EPD
INTERNATIONAL EPD SYSTEM

PV COMPONENTS: INVERTERS, BATTERY ENERGY STORAGE SYSTEMS, COMBINER BOXES AND TRACKER SYSTEMS

PRODUCT GROUP CLASSIFICATION: UN CPC 461, 462, 463, 464 (SUBSETS)

C-PCR-024 (TO PCR 2019:14)
VERSION 1.0.1

VALID UNTIL: 2028-01-02

TABLE OF CONTENTS

1 INTRODUCTION

1.1 GENERAL

This document constitutes complementary Product Category Rules (c-PCR) for developing Environmental Product Declarations (EPD) in the framework of the International EPD System: a programme for EPDs[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] developed in the framework of the International EPD System: a programme for type III environmental declarations[3] according to ISO 14025:2006. EPDs are voluntary documents for a company or an industry association to present transparent, consistent, and verifiable information about the environmental performance of their products (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. A PCR complements 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), thereby enabling the generation of consistent EPDs within a product category.

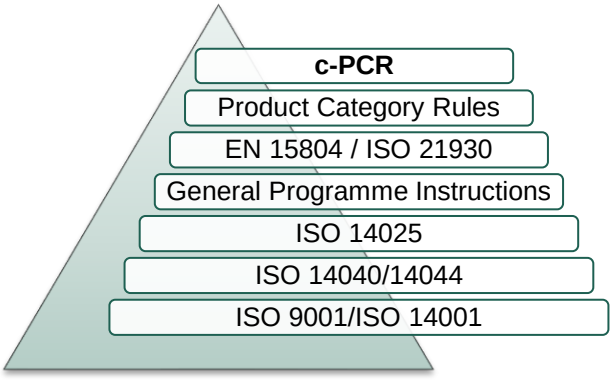


Figure 1 This c-PCR in relation to the hierarchy of standards and other documents.

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 other terms used in the document, see the GPI, normative standards, and PCR 2019:14 Construction products.

The latest version of the PCR is available on www.environdec.com.

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

Stakeholder feedback on PCRs is very much encouraged. Any comments on this PCR document may be sent directly to the PCR Moderator during its development or during the period of validity.

The programme operator maintains the copyright of the document to ensure that it is possible to publish, update when necessary, and 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 7 is intended unless otherwise stated.

3 Type III environmental declarations in the International EPD System are referred to as EPD, Environmental Product Declarations.

1.2 ROLE OF THIS DOCUMENT

This document provides complementary product category rules (c-PCR) to PCR 2019:14 Construction products, available on www.environdec.com. This document cannot be used by itself but shall be used together with PCR 2019:14 and EN 15804. The document can be used together with any valid version of PCR 2019:14, regardless of the version of PCR 2019:14 referred to in this document.

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

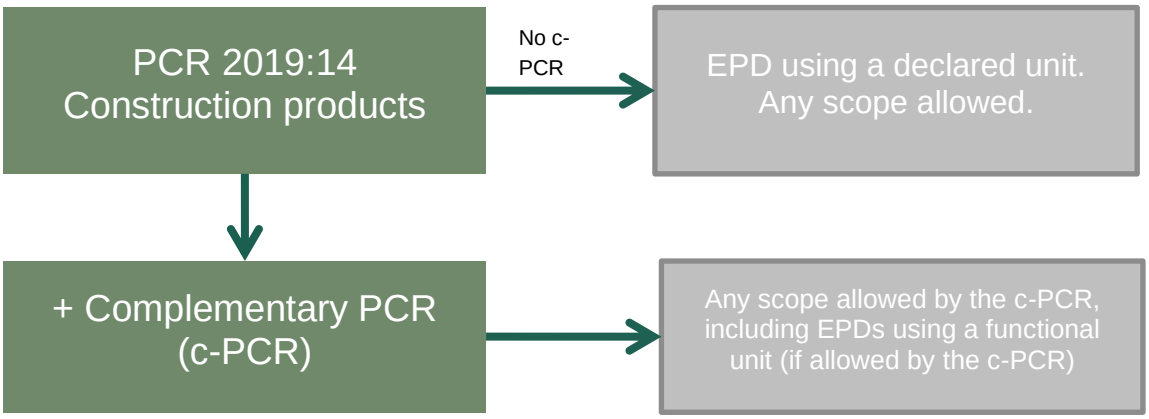


Figure 2 Overview of using PCR 2019:14 directly to develop an EPD or how to use it together with a c-PCR.

2 GENERAL INFORMATION

2.1 ADMINISTRATIVE INFORMATION

Name:	PV components: inverters, battery energy storage systems, combiner boxes and tracker systems
Registration number and version:	c-PCR-024, version 1.0.1
Programme:	EPD 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:	Mr. Zhang Yuyang, Power (Beijing) Certification Centre Co. Ltd, zhangyuyang@spic.com.cn
PCR Committee:	Power (Beijing) Certification Centre Co. Ltd, IVL Swedish Environmental Research Institute (Beijing Office), GoodWe Technologies Co. Ltd, Huawei Technologies Co. Ltd, XJ Electric Co., Ltd, China Photovoltaic Industry Association
Date of publication and last revision:	2026-04-16 (version 1.0.1) A version history is available in Section 8.
Valid until:	2028-01-02
Schedule for renewal:	This document will be revised upon its expiration. In case a c-PCR is developed by a CEN Product TC, the standard will replace this c-PCR with a transition period of 90 days.
Standards conformance:	For compliance to standards and other documents, see PCR 2019:14.
PCR language(s):	This PCR was developed and is available in English. 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 c-PCR is for the assessment of the environmental performance of photovoltaic (PV) power plant components, specifically PV inverters, PV battery energy storage systems, combiner boxes and tracker systems, and the declaration of this performance by an EPD. The product category corresponds to subsets of UN CPC 461, 462, 463 and 464. The products covered in the c-PCR are used for standalone modules (mounted on rooftop, façade or ground) or building integrated photovoltaics (BIPV) integrated into the building envelope, such as the roof or the façade materials. This is in line with the c-PCR-016 Photovoltaic modules and parts thereof, together with which most of components for the PV industry are covered.

Further description of the products covered by this c-PCR:

PV inverters are a type of electrical converter which converts the variable direct current (DC) output of a photovoltaic (PV) solar panel into a utility frequency alternating current (AC) that can be fed into a commercial electrical grid or used by a local, off-grid electrical network. It is a critical balance of system (BOS)–component in a photovoltaic system, allowing the use of ordinary AC-powered equipment. Solar power inverters have special functions adapted for use with photovoltaic arrays, including maximum power point tracking and anti-islanding protection.

PV battery energy storage systems capture surplus energy generated by PV system to allow storing energy for later use. Batteries can provide power when electrical loads require more power than the PV panels are generating. This can be due to the generation of less electricity due to adverse weather conditions, greater than normal power usage, or other anomalies with the PV power collection. Batteries also help establish the DC operating voltage for the required auxiliary components in the PV system.

PV combiner boxes can connect a certain number of photovoltaic cells with the same specifications in series to form one photovoltaic series, and then connect several photovoltaic series in parallel to the photovoltaic combiner box. Its main purpose is to combine multiple DC inputs from the panels in the system into a single DC output. This output is then connected to a charge controller or inverter, depending on the type of system. They also allow plant to transition to larger wires between the array and the batteries or inverter to minimize transmission voltage drop.

PV tracker systems help minimize the angle of incidence (the angle that a ray of light makes with a line perpendicular to the surface) between the incoming light and the panel, which increases the amount of energy the installation produces. Single-axis solar trackers direct solar panels or modules toward the sun. These devices change their orientation throughout the day to follow the sun's path to maximize energy capture. Single-axis solar trackers rotate on one axis moving back and forth in a single direction.

2.2.2 TYPE OF EPD AND INFORMATION MODULES INCLUDED

See PCR 2019:14.

Only type c EPD is applicable under this PCR:

c) Cradle to grave and module D (A + B + C + D).

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 2023-01-02

This c-PCR was available for open consultation from 2022-07-05 until 2022-09-04, during which any stakeholder was able to provide comments by contacting the PCR Moderator and/or the Secretariat.

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 at www.environdec.com.

3.2 PCR REVIEW

3.2.1 VERSION 2023-01-02

PCR review panel:	The Technical Committee of the International EPD® System. A full list of members is available at www.environdec.com. The review panel may be contacted via info@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:	Gorka Benito Alonso
Review dates:	2022-10-03 until 2022-11-25

3.3 EXISTING PCRS FOR THE PRODUCT CATEGORY

As part of the development of this c-PCR, existing PCRs/c-PCRs and other internationally standardised methods that could potentially act as c-PCRs 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. www.epd-norge.no
- EPDItaly. www.epditaly.it
- PEP Ecopassport. www.pep-ecopassport.org
- European Commission PEF. https://eplca.jrc.ec.europa.eu/EnvironmentalFootprint.html

Table 1 lists the identified PCRs and other standardised methods.

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

NAME OF PCR/STANDARD	PROGRAMME/ STANDARDISATION BODY	REGISTRATION NUMBER, VERSION NUMBER/DATE OF PUBLICATION	SCOPE
Part B for photovoltaic modules used in the building and construction industry, including production of cell, wafer, ingot block, solar grade silicon, solar substrates, solar superstrates and other solar grade semiconductor materials	EPD-Norge	NPCR 029, version 1.2, 2022-03-31	Photovoltaic modules used in the building and construction industry, including production of cell, wafer, ingot block, solar grade silicon, solar substrates, solar superstrates and other solar grade semiconductor materials
Electricity produced by photovoltaic modules	EPDItaly	EPDItaly 014, version 1.1, 2022-02-08	Electricity produced by photovoltaic modules
PEFCR-photovoltaic modules used in photovoltaic power systems for electricity generation	European Commission	Version: 1.1, 2019-02-12	Production of photovoltaic modules used in photovoltaic power systems for electricity generation
PEFCR - Product Environmental Footprint Category Rules for High Specific Energy Rechargeable Batteries for Mobile Application.	European Commission	Version: 1.1, 2020-02	The types of battery in the scope of the PEFCR only comprise part of the broader category of batteries identified under the CPA (European classification of products by activity) code: 27.20.23. (27. Electrical equipment/20. Batteries and accumulators/23. Nickel-cadmium, nickel metal hydride, lithium-ion, lithium polymer, nickel-iron and other electric accumulators)
Electricity, steam and hot/cold water generation and distribution	International EPD® System	Version 4.2, 2021-04-26	This document provides Product Category Rules (PCR) for the assessment of the environmental performance of electricity, steam and hot/cold water generation and distribution, and the declaration of this performance by an EPD. The product category corresponds to UN CPC 171 and 173.

3.4 REASONING FOR DEVELOPMENT OF C-PCR

This c-PCR was developed to provide requirements and guidelines 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.

For existing PCRs related to solar power, most of them are only applicable for PV panels. Only the PCR of EPD-Norge (which has been adopted by the International EPD® System) is applicable for some components used in PV systems (i.e. Part B for photovoltaic modules used in the building and construction industry, including production of cell, wafer, ingot block, solar grade silicon, solar substrates, solar superstrates and other solar grade semiconductor materials). However some other important components, such as inverters, energy storage systems, trackers, combiners boxes and other components or systems necessary to connect the photovoltaic module to the electrical grid are not included. It was therefore necessary to develop the present c-PCR to cover more components of PV systems.

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:

- Footprint analysis report of one row of trackers from Nextracker, 2020.
- Life Cycle Assessment of Current Photovoltaic Module Recycling, Report IEA-PVPS T12-13:2018
- LCA study of inverter GW136K-HTH of Goodwe company. China Quality Certification Centre, 2021-04.
- Life cycle assessment of low power solar inverters (2.5 to 20 kW), Laura Tschümperlin, Philippe Stolz, Rolf Frischknecht, Uster, 2016-10-03
- Life Cycle Assessment of Photovoltaic Systems in the APEC Region, APEC Energy Working Group, 2019-04
- Life Cycle Assessment of the 33 kW Photovoltaic System on the Dana Building at the University of Michigan, University of Michigan, Ann Arbor, 2006-06-01
- Optimization of PV generator/inverter coupling in terms of DC cable losses and series/parallel connections of PV module, Master Thesis, Andrea Orlandini, 2019-03
- Product Carbon Footprint Report of Inverter of Huawei, Reliability Laboratory of Huawei Technologies, Co., Ltd, 2021-04
- Preparatory study for solar photovoltaic modules, inverters and systems, Draft Report Task 5: Environmental and economic assessment of base cases, Dodd, Nicholas; Espinosa, Nieves – JRC B5 Van Tichelen, Paul; Peeters, Karolien – VITO
- Solar photovoltaic modules, inverters and systems: options and feasibility of EU Ecolabel and Green Public Procurement criteria, Dodd, N, Espinosa, Preliminary report, EUR 30474 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-26819-2, doi:10.2760/29743, JRC122430, 2021

4 GOAL AND SCOPE, LIFE CYCLE INVENTORY AND LIFE CYCLE IMPACT ASSESSMENT

This section provides specific rules, requirements and guidelines for developing an EPD for the product category as defined in Section 2.2.1.

4.1 DECLARED/FUNCTIONAL UNIT

EPDs based on this c-PCR shall be based on a functional unit. The functional unit shall be defined as:

- For PV inverters: the inverting functionality needed to be part of a reference PV system (with a service life of 25 years) that provides 1 kWh of AC energy output converted from DC energy generated from the panels.
- For PV battery energy storage systems: the storage functionality needed to be part of a reference PV system (with a service life of 25 years) that provides 1 kWh of AC energy output to the grid (or end users).
- For PV combiner boxes: the combining functionality needed to be part of a reference PV system (with a service life of 25 years) to support PV panels that provide 1 kWh AC energy output.
- For PV tracker systems: the mounting functionality needed to be part of a reference PV system (with a service life of 25 years) to support PV panels that provide 1 kWh AC energy output.

The LCA results shall be scaled to the 1 kWh output of the reference PV system[4]. The reference PV system should be defined by the EPD owner for the calculations according to the guidance in Section 4.7.4 of this c-PCR.

4.2 TECHNICAL SPECIFICATION, LIFESPAN AND REFERENCE SERVICE LIFE (RSL)

The following technical specifications of the product shall be provided in the EPD:

For inverters: rated output power (W), efficience (%), lifespan (years).

For PV battery energy storage systems: type of cell, energy storage capacity (kWh), effiency (%), lifespan (years), number of cell discharge cycles under defined End of Life (EoL, %) and Depth of Discharge(DoD, %).

For PV combiner boxex: rated voltage (V), rated current (A) efficience (%), lifespan (years).

For PV tracker systems: tracking type, lifespan (years).

The Reference Service Life (RSL) of the product, and the reference PV system, shall be 25 years.

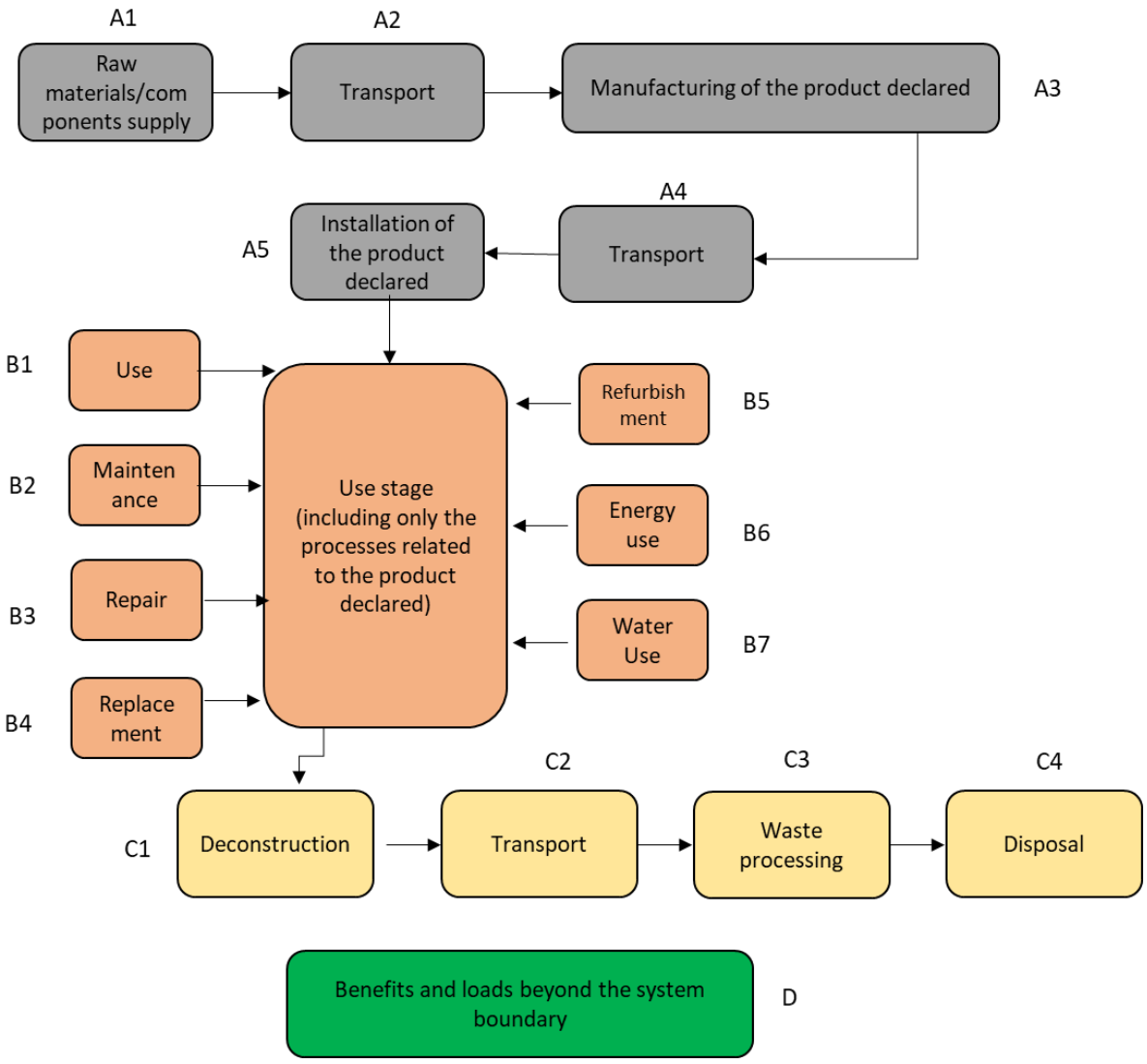
4.3 SYSTEM BOUNDARIES

See Sections 6.2 and 6.3.5 in EN 15804.

4.4 SYSTEM DIAGRAM

A generic system diagram for the product category is given below.

[4] The environment burden of other parts/components of the reference PV system shall not be allocated to the component covered by the EPD.



4.5 CUT-OFF RULES

See PCR 2019:14 and EN 15804.

4.6 ALLOCATION RULES

See PCR 2019:14 and EN 15804.

4.7 DATA QUALITY REQUIREMENTS

See PCR 2019:14 and EN 15804.

Below are further data quality requirements and scenarios for modeling. Exceptions to the requirements may be accepted, if justified in the EPD; such exceptions are subject to the approval by the verifier on a case-to-case basis.

4.7.1 MODULE A1-A2

Data on processes and activities for upstream in the supply chain shall be specific and collected on site if they are under the EPD owner's direct management control.

Data on main parts, packaging, or main auxiliaries should be provided by the contractor as specific data.

Data on transport of main parts and components along the supply chain to the manufacturing plant/place of service provision, should be specific and based on the actual transportation mode, distance from the supplier, and vehicle load.

4.7.2 MODULE A3

Data on processes and activities in module A3 shall be specific.

4.7.3 MODULE A4-A5

Data for these modules are usually based on scenarios, but specific data should be used when available and relevant.

The transport of the product to the customer should be described in the EPD. Transport-specific data from the manufacturing site to the intended location (e.g. construction site or market relevant for the product) should be considered and should be estimated based on information from the manufacturer. Data shall be justified and documented in the LCA report.

If no specific data are available, the following generic default values can be used for developing scenarios at the product level:

- For domestic production, the default travel distance from the manufacturing site to a relevant market for the product is 500 km.
- For imported products, the distance is measured from the manufacturing site to a specific storage location, plus a transport distance (500 km if not specified) from the storage location to a relevant market. If no specific storage location is given, then the capital city of the country that the product is being stored at may be used as an approximate location.

4.7.4 MODULE B1-B7

Data for these modules are usually based on scenarios, but specific data should be used when available and relevant.

Module B shall be calculated based on information provided by the manufacturer and relevant standard.

Module B2-B5, Maintenance, repair, replacement and refurbishment scenarios are provided by the manufacturer, and shall be relevant for the intended market and intended area of application.

Module B4:

If replacement of a product/component is needed during the reference PV system's RSL of 25 years, the production of the replacing product/component, as well as the end-of-life of the replaced product/component, shall be included in module B4.

Module B6

Energy consumption:

For inverters, battery storage systems and combiner boxes, the energy consumption shall be modelled as energy loss percentage of the total produced energy by the PV system. The energy loss percentage shall be documented in EPD with evidence.

Energy production:

The EPD shall in the description of module B6 include equations for the user of the EPD to be able to calculate the total produced electricity for the reference PV system, as described below.

Energy production in the first year of operation, kWh/year:

(1) E1 = Srad * A * y * PR * (1- deg)

Energy production second year of operation, kWh/year:

(2) E2 = E1 * (1 - deg)

Energy production n^{th} year of operation, kWh/year:

(3) En = E1 * $(1 - deg)^{n-1}$

Energy production over the RSL of the reference PV system, assuming linear annual degradation, kWh:

(4) $E_{RSL} = E_1 * (1 + \sum_{n=1}^{RSL-1}(1 - \deg)^n)$

- Srad = Site specific annual average solar radiation on module (shadings not included), kWh/kWp/year. The annual radiation must take into consideration the specific inclination (slope, tilt) and orientation.
- A = Area of module, m2 (stated in the EPD).
- y = Module yield: electrical power, kWp for standard test conditions (STC) of the module divided by the area of the module (stated in the EPD). *STC: The ratio is given for standard test conditions: irradiance 1000 W/m2, cell temperature 25 °C, wind speed 1 m/s, AM1.5.*
- PR = Performance ratio, coefficient for losses. Site specific performance ratio can be modelled with PV simulation software tools, such as PVSyst or similar. Losses included inverter losses, temperature losses, DC cables losses, AC cables losses, losses due to shadings, losses at weak radiation, losses due to dust or snow, and other losses.
- deg = Yearly degradation rate (stated in the EPD).

  Degradation: If no data is available, a default linear degradation rate of 0.007 (0.7 %) per year shall be applied. Product-specific degradation rate may be used if based on evidence.The nameplate capacity of the PV module, as printed in the data sheet, shall be used as the starting point of the degradation curve. If uncertainties on performance measurements are factored in the performance tolerance provided on the data sheet, e.g. +2.5 % / -0 %, the nameplate capacity without calculating uncertainties shall be used.
- n = Year of operation
- RSL = Reference service life for the energy-producing unit (the reference PV system), shall be 25 years and stated in the EPD.

Application of other method to calculate the total produced electricity for the reference PV system and the energy consumption of the covered product are possible if justified, for example by reference to technical standards or research papers. The justification shall be documented in the EPD.

4.7.5 MODULE C1-C4

The end-of-life life cycle modules C1, C2, C3 and C4 shall be calculated based on information provided by the manufacturer and be relevant for the intended market.

Default scenarios for life cycle module C2 transport to waste processing should be based on representative data, e.g. national statistics. A standard transport distance of 50 km may be assumed. The relevant scenario for waste treatment shall be justified and documented in the LCA report.

Any deviations from the scenario described above shall be justified and explained.

4.7.6 EXAMPLES OF DATABASED FOR GENERIC DATA

All commercial or publicly available databases that meet the data quality requirements maybe used. The specifications and the version of the database shall be reported in the EPD.

Some recommended databases are, for example, Ecoinvent database (www.ecoinvent.com), World Steel Association (www.worldsteel.org) and Gabi (https://gabi.sphera.com/).

4.8 ENVIRONMENTAL PERFORMANCE INDICATORS

See PCR 2019:14 and EN 15804.

4.9 INCLUDING MULTIPLE PRODUCTS IN THE SAME EPD

See PCR 2019:14.

5 CONTENT AND FORMAT OF EPD

See PCR 2019:14.

5.1 EPD LANGUAGE

See PCR 2019:14.

5.2 UNIT AND QUANTITIES

See PCR 2019:14.

5.3 USE OF IMAGES IN EPD

See PCR 2019:14.

5.4 EPD REPORTING FORMAT

See PCR 2019:14.

6 LIST OF ABBREVIATIONS

See PCR 2019:14.

7 REFERENCES

CEN (2021) EN 15804:2012+A2:2019/AC:2021, Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products.

EPD International (2025) PCR 2019:14 Construction products, version 2.0.0

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ISO (2006a) ISO 14025:2006, Environmental labels and declarations – Type III environmental declarations – Principles and procedures.

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ISO (2006c) ISO 14044: 2006, Environmental management – Life cycle assessment – Requirements and guidelines.

ISO (2017) ISO 21930:2017, Sustainability in buildings and civil engineering works -- Core rules for environmental product declarations of construction products and services.

Life Cycle Assessment of Current Photovoltaic Module Recycling, Report IEA-PVPS T12-13:2018

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Life Cycle Assessment of Photovoltaic Systems in the APEC Region, APEC Energy Working Group, 2019-04

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Optimization of PV generator/inverter coupling in terms of DC cable losses and series/parallel connections of PV module, Master Thesis, Andrea Orlandini, 2019-03

PCR ELECTRICITY PRODUCED BY PHOTOVOLTAIC MODULESl of EPDItaly, version 1.1, 2022-02-08

PEFCR-PHOTOVOLTAIC MODULES USED IN PHOTOVOLTAIC POWER SYSTEMS FOR ELECTRICITY GENERATION, Version 1.1, 2019-02-12

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Solar photovoltaic modules, inverters and systems: options and feasibility of EU Ecolabel and Green Public Procurement criteria, Dodd, N, Espinosa, Preliminary report, EUR 30474 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-26819-2, doi:10.2760/29743, JRC122430, 2021

8 VERSION HISTORY OF C-PCR

VERSION 2023-01-02

Original version of the c-PCR.

VERSION 2024-04-30

- Updated with prolonged validity to align the updated validity of PCR 2019:14 as of version 1.3.4.
- Updates in references.

VERSION 1.0.0, 2025-04-22

- Updated with prolonged validity, until five years from the original publication of the PCR.
- Changed from version date to version number.
- Other editorial changes and clarifications, e.g., related to the use of the c-PCR (see Section 1.2).
- Removed references to specific sections of PCR 2019:14, as the sections of PCR 2019:14 changed as of the publication of version 2.0.0 in 2025-04-07 and as this c-PCR is applicable together with any version of PCR 2019:14.

VERSION 1.0.1, 2026-04-16

- Updated spelling “invertor” to “inverter” and other editorial changes

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