

## Additional Information

### BILL OF MATERIALS

In the following tables the complete dataset regarding the inverters (from **Table S 1** to **Table S 3**), cell (**Table S 4**) and module (**Table S 5**) are reported.

The inventory of the inverter adopted in the rooftop plant consists of two datasets reported in **Table S 1** and **Table S 2** respectively, while in **Table S 3** the utility-scale inverter is shown.

**Table S 1 – Inventory for the inverter adopted in the rooftop PV plant. The data are referred to 1 kW<sub>DC</sub>. The inverter Rated DC input power is 3220 W. Data from laboratory test and IEA LCI report [1].**

Output	Amount	Unit
Inverter Sunterno SunWay MXS 3000 TL	1	kW
<b>Input</b>		
Aluminum alloy, GAISi 11	3.04E+00	g
Cable, connector for computer, without plugs	9.97E-04	m
Copper, cathode	6.36E-01	g
Electric connector, wire clamp	3.28E-02	g
Epoxy resin insulator, Al2O3	9.49E-01	g
Epoxy resin, liquid	3.25E-01	g
Ferrite	3.46E-01	g
Folding boxboard carton	3.60E-01	g
Liquid crystal display	1.25E-02	g
Nylon 6	7.27E-03	g
Plug, inlet and outlet, for network cable	4.38E-04	g
Polyethylene, high density, granulate	5.64E-02	p
Printed wiring board, surface mounted, unspecified, Pb free	1.39E-02	g
Printed board inverter Sunterno SunWay MXS 3000 TL_RSE	7.11E-01	g
Steel, low-alloyed	5.51E-02	g
Synthetic rubber	2.23E-02	g
Corrugated board box	2.05E-01	g
Packaging film, low density polyethylene	3.57E-03	g
Transport, freight train	1.29E+00	kgkm
Transport, freight, lorry	3.88E-01	kgkm
Transport, freight, sea, container ship	1.16E+02	kgkm
<b>Energy consumption</b>		
Electricity, medium voltage	3.29E-03	kWh
Heat, district or industrial, other than natural gas	7.02E-05	MJ
Heat, district or industrial, natural gas	3.97E-03	MJ
<b>Emissions in air</b>		
Water	6.18E+00	kg
<b>Emissions in water</b>		
Water, DE	1.17E-02	m <sup>3</sup>
<b>Treatment processes</b>		
Wastewater, unpolluted	6.18E-03	m <sup>3</sup>
Waste paperboard	5.65E-01	kg
Waste polyethylene/polypropylene product	3.57E-03	kg
Used printed wiring boards	3.79E-01	kg
Municipal solid waste	7.55E-02	kg

**Table S 2 Inventory for the printed wiring board of the Sunterno inverter. The dataset is referred to 1 kg of printed wiring board.**

<b>Output</b>	<b>Amount</b>	<b>Unit</b>
Printed wiring board inverter Sunterno SunWay MXS 3000 TL	1	kg
<b>Input</b>		
Capacitor, electrolyte type, < 2cm height	2.73E+01	g
Capacitor, film type, for through-hole mounting	1.05E+02	g
Copper	3.25E+01	g
Inductor, ring core choke type	1.10E+02	g
Insulated gate bipolar transistor	1.78E+01	g
Integrated circuit, logic type	1.00E+01	g
Printed wiring board	4.59E-02	m2
Printed wiring board	5.02E+00	m2
Resistor, auxiliaries	1.87E+01	g
Resistor, metal film type	1.97E+00	g
Resistor, surface-mounted	5.86E+00	g
Steel, low-alloyed	3.62E+00	g
Synthetic rubber	4.50E+00	g
Transformer	1.11E+02	g
Wire drawing	1.69E+00	g

**Table S 3 Inventory of the utility-scale inverter. The dataset is referred to 1 kW<sub>DC</sub>. The inverter Rated DC input power is 166 kW. Data from GOPV project [2] partners.**

<b>Output</b>	<b>Amount</b>	<b>Unit</b>
166-kW inverter	1	kW
<b>Input</b>		
Printed wiring board, surface mounted	5.42E-02	kg
Aluminum	1.20E-01	kg
Inductors	2.41E-01	kg
Epoxy potting	4.82E-02	kg
Aluminum, Heat sink	9.04E-02	kg
Cables	2.41E-02	kg
Switches	1.20E-02	kg
Electric connector	1.20E-02	kg
Freight train	3.01E-01	tkm
Freight lorry	3.01E-01	tkm
<b>Energy consumption</b>		
Electricity	1.20E-01	kWh

**Table S 4 Inventory of the cell PERC. The cell size is 210mmx210mm and the data are referred to 1 m<sup>2</sup>. Data provided by ISC Konstanz, <https://isc-konstanz.de/>.**

<b>Output</b>	<b>Amount</b>	<b>Unit</b>
Cell PERC (M12)	1	m <sup>2</sup>
<b>Input</b>		
Single-Si wafer (phosphorus doped)	1.04E+00	m <sup>2</sup>
Deionised water	2.88E+01	l
Additive1	1.67E-02	l
Hydrochloric acid in 37% solution state	3.39E-02	l
Sulfuric acid	3.21E-02	l
Nitric acid in 67% solution state	9.18E-02	l
Trimethyl-aluminium (TMA)	2.42E-04	kg
Potassium hydroxide in 40% solution state	6.08E-02	l
Phosphoryl trichloride	1.81E-04	kg
Hydrogen fluoride in 49% solution state	1.42E-01	l
Hydrogen peroxide in 30% solution state	3.64E-02	l
Nitrogen	6.48E-01	m <sup>3</sup>
Silicon tetrahydride	1.71E-03	m <sup>3</sup>
Ammonia	1.80E-02	m <sup>3</sup>
Oxygen	5.00E-02	kg
Nitrous oxide	1.71E-05	kg
Methane	1.11E-03	kg
Cooling water	2.32E-01	m <sup>3</sup>
Ag paste front side	4.08E+03	mg
Ag paste rear side	1.13E+03	mg
Al paste rear side	6.80E+03	mg
Screen finger (front + rear side)	6.59E-04	unit
Squeegee	1.23E-02	unit
Screen_BS_Pads RS + BB front side	9.22E-04	unit
<b>Energy consumption</b>		
Electricity (consumption of auxiliary services included)	5.80E+00	kWh
<b>Emissions in air</b>		
Water	3.96E+00	kg
Hydrogen fluoride	3.04E-02	kg
Silicon	2.62E-03	kg
Silver	6.64E-06	kg
Ammonia	3.07E-05	kg
Chlorine	2.48E-03	kg
NMVOG	1.26E-02	kg
<b>Emissions in water</b>		
Water	2.28E-01	m <sup>3</sup>
<b>Treatment processes</b>		
Treatment, PV cell production effluent, to wastewater treatment, Class 3	3.96E-05	m <sup>3</sup>
Disposal, waste, silicon wafer production, inorg, 9.4% water, to residual material landfill	2.32E+00	kg
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration	1.72E-01	kg

**Table S 5 Inventory of PERC module production with an area of 2.17 m<sup>2</sup> and an efficiency of 21.16%. Data are referred to 1 m<sup>2</sup> and provided by FuturaSUN S.p.A.**

<b>Output</b>	<b>Amount</b>	<b>Unit</b>
PERC Module (460 W)	1.00E+00	m <sup>2</sup>
<b>Input</b>		
PERC Cell (M6)	3.5E+01	unit
Aluminium alloy, Al6063-T5	1.20E+00	kg
Aluminium working process	1.20E+00	kg
Solar glass (3.2 mm)	7.70E+00	kg
Copper	7.51E-02	kg
Lead	1.02E-02	kg
Tin	6.82E-03	kg
Ethylene vinyl acetate (EVA), foil	9.95E-01	kg
Polyvinyl fluoride, film	4.56E-02	kg
Polyethylene terephthalate granulate	3.14E-01	kg
Silicone products	1.15E-01	kg
J-box + cables	1.15E+02	g
Anti-reflex coating	1.00E+00	m <sup>2</sup>
PV panel factory	4.07E-06	unit
Polystyrene	2.12E-02	kg
Cardboard	2.46E-01	kg
Pallet	1.17E-02	p
Tap water from public supply	7.05E-04	m <sup>3</sup>
<b>Energy consumption</b>		
Electricity	4.13E+00	kWh
<b>Treatment processes</b>		
Waste, from silicon wafer production	3.55E-03	kg
Waste plastic, mixture	4.41E-03	kg

## LIFE CYCLE IMPACT ASSESSMENT OF DIFFERENT SCENARIO

Table S 6 shows the full results of the potential environmental impacts generated by the three different scenarios.

Table S 6 – Potential environmental impacts generated by the production of 1 PERC module according to the three scenarios.

IMPACT CATEGORY	SCENARIO A	SCENARIO B	SCENARIO C
Climate change (kg CO <sub>2</sub> eq)	2.62E+02	2.48E+02	1.66E+02
Ozone depletion (kg CFC11 eq)	2.07E-05	2.10E-05	2.24E-05
Photochemical ozone formation (kBq U-235 eq)	9.70E-01	9.21E-01	6.17E-01
Particulate matter (kg NMVOC eq)	2.09E-05	1.93E-05	1.10E-05
Acidification (disease inc.)	1.65E+00	1.58E+00	1.10E+00
Eutrophication, freshwater (CTUh)	8.65E-02	9.05E-02	1.15E-01
Eutrophication, marine (CTUh)	4.78E-01	4.61E-01	3.59E-01
Eutrophication, terrestrial (mol H+ eq)	3.62E+00	3.43E+00	2.25E+00
Land use (kg P eq)	1.25E+03	1.23E+03	1.07E+03
Resource use, fossils (kg N eq)	2.79E+03	2.76E+03	2.43E+03
Resource use, minerals and metals (mol N eq)	1.09E-02	1.09E-02	1.08E-02
CED (MJ)	3.25E+03	3.24E+03	3.01E+03

## REFERENCES

- [1] R. Frischknecht, P. Stolz, L. Krebs, M. de Wild-Scholten, e P. Sinha, «Life Cycle Inventories and Life Cycle Assessments of Photovoltaic Systems 2020». IEA-PVPS T12-19:2020, dicembre 2020.
- [2] «European GOPV project». [Online]. Disponibile su: <https://www.gopvproject.eu/project/>