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A HYBRID EXPERIMENTAL MODELLING APPROACH TO SOLAR PHOTOVOLTAIC CELL TEMPERATURE PREDICTION

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Abstract – Solar cell temperature is critical in the determination of solar energy generated by a solar photovoltaic power plant. High temperatures are associated with a reduction in the energy generated, and hence prediction of photovoltaic cell temperature is essential in temperature mitigation and solar energy forecasting especially in commercial power plants. The present study focused on the development of a machine learning based predictive model for solar photovoltaic cell temperature prediction in commercial solar photovoltaic power plants. A physical experimental set up was developed to measure solar cell temperature under different weather and other related parameters. Satellite data were also collated for those parameters difficult to measure experimentally and were used to complement experimental data used in this study. Satellite data used in the study were statistically transformed for each parameter used to mimic experimentally measured data. Statistical approaches were adopted to analyse the influence of both the dependent and independent variables on solar cell temperature. The analysis included multicollinearity and correlation analysis with the aid of heat maps meant to establish the relationships among the independent and dependent variables. Feature selection and dimensionality reduction was also performed to reduce the input variables and maintain relevant data in the modelling process. Parameters with a strong correlation to each other had some of them eliminated in the modelling process. A solar cell temperature predictive model based on selected weather parameters was developed using a machine learning approach (Random Forests), and parameters used were selected from the statistical analysis. The prediction accuracy of the developed model was analysed using the coefficient of determination (R^2) and the mean absolute percentage error (MAPE). The results indicated a higher model performance compared to generic models used in cell temperature prediction. The prediction MAPE for the developed model was 0.83 °C while an R^2 value of 0.93 was obtained, which was indicative of a good model. The developed model was also comparable to other contemporary models developed to predict solar photovoltaic cell temperature. Simulations were also done to determine the annual energy generated with the incorporation of the solar cell temperature prediction model. The results revealed a 3.4 % difference in the annual energy generated between a simulation which considered solar cell temperature and which ignored the solar cell temperature. The study also revealed that this difference is even larger in monetary terms when lifetime energy generation is considered. The present study demonstrated that Random Forests, a machine learning approach to predictive modelling, can handle complex models and can provide models with a higher accuracy compared to statistical modelling approaches. The study recommends the use of solar cell predictive models to improve the accuracy of energy prediction on solar photovoltaic power plants, which in turn assists in energy planning and deployment.

Keywords – Cell temperature; empirical approach; predictive model; random forests; solar photovoltaic power plant