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Title

Module Temperature Modelling For Free-Standing Photovoltaic System In Equatorial Climate

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The final generation of energy is always one of the important issues in any assessment protocol in determining the performance of a photovoltaic (PV) system. This energy generation depends on several key factors, which may be linked and formulated in a mathematical model that addresses the operating PV module temperature (MT). Whilst much effort have been put into modelling these relationships, very few studies have been conducted in this aspect under equatorial rainforest and fully humid climate region, vis-a-vis Malaysia. Moreover, none of these models developed in Malaysia are for free-standing (FS) systems. This has large impact on solar farms, as an accurate model is critical, in view of the proliferation of such farms in Malaysia. This study presents the development of MT models for FS PV system in Malaysia via simple linear regression (SLR), multiple linear regression (MLR) and multi layer

feed-forward neural network (MLFFNN) techniques. These techniques address two specific issues; quantification of relative contribution of predictors to MT model such as: solar irradiance (SI), ambient temperature (AT), relative humidity (RH) and wind speed (WS); and the modelling performance of the simple linear, multiple linear and MLFFNN models. The modelling performance was analysed using root mean square error (RMSE), coefficient of determination (R^2) and mean absolute percentage error (MAPE). This study was done in four segments which are: field testing; mathematical modelling; statistical analysis; and artificial neural network (ANN). The field testing was conducted at a grid-connected PV system in Shah Alam, Malaysia. The mathematical and statistical segments are done to establish simple linear and multiple linear models. These models are developed using SLR and MLR techniques. Finally, the ANN segment is done to establish a nonlinear model via MLFFNN technique. The modelling performance of the models developed is then compared with other published

models. In this work, a new and novel data filtration technique was developed and a new threshold value of SI was established. The technique is called thermal equilibrium point (TEP) and the threshold value is 40 Wm^{-2} . With respect to the quantification of the relative contribution of the predictors towards MT, it was found that SI = 53.8 %, AT = 37.2 %, RH = 4.9 % and WS = 4.1 % respectively. In addition, the MLFFNN model perform better than the multiple linear model by 12.0 % and 5.3 % in terms of RMSE and R^2 respectively; but the multiple linear model perform better than MLFFNN model by 1.0 % in terms of MAPE. This shows that MLFFNN MT model is the best model in terms of modelling performance. In conclusion, this study has succeeded in quantifying the relative contribution of solar irradiance (SI), ambient temperature (AT), relative humidity (RH) and wind speed (WS) towards MT; establishing a new data filtration technique; identifying a new threshold value; and developing an accurate MT model for FS PV system in Malaysia.