

Product Category Rules (PCR)
for Preparing an Environmental Product
Declaration (EPD) for
Solar Photovoltaic Modules
PCR 2017:1.0

AU Optronics Corporation
Eterbright Solar Corporation

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This document complies with the relevant requirements of the International EPD®SYSTEM, as well as the management requirements of the Environment and Development Foundation (www.edf.org.tw)

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1. General information

This document is intended to be used as the product category rules (PCR) for the manufacturing of solar photovoltaic modules (“product”) globally, which include both the crystalline silicon solar photovoltaic modules and thin film solar photovoltaic modules. This PCR covers products with the Central Product Classification Code (CPC Code) of 47150, and Harmonized System (HS) Code of 854140. The requirements specified in this PCR are intended to be used for EPDs certified in accordance with the standard ISO 14025. This document shall be valid until August 31, 2020.

This PCR was first drafted by AU Optronics Corporation and Eterbright Solar Corporation together. Representatives from major Taiwanese manufacturers of similar products and stakeholders were invited by the Taiwan Photovoltaic Industry Association (TPVIA) to the open consultation meeting held on August 4, 2017, to participate in the discussion and review the draft of PCR. The Environment and Development Foundation (EDF) subsequently reviewed and approved this PCR.

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2. Company and product description

The EPD shall include information about the manufacturing company/organization. The information may include manufacturing process related information, and environmental management related information, such as the environmental management system information. The information may also include special issues, which the company/organization would like to emphasize, such as the products meeting certain environmental criteria, or environmental safety, and health related information.

This PCR covers the whole life cycle stages of the solar photovoltaic module products, and is applicable to the Business-to-Business (B2B) communications related only to the crystalline silicon solar photovoltaic modules and copper indium gallium selenide (CIGS) thin film solar photovoltaic modules. During the inventory of product related environmental impacts, the scope of inventory shall cover the packaging materials.

2.1 Product group functions

The solar photovoltaic modules (“products”) utilize sunlight to generate electricity through photovoltaic effect of semi-conductor solar cells. When such semi-conductors are exposed to sunlight, they can generate voltage or electric current through excitation of the electrons and holes. Therefore, the solar photovoltaic module can be used as a useful product to convert sunlight into electricity.

2.2 Product components

The product’s components may include but not limited to the following:

Main components:

- For crystalline silicon solar photovoltaic modules:
 - silicon solar cell
- For thin film solar photovoltaic modules:
 - cell glass
 - CIGS Thin film
- Common components:
 - superstrate: e.g., cover glass
 - substrate: e.g., back sheet
 - Packaging material: e.g., EVA
 - junction box

Secondary components

- Frame: e.g., aluminum frame
- Soldering material: e.g., solder ribbon
- Conductive paste

Packaging materials: For example, packaging paper, inner box, outer box, cushion material, pallets.

Other components: For example, other film materials attached to the surface of the cell glass.

2.3 Product technical description

The product technical description part of the EPD may include but not limited to the following information:

- Dimensions (length, width)
- Weight
- Power rating
- Average of conversion efficiency

2.4 Product lifetime

Product design life: As tested under conditions specified in IEC 61215 and IEC61730, the product design shall be able to guarantee the electricity generation is more than 80% initial power rating, after 20 to 25 years of product use.

3. List of materials and chemical substances

The contents of the following materials and substances in the product shall be declared:

- All materials of the product (excluding packaging material) with weight ratio (material weight/product weight (excluding packaging)) $\geq 1\%$;
- All materials of the packaging with weight ratio (material weight/packaging weight) $\geq 1\%$;
- All substances/materials in the product restricted/regulated by legal and customer requirements.

The content of substances regulated by EU's RoHS Directive in the main components may be declared.

The declaration of non RoHS-regulated substances may only be made when appropriate evidences are available (for example, test reports from accredited laboratories/testing facilities). The

following organizations may provide accreditation for testing facilities: Taiwan Accreditation Foundation (TAF), (Asia Pacific Laboratory Accreditation Cooperation (APLAC), International Laboratory Accreditation Cooperation (ILAC) or ILAC Mutual Recognition Arrangement (ILAC MRA). For definitions of testing methodology and confirmations of regulated hazardous substances based on the accredited laboratories' product testing methods, please refer to Standard IEC 62321.

4. Declared unit or functional unit

The declared unit is one (1) panel of solar photovoltaic module ("product"). The reason for adopting this unit is that the product is sold and marketed in the unit of panel on the market. If the product declaration is made in functional unit, the functional unit is in the unit of rated power rating (W).

5. System boundaries

The main system boundaries for the declared product system are presented as follows:

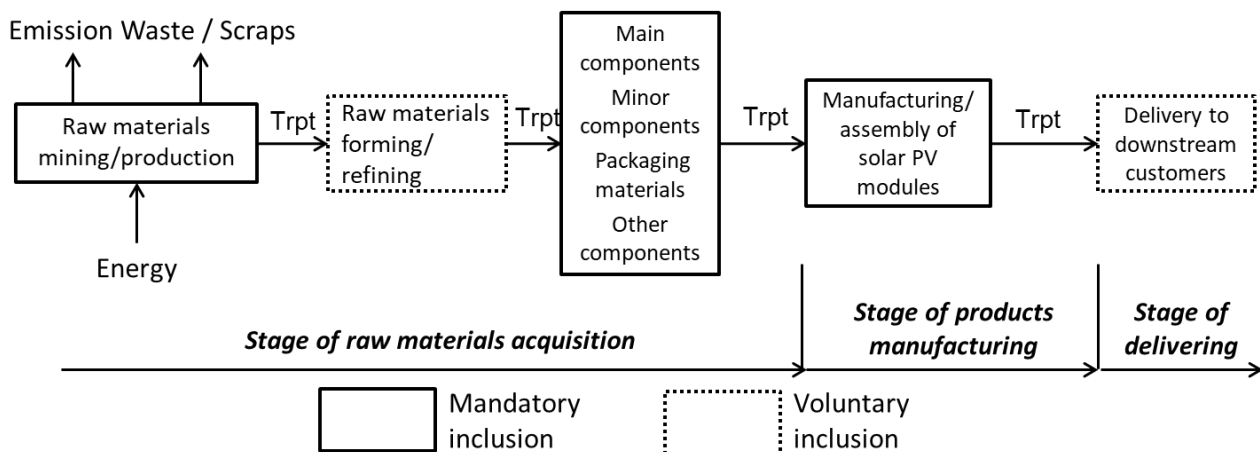


Figure 1 System boundary of the main product

As noted in Figure 1 above, the life cycle of a solar photovoltaic module ("product") covers three life cycle stages: raw material acquisition, product manufacturing, and delivering and marketing, as well as transportation among the stages. The data quality requirements for the life cycle inventory data of the main components are described in Section 9 on calculation rules and data quality requirements. Data related to the product's other components shall also be included in the EPD, but their data quality requirements are different from those of the main components.

Raw Materials Acquisition Stage and Product Manufacturing Stage

The LCA shall include information for the following unit processes:

- Environmental impacts related to the mining and production of raw materials used in main components, minor components, packaging materials and other components;
- Environmental impacts related to the manufacturing of main components, secondary components, packaging materials and other components;
- Environmental impacts related to the manufacturing and assembly of solar PV modules;
- Environmental impacts related to the transportation of main components, secondary components, packaging materials and other components to the product assembly plant/site.

The information that related to forming and refining of raw materials included into LCA is defined as voluntary report. Such optional information should be declared in the EPD if included in voluntary report.

Delivering and Marketing Stage

The LCA shall include information for the following unit processes:

- Transportation of products from manufacturing plant/site to customer designated sites.

5.1 Specification of different boundary settings

Boundary in time

The validity period for the LCA results presented in the LCA report shall be defined.

Boundary towards nature

If the manufacturing processes are located within Taiwan, the solid waste categories as defined in Taiwan's Waste Disposal Act shall be adopted. If the processes are located in other countries, equivalent legal requirements shall be considered.

The natural boundary of the system shall describe the boundary where the materials and energy

resources flow from nature into the system, and where the water,-air emissions and waste are released out of the system.

Only the quantity of the disposed waste needs to be considered; the landfilling process does not need to be considered. If the waste is generated through wastewater treatment or incineration process, such waste should be included into the wastewater treatment or incineration process.

Boundaries in the life cycle

The boundaries in the product life cycle are described in Figure 1. The construction of the site and infrastructure, as well as the production of manufacturing equipment and activities of site operators do not need to be included.

Boundaries towards other technical systems

Boundaries towards other technical systems describe the inputs of material and other components towards other systems, as well as outputs of materials towards other systems. For the inputs of recycled materials and energy towards the product manufacturing stage, the transportation between the recycling process and use of recycled materials shall be included in the data set. For the production of recyclable products during the manufacturing stage, the transportation towards the recycling process shall be included.

(Note: Further explanations are provided in Section 7 on open-loop recycling.)

Boundaries regarding geographical coverage

The manufacturing stage may cover manufacturing processes located on any sites around the world. For processes located in a specific region, the data used should be representative of the region. The data for the main constituents shall be the specific regional data for the region where the process takes place (see Section 9). For ease of comparison, no matter where the emissions are generated, the same environmental impact parameters should be used for life cycle impact assessment (see Section 10).

6. Cut-off rules

For any impact category, if the sum of various impacts from a specific process/activity is less than 1% of the impact equivalent in that category, such a process/activity may be neglected during the inventory analysis. Nonetheless, the accumulated impact of neglected process/activity may not exceed 5%. That is, at least 95% of the potential life cycle emissions shall be evaluated.

Components and materials omitted from the LCA shall be documented.

(Note: This judgment for this “1% Rule” is based on the environment relevance assessment of material input to the system, and does not consider special and exceptional environmental impacts.)

7. Allocation rules

The main allocation rules shall be valid for the entire product system. For other secondary processes, other allocation rules may be defined; however, the use of these rules should be justified. Product-specific information should be preferentially collected in order to avoid the need for allocation. While selecting allocation rules, the following principles are recommended.

- **Multi-output**: The allocations are based on the changes in the resource consumption and pollutant emissions (for example, adopted quantity allocation for some main component, or surface area allocation for some components), following the changes in the studied system’s output product or function or economical relationship.
- **Multi-input**: The allocation is based on actual relationship. For example, the manufacturing process’s emissions may be affected by the change in waste flow input.
- **Open loop recycling**: For the input of recycled materials or energy during the manufacturing stage of the product system, the transportation between the recycling process and the recycling to material use shall be included in the dataset. For the product which shall be recycled during the manufacturing stage, the transportation towards the recycling process shall be included.

(Notes: Allocation may be avoided through avoidance of dividing processes, for example as described in Section 6.3 of ISO/TR 14049; or through expansion of system boundary (for example as

described in Section 6.4), so that the amended system shares the same product exchanges as the original system.)

8. Units

The base units and derived units of the International System of Units (SI, *Système International d'unités*) shall be used preferentially.

Power & energy units:

- power unit: W
- energy unit: J

Specification units:

- length unit: m
- capacity unit: m³
- area unit: m²
- weight unit: kg

Optical unit:

- Luminous flux unit: lm

If necessary, prefixes may be used before the SI units:

- 10⁹ = giga, symbol "G"
- 10⁶ = mega, symbol "M"
- 10³ = kilo, symbol "k"
- 10⁻² = centi, symbol "c"
- 10⁻³ = milli, symbol "m"
- 10⁻⁶ = micro, symbol "μ"
- 10⁻⁹ = nano, symbol "n"

9. Calculation rules and data quality requirements

Data quality requirements for raw material acquisition stage and manufacturing stage

- Generic data may be used for the mining, production, forming and refining of raw materials used for various components of the products. Please refer to Appendix I for the common sources of generic data. The year of the data cannot be earlier than 2000.
- Site-specific data (for example, specific data for manufacturing plant or transportation) shall be used for the product manufacturing and assembly processes. If other types of information are used, description of the information and rationale for using the information shall be provided.
- Generic data may be used for the manufacturing processes of packaging materials and other components. Please refer to Appendix I for the common sources of generic data. The year of the data cannot be earlier than 2000.
- When generic data are used, the equivalence between the chemical and/or physical process or at least the same technical range of referred systems shall be considered.
- Generic data may be used when suppliers refuse to provide specific data, or when even if generic data are used in place of specific data, there is only minor impact to the results. The general rule is that if generic data are used in place of specific data, their combined contribution for all life cycle stages shall not be greater than 20% of total impacts for each impact category.
- The data shall be representative for the average of a specific year.
- The electricity mix for the manufacturing stage should be site specific data. If site specific data cannot be obtained, the official electricity mix for the country where the site is located may be used as approximate value, and such electricity mix should be documented and described.
- For the definition of hazardous waste, the definition as defined in Taiwan's Waste Disposal Act shall be used for sites located in Taiwan. For sites located outside Taiwan, legal requirements for the host country shall be observed.
- For the transportation of main materials to the manufacturing plant, the actual transportation modes used and distance traveled shall be considered.

Note: For purpose of inventory and declaration of product carbon footprint, where the organization implementing this PCR does not contribute 10% or more to the upstream GHG emissions of the product or input prior to its provision to another organization or the end-user, the primary activity data requirement shall apply to the emissions arising from those processes owned, operated or controlled by the first upstream supplier that does contribute 10% or more to the upstream GHG emissions of the product or input.

Data quality requirements for the delivering and marketing stage

- For transportation of products to the downstream distributors/retailers, the actual mode of transportation and distance traveled shall be considered.
- The inputs of energy and resource, and the outputs of waste during the delivering and marketing stage shall be considered.

10. Parameters to be declared in the EPD

The following parameters shall be declared in the EPD:

Energy consumption

- Consumption of energy shall be declared for all stages of the product life cycle, which includes energy consumption information (e.g., electricity, or consumption of oil, coal, gas, other fuels, purchased energy) at the user side/end.

Resource usage

- non-renewable resources
 - materials usage
 - energy (used for energy conversion purposes)
- renewable resources
 - Materials
 - energy (used for energy conversion)

- secondary resources
 - Secondary materials (pre-consumer or post-consumer recycling and reuse)
 - energy (used for energy conversion)
- recovered energy flows (such as thermal energy) expressed in MJ
- Indicators used by water resource shall also be calculated from the life cycle inventory. These indicators do not constitute a “water footprint” as potential environmental impacts due to the water use in different geographical locations is not captured. The minimum indicators for water resource use in the EPD shall be:
 - total amount of water (consider make-up water for in-plant recycling and reusing)
 - direct amount of water used by the core process
- The following requirements are applied for the indicators used in water resource. (This content is excerpted from water footprint inventory in *ISO 14046 Environmental management - Water footprint - Principles, requirements and guidelines*):
 - water usage includes evaporation, transpiration, product integration, release into different drainage basins or the sea, displacement of water from one water resource type to another water resource type within a drainage basin (e.g. from groundwater to surface water). In-stream water usage is not included.
 - for water used in closed loop processes (such as cooling system) and in power generation only the net water consumption (such as reintegrations of water losses) should be considered.
 - sea water usage shall not be included in the indicator.
 - tap water or treated water (e.g. from a water treatment plant), or waste water that is not directly released in the environment (e.g. sent to a wastewater treatment plant) are not elementary water flows, but intermediate flows from a process within the technosphere.
 - additional transparency in terms of geographical location, type of water resource (e.g. groundwater, surface water).

The following requirements on the resource declaration shall also apply:

- all parameters for resource consumption shall be expressed in mass, with the exception of renewable energy; resources used for the generation of hydroelectric, wind electricity and solar energy, which shall be expressed in MJ;
- all parameters shall not be aggregated but reported separately. Resources which contribute for less than 5% in each category shall be included in the resources list as “other”;
- nuclear power shall be reported among the non-renewable energy resources as kg of uranium calculated by converting the thermal energy (MJ) considering a reactor of III generation with an efficiency of 33%;
- the PCR can define other resources (for example rare materials originating from the LCI data) which may be listed and detailed in the EPD for each specific product category;
- the energy content of some products (such as paper or plastic based products) is useful information for the end of life management. For this reason, the “energy content of product” shall be declared in MJ: its estimation shall be made considering the gross calorific value of the product. Only the energy that is suitable for an eventual energy recovery at the end of life shall be considered (the carbon content of steel products, for example, shall not be considered since it is not practically recoverable);
- energy content of biomass used for feed or food purposes shall not be considered.

Potential environmental impacts are expressed as pollutant emissions

The potential environmental impacts associated with the various types of use of resources and pollutant emissions shall be reported into the following impact categories:

- Emission of greenhouse gases (expressed as the sum of global warming potential, GWP, 100 years, in CO₂ equivalents).
- Emission of acidifying gases (expressed as the sum of acidifying potential in sulphur dioxide (SO₂) equivalents).
- Emission of gases that contribute to the creation of ground-level ozone (expressed as the sum of ozone-creating potential, ethene-equivalents).
- Emission of substances to water contributing to oxygen depletion (expressed as phosphate (PO₄³⁻) equivalents).

Impacts category for optional (voluntary) declaration

In accordance with the LCA results of this product category, other categories of impacts with significance may also be declared.

Resource Recycling and Waste

- hazardous waste (as defined in waste management laws of the country where the waste is generated);
- Recyclable resources or materials (optional information)
- Regrind materials usage (optional information)

Note: For characterization factors of each impact category, please refer to *General Programme Instructions For The International EPD System, Version 2.5 (2015-5-11)*.

11. Recycling information

The recycling information shall include information such as dis-assembly instructions, which parts/components are suitable for recycling (such as metal cases) or not suitable for recycling. For example, information from final product manufacturers required for various national PV module recycling initiatives may be declared in the EPD.

If practical, information for the parts which cannot be recycled and reused, and therefore should be disposed of properly during the end-of-life stage may also be included.

12. Other environmental information (Optional)

The EPD may cover information including technology adopted, site of product manufacturing and assembly, as well as information on other working environment, health and risk-related aspects.

If this PCR is intended to be used for product carbon footprint declaration purpose, in the declaration, information regarding commitment on GHG reduction should be included and shall ensure that the commitment is measurable, reportable and verifiable. The organization may also list environmental and energy management related information, such as awards, commendations and system certifications (e.g., ISO 14001, ISO 14064-1, IECQ HSPM), etc.

13. Information about the certification

The information on PCR review, EPD verification and verification organization shall be included.

EPD Certification is valid until 20XX-__-__

According to the Requirements for the international EPD system, *General Programme Instructions, Version 2.5 (2015-05-11)* – www.environdec.com.

The PCR review for _____ (PCR 2017:) was administered by the Environment and Development Foundation and carried out by an LCA expert panel chaired by Dr. Wen-Ching Chen (wencc@edf.org.tw).

Independent verification of the declaration, according to ISO 14025:2006

Internal External

Third party verifier: Environment and Development Foundation in Taiwan.

LCA Expert Panel:

Name:

Title:

Organization:

Signature: _____

Name:

Title:

Organization:

Signature: _____

Name:

Title:

Organization:

Signature: _____

Environmental declarations from different programmes may not be comparable.

14. References

The EPD established in accordance with this PCR shall refer to the following documents:

- GENERAL PROGRAMME INSTRUCTIONS FOR THE INTERNATIONAL EPD® SYSTEM, Version 2.5 (2015-05-11), downloadable from:
<http://www.environdec.com/en/The-International-EPD-System/General-Programme-Instructions/>
- The underlying LCA report
- ISO 14040, “Environmental management — Life cycle assessment — Principles and framework”, second edition (2006-07-01)
- ISO 14044, “Environmental management — Life cycle assessment — Requirements and guidelines”, first edition (2006-07-01)
- Development of UN’s Central Product Classification (CPC), from the website of National Statistics of the Republic of China (Taiwan)
- Central Product Classification (CPC), Version 2.1 (2015-08)
- Technical specifications for high-performance solar photovoltaic modules, Bureau of Standards, Metrology and Inspection (BSMI), MOEA (2016)

When available, the following documents shall also be referenced:

- Other documents and recycling instructions that verify and complement the EPD.

Appendix I – Generic Data Sources for reference

For processes located within Taiwan, Taiwan generic data or the data published by the commercial, industrial and energy competent authorities of the Republic of China (ROC) government, may be used. However, for other regions (such as EU), if there are more relevant generic data available, these data should be used instead. Data from the following generic databases are recommended for use.

| Material | Database | Published |
|---|--|-----------|
| Industrial processes | ecoinvent 3.3 | 2016 |
| Packing materials, transport, Waste treatments | BUWAL 250, 2 nd edition | 2004 |
| Steel, Primary copper, Copper products, Electricity, Fuels, Aluminum, Chemicals, Transports, Waste management | ecoinvent 3.3 | 2016 |
| | PE-GaBi 14 | 2014 |
| | ELCD version 3.2 | 1995-2014 |
| | The Boustead Model 6.0 | 2013 |
| | EIME (Environmental Information and Management Explorer) EcoBilan | 1999-2014 |
| Plastics | PE Plastics Europe (Association of Plastics Manufacturers in Europe) | 1993-2016 |
| | PE-GaBi 14 | 2014 |
| | ELCD version 3.2 | 1995-2014 |
| | ecoinvent 3.3 | 2016 |
| | The Boustead Model 6.0 | 2013 |
| | EIME (Environmental Information and Management Explorer) EcoBilan | 1999-2014 |
| Electronic components | PE-GaBi 14 | 2014 |
| | ELCD version 3.2 | 1995-2014 |
| | ecoinvent 3.3 | 2016 |
| | The Boustead Model 6.0 | 2013 |
| | EIME (Environmental Information and Management Explorer) EcoBilan | 1999-2014 |
| LCA Database in Taiwan | Carbon Footprint Calculation Platform | 2017 |
| | DoITPro | 2017 |

Appendix II – Reporting Format for the EPD

This appendix provides guidance information for the titles of sections, types of data and required information to be reported in the mandatory reporting part of the EPD. As a generic reporting template, the following titles and sub-titles are recommended:

(Refer to the PCR manual for the section numbering, the information in Italics are the recommended data/information for inclusion)

Introductory part

Each EPD should have an introduction part on the top part of the EPD which includes the following information:

- *Company/organization name*
- *Product name*
- *EPD registration number*

Description of the company/organization and product/service

Company/Organization

- *Description of company/organization*
- *Description of overall working environment, existing quality system and environmental management system*

Product and services (see Section 2)

- *Product's main applications*
- *Description of product specification, manufacturing process, manufacturing sites (if there were several sites)*
- *For product's environmental performance aspects, characteristics which may improve the usefulness of product*
- *Other types of relevant information, for example, special manufacturing processes with special advantages to the environment*

List of materials and chemical substances

- *Content declaration (see Section 3)*

Presentation of the environmental performance

- *Outline of the LCA methodology, for example, period of LCA, declared units, system boundaries (graphical presentation), cut-off and allocation rules, and data sources.*

Raw Materials acquisition stage (see Section 10)

Manufacturing stage (see Section 10)

Delivering, Use and End-of-Life stage (see Section 10)

- *Geographical area where the product is delivered*
- *Transport data*
- *Design life*
- *End of life information*

Information about Company and Certification Organization

Recycling information (see Section 11)

Other environmental information (see Section 12)

Information regarding certification (see Section 13)

- *Names of certification and verification organizations*
- *Validity of certification certificates*
- *Compliance with legal and relevant requirements*

References (see Section 14)

- *relevant PCR documents*
- *General Programme Instructions for the International EPD® System, Version 2.5 (2015-05-11)*
- *underlying LCA study*
- *other supporting documents for LCA information*
- *other relevant documents regarding company/organization's environmental activities*

Appendix III - Note of abbreviations

| Acronyms | Common Name |
|----------|--|
| APLAC | Asia Laboratory Accreditation Cooperation |
| CFP | Carbon Footprint of Product |
| WFP | Water Footprint of Product |
| EPD | Environmental Product Declaration |
| ErP | Energy Related Product |
| ILAC | International Laboratory Accreditation Cooperation |
| ILAC MAR | International Laboratory Accreditation Cooperation Mutual Recognition Arrangement |
| ISO | International Organization for Standardization |
| LCA | Life Cycle Assessment |
| PCR | Product Category Rule |
| RoHS | The Restriction of the use of certain Hazardous Substances in electrical and electronic equipment |
| SPI | Society of the Plastics Industry |
| TAF | Taiwan Accreditation Foundation |
| TEC | Typical Energy Consumption |
| Trpt | Transportation |
| WEEE | The Waste Electrical and Electronic Equipment Directive |