

MEMO

Project: Recyclability index for PV products

Subject: Minutes of the Second Stakeholder Meeting (2024.10.09)

Date: 2024.10.30

To: Stakeholders of the project

Copy to:

From: Viegand Maagøe A/S

Minutes of the meeting

Participants to the meeting

Study Team:

Felice Alfieri (FA) - Viegand Maagøe A/S
 Nieves Espinosa (NE) – University of Murcia
 Cristina Leyre Pinto Fuste (CL) - CENER
 Ana Gracia Amillo (AA) – CENER (connected online)

European Commission / CINEA

Mauricio Richter – CINEA
 Davide Polverini – DG GROW

Stakeholder organisations attending the meeting:

This meeting took place the 9th of October 2024 at the Consejo Superior De Investigaciones Cientificas (CSIC), Rue du Trône 62, in Brussels. More than 60 stakeholders took part in the stakeholder meeting, most of them attending virtually via web conference. Here below the list of organisations attending the meeting:

2nd Cycle FlexCo	BMWK Germany	Electra
AIT - Austrian Institute of Technology GmbH, Center for Energy	Bundesamt für Energie	Elergone Energia SA (Sonae MC)
Aldowa Green	BFE	El-Kretsen
AMS Institute	CARBON	Engie
APPLiA	CENER	Enphase Energy
BASF	Chalmers University of Technology	Environment and Resources Authority
BayWa r.e.	CINEA	EPRI
Bern University of Applied Science	CLASP	Erion Compliance Organization S.C.A.R.L.
bifa Umweltinstitut GmbH	DAkKS	EucoLight
Biosphere Solar	Danish Energy Agency	Euroalliances
BMK	Danish Environmental Protection Agency	ederal environment agency Germany
BMUV	DTU	Federal Public Service
	E&E Solutions Inc.	Health, Food Chain
	EC-JRC	
	ECOS	

Safety and Environment, Belgium	KACO new energy GmbH	SENS eRecycling
FEICA (H.B. Fuller Company)	Lapmaster & Wolters	Siemens AG
First Solar GmbH	Leitat	SINTEF
Fraunhofer Institute for Solar Energy Systems	LightingEurope	SMA Solar Technology AG
ISE	LONGi Solar	SolarPower Europe
German Environment Agency	MHRT	Soren
German Federal Ministry for Economic Affairs and Climate Action	Michigan State University	SOREN (PRO FRANCE)
Glass for Europe	Müller-Guttenbrunn GmbH	SunR
Heliatek	National Renewable Energy Centre, CENER	Tatuine Medio Ambiente S.L
Hemholtz-Zentrum Berlin für Materialien und Energie	NILU	The International Bromine Council, BSEF
Holland Solar	OPEN Foundation	The Netherlands Enterprise Agency
HZB	Oxford PV	tialpi srl
ICF	Polymer Competence Center Leoben (PCCL)	Tohoku University
IEP - Portuguese Electrotechnical Institute	PV CYCLE	TotalEnergies
IPN SEPI ESCA STO	REC Solar EMEA GmbH	Trina Solar GmbH
TOMAS	RENAS AS	TU Delft
IPVF	RISE Research Institutes of Sweden	TÜV SÜD Product Service GmbH
	ROSI	UNITAR
	RS MOPE	Vestel
	Schaeffler AG	wambach-consulting
	Schuman Associates	WEEE Forum

Morning Session (10:30 – 12:30)

The meeting started with a welcome and initial remarks from Nieves Espinosa (University of Murcia) and the introduction of the study team (Viegand Maagøe, CENER, University of Murcia). After this short introduction, the European Commission (Davide Polverini - DG GROW) provided an introduction of the Policy Context of the study, followed by a Questions and Answers session. A stakeholder asked whether the Ecodesign for PV will come out in 1 year, another stakeholder asked whether the Recyclability Index is not too limited in scope and whether a Circularity Index would not be more beneficial.

On the first question DG GROW clarified that in 1 year we are likely to have the final outputs of this study. Regarding the final approval of the Ecodesign and Energy Labelling regulations for PV products DG GROW is not able to give an indication of the timeline. About the scope of the Index DG GROW and the study team clarified that the scope of this study is recyclability, nevertheless, as in other regulations (e.g. energy labelling of smartphone and tablets) a scoring index on a specific circularity aspect can be complementary to other information or minimum threshold requirements on other material efficiency aspects such as reliability / durability.

In the following session of the meeting (11:00 – 11:30) Felice Alfieri (Viegand Maagøe) and Nieves Espinosa exposed the scientific context of the Study. Existing scoring systems and scientific literature were presented and followed by a Q&A session.

A stakeholder asked if the "French Recyclability score" that was presented, apply to PV? The French PRO SOREN replied that it's not applicable to PV in France because they have asked the ministry of Environment to wait for the European PV recyclability index for implementation.

A stakeholder asked about the assessment of the three schemes presented: has there been an evaluation of how many companies apply to these standards? How broadly it is implemented in the respective industries? The study team replied that the uptake of these standards was not the objective of the analysis, nevertheless this can be integrated in the revision of the study report.

In the following session (11:30 – 12:30) the approach used for the development of the scoring system was presented, starting from the definition of recyclability parameters and differentiation between service-related parameters, dismantling-related parameters and material-related parameters. Felice Alfieri (Viegand Maagøe) described service and material related parameters, while dismantling related parameters and the associated testing procedures were presented by Cristina Pinto (CENER).

A stakeholder asked about Parameter 2: Substances of concern. *What thresholds or exemptions due to CBI¹ are planned here? Also why is there a link to Digital Product Passports (DPP) with mentioning block chain? The DPP under ESPR is not asking for block chain to my knowledge - so is a back tracking through the supply chain planned here? Or why such a reference?*

On Parameter 2 it was clarified that the aim is only to score based on the availability of information related to the substances: no thresholds are evaluated under parameter 2. The index is not a regulatory instrument, not being able to exempt from duty obligations. On DPP and blockchain it has been clarified by the study team that these options were mentioned only as examples for provisions of information, but they are not applicable in the context of the Ecodesign / Energy Labelling regulation for PV products, that have been developed under the Ecodesign Directive 2009/125/EC framework (i.e. without DPP obligation).

A stakeholder claimed that Brominated Flame Retardants, are currently integrated in the circular economy, being well-controlled and easily sorted during conventional recycling processes. *A 2023 study by DSS+ shows that over 95% of BFRs can already be eliminated in waste from electrical and electronic (WEEE) plastics, and continued advancement in technologies could offer a future longer-term alternative to mechanical recycling processes, supporting continued improvement in the efficiency of BFRs extraction. I would be happy to share the study and discuss further.*

A stakeholder asked about SoC, you mention antimony, PFAS, ... but not other hazardous materials. *Would that chapter not follow horizontal chemicals legislation (REACH, RoHS)?* On Parameter 8 the study team clarified that the selected substances are based on literature review and on the feedback received during the first consultation.

A stakeholder asked *why recycling efficiency of the recycling process is not considered as one of the criteria to assess the recyclability index?* The study team explained that the intention is to keep the scoring system technology neutral, as far as possible, in terms of recycling technologies. The aim is to award design approaches that could facilitate the separation and purity of the recycled fractions as much as possible.

A stakeholder asked *what proof of recycling process should be provided by the producers when putting the product on the market?* The study team clarified that the aim is to keep the scoring system independent from any specific recycling technique, as this would not be covered, in legal terms, by the assessment of compliance foreseen under Ecodesign measures, that takes place at the moment of the

¹ Confidential Business Information

placing on the market of the product. Dismantling performance parameters are expected to be based on dismantling tests that can be carried out in a laboratory environment (i.e. in a reproducible way).

A stakeholder commented that the recycling process shall also describe the end use of recycled materials and score them according to the environmental value ("recycling" has quite a wide scope in EU law). The study team explained that the weighting system introduced in the scoring system aims to award designs that facilitate higher purity and easier separation of the materials. A weighting system is included into the scoring system to take into account aspects as the environmental and economic relevance of the different parts/materials.

A stakeholder expressed appreciation for the approach to measuring and evaluating different technologies, particularly the consideration of dismantling depth without penalizing any specific type of fasteners. She also raised the following points:

- A balanced approach to be applied to criteria 7.4 and 10.
- Not to use language such as "avoid" regarding joining technologies, as this could negatively impact ongoing innovation efforts in the adhesives and sealants industry, particularly in developing removable/de-bondable solutions.

A stakeholder asked to what extent will you be able to use/prioritize different parameters + priority materials + scoring for different inverter/module architectures & purposes? There is a danger of comparing apples with oranges. A central inverter for a utility scale PV project is very different compared to a micro inverter for a balcony PV system.

The study team replied that it will be part of the next steps to further look into the comparability of results from different sub-categories of inverters.

A stakeholder commented that to recycle PV modules as quickly, efficiently, and with as low cost as possible, it seems crucial to be able to identify what is inside the module and their characteristics. Is it useful to refer to special categories (critical strategic, ...) of materials, as those lists (of critical strategic) can change? I believe that we need a very stable methodology (for 10 or more years) from the start because it is very time consuming to understand, apply and verify such methodology. The study team thanked the insightful input about the importance of identifying materials in PV modules and their characteristics for efficient recycling. While it's true that lists of critical materials may evolve, they provide valuable guidance on prioritizing materials based on current economic and environmental contexts. We agree that a stable and long-term methodology is crucial to avoid frequent adjustments. However, as the study team pointed out, creating a methodology that is entirely future proof is challenging due to the dynamic nature of technology and market shifts.

Some stakeholders asked about the energy consumption and the complexity of the recycling process and how and whether these aspects will be considered. The study team mentioned that these aspects are indirectly considered in the scoring system as they are related to the temperature of the tests and the number of steps needed.

Afternoon Session (14:00 – 16:00).

In the afternoon, the sessions were about the definition of priority materials and components (14:00 – 14:30) for both PV modules and PV Inverters (Nieves Espinosa), followed by Q&A session. The presentation from the study team (Felice Alfieri and Cristina Pinto) was about scoring and aggregation (14:30 – 15:00) and aimed to present the proposed scoring criteria, weighting and aggregation approach.

Finally, the study team presented the next steps, including deadline for written comments and proposals for testing and selection of the sample (15:00 – 15:30). The meeting was closed with a session for General Questions and Answers and Conclusions (15:30 – 16:00)

Questions on Scoring and Weighting:

Two stakeholders raised questions about the scoring and weighting of materials and components. The study team clarified the scoring process, and the criteria used for prioritization, emphasizing the transparency and openness to feedback.

A stakeholder asked if materials higher in the table get a higher weighted score and if the PV module itself gets a higher recyclability index score. The study team explained that the scoring and weighting are detailed in the annex of the draft interim report, and they are open to feedback. At the moment, there are no weighting factors assigned.

A stakeholder asked how criticality and EU strategy were chosen for components. The study team explained the 4-point scale used for criticality and strategic relevance, noting that Palladium is considered a critical raw material.

A stakeholder highlighted that Palladium is a critical raw material as part of the platinum group metals. The study team acknowledged the correction and confirmed it has been correctly considered as CRM.

A stakeholder pointed out the impact of silver scarcity on recycling, noting that reducing silver content may affect recyclability. The study team acknowledged the concern and discussed the trade-offs between current and future material usage.

A stakeholder raised concerns about the differences in inverter architectures, emphasizing the need to account for variations between central inverters, string inverters, and microinverters. The study team acknowledged the importance of considering these differences in the recyclability index.

A stakeholder from the solar industry was noting that the index is not integrating products that could be mainstream in future scenarios. For example PV tiles, that currently represent 3% but will very likely scale up by the time the new policy comes into force, are not included in the index. The key argument made is that given the innovation curve of PV products, not including products that are likely to scale following a reactive rather than proactive and future oriented approach could reduce the intended effect of the policy. The study team clarified that the index can be periodically evaluated and updated as for other metrics used in EU policy tools.

The study team outlined the testing and evaluation process for PV modules and inverters, including the selection of products, testing setups, and parameters to be measured. They detailed the steps for removing aluminium frames, performing peel tests, and evaluating the recyclability of different components.

A stakeholder asked whether a complex methodology would need a software (as planned for CO₂ evaluation) and would need often updates and parameters changes over time (old database could lead to wrong conclusions) to clarify this multi-dimensional and complex topics, *don't you think that a simple approach would be more pragmatic?* The study team clarified that once the method is associated to a policy measure, the revision of the metric would be done periodically according to the revision of the policy initiative. Moreover, in terms of complexity, the methodology is simple enough to be managed through an excel calculation tool.

A stakeholder asked *it is not only the material composition that is needed but materials / components / module characteristics. For example: frame / glass / encapsulation / cell thickness, presence of screws in the frame (which complicate the removing of the frame in contradiction to your point 7.4).* The study team clarified that the parameter on the use of reusable/removable fasteners is applied only in the case

of PV inverters and not for PV modules where other aspects are considered (i.e. frame and encapsulant layer removal).

A stakeholder commented about the dismantling parameters, that *if we don't know what would be the best recycling solutions in 20 or 30 years, how can we put conditions in this topic and have demands?* The study team explained that the method is not linked to any specific recycling technology, but it is based on general principles that would make the dismantling easier and ensure higher purity of the separated materials.

A stakeholder asked to react on the cell removal and damage impact, because damage does matter. *While today's benchmark recycling process often involves mechanical size reduction (crushing, shredding, grinding), emerging high-value recycling processes target recovery of higher purity output streams. While some of these processes can accommodate broken modules, some cannot, and intact modules are easier to handle.* The study team acknowledged this comment as this is in line with the current approach.

A stakeholder asked *why fasteners should be reusable in the context of recycling?* The study team clarified that reusability of fasteners is not a relevant aspect of a recyclability index and reusable fasteners should be rated at the same level of removable fasteners. Nevertheless, considering the different definitions it is still important to mention them as a category of fasteners.

A stakeholder suggested to test more bifacial modules as most of the modules installed nowadays are bifacial modules.

A stakeholder expressed concerns about the selection of inverters. *Microinverters are more related to DC optimizers than string inverters. It is not ideal that very large inverters are out of scope, but small inverters are.* The study team clarified that the next step of the study will help to better calibrate the scope of the proposed recyclability index.

A stakeholder from waste management sector asked whether the objective is to have a methodology valid only for Europe with European concerns and regulations and objectives, or a methodology and conclusions valid worldwide to help PV to progress from an environmental point of view. The stakeholder also commented that *in case a proper end-of life module collection is in place a not environmentally friendly component cannot be a problem if the recycler knows that it is present. For instance, antimony glass doesn't seem to be a problem for some recyclers and glass manufacturers.* It was clarified that the geographical scope of the study is EU and provision of information on composition is one of the aspects that can facilitate recycling.

A stakeholder asked about the plans *to also look at thin-film PV like CIGS, perovskites and tandems or is the study limited to Si wafer-based PV? Or would the exact same criteria apply to them?* The study team clarified that next steps of the study will also help to clarify how the scoring system can be applied across different sub-categories of PV panels and PV inverters.

A stakeholder pointed out that in their PV recycling installations, *during the frame removal step, the aluminium frame often doesn't come off completely clean in many bifacial modules, as the glass edges break and remain attached to the frame. As a result, an additional step is required to remove the broken glass from the aluminium frame.*

The stakeholder expressed his view that the framing of the index must be positive, to avoid it seeming as a punishment but rather an incentive. The argument made was that PVs are positive for the green energy transition, therefore the framing should align to this narrative. Otherwise it would be counter intuitive that the products used to create less green forms of energy are not regulated with a similar

index. The study team clarified that the aim of this study is to define parameters and scoring criteria and it would be a policy decision on how to communicate the index.

The meeting was adjourned at 15:45. The study team thanked for participation and informed stakeholders that written comments can be send to info@pv-recyclability-index.eu until [01/11/2024]. Slides from the meeting and minutes will be uploaded to: [Documents - Recyclability index for photovoltaic products](#)