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

IEA PVPS Task 12, Report IEA-PVPS T12-26:2024, March 2024
ISBN 978-3-907281-47-5

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The Technical Report is available for download from the IEA-PVPS website www.iea-pvps.org.

Executive Summary

The photovoltaic (PV) sector has undergone major expansions and evolutions during the last years, and the technologies that are currently marketed are numerous and very different. For Italy's energy sector, which aims to be sustainable from the environmental and economic perspective, it is important to evaluate and compare the environmental profile of the various PV generation technologies. Among high-efficiency technologies, the passivated emitter and rear cell (PERC) technology holds the largest market share. PERC modules are mostly made with half-cut monocrystalline silicon cells which allow an increase in the energy output of solar panels: by cutting the cells in half, their current is likewise cut in half, lowering resistive losses and allowing the solar cells to produce more electricity. Furthermore, using half-cut cells, the panel has more cells than regular panels, consequently the panel is divided in half so that the top and bottom halves act as two independent panels, producing electricity even if one half is shaded. In addition, the PERC cells are characterised by a rear surface passivation stack with lower surface recombination velocities and parasitic absorption than the back surface field layer in Al-BSF device. In this way, it is possible to increase the internal reflection, converting more solar energy into electricity, as compared to a monocrystalline silicon technology like aluminium back surface field technology (Al-BSF).

This report investigates the potential environmental impacts associated with PERC technology using a life cycle assessment (LCA) approach and compares them with those related to monocrystalline silicon technology (Al-BSF). At present, the number of published LCA studies related to PERC technology is small; they mostly use inventory data from the literature and are not tailored to the Italian context for the considered level of solar radiation. This LCA work helps to fill this gap by investigating a hypothetical 84.7 MWp power plant with PERC modules. A notable differentiating feature of this LCA is that it is based on primary data collected from the PERC cell manufacturer as well as primary data from manufacturing of the inverter and single-axis tracker. Two possible designs are analysed: (1) modules mounted on a single-axis solar tracker and (2) modules installed on a fixed structure. In addition, two possible PV plant sites with different irradiance levels are considered: one in the north of Italy and the other in the south of Italy.

For the analysed configurations, in the case of the PV plant installed in the south of Italy (with an annual irradiation of about 1,820 kWh/ m2/y), the estimated greenhouse gas emissions are 17.1 g CO2 eq. /kWh if the PV plant is equipped with mono-axial solar trackers and 20.7 g CO2 eq. /kWh if the modules are at fixed angle (34°). The obtained values are comparable but slightly lower (approximately -15%) than those estimated for conventional aluminium back surface field technology. Since data came from a specific manufacturer, it is not easy to understand whether advantages are due to technology gain or to specific more efficient processes. Finally, the results for the two installation sites (with the same PV system configurations) reveal, as expected, that the value of the incident solar radiation plays a crucial role in the systems' environmental performance, leading to lower potential environmental impacts per kWh electricity produced for sites with the highest solar irradiation levels.