EUROPEAN COMMISSION
DIRECTORATE-GENERAL
JOINT RESEARCH CENTRE
Directorate B – Growth and Innovation
**Circular Economy and Industrial Leadership**

Seville, 20th December 2018

**Cross-check and comparison of the PEF pilot and MEErP preliminary base case results from the Ecodesign Preparatory Study**

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## Comparison of the methodologies

In 2005, the Methodology for Ecodesign of Energy-using Products (MEEuP) was developed for assessing whether and which ecodesign requirements are appropriate for energy-using products under the Ecodesign Directive. Following the revision of the Ecodesign Directive and the extension of its scope to energy-related products in 2009, the Commission reviewed the effectiveness of the MEErP with a view to extend it to energy-related products. The updated methodology MEErP has been endorsed by the Ecodesign Consultation Forum of 20 January 2012 and shall be used as basis for ecodesign and energy labelling preparatory studies.

The MEErP methodology consists of seven tasks, of which Task 5 is on 'Environment and Economics' and entails the use of Life Cycle Assessment (LCA) and Life Cycle Cost (LCC) analysis. For MEErP assessments a reporting tool called EcoReport was developed that facilitates the necessary LCA calculations to translate product-specific characteristics into environmental impact indicators per product.

This annex of the Preparatory study compares:

- The environmental impact categories of the two methods;
- The results for the impact categories used in the PEFCR 2018 pilot and the MEErP methodology used in Task 5 to perform the Environmental impact assessment of the Preparatory study for Solar Photovoltaics,
- The hot spots identified by the interpretation provided by the first set of 2015 results from the PEF pilot and those of the MEErP Task 5 assessment.

The scope of the comparison is a multicrystaline photovoltaic module, although the sensitivity analysis within the PEF pilot that accounts for the inverter performance is also briefly referred to.

## Environmental impact categories

PEF considers 16 environmental impact categories; MEErP considers 13 environmental impact categories. Table 1 gives an overview of the impact categories considered in both methodologies. Common impact categories are ‘Climate change’, ‘Particulate matter’, ‘Acidification’, 'Photochemical ozone formation' ‘Eutrophication freshwater’ and ‘Water use’.

## Comparison of the results

The results are provided in the table below. The Ecoreport tool results here are the module-only results for a product incorporated into a 3 kW residential system and as obtained in the ecodesign preparatory study. The PEF results come from the record ‘electricity, PV, at 3kWp slanted-roof, multi-Si, panel, mounted/kWh/RER U’. The PEF results are for a module but include the DC electric installation and mounting structure. These two components are not included in the Ecoreport tool results.

Only the impact category *Climate change* is expressed in a common unit and characterized according to the same model. However, it may be possible to use conversion factors for categories as *Acidification, Photochemical ozone formation* and *Eutrophication freshwater*. *Particulate matter* is different because although both methods are based on particular sizes, in the PEFCR 2018 model it is evaluated as a disease incidence, so the damage the particulates can cause. This requires additional characterization factors.

A slight variance of 1.26% is obtained in the MEErP screening study over the result from PEF study for the climate change emissions.

For the total primary energy demand the variance is higher, around 10%. This may be accounted for by the difference in the calculation of the total energy. While the PEF is only considering fossil energy, in the MEErP the total energy accounts for other sources of energy such as renewable and nuclear energy. Energy generated during the operational lifetime of the PV module is not included in this calculation.

*Table 1: Impact categories considered in PEF and MEErP*

| ***PEF***[1] | | ***MEErP***[2] | |
|---|---|---|---|
| ***Impact category*** | ***Unit*** | ***Impact category*** | ***Unit*** |
| *Climate change GWP100 (IPCC 2013)* | *kg $CO_{2\ eq}$* | *Greenhouse Gases in GWP100 (IPCC 2007)* | *Mt CO2 eq.* |
| *Ozone depletion* | *kg CFC-11 $_{eq}$* | - | - |
| *Human toxicity, cancer* | *CTUh* | - | - |
| *Human toxicity, non-cancer** | *CTUh* | - | - |
| *Particulate matter* | *disease incidence (number of cases per kg of PM 2.5 inhaled)* | *Particulate Matter (PM10 equivalent, dust)* | *g* |
| *Ionising radiation, human health* | *kBq $U^{235}{}_{eq}$* | - | - |
| *Photochemical ozone formation, human health (LOTOS-EUROS 2008, ReciPe)* | *kg NMVOC $_{eq}$* | *NMVOC* | *g NMVOC* |
| *Acidification (Accumulated Exceedance)* | *mol H+ eq* | *Acidification, emissions (UNECE 1999 CLRTAP protocol )* | *kt SO2 eq* |
| *Eutrophication, terrestrial (Accumulated Exceedance)* | *mol N $_{eq}$* | - | - |
| *Eutrophication, freshwater (EUTREND 2009 ReciPe)* | *kg P $_{eq}$* | *Eutrophication (water) (Directive 91/271/EC (Urban Waste Water Treatment)* | *g $PO_4$* |
| *Eutrophication, marine* | *kg N $_{eq}$* | - | - |
| *Ecotoxicity, freshwater** | *CTUe* | - | - |
| *Land use* | • *Dimensionless (pt)*<br>• *kg biotic production*[3]<br>• *kg soil*<br>• *$m^3$ water*<br>➔<br>• *m3 groundwater* | - | - |
| *Water use* | *$m^3$ world $_{eq}$* | *Process water and cooling water* | *l* |
| *Resource use, minerals and metals* | *kg Sb $_{eq}$* | - | - |
| *Resource use, fossils* | *MJ* | | |
| | | *Total energy* | *PJ* |
| - | - | *Waste, non-haz./ landfill* | *kt* |
| - | - | *Waste, hazardous/ incinerated* | *kt* |

[1] Impact categories taken from 'Product Environmental Footprint Category Rules', European Commission, version 6.3 May 2018

[2] Impact categories taken from MEErP ecoreport tool version 2014

[3] This refers to occupation. In case of transformation the LANCA indicators are without the year (a)

| *PEF*[1] | | *MEErP*[2] | |
|---|---|---|---|
| ***Impact category*** | ***Unit*** | ***Impact category*** | ***Unit*** |
| - | - | *Persistent Organic Pollutants (POP) to air* | *ng i-Teq* |
| - | - | *Heavy metals to air* | *mg Ni eq.* |
| - | - | *PAHs to air* | *mg Ni eq.* |
| - | - | *Heavy metals to water* | *mg Hg/2O* |

*Table 2: Results for production (material input) of 1 kWh by a multi Si module using EcoReport tool*

| **Impact category** | ***PEFCR 2018 pilot*** | ***MEErP*** | **Variance** |
|---|---|---|---|
| *Climate change GWP100* | 0.04881 | 0.0495 | +1.26% |
| *Resource use, fossils, MJ* | 0.61604 | - | +11.09% |
| *Total Energy, MJ* | - | 0.77901 | |

## Comparison of the hotspots

Both the MEErp and the PEF study conclude that the production phase is the most important life cycle phase. The impact from the use phase is very limited[4]. This is obviously linked, to a great extent, to the fact that PV modules are energy generating (and not energy using) products.

Production in the context of the PEFCR for PV is understood to relate to the manufacturing stage for the modules and associated mounting structures. However in the PEFCR 2018, a distinction is introduced between raw material acquisition and preprocessing related to the production of PV modules and the 'production' of the main product, which relates to the assembly of a PV system.

Table 3 shows the relative contribution of the different materials and components to each impact category according to the EcoReport tool used for the Preparatory study. The heavy metals (Sn, Pb, Cu) used for interconnections are listed separately. The photovoltaic cell herein is mainly silicon but also contains some other materials such as silver for electrodes (contained in the metallization paste of the electrodes).

The photovoltaic cell can be seen to be responsible for the greatest contribution across the majority of the impact categories considered in MEErP. The aluminium frame for PAH and HMw and to a lesser extent GWP, POP and PM.



[4] Reference is made here to page 144 of the version 1.4 (19th August 2015) of the PEF since the PEFCR 2018 are not presenting an interpretation of the results.

*Table 3: Results for production (material input) of 1 kWh by a multi Si module using EcoReport tool*

| | weight | GER | water (proces + cool) | haz. Waste | non-haz. Waste | Greenh ouse Gases in | Acidifica tion, emissio | Volatile Organic Compou | Persiste nt Organic | Heavy Metals to air | Polycycli c Aromati | Particula te Matter | Heavy Metals to water | Eutrophi cation freshwa |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| photovoltaic cell | 4% | 72% | 96% | 98% | 91% | 79% | 80% | 70% | 77% | 91% | 12% | 76% | 35% | 86% |
| interconnection - Tin | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 0% | 0% | 1% | 0% | 0% |
| interconnection - Lead | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| interconnection - Copper | 1% | 0% | 0% | 0% | 0% | 0% | 2% | 0% | 1% | 1% | 0% | 0% | 6% | 0% |
| encapsulation - ethylvinylacetate | 7% | 3% | 1% | 0% | 1% | 1% | 0% | 9% | 0% | 1% | 0% | 0% | 0% | 3% |
| backsheet - PVF | 1% | 1% | 0% | 0% | 1% | 1% | 1% | 2% | 1% | 1% | 0% | 0% | 0% | 2% |
| backsheet - PET | 3% | 1% | 0% | 0% | 0% | 1% | 1% | 2% | 0% | 0% | 0% | 1% | 0% | 0% |
| pottant & sealing | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 1% | 0% |
| alu frame | 16% | 15% | 0% | 0% | 4% | 11% | 9% | 1% | 19% | 2% | 87% | 17% | 46% | 0% |
| solar glass | 66% | 6% | 1% | 0% | 4% | 6% | 6% | 15% | 2% | 4% | 0% | 3% | 2% | 6% |
| junction box - diode | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| junction box - HDPE | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| junction box - glass fibre | 2% | 1% | 1% | 1% | 0% | 1% | 1% | 0% | 0% | 0% | 0% | 1% | 9% | 1% |

| | |
|---|---|
| contribution to impact category | X > 50% |
| contribution to impact category | 25% < X < 50% |
| contribution to impact category | 10% < X < 25% |
| contribution to impact category | <10% |

A comparison of the identified hotspots for a number of impact categories is presented in Table 4. The hotspots are identified for those categories that are present in both methodologies even if they do not have the same units or are calculated according to the same methods. Further analysis is made difficult since the impact categories are not strictly comparable. It emerges clearly that the identified hotspots relate to key components and/or phases of the production process, depending on the level of granularity of the analysis.

The inclusion of the inverter for a 3 kW PV system has in PEF v1.4 been done as part of a sensitivity analysis. The most impacted category is *Eutrophication freshwater*. This additional impact is caused by the supply chain of copper (phosphate emissions when disposing sulphidic tailings off-site) used in the inverter. *Resource depletion* (due to silver and tantalum) and *Human toxicity* (due to copper, steel and aluminium) have been found to be sensitive as well due to the addition of an inverter to the modelled system.

*Table 4: Hotspot identification for the production stage of 1 kWh by a multi Si module using PEF and EcoReport tool*

| **Impact category** | ***PEFCR 2018 pilot*** | ***MEErP*** |
|---|---|---|
| ***Climate change GWP100*** | Wafer production (~88%) | Photovoltaic cell (79%)<br>Aluminium frame (11%) |
| ***Particulate matter*** | Silicon production (95%) | Photovoltaic cell (76%)<br>Aluminium frame (17%) |
| ***Photochemical ozone formation/ NMVOC*** | Supply chain of electricity production- coal- (90%) | Photovoltaic cell (70%)<br>Solar glass (15%) |
| **Acidification** | Supply chain of electricity production- coal- (90%) | Photovoltaic cell (80%) |
| ***Eutrophication freshwater*** | Hard coal and Silver mining (48%) and Copper mining (50%) | Photovoltaic cell (86%) |
| ***Water use/ Process water and cooling*** | Silicon production from hydro power (85%) | Photovoltaic cell (96%) |

According to the results from MEErP for the most impacted categories for a 2.5 kW inverter the contributions appear to be slightly different. For example, for *Eutrophication freshwater* copper is not identified as a hotspot; instead integrated circuits and printing wiring boards appear to be the hot spot components for this category. In general the greatest contributions (above 25%) are coming from aluminium, integrated circuits, copper and the printing wiring board. See Table 5.

*Table 5: Results for production (material input) of 1 kWh by a 2.5 kW inverter using EcoReport tool*

| | weight | GER | water (proces + cool) | haz. Waste | non-haz. Waste | Greenho use Gases in | Acidificat ion, emission | Volatile Organic Compou | Persisten t Organic Pollutant | Heavy Metals to air | Polycycli c Aromatic | Particulat e Matter (PM, | Heavy Metals to water | Eutrophic ation freshwat |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| aluminium | 43% | 10% | 0% | 0% | 12% | 11% | 7% | 2% | 70% | 2% | 79% | 27% | 3% | 0% |
| copper | 17% | 3% | 0% | 0% | 0% | 3% | 10% | 0% | 8% | 27% | 9% | 4% | 7% | 2% |
| steel | 8% | 1% | 0% | 0% | 25% | 2% | 1% | 1% | 10% | 1% | 0% | 3% | 0% | 1% |
| pp | 8% | 2% | 7% | 1% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 2% |
| PC | 10% | 5% | 29% | 2% | 3% | 4% | 3% | 0% | 0% | 0% | 0% | 11% | 0% | 8% |
| cable | 1% | 1% | 0% | 0% | 0% | 0% | 3% | 0% | 0% | 3% | 1% | 1% | 1% | 0% |
| integrated circuits | 2% | 64% | 0% | 7% | 31% | 67% | 53% | 90% | 5% | 40.9953% | 3% | 22% | 82.7118% | 66% |
| ferrite | 0% | 0% | 3% | 0% | 2% | 0% | 0% | 1% | 1% | 1% | 0% | 3% | 0% | 1% |
| PVC | 3% | 1% | 4% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 1% |
| PA | 1% | 1% | 7% | 0% | 0% | 1% | 1% | 0% | 0% | 0% | 0% | 1% | 1% | 4% |
| PWB | 3% | 4% | 35% | 88% | 21% | 3% | 11% | 2% | 1% | 9% | 2% | 17% | 4% | 11% |
| tin | 0% | 0% | 3% | 0% | 0% | 0% | 0% | 1% | 0% | 0% | 0% | 3% | 0% | 1% |
| transistor/diode/resistor | 1% | 7% | 12% | 1% | 3% | 7% | 9% | 3% | 0% | 12% | 0% | 5% | 0% | 2% |
| capacitor | 4% | 1% | 0% | 0% | 1% | 1% | 1% | 0% | 5% | 4% | 5% | 2% | 0% | 0% |

| | |
|---|---|
| contribution to impact category | X > 50% |
| contribution to impact category | 25% < X < 50% |
| contribution to impact category | 10% < X < 25% |
| contribution to impact category | <10% |

Finally, it is important to highlight the following in relation to the analysis specifically aimed at identifying potential Ecodesign requirements. The initial environmental hotspot analysis for a base case presented in this annex is an *intermediate* step of the MEErP, and not the final one. In order to derive potential Ecodesign requirements, as well as their stringency, further steps (to be carried out under task 6) are needed, namely:

- the environmental hotspot comparison of the base case vis-à-vis the design options, i.e. products with standard improvement options
- the identification of the design option (at product level, for PV modules and inverters, and at system level) with the least life cycle cost (provided that the economic gains from the generation of electricity will be accounted for in the LCOE modelling).