**KONSTAN**
JURNAL FISIKA DAN PENDIDIKAN FISIKA
Volume 10, Number 1, June 2025
E-ISSN : 2460-9129 dan P-ISSN : 2460-9110
http://jurnalkonstan.ac.id/index.php/jurnal

# The Effect of Variation in Number of Blades on Current and Voltage in Simple Waterwheel Props

**Marsa Raihanida Hakim[1,*)], Ziyanti Putri Setia Gandi[2], Nihayatu Zein[3], Nurul Esa Rahmah[4], Fuji Hernawati Kusumah[5]**

[1,2,3,4,5)]*Department of Physics Education, Faculty of Educational Sciences, UIN Syarif Hidayatullah Jakarta*
*Jl. Ir H. Juanda No.95, Ciputat, Ciputat Timur., Tangerang Selatan, Banten 15412, Indonesia.*

*E-mail korespondensi: marsaraihanida09@gmail.com

**Article Info:**

Sent:
June 11, 2025

Revision:
June 18, 2025

Accepted:
June 21, 2025

**Keywords:**

Waterwheel, Volt, Current

**Abstract**

The world's dependence on fossil fuels has caused energy crises and environmental pollution, making renewable energy a crucial solution to develop. This study aims to analyse the effect of blade number variation on current and voltage in a simple waterwheel system. A quantitative correlational design was used to measure the relationship between the number of blades and the resulting electric current and voltage. The experiment used an educational water turbine generator kit, a digital multimeter, a stopwatch, a beaker, and supporting tools. The procedure involved three stages: assembling the turbine kit, measuring current and voltage across four blade variations, and calculating water flow using a beaker and stopwatch. Blade variations tested were 8, 6, 4, and 2, with each configuration measured four times for accuracy. The results showed a direct correlation between the number of blades and the generated current and voltage. Reducing the blade count from 8 to 2 resulted in a 19.05% decrease in current (from 13.02 A to 10.54 A) and a 52.63% drop in voltage (from 0.38 V to 0.18 V). A key challenge during the experiment was the fluctuating water flow rate, which made it difficult to maintain a perfectly constant flow. Therefore, the flow rate was approximated using the discharge formula and considered relatively stable. This experiment confirms that increasing the number of blades enhances energy conversion efficiency. In conclusion, mechanical energy directly influences electrical output, with blade number being a key factor. Future studies should explore variations in blade design, materials, and water flow control for optimal micro-hydro efficiency.



## INTRODUCTION

Global dependence on fossil fuels has created serious challenges, ranging from energy crises caused by dwindling reserves to adverse environmental impacts, such as increased carbon emissions and accelerating global warming. In this context, the development and utilization of renewable energy have become a top priority for achieving energy sustainability and mitigating climate change. Indonesia, as an archipelago nation with a rich topography, particularly abundant water resources in mountainous areas and irrigation systems, possesses significant potential for hydropower development. Harnessing river flows through Micro Hydro Power Plants (PLTMH) or Pico Hydro Power Plants (PLTPH) can be a strategic solution to meet the electricity needs of communities, especially in remote areas that are not yet reached by conventional electricity infrastructure. The Indonesian government itself has set ambitious targets through its National Energy Policy (KEN) to increase the utilization of new and renewable energy to 23% by 2025 and 31% by 2050 [1], [2], [3].

Water turbines are the core of any hydropower generation system. Their function is crucial in converting the potential and kinetic energy from water flow into mechanical rotational energy, which is then transformed into electrical energy by a generator. Various types of water turbines have been designed and implemented according to water flow characteristics and power requirements, including crossflow turbines, vortex turbines, and undershot turbines. Each turbine type has a unique blade design and operational mechanism, leading to continuous research aimed at optimizing turbine design to achieve maximum efficiency and power output suitable for ideal electricity generation [3], [4].

One of the critical design parameters that significantly influence the hydrodynamic performance and efficiency of water turbines is the number of blades (vanes) on the waterwheel runner. Variations in the number of blades not only affect the visual appearance of the waterwheel but also directly impact the interaction between water and the blades, which in turn affects the torque and energy transfer. A study on crossflow water turbines has demonstrated how variations in blade number influence turbine power and efficiency. In this particular study, tests were conducted with blade variations of 18, 20, and 22 blades, as well as variations in nozzle attack angles. The results indicated that the combination of blade number and nozzle attack angle had a direct impact on the power and efficiency produced by the turbine [3].

One of the critical design parameters that significantly influence the hydrodynamic performance and efficiency of water turbines is the number of blades (vanes) on the waterwheel runner. Variations in the number of blades not only affect the visual appearance of the waterwheel but also directly impact the interaction between water and the blades, which in turn affects the torque and energy transfer. A study on crossflow water turbines has demonstrated how variations in blade number influence turbine power and efficiency. In this particular study, tests were conducted with blade variations of 18, 20, and 22 blades, as well as variations in nozzle attack angles. The results indicated that the combination of blade number and nozzle attack angle had a direct impact on the power and efficiency produced by the turbine [5], [4].

According to the study conducted by Benyamin et al., the number of blades has an effect on variation, where a waterwheel with 12 blades rotates faster. In comparison, a waterwheel with eight blades rotates more slowly [6]. This study aims to experimentally analyze the effect of blade number variation on the current and voltage generated by a simple waterwheel device. Unlike previous studies that focused on mechanical aspects and turbine efficiency, this research emphasizes the direct relationship between physical design (number of blades) and electrical output, which is a crucial aspect in micro or household-scale power generation systems. The study is expected to yield practical and applicable findings, particularly for the development of alternative energy systems in remote or rural areas that are not yet connected to the electricity grid. With a simple design and relatively low cost, waterwheel technology with an optimal number of blades has the potential to become a sustainable energy solution for everyday needs such as lighting, battery charging, and operating small-scale electronic devices.

Although previous studies have provided a strong understanding of the effect of blade number variation on the efficiency and mechanical power output of water turbines, there remains a gap in the literature that specifically examines the direct impact of this variation on fundamental electrical quantities such as current and voltage, particularly in simple waterwheel devices. This research also differs from earlier studies, as it focuses on the influence of blade number on the electrical output generated. A deeper understanding of the direct relationship between blade number and electrical parameters is essential for developing waterwheel designs that are more applicable and easily implemented for small-scale power generation needs. Therefore, this study focuses on a comprehensive analysis of the effect of blade number variation on the current and voltage produced by a simple waterwheel device. The findings of this research are expected not only to enrich the body of knowledge in the field of renewable energy but also to provide practical guidance for designing more efficient and economical waterwheels for harnessing water energy in various communities.

## RESEARCH METHODS

This study employed a quantitative approach with a correlational design aimed at determining the relationship between the number of blades on a waterwheel and the electric current and voltage generated (literature). Correlation research was chosen because it can measure the relationship between two or more variables [7]. The focus of this research lies within the scope of renewable energy, specifically hydropower (micro-hydro), with the research object being the conversion of mechanical energy from water flow into electrical energy through a simple turbine system. The study was conducted experimentally by manipulating the number of blades and measuring the resulting electrical output.


**Figure 1**. Data Collection Produce

**Data Collection Procedure**

1. **Preparation of Tools and Materials**
   a. Prepare the educational water turbine generator kit, which includes the main components such as the waterwheel, shaft, mini generator, wires, indicator light, and supporting frame.
   b. Assemble all parts of the device according to the instructions. Connect the waterwheel shaft to the generator, then attach the output wires from the generator to the indicator light.
   c. Connect a digital multimeter to the ends of the output wires to measure current (in amperes) and voltage (in volts). Make sure all wire connections are secure and won't come loose easily. The multimeter used in this study has been calibrated beforehand to ensure accuracy and reliability in measuring electrical current and voltage. Therefore, all data collected is based on valid and trustworthy measurements.
   d. Test the device by running water through it to check if the indicator light turns on when the waterwheel spins. If the light comes on, the system is working properly and ready for use.
2. **Variation of Blade Number (Blade/Paddle)**

   Conduct the experiment using four variations of blade numbers: 8 blades, six blades, four blades, and two blades. For each variation, attach the appropriate number of blades to the waterwheel. Make sure the blades are securely and symmetrically attached to ensure stable rotation.
3. **Measurement of Electric Current and Voltage**
   a. Please turn on the water flow from the hose or faucet, so it hits the waterwheel.
   b. Let the system run for a few seconds until the waterwheel spins steadily.
   c. Use a multimeter to measure the electrical voltage (in Volts) and current (in Amperes).

d. Record the readings of both voltage and current.
e. Repeat the measurements four times for each variation in the number of blades to ensure the data is more accurate and can be analyzed statistically.

**4. Measurement of Water Discharge**

a. Prepare the tools you need, such as a measuring container like a measuring cup or beaker with a known volume (for example, 250 ml or 0.25 liters), a stopwatch or timer to track the time, and a flowing water source like a faucet or hose.
b. Start by letting the water flow into the measuring container.
c. Begin the stopwatch as soon as the water starts to fill the container.
d. Let the water run until the container is full, make sure there's no overflow, and then stop the stopwatch right away to record the time it took.
e. Make sure you know the exact volume of water used (V), and record the time (t) in seconds. To calculate the water flow rate (or discharge), divide the volume of the water by the time it took to fill the container using the formula: $Q = \frac{v}{t}$

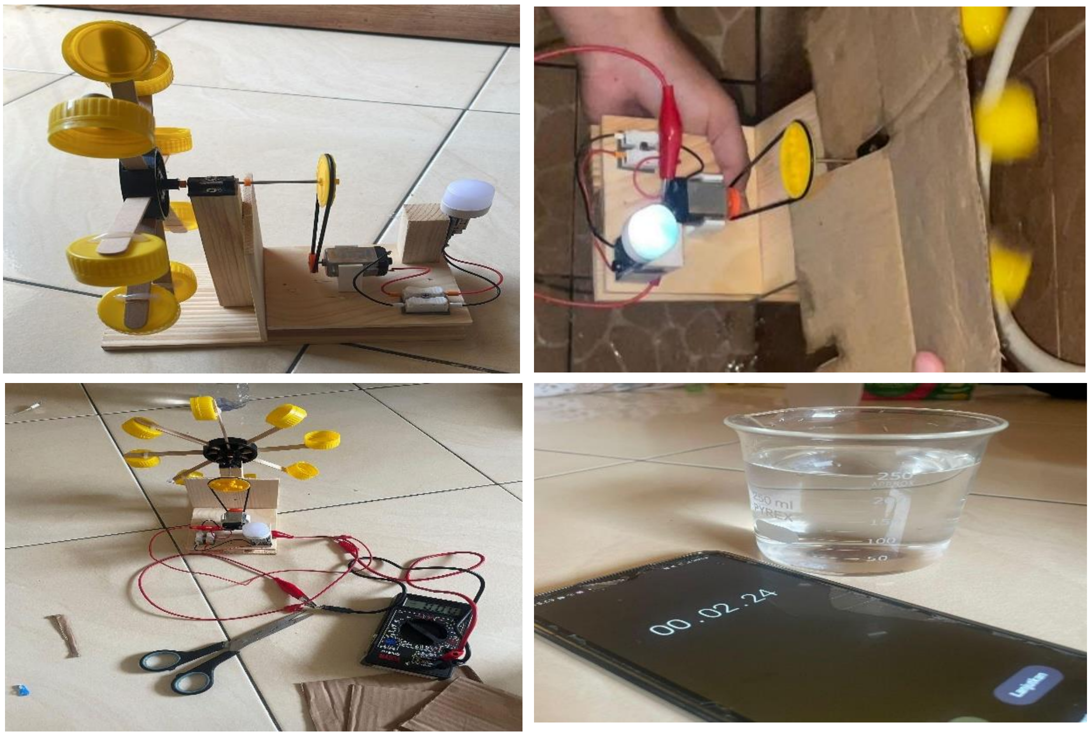


**Figure 2.** Stage Manufacture Water Turbine Generator Kit

The research was conducted at Jln. W.R. Supratman, Gg. Solo, RT.03/RW.04 No.13 Kampung Utan, Cempaka Putih, Ciputat Timur, South Tangerang City, Banten. The experimental activities were carried out in three main stages, namely: June 19 (assembly and initial testing of the equipment), June 26 (data collection of electric current and voltage based on blade number variation), and July 2 (measurement of water discharge)

In the data collection process, the experiment was conducted by varying the number of blades on the waterwheel in four variations: 2, 4, 6, and 8 blades. Each configuration was tested under a constant water flow, and the results in the form of electric current and voltage were measured using a digital multimeter.

In this study, the independent variable manipulated was the number of blades on the waterwheel, which was operationalized into four levels of variation: 2, 4, 6, and 8 blades. This variable is considered to represent the level of mechanical energy that the system can capture. Meanwhile, the dependent variables consist of two indicators: electric current (in amperes) and electric voltage (in volts) generated by the generator. These two variables were measured using a digital multimeter that had been calibrated in advance. The controlled variable in this study was the water discharge, which was measured and maintained consistently during each trial to ensure that the observed effect truly resulted from the differences in blade number, not from variations in water flow strength.

All data obtained from current and voltage measurements were recorded in tables based on blade number variation. These data were then analyzed in tabular form to observe the trend of the relationship between the number of blades and the magnitude of the electric current and voltage produced. In addition, a correlation test was used to determine how strong the relationship is between the number of blades as the independent variable and the electrical output as the dependent variable. This analysis aims to evaluate whether increasing the number of blades results in greater current and voltage, as suggested by the Theory of energy conversion and water turbine efficiency. With a structured design, strict control of variables, and repeated measurements, the results of this study are expected to possess high validity and reliability.

# RESULTS AND DISCUSSION

This study investigated the direct dependence between the number of blades in a simple waterwheel and the amount of electric current and voltage produced. With the water volume maintained at 0.25 kg/s, the experimental data consistently showed that a reduction in the number of blades was inversely correlated with a decrease in both current and voltage output. Specifically, a reduction in the number of blades from 8 to 2 led to a significant decline of 19.05% for current and 52.63% for voltage. Voltage and current measurements were taken using a digital multimeter and repeated four times to ensure data reliability.

**Electric Current Analysis**

In this study, we observed differences in the electric current generated as a result of reducing the number of waterwheel blades. Based on the data presented in Table 1, electric current measurements were made through four variations in the number of blades. For the first experiment with eight blades, an electric current of 13.02 A was obtained. In the second experiment with six blades, an electric current of 12.49 A was recorded. Furthermore, the third experiment with four blades resulted in an electric current of 11.36 A, and in the fourth experiment with two blades, an electric current of 10.54 A was measured.

**Table 1.** Measurement Process on Electric Current

| Experiment | Number of Blades | Electric Current (Ampere) |
|---|---|---|
| 1 | 8 | 13.02 |
| 2 | 6 | 12.49 |
| 3 | 4 | 11.36 |
| 4 | 2 | 10.54 |

From these results, it can be concluded that the number of 8 blades showed a consistently higher electric current output compared to the number of blades 6, 4, and 2. This finding indicates a direct relationship between the number of blades and the amount of electric current produced by a simple waterwheel trainer. To strengthen this finding, a linear regression analysis was performed to quantify the extent to which the number of blades affects the electric current. The study revealed a coefficient of determination (R2) of 0.985, indicating that the variation in the number of blades can explain 98.5% of the variation in electric current. This confirms a strong positive correlation (r=0.992) between the number of blades and the generated electric current, where an increase in the number of blades significantly correlates with an increase in electric current.

### Electric Voltage Analysis

In this experiment, we investigated the effect of reducing the number of waterwheel blades on the generated voltage. The measurement data presented in Table 2 shows the variation in voltage values for each blade count configuration. In the first experiment with eight blades, the measured voltage was 0.38 V. Then, in the second experiment with six blades, the voltage generated was 0.34 V. Furthermore, for the third experiment with four blades, the recorded voltage was 0.29 V. Finally, in the fourth experiment with two blades, the measured voltage was 0.18 V.

**Table 2.** Measurement Process on Voltage Current

| Experiment | Number of Blades | Voltage (V) |
|---|---|---|
| 1 | 8 | 0.38 |
| 2 | 6 | 0.34 |
| 3 | 4 | 0.29 |
| 4 | 2 | 0.18 |

From this experimental data, it can be seen that the waterwheel with eight blades produced a higher average voltage (0.38 V) compared to the 2-bladed waterwheel (0.18 V). This finding suggests that waterwheels with a greater number of blades have the potential to generate greater voltage. Similar to the electric current analysis, linear regression analysis was applied to the voltage data. The results showed a coefficient of determination (R2) of 0.991, indicating that the number of blades can explain 99.1% of the variation in voltage. This demonstrates a very strong positive correlation (r=0.995) between the number of blades and the generated voltage.

### Synthesis of Patterns and Implications for Optimal Design

Overall, a clear pattern emerges from the experimental results: there is a direct and significant relationship between the number of waterwheel blades and the electrical current and Voltage output. A reduction in the number of blades consistently leads to a substantial decrease in electrical production. The reduction from 8 to 2 blades resulted in a 19.05% decrease in current and a 52.63% decrease in voltage, indicating that voltage is more sensitive to changes in the number of blades than current. This relationship can be visually observed in Figure 1 and Figure 2.

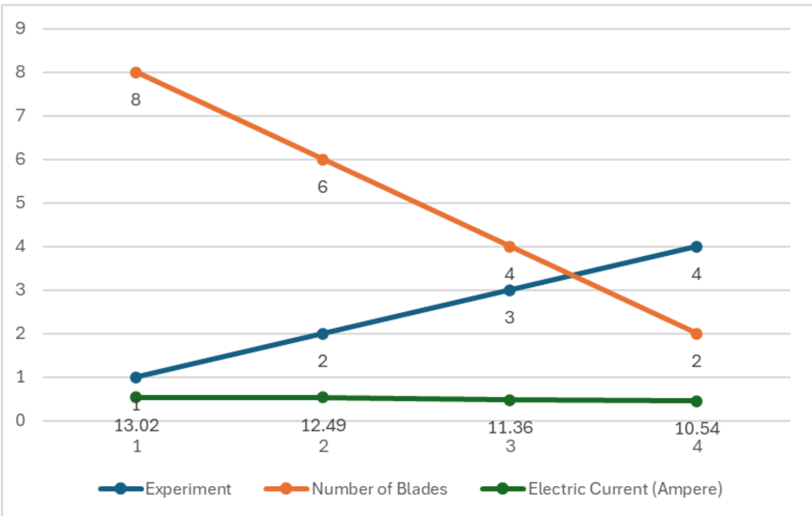


**Figure 3.** Graph of the Relationship between Number of Blades and Electric Current

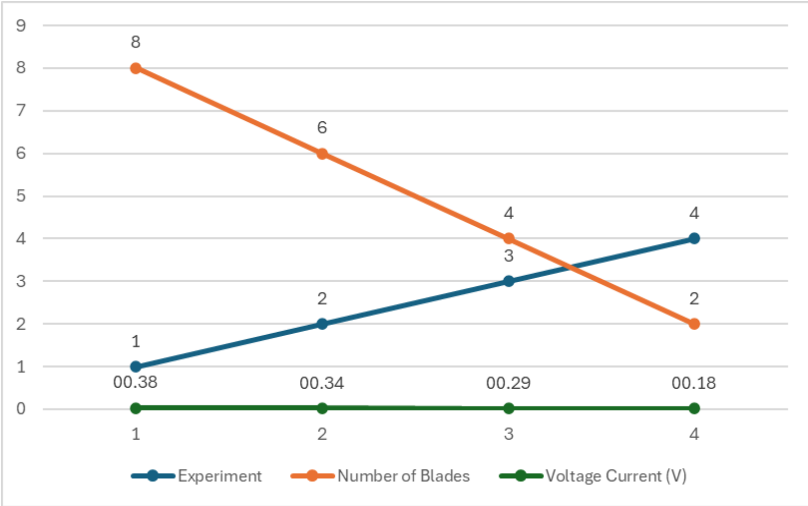


**Figure 4.** Graph of the Relationship between Number of Blades and Electric Voltage

These graphs visually reinforce the conclusion that the number of blades is a crucial factor in waterwheel design for optimizing electricity generation. This finding provides important insights into optimal waterwheel design, indicating that a higher number of blades, up to a certain hydrodynamically efficient limit, tends to yield higher electrical output. It is important to note that various other factors, such as the specific design of the waterwheel and the consistent water flow rate throughout the experiment, could also influence these results. Further studies could explore the optimal number of blades considering hydrodynamic efficiency and production cost factors.

The main factor in every hydroelectric power plant is the rotation of the turbine, which involves hydrodynamic (fluid) forces and thermodynamic effects acting on the turbine blades. The hydrodynamic force comes from the kinetic energy of flowing water and the momentum transferred to the blades when water hits and changes its direction. The hydraulic turbine acts as the main driver that converts the energy of falling water into mechanical rotation, which is then converted into electrical energy through a generator connected to the turbine. Thermodynamic factors such as water temperature and pressure can also affect turbine performance, especially in terms of efficiency and the amount of power generated.

This study can be applied in a simple and practical way, making it usable for local communities. By replacing a traditional waterwheel with a hydraulic turbine and increasing the generator's voltage output, it's possible to scale up the electricity production. The results also show that the more blades a turbine has, the greater the potential increase in voltage and electric current. This finding can be applied in designing small-scale micro-hydro systems in remote areas. However, adding blades to the turbine can't be done randomly—it must match the capacity of other components. The turbine or waterwheel design can be adjusted with the right number of blades to optimize power output based on the local community's energy needs.

Current and voltage follow Ohm's law, which states that the electric current flowing through a linear and homogeneous conductor is directly proportional to the voltage across the conductor and inversely proportional to its resistance [8]. This means that the greater the voltage applied to a circuit, the greater the resulting current, in direct proportion to the voltage [9]. However, if the applied voltage is low, the resulting current will also be low. This can be demonstrated through experimentation, where the number of blades influences the values of current and voltage generated.

The number of blades has a significant effect on the current and voltage produced. The working mechanism of the turbine blades, which are shaped like a waterwheel, involves their rotation driven by a constant flow of water. This rotational motion generates mechanical energy. The mechanical energy from the rotating blades is then converted into electrical energy by a generator. The resulting electricity is delivered through a circuit, enabling it to power electrical devices such as lamps.

The generator operates based on the principle of electromagnetic induction, in which mechanical motion from the shaft rotated by the turbine blades is converted into electrical current. When a greater number of blades is used, the generator receives a more consistent and stronger mechanical input. As a result, it produces higher electrical current and voltage. This electrical output can then be used to power devices such as lamps. Therefore, there is a direct and consistent relationship between the number of blades and the magnitude of the current and voltage generated.

However, increasing the number of blades must not be done arbitrarily. If too many blades are added without considering the balance and design of the turbine, it may increase resistance against the water flow. As a result, the turbine's rotation may slow down due to turbulence or excessive load. Hence, careful design is required to determine the optimal number of blades that will maximize energy conversion efficiency without causing performance losses.

This study is in line with [10], which shows that using 12 blades can increase the rotation speed of the waterwheel. The findings of this research confirm that the number of blades significantly affects the electric current and voltage produced. The more blades used, the greater the current and voltage generated by the waterwheel. This happens because adding more blades increases the water catchment area, allowing the kinetic energy of the water to be used more efficiently and improving the energy conversion process.

However, based on the current design, there are still some weaknesses that need improvement for future development. One major issue is the lack of a cover or protective roof for the electrical components. During testing, the circuit is very vulnerable to water splashes, which can affect the accuracy of current and voltage readings and cause the light to flicker. Therefore, adding a protective cover is necessary to ensure the safety and stability of the system, especially.

When used outdoors or near a water source. On the other hand, the turbine components have performed well. The turbine spins smoothly following the water flow, indicating that the conversion from mechanical to electrical energy is working as expected.

## CONCLUSIONS

This study shows a significant relationship between the number of blades on a simple waterwheel and the amount of electric current and voltage it produces. Large waterwheels, in particular, have a strong potential to contribute to large-scale electricity generation, especially in the context of renewable energy. With proper design and careful planning, waterwheels can become a sustainable and eco-friendly solution to meet future energy needs. Future research can focus on measuring the electrical power generated by the system more specifically. By knowing the exact amount of power produced, it will be easier to estimate the production costs of micro-hydro power plants, making budget planning more accurate and allowing for a more efficient and cost-effective system design.

### ACKNOWLEDGMENTS

The researchers would like to express their gratitude to God Almighty for His blessings and grace. The researchers would also like to thank Fuji Hernawati Kusumah, M.Si., who has contributed to guiding us, as well as journal editors who have provided constructive suggestions during the article writing process.

## REFERENCES

[1] J. Sih Setyono, F. Hari Mardiansjah, and M. Febrina Kusumo Astuti, "Potensi Pengembangan Energi Baru Dan EnergiTerbarukan Di Kota Semarang," *J. Riptek*, vol. 13, no. 2, pp. 177–186, 2019, [Online]. Available: http://riptek.semarangkota.go.id

[2] D. Corio, I. H. Tambunan, A. Aminur, and H. Yuliansyah, *Optimalisasi Pembangkit Listrik Tenaga Surya di Daerah Kepulauan*, vol. 1, no. Desember 2023. 2023.

[3] K. L. Pradisha, H. Bugis, and D. S. Wijayanto, "Pengaruh Jumlah Sudu Terhadap Daya Dan Efisiensi Turbin Air Crossflow Untuk Pembangkit Listrik Tenaga Pico Hidro," *NOZEL J. Pendidik. Tek. Mesin*, vol. 5, no. 2, p. 93, 2023, doi: 10.20961/nozel.v5i2.72139.

[4] M. Idris, I. Hermawan, and B. H. Simamora, "Analisis Kinerja Kincir Air Tipe Undershot Bahan Aluminium Dengan Jumlah 10 Sudu dan Sudut $20^0$," *IRA J. Tek. Mesin dan Apl.*, vol. 1, no. 3, pp. 37–43, 2023, doi: 10.56862/irajtma.v1i3.32.

[5] V. Rinanda and R. Permatasari, "Optimasi Desain Turbin Air Tipe Vortex Dengan 5 Variasi Jumlah Sudu Terhadap Efisiensi," *Semin. Nas. Cendekiawan ke 4 Tahun 2018 Buku 1 "Teknik, Kedokt. Hewan, Kesehatan, Lingkung. dan Lanskap"*, vol. 4, no. 4, pp. 785–790, 2018, [Online]. Available: https://www.event.lemlit.trisakti.ac.id/semnas/article/view/3543

[6] A. Buku, B. Tangaran, and C. P. H. Tiyow, "ANALISIS VARIASI JUMLAH SUDU PADA KINCIR AIR ARUS BAWAH SEBAGAI TENAGA IRIGASI SKALA LABORATORIUM," *Pros. Semin. Nas. Penelit. dan Pengabdi. Masy.*, vol. 2019, pp. 204–209, 2019.

[7] N. Nurhaswinda *et al.*, "PENELITIAN KORELASI," vol. 4, no. 2, pp. 2644–2655, 2025, [Online]. Available: file:///C:/Users/min1j/Downloads/Meynita+Pratasya.pdf

[8] Hilma and A. Malik, "Analisis Pengaruh Tegangan dan Hambatan Terhadap Kuat Arus dengan Menggunkan Phet Simulation," *JFT J. Fis. dan Ter.*, vol. 10, no. 2, pp. 76–85, 2024, doi: 10.24252/jft.v10i2.39275.

[9] Ratna Mustika Yasi and Charis Fathul Hadi, "Pengaruh Tegangan Terhadap Besar Kuat Arus Listrik Pada Persamaan Hukum Ohm," *J. Zetroem*, vol. 3, no. 1, pp. 34–36, 2021, doi: 10.36526/ztr.v3i1.1331.

[10] P. Aboutalebi, A. J. Garrido, I. Garrido, D. T. Nguyen, and Z. Gao, "Hydrostatic stability and hydrodynamics of a floating wind turbine platform integrated with oscillating water columns: A design study," *Renew. Energy*, vol. 221, no. August 2023, p. 119824, 2024, doi: 10.1016/j.renene.2023.119824.