Jurnal E-Komtek
Vol. 7, No. 2 (2023) pp. 311-320
https://jurnal.politeknik-kebumen.ac.id/index.php/E-KOMTEK
p-ISSN : 2580-3719 e-ISSN : 2622-3066

Optimization of Vertical Axis Darrieus Wind Turbine As Aerator Generator

Afrizal Abdi Musyafiq[1], Novita Asma Ilahi[2], Purwiyanto[3], Vicky Prasetia[4], Hera Susanti[5]
[1,3,4]Department of Electrical Engineering, Politeknik Negeri Cilacap, Indonesia, 53212
[2,5]Department of Electronics Engineering, Politeknik Negeri Cilacap, Indonesia, 53212

nasmailahi@pnc.ac.id

https://doi.org/10.37339/e-komtek.v7i2.1538

Published by Politeknik Piksi Ganesha Indonesia

Artikel Info
Submitted:
25-11-2023
Revised:
01-12-2023
Accepted:
07-12-2023
Online first :
13-12-2023

Abstract

Research has focused on a wind turbine system with a vertical-axis Darrieus design with a capacity of 15 watts, serving as an aerator for aeration or adding air to water. The Darrieus turbine, made of aluminium with three corners and a modified NACA 0018 model optimized to work at low wind speeds of 2 m/s, effectively powers a 4-watt DC aerator. Generator voltage readings show a minimum value of 2 volts at a wind speed of 1 m/s and a maximum value of 12.8 volts at a wind speed of 6.2 m/s. The calculated power coefficient is 0.3. Charging the accumulator with a 12 volts/12 Ah takes 23 hours with a generator voltage of 13 volts at a wind speed of 6 m/s. This research reflects Indonesia's progress in optimizing wind energy for sustainable power generation.

Keywords: Wind Energy, Vertical Axis Darrieus Wind Turbine, Aerator Generator, New Renewable Energy

Abstrak

Penelitian difokuskan pada sistem turbin angin dengan desain Darrieus sumbu vertikal berkapasitas 15 watt, yang berfungsi sebagai aerator untuk aerasi atau menambahkan udara ke dalam air. Turbin Darrieus, terbuat dari aluminium dengan tiga sudut dan model NACA 0018 yang dimodifikasi yang dioptimalkan untuk bekerja pada kecepatan angin rendah 2 m/s, secara efektif memberi daya pada aerator DC 4 watt. Pembacaan tegangan generator menunjukkan nilai minimum 2 volt pada kecepatan angin 1 m/s dan nilai maksimum 12,8 volt pada kecepatan angin 6,2 m/s. Koefisien daya yang dihitung adalah 0,3. Pengisian akumulator dengan 12 volt/12 Ah membutuhkan waktu 23 jam dengan tegangan generator 13 volt pada kecepatan angin 6 m/s. Penelitian ini mencerminkan kemajuan Indonesia dalam mengoptimalkan energi angin untuk pembangkit listrik yang berkelanjutan.

Kata-kata kunci*: Energi Angin, Turbin Angin Darrieus Sumbu Vertikal, Generator Aerator, Energi Baru Terbarukan*

1. Introduction

A significant increase in energy consumption accompanies advances in culture and technology in human life. This increase is directly related to the standard of living of the population as well as industrial progress. Since the Industrial Revolution, fuel use has continued to increase; at this time, fossil energy is an energy source widely used [1] [2]. The use of fossil energy causes adverse effects both from an economic and environmental perspective. The Handbook ff Energy & Economic Statistics of Indonesia in 2018 noted that fossil energy production is currently unable to meet national needs, hence the need for oil imports of 16 million kiloliters, which has implications for the country's foreign exchange reserves [3]. Fossil energy impacts the environment on a regional and global scale through air pollution and global warming [4] [5]. In 2019, the Indonesia Energy Outlook (IEO) highlighted a significant potential for new and renewable energy sources in the country, with a substantial capacity of 60.6 gigawatts (GW) attributed explicitly to wind energy for power generation. This underscores the promising landscape for diversifying the energy mix and incorporating sustainable solutions to meet the growing power demands in Indonesia [3].

Wind energy utilized in Indonesia has only reached 0.5 MW at an average wind speed of 5 m/s [6]. The potential for using wind turbines in Indonesia is enormous, considering that wind power plants still need development. The geographical location of Indonesia as a tropical country causes the wind characteristics in Indonesia to have low wind speeds and fluctuating wind directions [7]. Cilacap Regency, with an area of 2,385 km2, has wind direction characteristics that vary at an average wind speed from January 2015 to December 2019, which is 2.03 m/s [8]. The type of wind turbine that is reliable for wind conditions that change direction and low wind speed is a vertical axis wind turbine [9]. There are two types of vertical axis wind turbines, namely the Darrieus type and the Savonius type. The Darrieus type wind turbine can work at a wind speed of 3 m/s, and the Savonius type can work at a wind speed of 1.4 m/s [10].

The vertical Darrieus wind turbine can take advantage of varying wind speeds, and the VAWT turbine type can take advantage of wind from all directions [11]. One of the wind energy sources in Cilacap can be used as aeration. Aeration is the addition of air into water using an aerator [12]. Lack of oxygen can harm aquatic animals because it can cause stress, make it easy to contract diseases, inhibit growth, and even cause death [13]. PLN's power outages are also one of the things that hinder various community activities, especially the cultivation of aquatic animals that require oxygen [14][20][21]. Continuously turning on the aerator can cause operational costs to increase; as seen in January-March 2020, the electricity tariff per kWh reached Rp. 1,467.00, this is an essential factor for cultivators whose production process depends on electricity **[15][18][19]**.

Based on the problems described, a study was carried out by optimizing the vertical axis Darrieus wind turbine as an aerator generator as a first step that could be developed in the future to deal with the problems described above. The selection of the Darrieus type vertical axis turbine has a reason because this type of turbine has characteristics that can overcome problems. Namely, it does not depend on the direction of the wind and can rotate at relatively low wind speeds **[9][16][17]**.

2. Method

2.1 Data Collecting

The method used in data search is to find and collect journal references, theories taken from books about Darrieus vertical wind turbines, parameter data in the form of average wind speed results from January 2015 to December 2019 in Cilacap Regency taken from BMKG Cilacap Regency which later used as secondary research data, the average results of wind speed measurements on the side foundation of the Cilacap State Polytechnic F building and the average results of wind speed measurements at the Cilacap Fishing Port which will later be used as research primary data.

The data collection method used is the observation method. The observation method is part of the primary data collection in the study. Observations are made by making direct observations on the readings of measuring instruments. The type of observation used is monitoring the reading of measuring instruments (anemometer, multimeter, tachometer, stopwatch) during the research process. Data collection was repeated three times in each variable while taking the average wind speed. System design is an initial step before the tool is realized to ensure the system can run according to its function. The system design includes block diagrams, flowcharts, mechanical design, sensor design, and interface design.

2.2 System Planning

The design of the Darrieus vertical axis wind turbine system can be broadly explained in Figure 1 as follows. Figure 1 describes the outline of the system, starting from the input, process, and output, which will be explained as follows.

a. INA219 is a sensor that can also measure the voltage difference value in a circuit. This sensor is used in the system to detect the voltage and current value generated by the generator.

b. The turbine rotor will be driven by the appropriate wind and become a player or generator drive.

c. Arduino Uno receives and processes data detected by the INA219 voltage sensor and then displays it on the LCD screen.

d. LCDs information on the value of the voltage difference, generator current, and voltage, current, and power obtained from the aerator.

e. The generator converts energy from the motion energy produced by the rotation of the turbine rotor into electrical energy.

f. The accumulator is used to store electrical energy (power storage).

System diagram can be seen on **Figure 1**.

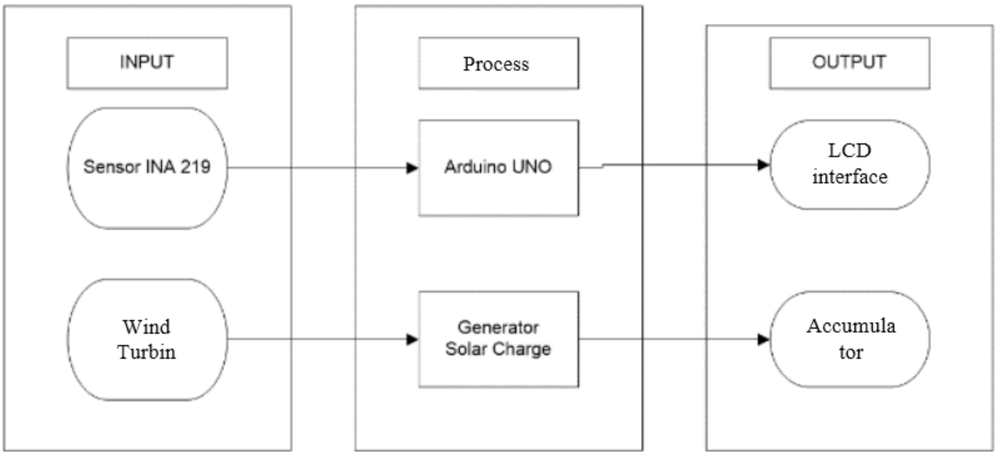

Figure 1. System Diagram.

2.3 Flowchart System

The system flowchart shows the system's overall workflow. This chart describes the sequence of procedures in the system. A system flow chart shows what is done in the system. The following is Figure 3.2, which is a system flowchart in research. The system flow diagram above explains that the tool has a working system as follows. The wind conditions initialize the system to rotate the wind turbine rotor; the INA219 sensor detects the generator voltage and current. If the wind thrust cannot rotate the turbine rotor, the turbine rotor will also not rotate the generator.

Conversely, the wind thrust can rotate the turbine rotor, and the turbine rotor will rotate the generator. This process is the conversion of energy from wind energy into motion energy.

When the generator rotates, there will be electromagnetic induction, which produces electrical energy, where motion energy is converted into electrical energy. Accumulator charging settings, both on and off, are regulated by the charger controller as a voltage regulator and automatic protection against overcharging on the accumulator. The following are the results of the tests that were carried out. Flowchart system is presented on **Figure 2**.

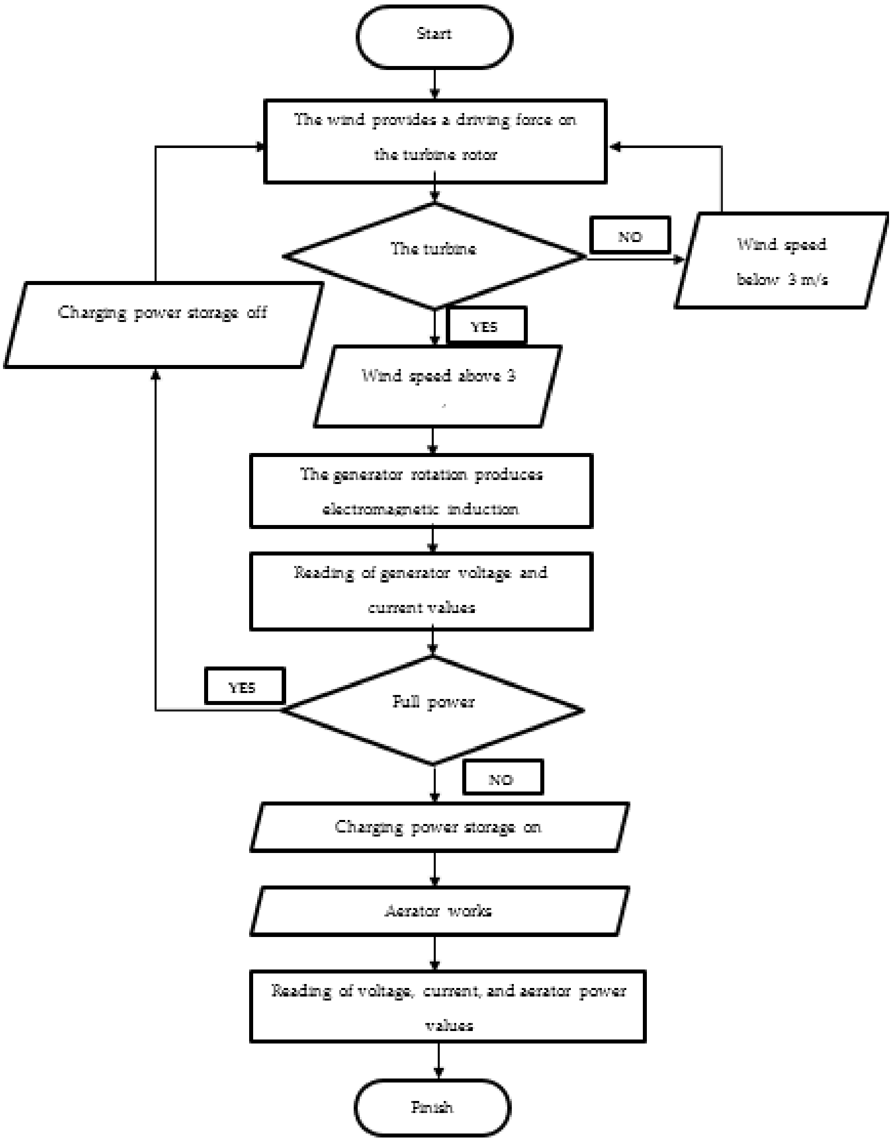

Figure 2. Flowchart System.

3. Results and Discussion

Tests are carried out after the tool design is implemented in order to find out and analyze the level of success, weaknesses and limitations in optimizing the Darrieus vertical axis wind turbine as an aerator generator that has been made. Data collection from testing the optimization of the vertical axis of the Darrieus wind turbine as an aerator generator was carried out at the Department of Electronics Engineering at the State Polytechnic of Cilacap and the Cilacap Fishery Port. Testing the Generator Performance by giving a rotation and calculating the value of different rotations per minute (rpm), then taking the output voltage value data using an electric motor as a generator player and measuring using a tachometer, multimeter, and INA219 sensor reading. Generator performance test is presented on **Table 1.**

Table 1. Generator Performance Test

Number	RPM	Voltage Multimeter	Voltage INA29	Error
1	109,5	5,78	5,77	0,9%
2	121,4	6,42	6,51	0,9%
3	148,7	7,63	7,62	0,9%
4	166,7	8,62	8,61	0,9%
5	186,2	9,88	9,87	0,9%
6	202,9	10,9	10,89	0,9%
7	220,7	11,69	11,68	0,9%
8	245,4	12,96	12,95	0,9%
9	271,1	13,95	13,94	0,9%
10	293,2	14,61	14,6	0,9%
11	313,7	15,36	15,35	0,9%

Generator performance test graph can be seen **Figure 3.**

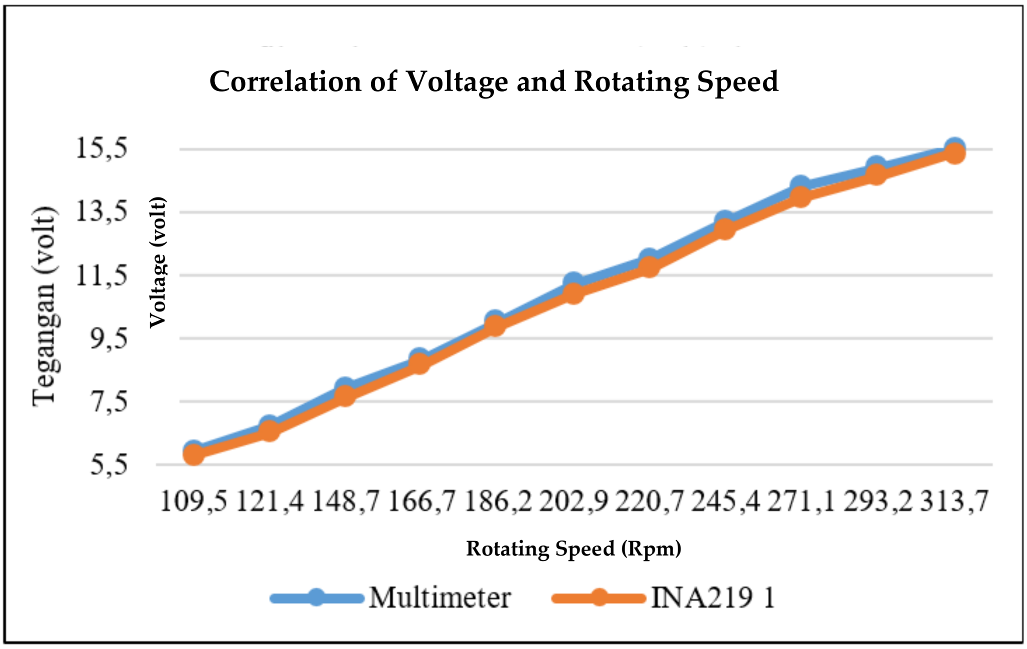

Figure 3. Generator Performance Test Graph

This test was conducted to determine the value of the power coefficient on the wind turbine to determine the ratio between the power generated and the power possessed by the wind by dividing the value of the turbine power by the turbine design value of 15 watts. The following table shows the value of the wind turbine power coefficient is presented on **Table 2** and turbine power coefficient test is presented on **Figure 4.**

Table 2. Turbine Power Coefficient Test

Number	Voltage	Current	Power	Power Coefficient
1	6,36	0,09	0,55	0,04
2	7,74	0,09	0,71	0,05
3	8,45	0,10	0,82	0,05
4	9,76	0,11	1,07	0,07
5	10,51	0,15	1,58	0,11
6	11,38	0,23	2,59	0,17

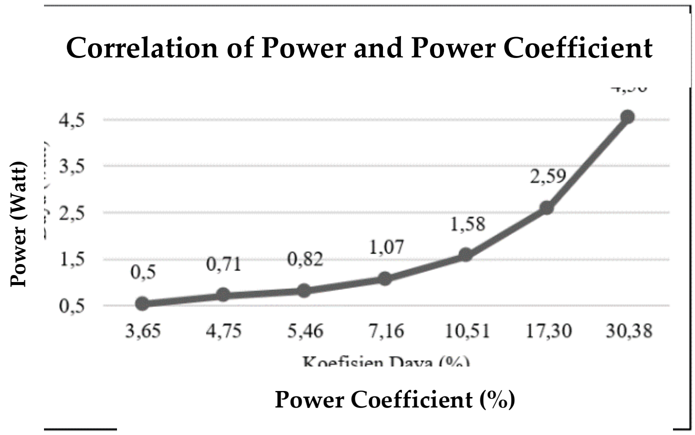

Figure 4. Turbine Power Coefficient Test

Furthermore, the battery discharge test with the system load is carried out to determine the time needed to supply the load. The battery discharge test was carried out with no input from the generator. The system loads that get power from the battery are Arduino Uno, Ina 219 sensor, relay, LCD, and DC aerator. The test was carried out starting at 23.00 on September 6, 2020, with the initial condition of the battery having a voltage of 12 volts. The results of the battery discharge test are shown in **Figure 5**.

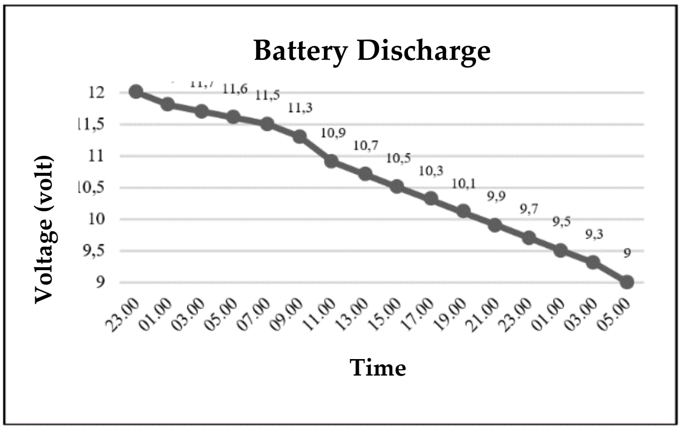

Figure 5. Battery Discharge Test

Charging the battery is done by converting electrical energy from wind power. Electrical energy generation is carried out when the wind speed allows, on September 7, 2020, from 12.00 to 10.00. The voltage is set to 13 Volts output from the solar charge controller. The results of the battery charging test are shown in **Figure 6**.

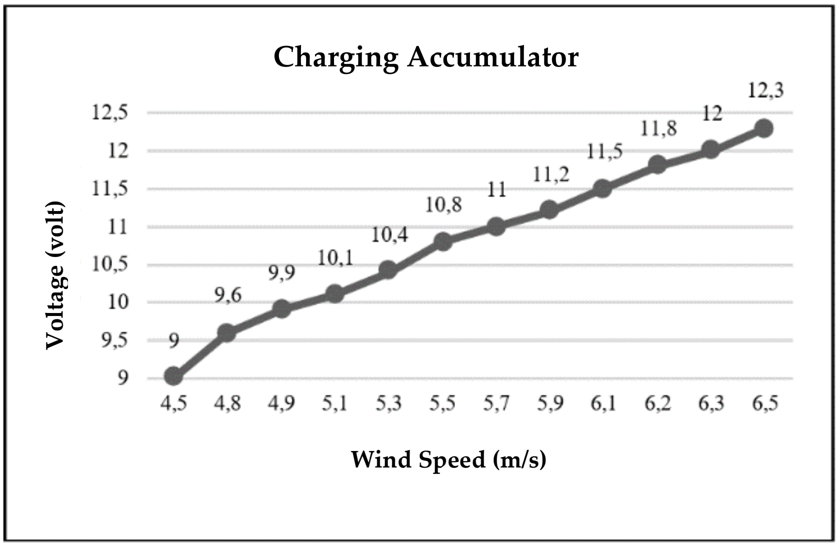

Figure 6. Battery Charging Test

4. Conclusion

A Darrieus vertical axis wind turbine has been made with a power plan of 15 watts, an area of 0.1133 m2, an arm radius of 0.18 m, and an arm diameter of 0.36 m using the NACA 0018 model producing a voltage of more than 12 volts at a wind speed of 6 m/ s with a power coefficient value of 0.3. The calculation results of the time of charging the accumulator with a voltage of 12 volts / 12 Ah are for 23 hours with an initial accumulator voltage of 9 volts and a generator voltage of 13 volts at an average wind speed of 6 m/s. The wind speed on data collection at the Cilacap State Polytechnic campus showed the highest wind speed obtained was 3.7 m/s; at PPC, it showed the highest wind speed obtained was 6.2 m/s.

5. Acknowledge

The Cilacap State Polytechnic DIPA funded this research with contract number 076/PL43/HK.07/2023 Fiscal Year 2023.

References

[1] Cahyo, B. N., Setiawan, A. A., Wilopo, W., & Musyafiq, A. A. 2018. Energy Demand and Supply Forecasting Based on Electricity Consumption Intensity and Production Capacity

for Development of Operating Support in Headquarters of Indonesian National Army. *In E3S Web of Conferences* (Vol. 73, p. 01004). EDP Sciences.

[2] Daryanto, Y. 2007. Kajian Potensi angin Untuk Pembangkit Listrik Tenaga Bayu. Yogyakarta: BALAI PPTAGG.

[3] Dewan Energi Nasional. 2019. Indonesia Energy Out Look 2019. Jakarta: Kementerian Energi Dan Sumber Daya Mineral.

[4] Musyafiq, A. A., & Purwanto, R. 2021. Peramalan Permintaan Pasokan Energi Berdasarkan Intensitas Konsumsi Listrik dan Kapasitas Pembangkit Listrik Terpasang. Infotekmesin, 12(1), 65-70.

[5] Meiviana, A; Sulistiowati, D. R., & Soejachmoen, M. H. 2004. Bumi Makin Panas. Jakarta: Yayasan Pelangi Indonesia.

[6] Riyadi, S; Mustaqim, & Farid, A. 2013. Turbin Angin Poros Vertikal Untuk Penggerak Pompa Air. Tegal. Universitas Pancasakti Tegal.

[7] Hafiz, M. I. Al. 2016. Analisis Pemanfaatan Low - Wind Speed (LWS) untuk Pembangkitan Energi Listrik. Rekayasa Energi Angin. Vol 1. Yogyakarta: Teknik Fisika UGM.

[8] BMKG Kab. Cilacap. 2019-2020. Buku Pengamatan Synop tiap-tiap jam. Cilacap: BMKG

[9] Budi, F. S; & Mukhtar, I. A. 2013. Kincir Angin Poros Vertikal Sebagai Alternatif Penggerak Pompa Irigasi Perkebunan Di Desa Karyamukti. Bandung. Teknik Mesin Politeknik Negeri Bandung.

[10] Mahardika, A. 2018. Unjuk Kerja Model Kincir Angin Tipe Giromill Dengan Variasi Bentuk Sudu Naca 0018, Naca 0021 Dan Naca 0024. pp. 34–55. Yogyakarta.

[11] Mohamed, M. H; Ali, A. M; & Hafiz, A. A. 2015. CFD analysis for H-rotor Darrieus turbine as a low-speed wind energy converter. Engineering Science and Technology, an International Journal. Cairo. Mesir.

[12] Supriyadi, B; & Androva, A. 2015. Perancangan Dan Pembuatan Aerator Kincir Angin Savonius Darrieus Sebagai Penggerak Pompa Untuk Aerasi Tambak. Riptek, 9. Universitas PGRI Semarang

[13] Maniagasi, R; Tumembouw, S. S; & Mudeng, Y. 2013. Analisis kualitas fisika kimia air di areal budidaya ikan Danau Tondano Provinsi Sulawesi Utara. e-Journal BUDIDAYA PERAIRAN, 1(2), 29–37.

[14] Yunginger, R; Nawir, & Sune, N. 2015. Analisis Energi Angin Sebagai Energi Alternatif Pembangkit Listrik Di Kota Di Gorontalo. Gorontalo: Universitas Negeri Gorontalo, Vol 15.

[15] PT. PLN Persero, 2020. Penetapan tarif tenaga listrik bln januari-maret 2020. Diakses pada tanggal 03 Maret 2020.

[16] Musyafiq, A. A., Ilahi, N. A., Nugroho, A. A. D., Rahmawati, P., Rizqy, F. M., Shodikin, K. A. H. A. H., & Fitriati, R. (2023). TEKNOLOGI ENERGI BARU TERBARUKAN: Sistem PLTS dan Penerapannya untuk Kesejahteraan Masyarakat. RUBEQ ID.

[17] Susanti, H., Musyafiq, A. A., Purnata, H., Ilahi, N. A., & Rahmat, S. (2023). Automated Water Heating Management with the Internet of Things. *Journal of Telecommunication Network (Jurnal Jaringan Telekomunikasi).*

[18] Rahmat, S., Purnata, H., Ilahi, N. A., & Musyafiq, A. A. (2023). Teknologi Panel Surya Untuk Pengolahan Limbah Sisa Penyulingan Minyak Kayu Putih. *Jurnal Berdaya Mandiri,* 5(2).

[19] Musyafiq, A. A., Dewi, R. P., Purwiyanto, P., & Subarkah, R. (2023). Unjuk Kerja Pengembangan Prototype Alat Pengering Padi Metode Thin Layer. *Infotekmesin*, 14(1), 77-84.

[20] Musyafiq, A. A., Ilahi, N. A., Dewi, R. P., & Barokah, U. (2022). Simulation of Piko Hydro Power Generator Using Thread Turbine With 10 Watt Power. *Journal of Telecommunication Network (Jurnal Jaringan Telekomunikasi),* 12(2), 100-104.

[21] Musyafiq, A. A., Firdaus, D. M., Aji, G. M., & Susanti, H. (2022). Prototipe Alat Pemarut Ubi Kayu Menggunakansensor Infrared E18-D50nk Berbasis Mikrokontroler Atmega 2560 Dilengkapi Monitor Arus Dan Tegangan. *TEKNO: Jurnal Teknologi Elektro dan Kejuruan*, 32(1), 233-243.