Pre-Feasibility Study on the Suitability of the Installation of Wind Solar Hybrid Energy System in Peninsular Malaysia

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Abstract

There were varies of renewable energy technologies available in market but these two types namely solar and wind have attracted more attention as wind and solar renewable energy systems can be set up as autonomous or stand-alone. Wind-solar hybrid system is the complementarily between the solar energy and the wind energy which one of the energy sources would offset shortfall of the other and produce significantly to meet the energy demand. Wind Solar Hybrid off-grid Energy System counted as a best hybrid model which compensate each other while create the expectation outcomes. This paper presents the pre-feasibility study for implementation of the wind solar hybrid off-grid energy system at the Peninsular Malaysia. This study was carried out by considering the meteorological data to determine the possible location and on-site collection data from the selected place. Based on the analysis of the findings, Wind Solar Hybrid off-grid Energy System consider having the potential possibility suitable installation in Peninsular Malaysia. Mersing, Johor had been identified as high potential condition to install this type of energy system. However, there were some barrier requirement such as size of land and capability of wind energy that need to be consider before installing the Wind Solar Hybrid off-grid Energy System. Awareness of hybrid energy system has been discover and attract attention by those energy department under government of Malaysia through this research.

KEYWORDS: Sustainable Energy; Wind Energy; Solar Energy; Hybrid Energy; Peninsular Malaysia

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Introduction

Society go across the world live under large demand of electrical energy which the world energy demand will increase by 56% from 2010 to 2040 [1]. Therefore, global authorities are placing significant conviction about technologies system of renewable energy for major component strategy to deal with depletion energy resources and reducing energy related environmental problems, particularly carbon dioxide emissions [2].

Malaysia experiencing a time of uncertainty on the ability of the interconnected system to meet the electricity demands. This will be a more serious issue especially to the urban and major cities area by experiencing a high rising population with average 0.4 million to 0.7 million per year [3]. The main concern will be in Peninsular Malaysia area where most of major cities such as Kuala Lumpur and Johor Bahru were located.

According to the report by Energy Commissioner Malaysia [4], Peninsular Malaysia consumed 86% of electricity from the overall Malaysia's demand. From year 2005 until 2013, the increasing demands of electricity were raised at rate of 300 ktoe to 400 ktoe every year. This demands becoming a threat when it keep increasing and recorded a highest ever demand on year 2016 at 17,788 megawatt [5].

In order to make sure the demands on electricity been fulfil, Malaysia Government had done lot of initiative to look forward into renewable energy. In 2015, Sustainable Energy Development Authority (SEDA) reported that 985 megawatts of electricity had been generated from the renewable energy [6]. There are variety of renewable energy technologies available in market but two of them namely solar and wind have attracted more attention as wind and solar renewable energy systems can be set up as autonomous or stand-alone.

Wind-solar hybrid system is the complementarily between the solar energy and the wind energy which one of the energy sources would offset shortfall of the other and produce significantly meet the energy demand [7]. Research done by Mann & Teilmann [8], discovered that wind solar hybrid energy system counted as a best hybrid model which grid connected state and compensate each other while create the expectation outcomes. Various wind-solar hybrid system had been researched and installed in many countries over a decade of years [7, 9, 10]. The most successful wind-solar hybrid system is named H2Ekokaravan which been made by Turkey [11]. This model had been travelling over the world to show the potential of harnessing wind-solar hybrid system. The majority of power supply for H2Ekokaravan depend from solar energy, which produced 2,200 kWh in estimate while wind energy will only produce 989 kWh whereas energy demand is 4,220 Wh per day. The concept of wind-solar hybrid energy system as shown in Fig. 1 which the AC power form the wind is straight delivered to the load via un-interruptible power supply (UPS). The additional power, if available, is used to control the battery through an AC/DC converter. The power gained from the PV is also used in charging the battery via a DC/DC converter [12].

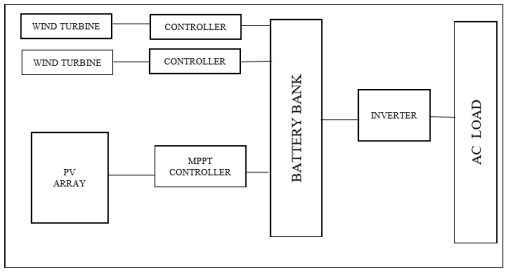

Fig. 1 Concept diagram of wind-solar hybrid energy system.

In 2012, SIRIM has successfully installed a preliminary demo of wind solar hybrid energy system at the tip of Borneo [13]. The area is at the meeting point of two major seas: the South China Sea and Sulu Sea which is near the coastal line and experiences strong wind throughout the year with high solar irradiation. This experiment shown that Malaysia had strong wind and solar energy to be harnessed at the tip of Borneo. Therefore, SIRIM hopes that this will lead to another breakthrough in commercialising solar and wind hybrid farms in the future.

This paper present a pre-feasibility study of a wind-solar hybrid energy system on the suitability of installation at the Peninsular Malaysia. The focus of this paper is to identify a possible location within the Peninsular Malaysia where the solar radiation and wind speed at suitable level. In addition, it also cover the policies and perceptions of the authorities in order to gain possible suitability of installation.

Materials and Methods

The focus of this work is to find a suitable location to install a wind-solar hybrid energy system in the Peninsular Malaysia. However, it will only depends on the weather data and observation as this study were still in pre-feasibility stage. Therefore, a climatic conditions and magnitude of wind and solar will be used as a primary data to point the most suitable location.

In order to determined, either there is any possibility to install this system, the global weather pattern need to be considered. It taken from NASA surface meteorological station which showed that Peninsular Malaysia received around 175 kWh of solar radiance and 4.0 m s^{-1} of wind speed [14].

Wind-solar hybrid energy system strongly depends on solar radiation and wind speed potential available on site [10]. Therefore, a data that proved existence of enough solar radiation and wind speed is important. This pre-feasibility study considered of having primary and secondary data. The secondary data were including weather pattern from NASA and from Malaysian Meteorological Department, which allowed narrowing down the potential location around Peninsular Malaysia. An exact data used for weather pattern were obtain from Malaysian Meteorological Department, which consists data from year 2013 until year 2015. The highest wind received is 2.87 m s^{-1} and the lowest is 0.76 m s^{-1}. The speed of wind received depend on the location, which near the ocean area.

Then, an observation were done at each of potential location in order to get the primary data for this pre-feasibility study. The Beaufort scale were used to estimate the wind strength according to the appearance of the sea and land. Table 1 showed a category for the scale with wind force '0' is calm while wind force '12' is a hurricane.

Category	Description
0	Calm, smoke rises vertically
1	Light air, direction of wind shown by smoke but not by wind vanes
2	Light breeze, wind felt on face and leave rustle
3	Gentle breeze, leave and small twigs in constant motion
4	Moderate breeze, raises dust and loose paper with small branches moved
5	Fresh breezes, small trees in leaf begin to sway, crested wavelets form an inland waters
6	Strong breeze, large branches in motion with whistling heard in telegraphic wires
7	Near gale, whole trees in motion and inconvenience walking against the wind
8	Gale, breaks twigs off trees and generally impedes progress
9	Strong gale, slight structural damage occurs
10	Storm, seldom experienced inland
11	Violent storm, accompanied by widespread damage
12	Hurricane

Sir Francis Beaufort from Navan devised the Beaufort scale and it was created more than 200 years ago. This scale were used to determine the wind speed by observation.

Results and Discussion

Wind energy potential

The wind speed information is essential in order to get a clear picture about the potential wave energy induced by wind power. It is necessary to calculate the amount of wind power and time of availability. In addition, the fluctuation of the wind power are needed for designing the energy storage and load scheduling.

According to the wind speed data given by Malaysia Metrological Department which taken from 2 meters above ground shown Malaysia has under goes strong wind speed in the early and end parts of year. Focus on the part of Peninsular Malaysia, Kota Bharu, Langkawi Island, Mersing and Kuala Terengganu has relatively high wind speed which having monthly mean of wind speed in exceed 3 m s^{-1} as compared to the others towns located at Peninsular Malaysia as per showed in Fig 2. Overall, daily mean wind speed in Peninsular Malaysia is 2 m s^{-1} which actually not a very high speed compared to other cities in a world.

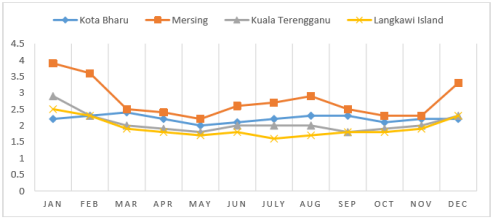

Fig. 2 Average wind speed over the cities at the coast of Peninsular Malaysia.

An observation analysis were done at four of the possible location based on the wind speed data provided by Malaysia Metrological Department. By using the Beaufort scale, Kota Bharu and Langkawi Island received wind force of '2' most of the time. The reason maybe due to lot of construction happened at the location and this increasing the temperature and reducing the wind speed.

However, certain towns, which near the ocean area such as Kuala Terengganu and Mersing received an enough minimum wind speed with assumption of '3 'to'4', wind force. This wind force observation will be greater when the location was increased to higher location with wind force of '5'. The idealized wind speed distribution for this hybrid system is around 4 m s^{-1} to 4.5 m s^{-1} especially around 10 am to the 12.00 pm [15].

Solar energy potential

Malaysia is a country located at one of the largest solar radiation region, which receive plentiful of sunshine all year long. By referring to table 2, the average of sunshine duration is about 4 till 8 hours per day with the average of solar radiation in 4,000 till 5,000 Wh m^{-2} [16]. Sensitivity analysis is done with three values around the mean, which are : 1.5, 3.15, and 5.0 kWh $m^{-2}d^{-1}$.

Table 2 Average annual temperature and solar irradiation

City	Average Temperature (ºC)	Average Irradiation (kWh m^{-2} d^{-1})
Kota Bharu	27.1	5.22
Kuala Terengganu	27.3	5.41
Langkawi	28	5.06
Mersing	26.5	4.54

Potential Location

After analysis all weather data and information given and recommend from Malaysia Metrological Department and on-site observation data, Mersing is a potential location for installation of Wind Solar Hybrid Energy System. Based on the location Mersing that situated at the Southeast Peninsular Malaysia with 43.6 MSL is the highest compared to other cities nearby the coast ocean. After observation analysis of wind speed among those cities in Peninsular Malaysia, Mersing considers experiences the highest potential wind energy installation with a cut in speed 2.5 m s^{-1} while some of the wind turbines require in 2 m s^{-1} and above. Various researcher had studied the potential of wind speed in Mersing [17–18]. The annual mean wind speed reach it highest value at 2.9 m s^{-1} in 2011. The lowest value is at 2.5 m s^{-1} in the year of 2012. Details are shown in Fig. 3. Based on the annual mean wind speed for these four years, suggest that Mersing has potential in generating wind energy as the minimum value for generating energy is 2.5 m s^{-1}.

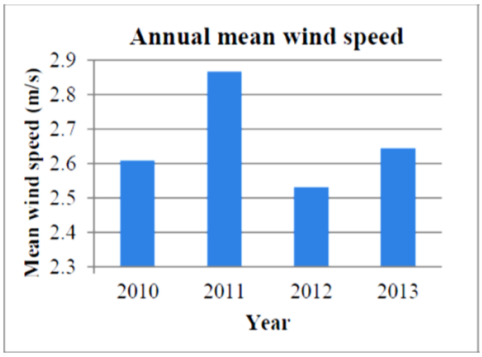

Fig. 3 Annual wind speed in Mersing, Johor.

The wind speed will be increases every 10% when doubling the height of system installation which means there might be a greater wind speed collected at Mersing [19]. While, the solar irradiation received around 4.54 kWh m^{-2} d^{-1} with average temperature of 26.5 ºC. Although Mersing encounter has a relatively low solar radiation received compared to Kuala Terengganu but battery provided for this system can be fully charged as long as there is 8 hours of sunshine per day. Therefore, availability of solar energy in Mersing will sufficiently operate the system.

Conclusion

The study revealed that Mersing showed a potential location to install this system. Based on the data, with annual wind mean values greater than 2.5 m s^{-1} and solar radiation of 4.54 kWl $m^{-2}d^{-1}$, it is an enough renewable sources to operate the Wind-Solar Hybrid Energy System. Further studies should be carried out at Mersing to locate the exact location that can trigger the highest wind and solar energy power. With that exact location, an accurate investigation may lead to a bigger discovery. The potential will be useless without any beneficial steps by all parties, including researchers, government and private sectors.

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