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Global assessment for reduction of solar photovoltaic potential due to meteorological and geomorphological limiting factors

Mustajab Ali[1,2] and Hyungjun Kim[1]
[1]Institute of Industrial Science, The University of Tokyo, Tokyo, Japan (mustajab@rainbow.iis.u-tokyo.ac.jp)
[2]Department of Civil Engineering, Mirpur University of Science & Technology (MUST), Mirpur -10250, (AJK) Pakistan

Solar Photovoltaic (PV) has the potential to fulfill a considerable amount of growing electricity demands worldwide. In addition, being neat and clean, it can help to keep the greenhouse gases emission within safe limits. This resource needs a substantial amount of area for its sitting to supply the required amount of electricity. Such an area mainly depends on the available solar resource which is mainly the function of the local environment where PV is installed. Although some previous studies exist at the global scale, however, they have not comprehensively considered environmental (e.g., temperature, dust deposition, and snow) limiting factors that affect the actual solar PV yield. This study addresses such shortcomings and deals with all limiting factors simultaneously to provide a reliable assessment of potential PV performance at a global scale. PV cell efficiency is reduced due to an increase in resistance between cells at a temperature above a certain limit. Meanwhile, the accumulation of soil (dust) and snow on PV modules are also proven to limit the solar PV resources as it tends to block the incoming solar radiation. Lastly, the geomorphological parameter, which is an arrangement of a PV module to face the sun, is also shown to change its power output.

PV cell efficiency corrections for temperature changes, soil, and snow covers are applied using the biased corrected data from Global Soil Wetness Project 3 (GWSP3), CanSISE Observation-Based Ensemble of Northern Hemisphere Terrestrial Snow Water Equivalent, Version 2 from National Snow and Ice Data Center (nsidc), and TERRA/MODIS Aerosol Optical Thickness data available from NASA Earth Observations (NEO). The daily mean solar climatological values near the Earth's surface for the last 14 years (2001–2014) with global coverage of 0.5° x0.5° are used in the analysis. The results have demonstrated that PV performance is affected by temperature increase, soil, snow, and varying tilt-angles. An annual maximum reduction of 5.7% in the total solar PV resource is seen in the Middle East due to the temperature changes. Likewise, a maximum loss of 6.45% in the total solar PV resource is witnessed for soil deposition for Sub-Saharan Africa. A higher reduction (~20%) is shown by snow covers for Russia and Canada in the upper Northern Hemisphere. In addition, a decline of 5–7% is observed for variation in the solar PV tilt-angles in comparison to optimum ones. As a whole, a maximum reduction of 19.45% in the total solar PV resource is found, which leads to a higher coefficient of determination (R^2= 0.78) than uncorrected estimation (R^2=0.67). This study will be helpful for household as well as large scale solar schemes and may contribute particularly to achieving the UN SDG No. 07 — Affordable and Clean Energy —

and No. 13 — Climate Action — quantitatively.