EPD
INTERNATIONAL EPD SYSTEM

WIND TURBINE BLADES FOR WIND ENERGY GENERATION

PRODUCT GROUP CLASSIFICATION: UN CPC 46131

C-PCR-XXX (TO PCR 2019:14)

VERSION 1.0.0 FOR OPEN CONSULTATION. DO NOT USE OR CITE.

VALID UNTIL 20XX-YY-ZZ *(TO BE ADDED BY THE SECRETARIAT)*

DRAFT FOR OPEN CONSULTATION

INTRODUCTION TO OPEN CONSULTATION

This draft PCR document is available for open consultation from 2026-08-19 until 2026-10-19. Feel free to forward the draft to any other stakeholder you might think is relevant, including colleagues and other organisations.

We are interested in comments from stakeholders on:

- General
  - Alignment with PCRs available in other programmes for type III environmental declarations, industry-specific LCA guidelines or similar.
- Scope of PCR
  - Product category definition and description
  - Classification of product category using CPC codes
- Goal and scope, life cycle inventory and life cycle impact assessment
  - Functional unit/declared unit

    The Secretariat would like to ask all relevant stakeholders for this c-PCR whether, in their view, a declared unit or a functional unit should be used for the type of product covered by this c-PCR.

    Please see section 4.2 for further details.

  - System boundary
  - Allocation rules
  - Data quality requirements
  - Recommended databases for generic data
  - Impact categories and impact assessment methodology
- Additional information

Comments shall be sent directly to the PCR Moderator (contact details available in Section 1). There is a template for comments on www.environdec.com that may be used.

For questions about the PCR, please contact the PCR moderator. For general questions about the International EPD System, EPD or PCR development, please contact the Secretariat via https://www.environdec.com/support.

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1 INTRODUCTION

1.1 GENERAL

This document constitutes complementary Product Category Rules (c-PCR) developed in the framework of the International EPD System: a programme for Environmental Product Declarations (EPD)[1] according to ISO 14025, ISO 14040, ISO 14044, and product-specific standards such as EN 15804, EN 15941 and ISO 21930 for construction products.[2] EPDs are voluntary documents for a company or organisation to present transparent, consistent and verifiable information about environmental performance of their product (goods or services).

The General Programme Instructions (GPI), publicly available on www.environdec.com, includes the rules for the overall administration and operation of the programme and the basic rules for developing EPDs registered in the programme. PCRs and c-PCRs complement the GPI and the normative standards by providing specific rules and guidelines for developing an EPD for one or more specific product categories (see Figure 1). A PCR/c-PCR should enable different practitioners using the PCR/c-PCR to generate consistent results when assessing products of the same product category.

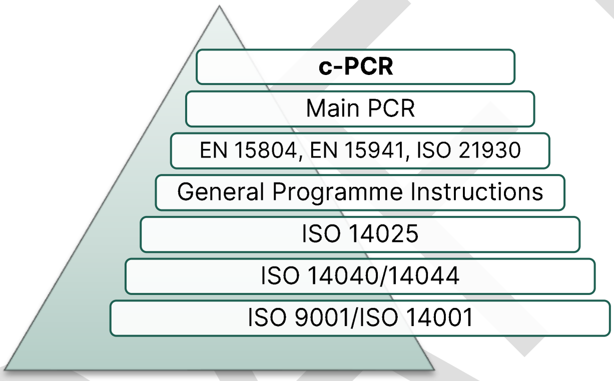

Figure 1. This c-PCR in relation to the hierarchy of standards and other documents.

The present c-PCR uses the following terminology:

- The term “shall” is used to indicate what is obligatory, i.e., a requirement.
- The term “should” is used to indicate a recommendation. Any deviation from a recommendation shall be justified in the EPD development process.
- The terms “may” or “can” are used to indicate an option that is permissible.

For definitions of further terms used in the document, see the GPI, the main PCR, and the normative standards.

A main PCR and its c-PCRs are valid for a pre-determined period of time to ensure that it is updated at regular intervals. The latest version of the PCR and its c-PCRs are available on www.environdec.com. Stakeholder feedback on PCRs and c-PCRs is very much encouraged. Any comments on this c-PCR may be sent directly to the PCR Moderator and/or the Secretariat during its development or during its period of validity.

Any references to this document shall include the PCR registration number, name and version.

The programme operator maintains the copyright of the PCR to ensure that it is possible to publish, update, and make it available to all organisations to develop and register EPDs. Stakeholders participating in PCR development should be acknowledged in the final document and on the website.

[1] Termed type III environmental declarations in ISO 14025.

[2] When standards are referred to in this document, the version listed in Section **Error! Reference source not found.** is intended unless otherwise stated.

1.2 ROLE OF THIS DOCUMENT

This c-PCR complements the main PCR of construction products in the International EPD System, PCR 2019:14 Construction products, available on www.environdec.com. The c-PCR cannot be used by itself but shall be used together with PCR 2019:14, and EN 15804 and EN 15941, for products within the scope of the PCR (see Section 2.2.1). It is required to use an applicable c-PCR after it has been published 90 days. It is optional to use the c-PCR if it has been published for less than 90 days.

This document shall be used together with a valid version of main PCR 2019:14.

If more than one c-PCR is applicable, the EPD owner may choose to use any of them, but it is recommended to use the one that is more specific in scope in terms of product function. An alternative is to use, and verify the EPD towards, several applicable c-PCRs, as long as there are no conflicting requirements in the c-PCRs.

If requirements in the main PCR and the c-PCR are in conflict, the requirements in the c-PCR take precedence over those in the main PCR.

See Figure 2 for an illustration on how PCR 2019:14 and this c-PCR relate to each other and the EPDs that may be based on them.

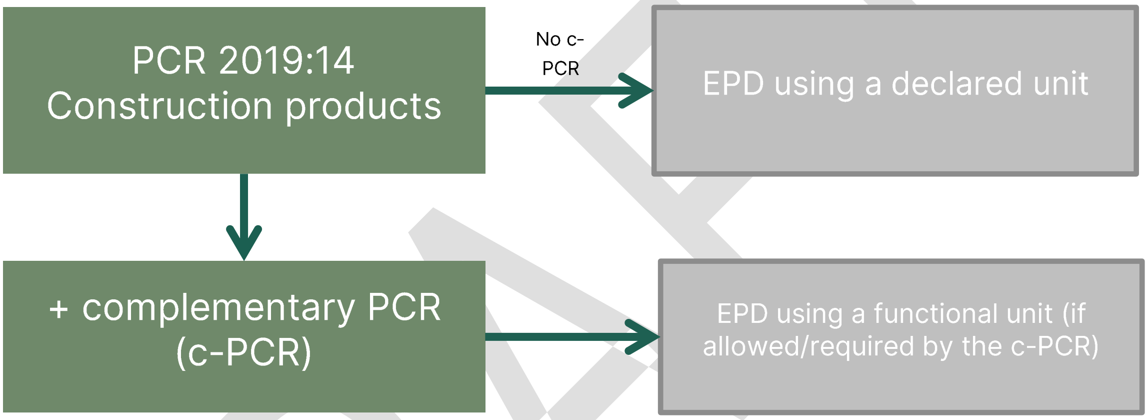

Figure 2. Overview of how PCR 2019:14 can be used directly, or together with a c-PCR, to develop an EPD. An EPD that uses a functional unit shall be based on a c-PCR. An EPD based on a declared unit can be developed without a c-PCR.

2 GENERAL INFORMATION

2.1 ADMINISTRATIVE INFORMATION

Name:	Wind Turbine Blades for wind energy generation
Registration number and version:	*To be added by the Secretariat*
Programme:	INTERNATIONAL EPD SYSTEM
Programme operator:	EPD International AB, Box 210 60, SE-100 31 Stockholm, Sweden. Website: www.environdec.com E-mail: support@environdec.com
PCR Moderator:	Wenhao Chen, Contemporary Amperex Technology Co., Ltd., ChenWenhao@catl.com
PCR Committee:	▪ Huadian Carbon Assets Ltd. ▪ IVL Swedish Environmental Research Institute ▪ China Mobile IoT Co., Ltd. ▪ Electric Energy (Beijing) Certification Center Co., Ltd. ▪ Goldwind Science & Technology Co., Ltd. ▪ IVL Environmental technology (Beijing) company., Ltd. ▪ SNITEF Ocean AS ▪ Vestas Wind Systems A/S ▪ Nordex SE ▪ Envision Energy Co. Ltd. ▪ China Materials Recycling Association Wind and Solar Equipment Recycling Specialized Committee ▪ Energy and Environment Committee of China Energy Research Society ▪ China Glass Fiber Industry Association ▪ Zhuzhou Times New Material Technology Co., Ltd. ▪ Beijing Huadian E-commerce Technology Co., Ltd. ▪ Sinoma Wind Power Blade Co., Ltd.
Publication date	*To be added by the Secretariat* See Section 9 for a version history of the c-PCR.
Valid until:	*To be added by the Secretariat* The validity may change. See www.environdec.com for the latest version of the PCR and the latest information on its validity and transition periods between versions.
Development and updates.	The c-PCR has been developed following ISO/TS 14027, including public consultation and review. The rules for the development and updating processes are described in Section 9 of the GPI. The c-PCR is valid for a pre-determined time period to ensure that it is updated at regular intervals. When the c-PCR is about to expire, the PCR Moderator shall initiate a discussion with the Secretariat on if and how to proceed with updating the c-PCR and renewing its validity. A c-PCR may be updated before it expires, based on changes in

	normative standards or provided significant and well-justified proposals for changes or amendments are presented. When there has been an update of the c-PCR, the new version should be used to develop EPDs. For small updates (change of third-digit version number), the previous version is normally immediately removed from the PCR library on www.environdec.com and there is no transition period. For medium updates (change of second-digit version number), the previous version of the c-PCR is valid in parallel during a transition period of at least 90 days, but not exceeding its previously set validity period. For large updates (change of first-digit version number), the previous version is valid in parallel during a transition period of at least 180 days, but not exceeding its previously set validity period. In case a c-PCR is developed by a CEN Product TC, the standard will replace this c-PCR, with a transition period of at least 90 days under which both are valid. Stakeholder feedback on PCRs is very much encouraged. Any comments on this PCR may be sent directly to the PCR Moderator and/or the Secretariat during its development or during its period of validity.
Standards documents and conformance:	For compliance to standards and documents, see PCR 2019:14.
PCR language(s):	At the time of publication, this c-PCR was available in English. If the c-PCR is available in several languages, these are available on www.environdec.com. In case of translated versions, the English version takes precedence in case of any discrepancies.

2.2 SCOPE

2.2.1 PRODUCT CATEGORY DEFINITION AND DESCRIPTION

This document provides complementary product category rules (c-PCR) for the assessment of the environmental performance of wind turbine blades and the declaration of this performance by an EPD. The product category corresponds to a subset of UN CPC 46131 (Parts of electric motors, generators and the like). Wind turbine blades for other uses than electricity generation are excluded from the scope.

This c-PCR covers wind turbine blades designed and manufactured for use in horizontal-axis wind turbines (HAWT) for the purpose of wind energy generation (electricity generation). Wind turbine blades are aerodynamic structural components that convert kinetic energy from wind into rotational mechanical energy at the turbine rotor hub.

Wind turbine blades covered by this c-PCR include:

- Blades for onshore wind turbines
- Blades for offshore wind turbines

The following products are explicitly excluded from the scope of this c-PCR:

- Wind turbine blades for non-electricity-generating applications (e.g., water pumping windmills)
- Vertical-axis wind turbine (VAWT) blades, which may be covered by future revisions
- Wind turbine components other than the blade (e.g. nacelle, hub, tower, foundation, electrical systems, etc.)
- Blade sub-components sold separately (e.g., root insert bolts, lightning protection systems sold independently)

2.2.2 TYPE OF EPD AND INFORMATION MODULES INCLUDED

See PCR 2019:14.

Following the requirements in Section 'Type of EPD and information modules included' of PCR 2019:14, an EPD based on this c-PCR is a type b EPD, including modules A1-A3, A4-A5, B1-B4, B6 if applicable, C1–C4 and D. Section 4.3 provides more rules on the system boundaries.

2.2.3 GEOGRAPHICAL SCOPE

This c-PCR may be used globally.

2.2.4 EPD VALIDITY

See PCR 2019:14.

3 PCR REVIEW AND BACKGROUND INFORMATION

This c-PCR was developed in accordance with the PCR development process described in the GPI of the International EPD® System, including open consultation and review.

3.1 OPEN CONSULTATION

3.1.1 VERSION 1.0

This c-PCR was available for open consultation from *date* until *date*, during which any stakeholder was able to provide comments by contacting the PCR Moderator and/or the Secretariat.

Above dates shall be given in the following format: 20YY-MM-DD.

Add information about any physical or web-based meetings held during the open consultation, if applicable.

Stakeholders were invited via e-mail or other means to take part in the open consultation and were encouraged to forward the invitation to other relevant stakeholders. The following stakeholders provided comments during the open consultation and agreed to be listed as contributors in the c-PCR and on www.environdec.com.

- *List of stakeholder names and affiliation (to be added after the open consultation).*

In case no stakeholders provided comments and agreed to be listed as contributors, the above sentence shall be adjusted accordingly ("No stakeholders provided comments during the open consultation and agreed to be listed as contributors in the PCR and on www.environdec.com.") and the bullet list shall be removed.

In case of multiple large updates of the c-PCR (version 1.0, 2.0, etc.), information about each open consultation shall be added as sub-sections (3.1.1, 3.1.2, etc.).

3.2 PCR REVIEW

3.2.1 VERSION 1.0

PCR review panel:	The Technical Committee of the International EPD System. A full list of members is available on www.environdec.com. The review panel may be contacted via support@environdec.com. Members of the Technical Committee were requested to state any potential conflict of interest with the PCR Committee, and if there were conflicts of interest they were excused from the review.
Chair of the PCR review:	*To be added by the Secretariat*
Review dates:	*To be added by the Secretariat*

In case of multiple large updates of the c-PCR (version 1.0, 2.0, etc.), information about each open consultation shall be added as sub-sections (3.2.1, 3.2.2, etc.).

3.3 EXISTING PCRS FOR THE PRODUCT CATEGORY

As part of the development of this c-PCR, existing PCRs and c-PCRs and other internationally standardised methods that could potentially act as c-PCRs for the product category in scope, were considered to avoid unnecessary overlaps in scope and to ensure harmonisation with established methods of relevance for the product category. The existence of such documents was checked among the following EPD programmes and international standardisation bodies:

- International EPD® System. www.environdec.com
- EPD Norge (Norwegian EPD Foundation). www.epd-norge.no

- Institut Bauen und Umwelt e.V. (IBU). www.ibu-epd.com / epd-online.com
- EPDItaly. www.epditaly.it
- Korea Environmental Industry & Technology Institute (KEITI). www.epd.or.kr
- FDES / INIES (France). www.inies.fr
- ISO Technical Committee TC 207. www.iso.org
- IEC Technical Committee TC 88. www.iec.ch
- European Committee for Standardisation (CEN), TC 350. www.cen.eu

Table 1 lists the identified PCRs and other standardised methods.

Table 1. Existing PCRs and other internationally standardised methods that were considered to avoid overlap in scope and to ensure harmonisation with established methods.

Name of PCR/standard, incl. registration number	Programme/ standardisation body	Version number/ date of publication	Scope
PCR 2019:14 — Construction products	International EPD® System	Version 2.0.1 2025-06-05 Valid until 2030-04-07	**Main PCR.** Covers all construction products and services according to EN 15804. Wind turbine blades fall within scope as components permanently incorporated into wind energy construction works (UN CPC 46131). This c-PCR is developed as a direct complement and shall be used together with PCR 2019:14.
EN 15804:2012+A2:2019/AC:2021 — Sustainability of construction works: EPDs; Core rules for the product category of construction products	CEN / TC 350	A2:2019/AC:2021	Normative basis for PCR 2019:14 and therefore for this c-PCR. Defines life-cycle modules A–D, system boundary, allocation procedure, cut-off rules, and environmental performance indicators applicable to all construction product EPDs including wind turbine blades.
PCR 2007:08 — Electricity, steam and hot/cold water generation and distribution	International EPD® System	Version 5.0.2 2024-07-02 Valid until 2028-07-02	Covers EPDs for electricity generated by all technologies including wind power (UN CPC 171 and 173). The primary PCR used for wind farm and wind turbine system-level EPDs in the International EPD® System, where the declared unit is 1 kWh of electricity delivered. Wind turbine blade EPDs under this c-PCR may serve as component input data for wind farm electricity EPDs under PCR 2007:08. The two PCRs are complementary and operate at different system levels (component vs. functional output). No scope overlap; no conflict identified.
EPDItaly 013 — PCR for wind turbines (Electricity produced by wind turbines)	EPDItaly	Rev. 1.2 2026-03-12 Valid until 2027-03-15	Covers electricity produced by wind turbines, UN CPC 171, with global geographical validity. Developed with ENEL as proposer, applicable under EPDItaly GPI version 6.0. Multiple major manufacturers have published EPDs under this PCR, with the declared unit being electricity generated over the wind farm lifetime. Like PCR 2007:08, it operates at the wind farm / electricity output level and treats the blade as one sub-component of the whole turbine system. No

			direct scope overlap with a blade-specific c-PCR under PCR 2019:14; the two are complementary at different system levels.
IBU PCR Part B — Requirements on the EPD for wind turbines *[EXPIRED — no successor identified]*	Institut Bauen und Umwelt e.V. (IBU)	Version 1.0, 2013 Expired	Covered the whole turbine system with the blade treated as a sub-component. No current valid equivalent found in the IBU library at time of review.

3.4 REASONING FOR DEVELOPMENT OF C-PCR

This c-PCR was developed to provide rules and guidance additional to those in PCR 2019:14 and EN 15804, for developing EPDs for the product category. The c-PCR thereby enables different practitioners to generate consistent results when assessing the environmental impact of products of the same product category, and thereby it supports comparability of products within a product category.

Wind turbines are a rapidly growing source of renewable electricity globally. As one of the main sub-components of the wind turbine, wind turbine blades contribute some potential environmental impacts to the whole life cycle of the the wind turbine, which is mainly caused by the raw material use, manufacturing energy, and the transportation of the blades. Additionally, the wind turbine blades are designed for high-performance operation over their lifetime which presents unique challenges for recycling at end-of-life.

This c-PCR has been developed to:

- Enable consistent EPDs for wind turbine blades across manufacturers and regions.
- Provide specific guidance on product-category-relevant aspects such as the declared/functional unit, reference service life, use-stage modules, and end-of-life scenarios.
- Ensure consistent LCA modelling and transparent and verifiable reporting for wind turbine blades in support of sustainability reporting, green procurement, and product design improvement.

3.5 UNDERLYING STUDIES USED FOR C-PCR DEVELOPMENT

The methodological choices made during the development of this c-PCR (declared/functional unit, system boundary, allocation methods, impact categories, data quality rules, etc.) were primarily based on the following underlying studies:

- Alavi, M., et al. (2024). End-of-life wind turbine blade management across energy transition: A life cycle analysis. Resources, Conservation and Recycling, 207, 107834. https://doi.org/10.1016/j.resconrec.2024.107834
- Bonou, A., Laurent, A., & Olsen, S. I. (2016). Life cycle assessment of onshore and offshore wind energy — from theory to application. Applied Energy, 180, 327–337. https://doi.org/10.1016/j.apenergy.2016.07.058
- Cameron, A., Spatari, S., Baxter, G., & Creighton, A. (2025). Life cycle assessment to quantify global warming and human health–respiratory impacts of using composites from waste wind turbine blades as feedstock for cement clinker and fiberglass production. Environmental Science & Technology. https://doi.org/10.1021/acs.est.5c07978
- Cho, H., Lee, J., Lee, S., & Yu, I. (2025). Life cycle assessment of recyclable and non-recyclable wind turbine blade materials: A case study of South Korea's offshore wind farm. Korean Journal of Chemical Engineering, 42(12), 2887–2909. https://doi.org/10.1007/s11814-025-00423-2
- Cong, X., Song, J., Zhang, Y., & Wu, Y. (2023). Life cycle assessment of carbon reduction potential of EoL wind turbine blades disposal scenarios in China. Environmental Impact Assessment Review, 100, 107072. https://doi.org/10.1016/j.eiar.2023.107072
- Corona, A., Markussen, M. V., Birkved, M., & Madsen, B. (2015). Comparative environmental sustainability assessment of bio-based fibre reinforcement materials for wind turbine blades. Wind Engineering, 39(1), 53–64. https://doi.org/10.1260/0309-524X.39.1.53

- DNV. (2024). DNV-ST-0376: Rotor blades for wind turbines (Edition 2024-04). DNV. https://www.dnv.com/energy/standards-guidelines/dnv-st-0376-rotor-blades-for-wind-turbines/?utm_source=chatgpt.com
- Eberle, A., et al. (2025). Environmental and economic assessment of wind turbine blade recycling approaches. ACS Sustainable Resource Management, 2, 39–49. https://doi.org/10.1021/acssusresmgt.4c00256
- Farazmandnia, N., & Ilinca, A. (2025). Recyclable wind turbine blades: A life cycle analysis. Materials, 18(16), 3762. https://doi.org/10.3390/ma18163762
- Envision Energy Co., Ltd. (2025). Wind turbines EN171-6.0/6.25/6.5 and EN182-6.25. EPDItaly. https://www.epditaly.it/en/epd/wind-turbines-en171-6-0-6-25-6-5-and-en182-6-25/
- Goldwind Science & Technology Co., Ltd.. (2020). Goldwind GW136-4.2 wind turbine (EPDITALY0135). EPDItaly. https://www.epditaly.it/en/epd/goldwind-gw136-4-2-wind-turbine/
- Goldwind Science & Technology Co., Ltd.. (2020). Goldwind GW155-4.5 wind turbine (EPDITALY0134). EPDItaly. https://www.epditaly.it/en/epd/goldwind-gw155-4-5-wind-turbine/
- Goldwind Science & Technology Co., Ltd.. (2025). Goldwind GWH170-7.2, GWH175-7.8 and GWH182-8.0 wind turbine (EPDITALY0852). EPDItaly. https://www.epditaly.it/en/epd/goldwind-gwh170-7-2-gwh175-7-8-gwh182-8-0-wind-turbine/
- Goldwind Science & Technology Co., Ltd.. (2025). Goldwind GW165-5.2/5.6/6.0 Wind Turbine (EPDITALY0817). EPDItaly. https://www.epditaly.it/en/epd/goldwind-gw165-5-2-5-6-6-0-wind-turbine-2/
- Goldwind Science & Technology Co., Ltd.. (2025). Goldwind GWH182-5.3/6.2/7.2/7.5 wind turbine (EPDITALY0508). EPDItaly. https://www.epditaly.it/en/epd/goldwind-gw165-5-2-5-6-6-0-wind-turbine-2/
- Henao, A., Grubert, E., Korey, M., Bank, L. C., & Gentry, R. (2024). Life cycle assessment and life cycle cost analysis of repurposing decommissioned wind turbine blades as high-voltage transmission poles. Journal of Construction Engineering and Management, 150(5). https://doi.org/10.1061/JCEMD4.COENG-13718
- IEA Wind TCP Task 45. (2022). Blade end-of-life treatments: State of the art, challenges, barriers & environmental impacts. IEA Wind TCP. https://iea-wind.org/task45/t45-publications/
- IEA Wind TCP Task 45. (2024). Annual report 2024: Recycling wind turbine blades. IEA Wind TCP. https://iea-wind.org/publications/task45-annual-report-2024-publish/
- International Electrotechnical Commission (IEC). (2019-present). IEC 61400 series — Wind energy generation systems (all parts). IEC. https://webstore.iec.ch/searchform&q=61400
- Johst, P., Kucher, M., Bühl, M., Schulz, P., Kupfer, R., Schilling, L., Santos, R. M., Carneiro, C., Voigt, P., Modler, N., & Böhm, R. (2023). Identification and environmental assessments for different scenarios of repurposed decommissioned wind turbine blades. Materials Circular Economy, 5, 13. https://doi.org/10.1007/s42824-023-00085-7
- Liu, P., & Barlow, C. Y. (2017). Wind turbine blade waste in 2050. Waste Management, 62, 229–240. https://doi.org/10.1016/j.wasman.2017.02.007
- Liu, P., Meng, F., & Barlow, C. Y. (2019). Wind turbine blade end-of-life options: An eco-audit comparison. Journal of Cleaner Production, 212, 1268–1281. https://doi.org/10.1016/j.jclepro.2018.12.043
- LM Wind Power. (2022). Sustainability report 2022. LM Wind Power. https://www.lmwindpower.com/sites/default/files/LM_Wind_Power_Sustainability_Report_2022/
- Nagle, A. J., Delaney, E. L., Bank, L. C., & Leahy, P. G. (2020). A comparative life cycle assessment between landfilling and co-processing of waste from decommissioned Irish wind turbine blades. Journal of Cleaner Production, 277, 123321. https://doi.org/10.1016/j.jclepro.2020.123321
- Nordex SE. (2020). Life Cycle Assessment of a Nordex Wind Farm withDelta4000 Turbines (V2.1). Nordex SE. https://www.nordex-online.com/wp-content/uploads/sites/2/2022/03/LCA_N149_4.0-4.5_TS105.pdf
- Nordex SE. (2023). EPD of a wind farm with Nordex Delta4000 N155/5.X turbines. EPDItaly. https://www.epditaly.it/en/wp-content/uploads/2016/12/EPD0365_N155_5X.pdf

- Nordex SE. (2023). EPD of a Nordex wind farm with Delta4000 N155/5.X turbines – LCA report (V1.0). Nordex SE. https://www.nordex-online.com/wp-content/uploads/sites/2/2023/03/LCA_Report_-_EPD_of_a_Nordex_wind_farm_with_Delta4000_N155-5.X_turbines_without_Annex_B.pdf
- Nordex SE. (2025). EPD of a wind farm with Nordex Delta N117/3600 turbines. EPDItaly. https://www.epditaly.it/en/wp-content/uploads/2016/12/EPD_N117_3600_korr03.pdf
- Nordex SE. (2025). EPD of a Nordex wind farm with Delta N117/3600 turbines – LCA report. Nordex SE. https://www.nordex-online.com/wp-content/uploads/sites/2/2025/06/LCA_Report_-_EPD_of_a_Nordex_wind_farm_with_Delta_N117-3600_turbines.pdf
- Nordex SE. (2026). EPD of a wind farm with Nordex Delta N175/6.X wind turbines. EPDItaly. https://www.epditaly.it/en/wp-content/uploads/2016/12/EPD_N175_6.X.pdf
- Nordex SE. (2026). EPD of a Nordex wind farm with Delta4000 N175/6.X turbines – LCA report (V1.0). Nordex SE. https://www.nordex-online.com/wp-content/uploads/sites/2/2026/06/Background-report-N175-6.X-TCS179-3.pdf
- Pender, K., Bacharoudis, K., Romoli, F., Greaves, P., & Fuller, J. (2024). Feasibility of natural fibre usage for wind turbine blade components: A structural and environmental assessment. Sustainability, 16(13), 5533. https://doi.org/10.3390/su16135533
- Pender, K., Romoli, F., & Fuller, J. (2024). Lifecycle assessment of strategies for decarbonising wind blade recycling toward net zero 2050. Energies, 17(12), 3008. https://doi.org/10.3390/en17123008
- Pender, K., Romoli, F., & Fuller, J. (2026). Multi-lifecycle assessment of close-loop recyclable wind turbine blades. Materials Circular Economy. https://doi.org/10.1007/s42824-025-00211-7
- Pender, K., Romoli, F., Bacharoudis, K., Greaves, P., & Fuller, J. (2024). Evaluating priority strategies for decarbonising offshore wind turbine blades through lifecycle assessment. Clean Technologies and Environmental Policy. https://doi.org/10.1007/s10098-024-03033-4
- Prieto, C., Lahuerta, F., Gesto, D., Johst, P., Kucher, M., & Mozas, E. (2025). Comparative life cycle assessment (LCA) of traditional and new sustainable wind blade construction. Sustainability, 17(5), 2026. https://doi.org/10.3390/su17052026
- Schmid, M., Gonzalez Ramon, N., Dierckx, A., & Wegman, T. (2020). Accelerating wind turbine blade circularity. WindEurope, Cefic, & EuCIA. https://windeurope.org/data/products/accelerating-wind-turbine-blade-circularity/
- Siemens Gamesa Renewable Energy. (n.d.). RecyclableBlade®. Siemens Gamesa Renewable Energy. https://www.siemensgamesa.com/global/en/home/explore/journal/recyclable-blade.html
- Siemens Gamesa Renewable Energy. (2024). Electricity from a European offshore wind farm using SG 11.0-200 DD wind turbines (EPD-IES-0009790:002). The International EPD System. https://www.environdec.com/library/epd9790
- Siemens Gamesa Renewable Energy. (2024). Electricity from a European offshore wind farm using SG 14-222 DD wind turbines (EPD-IES-0009791:002). The International EPD System. https://www.environdec.com/library/epd9791
- Siemens Gamesa Renewable Energy. (2024). Electricity from a European offshore wind farm using SG 14-236 DD wind turbines (EPD-IES-0009792:002). The International EPD System. https://www.environdec.com/library/epd9792
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4 LCA METHOD

This section provides rules for the LCA method used to develop an EPD for the product category as defined in Section 2.2.1.

4.1 MODELLING APPROACH

See PCR 2019:14.

4.2 DECLARED/FUNCTIONAL UNIT

The Secretariat would like to ask all relevant stakeholders for this c-PCR whether, in their view, a declared unit or a functional unit should be used for the type of product covered by this c-PCR.

If any of the two are seen as preferred or even necessary, please indicate so in the open consultation comments file including specific suggestions for the declared or the functional unit if present.

The PCR Committee recognises the advantages of a functional unit but difficulties arose defining it at the moment. Therefore, below a declared unit is proposed.
Note: Once a decision was made regarding the use of a declared or a functional unit, the entire document will be adjusted accordingly, e.g., the mention of RSL and definitions of scope/system boundaries.

4.2.1 DECLARED UNIT

The declared unit for wind turbine blade EPDs based on a declared unit shall be **1 entire set of wind turbine blades**.

The EPD shall additionally declare the following performance-related functional aspects:

- Blade mass (kg): the mass of one individual wind turbine blade as delivered (i.e. the convention factor to mass).
- Blade length (m): the physical length of one blade measured from blade root to blade tip.
- Rated power of associated turbine (kW or MW): the nameplate capacity of the wind turbine for which the blade is designed.
- Number of blades per set for the wind turbine: typically three pieces blades as one for horizontal-axis wind turbines.
- Application type: onshore or offshore wind turbine installation.
- Wind climate: the representative wind condition category (e.g. IEC wind class or equivalent site-specific wind regime) used to define the operational environment of the turbine and parameters including, but not limited to, average wind speed, shear, turbulence, and air density.
- Product lifespan: the designed lifespan of the wind turbine blade, expressed in years, representing the expected operational lifetime under defined design and maintenance conditions.

4.2.2 FUNCTIONAL UNIT

Will be adjusted according to open consultation feedback.

4.2.3 REFERENCE SERVICE LIFE (RSL)

See PCR 2019:14.

This RSL is consistent with the design requirements of IEC 61400-1:2019, which specifies a design service life of 20 years as the standard basis for wind turbine structural design. The RSL applies to both onshore and offshore wind turbine blades, unless specific design documentation justifies a different RSL (e.g., 30 years for some offshore turbines designed to an extended service life).

If the product-specific design service life differs from 20 years, this shall be declared in the EPD and justified with reference to applicable design standards or manufacturer documentation.

4.2.4 PRODUCT LIFESPAN

See PCR 2019:14.

The product lifespan of wind turbine blades shall be declared in years. The technical lifespan typically aligns with the RSL of 20 years. Where the technical lifespan has been verified (e.g., through type certification, fatigue testing, or field performance data), the documented lifespan shall be declared. Deviations from the 20 years default shall be justified in the EPD.

4.2.5 TECHNICAL SPECIFICATION

The general production technology used for manufacturing the wind turbine blade shall be declared, as production technology may significantly influence material consumption, energy use, and environmental impacts.

Where applicable, the presence and type of de-icing system integrated into the wind turbine blade shall also be declared, as de-icing systems may affect the material composition, manufacturing process, and use-stage energy consumption.

4.3 SYSTEM BOUNDARY

See PCR 2019:14.

EPDs that are developed based on this c-PCR shall cover product stage (A1-A3), construction process stage (A4 and A5), use stage (B1-B4, B6 if applicable), end-of-life stage (C1-C4) as well as benefits and loads beyond the system boundary (D). See Section 2.2.2. B5 and B7 are excluded, see Section 4.3.3.

The wind farm infrastructure (tower, foundation, grid connection, nacelle, generator, gearbox, transformer) is outside the system boundary of the wind turbine blade EPD.

The following subsections describe the covered information modules, respective processes, and other rules on the setting of system boundary. For detailed information on each module, see EN 15804 (Section 6.3.5). Here only specific descriptions related to this c-PCR are provided.

4.3.1 PRODUCT STAGE: MODULES A1-A3

See PCR 2019:14 and Section 6.3.5.2 of EN 15804.

Module A1: Raw Material Supply (including material extrusion and processing)

INCLUDED. Typical categories of blade raw materials include the following, details can be found in Annex I.:

- Primary structural materials
- Core materials
- Structural adhesives and fillers
- Surface protection materials
- Metallic and other functional components

Module A2: Transport of Materials to the Manufacturing Site

INCLUDED. The following default transport assumptions may be used when site-specific transport data are not available:

- Raw materials transported by sea over long distances between continents: 20000 km by ocean freight (container ship, average load factor)

- Raw materials transported within a continent: 1500 km by road (truck ≥20 t payload)

Product-specific transport data, where available, shall take precedence over these defaults.

Module A3: Manufacturing

INCLUDED. The following consumables and manufacturing activities and processes are specific to wind turbine blades and shall be included in Module A3, details can be found in Annex I.:

- Process consumables (included in A3 system boundary, not part of the final blade)
- Mould-based composite manufacturing processes
- Assembly and finishing processes with testing and quality control

Note: The energy consumed by test benches, non-destructive testing equipment (NDT), and quality control instrumentation shall be included in A3 as supporting activities per PCR 2019:14.

In addition, the following product-category specific clarifications apply:

- If blade moulds are used a limited number of times (e.g., prototype moulds, moulds used for a single production run), they shall be included in A3 and allocated to the declared product based on the actual or expected number of reuse cycles.
- Blade root inserts, lightning protection systems, and erosion protection coatings that are permanently integrated into the blade during manufacturing at the blade factory are within the system boundary of the blade EPD (A1-A3).

4.3.2 CONSTRUCTION PROCESS STAGE: MODULES A4-A5

See PCR 2019:14 and Section 6.3.5.3 of EN 15804.

Module A4: Transport from blade assembly plant to Wind Farm

INCLUDED. Module A4 covers transport of the wind turbine blade from the blade manufacturing site gate to the wind farm installation site. The mode, distance and transport utilisation is highly dependent on the vehicle/vessel specification, blade size, production location and the wind farm location. Transport activities to be included:

- Overland road transport: e.g. specialised low-loaders or multi-axle trailers for long blades (>50 m blades typically require oversize load permits and convoy escorts)
- Rail transport: i.e. where rail transport is used for part of the journey
- Sea or river transport: e.g. ro-ro or flat-rack container vessels or barges (particularly for offshore and for inter-continental transport)
- Port handling and storage (where applicable)
- Transport tooling and equipment (where single-use)
- Transport fixtures (e.g., racks, frames, pallets, and other transport fixtures) by allocating their impacts over the expected number of reuse cycles
- The return transportation of empty transport carriers

Transport distances, modes and product-specific data shall be used. Transport mode-specific utilisation data shall be used where available.

Module A5: Installation at Wind Farm

INCLUDED. Module A5 shall include the processes directly associated with the installation of the wind turbine blade at the wind farm site. This does not include the installation of other wind turbine or wind plant components (e.g. tower, nacelle, foundation, etc), which are outside the scope of the blade EPD. Processes to include in A5:

- Crane operation for detaching and lowering the blades from the hub (energy consumption of the crane), oil and lubricants.

- For offshore installation: installation vessel fuel consumption (diesel) for the period of blade installation and port fuel consumption.
- Blade installation consumables (e.g. bolting materials, torque tools, etc.) if not already included in A1-A3.
- On-site blade inspection and commissioning tests.

Note: Only processes under the direct control or procurement responsibility of the blade manufacturer shall be modelled with primary data in A5. For processes carried out by the wind farm developer or contractor independently of the blade supplier, representative secondary data or default data may be used.

4.3.3 USE STAGE: MODULES B1-B7

See PCR 2019:14 and Section 6.3.5.4 of EN 15804. The use stage shall be included when operational control of the EPD owner and should be included if the EPD owner could provide the data for the use stage.

Module B1: Use

INCLUDED. Wind turbine blades do not emit significant substances into the environment during normal operation. If any emission from the blade occur during the use stage, the details of the situation shall be reported in the EPD with the relevant results.

Module B2: Maintenance

INCLUDED. Maintenance of wind turbine blades over the reference service life shall be modelled in Module B2. Product-specific maintenance schedules (from manufacturer documentation, service agreements, or field data) shall take precedence over those defaults and shall be declared and justified in the EPD. The following maintenance activities are typical for wind turbine blades and shall be included:

- Leading edge erosion protection (LEP) maintenance: Leading edge erosion is a well-documented degradation mechanism for wind turbine blades. Maintenance of the leading edge protection system shall be modelled.
- Routine inspecions: annual visual inspection of the blade surface (drone-based or visual from ground) results in negligible material or energy inputs and may be excluded from B2 under the cut-off rules. Where rope access or crane-based inspection is required (e.g., following damage reports or scheduled structural inspection), the energy and materials for such activities shall be included or estimated.
- Minor surface repairs: minor surface defects (micro-cracks, delamination at surface ply, impact damage) that require small-scale composite repair shall be included in B2 or B3.
- Cleaning process: Water and/or detergent for blade cleaning if needed (e.g. cleaning per 5 years, which would be 3 times cleaning during a RSL).

Module B3: Repair

INCLUDED. Module B3 shall include significant structural or semi-structural repairs that are not part of routine maintenance (as defined in B2). Cranes may be applied for repairing. Examples include repair of impact damage, local delamination, bond line defects, or root insert damagee.

Module B4: Replacement

INCLUDED. If the product lifespan of the blade is equal to the RSL of 20 years, Module B4 shall be reported as zero, which means no blade replacement is required within the RSL. If the technical lifespan of the blade is less than 20 years (e.g., a blade designed for 10 years), Module B4 shall be included to model the replacement blade required to complete the 20-year RSL.

Module B5: Refurbishment

EXCLUDED because not applicable. This shall be stated as "ND" ("not declared") in the EPD.

Wind turbine blades do not have any activity related to refurbishment during operation. Note: Module B5 might be included in future versions of this c-PCR based on the development of common practices in wind turbine blade life cycles.

To clarify, if a wind turbine blade is removed from a wind turbine, “refurbished”, and subsequently installed for use on another wind turbine, the removal of the blade from its original application shall be considered the End-of-Life of the first product system. The “refurbishment” and subsequent use of the blade in another application shall be considered the beginning of a new product life cycle, which is not considered as B5 Refurbishment in the current LCA study. This includes, but is not limited to, the reuse of old offshore wind turbine blades for applying them to other onshore wind turbines, or the cutting, resizing, and assemblying of large blades for subsequent use as smaller blades on other wind turbines.

Module B6: Operational energy use

INCLUDED IF APPLICABLE. If not applicable, this shall be stated as "ND" ("not declared") in the EPD.

Module B6 shall be included when the wind turbine blades directly consume energy during operation such as blades with active de-icing or anti-icing systems incorporating integrated heating systems (e.g., resistive leading edge heating elements or hot air circulation systems for cold-climate operation). The operational energy consumption scenario shall be declared in accordance with PCR 2019:14, using representative annual operating hours and heating load data for the declared wind class and climate zone.

Note: Although the wind turbine as a whole generates electricity, the blade EPD does not model electricity generation. Only the environmental burdens associated with manufacturing, installing, operating & maintaining, and disposing of the blades are within scope.

Module B7: Operational water use

EXCLUDED because not applicable. This shall be stated as "ND" ("not declared") in the EPD.

Wind turbine blades are passive aerodynamic components that convert wind kinetic energy into rotational mechanical energy. They have no hydraulic system or water circuit in normal operation, and therefore have no operational water consumption pathway.

4.3.4 END-OF-LIFE (EOL) STAGE: MODULES C1-C4

See PCR 2019:14 and Section 6.3.5.5 of EN 15804.

Module C1: Decommissioning

INCLUDED. Module C1 shall include the processes directly associated with the decommissioning of the wind turbine blade at the wind farm site. This does not include the decommissioning of other wind turbine or wind plant components (e.g. tower, nacelle, foundation, etc), which are outside the scope of the blade EPD. Processes to include in C1:

- Crane operation for detaching and lowering the blades from the hub (energy consumption of the crane).
- For offshore de-installation: offshore vessel fuel consumption during blade removal.
- On-site cutting or sectioning of blades to road-transportable lengths (blades are commonly cut by using diamond wire saws, chainsaws, or abrasive cutting tools): energy and consumables for cutting equipment
- Any waste generated at the decommissioning site (cutting dust, cooling water, etc.)

Decommissioning of the tower, foundation, and other turbine components is outside the system boundary.

Module C2: Transport at End of Life

INCLUDED. Module C2 covers transport of decommissioned blade sections from the wind farm to the waste processing or recycling facility.

Module C3: Waste Processing

INCLUDED. Module C3 covers the processing of blade waste prior to final disposal or recovery. The end-of-life (EoL) of wind turbine blades is a subject of significant industrial and regulatory interest, given the large volumes of composite waste generated as the first generation of modern wind turbines approaches decommissioning. The EoL scenario shall be defined in accordance with the waste management practices and regulatory requirements applicable in the country or region where the wind farm is located, including but not limited to existing policies and infrastructure for wind turbine blade waste treatment. The selection of EoL treatment routes shall reflect the prevailing regional conditions for composite waste management and the relevant regulatory framework governing industrial waste, landfill restrictions, and recycling obligations. The EoL scenario of Module C3 may include, but is not limited to, the following treatment pathways:

- Route 1: Co-processing in cement kilns (recommended to model where regionally applicable). The GFRP blade material is shredded and used as an alternative fuel and raw material (AFR) in cement kilns. The organic content (resin) substitutes coal as fuel, and the glass fibre and mineral content substitute limestone and other raw materials in the cement clinker. This is currently the most established recycling route for GFRP in Europe.

- Route 2: Mechanical recycling (grinding/shredding to regrind). Blade material is mechanically processed to produce a glass fibre regrind material, which may be used as a filler or reinforcement in lower-value composite applications.
- Route 3: Thermal recycling: pyrolysis (emerging). Blades (especially CFRP blades) may be treated by pyrolysis to recover carbon fibres and potentially produce pyrolysis oil. This route is currently at pilot/commercial-pilot scale.
- Route 4: Solvolysis / chemical recycling (emerging for CFRP). Chemical dissolution of the thermoset matrix to recover fibre reinforcement. Currently at research and pilot scale. Where applicable, model with available primary or literature data.

Module C4: Waste disposal

INCLUDED. Module C4 covers final disposal of blade material that does not reach the end-of-waste state through recycling or energy recovery, e.g., landfill or incineration without energy recovery. Similar to Module C3, the EoL scenario of Module C4 shall be defined in accordance with the waste management practices and regulatory requirements applicable in the country or region where the wind farm is located.

4.3.5 BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY: MODULE D

See PCR 2019:14 and Section 6.4.3.3 of EN 15804.

INCLUDED. Module D shall declare the potential net benefits from material recovery and energy recovery associated with the end-of-life processing of wind turbine blades. See the following examples:

- Net benefits from metallic component recovery:
  - Steel scrap recovery (from root inserts, bolts): net benefit of avoided primary steel production.
  - Copper scrap recovery (from lightning protection): net benefit of avoided primary copper production.
  - Aluminium scrap recovery (if applicable): net benefit of avoided primary aluminium production.
- Net benefits from GFRP/CFRP end-of-life processing:
  - Co-processing in cement kiln: declare the benefit from substituted energy and the benefit from substituted raw material. The amount of energy and material substituted shall be calculated using co-processing industry data and declared with appropriate documentation, where available.
  - Mechanical recycling (regrind): declare the net benefit of regrind substituting primary material (e.g., virgin calcium carbonate filler or primary glass fibre). A market-based approach shall be used; if the regrind has no established substitution value, a conservative assumption of zero benefit may be applied.
  - Carbon fibre recovery (pyrolysis/solvolysis): declare the net benefit of recovered carbon fibre substituting primary carbon fibre, adjusted for quality reduction factor where applicable.

4.4 CUT-OFF RULES

See PCR 2019:14 and EN 15804.

In addition, electronic and electrical components, metals, and chemicals involved in the EU REACH regulation in raw materials of the wind turbine blade shall not be cut-off in modelling.

4.5 PROCESS FLOW DIAGRAM

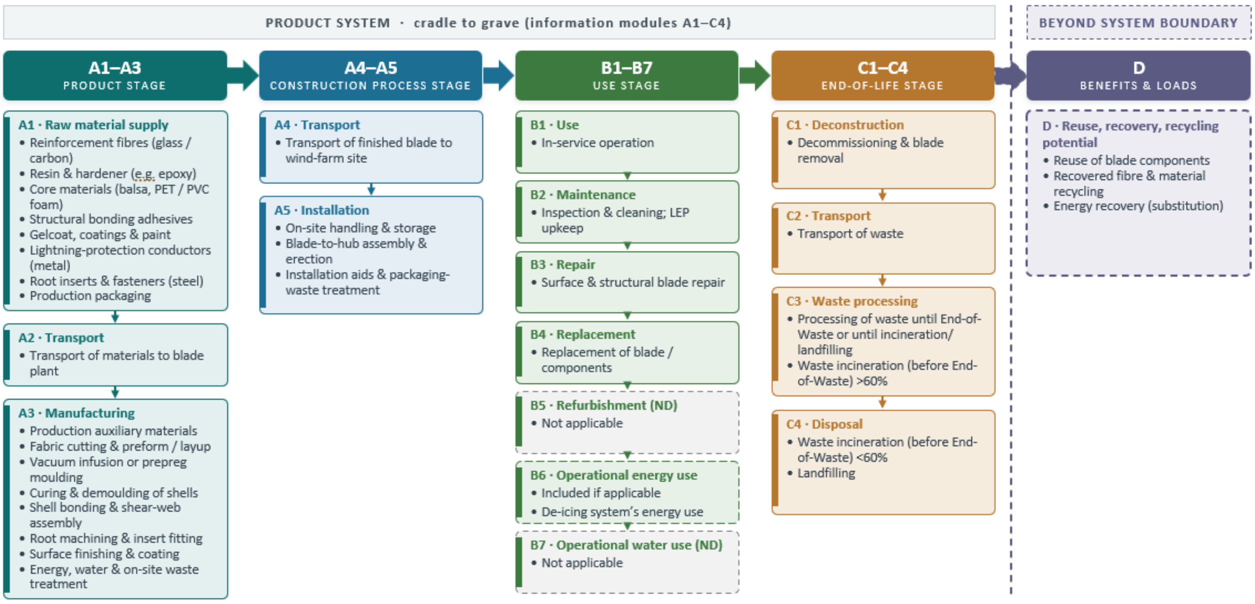

Figure 3. Process flow diagram illustrating the processes that shall be included in the product system, divided into the life-cycle stages. The illustration of processes to include may not be exhaustive.

4.6 ALLOCATION RULES

See PCR 2019:14 and EN 15804.

4.7 DATA CATEGORIES AND DATA QUALITY RULES

See PCR 2019:14 and EN 15804.

In addition, for wind turbine blade EPDs, the data quality assessment shall specifically address the five categories of following materials, which are typically significant contributors to the A1-A3 GWP-GHG results:

- Glass fibre and/or carbon fibre reinforcements
- Thermoset matrix resin (e.g. epoxy, polyester, or vinyl ester)
- Other core materials (e.g. balsa, PET foam, PVC foam, or other)
- Structural adhesives
- Steel root inserts

For these key materials, the geographical, technical and temporal representativeness of the LCI datasets shall be explicitly discussed in the LCA report and summarised in the EPD.

4.8 OTHER LCA RULES

See PCR 2019:14.

Please note, balsa wood is a biobased material containing biogenic carbon. Its biogenic carbon content shall be handled in accordance with EN 15804 Section 6.3.5.5 and PCR 2019:14 Annex 2.

4.9 SPECIFIC RULES PER LIFE-CYCLE STAGE AND MODULE D

See PCR 2019:14.

This section provides specific rules and guidance for each life-cycle stage of wind turbine blades. These rules supplement and, where explicitly stated, deviate from PCR 2019:14.

This c-PCR encourages the use of product-specific and site-specific data for the definition of scenarios wherever such data are available. Default values provided in this c-PCR for the construction stage (A4 and A5) and End-of-Life stage (C1-C4) shall only be used when representative primary data or other reliable documented information cannot reasonably be obtained. The default values specified in this c-PCR are intentionally conservative. They are designed to avoid the underestimation of environmental impacts and to encourage the use of actual project-specific data rather than the direct adoption of generic assumptions. EPD owners shall provide project-specific data whenever such data are available. Where default values are used, their use shall be justified in the EPD report.

4.9.1 PRODUCT STAGE, A1-A3

No additional rules or guidance.

4.9.2 CONSTRUCTION PROCESS STAGE, MODULES A4-A5

Module A4: Transport from blade assembly plant to Wind Farm

If product-specific transport data are not available, the following default scenarios in Table 2 may be applied.

Table 2. Default scenarios for the wind turbine blade transpor to the wind farm

Wind Farm Type	Geographic scope	Default Transport Scenarios	Note
Onshore wind farm	Transported within a continent	1500 km by road (truck ≥30 t payload), one truck per blade	Oversize transport
	Transported between continents	The following stages should be included: 1. From factory to port: 1000 km by road (truck ≥30 t payload), one truck per blade 2. From port to port: 20000 km by ocean freight 3. From port to wind fram: 1500 km by road (truck ≥ 30 t payload), one truck per blade	Oversize transport; sea transport to port
Offshore wind farm (near-shore)	Transported within a continent	The following stages should be included: 1. From factory to port: 1000 km by road (truck ⩾30 t payload), one truck per blade 2. From port to wind farm: 100 km by cargo vessel	Oversize transport; sea transport to port + vessel to offshore installation site
	Transported between continents	The following stages should be included: 1. From factory to port: 1000 km by road (truck ≥30 t payload), one truck per blade	Oversize transport; sea transport to port + vessel to offshore installation site

		2. From port to port: 20000 km by ocean freight 3. From port to wind fram: 100 km by cargo vessel	
Offshore wind farm (far-shore)	Transported within a continent	The following stages should be included: 1. From factory to port: 1000 km by road (truck ⩾30 t payload), one truck per blade 2. From port to wind farm: 500 km by cargo vessel	Oversize transport; sea transport to port + vessel to offshore installation site
	Transported between continents	The following stages should be included: 1. From factory to port: 1000 km by road (truck ≥30 t payload), one truck per blade 2. From port to port: 20000 km by ocean freight 3. From port to wind fram: 500 km by cargo vessel	Oversize transport; sea transport to port + vessel to offshore installation site

The default transportation distances specified in this c-PCR are intended to represent conservative yet realistic international supply chains for wind turbine blades. Wind turbine blades are frequently transported from manufacturing facilities to wind farms located in remote areas, resulting in transportation distances that are generally longer than those of conventional construction products. Therefore, the default road transportation distances are set at 1500 km for onshore delivery and 1000 km + 1500 km for offshore delivery. The default sea transportation distance of 20000 km represents a long intercontinental shipping route (e.g. East Asia to the east coast of the Americas) and is intended as a conservative default scenario rather than a typical transport distance.

Module A5: Installation at Wind Farm

If specific data are not available for crane operation, default values are 3.8 MWh energy consumption per blade for onshore crane operation.

4.9.3 USE STAGE, MODULES B1-B7

Module B5: Refurbishment

EXCLUDED because not applicable. See Section 4.3.3.

Note: Leading edge protection retrofits that involve the full removal and replacement of the protection system may be modelled in B2 (if periodic) or B3 (if a one-time event). This is distinct from blade refurbishment.

Module B6: Operational Energy Use

INCLUDED IF APPLICABLE. See Section 4.3.3.

Module B7: Operational Water Use

EXCLUDED because not applicable. See Section 4.3.3.

4.9.4 END-OF-LIFE STAGE, MODULES C1-C4

Module C1: Decommissioning

If specific data are not available for crane operation, default values are 3.8 MWh energy consumption per blade for onshore crane operation.

Module C2: Transport at End of Life

Where product-specific transport distances are not available, the following default scenario should be use:

- Onshore wind farm: 500 km by road (truck ≥20 t payload).

- Offshore wind farm (near-shore): 100 km by sea + 500 km by road (truck ≥20 t payload).
- Offshore wind farm (far-shore): 500 km by sea + 100 km by road.

4.9.5 CONSEQUENCES FOR RECOVERED MATERIAL/ENERGY BEYOND THE PRODUCT LIFE CYCLE (MODULE D)

No additional rules or guidance.

4.10 ENVIRONMENTAL PERFORMANCE INDICATORS

See PCR 2019:14 and EN 15804.

4.11 SPECIFIC RULES PER EPD TYPE

See PCR 2019:14.

5 CONTENT OF THE LCA REPORT

See PCR 2019:14.

In addition to PCR 2019:14, the LCA report for a wind turbine blade EPD shall include:

- A detailed description of the blade construction (fibre type(s), matrix resin type, core material(s), metallic components, and surface protection system), blade mass, blade length, and rated turbine power for the declared product.
- A description of the end-of-life scenarios modelled in modules C3 and C4, with justification of the chosen scenarios and declaration of the applicable regional regulatory context.

5.1 LAYOUT OF THE PRESENTATION

See PCR 2019:14.

5.2 DESCRIPTION OF THE LCA MODELLING

See PCR 2019:14.

6 CONTENT AND FORMAT OF EPD

See PCR 2019:14.

6.1 EPD LANGUAGES

See PCR 2019:14.

6.2 UNITS AND QUANTITIES

See PCR 2019:14.

6.3 USE OF IMAGES IN EPD

See PCR 2019:14.

6.4 SECTIONS OF THE EPD

See PCR 2019:14.

6.4.1 COVER PAGE

See PCR 2019:14.

6.4.2 GENERAL INFORMATION

See PCR 2019:14.

6.4.3 INFORMATION ABOUT EPD OWNER

See PCR 2019:14.

6.4.4 PRODUCT INFORMATION

See PCR 2019:14. In addition to PCR 2019:14, the production technology used for manufacturing the wind turbine blade shall be declared, and where applicable, the presence and type of de-icing system integrated into the wind turbine blade shall also be declared.

6.4.5 CONTENT DECLARATION

See PCR 2019:14.

6.4.6 LCA INFORMATION

See PCR 2019:14.

6.4.7 ENVIRONMENTAL PERFORMANCE

See PCR 2019:14.

6.4.8 ADDITIONAL ENVIRONMENTAL INFORMATION

See PCR 2019:14.

6.4.9 ADDITIONAL SOCIAL AND ECONOMIC INFORMATION

See PCR 2019:14.

6.4.10 INFORMATION RELATED TO SECTOR EPDS

See PCR 2019:14.

6.4.11 VERSION HISTORY

See PCR 2019:14.

6.4.12 ABBREVIATIONS

See PCR 2019:14.

6.4.13 REFERENCES

See PCR 2019:14.

7 LIST OF ABBREVIATIONS

In addition to abbreviations listed in PCR 2019:14, Section 7:

AFR	Alternative Fuel and Raw material
CFRP	Carbon Fibre Reinforced Polymer
DNV	DNV (formerly Det Norske Veritas)
EN	European Standard (Europäische Norm)
EoL	End of Life
EU	European Union
FDES	Fiche de Déclaration Environnementale et Sanitaire
GFRP	Glass Fibre Reinforced Polymer
GWP-GHG	Global Warming Potential – Greenhouse Gas emissions
HAWT	Horizontal-Axis Wind Turbine
IBU	Institut Bauen und Umwelt e.V.
IEA	International Energy Agency
IEC	International Electrotechnical Commission
INIES	Base de données française de référence pour les déclarations environnementales
KEITI	Korea Environmental Industry & Technology Institute
kW	Kilowatt
kWh	Kilowatt-hour
LEP	Leading Edge Protection
LRTM	Light Resin Transfer Moulding
MJ	Megajoule
MND	Module Not Declared
MW	Megawatt
NDT	Non-Destructive Testing
PET	Polyethylene Terephthalate
PVC	Polyvinyl Chloride
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals (EU Regulation)
SAN	Styrene-Acrylonitrile
TCP	Technology Collaboration Programme
VARTM	Vacuum Assisted Resin Transfer Moulding
VAWT	Vertical-Axis Wind Turbine
VOC	Volatile Organic Compound

8 REFERENCES

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9 VERSION HISTORY OF C-PCR

VERSION 1.0.0, 20YY-MM-DD

Original version of the c-PCR.

ANNEX I. DETAILED EXAMPLES FOR A1-A3 PRODUCTION STAGE

Typical blade raw materials as Module A1 raw materials include the following:

- Primary structural materials:
  - Glass fibre reinforcements (e.g. woven fabrics, non-crimp fabrics, chopped strand mat, rovings, winding, etc)
  - Carbon fibre reinforcements (e.g. woven fabrics, unidirectional tapes, non-crimp fabrics, etc)
  - Hybrid reinforcements (e.g. glass/carbon combinations, etc)
  - Thermoset matrix resins: epoxy (bisphenol-A diglycidyl ether and related), polyester, vinyl ester, polyurethane, etc
  - Curing agents and hardeners (e.g. amines, anhydrides, peroxides as applicable)
- Core materials:
  - Balsa wood (ochroma pyramidale)
  - Polyethylene terephthalate (PET) structural foam
  - Polyvinyl chloride (PVC) structural foam
  - Styrene-acrylonitrile (SAN) and other polymer foams
- Structural adhesives and fillers:
  - Epoxy-based structural adhesives (for blade shell bonding and web bonding)
  - Methacrylate and other structural adhesives
  - Paste adhesives and filler compounds
- Surface protection materials:
  - Polyurethane gel coats, topcoats, and varnishes
  - Epoxy gel coats
  - Leading edge protection (LEP) systems: polyurethane coatings, polyurethane shells, polyurethane or polyurea tapes, epoxy coatings
- Metallic and other functional components:
  - Steel root inserts (e.g. threaded bolts, T-bolts, barrel nuts, flanges embedded in the blade root laminate, etc)
  - Copper and/or aluminium lightning protection systems (e.g. down conductors, mesh, tip receptors, root connections, etc)
  - Steel bushings, inserts, and load-introduction elements, etc.

The following consumables and manufacturing activities and processes are specific to wind turbine blades which are typically included in Module A3 manufacturing:

- Process consumables (included in A3 system boundary, not part of the final blade)
  - Peel ply (nylon, polyester)
  - Distribution/infusion mesh and flow media
  - Vacuum bags (polyamide, PET)
  - Release films (polyamide, polyester)
  - Sealant tape and edge breathers
  - Resin infusion hoses and fittings

- The manufacturing moulds (blade moulds) if they are used a limited number of times (e.g., prototype moulds, moulds used for a single production run)

- Mould-based composite manufacturing processes:
  - Mould preparation and release agent application
  - Manual or automated fibre layup (glass and/or carbon fibre fabrics)
  - Placement of core materials (balsa, foam)
  - Root insert placement and pre-curing (if applicable)
  - Vacuum bagging and consumable placement
  - Resin infusion or injection (VARTM: Vacuum Assisted Resin Transfer Moulding; LRTM: Light Resin Transfer Moulding; or equivalent processes)
  - Curing of blade shells and webs (in-mould curing with heated mould, oven curing, or infrared curing)
  - Post-cure heat treatment (if required by the resin system)
  - Demoulding
- Assembly and finishing processes with testing and quality control:
  - Structural adhesive mixing and application for blade half joining and web bonding
  - Blade assembly (joining of pressure side and suction side shells with internal webs)
  - Root insert integration and bonding
  - Grinding, trimming, and surface preparation
  - Leading edge protection application (painting, shell bonding, or tape application)
  - Lightning protection system installation
  - Final inspection and testing (including non-destructive testing, if applicable)
- Energy and utilities to include in A3:
  - Electricity consumption
  - Thermal energy (e.g. natural gas, electricity, steam)
  - Compressed air consumption
  - Water use (e.g. for cleaning and process operations)
  - Chemical cleaning agents and solvents
- Atmospheric emissions from A3 to include:
  - VOC emissions (e.g. from resin infusion, gel coat application, and painting processes)
  - Other fugitive emissions (e.g. from cooling systems, etc)
  - Dust emissions from grinding and sanding operations
- Waste and wastewater from A3 to include:
  - Waste generated from the manufacturing process, including raw material waste, consumables, hazardous waste and industrial waste (and moulds, if applicable)
  - Wastewater generated from the manufacturing process

WIND TURBINE BLADES FOR WIND ENERGY GENERATION
PRODUCT GROUP CLASSIFICATION: UN CPC 46131