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Effects of partial soiling on Thermal Infrared imaging of crystalline PV modules

Thermal Infrared (TIR) imaging identifies abnormal thermal signatures in photovoltaic (PV) modules as cell areas operating at elevated temperature. Contaminants on a PV module glass can cause mismatch in operation of PV cells connected in series and can result in hotspots. The hotspots can occur due to different thermal emissivity of the module glass and contaminants and current mismatch created when the contaminants partially shade cells. TIR imaging is generally misinterpreted due to the dynamic nature of abnormal thermal signatures caused by mismatched cells when the modules operate under real field conditions. This paper analyses the behaviour of thermal signatures observed by TIR imaging of crystalline silicon PV modules operating under changing soiling conditions. PV modules in the field are prone to soiling just like any outdoor surface. Wind-blown dust, which is unavoidable, can settle on bottom rows of PV modules and unevenly shade the cells. When cells are partially soiled, defective and of poor quality, they can operate at elevated temperature which results in non-uniform temperature distribution in the affected modules and can be detected on TIR images. Uniform soiling on PV modules limits the irradiance incident onto the shaded modules and impact on power generation. Abnormally hot cells were identified on TIR images of an unsoiled module. The hot cells operated and appeared as good cells on TIR images that were captured when three good cells in different substrings were each partially soiled (≤10%). Partial soiling forced cracked cells, which were identified through electroluminescence (EL), to behave as good cells and not revealing their abnormal thermal signature on TIR images due to minimal current mismatch. The dynamics of thermal signatures were also observed on a large scale when an array of nine monocrystalline PV modules was operating with one module partially soiled. This scenario can mislead decisions during maintenance of PV plants to only cleaning the soiled modules yet other anomalies are hidden. Incorporating EL imaging and I-V measurements can give a better insight into the state and performance of PV cells. Abnormal thermal signatures can only emerge under certain operational conditions which create significant cell mismatch else, all cells (bad and good) will appear normal on TIR images. This results in dynamics of thermal signatures since the operational conditions of PV modules in the field always change.

Keywords: Shading, current mismatch, defective cells, thermal signature

Apply to be considered for a student ; award (Yes / No)?

Yes

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PhD

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