UNIVERSITI TEKNOLOGI MARA

AN IMPROVED MODEL FOR OUTPUT POWER OF GRID-CONNECTED PHOTOVOLTAIC SYSTEM UNDER MALAYSIAN CLIMATE

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Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science

Faculty of Applied Sciences

June 2018

ABSTRACT

The electrical power production of photovoltaic (PV) systems in the field depends on many factors and can be broadly clustered into three categories which are: effect from heat, sunlight and external factors. Among the external factors are shading, soiling and type of PV array mounting. The direct contribution to all these factors is PV module temperature (T_{cell}) that has a direct effect on the electrical output power. Due to the rapid growth of PV installations and applications in Malaysia, several studies have been conducted on modelling of T_{cell} to quantify the output power based on Malaysia climate. Whilst much efforts have been put into modelling the T_{cell} based on ambient environmental factors, very few studies were conducted on the effect to the type of PV array mounting. Moreover, very few of these studies have related it to the output power generation of PV modules under operation in equatorial climate conditions. Therefore, this study presents the development of a new de-rating factor of output power prediction for grid-connected photovoltaic (GCPV) system in Malaysian climate due to PV array mounting type. Three objectives have been identified which are: determination of the de-rating factor of PV array due to module temperature; determination of effective cell temperature and temperature difference using logged data; and development of a new de-rating factor for output power for each PV array mounting type. This new de-rating factor is defined as PV array mounting configuration factor (f_{m_p}). The data used in this study were obtained from the testing and commissioning (T&C) data of GCPV systems from Feed-in Tariff (FiT) scheme under Sustainable Energy Development Authority (SEDA), Malaysia. Several filtration processes were performed to ensure the selection of only reliable data. Mathematical and statistical approaches were employed to examine the correlation and relationship between the parameters. The results showed that building integrated (BI) PV mounting type has the highest de-rating temperature factor (f_{temp_p}) followed by retrofitted (RF) and free-standing (FS) mounting type. The highest effective cell temperature (T_{cell_eff}) was recorded by BI followed by RF and FS mounting type. BI mounting also recorded the highest temperature difference (ΔT). The ΔT represents the difference in temperature between T_{cell} and ambient temperature (T_{amb}). Finally, a new de-rating factor due to PV array mounting type was developed to modify existing output power prediction for GCPV system in Malaysia. The results showed that with the addition of f_{m_p} to the existing output power formula, a better prediction of expected output power was obtained.

ACKNOWLEDGEMENT

Alhamdulillah, with His graciousness and blesses, this thesis is completed.

Firstly, I wish to express my sincere gratitude to my main supervisor, Dr. Nor Zaini Ikrom Zakaria, for her great concern, motivation, enthusiasm and immense knowledge towards the completion of my studies. My deepest gratitude and appreciation are expressed to my co-supervisor, Associate Professor Dr. Sulaiman Shaari, for his guidance and encouragement towards successful completion of this study. My inmost gratitude also extended to my second co-supervisor Dr. Hedzlin Zainuddin, for her valuable inputs and continuous support throughout completing this work. To all my supervisors, thank you for the countless moments of attention, dedication and constructive comments.

My sincere appreciation goes to Assoc. Prof. Dr. Ahmad Maliki Omar for always making a time answering my question and the willingness to share his knowledge and expertise.

I am highly indebted to my father, En. Mat Yusoff Mahmood and my mother, [redacted], for the encouragement, emotional and technical support, and understanding throughout the duration of my studies. To my younger siblings; Farize, Fadila, Salsabila, Firdaus, Hidayah and Siti – may this be an inspiration to them in the pursuit for academic excellence.

My appreciation also goes to Sustainable Energy Development Authority (SEDA), Malaysia for providing me with the raw data for my research purposes.

A very special appreciation goes to Dr. Worajit Setthapun, Dean of Asian Development College, Community and Technology (adiCET), Chiang Mai Rajabhat University and Dr. Hathaitip Ninsonti (Chiang Mai Rajabhat University) for providing me with technical support and invaluable insights during my internship in adiCET. Not to forget all adiCET staffs especially, P'Prom, Heng, P'Chock, Nicky, Man, Keng, Beng, Peck and Ton, thank you for helping and cheering me up during my stay at adiCET.

My heartfelt also goes to my colleagues: Pn. Melly, Dayah, En. Langga, Zaky, Pn. Putri, Pn. Fari, Mukhzani, Suraya, Farah, Syazwani, Aisyah, Ayu, Faten, Zairi, Misha, Nabilah, Ainin, Amrina, En. Khalid, and GERC staffs.

I am grateful to Fakulti Sains Gunaan, Universiti Teknologi MARA (UiTM) and Ministry of Education for providing me the opportunity and financing to pursue this studies.

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF STUDY

Photovoltaic (PV) is a technology that converts sunlight directly into electricity. There are many factors affecting the electrical output from PV system, but heat and light are the main parameters that have the most dominant direct effect. Shading, soiling, and type of PV array mounting also affect the electrical output of PV system. Thus, all these factors must be considered accordingly for all PV installations.

Malaysia is situated in the tropical climatic zone. Koppen-Geiger world climate map has categorised Malaysia as equatorial rainforest and fully humid climate region, Af (Kottek et al., 2006). The general climatic characteristics of Malaysia are abundant sunshine and solar radiation, high and uniform temperature, high humidity, heavy rainfall, and light and variable wind (Malaysian Meteorological Office, 2017). Several PV system studies have been conducted in this climatic zone to investigate the effect of high solar irradiance to the output power of PV system. High solar irradiance will lead to high temperature. Having high temperature is a disadvantage because it will derate the voltage output thus the power drastically.

Since temperature is one of the key contributors that degrades the output power of PV modules, several studies had been conducted on modelling PV module temperature, T_{cell} to quantify the output power in hot and humid climate condition. The modelling can be divided into two categories which are analytical and empirical. Analytical modelling is solely based on theoretical formula while empirical modelling is based on experimentally measured data (either real site condition or simulation). The empirical modelling can be divided into two; one which includes only the ambient environmental factors and the other includes both the ambient environmental factors and PV array mounting factor.

The Sustainable Energy Development Authority (SEDA) Malaysia defines PV mounting configurations into three categories: building integrated (BI), free-standing (FS) and retrofitted (RF). In Malaysia, FS is typically applied for parking areas, street lighting and solar farm, BI is applied as a roof which becomes part of building materials,