STREET LIGHTING USING HYBRID SOLAR/WIND SYSTEM FOR BALAI CERAPAN UTM

LEE SOO EU

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DEDICATION

This project report is dedicated to

My beloved parents, Lee Hap Cheng and Teh Bee Heong

and

all my siblings

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ABSTRACT

Global issues such as global warming, rising sea level, deprivation of fossil fuel and rising electricity cost have accelerated the research and development on alternative energy sources. In recent years, wind and solar sources have become the prominent source of alternative energy. Wind and solar sources are popularly integrated together in renewable energy systems because solar cells can produce the electricity needed during sunny days while wind turbines can cover the electricity needs during windy days. In UTM, there are lots of street lights, powered by utility electricity installed. As the campus area of UTM is very wide, the amount of electricity cost incurred to UTM is very high. Hence, in this study, an alternative has been searched to reduce the dependency on fossil fuel electricity. Therefore, an appropriate hybrid solar/micro wind unit into a dedicated LED street lighting system has been proposed and installed at UTM's Balai Cerapan. The hybrid street light comprises of a 80W mini PV panel, a 300W micro wind turbine, a 90Ah battery, control unit and a 30W LED street light. The built in energy management control has been modified and tested to provide smarter control between PV panel and micro wind system throughout the day for a smarter energy management. This new algorithm is able to dim the LED lamp brightness when there is no motion detected. From the simulation, it has been found that potential energy savings of at least 77% can be achieved by using the new energy management algorithm. Hence, it can be concluded that the proposed hybrid solar/wind with dedicated LED street lighting system has been successfully installed, modified (through simulation) and operated at UTM's Balai Cerapan. As implication, it is hoped that installation of this similar proposed units will help to save the UTM's electricity bills on the street lighting purpose, without compromising the security and comfort to the users.

ABSTRAK

Isu-isu seperti pemanasan dunia, kenaikan paras air laut, sumber fosil yang berkurangan dan kenaikan harga elektrik menjadi pendorong utama penyelidikan dan pembangunan sumber tenaga alternatif. Kini, tenaga angin dan suria telah menjadi sumber tenaga alternatif utama yang digunakan bagi menggantikan sumber fosil. Sumber tenaga angin dan suria sering digandingkan dalam sistem tenaga boleh diperbaharui kerana panel suria boleh menjana tenaga elektrik pada waktu siang, manakala turbin angin boleh menjana tenaga elektrik pada waktu malam. Pada ketika ini, terdapat banyak lampu jalan yang bersambung dengan utiliti elektrik beroperasi sekitar kampus UTM. Kos elektrik yang perlu ditanggung adalah tinggi disebabkan kampus UTM yang luas. Satu pendekatan alternatif yang dapat mengurangkan kebergantungan terhadap elektrik fosil telah diterokai dalam kerja penyelidikan ini. Oleh yang demikian, satu lampu jalan LED yang berkonsepkan hibrid suria/ angin mini telah dicadangkan dan dipasang di Balai Cerapan UTM. Lampu jalan hibrid ini merangkumi komponen seperti panel suria mini 80W, turbin angin mini 300W, bateri 90Ah, unit kawalan dan lampu LED 30W. Unit kawalan asal telah diubahsuai dan diuji agar dapat memberikan kawalan yang lebih baik antara panel suria dan turbin angin mini sepanjang hari, bagi mencapai pengurusan tenaga yang lebih bijak. Pendekatan yang baru ini dapat mengurangkan kekuatan cahaya lampu LED semasa tiada pengerakan di sekitar kawasan lampu jalan. Hasil daripada simulasi yang dijalankan, adalah didapati bahawa pendekatan baru ini dapat menjimatkan sekurang-kurangnya 77% tenaga. Secara kesimpulannya, lampu jalan LED hibrid suria/angin mini yang dicadangkan telah berjaya dipasang, diubahsuai (secara simulasi) dan dioperasikan di Balai Cerapan UTM. Adalah diharapkan bahawa pemasangan lampu jalan yang serupa ini dapat menjimatkan kos elektrik lampu jalan UTM, tanpa menjejaskan keselamatan dan keselesaan penguna.

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LIST OF ABBREVIATIONS

WT	-	Wind Turbine
HAWT	-	Horizontal Axis Wind Turbine
VAWT	-	Vertical Axis Wind Turbine
PV	-	Photovoltaic
FC	-	Fuel Cell
LCOE	-	Levelized Cost of Energy
COE	-	Cost of Energy
DNI	-	Direct Normal Irradiation
LED	-	Light Emitting Diode
O&M	-	Operation and Maintenance
TNPC	-	Total Net Present Cost
SOC	-	State of Charge

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Global issues such as global warming, rising sea level, deprivation of fossil fuel and rising electricity cost have accelerated the research and development on alternative energy sources. In recent years, solar and wind source have become the prominent sources of alternative energy worldwide. Apart from power generation and transportation system, alternative energy has found their way into smaller scale applications such as remote villages, city lighting system, water pumping for irrigation and desalination [1].

Alternative energy or renewable energy has also been gaining momentum in ASEAN countries. Figure 1.1 shows the renewable energy establishment and targets for ASEAN countries as of year 2014. It can be seen that solar energy is the second most preferred renewable energy source for ASEAN countries. Meanwhile, solar energy is the most preferred and promising renewable energy technology in Malaysia [2]. There is also strong political support for solar energy in Malaysia as seen in the implementation of Feed-in Tariff (FiT) and Net Energy Metering (NEM) schemes for solar PV generations.

Country	Target Year	RE Targets	Most RE Technology Preference	RE Installed in 2014 (MW)	How Far?
Brunei Darussalam	2025	954 GWh	Solar energy (954 GWh)	1.67	0.2%
Cambodia	2020	2,241 MW	Hydropower (2,241 MW)	952	42%
Indonesia	2025	46,307 MW	Hydropower (21,300 MW)	6,680	16%
Lao PDR	2025	951 MW	Small hydro (534 MW)	3,348	5%
Malaysia	2050	21,370 MW	Solar energy (18,700 MW)	6,286	29%
Myanmar	2016	472 MW	Small hydro (472 MW)	3,204	N/A
Singapore	2020	350 MWp	Solar energy (350 MWp)	33.1	9%
The Philippines	2030	15,236 MW	Hydropower (8,937 MW)	5,898	38%
Thailand	2036	19,684 MW 15,236 MW	Solar energy (6,000 MW) Biomass (5,570 MW)	7,901	40%
Vietnam	2030	45,800 MW	Hydropower (27,800 MW)	17,140	37%

Figure 1.1 Power generation of different renewable energy in ASEAN [2]

From global view, there are huge potentials of wind energy that can be tapped into power generation worldwide. Figure 1.2 illustrates the wind velocities at different sites worldwide [3]. As of year 2014, China is the country that has the most number of established wind power capacity (114,609 MW) worldwide. Moreover, China strives to increase its wind power capacity by another 50% by year 2020, and is currently working on technologies to harness wind power in the lower wind speed areas. Wind energy development in Malaysia is a more challenging subject because Malaysia is located in a low wind speed area. Currently, wind energy is not included in the FiT scheme. The Sustainable Energy Development Authority (SEDA) of Malaysia has embarked on project to produce a comprehensive wind map for Malaysia [4]. It is worthwhile to conduct wind energy researches in Malaysia as the current micro wind turbine technologies are becoming more matured and reliable.

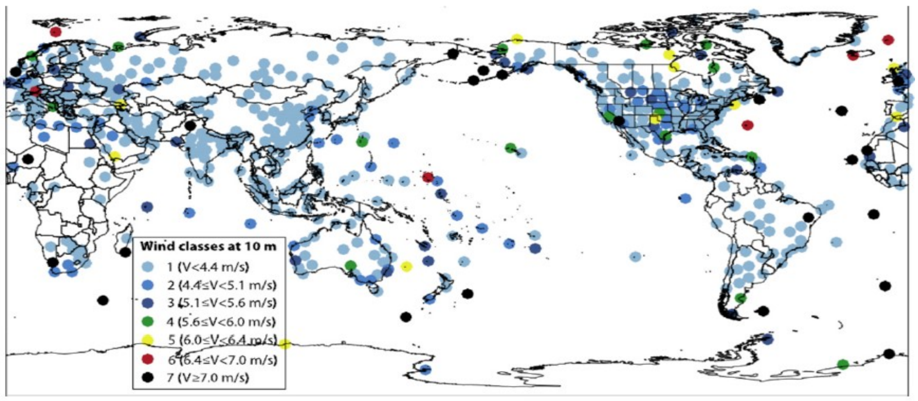

Figure 1.2 Malaysia belonged to wind class 1, wind speed less than 4.4 m/s [3]

One of example application that utilizes solar and wind technologies is street lights. Street lights themselves use 43.9 billion kWh of electricity annually. Conventional street lights are powered by utility connected electricity. They have higher carbon footprints, and are considered less sustainable plus less environmental friendly compared to renewable energy powered street lights [5]. In addition to that, most of the urban area street lights are controlled manually, by a control switch installed in each of the streetlight. Energy saving is very difficult to be achieved with manual control [6]. In Lebanon, the luminaries used for conventional street lights are the 250W and 400W high pressure sodium (HPS) lamps. It was mentioned that for the same output luminance, HPS lamps consumed 50% more energy than the newer type LED lamps [7].

The two more common types of hybrid street lights are solar PV streetlight and solar PV- wind turbine (PV-WT) streetlight. Table 1.1 shows the comparison between the two types of hybrid street lights. The advantage of solar PV streetlight is the relatively cheaper cost due to lesser components, such as the absence of costly wind turbine and sophisticated hybrid energy management control unit. On the other hand, the main disadvantage of solar PV streetlight is the unavailability to provide continuous illumination in places that are far away from the equator. The solar irradiation in these places depends much on the seasons. During winter season, solar irradiation is weaker. Since the daylight duration is shorter, the lighting duration and load also increased [8].

The coupling of solar PV and WT enables the street light to function better. When the solar PV is unable to perform, WT will act as a back-up, and vice-versa. Solar PV can generate electricity during day time, while WT can support the street light during cloudy days and also during night time where winds are usually available [9]. On cloudy days, wind speed is normally high, but the solar irradiation is poor. On sunny days, wind speed is low but the solar irradiation is high [10]. Another advantage of coupling solar PV and WT is that the electricity generating capacity can be increased, and the dependency of batteries is greatly reduced [11]. A simulation carried out showed that a solar-WT street light is able to illuminate 61%

of the needed lighting hours. In countries with cold climate, WT provided the main electricity supply during the winter season [12].

Table 1.1 Comparison between two different types of hybrid street lights

Solar PV streetlight	**Solar PV- WT streetlight**
Advantage: • Lower cost than solar PV-WT streetlight	Advantages: • WT can support during night time, cloudy days, and winter season • Bigger generating capacity • Smaller battery size
Disadvantage: • Unable to provide continuous illumination in places far away from equator	Disadvantage: • Higher cost than solar PV streetlight

The solar PV- WT street lights received widespread use [13]. Research on this newer system were carried out by various institutions worldwide, such as the Faculty of Technology of Marmara University, Turkey [14], Faculty of Electrical Engineering of UTeM, Malaysia [15], Technical University of Ostrava, Czech Republic [16], and Politechnic University of Marche, Italy [12]. In Bahrain and China, big buildings are already installed with street lights powered with solar PV and VAWTs. There has been an increase in the use of VAWTs over HAWTs because they have better aesthetic value and able to harness wind energy disregard of the wind direction [17].

1.2 Problem Statement

In UTM, there are lots of street lights installed, powered by utility electricity. As the campus area of UTM is very wide, the amount of electricity cost incurred to UTM is very high.

1.3 Objectives

The objective of this work is:

1. To install a micro street lighting system using hybrid solar/wind system at UTM’s Balai Cerapan.
2. To design, develop and test the performance of a smarter energy management algorithm in the installed hybrid unit.

1.4 Scopes

The scopes of this work are:

1. Usage of a 80 W mini PV panel and a 300 W micro wind turbine as free energy source.
2. The micro wind turbine will be of a hybrid Savonius-Darrieus type VAWT.
3. Smart control between PV panel and micro wind system during day and night.

1.5 Research Outline

In the following sections, further details on this work will be presented. The literature reviews related to this work are given in Chapter 2. The research process and method are described in Chapter 3. The preliminary results of the hybrid solar-wind street light are presented in Chapter 4. Finally, the work's conclusion based on the preliminary results is made in Chapter 5.

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