: ISO 21930:2017 PCR(s): ULE 10010 Part A - Building-Related Products and Services, ULE 10010-9 Part B - Structural and Architectural Wood Products
Biogenic Carbon Accounting and Source-Forest Rules	▲ -1 / +1 biogenic carbon accounting ▼ -1 for all biomass except from **native** forests ▲ +1 for CO_2 emitted or exiting the product system	▲ -1 / +1 biogenic carbon accounting ▼ -1 only if from **sustainably managed** forests ▲ +1 for CO_2 emitted or exiting the product system
Land Use and Land-Use Change Accounting	▼ GWP-luluc accounts for any land use and land-use change, including any biogenic carbon emissions from native forests	▼ GWP (land-use change) declared separately when "significant", and assumed zero for wood from sustainably managed forests ▼ Land use emissions not addressed
Carbon storage (temporary and permanent)	▲ No discounting for temporary carbon storage ▼ No permanent carbon storage allowed. Degradation calculated without time limit	▲ No discounting for temporary carbon storage ▼ Permanent carbon storage allowed. Landfill emissions accumulated up to 100 years after disposal, remainder is considered permanently stored
Impact categories required	▲ GWP-total includes biogenic carbon ▼ GWP-biogenic, GWP-luluc, and GWP-fossil reported separately ▼ Biogenic carbon content in product and packaging at the factory gate required to be reported separately as additional information. See Table 2 for more details.	▲ GWP-total includes biogenic carbon ▼ Additional biogenic carbon inventory indicators required to be reported separately. See Table 3 for more details.
Life Cycle Stages required	▼ LCA stages A1–A3, C1–C4, and D required	▼ LCA stages A1–A3 required

▲ Aligned

▼ Not aligned

Note: In North America, different organizations may publish a PCR for any given product category. For example, while UL Environment published the current PCR for structural wood products, SmartEPD published a PCR for wood pallets (https://smartepd.com/pcr-library) requiring distinct reporting rules from the UL PCR considered herein. Another common publisher of North American PCRs is the National Sanitation Foundation (NSF).

America, followed by a summary of key differences in biogenic carbon accounting, land use accounting, carbon storage, impact categories, and life cycle stages.

EN15804:2012+A2:2019 Required Impact Indicators and Information Describing Biogenic Carbon Content			
LCA Stages (*Required):	*A1-A3	*C1-C4	*D
Required GWP Impact Indicators:	GWP-total	GWP-total	GWP-total
	GWP-fossil	GWP-fossil	GWP-fossil
	GWP-biogenic	GWP-biogenic	GWP-biogenic
	GWP-luluc	GWP-luluc	GWP-luluc
Required Information Describing Biogenic Carbon Content at the Factory Gate:	Biogenic carbon content in product (at the factory gate)	---	---
	Biogenic carbon content in accompanying packaging (at the factory gate)	---	---

Table 3. Required impacts and biogenic carbon inventory parameters to be reported per ISO 21930:2017. Note that reporting of biogenic carbon inventory parameters is required for LCA stages A1–A3 and C3/C4, however core environmental impacts are only required to be reported for stages A1–A3. Source: International Organization for Standardization. (2017). ISO 21930:2017. (Sections 7.2.7 and 7.2.12)

ISO21930:2017 Required Impact Indicators and Inventory Parameters			
LCA Stages (*Required):	*A1-A3	C3/C4	D
Required GWP Impact Indicators:	GWP (total)	---	---
Required Biogenic Carbon Inventory Parameters:	Biogenic carbon removal from product (BCRP)	Biogenic carbon removal from product (BCRP)	---
	Biogenic carbon emission from product (BCEP)	Biogenic carbon emission from product (BCEP)	---
	Biogenic carbon removal from packaging (BCRK)	Biogenic carbon removal from packaging (BCRK)	---
	Biogenic carbon emission from packaging (BCEK)	Biogenic carbon emission from packaging (BCEK)	---
	Biogenic carbon emission from combustion of waste from renewable sources used in production (BCEW)	Biogenic carbon emission from combustion of waste from renewable sources used in production (BCEW)	---

4. EPD reporting: methods, impacts, and indicators

The required environmental impacts and other values reported in European and North American EPDs differ significantly, further preventing comparison. There are key differences in terms of which impact categories and inventory indicators are required by each, which minimum life cycle stages must be reported, and which characterization factors are used to calculate impacts from emissions.

4.1 Life cycle stages

Both EN 15804+A2 (section 7.5) and ISO 21930 allow impacts in LCA stages A1–A3 to be aggregated. However, as discussed in section 3.4, EN15804+A2 also requires C1-C4 and D stages, whereas ISO 21930 only requires reporting of A1-A3. Although required by EN 15804+A2, neither the European nor the North American wood PCRs have yet been updated to require LCA stages beyond A1–A3.

4.1 Impact categories and indicators

As noted previously, EN 15804+A2 requires impact categories and LCA stages beyond those required by ISO 21930, requiring GWP-fossil, GWP-biogenic, and GWP-luluc rather than just GWP-total. ISO 21930 uniquely requires reporting of additional biogenic carbon inventory indicators in stages A1–A3 and C3/C4, however these additional biogenic carbon inventory indicators are not technically comparable with the GWP-biogenic impact category required by EN 15804+A2.

Required GWP impact categories and LCA stages for European EPDs (per EN 15804+A2) and for North American EPDs (per ISO 21930) are shown below in Tables 2 and 3.

Table 2. Required impacts and biogenic carbon inventory parameters to be reported per EN 15804+A2:2019. Source: European Committee for Standardization. (2019). EN 15804:2012+A2:2019. (Sections 7.2.5 and C.1)

4.3 Characterization factors

Life cycle impact assessment uses the LCI data (i.e., material and energy flows) and LCI results (i.e., environmental outputs) to calculate the environmental impacts of products and processes. Environmental impacts are reported using impact categories and quantitatively expressed using impact category indicators. Global warming potential (GWP) is the impact category used to report the estimated climate change impact of a product, process, or project.

Characterization factors are derived from scientific research and are used to convert an assigned LCI result to the common unit of the impact category indicator. For example, over the course of 100 years, methane absorbs about 28 times more radiative energy than carbon dioxide; hence, 1 kg of methane is equivalent to 28 kgs of carbon dioxide. Methane's characterization factor for GWP is therefore 28 kg CO2e per kg. Characterization factors are used so that an impact category can be reported using a single indicator. For example, GWP is a combined weighted measure of GHGs, most importantly the non-fluorinated gases carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O).

Specific characterization factors are required by EN 15804+A2, and the EF v3 LCIA method was created specifically for conformance with EN 15804+A2. ISO 21930:2017 specifies use of the TRACI LCIA method for evaluating environmental impacts for North American EPDs. Characterization factors implemented in European and North American LCIA methods may therefore differ.

As noted in section 2, one of the major updates in 2019 to EN 15804+A2 was the requirement to use the 100-year time horizon GWP characterization factors without climate-carbon feedbacks from the IPCC 2013 Fifth Assessment Report (AR5) for reporting climate change impacts. GWP factors calculated without carbon feedbacks only consider the radiative forcing of directly emitted greenhouse gases, and do not take into account how climate change may further increase carbon emissions from natural sources.

While ISO 21930 identifies the IPCC AR5 method, citing IPCC Climate Change 2013 (AR5), as the default international characterization method for calculation of GWP, the US EPA TRACI 2.1 method (which still refers to IPCC AR4) is the default North American characterization method for all impact categories. For European EPDs, EN15804+A2 (annex C, table C1.) defines the default European characterization methods for all impact categories, which refers to IPCC AR5 for GWP. IPCC AR4 and AR5 characterization factors for greenhouse gases may differ, for example the AR4 characterization factor for methane (CH4) is 25 kg CO2e per kg while the AR5 characterization factor is 28 kg CO2e per kg. These differences in characterization methods innately cause differing results for the same product across regions, further preventing comparison.

5. Summary and Conclusions

Currently, while all building material EPDs generally follow the same core standard (ISO 14025), the specific rules for the quantification and reporting of biogenic carbon emissions have begun to diverge between core North American standards (ISO 21930 and the North American Wood Products PCR) and European standards (EN 15804+A2 and the European Wood Products PCR). This results in disharmonies between the prescribed calculation and reporting rules and prevents comparison of wood product EPDs internationally.

Critical aspects of wood product PCRs which currently lack global harmonization include:

- biogenic carbon removals accounting,
- treatment of biogenic carbon emissions and stocks at end-of-life,
- characterization of temporary and permanent carbon storage,
- source forest disclosure requirements,
- land use and land-use change (LULUC) accounting, and
- required environmental impacts and indicators to be reported.

Regarding biogenic carbon accounting, similar -1/+1 accounting frameworks are applied for compliance with EN and ISO standards. However, there exist key differences for crediting biogenic carbon removals with a -1 characterization factor (rather than 0). With respect to end-of-life (EOL) accounting rules, ISO 21930 allows permanent landfill carbon storage to be accounted for, while EN 15804+A2 disallows this by requiring all biogenic carbon entering the product system to exit as an emission. This results in significant differences in the net values reported on European and North American EPDs. Land use and land-use change (LULUC) accounting requirements of European EPDs are greater in detail and transparency compared to North American EPDs. Per EN 15804+A2, GWP-luluc must always be reported regardless of wood source, while the UL PCR (per ISO 21930) allows for zero GWP(land-use change) to be assumed if wood is harvested from any North American forest. Last, the required LCIA and impact indicators to be reported in European and North American wood EPDs differ, with EN 15804+A2 requiring disaggregated GWP impacts and EOL stages exceeding those required by ISO 21930.

The additional LCA stages and GWP impact categories required by EN 15804+A2 improve transparency of removals and emissions of biogenic carbon. The additional biogenic carbon indicators required by ISO 21930 also provide transparency beyond GWP-total, however are neither consistently reported in North American EPDs nor comparable to the GWP-biogenic impact category reported in European EPDs. In the future, the LCA stages and impact categories required by ISO 21930 may readily be updated to align with EN 15804+A2. Accounting rules in LCA standards for carbon storage in landfills should also strive for harmonization, prioritizing transparency and accuracy while acknowledging differences between common waste-handling practices in different regions.

For global trade, any companies exporting wood products to Europe must have EPDs that comply with European PCRs and standards. This incentivizes companies globally to produce wood product EPDs which comply with the additional requirements included in EN 15804+A2. However, the current language in the North American Wood Products PCR prohibits its use for any wood products that originate outside North America, making it difficult for foreign companies to assert that they comply with the PCR. Since wood products are traded internationally, architects and engineers may be interested in comparing EPDs from different regions when selecting materials for a project. However, current differences between ISO 21930 and EN 15804+A2 prevent comparison of European and North American EPDs.

Harmonizing ISO 21930 with EN 15804+A2 could improve the transparency of biogenic carbon reporting in North American EPDs, improve comparability between European and North American EPDs, and set precedent for international alignment of wood EPDs.

Despite technical disagreements and temporal misalignment resulting in differences across current regional wood product PCRs, global consensus on the need to improve transparency and accuracy of EPDs is already contributing to international harmonization efforts. Due to the increasingly global nature of construction material supply chains, harmonization of PCRs is necessary to improve global comparability of EPDs. In the near future, current misalignments between regional LCA standards and wood product PCRs may feasibly be remedied leading to vast improvements in global comparability of wood product EPDs and whole building LCA (WBLCA) models for which they are a critical data source.

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Definitions

Attributional LCA: An attributional life cycle assessment estimates the share of global environmental burdens attributed to a product or service.

Biogenic Carbon: "Carbon derived from/contained in biomass." (EN 16485:2015)

Consequential LCA: A consequential LCA gives an estimate of how the global environmental burdens are affected by the production and use of the product

Direct Land Use Change: "Change in human use or management of land at the location of the production, use or disposal of raw materials, intermediate products and final products, or wastes in the product system being assessed." (EN 16485:2014)

End-of-life (EOL): "The end-of-life stage of the construction product starts when it is replaced, dismantled or deconstructed from the construction works and does not provide any further functionality." (ISO 21930:2017). The end-of-life stages of an LCA are C1–C4.

Environmental Product Declaration (EPD): "An environmental declaration providing quantified environmental data using predetermined indicators and, where relevant, additional environmental information." (EN 15804:2012+A2:2019).

Land Use: "The type of activity being carried out on a unit of land." (IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry)

Land Use Change: "Change in human use or management of land at the location of the production, use or disposal of raw materials, intermediate products and final products or wastes in the product system being assessed." (ISO 21930:2017)

Life cycle Impact Assessment Method (LCIA): "The phase of LCA aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product." (ISO 21930:2017)

Native Forest: "A forest composed of indigenous trees not established by planting or/and seeding in the process of afforestation or reforestation." (UN-REDD)

Note: "Native forests exclude short term forests, degraded forests, managed forest, and forests with short-term or long-term rotations." (EN15804+A2)

Normative Reference: A reference that contains additional materials (rules or guidelines) that must be followed in order to correctly implement the standard.

Product Category Rule (PCR): "A set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories" (EN 15804:2012+A2:2019)

System Boundary: "A boundary representing which unit processes are part of a product system." (ISO 21930:2017)

Appendix A: Reference Standards and Additional Resources

Key Reference Standards and Product Category Rules (PCRs)

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Appendix B: Wood EPD Examples and Data

The authors collected structural wood product EPDs to review for metadata, product parameters, and reported environmental impact results. About 70 EPDs were collected from all global regions as available for products categorized as glued laminated timber (glulam), mass timber panels, or structural composite lumber.

The examples and figures below highlight the differences in reported results between EPDs complying with EN 15804+A2 and ISO 21930. In particular, note the different LCA stages included, impact categories and indicators reported, and difference in A1–A3 GWP values reported in the example EPD results.

Mandatory impact category indicators according to EN 15804+A2

Results per declared unit – 1 m³ CLT by Stora Enso													
Indicator	**Unit**	**A1**	**A2**	**A3**	**A1-A3**	**A4**	**A5**	**B1-B7**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-fossil	kg CO_2 eq.	3,26E+1	8,71E+0	1,12E+1	**5,26E+1**	2,59E+1	5,38E+0	0,00E+0	4,01E+0	2,04E+1	2,02E+1	0,00E+0	-2,67E+2
GWP-biogenic	kg CO_2 eq.	-7,62E+2	6,28E-3	3,40E-1	**-7,62E+2**	1,03E-2	1,00E-3	0,00E+0	6,98E-4	8,12E-4	7,62E+2	0,00E+0	-7,51E-1
GWP luluc	kg CO_2 eq.	8,26E-1	4,73E-3	4,76E-2	**8,78E-1**	9,72E-3	4,06E-4	0,00E+0	3,97E-4	7,67E-4	2,27E-3	0,00E+0	-2,77E-1
GWP total	kg CO_2 eq.	-7,29E+2	8,72E+0	1,16E+1	**-7,08E+2**	2,59E+1	5,38E+0	0,00E+0	4,01E+0	2,05E+0	7,82E+2	0,00E+0	-2,68E+2

Figure 4: Core environmental impacts for Stora Enso Cross-Laminated Timber (CLT), a typical European structural wood product EPD complying with EN 15804+A2 and EN 16485. Results above are the main results reported, assuming 100% of wood is incinerated at end-of-life (EOL). Since EOL biogenic carbon emissions from the product are reported in stage C3, the A1–A3 GWP-total is negative. Source: Stora Enso. (2023). EPD for Cross-Laminated Timber. Accessed at: https://api.environdec.com/api/v1/EPDLibrary/Files/1a41e427-c680-4160-ff75-08dc52cf9624/Data

Core environmental impacts (Element 5)

Table 6. Production stage (A1-A3) EPD results for 1 m³ CLT

Impact category and inventory indicators	Unit	CLT
Global warming potential, GWP 100[1)]	kg CO_2 eq	**122.0**
Ozone depletion potential, ODP[1)]	kg CFC-11 eq	**1.3E-05**
Smog formation potential, SFP[1)]	kg O_3 eq	**16.9**
Acidification potential, AP[1)]	kg SO_2 eq	**0.80**
Eutrophication potential, EP[1)]	kg N eq	**0.14**

Biogenic carbon indicators (Element 5)

Table 7. Biogenic carbon inventory parameters for 1 m³ of Element5 CLT (A1 to C4)

Additional inventory parameters	Unit	Total	A1	A2	A3	A5	C3/C4
BCRP: Biogenic Carbon Removal from Product[1)]	kg CO_2	-865.9	-865.9	0	0	0	0
BCEP: Biogenic Carbon Emission from Product[1)]	kg CO_2	865.9			90.3[2)]		775.6[3)]
BCRK: Biogenic Carbon Removal from Packaging	kg CO_2	0	0	0	0	0	0
BCEK: Biogenic Carbon Emission from Packaging	kg CO_2	0	0	0	0	0	0
BCEW: Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production	kg CO_2	0	0	0	0	0	0
Net GWP Bio	**kg CO_2**	**0**					

Notes to Table 7:
1) Biogenic CO_2 emissions are calculated on an oven-dry weight basis; Biogenic C content of the biomass is assumed 50%. To convert the amount of biogenic C to CO_2 emissions, the 44/12 molecular weight ratio is applied.
2) Biogenic CO_2 emissions of the biomass leaving the CLT manufacturing system in A3.
3) Biogenic CO_2 emissions of the declared products at the end-of-life (assumed to be reused, recycled, or combusted).

Additional information: Carbon sequestration (Element 5)

Cradle-to-grave carbon sequestration calculation for CLT:
1 m³ CLT = 423.0 oven dry kg = 211.5 kg C = 775.6 kg CO2 eq

Carbon sequestered in CLT at manufacturing gate: - 775.6 kg CO_2 eq

Methane emitted from fugitive landfill gas: 1.5 kg CH_4= 37.3 kg CO_2 eq emission

Carbon dioxide emitted from fugitive landfill gas and the combustion captured landfill gas: 87.2 kg CO_2 eq emission

Permanent carbon sequestration per cubic meter of CLT: - 651.1 kg CO_2 eq

Figure 5: Core environmental impacts, biogenic carbon indicators, and carbon sequestration additional information for Element 5 Cross-Laminated Timber (CLT), a typical North American structural wood product EPD complying with ISO 21930 and the UL PCR Part B. In this case biogenic carbon removals and emissions contribute net zero impact to A1–A3 GWP, and permanent landfill carbon sequestration is calculated and reported as additional information. In this EPD, carbon sequestered in the product at the manufacturing gate is additionally reported although not required by ISO 21930. Source: Element 5. (2022). EPD for Cross-Laminated Timber. Accessed at: https://elementfive.co/?download=3807

Appendix C: Structure of key standards and references informing PCRs

European PCR for Wood Construction Products (EN 16485:2014)

Normative references for EN 16485:2014 include EN 15804:2012+A2:2019, ISO 14025:2006, and ISO 14044:2006. ISO 14044 specifies requirements and provides guidelines for conducting life cycle assessments (LCAs). ISO 14025 establishes the principles and procedures for creating Type III environmental declarations (EPDs), and specifies use of the ISO 14040 series of standards. In other words, ISO 14025 requires that EPDs follow the ISO 14040:2006 and ISO 14044:2006 LCA methodology. These rules apply to creation of all European EPDs, including wood construction product EPDs. While it is not listed as a normative reference for this standard, it should be noted that ISO 21930:2017 "provides the principles, specifications and requirements to develop an environmental product declaration (EPD) for construction products''.

The full suite of standards intended to assess the sustainability of construction works consists of:

- **EN 15804:2012+A2:2019**, which provides the core rules for the product category of construction products.
- **EN 15643:2021;** which "provides principles and requirements for the assessment of environmental, social and economic performance of buildings and civil engineering works taking into account their technical characteristics and functionality."
- **EN 15978:2011**, which specifies the calculation method and reporting requirements for building LCAs.
- **CEN/TR 15941:2010**, a technical report providing guidance on the use of generic data in accordance with the rules EN 15804.
- **EN 15942:2022,** which "specifies and describes the communication format for the information defined in EN 15804 for business-to-business communication."

The structure of key standards and references informing EN 16485:2014 is shown in the figure 6 below.

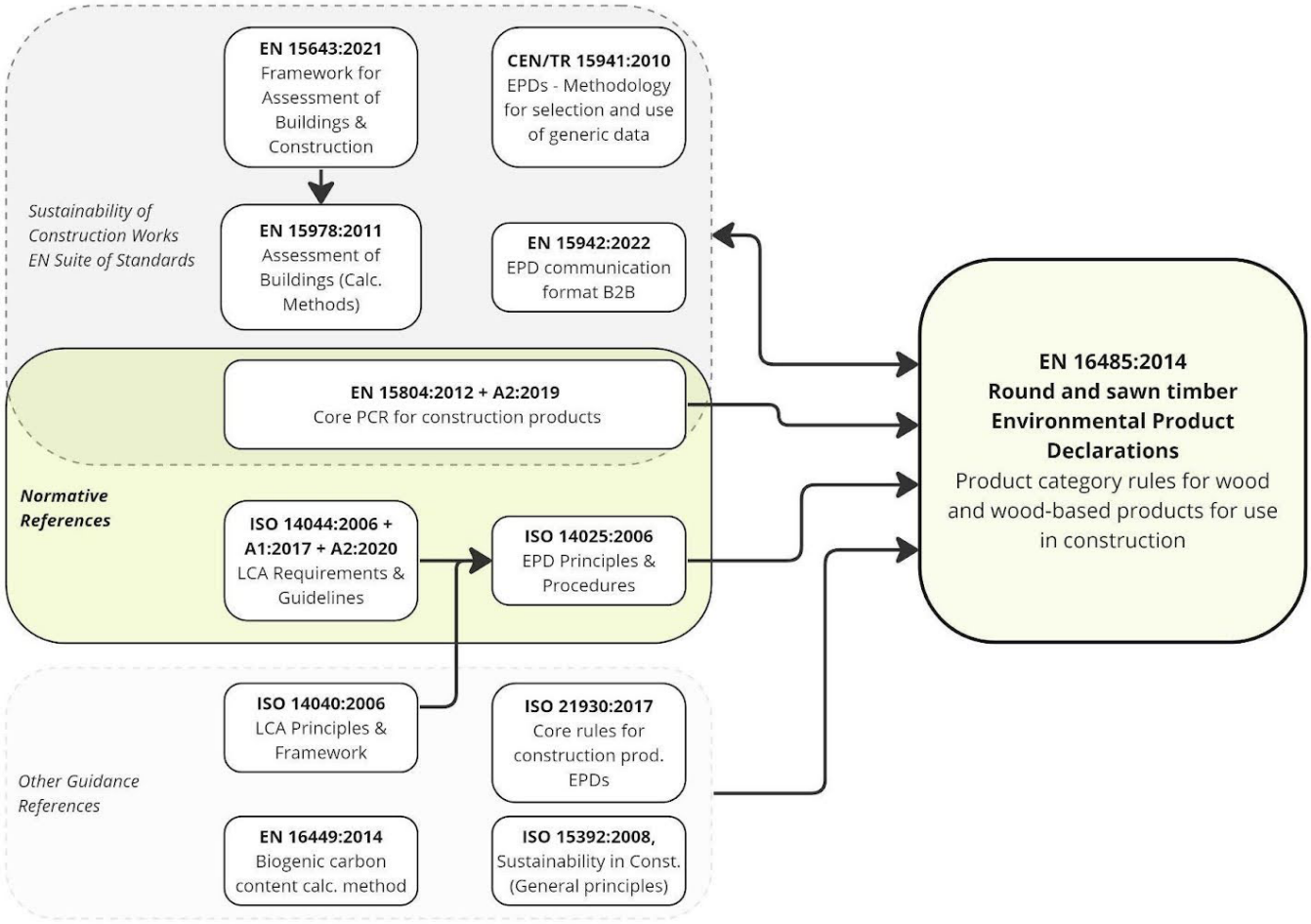

Figure 6: Full structure of normative and guidance references for European Product Category Rule applying to Wood Product EPDs, based on EN 16485:2014.

North American PCR for Wood Construction Products (EN 16485:2014)

Normative references for the UL PCR Part B: Structural and Architectural Wood Products EPD Requirements include Part A of the UL PCR, EN 15804:2012+A2:2019, ISO 21930:2017, ISO 14025:2006, ISO 14040:2006, and ISO 14044:2006.

These normative references are nearly identical to the normative references for the European PCR for wood products (EN 16485:2014), except that EN 16485 lists the ISO standards (21930, 14040, 14044) as guidance references rather than normative references. This indicates that North American EPDs for wood products must comply with these ISO standards, while European EPDs for wood products may only use ISO 21930:2017 for guidance.

Additional references listed for guidance in the UL PCR include the PCR for preparing an EPD for North American Structural and Architectural Wood Products (FPInnovations, 2011), PCR for preparing an EPD for Product Group: North American Pressure-treated Wood Products (ASTM, 2016), and EN 16485:2014. For calculating end-of-life biogenic carbon landfill emissions, the UL PCR refers to the EPA WARM methodology (US EPA, 2019). The structure of key standards and references informing the UL PCR Part B for wood products is shown in the diagram below.

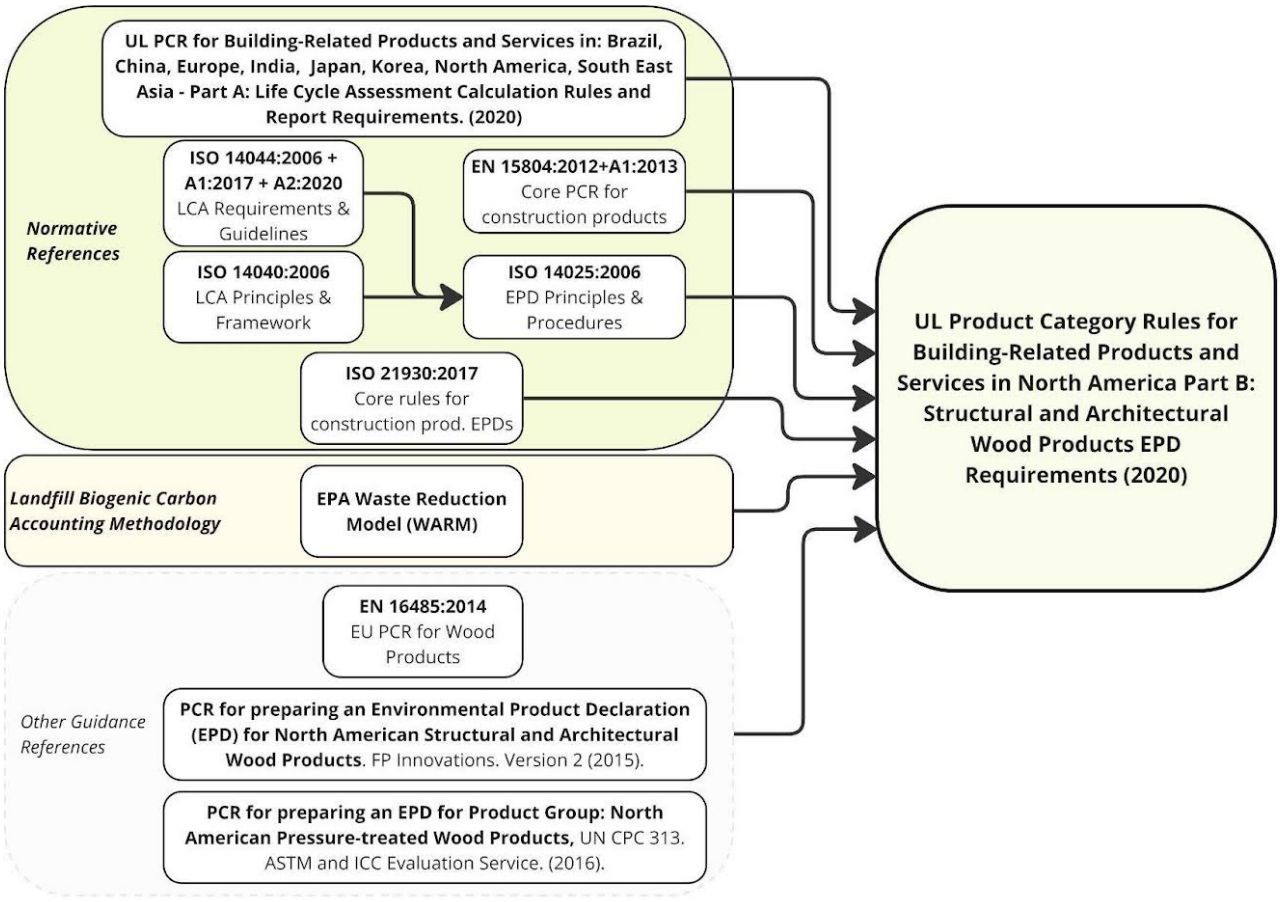

Figure 7: Full structure of normative and guidance references for North American Product Category Rule applying to Wood Product EPDs, based on UL PCR Part B Wood Products EPD Requirements.

Appendix D: Comparison of All Required Impact Categories and Indicators

The following table compares the required impact categories specified by EN 15804+A2 for European EPDs and ISO 21930 (and Part A of the UL PCR) for North American EPDs. The impact categories, indicators, and models used in the left-most column reflect the terminology used in EN 15804+A2. If the UL PCR Part A uses different terminology or unit for an equivalent impact category or indicator, this is noted next to the check box in the relevant cell.

Table 4. Required LCIA impact categories to be reported for each LCA stage.

Impact Category / [Indicator] / {Model}	Unit (per functional unit or declared unit)	Required by EN 15804:2012+A2:2019 (Europe)	Required by ISO 21930 and UL PCR Part A (North America)
Climate change - total [GWP-total] {IPCC 2013}	[kg CO_2 eq.]	☑ 100 years (Sum of GWP-fossil, GWP-biogenic, and GWP-luluc)	☑ "GWP 100"
Climate change - fossil [GWP-fossil] {IPCC 2013}	[kg CO_2 eq.]	☑ 100 years	☐
Climate change - biogenic [GWP-biogenic] {IPCC 2013}	[kg CO_2 eq.]	☑ 100 years	☐
Climate change - land use and land use change [GWP-luluc] {IPCC 2013}	[kg CO_2 eq.]	☑ 100 years	☑ "GWP (land-use change)" **Required only when significant*
Ozone Depletion [ODP]	[kg CFC-11 eq.]	☑	☑
Acidification [AP]	[mol H^+ eq.]	☑	☑ [kg SO_2 eq.]
Eutrophication potential (total) [EP]	[kg N eq.]	☐	☑
Eutrophication aquatic freshwater [EP-freshwater]	[kg PO_4 eq.]	☑	☐
Eutrophication aquatic marine [EP-marine]	[kg N eq.]	☑	☐
Eutrophication terrestrial [EP-terrestrial]	[mol N eq.]	☑	☐
Photochemical ozone formation [POCP]	[kg NMVOC eq.]	☑	☑ "Smog formation potential" (SFP) [kg O_3 eq.]
Depletion of abiotic resources - minerals and metals (ADP-minerals&metals)	[kg Sb eq.]	☑	☐
Depletion of abiotic resources - fossil fuels [ADP-fossil]	[MJ, net calorific value]	☑	☑ [MJ, LHV]
Water Use	[m^3 world eq. deprived]	☑	☐

In addition to the differences in impact categories required to be reported for each LCA stage, there are a number of indicators (not included in the LCIA) which quantify resource use, waste categories, and output flows. These indicators are not reported for each LCA stage, and are reported separately from the impact categories above.

Table 5 compares the resource use, waste category, and output flow indicators required by EN 15804+A2 for European wood products and ISO 21930 (and the UL PCR Part A) for North American wood products. Abbreviations used in the UL PCR Part A are included in parentheses.

Table 5: Required non-LCIA indicators or parameters to be reported.

Parameter / (indicator)	**Unit (per functional unit or declared unit)**	**Required by EN 15804:2012 + A2:2019 (Europe)**	**Required by ISO 21930 and UL PCR Part A (North America)**
Resource Use Indicators		*EN15804+A2. section 7.2.4.2, Table 6*	*UL PCR Part A , section 4.1, Table 6*
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	[MJ]	☑"MJ, net calorific value"	☑ (RPR_E)
Use of renewable primary energy resources used as raw materials	[MJ]	☑ "MJ, net calorific value"	☑ (RPR_M)
Total use of renewable primary energy re-sources (primary energy and primary energy resources used as raw materials)	[MJ]	☑ "MJ, net calorific value"	☐ ($RPR_T = RPR_E + RPR_M$) **not required*
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	[MJ]	☑ "MJ, net calorific value"	☑ ($NRPR_E$)
Use of non-renewable primary energy resources used as raw materials	[MJ]	☑ "MJ, net calorific value"	☑ ($NRPR_M$)
Total use of non-renewable primary energy resources(primary energy and primary energy resources used as raw materials)	[MJ]	☑ "MJ, net calorific value"	☐ ($NRPR_T = NRPR_E + NRPR_M$) **not required*
Use of secondary material	[kg]	☑	☑ (SM)
Use of renewable secondary fuels	[MJ]	☑ "MJ, net calorific value"	☑ (RSF)
Use of non-renewable secondary fuels	[MJ]	☑ "MJ, net calorific value"	☑ (NRSF)
Recovered energy (from disposal of waste in previous systems, such as energy recovery from combustion of landfill gas or energy recovered from other systems using energy sources)	[MJ]	☐	☑ (RE)
Net use of fresh water	[m^3]	☑	☑ (FW)

Parameter / (indicator)	Unit (per functional unit or declared unit)	Required by EN 15804:2012 + A2:2019 (Europe)	Required by ISO 21930 and UL PCR Part A (North America)
Waste Categories and Output Flows		*EN15804+A2, sections 7.2.4.3 - 7.2.4.4, Tables 7 and 8*	*UL PCR Part A, section 4.1.2, Table 7*
Hazardous waste disposed	[kg]	☑	☑ (HWD)
Non-hazardous waste disposed	[kg]	☑	☑ (NHWD)
Radioactive waste disposed	[kg]	☑	☐
High-level radioactive waste, conditioned, to final repository	[kg] or [m^3]	☐	☑ *(HLRW)*
Intermediate- and low-level radioactive waste, conditioned, to final repository	[kg] or [m^3]	☐	☑ *(ILLRW)*
Components for re-use	[kg]	☑	☑ *(CRU)*
Materials for recycling	[kg]	☑	☑ *(MR)*
Materials for energy recovery	[kg]	☑	☑ *(MER)*
Exported energy	[MJ per energy carrier]	☑	☑ *(EE), [MJ, heating value (lower heating value) per energy carrier]*
Carbon Emissions and Removals / Biogenic Carbon Content		*EN15804+A2, sections 7.2.5, Table 9*	*UL PCR Part A, section 4.6, Table 8*
Biogenic carbon content in product	[kg C]	☑	☐
Biogenic carbon removal from product	[kg CO_2]	☐	☑ (BCRP)
Biogenic carbon emission from product	[kg CO_2]	☐	☑ (BCEP)
Biogenic carbon content in accompanying packaging	[kg C]	☑	☐
Biogenic carbon removal from packaging	[kg CO_2]	☐	☑ (BCRK)
Biogenic carbon emission from packaging	[kg CO_2]	☐	☑ (BCEK)
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	[kg CO_2]	☐	☑ (BCEW)
Calcination Carbon Emissions	[kg CO_2]	☐	☑ (CCE)
Carbonation Carbon Removals	[kg CO_2]	☐	☑ (CCR)
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	[kg CO_2]	☐	☑ (CWNR)