PROGRESS IN ENGINEERING APPLICATION AND TECHNOLOGY
e-ISSN: 2773-5303

PEAT

Vol. 5 No. 2 (2024) p. 149-158
https://publisher.uthm.edu.my/periodicals/index.php/peat

Investigation on the Performance of Solar Panels as Wind Turbine Blades for Sustainable Power Generation

Muhammad Izhar Nor Zahari[1], Lilywati Bakar[1*],Farahiyah Mustafa[1], Amirul Syafiq Sadun[1]

[1] *Department of Electrical Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, 84600, Pagoh, Johor, MALAYSIA Y*

*Corresponding Author: lilywati@uthm.edu.my
DOI: https://doi.org/10.30880/peat.2024.05.02.015

Article Info

Received: 27 June 2024
Accepted: 18 July 2024
Available online: 25 November 2024

Keywords

Renewable energy,Solar panel, Wind turbine blades,One entity,DC electricity, Hybrid.

Abstract

Over the last decade, the world's population has grown dramatically, resulting in a significant increase in energy demand. The depletion of fossil fuels and environmental issues like global warming necessitate the adoption of renewable energy sources such as solar, wind, hydro, and biomass. The main objectives of this research are to study the efficiency and viability employing solar panels as wind turbine blades in achieving high output power and to evaluate the performance in harnessing wind and solar energy and the continuity to sustainable power generation. This project is unique because it combines two different inputs, wind and sunlight, to produce DC electricity as output in a single entity. Wind converts kinetic energy into rotational energy, which is then transferred to a generator via a shaft, generating electrical energy. Solar panels replace rotating blades with PV cells, which absorb sun energy, generating electrical charges that react with internal electrical fields, resulting in electricity flow. This study analyses the value of voltage and current produced by both sources to ensure the level of solar efficiency in generating electricity when the turbine rotates. The analysis shows parallel data between the two even when the blade is rotating but still has a difference of less or an increase of 0.9V. In conclusion, this project innovatively combines hybrid energy by designing a small-scale wind turbine. It aims to show that this technology can be a feasible, environmentally friendly, and cost-effective solution for the industrial and economic sector.

1. Introduction

Around the world, people have been using wind turbines to create electricity, from modest residential wind turbines to offshore wind farms. Although solar, biomass, and micro hydropower were Malaysia's main sources of renewable energy, considerable research had been done on the viability of using wind energy as one of the sources [1-3]. Furthermore, the northeast monsoon season, which occurs from November to March on the east coast of Peninsular Malaysia, features wind speeds that can reach up to 15 m/s [4]. In general, the least wind speed required to rotate the installed wind turbine is 5 m/s, and it will stop at 15 m/s to prevent damage [5]. Due to Malaysia's geological position, only about 10.74% of the country's electricity is generated by renewable energy sources, specifically hydropower [6].

According to a research, Malaysia has an average wind speed of 1.3 m/s to 2.7 m/s inland and a fluctuation of 3.5 m/s to 4.5 m/s on the coast line, which is regarded low potential wind [7]. Because of this, it is very unsuitable for horizontal axis wind turbines (HAWT) but still presents an opportunity for vertical axis wind

turbines (VAWT). One of the things that gave rise to the idea of creating this hybrid in one entity project was when to break the chain of greenhouse gas production by creating a generation system through natural resources, but during the creation process, it still interferes with the production of oxygen for humans by destroying the entirety of the current plant life even if it is a small scale to use as a new power plant site. More simply, it requires the use of a very wide area, especially for hybrids because it must be done in a separate area. Wind speed in Malaysia varies seasonally and geographically, causing turbines to fail to generate electricity. Integrating solar energy can address this gap, ensuring optimal use even without turbine rotation.

Objective this project is to develop solar panels as wind turbine blade for power generation and to study the efficiency and viability employing solar panels as wind turbine blades in achieving high output power. Perpendicular to that, evaluate the performance in harnessing wind and solar energy and the continuity to sustainable power generation.

2. Previous Research

Solar energy, wind, falling water, the heat of the earth (geothermal), plant materials (biomass), waves, ocean currents, temperature differential in the oceans, and tide energy are all renewable resources. All resources generate power, heat, or mechanical energy by converting them to electricity or motive power [9]. Some researchers look on country-specific environmental improvement opportunities, such as Xue et al. for China [10]. investigate geographical disparities, for example, Lenzen et al. examine the energy embodied in wind turbines in Brazil and Germany [11]. Many evaluate various technologies and application scenarios ranging from rooftop microgeneration to multimegawatt wind turbines [12,13], and [14]. However, gaps and limitations in the literature can be identified that offshore is less covered than onshore

A wind turbine, also known as a wind generator, is a device that converts wind energy (a natural and renewable source) into electricity. VAWTs feature blades that rotate perpendicular to the ground as opposed to HAWTs, which have blades that revolve parallel to the ground. In comparison to conventional horizontal-axis wind turbines HAWTs, VAWTs have a number of advantages. Based on the energy produced by the study of the hybrid wind and solar energy system for the generation of power. The model is a hybrid of a horizontal axis wind turbine and solar panels, with the wind turbine blades built of PVC pipes and the solar panel tiles installed alongside the turbine blades it can be used for residential load [15]. According to the studied data produced by the Domestic Solar-Wind Hybrid Energy System shows a positive result where the energy production between solar and wind turbine can be generated simultaneously [16]. Fig 1 shows A picture of the constructed hybrid system.

Fig 1 A picture of the constructed hybrid system

Apart from solar and wind, there are also some studies that prove that hybrids can be used as permanent electricity generators, namely offshore wind turbines, that the usage of both wind and wave energy is determined to be an unavoidable trend for the growth of offshore renewable energy in the future. Additionally, it is determined that integrated systems can provide significantly more dispatchable and predictable electricity in addition to reducing intermittency and increasing power generation. [17].

3. Methodology

Progress in Engineering Application and Technology Vol. 5 No. 2 (2024) p. 149-158

Figure 2 shows the system flow of all the related elements in the wind turbine in a simplified form. This project is quite unique compared to existing renewable energy tools because it was created to attract two different inputs, namely wind and sunlight to produce DC electricity as output. The charge controller regulates the voltage and current from the solar panels and wind turbines to prevent overcharging. Wind turns rotor blades, converting kinetic energy into rotational energy. This energy is transferred to a generator, generating electrical energy. Solar panels absorb sun energy, generating electrical charges that move in response to an internal electrical field.

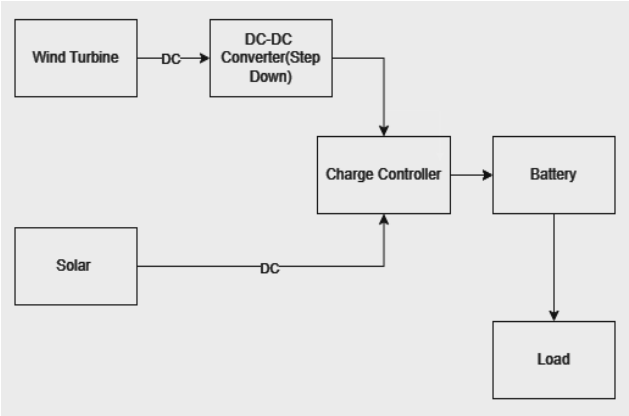


Fig 2 System block diagram

Fig 3 shows the flowchart that diagrammatic representation working principle process from main input to output. This system can also be known as a two-way system where it still supplies electricity to the battery even if only one source is available. Other that, the load is a single output and it is fully dependent on the battery. Theoretically if the battery cannot store electricity, the load cannot operate and function until one of the main sources is supplied with natural energy

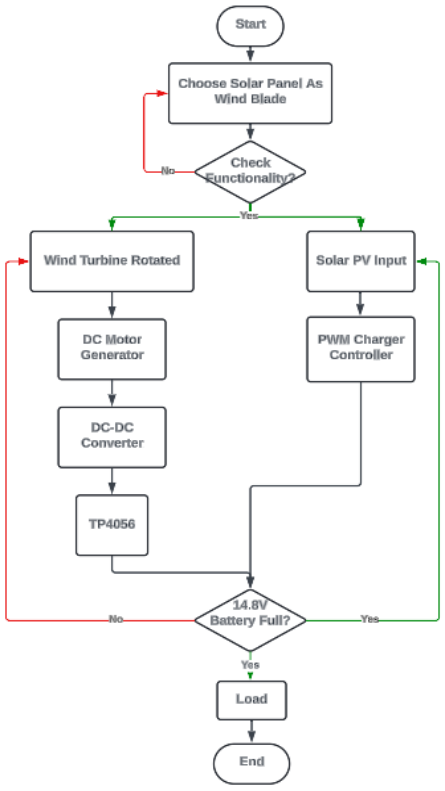


Fig 3 Project flowchart

4. Project Development

For 3D printing, almost all parts use a very long time for each part, for example for the blade alone it takes 8 hours for 1 blade and it is necessary to print as many as 6 blades. So, the expected time consumption for this process is more than a week. All designs need meet the correct size and fit the machine used to avoid failure when printing. The type of filament used is Polylactic Acid PLA 3.75mm. The blade print process is shown in Fig 4.

Fig 4 shows the printing process of blades part

Fig 5 shows that after the printing process of all parts is completed, everything is collected and joined using glue and screws to strengthen the project structure from shaking through a strong wind. While for the system in the turbine, the motor is placed in the electronic compartment together with the DC-DC converter, TP4056 and battery. This is to protect the components from the unpredictable weather. In addition, for the solar panel, it has been affixed to a part of the wind turbine blade vertically along with the PWM controller charger and battery on top of the solar blade holder. After everything is put together, the outdoor testing process is started to see the output and the initial sketch of the place to be destined.

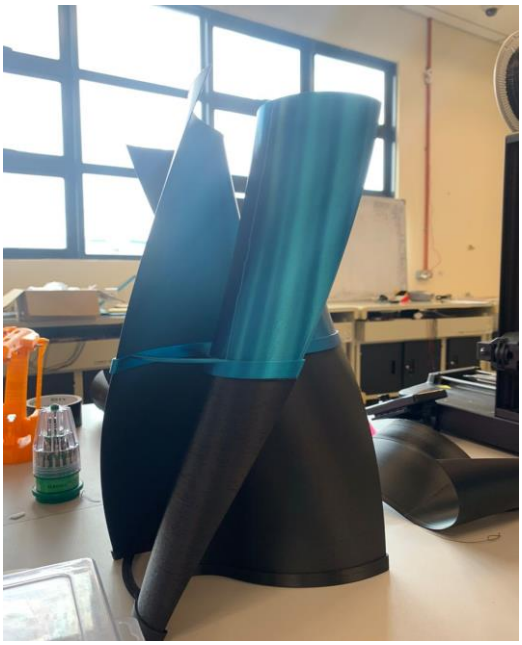


Fig 5 shows that the printing process of all parts is completed

5. Result and Discussions

Progress in Engineering Application and Technology Vol. 5 No. 2 (2024) p. 149-158

Each data point is collected simultaneously to observe the combined effect of wind and solar energy, aiming for a more consistent output. This approach helps evaluate the efficiency and capability of solar panels in generating electricity when the turbine blades operate at varying levels of functionality. It extends the study of solar panel sensitivity to light in practical applications for potential industrial implementation.

Similarly, the turbine, though slightly burdened by additional components when solar panels are attached, demonstrates good functionality even with the increased starting torque required due to the added load. This additional load may have benefits, as each rotation of the blade involves inertia. Inertia, in physics, refers to an object's resistance to changes in its state of motion or rest and is directly related to its mass. In rotational dynamics, the "moment of inertia" describes an object's resistance to changes in its rotational motion, depending on the mass distribution relative to the axis of rotation.

5.1 Actual Prototype

The realization of this study requires the use of practical materials and equipment. For the full setup of this project, it will make a 12V-310V DC motor with a speed of 1200 rpm as a generator and the solar cell panel 55x60mm to be pasted on the blade as an embodiment of solar blade research. Both sources will be connected to the charger controller and the energy produced has been stored in the battery. Fig 6 presents the full setup of the project after all parts are combined and all systems are implemented including solar.

Fig 6 show the project full setup with solar panel

5.2 Location Selection Process

The selection of the destination becomes one of the most important things in the study because the existence of wind and solar is very limited and not fixed. Therefore, the place chosen is based on the place that has both sources at a high level. Fig 7 to 12 shows different places tried for data collection.

Fig 7 Located in the middle of block A11 on the 2nd floor in Pagoh residential college

Fig 8 Located in the Muhammad Yassin Mosque parking lot area

Fig 9 Located on the rooftop of the building in block B on the UTHM campus

Progress in Engineering Application and Technology Vol. 5 No. 2 (2024) p. 149-158

Fig 10 Located in the middle of block A12 on the 3nd floor in Pagoh residential college

Fig 11 Located in room D of house B205 block A11

Fig 12 Located at the volleyball court inside the UTHM campus

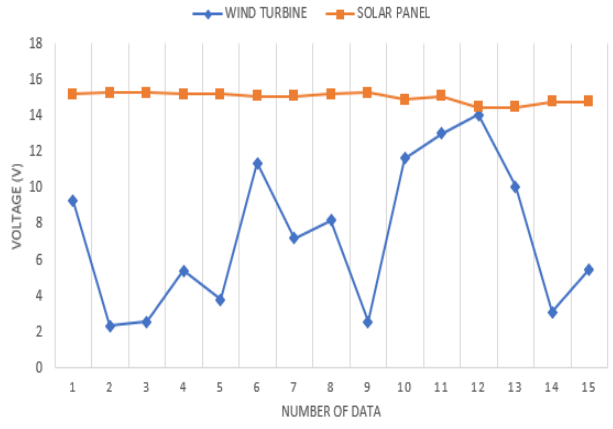
5.3 Data analysis

Table 1 show the production of relatively high voltage values even though the weather changes are very significant. The production of voltage and current on solar panels is more constant compared to wind turbine even if they are both run simultaneously. This may happen because of the existence but the wind is very uncertain if once it passes through the turbine, it will be proven that the power produced by the wind turbine is higher. In addition, this can also relate or can be hypothesized some other factors for example is the relationship between wind speed and rotor speed or temperature and irradiance.

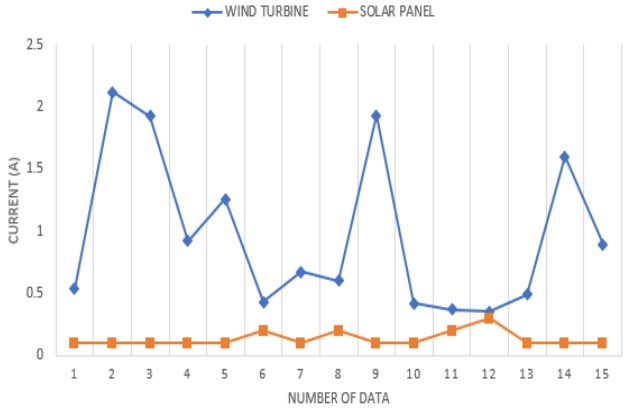
Table 1 Hybrid measured data

Wind Turbine				Solar Panel			
Wind Speed (m/s)	Rotor Speed (rpm)	Voltage (V)	Current (A)	Irradiance (W/m^2)	Temperature (°C)	Voltage (V)	Current (A)
1.8	95.659	9.28	0.536	274	35.0	15.2	0.1
1.1	25.513	2.33	2.121	434	36.9	15.3	0.1
1.5	31.750	2.58	1.929	514	37.1	15.3	0.1
1.4	37.737	5.42	0.921	546	35.9	15.2	0.1
1.0	34.713	3.82	1.258	562	37.5	15.2	0.1
1.9	109.46	11.38	0.430	628	37.4	15.1	0.2
1.8	90.825	7.22	0.672	546	37.4	15.1	0.1
1.8	93.726	8.21	0.602	559	38.3	15.2	0.2
1.0	33.241	2.58	1.932	549	38.5	15.3	0.1
1.6	103.44	11.66	0.418	529	38.4	14.9	0.1
1.6	103.69	13.01	0.372	551	38.1	15.1	0.2
1.8	108.23	14.06	0.351	621	38.5	14.5	0.3
1.4	97.532	10.1	0.489	501	38.5	14.5	0.1
1.1	30.774	3.1	1.599	364	37.4	14.8	0.1
1.7	70.827	5.5	0.895	266	37.4	14.8	0.1

The graph voltage generated by solar and wind turbine in the Fig 3 (a) and graph current generated by solar and wind turbine in the Fig 3(b) gives an overview of the flow of voltage and current generation from both sources where the voltage reading produced by the solar panel is more stable than the wind turbine. This proves that the rotation does not have too much of an effect on the production of electricity from the solar panel because each value the voltage taken only has a reduction of 0.9 V maximum when the wind turbine generates 14.06 V. In terms of achievements for wind turbines it should not be denied that Malaysia experiences relatively low average wind speeds. So, from the concept of use for vertical wind turbines, it has been proven the existing wind is sufficient to generate electricity even though it is not constant but it is still very practical and not impossible to make it happen.



(a)



(b)

Fig 3 Generated (a) voltage and (b) current for hybrid system

6. Conclusion

In this work, it has been proven that the possibility for a solar panel to become a wind turbine blade is very high because it can still generate electricity even if it moves from the minimum point to the optimal point of the wind turbine rotation. There can be no doubt that this vertical type wind turbine is capable of generating electricity even though Malaysia has been marked as a country with a low wind distribution rate, but from this research it can be confirmed that if Malaysia is able to generate 112W per day then it is not impossible in the country outside. Finally, for the hybrid system in one entity, this is still new and needs to be implemented in general because it is economical and cost-saving, however, it still needs to be studied more deeply to get more productive results so that it can be made into an on-grid system to accommodate more loads.

Acknowledgement

Communication of this research is made possible through monetary assistance from Universiti Tun Hussein Malaysia and the UTHM Publisher's Office via Publication Fund E15216.

References

[1] Soile, I.O. 2014. Energy security in Malaysia: Magnitude and economic effects. Malaysian Journal of Economic Studies 51(2): 167-181

[2] Research Unit of Parliament of Malaysia. 2013. Energy security, energy dialogue and energy efficiency. http://www.paelimen.gov.my/images/webuser/ artikel/halisah/

[3] KeTTHA. 2017. Slide presentation of Kementerian Tenaga, Teknologi Hijau dan Air: Malaysian Energy Policy Focusing on Sustainable Energy Development and The Way Forward.

[4] Mekhilef. S., Safari, A., Kasper, D.L. & Chandrasegaran, D. 2012. *Feasibility study of off-shore wind farms in Malaysia*. Energy Educ. Sci. Technol. Part A Energy Sci. Res. 29(1): 519-530.

[5] Daut, I, Razlina, A.R.N., Irwan, Y.M. & Farhana, Z. 2012. *A study on the wind as renewable energy in Perlis*, Northern Malaysia. Energy Procedia 18:1-10.

[6] Suruhanjaya Tenaga (2016). Malaysia Energy Statistic Handbook. Putrajaya: Suruhanjaya Tenaga.

[7] Ahmad S & Mat Tahar R (2013), *Selection of Renewable Energy Sources for Sustainable Development*. Renewable Energy, 458-466

[8] Qunwu Huang, Yeqiang Shi, Yiping Wang, Linping Lu, Yong Cui. (2014). *Multi-turbine wind-solar hybrid system.* Renewable Energy.76,401-407. DOI:10.1016/j.renene.2014.11.060.

[9] *What is renewable energy?* United Nation: Climate action https://www.un.org/en/climatechange/what-is-renewable-energy.

[10] *Xue B, Ma Z, Geng Y, Heck P, Ren W, Tobias M, et al. A life cycle co-benefits assessment of wind power in China. Renew Sustain Energy Rev 2015; 41:338–46 http://dx.doi.org/10.1016/j.rser.2014.08.056*.

[11] Lenzen M, Wachsmann U. *Wind turbines in Brazil and Germany: an example of geographical variability in life-cycle assessment*. Appl Energy 2004; 77:119–30.http://dx.doi.org/10.1016/S0306-2619(03)00105-3.

[12] Martínez E, Sanz F, Pellegrini S, Jiménez E, Blanco J. *Life cycle assessment of a multi-megawatt wind turbine*. Renew Energy 2009; 34:667–73. http://dx.doi.org/10.1016/j.renene.2008.05.020.

[13] Martínez E, Sanz F, Pellegrini S, Jiménez E, Blanco J. *Life cycle assessment of a multi-megawatt wind turbine*. Renew Energy 2009; 34:667–73. http://dx.doi.org/10.1016/j.renene.2008.05.020.

[14] Haapala KR, Prempreeda P. *Comparative life cycle assessment of 2.0 MW wind turbines.* Int J Sustain Manuf 2014; 3:170.. http://dx.doi.org/10.1504/IJSM.2014.062496.

[15] B.N. Prashanth, R. Pramod, G.B. Veeresh Kumar. (2017). Design and Development of Hybrid Wind and Solar Energy System for Power Generation. Materials Today: Proceedings 5 (2018) 11415–11422 DOI:10.1016/j.matpr.2018.02.109.

[16] Uğur Fesli, Raif Bayir and Mahmut Özer. (2009). Design and implementation of a domestic solar-wind hybrid energy system. 2009 International Conference on Electrical and Electronics Engineering - ELECO 2009.DOI: 10.1109/ELECO.2009.5355323

[17] Qiang Gao, Nesimi Ertugrul , Boyin Ding and Michael Negnevitsky .(2020).*Offshore Wind, Wave and Integrated Energy Conversion Systems: A Review and Future.* Australasian Universities Power Engineering Conference (AUPEC). https://ieeexplore.ieee.org/document/9344500