SolarPower Europe

Input paper for the EC/JRC preparatory study on sustainable product policies for PV panels and inverters

13 September 2017

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Acronyms

AC	Alternating current
CAPEX	Capital expenditure
CENELEC	European Committee for Electrotechnical Standardization
CLP	Classification, Labelling and Packaging (CLP) Regulation ((EC) No 1272/2008)
c-Si	Crystalline silicon
DC	Direct current
EC	European Commission
EPBT	Energy pay-back time
EROI	Energy return on energy invested
EU	European Union
GPP	Green public procurement
ICT	Information and communication technology
IEA PVPS	International Energy Agency Photovoltaic Power Systems Programme
IEC	International Electrotechnical Commission, the international standards and conformity assessment body for all fields of electrotechnology
JRC	Joint Research Centre
LCA	Life cycle assessment
LCOE	Levelised cost of electricity
MEErP	Methodology for the Ecodesign of Energy-related Products
NSF	NSF International, an independent public health and safety organisation that independently tests, audits, certifies, trains and consults for the food, water, health science, sustainability and consumer product sectors
OPEX	Operational expenditure
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
PERC	Passivated Emitter and Rear Cell
PID	Potential Induced Degradation
PV	Photovoltaic
PVDI	PV Durability Initiative
REACH	EU Regulation concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (Regulation (EC) No 1907/2006)
RoHS	EU Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (Directive 2011/65/EU)
WEEE	EU Directive concerning Waste of electrical and electronic equipment (Directive 2012/19/EU)

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1. Introduction

In the framework of the Ecodesign Working Plan 2016-2019, the European Commission is currently exploring the potential of sustainable product policies such as Ecodesign, Energy Labelling and Ecolabel and Green Public Procurement for PV panels and inverters. The Ecodesign and Energy Labelling Directives are the two pillars of the European policy for energy efficient products. Products covered by the Ecodesign Directive can only be put on the European market if they fulfil minimum requirements related to energy efficiency and circular economy. The EU Ecolabel is a voluntary label promoting environmental excellence by identifying products and services with reduced environmental impact.

After including PV panels and inverters in the Ecodesign Working Plan in December 2016, the European Commission decided to mandate the Joint Research Centre (JRC) to carry out a comprehensive preparatory study to evaluate and assess if and which of the following regulatory options would be best suited for this product group: Ecodesign, Energy labelling, Ecolabelling, or Green Public Procurement (GPP). SolarPower Europe would like to support the JRC preparatory study by providing comprehensive technical and market related data. In line with previous communications on this matter with EU regulators, we have full confidence that this data will help to accurately assess the different regulatory options and will lead to recommendations in line with the overall objective of the Ecodesign Working Plan, which is to increase the environmental performance of PV systems on the EU market and to further the decarbonisation of the EU energy system in line with the Paris Agreement.

SolarPower Europe would like to actively participate in the stakeholder consultations linked to the preparatory study, and is prepared to share views on the methodologies to be used, drafts, preliminary results and final results of the preparatory study. We wish to underline, however, that SolarPower Europe does not currently (as of September 2017) have a position on whether Ecodesign, Energy label, Ecolabel, GPP or a combination of these instruments should be used for PV or not.

In Chapter 2, we present our preliminary high-level considerations regarding European sustainable product policies for PV. In Chapter 3, we specify parameters that could be included in the MEErP methodology to evaluate the potential of eco-design for PV. Chapter 4 summarises our recommendations and suggestions. Chapters 5 and 6 provide a list of references of market information and documents that we consider relevant given the objective of the preparatory study.

This Input Paper has been prepared by SolarPower Europe's Environmental Footprint Task Force.

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2. Preliminary considerations

2.1 Interactions between different policies

A synchronised approach for the joint preparatory study for Ecodesign, Energy label, Ecolabel and GPP:

As stated in the letter sent by SolarPower Europe to the European Commission on 17 March 2017, careful attention should be paid to the interactions between ecodesign and ecolabel as well as any further potential sustainable product policies. **A streamlined approach is needed in order to avoid potential duplications or delays.**[1]

Interactions between Ecolabel and the RoHS Directive (technology neutrality):

As stated in the SolarPower Europe letter sent to the European Commission in March 2017, no technologies should be excluded a priori from the scope of Ecolabel.[2] Difficulties which may arise because of **articles 6.6 and 6.7 of the Ecolabel Regulation should be taken into account by the European Commission and the JRC from the beginning of the process.**

Coherence between EU sustainable product policies and the EU electricity market legislation:

The preparatory study should fully take into account the increasing complexity of the EU electricity system, since the main challenge for the environmental performance of new PV installations is not only the internal efficiency of the PV system itself, but also the lack of flexibility of the electricity system (which leads to curtailment of renewable electricity generation capacities.[3])

Coherence between EU product legislation and EU electricity market legislation which is currently under revision is necessary. Although the market is not yet fit for renewables (lack of flexibility, openness, granularity), EU decision makers are currently willing to strengthen the integration of renewables on a market basis, arguing that a strict approach towards competition is key for the development of the EU energy market. SolarPower Europe favours a stepwise approach towards the market-based development of renewables in order to ensure fair competition and a level playing field. Some of the measures being discussed in the EU electricity market legislation process would make the development of solar power more difficult, which will eventually have environmental impacts. As an example, the removal of priority dispatch and priority access for renewables would cause an increase

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[1] "[SolarPower Europe] consider that these different building blocks should be used as much as possible in a consistent manner to avoid potential duplications or delays as it seems that some elements of the EU Ecolabel process may be used within the context of the eco-design process. A streamlined approach which would at the same time preserve the respective timelines of both processes is needed." (SolarPower Europe, 2017a)

[2] "No technologies should be excluded a priori from the scope of the Ecolabel. This raises the question of the compliance with Article 6.6 and 6.7 of the Ecolabel Regulation, for which a thorough consultation of potentially affected industrial stakeholders should take place before a decision is taken on which criteria to develop and retain. To our knowledge, this has not been the case so far and we expect that such a consultation will take place in the context of the upcoming work." (SolarPower Europe, 2017a)

[3] "[I]n 2014 [in Germany], 1.6 TWh of wind/PV and biomass generation (ca. 1.2% of total generation from these sources) were curtailed. (…) [In Spain,] the amount of curtailment is expected to increase to yearly 2.3 TWh (3.1% of renewable generation) in 2020. In Italy, the amount of curtailed wind energy was reduced from 10.7% in 2009 to 1.24% in 2013 due to a significant reinforcement of the transmission grid capacities. In Ireland, 110 GWh wind energy were curtailed in the year 2012. This is approximately 2% of the total wind generation. (…) With increasing renewable shares, the curtailed amount of energy consequently grows. Therefore, considering curtailment will be of increasing importance in the future." (Kies et al., 2016).

of 11% of CO_2 emissions of the electricity system according to the European Commission impact assessment. Increasing curtailment ratios would, by far, outweigh the potential benefits of component / PV system optimisation. The preparatory study should fully take into account the relation between the benefits gained due to sustainable product policies on the one hand and the economic and regulatory environment that the solar power sector is currently facing on the other hand and ensure that EU legislation ensures, overall, a level playing field for the development of the solar power sector in Europe.

Relevance for industrial policy:

Primarily aimed at enhancing the environmental performance of products used in Europe, **European sustainable product policies can have implications for industrial policy**. As such the preparatory study should take into account the industrial base existing in Europe and that new policies should not affect negatively these industries. It should also be remembered that sustainable product policies taken on module level would mainly affect non-EU manufacturers.

2.2 Suitability of sustainable product policies for solar PV

In line with the considerations provided by the Ecodesign Directive[4] and the EC Communication on the Ecodesign Working Plan 2016-2019 (European Commission, 2016), SolarPower Europe asks that the suitability of Ecodesign for PV be thoroughly assessed. The sector has indeed shown a very dynamic development over the last decade, including the emergence of new technologies, the increase of conversion efficiencies and the rapid decrease of manufacturing costs as well as resource, materials and energy use per unit produced.

The significant downward trend of manufacturing costs of PV modules is illustrated by the learning curve in Figure 1. (Learning rate is defined as the rate at which unit costs decrease with each doubling of historical global cumulative production. In calculating long-term cost learning curves, price can be used as a proxy for module manufacturing cost.)

In addition, the energy learning rate (which describes how energy demand for establishing PV systems decreases with each doubling of the cumulative installed capacity) of PV modules should also be considered. The average energy learning rate of PV modules is around 17%-20% (Görig et al, 2012), which demonstrates the trend of PV modules becoming more environmentally friendly over time. At the same time, the high speed of cost reduction disrupts the PV market, and may entail the risk that environmentally friendly solutions are disadvantaged in order to sustain the cost reduction expected in the market.

Looking at the average Levelised cost of electricity (LCOE) of utility-scale PV systems, the cost decline has also been significant, with an LCOE decrease of more than 50% between 2010-2015 and an expected to fall by 59% between 2015-2025 (IRENA, 2016).

It should also be taken into consideration, that rapid research and development cycles in the PV industry also lead to the emergence of ”quantum-jump” technologies (such as diamond wire sawing of Passivated Emitter and Rear Cell, PERC technology) in fairly short timespans and that the trajectory towards double-digit terawatt capacities by the mid of the century – which is required to stay within the boundaries of the Paris Agreement (Haegel et.al., 2017) – will require further significant growth and efficiency improvements in all parts of the solar PV value chain.

Current industry expectations are that these trends will continue, hence the technology landscape after the finalisation of the preparatory study and the Ecodesign/Ecolabel regulatory process should differ significantly from the landscape seen today.

Therefore, SolarPower Europe call on the European Commission and JRC to:

[4] "[T]he product shall present significant potential for improvement in terms of its environmental impact without entailing excessive costs, taking into account in particular: (i) the absence of other relevant Community legislation or failure of market forces to address the issue properly" (Ecodesign Directive, 2009)

- **consider the necessity for the preparatory study, the regulatory process, as well as potential future sustainable product policie(s)to keep pace with the progress of technology,**
- **ensure that potential future sustainable product policies will lead to products with better environmental performance than those industry would have developed without such policies.**

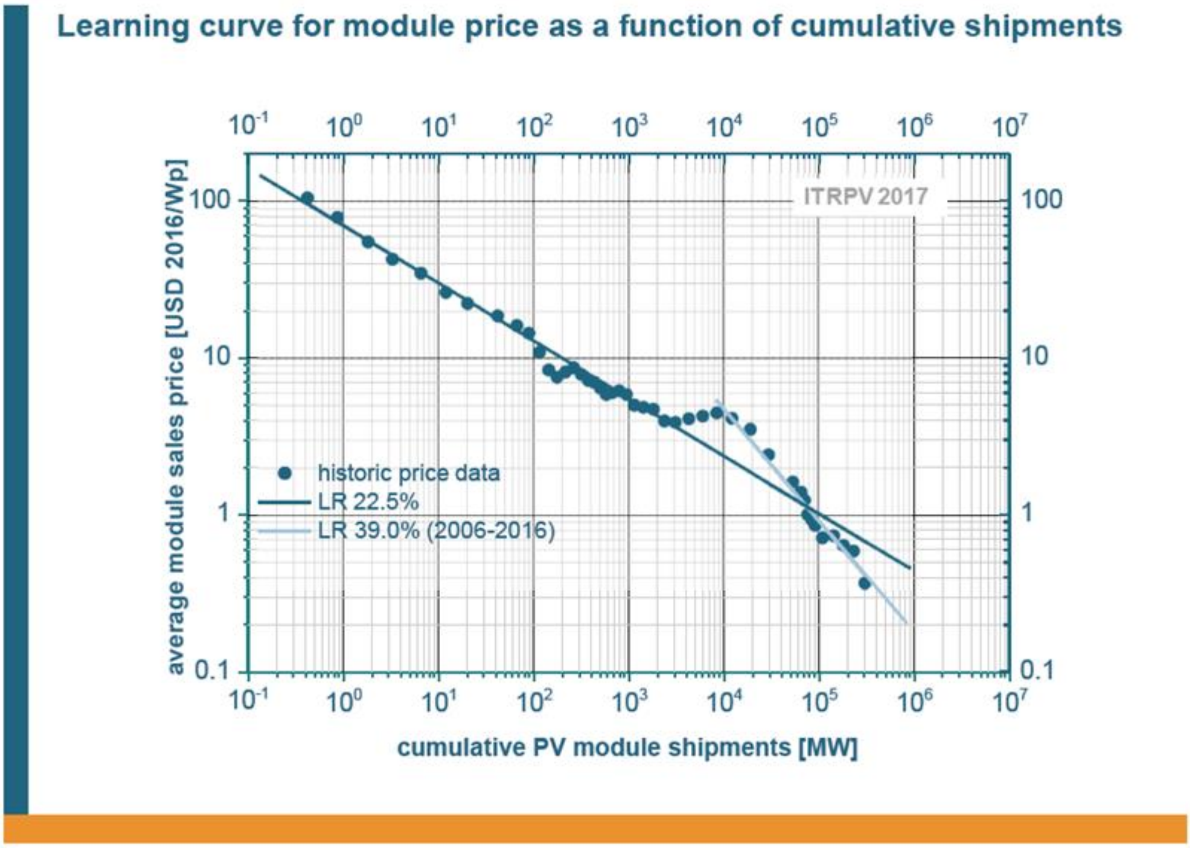

Fig. 55: Learning curve of module price as a function of cumulative PV module shipments and calculated learning rates for the period 1979 to 2016 and 2006 to 2016 respectively.

Figure 1 - Learning curve for PV module price (ITRPV, 2017)

The preparatory study should also draw on the experience of comparable product groups such as solar heaters (as an energy generating product group) or ICT products (as a very fast-moving sector) with sustainable product policies such as Ecodesign, Energy labelling and Ecolabel. For example, solar heaters are covered by Ecodesign Regulations EU 813/2013 and EU 814/2013 and Energy Labelling Regulations EU 811/2013 and EU 812/2013. The results presented in deliverable D4.1 "Package Label implementation assessment report" and the project poster[5] of the LabelPack A+ project funded by the EU's Horizon 2020 programme (grant agreement No. 649905) provide a useful insight in the strengths, weaknesses, opportunities and threats linked to the solar heater energy label. LabelPack A+'s assessment suggests that the solar heater energy label is not properly understood by clients and is considered an extra effort with little marketing value by installers. As for ICT products, the European Commission concludes that "it has proven very difficult to make a reliable estimate of their energy savings potential, given the uncertainty about future market developments. Moreover, for the fast moving ICT product sectors, questions have arisen as to the suitability of the ecodesign/energy labelling process (which takes on average around 4 years) for establishing minimum energy and resource efficiency criteria" (European Commission, 2016).

[5] LabelPack A+ project poster: http://www.label-pack-a-plus.eu/wp-content/uploads/2017/05/20170505_LPA_poster.pdf

2.3 Further enhancing environmental performance

Any possible future sustainable product policy should enhance the energy, environmental and material efficiency and safety of solar products while creating business opportunities, in line with Ecodesign Working Plan 2016-2019.[6] The preparatory study should take into consideration how the industry and technology is developing without such measures in place. SolarPower Europe could contribute to this evaluation.

With regard to environmental performance improvement, the preparatory study should closely evaluate the currently available enhanced life cycle, quality and reliability testing standards which are applied across the board by all tier 1 manufacturers – hence the evaluation of the state-of-the-art should go beyond the IEC tests and also closely look at the standards and other non-standard tests listed in the tables below to evaluate the current quality of the solar products.

It should be noted that product lifetime, an important variable of life cycle analyses, has a significant influence on environmental performance and resource efficiency. We wish to stress that current attempts to capture lifetime, such as standards and non-IEC initiatives, do not provide reliable information on real lifetime and lifetime variations in different climatic or operating conditions. Existing LCA analyses are based on theoretical lifetimes which are not yet proven. In the absence of proven lifetime data, the lifetime warranties provided by manufacturers can be used as a proxy for product lifetime.

Module Third Party Test (Standards)	**Description/Purpose**
IEC 61215 and 61646 Design Qualification and Type Approval	IEC 61215 and IEC 61646 tests (c-Si and thin film, respectively, and soon to be replaced by 61215-2) are the minimum performance and reliability tests that a PV module has to meet. They are required for standard design qualification and type approval. All modules on the market have this certification. The tests include: • Bypass diode (for c-Si) • Mechanical loading • Thermal cycling • Humidity exposure • Light exposure • Hot spots • Validation of data sheet parameters Each sub-test is carried out on its own new panel. Generally, the pass criteria is <5% power degradation during the accelerated test.

[6] "Ecodesign, complemented by energy labelling rules, supports the Commission's overarching priority to strengthen Europe's competitiveness and boost job creation and economic growth; it ensures a level playing field in the internal market, drives investment and innovation in a sustainable manner, and saves money for consumers while reducing CO2 emissions. (…) The Ecodesign and Energy Labelling legislative framework has the dual purpose of ensuring that more energy-efficient products come to the market (through ecodesign) while encouraging and empowering consumers to buy the most efficient products based on useful information (through energy labelling). By doing so, it reduces the energy consumption of consumers and businesses, and thereby their energy and utilities bills. Furthermore, it safeguards the internal market and prevents unnecessary costs for business and consumers due to divergent national requirements." (European Commission, 2016)

IEC 62804 Test methods for the detection of potential-induced degradation (PID)	This test applies a voltage bias whilst simultaneously subjecting the module to thermal and humidity stress and measures the resulting power loss to simulate loss of performance which can occur due to high potential differences between module cells and ground. Metallic framed modules tend to be more susceptible to Potential Induced Degradation (PID). Whilst most modules have this certification, it is rare for the test to cover the entire combination set of the module Bill of Materials.
IEC 61701 Salt Mist Corrosion	This test is designed to assess module performance in marine environments. The salt content in the air increases the risk of corrosion of the frame, cell interconnections and all metal parts.
IEC 62716 Ammonia Resistance	This test is designed to test modules installed in agricultural regions. Ammonia from fertilizer has been found to accelerate the corrosion of cells and polymers in some modules.
IEC 60068-2 Desert sand resistance	This third party test evaluates the effect of sand on the insulation of a module (e.g. the junction box, module cables, edge seal etc). It also assesses the effect of sand abrasion on module performance.

Module Third Party Test (Non-standard lab tests)	**Description/Purpose**
Independent Thresher Test	The thresher test is a type of test-to-failure assessment that subjects modules to stresses such as thermal cycling and damp heat until module failure. It is used to identify primary failure modes and acceleration coefficients. The Independent Thresher Test is implemented based on a determined number of repetitions and has set pass criteria.
Long-term Sequential Test	This is a third party pass/fail extended reliability test which goes beyond the general IEC61215 test (minimum requirement). While the IEC61215 test applies each sub-test to a separate (new) module, the sequential test runs various IEC 61215 tests (DH, TC200, HF) sequentially on the same panel (one test after the other). While this test is designed to simulate harsher real-world conditions where modules are subjected to multiple stress modes simultaneously, it doesn't identify the exact failure mechanism.
Atlas 25+	The Atlas test is a pass/fail assessment designed to provide a theoretical equivalence to 25 years of in-field operation. Similar to the sequential test, it exposes the same modules to UV exposure, thermal cycling, and humidity, but does so simultaneously at stress levels calculated to theoretically accelerate a 25 year lifetime. However, there is no scientific evidence that the test is equivalent to 25ys in the field exposure.
Fraunhofer – PV Durability Initiative (PVDI)	The Fraunhofer PV Durability Initiative test is similar to the thresher test. Fraunhofer PVDI test runs to a specific number of cycles and provides modules a score out of 5 for their performance.
CERTISOLIS – Carbon footprint assessment	CERTISOLIS delivers Carbon Footprint certificates according to French tenders requirements based on calculation Gwp using standard values or LCA values according to ISO 14040.

Inverter Third Party Test	Description/Purpose
EC 61683:1999 Measurement of photovoltaic system efficiency	Guidelines for measuring the efficiency of power conditioners used in stand-alone and utility-interactive photovoltaic systems, where the output of the power conditioner is a stable a.c. voltage of constant frequency or a stable d.c. voltage.
Class 4K4H as in IEC 60721-3-4 Classification of environmental conditions	Groups of environmental parameters and their severities to which products are subjected when mounted for stationary use at locations which are non-weather protected, including periods of erection work, downtime, maintenance and repair.
IEC 62093:2005 (currently under review) Balance-of-system components for photovoltaic systems - Design qualification natural environments	Sets requirements for the design qualification of balance-of-system (BOS) components used in terrestrial photovoltaic systems. Is suitable for operation in indoor, conditioned or unconditioned; or outdoor in general open-air climates, protected or unprotected. Is written for dedicated solar components such as batteries, inverters, charge controllers, system diode packages, heat sinks, surge protectors, system junction boxes, maximum power point tracking devices and switch gear, but may be applicable to other BOS components.
IEC 60068-2-1 Cold test	Cold tests applicable to both non heat-dissipating and heat-dissipating specimens.
IEC 60068-2-2 Dry heat test	Dry heat tests applicable both to heat-dissipating and non heat-dissipating specimens.
IEC 60068-2-14 Rapid changes of temperature test	Test to determine the ability of components, equipment or other articles to withstand rapid changes of ambient temperature.
IEC 60068-2-30 Damp heat test	Determines the suitability of components, equipment or other articles for use, transportation and storage under conditions of high humidity – combined with cyclic temperature changes and, in general, producing condensation on the surface of the specimen.
EN 60068-2-52 Salt Mist test	This test applies to components or equipment designed to withstand a salt-laden atmosphere, depending on the chosen severity. Salt can degrade the performance of parts manufactured using metallic and/or non-metallic materials. The mechanism of salt corrosion in metallic materials is electrochemical, whereas the degradation effects experienced on non-metallic materials are caused by complex chemical reactions of the salts with the materials involved. The rate at which corrosive action takes place is dependent, to a large extent, on the supply of oxygenated salt solution to the surface of the test specimen, the temperature of the specimen and the temperature and humidity of the environment. Apart from the corrosive effects, this test may be used to indicate deterioration of some non-metallic materials by assimilation of salts. In the following test methods, the period of spraying with the relevant salt solution is sufficient to wet the specimen thoroughly.
TÜV Rheinland 2PfG 1911/04.16 Ammonia Corrosion test)	This test derives from the IEC 62716. It is used to test inverters installed in agricultural regions, where the risk of contact with ammonia may accelerate the corrosion of inverters.

Low voltage directive 2014/35/EU	Rules for making available on the market electrical equipment designed for use within certain voltage limits.
EMC directive 2014/30/EU	The EMC Directive first limits electromagnetic emissions from equipment in order to ensure that, when used as intended, such equipment does not disturb radio and telecommunication as well as other equipment. The Directive also governs the immunity of such equipment to interference and seeks to ensure that this equipment is not disturbed by radio emissions when used as intended.
Radio Equipment Directive 2014/53/EU	The Directive ensures a single market for radio equipment by setting essential requirements for safety and health, electromagnetic compatibility and the efficient use of the radio spectrum. It applies to all products using the radio frequency spectrum.

Furthermore we recommend to get in touch with the CENELEC Technical Committee 10, which is working on the "Standardisation request to the European standardisation organisations as regards ecodesign requirements on material efficiency aspects for energy-related products in support of the implementation of Directive 2009/125/EC of the European Parliament and of the Council" issued by the European Commission to CEN and CENELEC on 2015-12-17, as part of Commission Implementing Decision C(2015) 9096 (CENELEC, 2017).

2.4 Boundaries of the product group "PV system"

As mentioned in Section 2.1, it is of utmost importance to adopt a streamlined and consistent approach to evaluating the various regulatory options.

As the final product that is placed on the market is the PV system, and also because Ecodesign is aimed at end-user products rather than components and sub-assemblies[7], we suggest that the analysis in the preparatory study should consider the complexities of the PV system with modules, inverters etc. being components thereof. The installation process, which affects the environmental performance of the "end product" should also be taken into account. The challenge will be how to account for the considerable number of possible combinations of different components.

SolarPower Europe therefore suggests to differentiate:

- between residential, commercial and utility-scale installations
- between central, string and microinverters
- between ground-mounted vs rooftop installations
- between systems with and without storage
- between PV systems with tracker (1-2 axes) and without tracker.

Also, PV systems are becoming increasingly complex and "smart" with new functionalities such as storage services, grid services, smart meters, performance monitoring, internet connectivity etc. The state of PV installations today means that product complexity in the PV sector is comparable to that of ICT products. This raises questions such as: who guarantees the performance of a PV system? Will it be the panel producer or the inverter manufacturer?

Although the preparatory study analysis should be carried out on the PV system level, a possible outcome of the preparatory study could still be a recommendation to implement measures on component (e.g. module) level.

[7] "'Components and sub-assemblies' means parts intended to be incorporated into products which are not placed on the market and/or put into service as individual parts for end-users or the environmental performance of which cannot be assessed independently;" (Ecodesign Directive, 2009)

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3. Parameters to evaluate in the Preparatory Study

The Methodology for the Ecodesign of Energy-related Products (MEErP) has been mainly used to draft implementation measures on the energy consumption of energy-related products. However, the MEErP can also be used to assess other resource-related parameters, specifically parameters related to material efficiency and the circular economy[8]. Including circular economy-related parameters in the Preparatory Study will be in line with the Ecodesign Working Plan 2016-2019[9]. In the following sections, SolarPower Europe gives examples of parameters to be evaluated in the Preparatory Study.

3.1 Unit of analysis

As outlined in Section 2.4 above, the preparatory study should consider the entire PV system, including the modules, the inverters, BoS, as well as the installation process and the entire value chain. In the analysis carried out on the PV system level, the unit of analysis should be 1 kWh of AC electricity. There should be a distinction between the following types of kWh:

- 1 kWh AC generated in the building for self-consumption (on site self-generation – not subject to curtailment, enhanced through storage unit)
- 1 kWh AC generated on site and fed into the grid system (subject to curtailment). The provision of ancillary services (storage, active/re-active power, frequency stabilisation etc.) has to be considered as well.
- A mixed case with a part of the generated kWh AC is self-consumed with the excess fed into the grid.

If the preparatory study conducted at PV system level finds that a sustainable product policy(such as Ecolabel) on module level (rather than PV system level) would make sense, then the unit of measurement for defining the eligibility requirements of PV modules should be 1 kWh of DC electricity. (In line with the PEFCR for PV modules, where the unit of analysis is 1 kWh of DC electricity.)

The necessity to differentiate between several types of electricity and consider ancillary services shows how difficult measuring PV generated electricity is compared to electricity consumed by most appliances currently covered by Ecodesign/Ecolabel. SolarPower Europe suggest to discuss this issue in the planned workshop with the European Commission and JRC.

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[8] "The study assesses further available methods to evaluate material efficiency, and whether these could be adapted for ecodesign purposes (…) [T]he most significant parameters regarding material efficiency that may be used in MEErP (…) are: Recyclability benefit rates (…); Recycled content (…); Lifetime (…); and Critical Raw Material Index (…)." (BIO Intelligence Service, 2013)

[9] "The Ecodesign directive already covers all significant environmental impacts along the life-cycle of products but the focus so far has been on energy efficiency improvements. In future, Ecodesign should make a much more significant contribution to the circular economy, for example by more systematically tackling material efficiency issues such as durability and recyclability." (European Commission, 2015)

The following parameters should be evaluated on the basis of the unit of analysis.

3.2 Energy-related parameters

SolarPower Europe suggest that the following energy-related aspects be considered to form the basis for the main Ecodesign/Ecolabel etc. requirements for PV:

- Lowest LCOE (€/kWh AC)
    - Lowest System CAPEX and OPEX (€) + financing parameters (€)
    - Highest Lifetime Energy Yield (MWh AC)
    - Conversion efficiency / degradation / longevity of system components
    - Installation parameters (tilt, orientation, optimisation)
    - System feedback (ancillary services, curtailment …)
- Energy Pay-Back Time (EPBT)
- Energy Return on Energy Invested (EROI)
- Energy consumption of specific input factors (e.g. Energy per watt of a PV module),
- Energy use for end-of-life treatment
- Primary energy input per kWh

Consider the energy learning curve describing the decrease of energy needed to produce one unit with each doubling of the cumulative capacity (Görig and Breyer, 2012).

3.3 Other environmental parameters

SolarPower Europe suggest to consider the following non-energy related requirements[10]:

- Lowest Life Cycle Environmental Impact (per MWh AC) / lowest LCOE (€/MWh AC)
    - Integrated LCA / conversion of impact to monetary units
    - PEF impact categories (equal weighting / qualified weighting according to EU environmental priorities …)
- Carbon manufacturing footprint.
- Water consumption (ISO 14046 water footprint standard);

[10] "For solar power, ecodesign measures could e.g. be:
-Energy consumption for extraction of raw materials and for manufacturing
-Water consumption, depletion of scarce resources
-Design for recycling
-Reduction in material usage (e.g. thinner silicon wafers, thin-film modules)
-Favouring solar cell types with non-toxic materials
-Favouring development of polymer solar cells made by simple and easily available polymer material (…)
It is also recommended to include all PV panels and inverters in a possible preparatory study, as mentioned for wind turbines, wider resources aspects and the whole life cycle should be taken into consideration in the study. Energy Pay Back Time or quantifying so-called Embedded Energy could be an aiding tool to MEErP." (Viegand Maagøe in collaboration with VITO, 2013)

- Emissions to air, water and soil (GHG protocol standard);
- Hazardous materials content, toxicity;
- Use of scarce resources, critical minerals.

In terms of transport footprint, the analysis should cover both the transportation required for manufacturing the product (components such as modules and inverters) and the transportation required to establish the installation (moving modules and inverters to the site of installation).

For inverters, the following could be the units of measure:

- GWP: greenhouse warming potential in kg CO2e
- HTP: human toxity potential in kg DCBe
- ADP: abiotic depletion potential in kg Antimony e
- CED: cumulated energy demand in kwh

It is important to take into account the interaction with the following:

- PEFCR and the results of the PEF screening report for electricity from PV panels
- NSF 457 Sustainability Leadership Standard for PV Modules
- RoHS Directive, which excludes from the scope of the Directive "photovoltaic panels intended to be used in a system that is designed, assembled and installed by professionals for permanent use at a defined location to produce energy from solar light for public, commercial, industrial and residential applications" (RoHS Directive, 2011/65/EU article 2.4 (i))
- REACH and CLP
- PEFCR and the results of the PEF screening report for High Specific Energy Rechargeable Batteries for Mobile Applications, when it comes to LCA of PV systems with storage (as of now there has been no PEFCR conducted for stationary batteries)

The Preparatory Study should comprise a PEF screening report of AC electricity of photovoltaic systems.

3.4 Circular economy and material efficiency-related parameters

According to the Ecodesign Working Plan 2016-2019, Ecodesign should make a much more significant contribution to the circular economy with requirements in areas such as:

- durability (e.g. minimum lifetime of products or critical components),
- reparability (e.g. availability of spare parts and repair manuals, design for repair),
- upgradeability,
- design for disassembly (e.g. easy removal of certain components),
- information (e.g. marking of plastic parts) and
- ease of reuse and recycling (e.g. avoiding incompatible plastics),

Interaction with the following:

- PV panels: EU WEEE Directive/CENELEC standards
    - EN 50625-1: Collection, logistics & treatment requirements for WEEE - Part 1: General treatment requirements

    - TS 50625-3-1: Collection, logistics & treatment requirements for WEEE. Specification for de-pollution. General
    - EN 50625-2-4: Collection, logistics & treatment requirements for WEEE -- Part 2-4: Treatment requirements for photovoltaic panels (not yet published)
    - TS 50625-3-5: Collection, logistics & treatment requirements for WEEE -- Part 3-5: Specification for de-pollution- photovoltaic panels (not yet published)
- Comparable standards for inverters
- EN 50548: Junction Boxes for PV modules
- EN 50521: Connectors for PV systems

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4. Recommendations

SolarPower Europe's recommendations and suggestions for the Preparatory Study:

1 **Ensure synergy between the different sustainable product policies** to be evaluated in the preparatory study: the different building blocks should be used as much as possible in a consistent manner to avoid potential duplications or delays as it seems that some elements of the Ecolabel process may be used within the context of the Ecodesign process. A streamlined approach which would at the same time preserve the respective timelines of both processes is needed.

2 **Take into account the increasing complexity of the EU electricity system** and ensure that EU legislation ensures, overall, a level playing field for the development of the solar power sector in Europe.

3 **Take into account sustainable product policies' implications for industrial policy** and that new policies should not affect negatively the solar industry in Europe.

4 **Ensure technology neutrality** and consider Articles 6.6 and 6.7 of the Ecolabel Regulation at the beginning of the preparatory study.

5 Necessity for the preparatory study, the regulatory process, as well as potential future sustainable product policie(s) to be able to **keep pace with the progress of technology**.

6 Make sure that any potential future sustainable product policy should create results that **go beyond "business-as-usual" in terms of enhancing product environmental performance** and material efficiency and creating business opportunities.

7 **The preparatory study analysis should be carried out on the level of the PV system.** Although the preparatory study analysis should be carried out on the PV system level, a possible outcome of the study could still be a recommendation to implement measures on component (e.g. module) level.

8 **Draw on the experience of comparable product groups** with sustainable product policies.

9 **Take into account and draw on related directives, standards and initiatives**.

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5. Sources of technical and market data

SolarPower Europe would like to support the JRC preparatory study by providing comprehensive technical and market related data.

Total PV capacity connected to the grid – SolarPower Europe Global Market Outlook (http://www.solarpowereurope.org/reports/global-market-outlook-2017/)

It is important to distinguish capacities connected to the grid (as in the SolarPower Europe Global Market Outlook) and the shipments of products over a year, which do not necessarily get connected immediately (stored in warhouses, exported). The main measurement parameter under the Ecodesign framework is the number of products placed on the market.

Module shipments data – IHS Solar Research Group, Apricum

Inverters – SMA, ABB, Huawei, IHS Solar Research Group, Apricum

Batteries – EUROBAT

Additional sources:

- IEA PVPS Task12 LCA and Net Energy Analysis Guidelines
- IEC CLC/TC82 (see documents on the EcoDesign Coordination group)
- SPV Market Research - http://www.spvmarketresearch.com/

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