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A Primary Study of Tracking Photovoltaic System for Mobile Station in Malaysia

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ABSTRACT

This paper describes the performance of tracking photovoltaic (PV) system for mobile station. The system consists of tracking PV array, the battery bank, the maximum power point tracking (MPPT) controller and the DC/AC inverter. This system is the first full solar power station, which acts as pilot project by Celcom Sdn. Bhd. Success of this system shows potential of electrify rural remote area. The design is hoped to be a pioneer and acts as well-known system in order to ensure renewable energy is the future supply of electricity in far located urban area. This paper showes the record of the battery state-of-charge (SOC) as a function of time for rainy and sunny days.

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1. INTRODUCTION

Alternative energy resources are becoming increasingly attractive. Solar energy, an alternative energy resource, comes from the energy of the sun and serves as one of the most abundant permanent energy sources. Solar energy can meet a significant proportion of the energy needs of the world and is available for many applications. Solar energy is free, secure, clean, and available on earth throughout the year. This form of clean energy is important to the world, especially during these times of high fossil fuel costs and environmental concerns arising from fossil fuel applications [1] [2] [3] [4] [5].

The rapid development of technology and industry in Malaysia resulted in the high demand of energy. The future trend in Malaysia and the world energy markets is changing towards fossil fuel reduction and increasing energy consumption in the industrial sector [6]. Energy systems in the foreseeable future will tend to be environmental friendly; in which renewable energy resources offer a most promising option. These renewable energy resources are not only clean but they are uniquely sustainable. One of the most promising renewable energy resources is solar energy. Solar energy can be utilized as thermal energy, direct electricity, or a combination of both. Within a variety of renewable and sustainable energy technologies in progress, photovoltaic (PV) system appears to be one of the most promising ways meeting the future energy demands as well as environmental issues.

Solar energy can be transformed into thermal and electricity by many ways for commercial or industrial applications, such as PV systems. The PV system is the clean and friendly environment energy system and it is known as the appropriate future energy system to be implemented on the transmission system from the use of conventional fuel to the renewable energy. The PV system can reduce the air pollutant so that the warming global and climate changes can be slowed down and diminished. The PV system converts the direct solar energy to direct current (DC) electrical energy.

Due to the reason that the solar energy functions in the noon light, the energy storage system is needed here so that energy still can be used if there is no sun light [7] [8] [9] [10]. Recently, several studies of maximum power point tracking (MPPT) on PV system was reported [11] [12] [13] [14] [15] [16] [17]. The application of PV system has been conducted for stand-alone street light [18]. Objective of this paper is to present the performance of tracking PV system for mobile station in Malaysia under rainy and sunny days, which focus to state-of-charge (SOC). The SOC of a battery cell is defined as the ratio of the remaining capacity to the nominal capacity of the cell. It is one of the most important battery state variables, and an accurate SOC gauge is critical to the optimal management of batteries [19].

2. DESCRIPTION OF THE SYSTEM

Figure 1 and Figure 2 show the schematics and photograph of tracking PV system for mobile station (Celcom) installed in the Green Energy Technology Innovation Park at Universiti Kebangsaan Malaysia (UKM) in Bangi, Malaysia. The main components of this system are, tracking PV system, BOS components (i.e., the battery bank, the charge controller and the DC/AC inverter), and an electricity generation device equipped with a wiring setup and supporting structure.

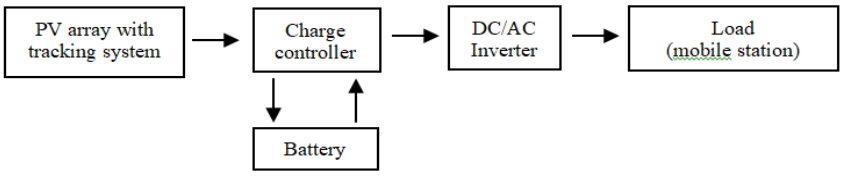

Figure 1. Schematic of tracking PV system for mobile station

Figure 2. Photograph of tracking PV system for mobile station

Figure 3. Photograph of charge controller, DC/AC inverter and wireless data logger

Panasonic HIT power solar panels are used for its high efficiency in sunlight conversion efficiency. A total of 50 PV panels with rated capacity 12 kW are used. Each PV panel is rated 240 W with voltage Vmp of 43.7 V and short circuit current, Isc of 5.85 A. Four arrays with 12 panels are connected in series. Figure 3 shows a total of 3 MPPT solar charge controller vario track is used to stimulate and control system, so that BOS system can synchronize into working the system at its highest efficiency. The controller is capable of showing solar, battery, and inverter output at rear time value and also storage data for a few days' data. A total of 24 batteries with capacity 1000 Ah of each cell are used in this system, which 12 batteries are connected in series and paralleled in 2 arrays. Each battery is 2 V, which lead acid battery was chosen as the storage system.

3. RESULTS AND DISCUSSION

The performance of the system was recorded by in-situ measurement techniques during two days in monsoon season which occurred in the December, and two day in January for sunny days. Relevant data for two day in monsoon season (December 21 and 22) is presented in Figure 4. The record of the SOC as a function of time for rainy days. Figure 5 shows the record of the SOC as a function of time for sunny days. The battery temperature recorded was about 29–33 ºC as shown in Figure 6.

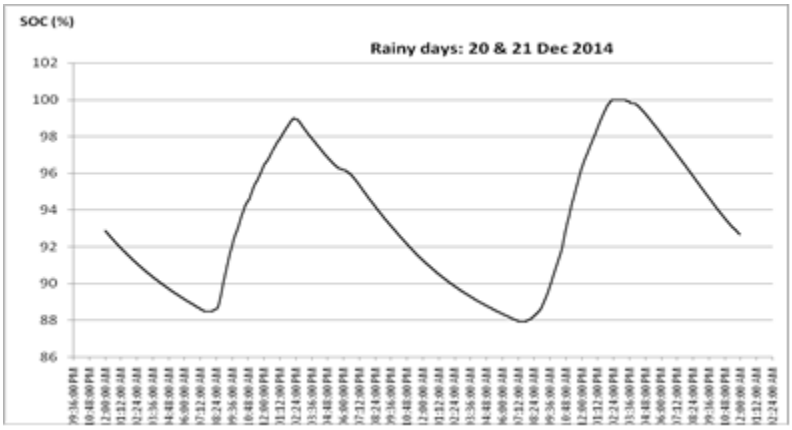

Figure 4. The record of the SOC as a function of time for rainy days

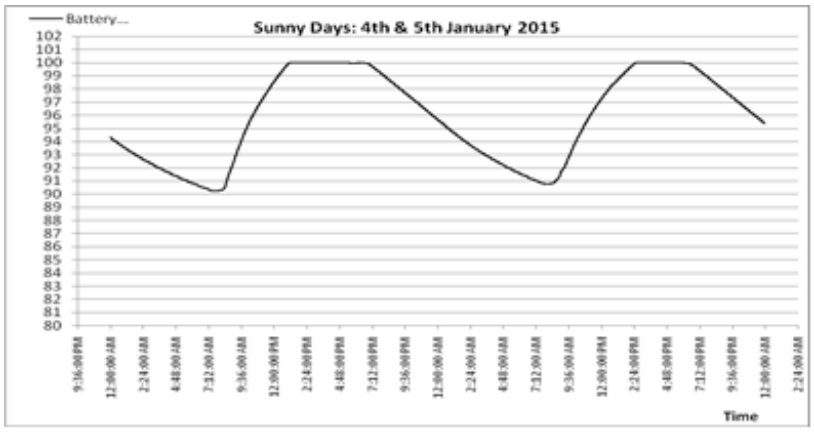

Figure 5. The record of the SOC as a function of time for sunny days

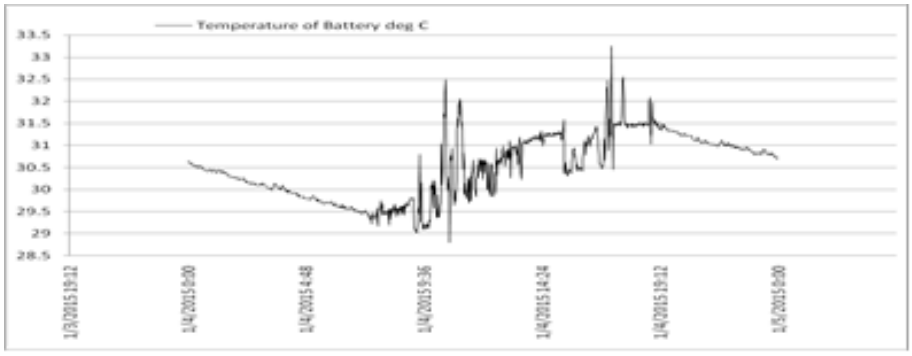

Figure 6. The record of battery temperature as a function of time for sunny days

4. CONCLUSION

The tracking photovoltaic (PV) system for mobile station is the clean and friendly environment energy system and it is knows as the appropriate future energy system to be implemented on the transmission system from the use of conventional fuel to the renewable energy. This system can reduce the air pollutant so that the warming global and climate changes can be slowed down and diminished. In conclusion, there is a good potential for pilot tracking photovoltaic system for mobile station at remote, rural area. This system is the first full solar power station, which acts as pilot project by Celcom Sdn. Bhd. Success of this system shows potential of electrifying rural, remote area. The design is hoped to be a pioneer and acts as well-known system in order to ensure renewable energy is the future supply of electricity in far located urban fringe area.

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BIOGRAPHIES OF AUTHORS

Ahmad Fudholi, Ph.D, M.Sc obtained his S.Si (2002) in physics. He has working experience about 4 years (2004-2008) as Head of Physics Department at Rab University Pekanbaru, Riau, Indonesia. A. Fudholi started his master course in Energy Technology (2005-2007) at Universiti Kebangsaan Malaysia (UKM). After his master he became Research Assistant at UKM up to 2012. After his Ph.D (2012) he became Postdoctoral in Solar Energy Research Institute (SERI) UKM up to 2013. He joined the SERI as a Lecture in 2014. More than USD 310,000 research grant (13 grant/ project) in 2014–2017 involved. More than 25 M.Sc project supervised and completed. Until now, he managed to supervise 5 Ph.D (4 main supervisor and 1 Co. supervisor), 2 Master's student by research mode, and 5 Master's student by coursework mode, he was also as examiner (3 Ph.D and 1 M.Sc). His current research focuses on renewable energy, especially solar energy technology, photovoltaic thermal (PVT) systems and solar drying systems. He has published more than 100 peer-reviewed papers, which 25 papers in ISI index (20 Q1, impact factor more than 3) and more than 50 papers in Scopus index, 10 more currently accepted manuscript, 20 more currently under review, and 2 book chapters. Addition, he has published more than 70 papers in international conferences. His total citations of 601 by 411 documents and h-index of 12 in Scopus (Author ID: 57195432490). His total citations of 1109 and h-index of 19 in google scholar. He is appointed as reviewer of high impact (Q1) journal such as Renewable and Sustainable Energy Reviews, Energy Conversion and Management, Applied Energy, Energy and Buildings, Applied Thermal Engineering, Energy, Industrial Crops and Products, etc. He is appointed as reviewer of reputation journals such as Drying Technology, International Journal of Green Energy, Biosystem Engineering, Journal of Sustainability Science and Management, Journal of Energy Efficiency, Sains Malaysiana, Jurnal Teknologi etc. He is also appointed as editor journals. He has received several awards such as Gold Medal Award at the International Ibn Al-Haytham's Al-Manazir Innovation and Invention Exhibition 2011, Silver Medal Award at the International Technology EXPO (ITEX) 2012, Silver Medal Award at the Malaysia Technology Expo (MTE) 2013, Bronze Medal Award at International Exposition of Research and Invention (PECIPTA) 2011, also 2 Bronze Medal Award at PECIPTA 2017. He was also invited as speaker: Workshop of Scientific Journal Writing; Writing Scientific Papers Steps Towards Successful Publish in High Impact (Q1) Journals.

Ar. Dr. Lim Chin Haw is a Senior Research Fellow at the Solar Energy Research Institute (SERI), University Kebangsaan Malaysia and a professional registered Architect with the Malaysia Board of Architects. He has 15 years of professional architectural practice experience and more than 13 years as an avid researcher covering a variety of projects both local and international. He is actively involved in many solar energy researches and demonstration projects with industries and international collaboration with renowned research institute such as Fraunhofer Solar Energy Research Institute, Germany. His area of expertise encompasses Passive and Low Energy Architecture, Building Integrated PV System (BIPV), Energy Efficiency in Buildings, Solar Assisted Air-Conditioning system, Building Performance Simulation and Natural Ventilation. He has also received several awards namely the Asean Energy Awards 2004 and 2014, Silver Medal Award for Building Integrated PV Thermal Solar Collectors at International Exposition of Research and Invention (PECIPTA) 2009, Silver Medal Award for Ultra Low Energy House at the Malaysia Technology Expo (MTE) 2010 and Gold Medal Award for Inverted Air Foil Wind Driven Ventilation Tower at the International Ibn Al-Haytham's Al-Manazir Innovation and Invention Exhibition 2011.

Prof Dato' Dr. Kamaruzzaman Sopian graduated with the BS Mechanical Engineering from the University of Wisconsin-Madison in 1985, the MS in Energy Resources University of Pittsburgh in 1989 and PhD in Mechanical Engineering from the Dorgan Solar Laboratory, University of Miami at Coral Gables in 1997. His MS thesis was on Solar Absorption Cooling System and the PhD dissertation was about the Double-Pass Photovoltaic Thermal Solar Collectors. Upon graduation, he has been appointed as an Assistant Professor at the Department of Mechanical and Materials Engineering, Universiti Kebangsaan Malaysia (National University of Malaysia). He was promoted to the post of Professor of Renewable Energy in the Department of Mechanical and Material Engineering, at the Universiti Kebangsaan Malaysia (the National University of Malaysia) in 2001 and currently is the Director of the Solar Energy Research Institute in the same university since 2005. He has been involved in the field of renewable energy for more than 25-years. His main contributions are in solar radiation modeling and resource assessment, advanced solar photovoltaic systems (grid-connected photovoltaic, solar powered regenerative fuel cell, solar hydrogen production, thin film silicon solar cell) and advanced solar thermal systems (solar cooling, solar heat pump, solar assisted drying, combined photovoltaic thermal or hybrid collector). He has secure research funding from the Malaysian

Minstry of Science and Malaysian Ministry of Education and industry for more than USD 6 million. He has conducted renewable enery courses the Asian School of Energy (2007 - 2014) funded by ISESCO, COMSAT, TIKA and UNESCO. He has published over 800 research papers in journals and conferences (SCOPUS h index = 49, no. of citation = 8001) (Google Scholar h index = 60, no. of citation = 13473). A total of 32 MSc (coursework), 15 MSc (research mode) and 40 PhD candidates from various countries such as Bangladesh, Iran, Iraq, Algreria, Libya, Indonesia, Nigeria, Oman, Yemen, Malaysia and Jordan have graduated under his supervision. He has delivered keynotes and planery speeches at national and international conferences on renewable energy in Malaysia, China, India, Iraq, Iran, France, Greece, Morroco, United Kingdom, United States, Hungary, Egypt, Libya, United Arab Emirates, Syria, Saudi Arabia, Bahrain, Indonesia, Thailand, Philiphines, Japan, Singapore, Germany, Holland, Italy, Maldives, and Combodia. He has undertaken short assignments in about 10 countries for international agencies and programs such as UNDP-GEF, UNIDO, ASEAN EU-Energy Facility, ASEAN-Australia Economic Co-operation Program, ASEAN-CIDA (Canada International Development Agency), JSPS-VCC, British Council CHICHE, ISESCO and UNESCO related to renewable energy technology. He has been appointed as the Honorary Professor of Renewable Energy, at the Faculty of Built Environment, University of Nottingham, United Kingdom (2009 -2013). In addition, he has been appointed as the associate editors of the Journal of Renewable Energy (2005 – 2010) and Journal of Sustainable Cities and Society published by Elsevier Ltd, and Journal of Energy, Hindawi. Journal of Sustainable Energy and the Environment (Thailand), Jordan Journal of Mechanical and Industrial Engineering (JJMIE) (Jordan), International Journal of Thermal and Environmental (Canada) and Palestine Technical University Research Journal (Palestine). He won several international awards for his academic contribution in renewable energy including the IDB (Islamic Development Bank) S&T Prize 2013, World Renewable Energy Network Pioneer Award 2012, Malaysia Green Technology Award 2012, and the ASEAN Energy Awards (2005, 2007, 2013 and 2014). He has 4 patents, 20 patents pending, 6 copyrights, and 1 trademark for his innovation in renewable energy technology. The innovation and invention in renewable energy technology have won 80 medals in national and international innovation and invention competitions including special innovation awards such as Prix de L 'Environnement by the Swiss Society for Environmental Protection, 2001, Geneva, Sustainable Development Award INNOVA 2007, Special Prize, Korea Invention Promotion Association at the INPEX Pittsburgh 2008 and Energy and Environmental Award, at INNOVA 2013 in Brussels. His Royal Highness The Sultan of Perak conferred the Paduka Mahkota Perak (PMP) in 2003 and the Dato' Paduka Mahkota Perak (DPMP) in 2013. He was conferred as a Fellow of the Malaysia Academy of Sciences (FASc) in 2011. Promoting renewable energy technology to the communities and industries has always been his passion. He has developed and delivered solar dryers for fish and seaweeds in Karkor Cambodia and Semporna Malaysia respectively. In addition, he has developed a cottage industry for manufacturing of photovoltaic panels in Kuala Trengganu. He has also delivered the first pico hydro system for an orang asli community in Kampung Tuel, Kelantan. He has designed and commissioned the first large scale solar assisted hot water system for a 1000 bed hospital in Malaysia and also a solar assisted drying system for old palm fronds for a palm oil factory in Malaysia.