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**[WORKING DOCUMENT ON A] COMMISSION REGULATION (EU) …/…**

**of XXX**

**laying down ecodesign requirements for photovoltaic modules and photovoltaic inverters pursuant to Directive 2009/125/EC of the European Parliament and of the Council**

(Text with EEA relevance)



**EN**

**WORKING DOCUMENT ON A POTENTIAL COMMISSION REGULATION (EU) …/…**

**of XXX**

**laying down ecodesign requirements for photovoltaic modules and photovoltaic inverters pursuant to Directive 2009/125/EC of the European Parliament and of the Council**

(Text with EEA relevance)

THE EUROPEAN COMMISSION,

Having regard to Article 114 of the Treaty on the Functioning of the European Union,

Having regard to Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products[1], and in particular Article 15(1) and Article 15(4)(a) thereof,

Whereas:

(1) Pursuant to Directive 2009/125/EC the Commission should set ecodesign requirements for energy-related products which account for significant volumes of sales and trade in the Union and which have a significant environmental impact and presenting significant potential for improvement through design in terms of their environmental impact, without entailing excessive costs.

(2) The Commission established a third Working Plan in accordance with Directive 2009/125/EC on 30 November 2016[2], covering the years 2016 to 2019, identifying solar panels and inverters as one of the non-regulated product groups with the largest potential for environmental savings and indicating the need for investigating in more detail the possible environmental improvements.

(3) The Commission has carried out a preparatory study[3] to analyse the technical, environmental and economic aspects of photovoltaic modules, inverters and systems. The study has been carried out with stakeholders and interested parties from the Union and third countries, and the results have been made publicly available.

(4) The preparatory study identified a number of areas for potential regulatory intervention, aimed to a) foster module and inverter designs that have improved long-term energy yield, circularity and smart readiness, b) take products off the market that are of a low quality and that have higher life cycle costs and c) inform users in a

[1] OJ L 285, 31.10.2009, p. 10.
[2] COM(2016) 773 final
[3] 'Preparatory study for solar photovoltaic modules, inverters and systems', DOI: 10.2760/852637

comparable manner about module performance and carbon footprint to provide them with a common basis to compare different products before making their purchase.

(5) The environmental aspects of photovoltaic modules in the scope of this Regulation that have been identified as significant for the purposes of this Regulation are energy consumption related to manufacturing, the life-cycle carbon footprint (of photovoltaic modules), and resource efficiency, in particular on the aspects related to reparability, recyclability and reliability.

(6) Ecodesign requirements should harmonise requirements related to these aspects throughout the Union, in order to improve the environmental performance of photovoltaic modules and inverters, achieve the European Union's environmental objectives, and for the internal market to operate better.

(7) The annual electricity production of new capacity installed in 2021 in the EU27 of photovoltaic modules and inverters subject to this Regulation is estimated at around 643 TWh in their lifetime. In total this new capacity installed in Europe consumed in their manufacturing around 59.5 TWh. The combined effect of an ecodesign and energy labelling regulation will increase the electricity generation of photovoltaics by 3-5% (by additional 11-14 TWh in 2030), and will help saving up to 25% of the primary energy consumption for their manufacturing.

(8) The preparatory study showed that the life-cycle greenhouse gas emissions are a significant environmental aspect of photovoltaic modules and that the EU consumption of those products is linked to a significant amount of greenhouse gas emissions. Photovoltaic modules placed on the EU market, the amount of which is expected to rapidly increase over the coming decades, thereby contributes to global climate change and associated biodiversity loss, which is having effects also within the EU.

(9) The carbon footprint of photovoltaic modules is largely determined at the design stage. First, the manufacturer's choice of materials and components in terms of their amount, origin, their quality decides, to a large extent, the overall carbon intensity of the module. Second, a comparison of the output of the module, which is also largely dependent on its design, with the carbon intensity of these material inputs then determines the carbon footprint. Apart from these design factors, the carbon intensity of the energy mix used during the manufacturing process also influences the carbon footprint. The preparatory study therefore showed that there is significant improvement potential that could be attained by means of such design choices.

(10) Photovoltaic modules should be accompanied by a carbon footprint declaration when placed on the market. This will create transparency on the market and allow consumers and public authorities to compare the carbon footprint of different modules placed on the market in line with Annex I Part 2 of Directive 2009/125/EC. This increased transparency should facilitate a shift in the Union market towards lower carbon modules, regardless of where they are produced, contributing to the Union's objective of reaching climate neutrality by 2050. It may also enable other policies at Union and national level, such as incentives or green public procurement criteria, fostering the consumption of modules with lower environmental impacts.

(11) In the case of polycrystalline silicon and monocrystalline silicon photovoltaic modules, representing the vast majority of the market, the declared carbon footprint should not exceed a maximum threshold. With a mandatory carbon footprint declaration alone, and the associated market transparency, the photovoltaic modules with the highest adverse environmental and climate change impact would still be available on the EU market. Therefore, in order to more effectively reduce the carbon footprint of photovoltaic modules and achieve the EU's environmental objectives, maximum thresholds should be set to ensure that only those products which meet the

EU's level of ambition in emissions reduction are available on the market. In order to progressively phase out the worst performing products and to give the market sufficient time to adjust, a threshold of 25gCO2eq/kWh should apply from XX/YY/20ZZ, which will phase out the most inefficient polycrystalline modules. From XX/YY/20ZZ, the threshold should be lowered to 18g CO2eq/kWh, which will then phase out the most inefficient monocrystalline modules.

(12) To ensure comparability, the declared carbon footprint should be based on harmonised calculation rules and be calculated using a single, freely accessible calculation tool based on those rules that is provided by the Commission for that purpose. The carbon footprint calculation should focus on those life-cycle stages where the bulk of emissions take place, in this case the raw material acquisition and pre-processing, manufacturing and – possibly - distribution phases.

(13) The Annex IV related to the calculation of the carbon footprint of the manufacturing of photovoltaic modules builds on the Product Environmental Footprint Category Rules (PEFCR) for photovoltaic modules used in photovoltaic power systems for electricity generation (Version 1.2 – February 2020)[4].

(14) The requirements on design for reliability oblige photovoltaic modules to be capable of withstanding prolonged exposure to open-air climates. The sequence of tests simulating a range of environmental stressors (e.g. damp heat, hail) that could lead to product failure or decreased performance is aimed to ensure the reliability of photovoltaic modules throughout the designed technical lifetime of around 30 years.

(15) The formulation of the requirements on the design for reliability of photovoltaic modules is consistent with the terminology of the EN IEC 61215 standard series.

(16) The formulation of the requirements on the design for reliability of photovoltaic inverters is consistent with the terminology of the EN IEC 62093:2005 standard.

(17) The relevant product parameters should be measured using reliable, accurate and reproducible methods. Those methods should take into account recognised state-of-the-art measurement methods including, where available, harmonised standards adopted by the European standardisation bodies, as listed in Annex I to Regulation (EU) No 1025/2012 of the European Parliament and of the Council[5].

(18) In accordance with Article 8 of Directive 2009/125/EC, this Regulation specifies the applicable conformity assessment procedures. In line with paragraph 2 of that Article, it specifies a module from among the modules set out in Annex II to Decision No 768/2008/EC as this is duly justified by and proportionate to the relevant risks.

(19) The conformity assessment procedure outlined in Annex V follows the steps of module D1, which provides for quality assurance of the production process, adapted to fit the nature of the products and requirements concerned. Compared to the internal design control procedure commonly used in relation to ecodesign requirements, Annex V includes additional conformity assessment steps in relation to the requirements on

[4] https://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm

[5] Regulation (EU) No 1025/2012 of the European Parliament and of the Council of 25 October 2012 on European standardization, amending Council Directives 89/686/EEC and 93/15/EEC and Directives 94/9/EC, 94/25/EC, 95/16/EC, 97/23/EC, 98/34/EC, 2004/22/EC, 2007/23/EC, 2009/23/EC and 2009/105/EC of the European Parliament and of the Council and repealing Council Decision 87/95/EEC and Decision No 1673/2006/EC of the European Parliament and of the Council (OJ L 316, 14.11.2012, p. 12).

design for reliability and the requirements on the carbon footprint of photovoltaic modules, while retaining only the elements of the standard internal design control procedure in relation to the other requirements. The module includes the involvement of an independent conformity assessment body in relation to those requirements in order to take account of the specificities of photovoltaic products as well as the complexity of the relevant requirements.

(20) The preparatory study showed that, more than other parameters, the reliability of photovoltaic products relies on the effective management and quality of the production process. When photovoltaic modules are mass-produced, a lack of quality control of the production process can, among other things, lead to deviations from the model design, variations in material quality or lapses in precision manufacturing. Such problems are liable to interfere with the continuous achievement of the required reliability performance. Therefore, in addition to testing a product model for compliance with the requirements on design for reliability, manufacturers should carefully manage their production process and safeguard its quality in order to ensure that all units they place on the market are reliable. Therefore, in order to effectively manage the environmental and non-compliance risks involved, the conformity assessment procedure linked to the requirements on the design for reliability requires manufacturers to operate a quality system approved by a conformity assessment body. The approved quality system is complementary to the manufacturer's responsibility to establish technical documentation based on the appropriate tests to allow the assessment of a product's conformity with the requirements on design for reliability. By focussing on the quality of the production process rather than the product, a quality system aims to ensure that each individual unit of a certain product subsequently placed on the market actually achieves the reliability performance described in the technical documentation.

(21) The elements of the quality system for photovoltaic modules referred to in Annex V take inspiration from and aim at an aligned approach with the factory production control instructions set out in IEC EN 62941.

(22) The elements of the quality system for photovoltaic inverters referred to in Annex V take inspiration from and aim at an aligned approach with the factory production control instructions set out in IEC TS 63157.

(23) To ensure that the declared carbon footprint of photovoltaic modules is reliable, credible and correct, manufacturers should apply for verification of their declared footprint by an independent conformity assessment body. Third-party verification further ensures comparability of claims and allows for the more effective management of the environmental and non-compliance risks involved. The verification should focus on the use made and information put into the carbon footprint calculation tool made available by the Commission. It shall in particular ensure the reliability of the company-specific data used by manufacturers. Such data, relating to for example the material and energy used in the production process, cannot be cross-checked on the product itself as is the case for, for example, the energy yield. The pre-market involvement of a conformity assessment body in assessing the reliability of company-specific data should provide additional assurance for the reliability of the declared carbon footprint. The verified carbon footprint should be valid for no longer than three years and should be updated, also during its validity period, in case of significant changes.

(24) The conformity assessment procedures set out in this Regulation require the intervention of conformity assessment bodies. In order to ensure a uniform implementation of the provisions in this Regulation, those bodies should be notified by the Member State authorities to the Commission.

(25) In order to ensure a consistent level of quality in the performance of conformity assessment, it is necessary to set requirements for notifying authorities involved in the assessment, notification and monitoring of notified bodies. In particular, it should be ensured that the notifying authority is objective and impartial with regard to its activity. Furthermore, notifying authorities should be required to safeguard the confidentiality of the information it obtains but should nonetheless be able to exchange information on notified bodies with national authorities, the notifying authorities of other Member States and the Commission to ensure consistency in the conformity assessment.

(26) It is essential that all notified bodies perform their functions to the same level and under conditions of fair competition and autonomy. Therefore, requirements for conformity assessment bodies wishing to be notified in order to provide conformity assessment activities should be set. Those requirements should continue to apply as a prerequisite for the maintenance of the competence of the notified body. To ensure its autonomy, the notified body and the staff it employs should be required to maintain independence from economic operators in the photovoltaic products value chain and from other companies, including business associations and relevant parent companies and subsidiaries. The notified body should be required to document its independence and provide that documentation to the notifying authority.

(27) If a conformity assessment body demonstrates conformity with the criteria laid down in harmonised standards it should be presumed to comply with the corresponding requirements set out in Chapter II of this Regulation.

(28) Conformity assessment bodies frequently subcontract parts of their activities linked to the assessment of conformity or have recourse to a subsidiary. Certain activities and decision-making processes, both regarding the conformity assessment and other activities internal to the notified body, should however exclusively be carried out by the individual notified body itself, in order to ensure its independence and autonomy. Furthermore, in order to safeguard the level of protection required for photovoltaic products to be placed on the Union market, conformity assessment subcontractors and subsidiaries should fulfil the same requirements as notified bodies in relation to the performance of conformity assessment tasks under this Regulation.

(29) Since the services offered by notified bodies in a Member State might relate to photovoltaic modules or inverters made available on the market throughout the Union, it is appropriate to give the other Member States and the Commission the opportunity to raise objections concerning a notified body. In order to ensure uniform conditions for the implementation of this Regulation, the Commission should be able to direct the notifying authority to take corrective action in case a notified body does not meet or no longer meets the requirements of this Regulation.

(30) In the interest of facilitating and accelerating the conformity assessment procedure and market access, and in view of the complexity of the requirements on design for reliability and on the carbon footprint of photovoltaic modules, it is crucial that notified bodies have continuous access to all necessary equipment and qualified personnel and that they apply the procedures without creating unnecessary burdens for economic operators. For the same reason, and to ensure equal treatment of economic operators, it is necessary that the notified bodies apply the conformity assessment procedures consistently.

(31) Prior to taking a final decision on whether the manufacturer can be granted a carbon footprint certificate or quality system approval, the economic operator that wishes to place a photovoltaic module or inverter on the market should be allowed to complement once the documentation on the product.

(32) The Commission should enable appropriate coordination and cooperation between notified bodies.

(33) The manufacturer, having detailed knowledge of the design and production process, is best placed to carry out the conformity assessment procedure. Conformity assessment should therefore remain mainly the obligation of the manufacturer.

(34) It is necessary to ensure that photovoltaic modules or inverters from third countries entering the Union market comply with the requirements of this Regulation. Provision should therefore be made for importers to make sure that appropriate conformity assessment procedures have been carried out by manufacturers with regard to the products they place on the market.

(35) To facilitate compliance checks, manufacturers, importers or authorised representatives should provide information in the technical documentation referred to in Annexes IV and V to Directive 2009/125/EC in so far as this information relates to the requirements laid down in this Regulation.

(36) For market surveillance purposes, manufacturers, importers or authorised representatives should be allowed to refer to the product database if the technical documentation as per Commission Delegated Regulation (EU) 20XX/XXX[6] contains the same information.

(37) To improve the effectiveness of this Regulation and to protect consumers, products that automatically alter their performance in test conditions to improve the declared parameters should be prohibited.

(38) In addition to the legally binding requirements laid down in this Regulation, indicative benchmarks for best available technologies should be identified to make information on the products' environmental performance over their life cycle subject to this Regulation widely available and easily accessible, in accordance with Directive 2009/125/EC, Annex I, part 3, point (2).

(39) A review of this Regulation should assess the appropriateness and effectiveness of its provisions in achieving its goals. The timing of the review should allow for all provisions to be implemented and show an effect on the market.

(40) [The measures provided for in this Regulation are in accordance with the opinion of the Committee established by Article 19(1) of Directive 2009/125/EC],

HAS ADOPTED THIS REGULATION:

# Chapter I
# General provisions

*Article 1*

***Subject matter and scope***

1. This Regulation establishes ecodesign requirements for the placing on the market of photovoltaic modules and photovoltaic inverters.

2. This Regulation shall not apply to the following products:

[6] Commission Delegated Regulation (EU) 2022/XXX *[full OJ-L references of Regulation EL smartphones/tablets]*

(a) photovoltaic modules with a direct current (DC) output power of less than 50 Watts under Standard Test Conditions;

(b) building integrated photovoltaics;

(c) photovoltaic modules integrated into consumer electronic products, or other multifunctional applications requiring specialised designs for which energy production is not the only purpose/functionality such as, but not limited to, street furniture, large-area shading, specific agri-photovoltaic applications or other similar;

(d) photovoltaic modules based on organic perovskite layers. Tandem solar cells made with silicon and these materials are inside the scope of this Regulation;

(e) photovoltaic modules based on new technologies entering the market with a cumulative yearly global production less than 500 MW;

(f) central photovoltaic inverters that are packaged with transformers as defined in Commission Regulation (EU) No 548/2014 on Ecodesign requirements for small, medium and large power transformers.

*Article 2*

***Definitions***

For the purpose of this Regulation, the following definitions shall apply:

(1) 'photovoltaic module' means a framed or unframed assembly of solar photovoltaic cells designed to generate DC power. A photovoltaic module consists of:

- strings of photovoltaic cells (crystalline technology) and/or semiconductor layers (thin film technology),
- a substrate, encapsulation and cover materials,
- the interconnections of the cells,
- the junction box and associated cabling, and
- the framing material (where applicable);

(2) 'Direct current (DC) output power' means the power measured at the DC output port;

(3) 'Standard Test Conditions' (STC) means a standard set of reference conditions used for the testing and rating of photovoltaic cells and modules. The standard test conditions are: photovoltaic cell temperature of 25 °C; irradiance in the plane of the PV cell or module of 1000 W/m$^2$ and light spectrum corresponding to an atmospheric air mass of 1.5g;

(4) 'Building integrated photovoltaic' means photovoltaic modules that incorporate solar photovoltaic cells and form a construction product providing a function as defined in the European Construction Product Regulation CPR 305/2011;

(5) 'central photovoltaic inverter' means a photovoltaic inverter falling within Category 3 as defined in draft IEC 62093 ED2 ('Large-scale power electronics') and designed to interface multiple series or parallel connected modules, but due to its complexity, size and weight are housed in a free-standing electrical enclosure and are usually packaged with transformers;

(6) 'accreditation' means accreditation as defined in Article 2(10) of Regulation (EC) No 765/2008;

(7) 'national accreditation body' means a national accreditation body as defined in Article 2(11) of Regulation (EC) No 765/2008;

(8) ‘conformity assessment’ means the process demonstrating whether the requirements of this Regulation relating to photovoltaic modules and photovoltaic inverters have been fulfilled;

(9) ‘conformity assessment body’ means a body that performs conformity assessment activities including calibration, testing, certification and inspection;

(10) ‘notified body’ means a conformity assessment body notified in accordance with Chapter II of this Regulation;

For the purposes of the Annexes, additional definitions are set out in Annex I.

*Article 3*

***Ecodesign requirements***

The ecodesign requirements set out in Annex II shall apply from the dates indicated therein.

*Article 4*

***Conformity assessment***

1. The conformity assessment procedure referred to in Article 8 of Directive 2009/125/EC shall be the quality assurance system set out in Annex V.

2. For the purposes of conformity assessment pursuant to Article 8 of Directive 2009/125/EC, the technical documentation shall contain a copy of the product information provided in accordance with Annex II to this Regulation, and the details and the results of the calculations set out in Annex III to this Regulation.

3. Where the information included in the technical documentation for a particular model has been obtained:

(a) from a model that has the same technical characteristics relevant for the technical information to be provided but is produced by a different manufacturer, or

(b) by calculation on the basis of design or extrapolation from another model of the same or a different manufacturer, or both,

the technical documentation shall include the details of such calculation, the assessment undertaken by the manufacturer to verify the accuracy of the calculation and, where appropriate, the declaration of identity between the models of different manufacturers.

The technical documentation shall include a list of all equivalent models, including the model identifiers.

*4.* The technical documentation shall include the information in the order and as set out in Annex VI of Regulation (EU) 20YY/XXX *[EL photovoltaic modules/systems]*. For market surveillance purposes, manufacturers, importers or authorised representatives may, without prejudice to Annex IV, point 2(g) of Directive 2009/125/EC, refer to the technical documentation uploaded to the product database which contains the same information laid down in Regulation (EU) 20YY/XXX *[EL photovoltaic modules/systems]*.

*5.* Before placing a photovoltaic module or a photovoltaic inverter on the market or putting it into service, importers shall verify that the relevant conformity assessment procedures referred to in paragraphs 1 and 2 have been carried out by the manufacturer.

*Article 5*

***Verification procedure for market surveillance purposes***

Member States shall apply the verification procedure laid down in Annex VI when performing the market surveillance checks referred to in point 2 of Article 3 of Directive 2009/125/EC.

*Article 6*

***Circumvention***

The manufacturer, importer or authorised representative shall not place on the market products designed to be able to detect they are being tested (for example by recognising the test conditions or test cycle) and to react specifically by automatically altering their performance during the test with the aim of reaching a more favourable level for any of the parameters in the technical documentation or included in any documentation provided.

The energy consumption of the product and any of the other declared parameters shall not deteriorate after a software or firmware update when measured with the same test standard originally used for the declaration of conformity, except with explicit consent of the end-user prior to the update. No performance change shall occur as a result of rejecting the update.

A software update shall never have the effect of changing the product's performance in a way that makes it noncompliant with the ecodesign requirements applicable for the declaration of conformity.

*Article 7*

***Indicative benchmarks***

The indicative benchmarks for the best-performing products and technologies available on the market at the time of adopting this Regulation are set out in Annex VII.

# Chapter II
# Notification of conformity assessment bodies

*Article 8*

***Notification***

Member States shall notify the Commission and the other Member States of bodies authorised to carry out the third-party conformity assessment in accordance with this Regulation. *Article 9*

***Notifying authorities***

Member States shall designate a notifying authority that shall be responsible for setting up and carrying out the necessary procedures for the assessment and notification of conformity assessment bodies and the monitoring of notified bodies, including compliance with the provisions of Article 14.

3. Member States may decide that the assessment and monitoring referred to in paragraph 1 shall be carried out by a national accreditation body within the meaning of and in accordance with Regulation (EC) No 765/2008.

Where the notifying authority delegates or entrusts the assessment, notification or monitoring referred to in paragraph 1 to a body which is not a governmental entity, that body shall be a legal entity and shall comply *mutatis mutandis* with the requirements laid down in Article 10. In addition, it shall have arrangements to cover liabilities arising out of its activities.

4. The notifying authority shall take full responsibility for the tasks performed by the body referred to in paragraph 3.

*Article 10*

***Requirements relating to notifying authorities***

5. A notifying authority shall be established in such a way that no conflict of interest with conformity assessment bodies or notified bodies occurs.

6. A notifying authority shall be organised and operated so as to safeguard the objectivity and impartiality of its activities.

7. A notifying authority shall be organised in such a way that each decision relating to notification of a conformity assessment body is taken by competent persons different from those who carried out the assessment.

8. A notifying authority shall not offer or provide any activities that conformity assessment bodies perform, or consultancy services on a commercial or competitive basis.

9. A notifying authority shall safeguard the confidentiality of the information it obtains. However, it shall, upon request, exchange information on notified bodies with the Commission, with notifying authorities of other Member States and with other relevant national authorities.

10. A notifying authority shall take as a basis for notification only the specific conformity assessment body applying for notification and not take account of the capacities or personnel of parent or sister companies. The authority shall assess that body against all relevant requirements and conformity assessment tasks.

11. A notifying authority shall have a sufficient number of competent personnel and sufficient funding at its disposal for the proper performance of its tasks.

*Article 11*

***Information obligation on notifying authorities***

Member States shall inform the Commission of their procedures for the assessment and notification of conformity assessment bodies and the monitoring of notified bodies, and of any changes thereto.

The Commission shall make that information publicly available.

Article *12*

***Requirements relating to notified*** bodies

12. For the purposes of notification, a conformity assessment body shall meet the requirements laid down in paragraphs 2 to 11.

13. A conformity assessment body shall be established under the national law of a Member State and have legal personality.

14. A conformity assessment body shall be a third-party body independent of the organisation or the product it assesses. It shall not have any business ties with organisations that have an interest in the products it assesses, in particular manufacturers, their trade partners and their shareholding investors. This shall not preclude the conformity assessment body from carrying out conformity assessment activities for competing manufacturers.

15. A conformity assessment body, its top-level management and the personnel responsible for carrying out the conformity assessment tasks shall not be the designer, manufacturer, supplier, importer, distributor, installer, purchaser, owner, user or maintainer of the products which they assess, nor the representative of any of those parties. This shall not preclude the use of assessed products that are necessary for the operations of the conformity assessment body or the use of such products for personal purposes.

A conformity assessment body, its top-level management and the personnel responsible for carrying out the conformity assessment tasks shall not be directly involved in the design, manufacture or construction, the marketing, installation, use or maintenance of those products, or represent the parties engaged in those activities. They shall not engage in any activity that may conflict with their independence of judgement or integrity in relation to conformity assessment activities for which they are notified. This shall apply in particular to consultancy services.

Conformity assessment bodies shall ensure that the activities of its parent or sister companies, subsidiaries or subcontractors do not affect the confidentiality, objectivity or impartiality of their conformity assessment activities.

The establishment and the supervision of internal procedures, general policies, codes of conduct or other internal rules, the assignment of personnel to specific tasks and the conformity assessment decisions may not be delegated to a subcontractor or a subsidiary.

16. Conformity assessment bodies and their personnel shall carry out the conformity assessment activities with the highest degree of professional integrity and the requisite technical competence in the specific field. They shall be free from all pressures and inducements, particularly financial, which might influence their judgement or the results of their conformity assessment activities, especially as regards persons or groups of persons with an interest in the results of those activities.

A conformity assessment body shall be capable of carrying out all the conformity assessment tasks assigned to it by Annex V and in relation to which it has been notified, whether those tasks are carried out by the conformity assessment body itself or on its behalf and under its responsibility.

At all times and for each conformity assessment procedure, and for each kind or category of products in relation to which it has been notified, a conformity assessment body shall have at its disposal the necessary:

(g) personnel with technical knowledge, and sufficient and appropriate experience to perform the conformity assessment tasks. Personnel responsible for taking assessment decisions shall be employed by the conformity assessment body under the national law of the notifying Member State, shall not have any other potential conflict of interest, shall be competent to verify the assessments made

by other staff, external experts or subcontractors. The number of such personnel shall be sufficient to ensure business continuity and a consistent approach to conformity assessments;

(h) descriptions of procedures in accordance with which conformity assessment is carried out, ensuring the of these procedures and the ability to reproduce them. This shall include a qualification matrix that matches relevant personnel, their respective status and tasks within the conformity assessment body with the conformity assessment tasks in relation to which the body intends to be notified;

(i) appropriate policies and procedures to distinguish the tasks it carries out as a notified body from other activities;

(j) procedures for the performance of activities, which take due account of the size of an undertaking, the sector in which it operates, its structure, the degree of complexity of the product technology in question and the mass or serial nature of the production process.

It shall have the means necessary to perform the technical and administrative tasks connected with the conformity assessment activities in an appropriate manner and shall have access to all necessary equipment or facilities.

17. The personnel responsible for carrying out conformity assessment activities shall have the following:

(k) sound technical and vocational training covering all the conformity assessment activities in relation to which the conformity assessment body has been notified;

(l) satisfactory knowledge of the requirements of the assessments they carry out and adequate authority to carry out those assessments, including appropriate knowledge and understanding of the relevant legislation, test, measurement and calculation requirements, of the applicable harmonised standards or common specifications and of the relevant provisions of this Regulation;

(m) the ability to draw up certificates, records and reports demonstrating that assessments have been carried out.

18. The impartiality of the conformity assessment bodies and their top-level management and of the assessment personnel shall be guaranteed.

The remuneration of the top-level management and assessment personnel of a conformity assessment body shall not depend on the number of assessments carried out or their results.

19. Conformity assessment bodies shall take out liability insurance unless liability is assumed by the State in accordance with national law, or the Member State itself is directly responsible for the conformity assessment.

The personnel of a conformity assessment body shall observe professional secrecy regarding all information obtained in carrying out the conformity assessment activities in accordance with Annex V, except in relation to the notifying authorities and other national authorities of the Member State in which its activities are carried out. Proprietary rights shall be protected.

20. Conformity assessment bodies shall participate in, or ensure that their assessment personnel are informed about, the relevant standardisation activities and apply as

general guidance the administrative decisions and documents produced as a result of the work of that group.

*Article* 13

***Presumption of conformity of* conformity assessment *bodies***

Where a conformity assessment body demonstrates its conformity with the criteria laid down in the relevant harmonised standards or parts thereof the references of which have been published in the *Official Journal of the European Union* it shall be presumed to comply with the requirements set out in Article 12 in so far as the applicable harmonised standards cover those requirements.

*Article* 14

***Subsidiaries of and subcontracting by notified bodies***

1. Where a notified body subcontracts specific tasks connected with conformity assessment or has recourse to a subsidiary, it shall ensure that the subcontractor or the subsidiary meets the requirements set out in Article 12 and shall inform the notifying authority accordingly.

21. Notified bodies shall take full responsibility for the tasks performed by subcontractors or subsidiaries wherever these are established. The relevant notified bodies shall establish procedures for the on-going monitoring of the competence, activities and performance of its subcontractors or subsidiaries, taking into account the qualification matrix referred to in Article 12(6).

22. Activities may be subcontracted or carried out by a subsidiary only with the agreement of the client.

Notified bodies shall keep at the disposal of the notifying authority the relevant documents concerning the assessment and monitoring of the qualifications of the subcontractor or the subsidiary and the work carried out by them under Annex V.

*Article* 15

***Application for notification***

23. A conformity assessment body shall submit an application for notification to the notifying authority of the Member State in which it is established.

That application shall be accompanied by a description of the conformity assessment activities, the conformity assessment module set out in Annex Vs and the product or products for which that body claims to be competent, the qualification matrix referred to in Article 12(6), as well as by an accreditation certificate, where one exists, issued by a national accreditation body attesting that the conformity assessment body fulfils the requirements laid down in Article 12. The accreditation certificate shall relate only to the precise legal body applying for notification and shall be based, in addition to relevant harmonised standards, on the specific requirements and conformity assessment activities set out in this Regulation, in addition to relevant harmonised standards.

24. Where the conformity assessment body concerned cannot provide an accreditation certificate, it shall provide the notifying authority with all the documentary evidence necessary for the verification, recognition and regular monitoring of its compliance with the requirements laid down in Article 12.

*Article* 16

***Notification procedure***

Notifying authorities only notify conformity assessment bodies which have satisfied the requirements laid down in Article 12.

25. They shall notify the Commission and the other Member States using the electronic notification tool developed and managed by the Commission.

26. The notification shall include full details of the conformity assessment activities, the conformity assessment module or modules and product or products concerned and the relevant attestation of competence.

Where a notification is not based on an accreditation certificate as referred to in Article 15(2), the notifying authority shall provide the Commission and the other Member States with documentary evidence which attests to the conformity assessment body's competence and the arrangements in place to ensure that that body will be monitored regularly and will continue to satisfy the requirements laid down in Article 12.

27. The body concerned may perform the activities of a notified body if the Commission or the other Member States do not raise any objections within 2 weeks of a notification where an accreditation certificate is used, or within 2 months of a notification where accreditation is not used.

Only such a body shall be considered a notified body for the purposes of this Regulation.

28. The notification shall become valid the day after the body is included in the list of notified bodies referred to in Article 16(2) by the Commission. The body concerned may perform the activities of a notified body only after the notification has become valid.

The Commission shall not publish a notification if it is aware or becomes aware that the relevant notified body does not meet the requirements laid down in Article 12.

29. The Commission and the other Member States shall be notified of any subsequent relevant changes to the notification.

*Article* 16

***Identification numbers and lists of notified bodies***

30. The Commission shall assign an identification number to a notified body.

It shall assign a single such number even where the body is notified under several Union acts.

31. The Commission shall make the list of the bodies notified under this Regulation publicly available, including the identification numbers that have been allocated to them and the activities for which they have been notified.

The Commission shall ensure that that list is kept up to date.

*Article* 17

***Changes to notifications***

Where a notifying authority has ascertained or has been informed that a notified body no longer meets the requirements laid down in Article 12 or that it is failing to fulfil its obligations, the notifying authority shall restrict, suspend or withdraw notification as appropriate, depending on the seriousness of the failure to meet those requirements or fulfil those obligations. It shall immediately inform the Commission and the other Member States accordingly.

32. In the event of restriction, suspension or withdrawal of notification, or where the notified body has ceased its activity, the notifying Member State shall take

appropriate steps to ensure that this body's files are either processed by another notified body or kept available for the responsible notifying and market surveillance authorities at their request.

*Article* 18

***Challenge of the competence of notified bodies***

33. The Commission shall investigate all cases where it doubts, or doubt is brought to its attention regarding, the competence of a notified body or the continued fulfilment by a notified body of the requirements and responsibilities to which it is subject.

34. The notifying Member State shall provide the Commission, on request, with all information relating to the basis for the notification or the maintenance of the competence of the body concerned.

35. The Commission shall ensure that all sensitive information obtained in the course of its investigations is treated confidentially.

Where the Commission ascertains that a notified body does not meet or no longer meets the requirements for its notification, it shall inform the notifying Member State accordingly and request it to take the necessary corrective measures, including de-notification if necessary. The notifying Member State shall take the corrective measures requested by the Commission.

*Article 19*

***Operational obligations of notified bodies***

Notified bodies shall carry out conformity assessments in accordance with the conformity assessment procedures set out in Annex V.

36. Conformity assessments shall be carried out in a proportionate manner, avoiding unnecessary burdens for economic operators. Conformity assessment bodies shall perform their activities taking due account of the size of an undertaking, the sector in which it operates, its structure, the degree of complexity of the product technology in question and the mass or serial nature of the production process.

In so doing they shall nevertheless respect the degree of rigour and the level of protection required for the compliance of the product with the relevant requirements.

37. Where a notified body finds that a manufacturer does not meet the relevant requirements or corresponding harmonised standards, common specifications or other technical specifications, it shall require that manufacturer to take appropriate corrective measures in view of a second and final conformity assessment, unless the deficiencies cannot be remedied, in which case it shall not issue a certificate or approval decision.

38. Where, in the course of the monitoring of conformity following the issue of a certificate or approval decision, a notified body finds that a product or the manufacturer does not comply or no longer complies, it shall require the manufacturer to take appropriate corrective measures and shall suspend or withdraw the certificate or approval decision if necessary.

39. Where corrective measures are not taken or do not have the required effect, the notified body shall restrict, suspend or withdraw any certificates or approval decisions, as appropriate.

40. When taking conformity assessment decisions, including when deciding on the need to suspend or withdraw a certificate or approval decisions in light of possible non-compliance, notified bodies shall apply clear and pre-determined criteria.

41. Notified bodies shall ensure rotation among the personnel carrying out different conformity assessment tasks.

Article 20

***Information obligation on notified bodies***

42. Notified bodies shall inform the notifying authority of the following:

(n) any refusal, restriction, suspension or withdrawal of a certificate;

(o) any circumstances affecting the scope of and conditions for notification;

(p) any request for information which they have received from market surveillance authorities regarding conformity assessment activities;

(q) on request, conformity assessment activities performed within the scope of their notification and any other activity performed, including cross-border activities and subcontracting.

43. Notified bodies shall provide the other bodies notified under this Regulation which carry out similar conformity assessment activities that cover the same products with relevant information on issues relating to negative and, on request, positive conformity assessment results.

44. Where the Commission or a Member State's market surveillance authority submits a request to a notified body established on the territory of another Member State relating to a conformity assessment carried out by that notified body, it shall send a copy of that request to the notifying authority of that other Member State. The notified body concerned shall respond without delay and within 15 days at the latest to the request. The notifying authority shall ensure that such requests are resolved by the notified body unless there is a legitimate reason for not doing so.

45. Where notified bodies have or receive evidence that:

(r) another notified body does not comply with the requirements laid down in Article 12 or its obligations; or

(s) a product placed on the market does not comply with ecodesign requirements set out in this Regulation; or

(t) a product placed on the market, due to its physical condition, is likely to cause a serious risk;

they shall alert and share such evidence with the relevant market surveillance or notifying authority, as appropriate.

Article 21

***Exchange of experience***

The Commission shall provide for the organisation of exchange of experience between the Member States' authorities responsible for notification policy.

*Article 22*
*Coordination of notified bodies*

46. The Commission shall ensure that appropriate coordination and cooperation between bodies notified under this Regulation are put in place and properly operated in the form of a group or groups of notified bodies.

47. Notified bodies shall participate in the work of any relevant group, directly or by means of designated representatives.

48. Notified bodies shall apply as general guidance any relevant documents produced as a result of the work of the groups referred to in paragraph 1.

Coordination and cooperation in the groups referred to in paragraph 1 shall aim at ensuring the harmonised application of this Regulation. In doing so, the groups shall follow as general guidance any relevant documents produced by the administrative cooperation group set up pursuant to Article 12 of Directive 2009/125/EC.

# Chapter III
# Final provisions

*Article 23*

***Review***

The Commission shall review this Regulation in the light of technological progress and present the result of this assessment, including, if appropriate, a draft revision proposal, to the Consultation Forum by *[5 years after its entry into force]*.

The review shall in particular assess:

(a) the need to revise the scope definition to reflect market evolution;
(b) the appropriateness to set quantitative ecodesign requirements on the carbon footprint of photovoltaic module technologies covered by information ecodesign requirements on the carbon footprint in the present Regulation

*Article 24*

***Entry into force and application***

This Regulation shall enter into force on the twentieth day following its publication in the Official Journal of the European Union.

It shall apply from xx.yy.zz.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels,

*For the Commission*
*The President*
Ursula VON DER LEYEN

*ANNEX I*

For the purposes of the Annexes the following definitions shall apply:

(2) ‘spare part’ means a separate part that can replace a part with the same or similar function in a product;

(3) ‘part’ means hardware, firmware or software constituent of a product;

(4) ‘professional repairer’ means an operator or undertaking which provides services of repair and professional maintenance of photovoltaic modules or photovoltaic inverters;

(5) ‘declared values’ means the values provided by the manufacturer, importer or authorised representative for the stated, calculated or measured technical parameters in accordance with Article 4, for the verification of compliance by the Member State authorities;

(6) ‘equivalent model’ means a model which has the same technical characteristics relevant for the technical information to be provided, but which is placed on the market or put into service by the same manufacturer, importer or authorised representative as another model with a different model identifier;

**Definitions related to photovoltaic modules:**

(7) ‘Carbon footprint’ means the climate change life cycle impact expressed in kg of $CO_2$eq per kWh generated by a photovoltaic module, calculated in accordance with Annex IV;

(8) ‘Carbon footprint verification’ means the conformity assessment process carried out by a notified body to check whether the carbon footprint calculation has been carried out in compliance with the calculation rules set out in Annex IV and whether information and data used in and resulting from the calculation are reliable, credible and correct;

(9) ‘Disassembly’ means a process whereby a product is taken apart in such a way that it could subsequently be reassembled and made operational;

(10) ‘Detachable’ means capable to be disconnected without damaging the integrity of the equipment/parts;

(11) ‘Energy Efficiency Index’ ($EEI_M$) of a photovoltaic module means the ratio of the DC energy yield delivered by one module ($EY_{M(DC)\_Y1\_c}$) over one year (considered the first year of installation) under a reference climate condition, expressed in kWh, divided by the module area ($A_M$), expressed in $m^2$;

(12) ‘Energy conversion efficiency’ means the ratio of electric power generated by a photovoltaic module per unit area to its incident irradiance as measured under STC;

(13) ‘Monofacial photovoltaic module’ means a photovoltaic module that generates power from only one side of its surface.

(14) ‘Bifacial photovoltaic module’ means a photovoltaic module that generates power from both sides of its surface (front and rear sides).

(15) ‘Bifaciality’ means the ratio between the main characteristics of the rear side and the front side of a bifacial photovoltaic module quantified by specific bifaciality coefficients (the short-circuit current ($\varphi_{Isc}$), the open-circuit voltage ($\varphi_{Voc}$) and the maximum power bifaciality coefficient ($\varphi_{Pmax}$));

(16) ‘Thin film photovoltaic module’ means a photovoltaic module made by depositing of thin layers of photovoltaic materials onto different substrates;

(17) ‘Heterojunction photovoltaic module’ means a photovoltaic module that combines crystalline silicon solar cells with amorphous silicon thin film;

(18) ‘Climatic Specific Energy Rating (CSER)’ means the module performance ratio of the normalized energy collection for the reference climatic profile. The relevant reference climates for Europe are: Subtropical arid, Temperate continental and Temperate coastal;

(19) ‘Lifetime performance degradation’ means the average linear degradation rate expected over a notional service lifetime.

(20) ‘Degradation rate ($\tau_{deg}$, %/year)’ for a photovoltaic module means the annual percentage decrease of the photovoltaic module’s power output, when compared to the initial value.

Further definitions related to the calculation of the carbon footprint of photovoltaic modules are listed in Annex IV.

**Definitions related to photovoltaic inverters:**

(21) ‘Inverter’ means an electric energy converter that changes direct electric current (DC) to single-phase or poly-phase alternating current (AC);

(22) “Inverter with storage” means an inverter that includes battery management system. It could be DC or AC-coupled (integrated in the inverter on the DC or AC side) or generator coupled with own management system;

(23) ‘Euroefficiency’ means the overall efficiency of an inverter over a full year of power distribution of a middle-Europe climate;

(24) ‘Temperature derating effect” means a decrease in the AC energy output and thus in inverter’s efficacy as a result of temperature and working conditions (input power or voltage);

(25) ‘Stand-by power consumption’ means the power consumption, expressed in Watts, when the inverter is on but not converting energy as it is below the start-up input voltage

(26) ‘start-up input voltage’ means the input voltage at which the inverter starts energizing the utility grid;

(27) ‘night-time power consumption’ means the power loss of the inverter, expressed in Watts, which is supplied from the public grid when no solar generator power is present.

*ANNEX II*

**Ecodesign requirements**

**Photovoltaic modules**

From 1 xxx 2023, photovoltaic modules shall meet the following requirements:

1. RESOURCE EFFICIENCY REQUIREMENTS

**1.1 Design for reliability**

Manufacturers, importers or authorised representatives shall ensure that photovoltaic modules are able to withstand prolonged exposure in open-air climates. In particular, photovoltaic modules shall be able to withstand:

i. exposure to outdoor conditions;

ii. hot-spot heating effects;

iii. thermal mismatch, fatigue and other stresses caused by repeated changes of temperature;

iv. the effects of high temperature and humidity followed by sub-zero temperature;

v. the effects of long-term penetration of humidity;

vi. a minimum static load;

vii. the impact of hail.

In addition, the design of photovoltaic modules shall ensure:

viii. adequate insulation, including under wet operating conditions;

ix. robustness of termination;

x. the adequacy of the thermal design;

xi. the long-term reliability of the bypass diodes.

2. CARBON FOOTPRINT REQUIREMENTS

1. From XX/YY/20ZZ, for photovoltaic modules models belonging to one of the categories below:

i. Multicrystalline Silicon photovoltaic modules (multi-Si)

ii. Monocrystalline Silicon photovoltaic modules (mono-Si)

iii. Cadmium-Telluride photovoltaic modules (CdTe)

the declared carbon footprint of photovoltaic modules referred to in point (d) of Part 2.1.4 of this Annex shall not exceed 25 $gCO_2eq/kWh$.

2. From XX/YY/20ZZ, for photovoltaic modules models belonging to one of the categories below:

i. Multicrystalline Silicon photovoltaic modules (multi-Si)

ii. Monocrystalline Silicon photovoltaic modules (mono-Si)

iii. Cadmium-Telluride photovoltaic modules (CdTe)

the declared carbon footprint of photovoltaic modules referred to in point (d) of Part 2.1.4 of this Annex shall not exceed 18 $gCO_2eq/kWh$.

3. From XX/YY/20ZZ, for photovoltaic modules models belonging to one of the categories below:

i. Copper-Indium-Gallium-Selenide photovoltaic modules (CIS / CIGS)

ii. Micromorphous Silicon photovoltaic modules (micro-Si)

a carbon footprint declaration shall be provided.

4. The carbon footprint declaration shall include:

(a) administrative information about the manufacturer

(b) information about the product model for which the declaration applies;

(c) information about the geographic location of the manufacturing facility for which the declaration applies;

(d) the carbon footprint calculated in accordance with the calculation rules laid down in Annex IV and using the calculation tool made available by the Commission for that purpose,

(e) the carbon footprint differentiated per life cycle stage as described in Annex IV;

(f) the reference of the carbon footprint certificate obtained in accordance with Annex V and the identification number of the notified body that has issued it;

(g) a web link to get access to a public version of the study supporting the carbon footprint calculation.

The manufacturer, importer or authorised representative shall ensure that the information referred to under point (d) and (f) is, wherever possible, given on the module itself. If not, it shall accompany the product as placed on the market. In addition, the manufacturer, importer or authorised representative shall ensure that the information referred to under point (d) and (f):

- is provided on a free access website;
- is printed on the packaging of the product;
- in case of distance selling or sale though the internet, it is clearly visible;
- is included in any promotional material or visual advertisement concerning the relevant product model.

3. INFORMATION REQUIREMENTS

User and installer instructions shall be provided in the form of a user manual on a free access website of the manufacturer, importer or authorised representative, and shall include:

(a) manufacturer's name, registered trade name and registered trade address at which they can be contacted;

(b) product model number;

(c) year of manufacture;

(d) the $EEI_M$ under 'temperate coastal', 'temperate continental' and 'subtropical arid' climate conditions, expressed in $kWh/m^2$ and rounded to the unit;

(e) lifetime performance degradation rate, expressed in % and rounded to the second decimal place;

(f) information on how to access and replace the bypass diodes in the junction box;

(g) information on how to replace the whole junction box of the module;

(h) information on how to separate and recover the semiconductor from the frame, glass, encapsulants and backsheet;

(i) information on the feasibility of clean separation without breakage of the glass, contacts and internal layers during the dismantling operations at the end of life shall be detailed.

(j) results of the test on the capability to withstand prolonged exposure in open-air climates;

(k) indicative weight range of the following critical raw materials and environmentally relevant materials :

- Cadmium (weight range: less than 2 g, between 2 g and 20 g, above 20 g)
- Silicon metal (weight range: less than 2 g, between 2 g and 10 g, above 10 g)
- Silver (weight range: less than 2 g, between 2 g and 10 g, above 10 g)
- Indium (weight range: less than 2 g, between 2 g and 10 g, above 10 g)
- Gallium (weight range: less than 2 g, between 2 g and 10 g, above 10 g)
- Tellurium (weight range: less than 5 g, between 5 g and 20 g, above 20 g)
- Lead (weight range: less than 5 g, between 5 g and 20 g, above 20 g)
- Metal solder and contacts (weight range: less than 2 g, between 2 g and 10 g, above 10 g)
- Glass fining agents (weight range: less than 2 g, between 2 g and 10 g, above 10 g)
- Phthalates in power cables (weight range: less than 2 g, between 2 g and 10 g, above 10 g)

(l) Weight, expressed in grams, and type of polymers used, including whether it is fluorinated or contains fluorinated additives, for the encapsulant and backsheet

**Photovoltaic inverters**

From 1 xxx 2023, photovoltaic inverters shall meet the following requirements:

4. RESOURCE EFFICIENCY REQUIREMENTS

**4.1. Design for repair**

(1) availability of spare parts:

(1) manufacturers, importers or authorised representatives shall make available to professional repairers at least those proprietary and specificaly designed components as spare parts for a minimum period from 6 months after placing the first unit of a model on the market until fifteen years after placing the last unit of the model on the market, when present:

- Inductor(s)
- Transformers
- Power supply/ section boards
- Control board, which includes the main microprocessor(s).

(2) Power supply manufacturers, importers or authorised representatives shall make available to professional repairers the technical characteristics of at least the following components, when present:

- Power semiconductors: Transistor(s), diode(s),
- Safe and protection components: fuses, relays, varistors or other voltage supresor devices, X and Y capacitors.
- Capacitor(s) – electrolytic capacitors with short life time (<10000 hours)
- Input/Output connectors
- Power supply when not proprietary designed

(3) the list of spare parts concerned by point (a) and the procedure for ordering them shall be publicly available on the free access website of the manufacturer, importer or authorised representative, from 6 months after placing the first unit of a model on the market and until the end of the period of availability of these spare parts;

(2) access to repair and maintenance information

From 6 months after placing on the market the first unit of a model and until seven years after placing the last unit of the model on the market, the manufacturer, importer or authorised representative shall provide access to repair and maintenance information to professional repairers for parts concerned by point 1(a) in the following conditions:

(a) the manufacturer's, importer's or authorised representative's website shall indicate the process for professional repairers to register for access to information; to accept such a request, the manufacturers, importers or authorised representatives may require the professional repairer to demonstrate that:

(i) the professional repairer has the technical competence to repair photovoltaic inverters and complies with the applicable regulations for repairers of electrical equipment in the Member States where it operates. Reference to an official registration system as professional repairer,

where such system exists in the Member States concerned, shall be accepted as proof of compliance with this point;

(ii) the professional repairer is covered by insurance covering liabilities resulting from its activity regardless of whether this is required by the Member State;

(b) manufacturers, importers or authorised representatives shall accept or refuse the registration within 5 working days from the date of request;

(c) manufacturers, importers or authorised representatives may charge reasonable and proportionate fees for access to the repair and maintenance information or for receiving regular updates. A fee is reasonable if it does not discourage access by failing to take into account the extent to which the professional repairer uses the information;

(d) once registered, a professional repairer shall have access, within one working day after requesting it, to the requested repair and maintenance information. The information may be provided for an equivalent model or model of the same family, if relevant;

(e) the repair and maintenance information referred to in (a) shall include:

i. the unequivocal photovoltaic inverter identification information;

ii. a disassembly map or exploded view;

iii. technical manual of instructions for repair;

iv. a list of necessary repair and test equipment;

v. component and diagnosis information (such as minimum and maximum theoretical values for measurement);

vi. wiring and connection diagrams;

vii. diagnostic fault and error codes (including manufacturer-specific codes where applicable);

viii. instructions for installation of relevant software and firmware including reset software; and

ix. information on how to access data records of reported failure incidents stored on the device (where applicable).

(3) maximum delivery time of spare parts

(a) During the period mentioned under point 1(a) the manufacturers, importers or authorised representatives shall ensure the delivery of the spare parts within 5 working days after having received the order.

(b) in the case of spare parts concerned by point 1(a) the availability of spare parts may be limited to professional repairers registered in accordance with point 2 (a) and (b);

(4) disassembly requirements

Manufacturers, importers or authorised representatives meet the following disassembly requirements:

(a) for photovoltaic inverters of nominal power lower than 30kW, manufacturers, importers or authorised representatives shall ensure that the repairing operations meet the following criteria:

- Fasteners and connectors shall be reusable;
- Repairs shall be feasible either without the use of tools, with a tool or set of tools that is supplied with the product or spare part, or with basic tools;
- Repairs shall be feasible at least in the use environment;
- Repairs shall not require a higher skill level than 'Generalist'.

(b) for photovoltaic inverters of nominal power equal to or higher than 30kW, manufacturers, importers or authorised representatives shall ensure that the repairing operations meet the following criteria:

- Fasteners and connectors shall be reusable;
- Repairs shall at least be feasible with product specific tools;
- Repairs shall be feasible at least in a workshop environment
- Repairs shall not require a higher skill level than 'Expert'.

(5) Control board

(a) Manufacturers, importers or authorised representatives shall ensure that the control board is detachable and replaceable;

(b) At the end of the reparations, the control board shall be able to communicate with the rest of sections (communications, power components etc.)

**4.2 Design for reliability**

4.2.1. Manufacturers, importers or authorised representatives shall ensure that photovoltaic inverters are capable to withstand prolonged exposure in open-air climates. In particular, photovoltaic modules shall be able to withstand:

i. exposure to outdoor conditions;
ii. mechanical impacts;
iii. the penetration of dust, water and foreign bodies;
iv. vibrations during shipping;
v. shocks from handling;
vi. exposure to ultra-violet radiation;
vii. thermal mismatch, fatigue and other stresses caused by repeated changes of temperature;
viii. the effects of high temperature and humidity followed by sub-zero temperature;
ix. the effects of long-term penetration of humidity; and
x. conditions of high humidity when combined with cyclic temperature changes.

In addition, the design of photovoltaic inverters shall ensure:

(a) adequate insulation; and

(b) robustness of terminals.

## 5. ENERGY EFFICIENCY REQUIREMENTS

### 5.1. Euroefficiency and minimum system efficiency

(1) the euroefficiency of photovoltaic inverters, except for photovoltaic inverters with possibility to connect storage or with integrated storage, shall not be less than 96%;

(2) the minimum system efficiency of photovoltaic inverters with possibility to connect storage or with integrated storage, shall not be less than 90% at 25% of nominal power.

### 5.2 Design for smart readiness

5.2.1. Manufacturers, importers or authorised representatives shall ensure that:

i. photovoltaic inverters have physical and/or wireless connectivity and are capable of communicating with other devices using an open standard data transfer protocol;

ii. photovoltaic inverters are capable of communicating with the distribution networks and have cybersecurity capabilities for data transfer authentication, authenticated-only access, prevention of eavesdropping, prevention of playback and spoofing, and intrusion detection.

iii. photovoltaic inverters are provided with external monitoring of AC electrical output with a sampling interval of 1 minute or less;

iv. photovoltaic inverters intended to be used in large-scale photovoltaic systems with power higher than 40MW shall support the following data monitoring systems:

- basic system performance assessment, with medium accuracy
- documentation of a performance guarantee, with medium accuracy
- system losses analysis, with medium accuracy.

## 6. INFORMATION REQUIREMENTS

User and installer instructions shall be provided in the form of a user manual on a free access website of the manufacturer, importer or authorised representative, and shall include:

(a) manufacturer's name, registered trade name and registered trade address at which they can be contacted;

(b) product model number;

(c) year of manufacture;

(d) euroefficiency, expressed in % and rounded to the first decimal place;

(e) system efficiency at 25% of nominal power, expressed in % and rounded to the first decimal place, for photovoltaic inverters with possibility to connect storage or with integrated storage;

(f) tabulated values for each of the partial MPP power levels;

(m) tabulated values for temperature derating;

(n) information on cybersecurity and demand response management capabilities;

(o) results of the test on the capability to withstand prolonged exposure in open-air climates;

(p) stand-by power consumption, expressed in Watts and rounded to the second decimal place;

(q) night-time power consumption, expressed in Watts and rounded to the second decimal place;

(r) indicative weight of the following critical raw materials and environmentally relevant materials:

- Cadmium
- Lead
- Silicon carbide
- Silver
- Indium
- Gallium
- Tantalum
- Metal solder and contacts
- Glass fining agents
- Phthalates in power cables.

*ANNEX III*

**Measurements and calculations**

1. For the purposes of compliance and verification of compliance with the requirements of this Regulation, measurements and calculations shall be made using harmonised standards, or other reliable, accurate and reproducible methods, which take into account the generally recognised state-of-the-art methods and are in line with the provisions set out below. The reference numbers of these harmonised standards have been published for this purpose in the Official Journal of the European Union.

2. Where a parameter is declared pursuant to Article 4, its declared value shall be used by the manufacturer, importer or authorised representative for the calculations in this Annex.

3. In the absence of existing relevant standards and until the publication of the references of the relevant harmonised standards in the Official Journal, the transitional testing methods set out in Annex IIIa or other reliable, accurate and reproducible methods, which take into account the generally recognised state-of-the-art, shall be used.

## 4. Measurements and calculations methods for photovoltaic modules

### 4.1 Energy efficiency index ($EEI_M$)

The $EEI_M$ is expressed in kWh/m$^2$ and calculated as follows for each of the three European reference climatic conditions 'temperate coastal', 'temperate continental' and 'subtropical arid':

$$EEI_{M\_c} = {EY_{M(DC)\,Y1\,c}}/{A_M}$$

Where:

- $EY_{M(DC)\_Y1\_c}$ is the DC energy yield from one photovoltaic module over one year under the climatic conditions in the reference climate *c*, assuming no degradation or losses, expressed in kWh.
- $A_M$ is the area of the photovoltaic module expressed in m$^2$.

The photovoltaic module is assumed ground-mounted on a fixed-open rack facing the equator with an inclination angle of 20º. Degradation and other losses due to soiling or shadows from surrounding obstacles are not considered. Ground albedo is not considered for monofacial PV modules.

Photovoltaic modules containing micro-inverters integrated/embedded shall be tested before the integration occurs.

### *4.2 Calculation of the DC energy yield*

#### *Calculation of the DC energy yield of monofacial photovoltaic modules*

For monofacial PV modules, the yearly DC energy yield ($EY_{M(DC)\_Y1}$, kWh) shall be calculated using the input data:

a. Matrix of Pmax versus irradiance (at AM1.5g) and versus module temperature which may be interpolated to obtain the instantaneous power at a given irradiance

and module temperature. For linear modules, Pmax dependence on irradiance and on temperature are independent.

b. Thermal coefficients $u_0$, $u_1$ describing module operating temperature as a function of irradiance, ambient temperature and wind speed, which are used to calculate instantaneous module temperature.
c. Angle of incidence response $a_r$ used to calculate the effective light transmission into the module at different incident angles.
d. Spectral responsivity, used to calculate spectral mismatch and hence to correct reference spectral conditions.
e. Standard reference climatic profiles for the reference climatic conditions relevant to Europe defined as 'Subtropical arid', 'Temperate continental' and 'Temperate coastal'.

where Pmax is the DC power output of a module under standard testing conditions (air mass 1.5g spectrum, 1000 W/m2, 25°C).

The method does not include degradation or other losses other than those due to angle of incidence effect, spectral response or module efficiency dependence on irradiance and temperature. or degradation.

The DC energy yield of the module over its first year of installation $EY_{M(DC)\_Y1}$ is calculated according:

$$EY_{M(DC)\,Y1} = \sum_{j=1}^{j=8760} EY_{M,j}$$

Where

j ranges from 1 to 8760 in the reference period (one year)

$EY_{M,j}$ (kWh) is the energy output of the module in the period j (1h) and it calculated as:

$$EY_{M,j} = P_{M,j} \cdot \left(G_{corr,j}, T_{M,j}\right) \cdot 1\ hour$$

$P_{M,j}$ is the module power output for $j^{th}$ hour (W)

$G_{corr,j}$ is the corrected global in-plane irradiance for $j^{th}$ hour (W/m$^2$)

$T_{M,j}$ is the module temperature for $j^{th}$ hour ($^{\circ}$C)

The $EY_{M(DC)\_Y1}$ is one of the outputs along with the CSER (Climate Specific Energy Rating). Both are related as follows:

$$CSER = \frac{EY_{M(DC)Y1} \cdot G_{ref}}{P_{max,STC} \cdot H_p}$$

Where:

$G_{ref}$ is 1000 W/m$^2$, the irradiance used to measure the $P_{max,STC}$ which is the maximum power output of the PV module under STC conditions.

$H_p$ is the yearly total global in-plane irradiation, expressed in kWh/m$^2$ for the reference climatic conditions.

***Calculation method of the energy yield of bifacial photovoltaic modules***

Bifaciality is quantified with reference to bifaciality coefficients, for the short-circuit current ($\varphi_{Isc}$), the open-circuit voltage ($\varphi_{Voc}$) and the maximum power bifaciality coefficient ($\varphi_{Pmax}$), defined as:

$$\varphi_{Pmax}(\%) = \frac{P_{max\ Rear}}{P_{\max Front}} \cdot 100$$

Where:

Pmax $_{Rear}$ and Pmax $_{Front}$ are the module output power measured of rear and the front side at STC.

***[A calculation method of the energy yield of bifacial photovoltaic modules will be added]***

### 4.3 DC total energy yield over the service life

For monofacial PV modules, the DC total energy yield over the service life ($EY_{M(DC)\_LT}$), shall be calculated from the yearly DC energy yield ($EY_{M(DC)\_Y1}$, kWh), by considering 30 years of service life ($T_{LT}$) and factoring in the degradation rate ($\tau_{deg\ M}$, %/year).

$$EY_{M(DC)\ LT} = EY_{M(DC)\ Y1} \cdot T_{LT} \cdot \left(1 - \tau_{\deg M} \cdot \left({}^{T_{LT}}/_{2}\right)\right)$$

Where:

- $EY_{M(DC)\_Y1}$ is the DC energy yield delivered by one PV module over the first year of installation under the applicable reference climate conditions, expressed in kWh.
- $T_{LT}$ is lifetime of the PV module, which is assumed as 30 years.
- $\tau_{deg\_M}$ is the PV module lifetime performance degradation rate, expressed here in decimal format. A degradation rate of 1% should be applied here as 0.01.

## 5. Measurements and calculations methods for photovoltaic inverters

### 5.1 AC ENERGY YIELD OF INVERTERS ($EY_{AC}$)

The annual AC energy yield ($EY_{AC}$) from a reference photovoltaic array under predefined climatic and installation conditions is estimated from the annual DC energy yield ($EY_{DC}$) over the same time period and the inverter's Euroefficiency ($\mu_{Euro}$) in several steps:

*Step 1. DC energy yield ($EY_{DC}$)*

The DC energy yield *($EY_{DC}$)* from a reference 1kWp PV module array mounted in a free-standing rack, with an inclination angle of 20° and facing the equator, over a year (kWh/year) for specific climate profile is calculated according to:

$$EY_{DC} = \frac{CSER \cdot P_{max} \cdot H_p}{G_{ref}}$$

Where:

*CSER* is Climate Specific Energy Rating parameter (*CSER*) calculated according to:

$$CSER = \frac{EY_{DC} \cdot G_{ref}}{P_{max} \cdot H_p}$$

$EY_{DC}$ is the DC energy output (energy yield) from the 1 kWp installed PV array, calculated on hourly basis over a year (first year of installation) expressed in kWh.

$G_{ref}$ is the STC irradiance (1000 $Wm^{-2}$)

$P_{max}$ is the maximum power of the PV module under consideration as stated in the datasheet

$H_p$ is the yearly global in-plane irradiation received by the plane of array ($kWh \cdot m^{-2} \cdot year^{-1}$) for the three European reference climatic conditions.

*Step 2. Euroefficiency*

The European efficiency or Euroefficiency ($\mu_{Euro}$) is an averaged operating efficiency over a yearly power distribution corresponding to middle-Europe climate. It is present at almost any inverter's datasheet. It could be also calculated by the sum of weighted efficiencies obtained by assigning a percentage of time the inverter resides in a given operating range.

$$\text{European efficiency } (\mu_{Euro}) = 0.03 \times \mu\ 5\% + 0.06 \times \mu\ 10\% + 0.13 \times \mu\ 20\% + 0.1 \times \mu\ 30\% + 0.48 \times \mu\ 50\% + 0.2 \times \mu\ 100\%$$

Where:

$\mu_{Euro}$ is expressed in decimal format (%)

$\mu$ i% is the static MPPT efficiency at partial MPP power MPP_i (MPP power normalized to rated DC power)

*Step.3 AC energy yield of inverter ($EY_{AC}$)*

AC energy yield ($EY_{AC\_c}$) from a reference PV system over the period of a year for the different reference climatic conditions ( 'temperate coastal', 'temperate continental' or 'subtropical arid') can be estimated as the product of the DC energy yield for the relevant climatic condition ($EY_{DC\_c}$) and the Euroefficiency of the inverter:

$$EY_{AC\ c} = EY_{CD\ c} \cdot \mu_{Euro}$$

Where:

$EY_{DC\ c}$ is a yearly DC energy output (energy yield) for the reference climatic conditions c expressed in kWh/year per installed kWp.

$\mu_{Euro}$ is the inverter's Euroefficiency expressed in the equation in decimal format (A Euroefficiency of 97% would be used here as 0.97).

## *ANNEX IIIa*

## Transitional Methods

*Table 1*

**References and qualifying notes for photovoltaic modules**

| Parameter | Source | Reference Test Method | Notes |
|---|---|---|---|
| Electrical performance at standard test conditions | CENELEC | EN IEC 60904-1 | |
| Energy conversion efficiency | CENELEC | EN IEC 60904-1 | Ratio between the maximum power at STC and the module area |
| Energy yield DC | CENELEC | EN 61853-1<br>EN 61853-2<br>EN IEC 61853-3<br>EN IEC 61853-4 | Year zero excluding degradation, for each of the three climate zones defined in EN IEC 61853-4 that best represent the European climatic conditions (Subtropical arid, Temperate continental and Temperate coastal). *Modules with inseparable AC integrated inverters are not considered here.* |
| Reference climatic conditions | | EN IEC 61853-4 | The relevant reference climates for Europe are: Subtropical arid, Temperate continental and Temperate coastal |
| Bifaciality coefficient | | IEC TS 60904-1-2 | |
| Ability of the module to withstand prolonged exposure in open-air climates | CENELEC | EN IEC 61215:2021 series | The series contains subparts, each of which relates to specific requirements for different PV technologies |
| Critical raw material (CRM) content | | EN 45558:2019 | |

*Table 2*

**References and qualifying notes for photovoltaic inverters**

| Parameter | Source | Reference Test Method | Notes |
|---|---|---|---|
| Euroefficiency | CENELEC | EN 50530:2010/A1: 2013 | Overall efficiency of grid connected photovoltaic inverters. For inverters with built in or dedicated batteries and connection/software, the value corresponds to performance with a fully charged battery. |

| Parameter | Source | Reference Test Method | Notes |
|---|---|---|---|
| | | | Report resulting efficiency for each of the partial MPP power levels used in formula D.1 for the calculation of the Euroefficiency |
| Efficiency curve for PV inverters with possibility to connect storage or with integrated storage | Bundesverband Energiespeicher (Germany) | Guideline for PV Storage Systems 2.0 / Effizienzleitfaden für PV-Speichersysteme 2.0, 2019 | German and English versions available at https://www.bves.de/effizienzleitfaden_2/ |
| Temperature derating factor | CENELEC | EN 50524:2009 | Efficiency dependency on inverter's temperature. **Detailed tabulated for temperature derating information should be provided**. EN 50524:2009 will be superseded by prEN50524. |
| Critical Raw Material Content | | EN 45558:2019 | Specifies the procedure, content, and form relating to material declarations for products and accessories of organizations operating in and supplying to the electro technical industry. |
| Smart readiness | IEC | IEC 61724-1:2017 ED1 | Class C data monitoring |
| Connectivity | CENELEC | EN IEC 61158 | Connectivity with other devices |
| Communication with distribution networks | CENELEC | 50549 | |
| Disassembly requirements | CEN | EN 45554:2020 | Fasteners and connectors: please refer to Table A.1<br>Tools: please refer to Table A.2<br>Working environment: please refer to Table A.4<br>Skill level: please refer to Table A.5 |
| Ability of the inverter to withstand prolonged exposure in open-air climates | CENELEC | EN IEC 62093:2005 | |

*ANNEX IV*

**Harmonised rules for the calculation of the carbon footprint of photovoltaic modules**

## Part 1 – Harmonised calculation rules

1. Definitions

For the purposes of this Annex, the following definitions shall apply:

(a) ‘Activity data’ means the information associated with processes while modelling Life Cycle Inventories (LCI). The aggregated LCI results of the process chains that represent the activities of a process are each multiplied by the corresponding activity data and then combined to derive the carbon footprint associated with that process;

(b) ‘Aggregated dataset’ this term is defined as a life cycle inventory of multiple unit processes (e.g. material or energy production) or life cycle stages (cradle-to-gate), but for which the inputs and outputs are provided only at the aggregated level. Aggregated datasets are also called "LCI results", “cumulative inventory” or “system processes” datasets

(c) ‘Bill of materials’ means list of the materials, sub-assemblies, intermediate assemblies, sub-components, parts and the quantities of each needed to manufacture the product in scope of the study;

(d) ‘carbon footprint’ (CF) means the sum of greenhouse gas (GHG) emissions and GHG removals in a product system, expressed as carbon dioxide ($CO_2$) equivalents and based on a Product Environmental Footprint[7] (PEF) study using the single impact category of climate change ;

(e) ‘Company-specific data’ refers to directly measured or collected data from one or multiple facilities (site-specific data) that are representative for the activities of the company. It is synonymous to 'primary data';

(f) ‘Functional unit’ means the qualitative and quantitative aspects of the function(s) and/or service(s) provided by the product being evaluated;

(g) ‘Life cycle’ means the consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal;

(h) ‘Life cycle inventory (LCI)’ means the combined set of exchanges of elementary, waste and product flows in a LCI dataset;

(i) ‘Life cycle inventory (LCI) dataset’ means a document or file with life cycle information of a specified product or other reference (e.g., site, process), covering descriptive metadata and quantitative life cycle inventory. A LCI dataset could be a unit process dataset, partially disaggregated or an aggregated dataset;

(j) ‘Partially disaggregated dataset’ a dataset with a LCI that contains elementary flows and activity data, and that only in combination with its complementing underlying datasets yield a complete aggregated LCI data set

(k) ‘Reference flow’ means the measure of the outputs from processes in a given product system required to fulfil the function expressed by the functional unit;

[7] https://ec.europa.eu/environment/publications/recommendation-use-environmental-footprint-methods

(l) ‘Secondary data’ means data not from a specific process within the supply-chain of the company performing a carbon footprint study. This refers to data that is not directly collected, measured, or estimated by the company, but sourced from a third party LCI database or other sources. Secondary data includes industry average data (e.g., from published production data, government statistics, and industry associations), literature studies, engineering studies and patents, and may also be based on financial data, and contain proxy data, and other generic data;

(m) ‘System boundary’ means the aspects included or excluded from the life cycle study;

(n) ‘Circular Footprint Formula’ (CFF) describes how burdens and benefits from disposal and recovery of the product or service assessed as well as use of secondary materials (i.e. recycled content) into that product or service are allocated to the system under study;

(o) ‘Data Needs Matrix’ (DNM) describes the requirements for the use of company specific data and secondary data, depending on the level of influence the applicant has on the processes along the value chain;

(p) ‘Manufacturer’ producer of the PV modules;

(q) ‘Unit process’ is the smallest element considered in the LCI for which input and output data are quantified (based on ISO 14040:2006);

(r) ‘Tracking system’ (electricity) System applying the process of assigning electricity generation attributes to electricity consumption

(s) ‘Regional storage’ physical place, located in the EU, where PV panels are stored before they are transported to the place of installation

2. Scope

This Annex provides harmonised rules on how to calculate the carbon footprint of photovoltaic modules. It also applies to bifacial photovoltaic modules.

The calculation of the carbon footprint shall be based on the bill of material, the energy, and auxiliary materials used to produce a specific photovoltaic module model. In particular, the photovoltaic cells, the glass, the frame materials and the electronic components (e.g. junction boxes, cabling) have to be accurately identified, for the specific product odel, as they may become a relevant contributor to the carbon footprint of a photovoltaic module.

The bill of materials shall be based on company-specific data for the specific product model that cover a time period of at least one year (12 months). If 12 month data are not available, shorter periods and/or product design and pilot scale data may be used. In the latter situation, the carbon footprint calculation shall be updated once data covering 12 month production become available.

The material losses during module manufacturing shall be taken into account.

If the photovoltaic module is supplied without frame, and the photovoltaic module does not require any frame for being installed, no frame shall be accounted in the carbon footprint calculation.

3. Functional unit and reference flow

The functional unit is defined as one kWh (kilowatt-hour) of the total DC electric energy generated over a photovoltaic module's service life. The total DC electric energy generated over a module's service life is calculated according to Annex III, point 4.3.

The reference flow is the amount of product needed to fulfil the defined function and shall be measured in $m^2$ of photovoltaic module per kWh of the total energy required by the application over its service life. All quantitative input and output data collected by the manufacturer to quantify the carbon footprint shall be calculated in relation to this reference flow.

4. System boundary

The following life cycle stages and processes of the PV modules shall be included in the system boundary:

| LIFE CYCLE STAGE | SHORT DESCRIPTION OF THE PROCESSES INCLUDED |
|---|---|
| **RAW MATERIAL ACQUISITION, PRE-PROCESSING AND MODULE MANUFACTURING** | Includes mining and pre-processing, up to the manufacturing of silicon ingot, wafers, photovoltaic cells and the supply chain of electric/electronic components and other components such glass, silver, frame and encapsulant materials.<br><br>Assembly of photovoltaic cells and assembly of modules with the frame (in case) and the electric/electronic components. |
| **DISTRIBUTION** | Transportation of PV modules from manufacturing plants to a regional storage located in the EU (to be identified and justified). |

Manufacturing of equipment (capital goods) for modules assembly and recycling shall be excluded from the assessment.

All other processes belonging to the subsequent life cycle stages, i.e., assembly of the system, use and disposal, dismantling and recycling of the photovoltaic modules, shall be excluded from the lifecycle calculations. Benefits and burdens of recycling are considered in the application of the CFF to the module production.

The manufacturing of photovoltaic modules shall cover raw material extraction to wafer, cell and module production in case of crystalline silicon modules, the supply chain of semiconductors (micromorphous silicon, cadmium sulphide, cadmium telluride, gallium and other materials used in thin film technologies) in case of thin film modules, and the supply chain of carrier and connection materials (such as glass, silver, junction box and frame) in case of all modules. A more detailed depiction of the supply chain of mono-Si, multi-Si, micro-Si, CdTe and CIS / CIGS PV modules is shown in Fig. 1 and Fig. 2.

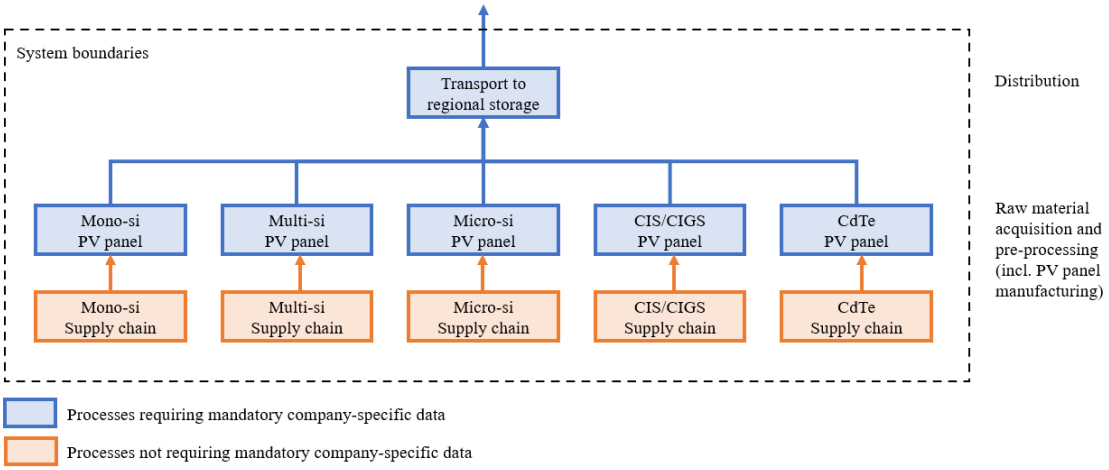


**Figure 1 – System diagram for the PV technologies included in scope. The supply chain of the individual PV technologies is shown in more detail in Fig. 2.**

**Figure 2 – Excerpt of the supply chain for the PV technologies included in scope.**

According to this Annex, no cut-off is applicable to the processes involved in the system diagrams of Fig. 1 and 2, beyond the capital goods identified above.

5. Use of company specific data and secondary datasets

The manufacturer shall use company specific data for the processes listed in table 1A and further detailed in Part 2 of this Annex.

**Table 1A – List of processes for which the use of company-specific data is mandatory.**

| Technology | Life cycle stage | Process |
|---|---|---|
| Cadmium-Telluride PV modules | Raw materials acquisition, pre-processing and PV module manufacturing | Photovoltaic laminate, CdTe, at plant |
| | Distribution | Photovoltaic laminate, CdTe, at regional storage |
| Copper-Indium-Gallium-Selenide PV modules | Raw materials acquisition, pre-processing and PV module manufacturing | Photovoltaic laminate, CIS, at plant |
| | Raw materials acquisition, pre-processing and PV module manufacturing | Photovoltaic panel, CIS, at plant |
| | Distribution | Photovoltaic panel, CIS, at regional storage |
| Micromorphous Silicon PV modules | Raw materials acquisition, pre-processing and PV module manufacturing | Photovoltaic panel, micro-Si, at plant |
| | Distribution | Photovoltaic panel, micro-Si, at regional storage |
| Multicrystalline Silicon PV modules | Raw materials acquisition, pre-processing and PV module manufacturing | Photovoltaic cell, multi-Si, at plant |
| | Raw materials acquisition, pre-processing and PV module manufacturing | Photovoltaic panel, multi-Si, at plant |
| | Distribution | Photovoltaic panel, multi-Si, at regional storage |
| Monocrystalline Silicon PV modules | Raw materials acquisition, pre-processing and PV module manufacturing | Photovoltaic cell, mono-Si, at plant |
| | Raw materials acquisition, pre-processing and PV module manufacturing | Photovoltaic panel, mono-Si, at plant |
| | Distribution | Photovoltaic panel, mono-Si, at regional storage |

The activity data to be collected and the default secondary datasets to be used for each process are listed in the spreadsheet named "CF_Annex_PV_modules-Life_cycle_inventory"[8].

[8] https://ec.europa.eu/docsroom/documents/46532

If the applicant has access to company specific data for other processes along the supply chain (e.g. electricity mix for silicon wafer production), the applicant may use such data following the rules of the Data Needs Matrix (see section 7). Where company specific data is used to claim a lower carbon intensity for raw material or intermediate products used (e.g. silicon ingots), the corresponding data shall be compliant with the Product Environmental Footprint method.

6. Life cycle stages

**Raw material acquisition, pre-processing and module manufacturing**

This life cycle stage includes raw material acquisition and pre-processing, as well as the manufacturing of the photovoltaic modules. The supply chain of the modules shall include the production of the modules, the cells and wafers (if applicable) and the supply chain of the materials required in the module and in manufacturing (such as working materials and process gases, energy carriers), including raw material extraction and refining towards the directly employed material. The supply chain of the frame (if applicable), shall similarly include raw material extraction and refining.

The processes taking place in the life cycle stage raw material acquisition and pre-processing, the inputs and outputs as well as the default datasets to be used are listed in the file named "CF_Annex_PV_modules-Life_cycle_inventory[8]", sheet "Raw-Materials&Pre-Processing". Processes that are expected to be run by the company are written in capital letters (see column A in the spreadsheet).

<u>Transport of raw materials and intermediate products</u>

Transport of raw materials and intermediate products to the production site shall be included in this life-cycle stage.

Table 2B shows the default transport distances by train and lorry (lorry >32 t, EURO 4) for some frequently used raw materials and intermediate products. These default values may also be used to estimate default transport distances for similar products required in the supply chain of PV modules. The default transport distances shown in Table 2B shall be used in case company-specific information is not available. For transports by lorry, a default utilization ratio of 64 % shall be used if specific data are not available. This utilization ratio includes empty return trips.

For suppliers located outside Europe, the default transport scenario described in the file named "CF_Annex_PV_modules-Life_cycle_inventory[8]", sheet Transport-Scenarios should be used. This scenario includes the transport of raw materials or intermediate products between the harbour or airport and the factories in and outside Europe, which is estimated to 1'000 km by lorry (>32 t, EURO 4). The intercontinental transport to Europe occurs either by transoceanic container ship (18'000 km) or by cargo airplane (10'000 km). If the location of the supplier is known, specific data may be used to calculate the transport distances and modelling the applicable transport modes to the production site.

Air cargo shipping of semi-finished products such as wafers and cells shall be included according to its share in supply logistics in a three years period.

**Table 2B – Default distances for transport of raw materials and intermediate products**

| | Density [kg/m3] | consumption in Europe | |
|---|---|---|---|
| | | km train | km lorry 32t |
| ***mineral products*** | | | |
| gravel/sand | 2000 | - | 50 |
| ***metals*** | | | |
| steel/cast iron | 7900 | 200 | 100 |
| copper | 8900 | 200 | 100 |
| aluminium | 2700 | 200 | 100 |
| ***plastics*** | | | |
| PVC | 1400 | 200 | 100 |
| PE | 950 | 200 | 100 |
| PP | 900 | 200 | 100 |
| ***wood products*** | | | |
| particle board | 680 | 200 | 50 |
| ***basic chemicals, inorganic (carrier substance to be considered additionally)*** | | | |
| caustic soda | 1045 | 600 | 100 |
| soda (sodium carbonate | 2532 | 600 | 100 |
| hydrochloric acid | 909 | 200 | 100 |
| sulphuric acid | 1840 | 600 | 100 |
| nitric acid | 1383 | 600 | 100 |
| phosphoric acid | 1685 | 600 | 100 |
| hydrofluoric acid | 993 | 600 | 100 |
| ***Basic chemicals, organic*** | | | |
| ethylene | | 600 | 100 |
| naphta | | 600 | 100 |
| refrigerants | | 600 | 100 |
| organ. Solvents | | 600 | 100 |
| ***gases (if not produced on the spot) if bought in cylinders: doubling of transport distances (due to tare weight)*** | | | |
| oxygen | | 100 | 50 |
| nitrogen | | 100 | 50 |
| hydrogen | | 100 | 50 |
| helium | | 100 | 50 |



Packaging materials

The use and disposal of packaging materials shall be considered for the entire product system and modelled as part of the raw material acquisition stage. The raw material consumption of reusable packaging shall be calculated by dividing the actual weight of the packaging by the reuse rate. The reuse rate affects the quantity of transport that is needed per functional unit. The transport impact shall be calculated by dividing the one-way trip impact by the number of times this packaging is reused.

For reusable packaging, the default reuse rates provided below shall be used, unless data of better quality are available:

- Plastic pallets: 50 trips
- Wooden pallets: 25 trips

Modelling recycled content and materials recycling

The recycled content of materials used in PV modules as well as their recycling potential at the end-of-life shall be modelled according to the following formula:

$$(1 - R_1) \cdot E_v + R_1 \cdot \left( AE_{recycled} + (1 - A) \cdot E_v \cdot \frac{Q_{Sin}}{Q_p} \right) + (1 - A) \cdot R_2 \cdot \left( E_{recyclingEoL} - E_v^* \cdot \frac{Q_{Sout}}{Q_p} \right)$$

**A:** allocation factor of burdens and credits between supplier and user of recycled materials.

**$R_1$:** it is the proportion of material in the input to the production that has been recycled from a previous system.

**$R_2$**: it is the proportion of the material in the product that will be recycled (or reused) in a subsequent system. $R_2$ shall therefore take into account the inefficiencies in the collection and recycling (or reuse) processes. $R_2$ shall be measured at the output of the recycling plant

**$E_v$:** specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material.

**$E_{recycled}$ ($E_{rec}$):** specific emissions and resources consumed (per functional unit) arising from the recycling process of the recycled (reused) material, including collection, sorting and transportation process.

**$E_{recyclingEoL}$ ($E_{recEoL}$)**: specific emissions and resources consumed (per functional unit) arising from the recycling process at EoL, including collection, sorting and transportation process.

**$E^*_v$**: specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material assumed to be substituted by recyclable materials.

**$Q_{Sin}$:** quality of the ingoing secondary material, i.e. the quality of the recycled material at the point of substitution.

**$Q_{Sout}$**: quality of the outgoing secondary material, i.e. the quality of the recyclable material at the point of substitution.

**$Q_p$:** quality of the primary material, i.e. quality of the virgin material**.**

The R1 values applied shall be supply-chain specific or default ones. Material-specific values based on supply market statistics are not accepted as a proxy. The applied R1 values shall be subject to verification.

When using supply-chain specific R1 values other than 0, traceability throughout the supply chain is necessary. The following general guidelines shall be followed when using supply-chain specific R1 values:

- The supplier information (through e.g., statement of conformity or delivery note) shall be maintained during all stages of production and delivery at the converter.
- Once the material is delivered to the converter for production of the end products, the converter shall handle information through their regular administrative procedures.
- The converter for production of the end products claiming recycled content shall demonstrate through his management system the [%] of recycled input material into the respective end product(s).
- The latter demonstration shall be transferred upon request to the user of the end product.
- Company-owned traceability systems can be applied as long as they cover the general guidelines outlined above.

The default parameter values for applying the CFF and the default values for R1 and R2 are listed in the spreadsheet "CF_Annex_PV_modules-Life_cycle_inventory[8]", sheet CFF-parameters. For all materials not listed in the sheet CFF-parameters, it is assumed that R2=0.

**Distribution**

The transportation of photovoltaic modules from factory to EU borders, shall be modelled within this life cycle stage. The distance and mass transported shall be characterised with company-specific data. For producers located in EU Member States, this step is not applicable

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The transport from regional storage to the photovoltaic power system where the photovoltaic modules are installed is excluded from the system boundary. If photovoltaic modules are produced in several production sites, the share of each facility in the European supply mix shall be accounted for in the life cycle stage distribution.

The processes taking place in the life cycle stage distribution, the inputs and outputs as well as the default datasets are listed in the spreadsheet named "CF_Annex_PV_modules-Life_cycle_inventory[8]", sheet "Distribution". Processes that are expected to be run by the company applying the Annex are written in capital letters (see column A in the spreadsheet).

7. Other modelling requirements

**Sampling**

Sampling is allowed in case of a high number of production sites are involved in the production of the module for which the carbon footprint is calculated. In case sampling used to collect data from different production sites, different sub-populations shall be identified by considering the geographical distribution, the technologies applied and the production capacity of all facilities. The number of sub-populations (*Nsp*) shall be identified as:

$Nsp = g \cdot t \cdot c$

where *g* is the number of countries in which the plants are located, *t* is the number of technologies and *c* is the number of classes of plant capacity.

Once the sub-populations have been identified, for each sub-population the size of sample shall be calculated (the sub-sample size) based on the total production of the sub-population. The total production shall represent the product under analysis (e.g. total amount of multi-Si PV cells or modules produced, measured in $m^2$). The percentage of production to be covered by each sub-population shall not be lower than 75 %. The data collected from different production sites shall be weighted based on the production volume of each facility.

The company applying this Annex shall describe the sub-populations and report the percentage of the total production that is covered by the collected samples.

**Data needs matrix (DNM)**

All processes required to model the product and outside the list of mandatory company-specific (listed in section 5) shall be evaluated using the Data Needs Matrix (see Table 3). The DNM shall be used by the applicant to evaluate which data is needed and shall be used within the modelling of its carbon footprint assessment, depending on the level of influence the applicant (company) has on the specific process. The following three cases are found in the DNM and are explained below:

- **Situation 1**: the process is run by the company applying this Annex
- **Situation 2**: the process is not run by the company applying this Annex but the company has access to (company-)specific information.
- **Situation 3**: the process is not run by the company applying this Annex and this company does not have access to (company-)specific information.

**Table 3 – Data Needs Matrix.**

| Situation | Requirement |
|---|---|
| *Situation 1*: process run by the company applying this Annex | Use company-specific data |
| *Situation 2*: process not run by the company applying this Annex but with access to company-specific information | Use company-specific data |
| *Situation 3*: process not run by the company applying this Annex and without access to company-specific information | Use default secondary dataset |

**Allocation rules**

There is one instance in the crystalline silicon PV supply chain, where a multiproduct process occurs (see Table 4). Cuttings (circular segments) from monocrystalline wafer production are fed into multicrystalline silicon casting. The cradle to gate efforts and impacts of the supply of solar grade silicon used in Czochralski monocrystalline production shall be fully allocated to the monocrystalline silicon wafers. The (internal) recycling efforts and impacts required to

prepare the cuttings for an input into the multicrystalline casting process shall fully be allocated to the multicrystalline silicon wafers.

**Table 4 – Allocation rules for the silicon supply chain.**

| Process | Allocation rule | Modelling instructions |
|---|---|---|
| single-Si wafer, photovoltaics, at plans | Allocation according to internal book-keeping standards. | The cuttings are considered as waste and the supply chain impacts related to these cuttings shall be fully allocated to the production of monocrystalline silicon wafers. |
| silicon, multi-Si, casted, at plant | Allocation according to internal book-keeping standards. | The cuttings from monocrystalline wafer production are burden-free. The recycling efforts to prepare the cuttings for use in the multicrystalline silicon casting process shall be fully allocated to the multicrystalline silicon wafers. |

Allocation of electricity consumption

Wherever possible, allocation should be avoided by subdivision of the process system. This means for instance, that the electricity demand of a production plant producing several products should be measured separately for each process or product. If this is not possible, the allocation rules for electricity described in Table 5 shall be followed.

**Table 5 – Allocation rules for electricity.**

| Process | Physical relationship | Modelling instructions |
|---|---|---|
| PV cell production | Area ($m^2$ of PV cells) | The allocation of the electricity consumption of a specific production plant shall be based on the total amount of PV cells produced at this site, measured in $m^2$ on a yearly basis. |
| PV module production | Area ($m^2$ of PV modules) | The allocation of the electricity consumption of a specific production plant shall be based on the total amount of PV modules produced at this site, measured in $m^2$ on a yearly basis. |
| PV cell and module production in the same plant | Area ($m^2$ of PV cells and modules), weighted by the default specific electricity consumption per $m^2$ | The allocation of the electricity consumption of a specific production plant shall be based on the total amount of PV cells and modules produced at this site, measured in $m^2$ on a yearly basis. The areas of PV cells and modules produced shall be weighted based on the specific electricity consumption per $m^2$ (outer dimensions including production losses). The following formulae shall be used to calculate the allocation factors (AF): $AF_{cells} = \frac{Production_{cells}[m^2] \cdot 51.8 \frac{MJ}{m^2}}{Production_{cells}[m^2] \cdot 51.8 \frac{MJ}{m^2} + Production_{modules}[m^2] \cdot 13.4 \frac{MJ}{m^2}}$ $AF_{modules} = \frac{Production_{modules}[m^2] \cdot 13.4 \frac{MJ}{m^2}}{Production_{cells}[m^2] \cdot 51.8 \frac{MJ}{m^2} + Production_{modules}[m^2] \cdot 13.4 \frac{MJ}{m^2}}$ |

If the consumed electricity comes from more than one electricity mix, each mix source shall be used in terms of its proportion in the total kWh consumed. For example, if a fraction of this total kWh consumed is coming from a specific supplier a supplier-specific electricity mix shall be used for this part; the requirements on "electricity modelling" below fully apply. See below for on-site electricity use.

A specific electricity type may be allocated to one specific product in the following conditions:

a) The production (and related electricity consumption) of a product occurs in a separate site (building), the energy type physical related to this separated site may be used.
b) The production (and related electricity consumption) of a product occurs in a shared space with specific energy metering or purchase records or electricity bills, the product specific information (measure, record, bill) may be used.
c) All the products produced in the specific plant are supplied with a public available Product Environmental Footprint (PEF) study. The company who wants to make the claim shall make all PEF studies available. The allocation rule applied shall be clearly documented, consistently applied in all PEF studies connected to the site and verified. An example is the 100% allocation of a greener electricity mix to a specific product.

**Electricity modelling**

The guidelines in this section shall only be used for the processes where company-specific information is collected.

The following electricity mix shall be used in hierarchical order:

I. Supplier-specific electricity product shall be used if:

   a) available, and
   b) the set of minimum criteria referred to in the section below to ensure the contractual instruments are reliable is met.

II. The supplier-specific total electricity mix shall be used if:

   a) available, and
   b) the set of minimum criteria referred to in the section below to ensure the contractual instruments are reliable is met.

III. As a last option the 'country-specific residual grid mix, consumption mix' shall be used. Country-specific means the country in which the life cycle stage occurs. This may be an EU country or non-EU country. The residual grid mix characterizes the unclaimed, untracked or publicly shared electricity. This prevents double counting with the use of supplier-specific electricity mixes in (I) and (II).

Note: if for a country, there is a 100% tracking system in place, case (I) shall be applied.

<u>Set of minimum criteria to ensure contractual instruments from suppliers are reliable:</u>

A supplier-specific electricity product/mix may only be used when the applicant ensures that any contractual instrument used meets the criteria specified below. If any of the contractual instruments do not meet the criteria, then 'country-specific residual grid mix, consumption mix' shall be used in the modelling.

A contractual instrument used for electricity modelling shall:

1. Convey attributes:
   - Convey the energy type mix associated with the unit of electricity produced and include an explanation of the calculation method used to determine this mix.
   - The energy type mix shall be calculated based on delivered electricity, incorporating certificates sourced and retired on behalf of the relevant company (for the supplier-specific electricity product) or on behalf of the supplier’s customers (for the supplier-specific electricity mix). Electricity from facilities for which the attributes have been sold off (via contracts or certificates) shall be characterized as having the environmental attributes of the country residual consumption mix where the facility is located.
2. Be a unique claim:
   - Be the only instruments that carry the environmental attribute claim associated with that quantity of electricity generated.

- Any certificates incorporated in the energy type mix shall be redeemed, retired, or cancelled by or on behalf of the company (e.g. by an audit of contracts, third-party certification, or may be handled automatically through other disclosure registries, systems, or mechanisms).
- A certificate may only be incorporated if it:

a. allows for the unambiguous identification of the type, age and location and capacity of the energy generation facility to which it refers;

b. the energy generation facility to which it refers is located in a country with a tracking system in place that meets the minimum criteria for tracking systems listed in the section below;

c. in case the energy generation facility to which it refers is located in a country with a multi-certificate tracking system, it is accompanied by any additional contractual instrument necessary to show and ensure there is no risk of double counting.

3. Be as close as possible to the period to which the contractual instrument is applied.

<u>Set of minimum criteria for tracking systems</u>

A supplier-specific electricity product/mix may only incorporate certificates redeemed, retired, or cancelled by or on behalf of the relevant company if those certificates stem from a tracking system that:

- has a share of untracked production below 95%;
- is based on objective, non-discriminatory and transparent criteria for the issuing certificates;
- allows certificates to be valid no longer than 12 months after the production of the relevant energy unit;
- relies on accurate, reliable and fraud-resistant mechanisms for the issuance, transfer and cancellation of certificates;
- entrusts the issuance of certificates, as well as the supervision of their transfer and cancellation of certificates, to an entity or entities:

(a) that are independent from energy production, trade and supply activities, and of any commercial interest of customers on whose behalf certificates are redeemed, retired, or cancelled;
(b) whose activities are governed by transparent rules and procedures laid down by law;
(c) whose decisions may be challenged and reviewed in the context of proceedings before an independent judiciary.

<u>Modelling 'country-specific residual grid mix, consumption mix'</u>:

Datasets for residual grid mix are available in the nodes listed in the spreadsheet "CF_Annex_PV_modules-Life_cycle_inventory", sheet Data sources. If no dataset is available, the following approach may be used:

Determine the country consumption mix (e.g. X% of MWh produced with hydro energy, Y% of MWh produced with coal power plant) and combine them with LCI datasets per energy type and country/region (e.g. LCI dataset for the production of 1MWh hydro energy in Switzerland):

- Activity data related to non-EU country consumption mix per detailed energy type shall be determined based on:
    - Domestic production mix per production technologies
    - Import quantity and from which neighbouring countries
    - Transmission losses
    - Distribution losses
    - Type of fuel supply (share of resources used, by import and / or domestic supply)
- Available LCI datasets per fuel technologies in the node. The LCI datasets available are generally specific to a country or a region in terms of:
    - Fuel supply (share of resources used, by import and / or domestic supply),
    - Energy carrier properties (e.g. element and energy contents)
    - Technology standards of power plants regarding efficiency, firing technology, flue-gas desulphurisation, NOx removal and de-dusting.

<u>On-site electricity generation</u>:

If on-site electricity production is equal to the site own consumption, two situations apply:

- No contractual instruments have been sold to a third party: the own electricity mix (combined with LCI datasets) shall be modelled.
- Contractual instruments have been sold to a third party: the 'country-specific residual grid mix, consumption mix' (combined with LCI datasets) shall be used.

If electricity is produced in excess of the amount consumed on-site within the defined system boundary and is sold to, for example, the electricity grid, this system can be seen as a multifunctional situation. The system will provide two functions (e.g. product + electricity) and the following rules shall be followed:

- If possible, apply subdivision.
- Subdivision applies both to separate electricity productions or to a common electricity production where you can allocate based on electricity amounts the upstream and direct emissions to your own consumption and to the share you sell out of your company (e.g. if a company has a wind mill on its production site and export 30% of the produced electricity, emissions related to 70% of produced electricity should be accounted in the carbon footprint).
- If not possible, direct substitution shall be used. The country-specific residual consumption electricity mix shall be used as substitution.

- Subdivision is considered as not possible when upstream impacts or direct emissions are closely related to the product itself.

8. Carbon footprint assessment

The carbon footprint shall be calculated according to the impact assessment method reported in Table 6.

**Table 6 – method for calculating the carbon footprint**

| Impact category | Indicator | Unit | LCIA method |
|---|---|---|---|
| Climate change[9] | Radiative forcing as Global Warming Potential (GWP100) | kg CO2 eq | Baseline model of 100 years of the IPCC (based on IPCC 2013) |

The full list of characterization factors is available in the spreadsheet "CF_Annex_PV_modules-Life_cycle_inventory[8]", sheet GWP CF.

The results shall be reported using the unit of measure $gCO_2eq/kWh$.

The results shall be provided as "cradle-to-EU market" total CF value as well as separate values for the two life cycle stages described in section 4.

[9] The contribution of the sub-categories "Climate change – biogenic" and "Climate change – land use and land transformation" to the total climate change impacts is lower than 5 %. The environmental impacts shall therefore only be calculated for the category "Climate change" but not for the sub-categories "Climate change – biogenic" and "Climate change – land use and land transformation".

## Part 2 - List of mandatory company-specific data

The following tables show the mandatory company-specific data for each of the PV technologies included in the Scope of this Annex. Further details including the list of secondary datasets to be used are available in the spreadsheet "CF_Annex_PV_modules-Life_cycle_inventory[8]". In case other materials are used (e.g. other plastics/blends, solvents, etc.) the selection of appropriate datasets shall follow the hierarchy described in the spreadsheet "CF_Annex_PV_modules-Life_cycle_inventory[8]" sheet Data sources.

### Cadmium-Telluride photovoltaic modules (CdTe)

| **Photovoltaic laminate production** | | |
|---|---|---|
| **Activity data to be collected** | **Specific requirements (e.g. frequency, measurement standard, etc)** | **Unit of measure** |
| **INPUT** | | |
| Electricity | Measurement (e.g. electricity meter or electricity bills); Yearly average | MJ |
| Solar glass | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Flat glass tempering | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Flat glass (uncoated) | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Copper | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Cadmium sulphide | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Cadmium telluride | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Ethylene vinyl acetate (EVA) | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Glass fibre reinforced plastic | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Silicone | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Silica sand | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Tap water | Measurement (e.g. water meter or water bills); Yearly average | kg |
| Nitrogen | Measurement; Yearly average | kg |
| Nitric acid | Measurement; Yearly average | kg |
| Sulphuric acid | Measurement; Yearly average | kg |
| Hydrogen peroxide | Measurement; Yearly average | kg |
| Sodium hydroxide | Measurement; Yearly average | kg |
| Sodium chloride | Measurement; Yearly average | kg |
| Isopropanol | Measurement; Yearly average | kg |
| Corrugated board | Measurement; Yearly average | kg |
| Freight train transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Lorry transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Ship transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Airplane transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Share in supply logistics in a 3 years period | kgkm |

| | | |
|---|---|---|
| **OUTPUT** | | |
| Photovoltaic laminate, CdTe, at plant | Specify the size of the PV panel | m2 |
| Plastic waste (incineration) | Measurement; Yearly average | kg |
| Municipal solid waste (incineration) | Measurement; Yearly average | kg |

| **Distribution** | | |
|---|---|---|
| **Activity data to be collected** | **Specific requirements (e.g. frequency, measurement standard, etc)** | **Unit of measure** |
| **INPUT** | | |
| Photovoltaic laminate, CdTe, at plant | Specify the mass per m2 PV panel<br>Calculate the share of each facility in the European supply mix in case of several production sites<br>Yearly average | m2 |
| Freight train transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Lorry transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Ship transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Airplane transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Share in supply logistics in a 3 years period | kgkm |
| **OUTPUT** | | |
| Photovoltaic laminate, CdTe, at regional storage | | m2 |

## Copper-Indium-Gallium-Selenide photovoltaic modules (CIS / CIGS)

| **Photovoltaic laminate production** | | |
|---|---|---|
| **Activity data to be collected** | **Specific requirements (e.g. frequency, measurement standard, etc)** | **Unit of measure** |
| **INPUT** | | |
| Electricity | Measurement (e.g. electricity meter or electricity bills); Yearly average | MJ |
| Solar glass | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Flat glass tempering | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Flat glass (uncoated) | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Aluminium | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Copper wire | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Tin | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Zinc oxide | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |

| | | |
|---|---|---|
| Molybdenum | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Indium | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Gallium | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Selenium | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Cadmium sulphide | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Diode | Bill of materials of the PV panel (including manufacturing losses) Yearly average | p |
| Flux | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Ethylene vinyl acetate (EVA) | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Polyvinyl butyral (PVB) | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Polyethylene terephthalate (PET) | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| High-density polyethylene (HDPE) | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Polyphenylene sulphide (PPS) | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Silicone | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Tap water | Measurement (e.g. water meter or water bills); Yearly average | kg |
| Nitrogen | Measurement; Yearly average | kg |
| Argon | Measurement; Yearly average | kg |
| Ammonia | Measurement; Yearly average | kg |
| Urea | Measurement; Yearly average | kg |
| Hydrogen peroxide | Measurement; Yearly average | kg |
| Sodium hydroxide | Measurement; Yearly average | kg |
| Hydrochloric acid | Measurement; Yearly average | kg |
| Sulphuric acid | Measurement; Yearly average | kg |
| Hydrogen sulphide | Measurement; Yearly average | kg |
| Butyl acrylate | Measurement; Yearly average | kg |
| Diborane | Measurement; Yearly average | m3 |
| Freight train transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Lorry transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Ship transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Airplane transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Share in supply logistics in a 3 years period | kgkm |
| **OUTPUT** | | |
| Photovoltaic laminate, CIS, at plant | Specify the size of the PV laminate | m2 |
| Inert waste (landfill) | Measurement; Yearly average | kg |
| Inert waste (incineration) | Measurement; Yearly average | kg |
| Plastic waste (incineration) | Measurement; Yearly average | kg |
| Wastewater (wastewater treatment plant) | Measurement; Yearly average | kg |

## Photovoltaic panel production

| Activity data to be collected | Specific requirements (e.g. frequency, measurement standard, etc) | Unit of measure |
|---|---|---|
| **INPUT** | | |
| Photovoltaic laminate, CIS, at plant | Specify the size of the PV panel | m2 |
| Thermal energy from light fuel oil | Measurement (e.g. energy meter or energy bills); Yearly average | MJ |
| Aluminium alloy | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Glass fibre reinforced plastic | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Freight train transport | Calculation (mass x distance) Transport of all input materials to the production site and transport of waste materials to treatment site Yearly average | kgkm |
| Lorry transport | Calculation (mass x distance) Transport of all input materials to the production site and transport of waste materials to treatment site Yearly average | kgkm |
| Ship transport | Calculation (mass x distance) Transport of all input materials to the production site and transport of waste materials to treatment site Yearly average | kgkm |
| Airplane transport | Calculation (mass x distance) Transport of all input materials to the production site and transport of waste materials to treatment site Share in supply logistics in a 3 years period | kgkm |
| OUTPUT | | |
| Photovoltaic panel, CIS, at plant | Specify the size of the PV panel | m2 |
| Plastic waste (incineration) | Measurement; Yearly average | kg |

## Distribution

| Activity data to be collected | Specific requirements (e.g. frequency, measurement standard, etc) | Unit of measure |
|---|---|---|
| **INPUT** | | |
| Photovoltaic panel, CIS, at plant | Specify the mass per m2 PV panel<br>Calculate the share of each facility in the European supply mix in case of several production sites<br>Yearly average | m2 |
| Freight train transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Lorry transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Ship transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Airplane transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Share in supply logistics in a 3 years period | kgkm |
| **OUTPUT** | | |
| Photovoltaic panel, CIS, at | | m2 |

| | | |
|---|---|---|
| regional storage | | |

## Micromorphous Silicon photovoltaic modules (micro-Si)

| **Photovoltaic Panel manufacturing** | | |
|---|---|---|
| **Activity data to be collected** | **Specific requirements (e.g. frequency, measurement standard, etc)** | **Unit of measure** |
| **INPUT** | | |
| Electricity | Measurement (e.g. electricity meter or electricity bills); Yearly average | MJ |
| Natural gas | Measurement (e.g. energy meter or energy bills); Yearly average | MJ |
| Aluminium alloy | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Copper wire | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Silver | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Solar glass | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Flat glass tempering | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Cable | Bill of materials of the PV panel (including manufacturing losses) Yearly average | m |
| Ethylene vinyl acetate (EVA) | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| High-density polyethylene (HDPE) | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Injection moulding of HDPE | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Silicone | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Silane (silicon tetrahydride) | Measurement; Yearly average | kg |
| Deionised water | Measurement; Yearly average | kg |
| Decarbonised water | Measurement; Yearly average | kg |
| Hydrogen | Measurement; Yearly average | kg |
| Nitrogen | Measurement; Yearly average | kg |
| Oxygen | Measurement; Yearly average | kg |
| Carbon dioxide | Measurement; Yearly average | kg |
| Argon | Measurement; Yearly average | kg |
| Phosphane | Measurement; Yearly average | kg |
| Diborane | Measurement; Yearly average | kg |
| Trimethyl borate | Measurement; Yearly average | kg |
| Bisphenol A | Measurement; Yearly average | kg |
| Zeolite | Measurement; Yearly average | kg |
| Compressed air | Measurement; Yearly average | m3 |
| Freight train transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Lorry transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Ship transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Airplane transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Share in supply logistics in a 3 years period | kgkm |
| **OUTPUT** | | |
| Photovoltaic panel, micro-Si, at plant | Specify the size of the PV panel | m2 |

| | | |
|---|---|---|
| Inert waste (incineration) | Measurement; Yearly average | kg |
| Plastic waste (incineration) | Measurement; Yearly average | kg |
| Hazardous waste (incineration) | Measurement; Yearly average | kg |
| Wastewater (wastewater treatment plant) | Measurement; Yearly average | kg |
| Nitrogen trifluoride (NF3) | Measurement; Yearly average | kg |

| **Distribution** | | |
|---|---|---|
| **Activity data to be collected** | **Specific requirements (e.g. frequency, measurement standard, etc)** | **Unit of measure** |
| **INPUT** | | |
| Photovoltaic panel, micro-Si, at plant | Specify the mass per m2 PV panel<br>Calculate the share of each facility in the European supply mix in case of several production sites<br>Yearly average | m2 |
| Freight train transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Lorry transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Ship transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Airplane transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Share in supply logistics in a 3 years period | kgkm |
| **OUTPUT** | | |
| Photovoltaic panel, micro-Si, at regional storage | | m2 |

## Multicrystalline (Multi-Si) Silicon PV modules

| **Photovoltaic cell manufacturing** | | |
|---|---|---|
| **Activity data to be collected** | **Specific requirements (e.g. frequency, measurement standard, etc)** | **Unit of measure** |
| **INPUT** | | |
| Electricity | Measurement (e.g. electricity meter or electricity bills); Yearly average | MJ |
| Thermal energy from natural gas | Measurement (e.g. energy meter or energy bills); Yearly average | MJ |
| Thermal energy from light fuel oil | Measurement (e.g. energy meter or energy bills); Yearly average | MJ |
| Wafer, multi-Si | Bill of materials of the PV panel (including manufacturing losses) Yearly average | m2 |
| Metallization paste, front side | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Metallization paste, back side | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Metallization paste, back | Bill of materials of the PV panel (including manufacturing losses) | kg |

| | | |
|---|---|---|
| side, aluminium | Yearly average | |
| Ammonia | Measurement; Yearly average | kg |
| Phosphoric acid | Measurement; Yearly average | kg |
| Phosphoryl chloride | Measurement; Yearly average | kg |
| Isopropanol | Measurement; Yearly average | kg |
| Calcium chloride | Measurement; Yearly average | kg |
| Hydrochloric acid | Measurement; Yearly average | kg |
| Hydrogen fluoride | Measurement; Yearly average | kg |
| Nitric acid | Measurement; Yearly average | kg |
| Sulphuric acid | Measurement; Yearly average | kg |
| Sodium hydroxide | Measurement; Yearly average | kg |
| Potassium hydroxide | Measurement; Yearly average | kg |
| Hydrogen peroxide | Measurement; Yearly average | kg |
| Ammonium sulphate | Measurement; Yearly average | kg |
| Lime | Measurement; Yearly average | kg |
| Tetrafluoroethane (R134a) | Measurement; Yearly average | kg |
| Silane (silicon tetrahydride) | Measurement; Yearly average | kg |
| Nitrogen | Measurement; Yearly average | kg |
| Oxygen | Measurement; Yearly average | kg |
| Tap water | Measurement (e.g. water meter or water bills); Yearly average | kg |
| Freight train transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Lorry transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Ship transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Airplane transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Share in supply logistics in a 3 years period | kgkm |
| Photovoltaic cell factory | Estimation<br>Use a default demand of 4.00E-7 p if specific data are not available | P |
| **OUTPUT** | | |
| Photovoltaic cell, multi-Si | | m2 |
| Hazardous waste (incineration) | Measurement; Yearly average | kg |
| Wastewater (wastewater treatment plant) | Measurement; Yearly average | kg |

| **Photovoltaic panel manufacturing** | | |
|---|---|---|
| **Activity data to be collected** | **Specific requirements (e.g. frequency, measurement standard, etc)** | **Unit of measure** |
| **INPUT** | | |
| Electricity | Measurement (e.g. electricity meter or electricity bills); Yearly average | MJ |
| Diesel | Measurement; Yearly average | kg |
| Photovoltaic cell, multi-Si | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | m2 |
| Aluminium alloy | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Copper wire | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Tin | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Lead | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |

| | | |
|---|---|---|
| Diode | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | P |
| Solar glass | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Flat glass tempering | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Ethylene vinyl acetate (EVA) | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Polyvinyl fluoride (PVF) | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Polyethylene terephthalate (PET) | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| High-density polyethylene (HDPE) | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Glass fibre reinforced plastic | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Silicone | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Tap water | Measurement (e.g. water meter or water bills); Yearly average | kg |
| Hydrogen fluoride | Measurement; Yearly average | kg |
| Potassium hydroxide | Measurement; Yearly average | kg |
| 1-propanol | Measurement; Yearly average | kg |
| Isopropanol | Measurement; Yearly average | kg |
| Soap | Measurement; Yearly average | kg |
| Corrugated board | Measurement; Yearly average | kg |
| Pallet, wood | Default reuse rate: 25 trips | kg |
| Freight train transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Lorry transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Ship transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Airplane transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Share in supply logistics in a 3 years period | kgkm |
| Photovoltaic panel factory | Estimation<br>Use a default demand of 4.00E-6 p if specific data are not available | P |
| **OUTPUT** | | |
| Photovoltaic panel, multi-Si, at plant | Specify the size of the PV panel | m2 |
| Plastic waste (incineration) | Measurement; Yearly average | kg |
| Hazardous waste (incineration) | Measurement; Yearly average | kg |
| Municipal solid waste (incineration) | Measurement; Yearly average | kg |
| Wastewater (wastewater treatment plant) | Measurement; Yearly average | kg |

| **Distribution** | | |
|---|---|---|
| **Activity data to be collected** | **Specific requirements (e.g. frequency, measurement standard, etc)** | **Unit of measure** |
| **INPUT** | | |
| Photovoltaic panel, multi-Si, at plant | Specify the mass per m2 PV panel<br>Calculate the share of each facility in the European supply mix in case of | m2 |

| | | |
|---|---|---|
| | several production sites<br>Yearly average | |
| Freight train transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Lorry transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Ship transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Airplane transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Share in supply logistics in a 3 years period | kgkm |
| **OUTPUT** | | |
| Photovoltaic panel, multi-Si, at regional storage | | m2 |

## Monocrystalline (Mono-Si) Silicon PV modules

| **Photovoltaic Cell manufacturing** | | |
|---|---|---|
| **Activity data to be collected** | **Specific requirements (e.g. frequency, measurement standard, etc)** | **Unit of measure** |
| **INPUT** | | |
| Electricity | Measurement (e.g. electricity meter or electricity bills); Yearly average | MJ |
| Thermal energy from natural gas | Measurement; Yearly average | MJ |
| Wafer, mono-Si | Bill of materials of the PV panel (including manufacturing losses) Yearly average | m2 |
| Metallization paste, front side | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Metallization paste, back side | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Metallization paste, back side, aluminium | Bill of materials of the PV panel (including manufacturing losses) Yearly average | kg |
| Ammonia | Measurement; Yearly average | kg |
| Phosphoryl chloride | Measurement; Yearly average | kg |
| Isopropanol | Measurement; Yearly average | kg |
| Hydrochloric acid | Measurement; Yearly average | kg |
| Hydrogen fluoride | Measurement; Yearly average | kg |
| Sodium hydroxide | Measurement; Yearly average | kg |
| Lime | Measurement; Yearly average | kg |
| Tetrafluoroethane (R134a) | Measurement; Yearly average | kg |
| Silane (silicon tetrahydride) | Measurement; Yearly average | kg |
| Nitrogen | Measurement; Yearly average | kg |
| Tap water | Measurement (e.g. water meter or water bills); Yearly average | kg |
| Freight train transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Lorry transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |

| | | |
|---|---|---|
| Ship transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Airplane transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Share in supply logistics in a 3 years period | kgkm |
| **OUTPUT** | | |
| Photovoltaic cell, mono-Si | | m2 |
| Hazardous waste (incineration) | Measurement; Yearly average | kg |
| Wastewater (wastewater treatment plant) | Measurement; Yearly average | kg |

| **Photovoltaic Panel manufacturing** | | |
|---|---|---|
| **Activity data to be collected** | **Specific requirements (e.g. frequency, measurement standard, etc)** | **Unit of measure** |
| **INPUT** | | |
| Electricity | Measurement (e.g. electricity meter or electricity bills); Yearly average | MJ |
| Diesel | Measurement; Yearly average | kg |
| Photovoltaic cell, mono-Si | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | m2 |
| Aluminium alloy | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Copper wire | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Tin | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Lead | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Diode | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | p |
| Solar glass | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Flat glass tempering | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Ethylene vinyl acetate (EVA) | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Polyvinyl fluoride (PVF) | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Polyethylene terephthalate (PET) | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| High-density polyethylene (HDPE) | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Silicone | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Glass fibre reinforced plastic | Bill of materials of the PV panel (including manufacturing losses)<br>Yearly average | kg |
| Tap water | Measurement (e.g. water meter or water bills); Yearly average | kg |
| Hydrogen fluoride | Measurement; Yearly average | kg |
| Potassium hydroxide | Measurement; Yearly average | kg |
| 1-propanol | Measurement; Yearly average | kg |
| Isopropanol | Measurement; Yearly average | kg |
| Soap | Measurement; Yearly average | kg |
| Corrugated board | Measurement; Yearly average | kg |
| Pallet, wood | Estimation<br>Default reuse rate: 25 trips | kg |
| Freight train transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Lorry transport | Calculation (mass x distance) | kgkm |

| | | |
|---|---|---|
| | Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | |
| Ship transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Yearly average | kgkm |
| Airplane transport | Calculation (mass x distance)<br>Transport of all input materials to the production site and transport of waste materials to treatment site<br>Share in supply logistics in a 3 years period | kgkm |
| **OUTPUT** | | |
| Photovoltaic panel, mono-Si, at plant | Specify the size of the PV panel | m2 |
| Plastic waste (incineration) | Measurement; Yearly average | kg |
| Hazardous waste (incineration) | Measurement; Yearly average | kg |
| Municipal solid waste (incineration) | Measurement; Yearly average | kg |
| Wastewater (wastewater treatment plant) | Measurement; Yearly average | kg |

| **Distribution** | | |
|---|---|---|
| **Activity data to be collected** | **Specific requirements (e.g. frequency, measurement standard, etc)** | **Unit of measure** |
| **INPUT** | | |
| Photovoltaic panel, mono-Si, at plant | Specify the mass per m2 PV panel<br>Calculate the share of each facility in the European supply mix in case of several production sites<br>Yearly average | m2 |
| Freight train transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Lorry transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Ship transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Yearly average | kgkm |
| Airplane transport | Calculation (mass x distance)<br>Transport of PV panels from the production site to a regional storage in Europe<br>Use a weighted average in case of several production sites<br>Share in supply logistics in a 3 years period | kgkm |
| **OUTPUT** | | |
| Photovoltaic panel, mono-Si, at regional storage | | m2 |

*ANNEX V*

**Conformity assessment procedure**

## MODULE D1 – QUALITY ASSURANCE OF THE PRODUCTION PROCESS

1. Description of the module

Quality assurance of the production process is the conformity assessment procedure whereby the manufacturer fulfils the obligations laid down in points 2, 3, 4, 5, 6, 7 and 8, and ensures and declares on his sole responsibility that the products concerned satisfy the applicable requirements.

2. Technical documentation

The manufacturer must compile a technical documentation file making possible an assessment of the conformity of the product with the relevant requirements. The documentation may be integrated with the technical documentation drawn up in accordance with other applicable conformity assessment procedures.

The technical documentation shall specify the applicable requirements referred to in point 1 and cover, as far as relevant for the assessment, the design, manufacture and operation of the product.

The documentation must contain, in particular:

(a) a general description of the product and of its intended use;

(b) conceptual design and manufacturing drawings and schemes of components, sub-assemblies, circuits, etc.;

(c) descriptions and explanations necessary for the understanding of those drawings and schemes and the operation of the product;

(d) the results of relevant environmental assessment studies carried out by the manufacturer, and/or references to environmental assessment literature or case studies, which are used by the manufacturer in evaluating, documenting and determining product design solutions;

(e) elements of the product design specification relating to environmental design aspects of the product;

(f) a list of the appropriate standards referred to in Article 10 of Directive 2009/125/EC, applied in full or in part, and a description of the solutions adopted to meet the relevant requirements where the standards referred to in Article 10 of Directive 2009/125/EC have not been applied or where those standards do not cover entirely the relevant requirements;

(g) a copy of the information concerning the environmental design aspects of the product provided in accordance with the requirements specified in Annex I, Part 2; and

(h) results of design calculations made, test reports, examinations carried out, etc., including the results of measurements on the ecodesign requirements carried out and the details of the conformity of these measurements as compared with the ecodesign requirements set out in this implementing measure.

3. The manufacturer shall keep the technical documentation at the disposal of the relevant national authorities for 10 years after the product has been placed on the market.

4. Manufacturing

The manufacturer shall operate an approved quality system for production, final product inspection and testing of the products concerned as specified in point 5, it shall have the carbon footprint of photovoltaic modules included in the carbon footprint declaration for the product concerned verified as specified in point 6, and shall be subject to surveillance as specified in point 7.

5. Quality system

5.1. The manufacturer shall lodge an application for assessment of his quality system with the notified body of his choice, for the products concerned.

The application shall include:

— the name and address of the manufacturer and, if the application is lodged by the authorised representative, his name and address as well,

— a written declaration that the same application has not been lodged with any other notified body,

— all relevant information for the product category envisaged,

— the documentation concerning the quality system,

— the technical documentation referred to in point 2.

For photovoltaic modules, the application shall be combined with the application referred to under point 6.1.

5.2. The quality system shall ensure compliance of the products with the requirements set out in Annex II Part 1 for photovoltaic modules or with the requirements set out in Annex II Part 4.2 for photovoltaic inverters.

All the elements, requirements and provisions adopted by the manufacturer shall be documented in a systematic and orderly manner in the form of written policies, procedures and instructions. The quality system documentation shall permit a consistent interpretation of the quality programmes, plans, manuals and records.

The quality system shall at least include:

a) the quality objectives,

b) the organisational structure and the responsibilities and powers of the management with regard to product quality in the form of a control plan and process flow diagram,

c) the corresponding manufacturing, quality control and quality assurance techniques, processes and systematic actions that will be used – these shall include measurement techniques, sampling plans, acceptance criteria, preventive maintenance, and reaction plans for when acceptance criteria are not met,

d) maintenance of quality records, such as inspection reports and test data, calibration data, qualification reports on the personnel concerned, etc.,

e) methods to monitor the performance and accuracy of the equipment used in the product realization process,

f) definitions of product problems and rules and processes to minimize their impact,

g) procedures to monitor the achievement of the required product quality and conformity to the requirements of the product design specifications – including:
   - inspection of the product in-process, in addition to the final inspection, to ensure that the requirements of the product specification are met and defective products are prevented from release;
   - to that end, a specification of the examinations and tests to be carried out before, during and after manufacturing, and the frequency with which they are to be carried out,

h) a change management system for materials and processes ensuring all changes impacting form, fit and function do not negatively affect adherence to the relevant requirements,

i) procedures to ensure the documentation and traceability of changes to the product and impact from those changes for previous and future products,

j) procedures to validate the software used in the servicing of products,

k) identification, documentation, and review of the manufacturing process design input requirements, including product design output data and key materials used in manufacturing with a view to ensure continued adherence to the relevant requirements,

l) procedures to ensure that the components, sub-assemblies and assemblies that have a safety, performance, or reliability implication on the finished product and that are purchased from or prepared by a supplier, meet the quality plans, including by:
   - evaluating the quality performance of key materials;
   - ensuring that materials used in the product conform with material specifications;
   - performing regular periodic onsite audits to check that:
     - the material produced is conformal with applicable organization or manufacturer specifications;
     - the supplier maintains product quality consistently, notifies and seeks approval when there is any change of products, process, and manufacturing location, or a significant process excursion that may affect form, fit, function, reliability, or performance.
   - applying pre-defined methods for incoming inspections and preparation of raw materials,

m) control plans for all appropriate processes, sub-assemblies, components, and materials for the final product - control plans shall:
   - be based on a risk analysis such as design or process FMEA (failure mode evaluation analysis) outputs, or equivalent;
   - list the controls used for the manufacturing process control;
   - provide for the initiation of a specific out of control action plan (OCAP) when a process becomes unstable or not statistically capable. These plans shall include the containment of products and 100% inspection, as appropriate. A corrective action plan shall be completed by the organization, indicating specific timing and assigned responsibilities to ensure that the process becomes stable and capable,

n) procedures for conducting a systematic material review related to disposition processes including rework, reuse, and recycle of non-conforming products and their constituent raw materials. Products with unidentified or suspect status shall be identified as potentially non-conforming product and subjected to a systematic review process,

o) procedures to monitor the effective operation of the quality system, including a periodic reliability monitoring program that uses appropriate tests for the known failure mechanisms of the product. The tests shall be conducted on the samples that are selected by the internal sampling procedure. Records of the results of any ongoing/periodic reliability testing/production monitoring program activities and any necessary actions arising from such activities shall be maintained.

5.3. The notified body shall assess the quality system to determine whether it satisfies the requirements referred to in point 5.2.

In addition to experience in quality management systems, the auditing team shall have at least one member with experience of evaluation in the relevant product field, product technology and manufacturing process concerned, and knowledge of the applicable requirements of the legislative instrument. The audit shall include an assessment visit to the manufacturer's premises.

The auditing team shall review the technical documentation referred to in point 2 in order to verify the manufacturer's ability to identify the relevant requirements of the legislative instrument and to carry out the necessary examinations with a view to ensuring compliance of the product with those requirements.

The decision shall be notified to the manufacturer. The notification shall contain the conclusions of the audit and the reasoned assessment decision.

If during the assessment the notified body finds deficiencies in the quality system that might have affected the conformity of products placed on the market by the relevant manufacturer with the requirements of this Regulation, including but not limited to the requirements set out in Annex II Parts 1 and 4.2, it shall inform the market surveillance authority of the notifying Member State.

5.4. The manufacturer shall undertake to fulfil the obligations arising out of the quality system as approved and to maintain it so that it remains adequate and efficient.

5.5. The manufacturer shall keep the notified body that has approved the quality system informed of any intended change to the quality system.

The notified body shall evaluate any proposed changes and decide whether the modified quality system will continue to satisfy the requirements referred to in point 5.2 or whether reassessment is necessary.

It shall notify the manufacturer of its decision. The notification shall contain the conclusions of the examination and the reasoned assessment decision.

6. Carbon footprint verification

6.1. The manufacturer shall lodge an application for verification of the carbon footprint of photovoltaic modules referred to in Part 2 of Annex II  notified body of his choice, for the products concerned. This may be the notified body referred to in point 5.1. In that case, the application shall be combined with the application referred to in that point.

If the application is lodged with a different notified body, both bodies shall make available to each other all information and documentation gathered in relation to their conformity assessment activities in relation to the relevant product.

The application shall make it possible to understand the design, material composition and manufacture of the product, as well as all steps taken and data used in the calculation of the carbon footprint. It shall include at least:

—the name and address of the manufacturer and, if the application is lodged by the authorised representative, his name and address as well,

— a written declaration that the same application has not been lodged with any other notified body,

— the technical documentation referred to in point 2,

— the carbon footprint calculated in line with Annex IV using the carbon footprint calculation tool provided by the Commission for that purpose,

— a study supporting the carbon footprint calculation,

— the notified body may request further information if needed

The supporting study shall document in a systematic, orderly and comprehensive manner all steps taken in the use of the carbon footprint calculation tool referred to in Part 2 of Annex II. It shall permit the effective verification of all information put into and derived from the calculation tool as specified in point 6.3.

It shall at least include detailed description and documentation of:

a) any company-specific data put into the calculation tool, including:
   - a list of processes covered by company-specific data indicating to which life cycle stage they belong;
   - a list of resource use and emissions (i.e. direct elementary flows);
   - a list of activity data used;
   - a detailed bill of materials and/or ingredients (including substance names, units and quantities, including information on grades/ purities and other technically and/or environmentally relevant characterisation of these);
   - the company-specific data collection/estimation/calculation procedures used;
b) any steps or datasets added or changed by the manufacturer compared to the default model provided through the tool,
c) any underlying documentation needed to establish the reliability of the company-specific data and/or additional steps and datasets,
d) sampling procedure applied, if any.

This application shall where necessary include confidential information. Confidential information shall be used only during the verification process and the manufacturer may ask to the verifiers to sign a non-disclosure agreement.

6.2. The notified body shall assess the application to determine whether the declared carbon

footprint is reliable, credible and correct and whether the declared carbon footprint does not exceed the maximum carbon footprint provided in Annex II Part 1.1.

The responsible verifiers shall meet at least the minimum score specified in Section 8.3.1 of the updated PEF method.[10]

6.3. The verification shall ensure that:

- the data and information used for the calculation of the carbon footprint are consistent, reliable and traceable; and

- any calculations performed do not include significant mistakes.

The verification shall include at least a documental review. The documental review includes the supporting study, including the data put into the tool, through available or requested underlying documentation. The notified body may organise the documental review either as an "at desk" or "on site" exercise, or as a mix of the two. The verification of the company-specific data shall always be organised through a visit of the production site(s) the data refer to.

In case the manufacturer adds or changes any steps or datasets compared to the default model provided through the tool, the verification should also include the new model and all the newly used secondary datasets and activity data. This verification may take place at the production site of the manufacturer, or site they refer to, or be organised remotely. The notified body shall access the model to verify its structure, the data used, and its consistency with the supporting study.

The company-specific data reported shall be checked against the underlying documentation in order to check their consistency.

The notified body shall ensure that the verification of company-specific data includes:

(a) coverage, precision, completeness, representativeness, consistency,

reproducibility, sources and uncertainty;

(b) plausibility, quality and accuracy of the data;

(c) quality and accuracy of the underlying documentation.

The notified body shall as a minimum:

- ensure that all secondary datasets used in the model correspond to the list required by Annex IV and enclosed spreadsheets;
- verify all mandatory company-specific data used;
- check the correct application of the electricity modelling rules prescribed in the

[10] https://eplca.jrc.ec.europa.eu/permalink/PEF_method.pdf

Annex IV;

- assess and confirm whether the calculation methodologies applied are of acceptable accuracy, reliable, are appropriate and performed in accordance with Annex IV;
- confirm the correct application of conversion of measurement units;
- check if applied sampling procedures are in accordance with the sampling procedure defined in Annex IV;
- evaluate whether the methods for making estimates are appropriate and have been applied consistently;
- assess alternatives to estimations or choices made to determine whether a conservative choice has been selected;
- identify uncertainties that are greater than expected and assess the effect of the identified uncertainty on the final results.

6.4. Where the notified body concludes that the carbon footprint is reliable, credible and correct, and that it was calculated in compliance with the calculation rules set out in Annex IV it shall issue a carbon footprint certificate to the manufacturer.

The following elements and aspects shall be included in the certificate, as a minimum:

- an identifier (e.g. commercial name) of the product model to which the footprint relates, together with the exact value of the carbon footprint (total and separated per life cycle stage);
- the name and address of the manufacturer;
- the verifiers with the identification of the lead verifier;
- the conclusions of the examination and the conditions (if any) for its validity;
- any limitations of the verification outcomes;
- date in which the certificate has been issued;
- signature by the verifiers and identification number of the notified body.

A verification report shall be annexed to the carbon footprint certificate. The report shall include all findings of the verification process, the actions taken by the manufacturer to answer the comments of the verifiers, and the final conclusion. It shall also include documents proofing the qualifications of the verifiers in line with Section 8.3.1 of the updated PEF method.[11] The report is mandatory, but it may be confidential.

Where the carbon footprint does not satisfy the applicable requirements, the notified body shall refuse to issue a certificate and shall inform the applicant accordingly, giving detailed reasons for its refusal.

The maximum validity of the certificate shall not exceed three years starting from its issue

[11] https://eplca.jrc.ec.europa.eu/permalink/PEF_method.pdf

date.

6.5. During validity period, the manufacturer shall keep the notified body that has issued the certificate informed of any modifications to the relevant product or its production process that might lead to relevant changes in the carbon footprint as calculated in line with Annex IV.

In case:

- the bill of materials, including their origin, changes,
- the energy mix used to produce the product changes, or
- the carbon footprint worsens by more than 10.0% compared to the verified data,

the manufacturer shall immediately re-calculate the carbon footprint and lodge a new application for verification pursuant to point 6.1. The initial certificate ceases to be valid after the verification decision taken pursuant to point 6.4 in relation to the re-calculated carbon footprint. If the manufacturer does not lodge an application for the verification of a re-calculated footprint, the notified body shall withdraw the initial certificate.

7. Surveillance under the responsibility of the notified body

7.1. The purpose of surveillance is to make sure that the manufacturer duly fulfils the obligations arising out of the approved quality system and that the verified carbon footprint remains representative of the relevant product and its production process.

7.2. The manufacturer shall, for assessment purposes, allow the notified body access to the design, manufacture, inspection, testing and storage sites, and shall provide it with all necessary information, in particular:

— the quality system documentation,

— the quality records as provided for by the design part of the quality system, such as results of analyses, calculations, tests, etc.,

— the quality records as provided for by the manufacturing part of the quality system, such as inspection reports and test data, calibration data, qualification reports on the personnel concerned, etc.;

— any documentation relevant for judging the continued reliability of the (updated) company-specific data.

7.3 The notified body shall carry out periodic audits to make sure that the manufacturer maintains and applies the quality system and to ensure that the content of the verified carbon footprint is still consistent with the current situation. In addition, the notified body shall carry out periodic audits of any other production site that relevant company-specific data refers to. It shall provide the manufacturer with an audit report.

Audits shall take place at least once per year. In preparation for each audit, the manufacturer shall update the company-specific data used in the calculation of the carbon footprint and provide the notified body with the updated version of the application referred to in point 6.1.

In addition to the on-site inspection, the audit may also include documental review. The checks performed in relation to the carbon footprint shall focus on the parameters that according to the verifiers might lead to relevant changes in the carbon footprint. A non-exhaustive list of such parameters is:

- bill of material/ bill of components;
- energy mix used in production;
- change of packaging;
- changes in the suppliers (materials/ geography);
- changes in the logistics;
- relevant technological changes

The notified shall in particular check whether the company-specific data is reliable and was updated correctly, including by verifying whether the data remains representative of the processes and related inputs and outputs it relates to.

If the notified body finds changes to the relevant product or its production process that indicate that the approved carbon footprint may no longer be representative of the product and its production process, and shall determine whether such changes require recalculation in line with point 6.5. If so, the notified body shall inform the manufacturer accordingly.

7.4. In addition, the notified body shall pay unexpected visits to the manufacturer. During such visits, the notified body shall check the proper functioning of the quality system. In addition, it shall carry out checks to ensure that the content of the verified carbon footprint and company-specific data is still consistent with the current situation as specific in point 7.3. It shall provide the manufacturer with a visit report and, if tests have been carried out, with a test report.

Reasons for initiating unexpected visits shall include, but are not limited to:

- The notified body becoming aware of non-conformities of products placed on the market by the relevant manufacturer with any requirement of this Regulation;
- The notified body having reason to believe such non-conformities exist.

7.5. If during surveillance the notified body finds deficiencies in the quality system that might have affected the conformity of products placed on the market by the relevant manufacturer with the requirements of this Regulation, including but not limited to the requirements set out in Annex II Parts 1, 2 and 4.2, it shall inform the market surveillance authority of the notifying Member State.

8. Conformity marking and declaration of conformity

8.1. The manufacturer shall affix the required conformity marking set out in the legislative instrument, and, under the responsibility of the notified body, the latter's identification number to each individual product that is in conformity with the carbon footprint certificate for the relevant product model and satisfies the applicable requirements of the legislative instrument. The identification number shall be followed by an identifier of the requirements in relation to which the relevant notified was involved.

8.2. The manufacturer shall draw up a written declaration of conformity for each product model and keep it at the disposal of the national authorities for 10 years after the product has been placed on the market. The declaration of conformity shall identify the product model for which it has been drawn up.

A copy of the declaration of conformity shall be made available to the relevant authorities upon request.

9. The manufacturer shall, for a period ending at least 10 years after the product has been placed on the market, keep at the disposal of the national authorities:

—the documentation referred to in point 5.1 and 6.1,

—the change referred to in point 5.5, as approved,

—the decisions and reports of the notified body referred to in points 5.5, 6.4, 7.3 and 7.4,

— a copy of the carbon footprint certificate, its annexes and additions.

10. Each notified body shall inform its notifying authorities of quality system approvals issued or withdrawn, and shall, periodically or upon request, make available to its notifying authorities the list of quality system approvals refused, suspended or otherwise restricted.

Each notified body shall inform the other notified bodies of quality system approvals which it has refused, suspended or withdrawn, and, upon request, of quality system approvals which it has issued.

In addition, it shall inform its notifying authorities concerning the carbon footprint certificates which it has issued or withdrawn, and shall, periodically or upon request, make available to its notifying authorities the list of certificates refused, suspended or otherwise restricted. Each notified body shall inform the other notified bodies concerning the carbon footprint certificates which it has refused, withdrawn, suspended or otherwise

restricted, and, upon request, concerning the certificates and/or additions thereto which it has issued.

The Commission, the Member States and the other notified bodies may, on request, obtain a copy of the carbon footprint certificates. On request, the Commission and the Member States may obtain a copy of the technical documentation and the results of the examinations carried out by the notified body. The notified body shall keep a copy of the certificate, its annexes and additions, as well as the technical file including the documentation submitted by the manufacturer, until the expiry of the validity of the certificate.

11. Authorised representative

The manufacturer's obligations set out in points 3, 5.1, 5.5, 8 and 9 may be fulfilled by his authorised representative, on his behalf and under his responsibility, provided that they are specified in the mandate.

*ANNEX VI*

**Verification procedure for market surveillance purposes**

The verification tolerances defined in this Annex relate only to the verification by Member State authorities of the declared values and shall not be used by the manufacturer, importer or authorised representative as an allowed tolerance to establish the values in the technical documentation or in interpreting these values with a view to achieving compliance or to communicate better performance by any means.

Where a model has been designed to be able to detect it is being tested (e.g. by recognising the test conditions or test cycle), and to react specifically by automatically altering its performance during the test with the objective of reaching a more favourable level for any of the parameters specified in this Regulation or included in the technical documentation or included in any of the documentation provided, the model and all equivalent models shall be considered not compliant.

As part of verifying the compliance of a product model with the requirements laid down in this Regulation pursuant to Article 3(2) of Directive 2009/125/EC, the authorities of the Member States shall apply the following procedure for the requirements referred to in Annex II:

1. The Member State authorities shall verify one single unit of the model, except for the requirements referred to in Annex II Part 1.1 (design for reliability of photovoltaic modules), where the test shall be performed with ten units of the model, and the requirements referred to in Annex II 4.2 (design for reliability of photovoltaic inverters), where the test shall be performed with three units of the model.

2. The model shall be considered to comply with the applicable requirements if:

(a) the values given in the technical documentation (declared values), and, where applicable, the values used to calculate these values, are not more favourable for the manufacturer, importer or authorised representative than the results of measurements on the ecodesign requirements carried out; and

(b) the declared values meet any requirements laid down in this Regulation, and any required product information published by the manufacturer, importer or authorised representative does not contain values that are more favourable for the manufacturer, importer or authorised representative than the declared values or the carbon footprint as reported in a carbon footprint certificate applicable to the relevant product that is confirmed by the responsible notified body, upon request of the relevant Member State authority, to have been valid at the time of the placing on the market; and

(c) in case the manufacturer is still manufacturing the relevant product, the manufacturer operates a quality system in line with Annex V and this is confirmed by the responsible notified body upon request of the relevant Member State authority; and

(d) any required product information has been published by the manufacturer in the manner prescribed and is reliable, credible and correct; and

(e) when the Member State authorities check the unit of the model, they check whether the manufacturer, importer or authorised representative has put in place a system that complies with the requirements in the second paragraph of Article 6; and

(f) when the Member State authorities check the units of the model, it complies with the requirements referred to in Annex II Part 1.1 (for photovoltaic modules) and Annex II Part 4.2 (for photovoltaic inverters); and

(g) when the Member State authorities test the unit of the model, the determined values (the values of the relevant parameters as measured in testing and the values calculated from these measurements) comply with the respective verification tolerances as set out in Table 3B.

3. If the results referred to in point 2(a), (b), (c), (d), (e) or (f) are not achieved the model and all equivalent models shall be considered not to comply with this Regulation.

4. If the result referred to in point 2(g) is not achieved, the Member State authorities shall select three additional units of the same model for testing. As an alternative, the additional units selected may be of one or more equivalent models.

5. The model shall be considered to comply with the applicable requirements if, for these units, the arithmetical mean of the determined values complies with the respective verification tolerances set out in Table 3B.

6. If the result referred to in point 5 is not achieved, the model and all equivalent models shall be considered not to comply with this Regulation.

7. The Member State authorities shall provide all relevant information to the authorities of the other Member States and to the Commission without delay once a decision has been taken on the non-compliance of the model according to points 3, 6 or the second paragraph of this Annex.

The Member State authorities shall use the measurement and calculation methods set out in Annex III.

The Member State authorities shall only apply the verification tolerances that are set out in Table 3B and shall use only the procedure described in points 1 to 7 for the requirements set out in this Annex. For the parameters in Table 3, no other tolerances, such as those set out in harmonised standards or in any other measurement method, shall be applied.

*Table 3B*

| Parameter | Verification tolerances |
|---|---|
| Energy yield DC | The determined value (*) shall not be less than 0.97 times the declared value |
| Euroefficiency | The determined value (*) shall not be less than 0.99 times the declared value |
| System efficiency at 25% of nominal power | The determined value (*) shall not be less than 0.99 times the declared value |

(*) In the case of three additional units tested as prescribed in point 4, the determined value means the arithmetical mean of the values determined for these three additional units.

*ANNEX VII*

**Benchmarks**

At the time of entry into force of this Regulation, the best available technology on the market was identified as follows.

Photovoltaic modules:

(a) energy yield DC: 832 KWh for Sub Tropical arid climate
(b) lifetime performance degradation rate: 0.50%/year

Photovoltaic inverters:

(a) euroefficiency: 98%

(b) system efficiency at 25% of nominal power, for photovoltaic inverters with possibility to connect storage or with integrated storage: tbd