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Application of extreme learning machine for short term output power forecasting of three grid-connected PV systems

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ABSTRACT

The power output (PO) of a photovoltaic (PV) system is highly variable because of its dependence on solar irradiance and other meteorological factors. Hence, accurate PO forecasting of a grid-connected PV system is essential for grid stability, optimal unit commitment, economic dispatch, market participation and regulations. In this paper, a day ahead and 1 h ahead mean PV output power forecasting model has been developed based on extreme learning machine (ELM) approach. For this purpose, the proposed forecasting model is trained and tested using PO of PV system and other meteorological parameters recorded in three grid-connected PV system installed on a roof-top of PEARL laboratory in University of Malaya, Malaysia. The results obtained from the proposed model are compared with other popular models such as support vector regression (SVR) and artificial neural network (ANN). The performance in terms of accuracy and precision of the prediction models is conducted with standard statistical error indicators including: relative root mean square error (RMSE), mean absolute percentage error (MAPE), mean absolute bias error (MABE) and coefficient of determination (R^2). The comparison of results obtained from the proposed ELM model to other models showed that ELM model enjoys higher accuracy and less computational time in forecasting the daily and hourly PV output power.

1. Introduction

The fossil fuels such as oil, gas, and coal are depleting at a rapid rate and at the same time, their prices are highly unpredictable. In addition to this, global CO_2 emission associated with such energy generation and consumption remained an issue of concern (Shezan et al., 2016). There are growing discussion and research on renewable energy to provide energy access to about 1.1 billion of world population without access to electricity and to mitigate prevalent global climate change (Hossain et al., 2017). Solar energy is renewable, abundant and environmentally friendly and globally photovoltaic (PV) technology has achieved huge popularity, development, and exploration for both rural and urban electrification (Halabi et al., 2017; Izadyar et al., 2016). It is observed that since 2000, installed PV system capacity around the world has reached 178 GW as at 2014 (Diab et al., 2016; REN21, 2016).

The solar resources are highly variable in nature (Chiteka and Enweremadu, 2016) and the output power of PV system is subjected to ramping. Ramping is an indicator representing the difference between renewable energy generation in a single-hour time interval and it is expressed in relative units referred to the actual demand. The PV output power forecasting is a desperate need to ensure grid stability, economic dispatch, and optimal unit commitment (Andrychowicz et al., 2017). The instantaneous gap between forecast and measurement is a matter significantly to end users in particular (the network operators) because it helps to predict a sudden and significant change in the PV output. This concept is often referred to as a “ramp event” and is of particular interest in very short-term to medium-term solar forecasting (Vallance et al., 2017). It is believed that ramping is a key aspect in solar power management and dispatch and large ramps have to be correctly forecasted in terms of time and rate for safe operation of

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