

Cost-efficiency potential of solar energy on a global scale: Case studies for Si solar modules with PERC and heterojunction structures

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Abstract

Levelized cost of electricity (LCOE) is a crucial metric for assessing the socio-economic cost-efficiency potential of various energy sources including solar photovoltaics. Nevertheless, accurate LCOE estimations for commercialized high-efficiency Si solar modules with passivated emitter and rear cell (PERC) and silicon heterojunction (SHJ) structures have been lacking. In this study, we present the first global LCOE estimates for a PERC module (20% cell efficiency) and a SHJ module (23% cell efficiency), which have been derived by (i) performing rigorous energy-yield calculations with full-spectral and temperature-dependent simulations that incorporate all essential meteorological effects and (ii) considering country-specific capital costs and discount rates. Moreover, to determine the universal global LCOE, the LCOEs for three distinct installation capacities (100 MW for a utility, 500 kW for a commercial, and 5 kW for a residential system) have been unified by selecting an appropriate system size at each location based on a population density. We find that the LCOEs of both PERC and SHJ systems are below 3 cent/kWh in 2020 US dollar in many areas of China, Saudi Arabia, the United States, Australia, Chile, and Botswana where the conditions of a high energy yield, low population density, low capital cost, and low country-risk premium are satisfied simultaneously. In contrast, many European countries exhibit a moderate LCOE of 3~5 cent/kWh. Notably, Japan and Russia exhibit quite high LCOEs (6~10 cent/kWh) primarily due to significantly higher installation costs and moderate energy yields. Importantly, the global LCOEs of the PERC and SHJ modules are quite similar, with the SHJ module showing a slightly better cost performance in the regions near equator due to its low temperature coefficient. Conversely, the PERC module demonstrates cost advantage in the northern hemisphere due to a lower module cost.

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