Environmental Life Cycle Assessment of Passivated Emitter and Rear Contact (PERC) Photovoltaic Module Technology

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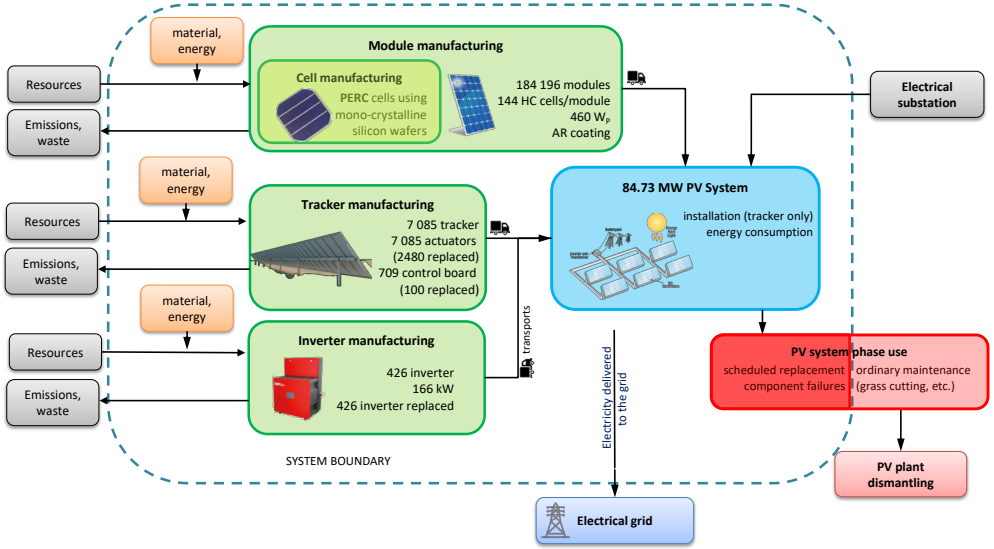
Report content: LCA study covering the entire life cycle of an 84.73 MW PV plant, including: components (cells, modules, inverter and trackers) manufacturing, plant installation, operation phase and end of life (limited to the disposal of the panels).

Goal…

- Assess life cycle environmental impacts of a utility scale PV plant based on PERC technology. Two possible configurations are considered: modules at fixed tilt and modules on a single axis tracker.
- Enhancing awareness on the crucial role played by current PV technologies in the decarbonization of the energy sectors, based on Carbon Footprint and LCA studies.



….and Scope

- The study uses primary data about cell and module manufacturing, inverter and tracker manufacturing,
- Two locations are considered: in the north of Italy (Piacenza) and in the south of Italy (Catania)
- The Functional unit is 1 kWh of produced electricity (AC)

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Impact category	South Italy (GHI 1,819 kWh/m²/y)		North Italy (GHI 1,368 kWh/m²/y)	
	tracker	fixed tilt	tracker	fixed tilt
Climate change (kg CO2 eq.)	1.71E-02	2.07E-02	2.28E-02	2.57E-02
Ozone depletion (kg CF11 eq.)	1.50E-09	1.81E-09	1.99E-09	2.25E-09
Photochemical ozone formation (kg NMVOC eq.)	6.57E-05	7.86E-05	8.75E-05	9.78E-05
Respiratory inorganics (disease inc.)	1.12E-09	1.35E-09	1.50E-09	1.68E-09
Acidification (mol H+ eq.)	1.05E-04	1.24E-04	1.40E-04	1.54E-04
Freshwater eutrophication (kg P eq.)	6.81E-06	7.94E-06	9.07E-06	9.88E-06
Marine eutrophication (kg N eq.)	2.73E-05	3.25E-05	3.64E-05	4.04E-05
Terrestrial eutrophication (mol N eq.)	2.25E-04	2.70E-04	2.99E-04	3.36E-04
Land use (Pt)	3.25E-01	3.98E-01	4.33E-01	4.94E-01
Resource use, energy carriers (MJ)	2.08E-01	2.51E-01	2.77E-01	3.12E-01
Resource use, mineral and metals (kg Sb eq.)	8.04E-07	9.33E-07	1.07E-06	1.16E-06

Table: environmental impacts of ground mounted PV system located in Italy and based on PERC technology (460 W mono-facial module with 144 half-cut PERC cells and an efficiency of 21.16%).

Results related to two different solutions: modules on a solar tracker and modules at fixed tilt.

Characteristics of the PV system:

- Average annual yield over lifetime for PV plant located in South Italy (Catania): 2096 kWh/kW$_p$ with modules on mono-axial solar tracker and 1700 kWh/kW$_p$ with modules at fixed tilt.
- Average annual yield over lifetime for PV plant located in North Italy (Piacenza): 1572 kWh/kW$_p$ with modules on mono-axial solar tracker and 1364 kWh/kW$_p$ with modules at fixed tilt.
- Module degradation: 3% the first year, 0.4% from the second to the twentieth year, and 0.5% in the following years.
- Module lifetime: 25 years.
- Inverter lifetime: 17 years.

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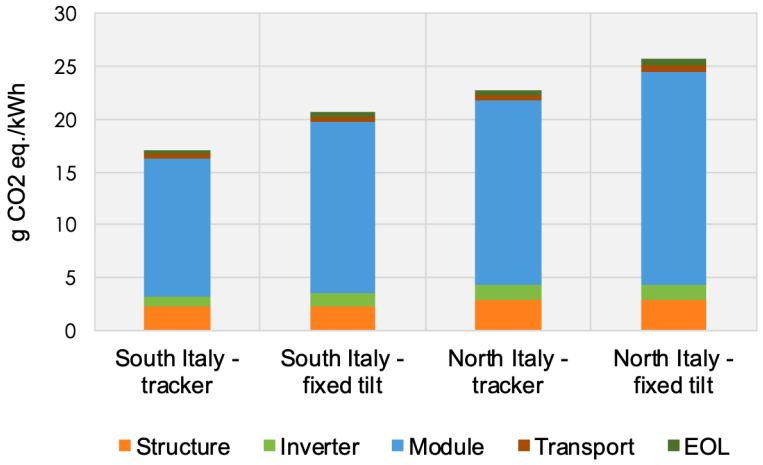

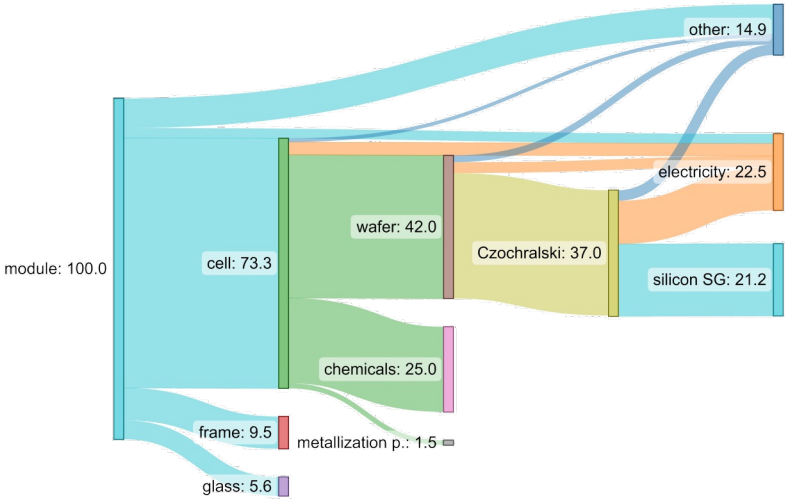

In all the configurations analysed, the impact associated with the module production (i.e., from the raw material extraction to the module production) covers more than 70% of the total impact in the *Climate Change* impact category.

The tracker component covers approximately 10% of the impact due to metal extraction and processing.

Upper graph: Analysis of contribution to *Climate Change* impact category for production of a PERC module.

The main contribution is associated with cell production (from the raw material extraction to the cell production), which is responsible for 73% of the impacts. The other components and processes (e.g., frame, glass, junction box, end of life) cause less than 30% of the total impacts.

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Main messages

- The LCA study showed that the greenhouse gas emissions (*Climate Change* impact category) range between 25.7 g CO_2 eq./kWh (PV plant located in North Italy, c-Si PERC modules at fixed tilt and with an average annual yield of 1364 kWh/kW_p) and 17.1 g CO_2 eq./kWh (PV plant located in South Italy equipped with mono-axial solar tackers and with an average annual yield of 2096 kWh/kW_p), in case the module lifetime is 25 years.
- The analysis of two different mounting systems (fixed tilt and tracker) shows that the solution with modules mounted on a mono-axial solar tracker is preferable from an environmental point of view, at least at Italian latitudes.
- The use of state-of-the-art PERC modules with high efficiency reduces the environmental burdens - and in particular the Carbon Footprint - of electricity produced compared with PV systems with Al-BSF modules.

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