Forecasting and Analysis of Solar Power Output from Integrated Solar Energy and IoT System

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2021 5th International Conference on Informatics and Computational Sciences (ICICoS) | 978-1-6654-3807-0/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICICOS53627.2021.9651831

***Abstract*—Solar-powered irrigation systems has attracted enormous attention considering because it is a green energy source and cost-effective green energy and power supply source for plantations and farms, especially those located in rural areas. Solar power generation systems may experience either insufficient voltage or overvoltage of solar power generation usually occurs especially for the based on the specific country that has specific climate of the installation spot. East coast states of Malaysia face northeast monsoon every year and during this season, the outputs from solar power generation systems will fluctuate greatly that the solar power distribution throughout the year was never reported elsewhere. Thus, in this study, auto-tracking solar panel was installed in a mini farm equipped with Internet-of-Thing (IoT) system for 24/7 data monitoring. From the results, the highest amount of energy generated was found from between 12 pm until 2 pm with approximately 45.9% efficiency. Then, ARIMA (11, 2, 4) model was applied using Python tool to forecast the energy generation data obtained. This forecast found the Mean Absolute Percentage Error (MAPE) of around 32.0%, which of Mean Absolute Percentage Error (MAPE) implies that the prediction was is about 68.0% validity with Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MASE) figures of recorded with 1.70 and 0.32, respectively. Forecasting the output is important to ensure the availability of existing and back-up of electricity supply, besides to avoid over and underutilization of electricity.**

Keywords—solar energy, auto-track, internet-of-things, irrigation, ARIMA, forecast

I. INTRODUCTION

Recently, enormous attention has been given to apply solar photovoltaic (PV) technology for irrigation, considering that it is renewable, easy to install, has low maintenance cost, durable, and a cost-effective power supply source for remote areas far from electricity grid. Meanwhile, a variety of industries have realized the advantage of IoT system to aid operations and maintenance, perform real time data monitoring, and provide alerts [1]. The IoT concept is generally based on connection of sensors and devices to a shared network via wired or/and wireless means [2]. In other words, data access and devices monitoring is possible from anywhere and anytime via IoT system through the aid of internet connection. The goal of this IoT system is to automate the overall process and eliminate human interference as much as possible [3].

It is known that east coast states of Malaysia including Kelantan face northeast monsoon every year. Output of solar PV generation highly relies on the weather. Accurate forecasting of solar power output is an important aspect to ensure the availability of existing and back-up electricity supplies. Such prediction can also avoid overutilization or underutilization of electricity. Various studies used different methods to predict power output such as by using Autoregressive (AR), Autoregressive Moving Average (ARMA), Auto Regressive Integrated Moving Average (ARIMA) and Seasonal Autoregressive Integrated Moving Average (SARIMA) models [4]. ARIMA model was widely used because it is an appropriate method especially for short-term time series forecasting and it can improve prediction accuracy while keeping parameter values to a minimum [5]. ARIMA or also known as Box-Jenkins method is a class of models that explains a given time series using its own previous values to estimate future values [6]. ARIMA can capture complex interactions with error and lagged terms observations.

There is limited number of studies on predicting solar power output in the east coast of Malaysia. Prediction and analysis are essential to ensure efficient energy consumption and sustainable energy resources. Hence, in this study, auto-tracking solar panel equipped with Internet-of-Thing (IoT) system was installed to irrigate a mini farm. This study used Python, an object-oriented, high-level programming language with dynamic semantics. This programming tool is relatively simple to utilize because it uses open-source language, has good readability and requires minimum processing power [7]-[9]. Python was chosen to conduct the analysis based on its English-like syntax, simple importing process, and large number of libraries available with free and open-source