International Journal of Synergy in Engineering and Technology Vol.7 No.1 (2026) 24-36

International Journal of Synergy in Engineering and Technology

IJSET

Journal homepage: https://tatiuc.edu.my/ijset/index.php/ijset/ e-ISSN: 2735-0622

Real Time IoT-Driven Monitoring System on Wind Energy Harvesting for Support Motorcycle's Battery Storage

Kharudin Ali[1*], M. Zikri Zhafri Darobi[1], Afidatul Nadia Mok Hat[1], Zulkifli Abd Rahman[1], Damhuji Rifai[1], M. Redhwan Abd Aziz[1], Ahmad Joraimee Mohamad[1], Wan Zulkarnain Othman[1], Zammeri Abd Rahman[2], Muhamad Syakir Mohd Zin[2], Johnny Koh Siaw Paw[3], Yaw Chong Tak[3] and Ahmed N Abdalla[4]

[1]Faculty of Engineering Technology, University College TATI, Jalan Panchor, Telok Kalong, 24000 Kemaman, MALAYSIA
[2]Faculty of Innovative Design and Technology, Universiti Sultan Zainal Abidin (UniSZA), Kampus Gong Badak, 21300 Kuala Nerus. Terengganu. Malaysia
[3]Institute of Sustainable Energy, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia.
[4]Faculty of Electronic Information Engineering, Huaiyin Institute of Technology, Huai'an Jiangsu, China.

*Corresponding author email: kharudin@uctati.edu.my

KEYWORDS

Energy Harvesting

IoT

Motorcycle

Wind Turbine

RSM

ABSTRACT

Wind energy, which comes from the kinetic energy of moving air, can be turned into mechanical power or electrical energy. A wind turbine is an important part of any wind energy system, as it converts wind into mechanical power for various uses. Improvements in turbine design, generator technology, and power electronics have increased efficiency, including gearless turbine designs. Motorcycles produce a lot of kinetic energy while moving, but this energy is usually wasted. There is no current system to capture and store this energy for later use. This paper offers a solution by developing a mini DC generator turbine system for motorcycles, combined with real-time IoT monitoring for power usage and turbine speed. A DC motor is installed on the motorcycle to generate electrical energy from wind during motion. The energy is stored in a battery and used when needed and providing a sustainable power source. To make the system efficient and reliable, a real time IoT platform is used to monitor energy generation, battery storage, and system performance. This helps users manage energy use, perform maintenance and avoid system failure. By combining wind energy with IoT system, this project supports eco-friendly transportation and energy efficiency. Results show that when the wind turbine speed increases, the voltage also increases. The system can generate up to 12V when the turbine reaches 36 m/s. For every 1 m/s increase in speed, the voltage increases by 0.33V, with a ratio of 3 m/s : 1 V. The results confirm that wind speed is directly proportional to voltage, and the increase is consistent as speed changes.

Received 15 January 2026; Revised 10 March 2026; Accepted 31 March 2026; Published 01 April 2026

1.0 INTRODUCTION

The rapid growth of the global population, combined with technological advancements, has led to a significant rise in the consumption of fossil fuels, which are finite and contribute heavily to environmental issues like global warming and climate change(1)(2)(3). As a result, researchers globally are actively exploring alternative methods to reduce or eliminate the reliance on fossil fuels. Three primary strategies have emerged to address this challenge: improving the efficiency of traditional energy conversion systems through waste heat recovery, developing environmentally friendly energy technologies like fuel cells, and shifting towards renewable energy sources that have minimal environmental impact(4)(5). Among these approaches, renewable energy is considered the most viable long-term solution, as it can substantially reduce or eliminate dependence on fossil fuels. In the past decade, there has been notable progress in the production and utilization of renewable energy, with large-scale applications in solar, wind, biomass, and ocean energy. These advancements demonstrate the potential of renewable energy to meet global power demands sustainably. Table 1 shows some of the large-scale projects implemented worldwide(6)(7)(8).

Table 1: Examples of The Largest Renewable Energy Projects of Different Technologies Around The World

Power Plant Name	Technology	Country	Year	Installed Capacity (MW)
Three Gorges Dam	Hydroelectric Power	China	2003	22,500
Itaipu Dam	Hydroelectric Power	Brazil and Paraguay	1984	14,000
Bhadla Solar Park	Photovoltaics	India	2018	2245
Longyangxia Dam Solar Park	Photovoltaics & Hydroelectric Power	China	2015	2130
Huanghe Hydropower Hainan Solar Park	Photovoltaics	China	2020	2200
Gansu Wind Farm	On-Shore Wind Farm	China	2009	7965
Alta Wind Energy Center	On-Shore Wind Farm	United States	2010	1550
Muppandal wind farm	On-Shore Wind Farm	India	-	1500
Ironbridge power plant	Biomass Power Plant	United Kingdom	2012	740
Alholmens Kraft Power Plant	Biomass Power Plant	Finland	2002	240
Polaniec biomass power plant	Biomass Power Plant	Poland	2012	220
Ouarzazate Solar Power Station	Parabolic trough and solar power tower (CSP)	Morocco	2016	580
Ivanpah Solar Power Facility	solar power tower (CSP)	United States	2014	377
Mojave Solar Project	Parabolic trough (CSP)	United States	2014	280

Wind energy, derived from the kinetic energy of the wind, can be converted either directly into mechanical power or indirectly into electrical energy. A wind turbine is a crucial component of any wind energy system, responsible for transforming the wind's potential energy into mechanical power usable in various applications(9)(10). The first wind turbine designed to generate electrical power was constructed in the early 20th century. Since then, while wind turbine technology has steadily progressed, significant advancements have particularly been made in wind turbine design. Modern innovations and enhancements to turbine components have led to notable improvements in power production and efficiency. Additionally, advancements in generator technology and the incorporation of power electronics have facilitated the development of gearless turbine designs. The main components of a wind turbine include the tower, blades, and nacelle, which houses the generator, gears, and control systems. Just as an airplane wing generates lift, the wind moves the blades, causing them to rotate. The generator within the nacelle converts the kinetic energy generated by the turbine into electrical energy, which is then transmitted to the grid via a transformer. As illustrated in Figure

1.1, modern wind turbines are primarily categorized into two types: horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT). HAWTs dominate the wind energy sector due to their higher efficiency and greater electricity output compared to VAWTs. In contrast, VAWTs, which are typically situated closer to the ground and thus less exposed to the wind, tend to produce less power and are inherently less reliable. Furthermore, VAWTs are generally more expensive, as they require more material and a larger size to achieve the same output as AWTs(11)(12)(13)(14).

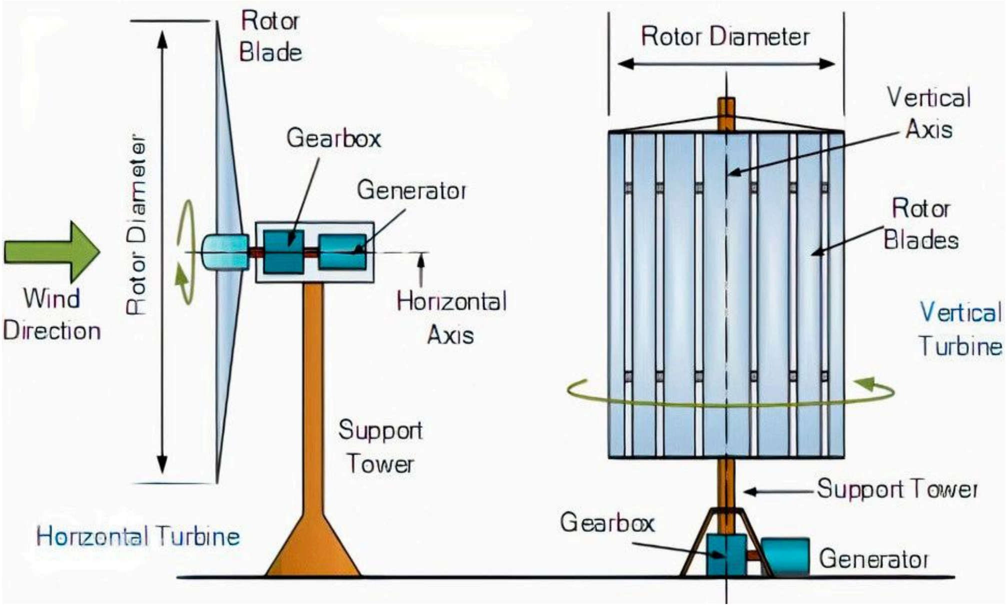


Figure 1: Wind turbine types: VAWT and HAWT

The increasing global demand for sustainable energy solutions has driven innovation in various sectors, including transportation. Motorcycles, a widely used mode of transportation, primarily rely on fossil fuels, contributing to environmental pollution and energy inefficiency. To address this issue, integrating renewable energy systems into motorcycles presents a promising alternative. One such approach is the development of a wind-powered energy storage system that can harness the kinetic energy generated by a motorcycle's movement(15)(16)(17)(18).

Motorcycles generate significant amounts of kinetic energy during motion, yet this energy typically goes to waste as there is no system in place to capture and store it for later use. This presents a missed opportunity to harness renewable energy and reduce reliance on fossil fuels. While installing a wind-powered DC motor to capture energy from the movement of the motorcycle is a potential solution, the absence of a real-time monitoring system for energy generation and storage limits its effectiveness(19)(20)(21)(22). Without real-time data on energy levels, storage capacity, and system performance, it becomes challenging to optimize energy use and ensure the system operates efficiently. Additionally, the unpredictability of system performance poses a significant challenge, as components like the DC motor and battery are prone to wear and tear. Without a monitoring system in place, potential issues cannot be detected early, leading to unexpected breakdowns and reduced efficiency in energy storage. Therefore, a comprehensive IoT-based system that provides real-time monitoring and predictive maintenance is essential to ensure the reliability and sustainability of wind-powered energy storage in motorcycles(23)(24)(25)(26)(27)(28)(29)(30).

This paper proposes an innovative solution to this challenge by utilizing a DC motor installed on the motorcycle, which generates electrical energy from the wind created during motion. The generated energy will be stored in a battery and made available for later use, providing an additional, sustainable power source for the vehicle. However, to ensure the efficiency and reliability of this system, a real-time IoT monitoring platform is crucial. This platform will allow users to track energy generation, storage levels, and system performance, ensuring optimal energy utilization and enabling predictive maintenance to prevent unexpected system failures. By combining renewable energy generation with Internet of Things (IoT) technology, this paper aims to reduce the environmental impact of motorcycles and provide an efficient, self-sustaining energy system. This integration offers the potential for energy optimization and real-time management, contributing to the advancement of eco-friendly transportation solutions. This paper will focus on the design and implementation of the Wind Energy Harvesting Storage System (WEHSS), the development of the IoT-based real-time monitoring platform, and the enhancement of energy efficiency through predictive maintenance.

2.0 METHODOLOGY

2.1 Materials and equipment

The development of the system consists of three main parts: input, processing, and output. The input components include a DC generator, voltage sensor, current sensor, and speed sensor, which function to measure the electrical output and wind speed generated during motorcycle movement. The second part is the processing unit, where the ESP32 microcontroller is used to process sensor data and manage communication. Lastly, the output includes an OLED display to show voltage, current, and wind speed values, and a power bank to store the generated electrical energy. Figure 2 shows the block diagram of the WEHSS system.

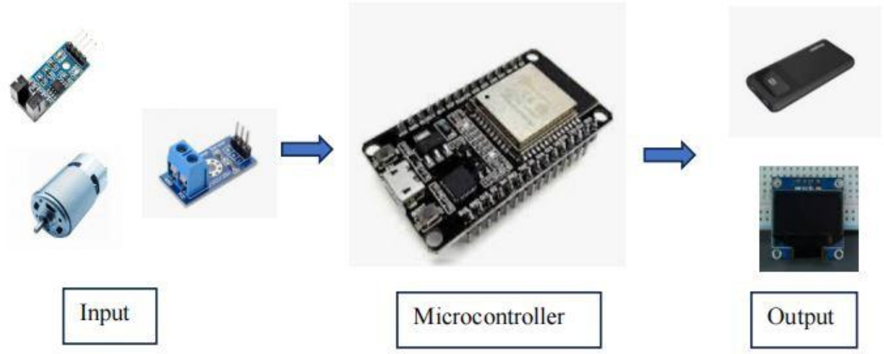


Figure 2: Block Diagram for WEHSS System

The paper begins when the motor starts moving, causing the wind turbine to rotate. This rotation drives the DC generator to produce electrical power. The system then displays the voltage and current readings. If the output voltage from the buck converter is greater than or equal to 5V, the power bank begins to charge, and the data is sent to the IoT platform. If the voltage is less than 5V, the system returns to the DC generator to continue producing power until the required voltage is reached. Figure 3.9 shows flow chart of WEHSS system.

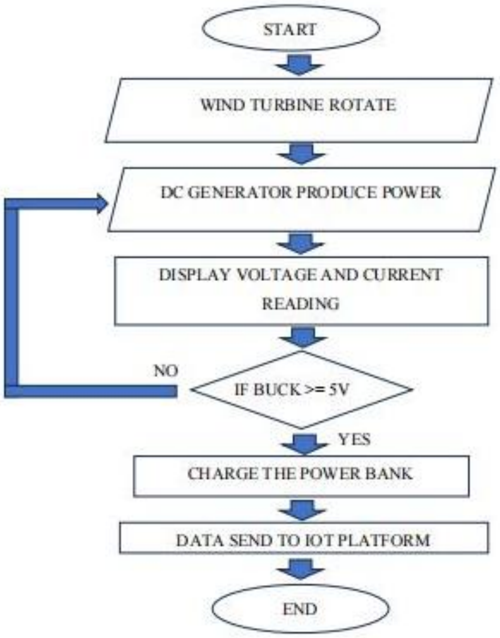
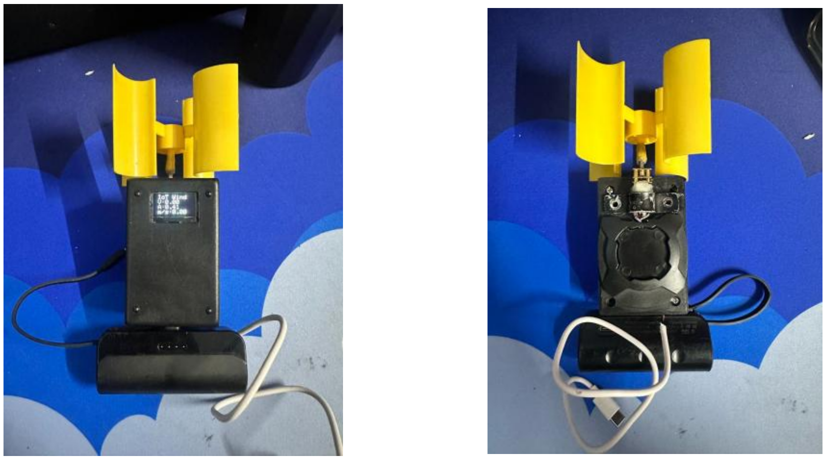


Figure 3: Flow Chart for WEHSS System

2.2 WEHSS Design

Below is the actual project design for WEHSS. Figure 4(a) shows the top view of the project, where the upper section features the wind turbine blade, and the middle section consists of a casing. On top of the casing is an OLED display, while inside of box the voltage sensor and current sensors along with the ESP32 microcontroller. The lower part contains a power bank that function to receive the power from wind turbine and also for supplies power to the ESP32. Figure 4(b) presents the back view of the project, where the DC generator is positioned at the top of the middle section. The remaining structure is a bracket designed for mounting the system onto a motorcycle. A white USB cable is connected to the power bank for charging purposes.



(a) Front View

(b) Back View

Figure 4: WEHSS Design

a. WEHSS Schematic Design

The schematic design had created using fritzing software. Fritzing is an open-source hardware initiative that make electronics accessible as a creative material for anyone. In Figure 5, it shows how component had connected to microcontroller ESP 32. A DC generator, wind turbine blades, voltage and current sensors, an ESP32 microcontroller, an OLED display for real-time monitoring, and a power bank to both supply and store energy. Once all components are gathered, the next phase is to assemble them neatly within a compact case. This involves securely mounting the generator and blades, installing the sensors and display, and carefully wiring the components to ensure proper electrical connections and reliable system operation.

This paper operates by capturing wind energy generated during vehicle movement using a small turbine connected to a DC generator. The system begins operation when the motor starts moving, causing the wind turbine to rotate. This rotation drives the DC generator, which converts mechanical energy into electrical energy. Voltage and current sensors measure the generated power, and the ESP32 microcontroller processes this data, also estimating wind speed based on voltage output. These real-time values voltage (V), current (mA), and wind speed (m/s) are displayed locally on a 128x64 OLED screen. If the output voltage from the buck converter is greater than or equal to 5V, the system directs power to charge the power bank while simultaneously transmitting data to the Thinger.io IoT platform for remote monitoring. If the voltage is below 5V, the system continues operating the DC generator until the required voltage is achieved. This smart energy management ensures efficient harvesting and storage.

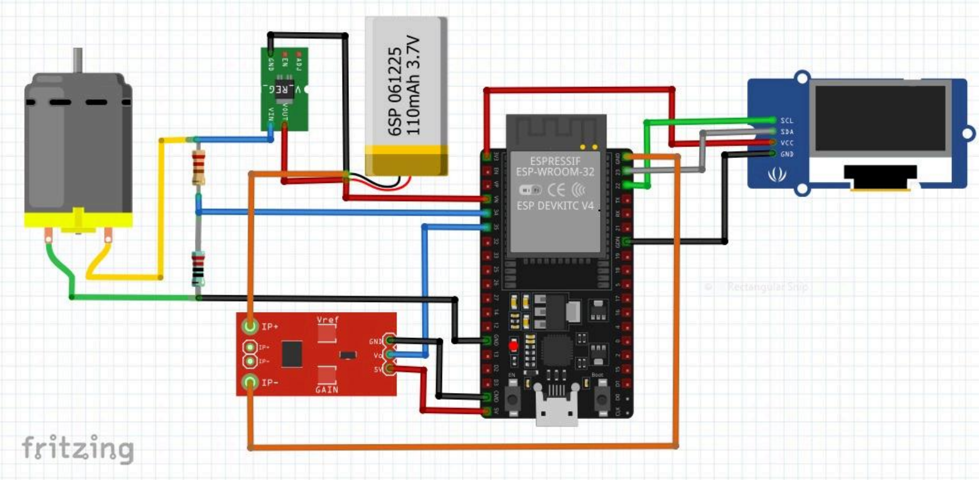
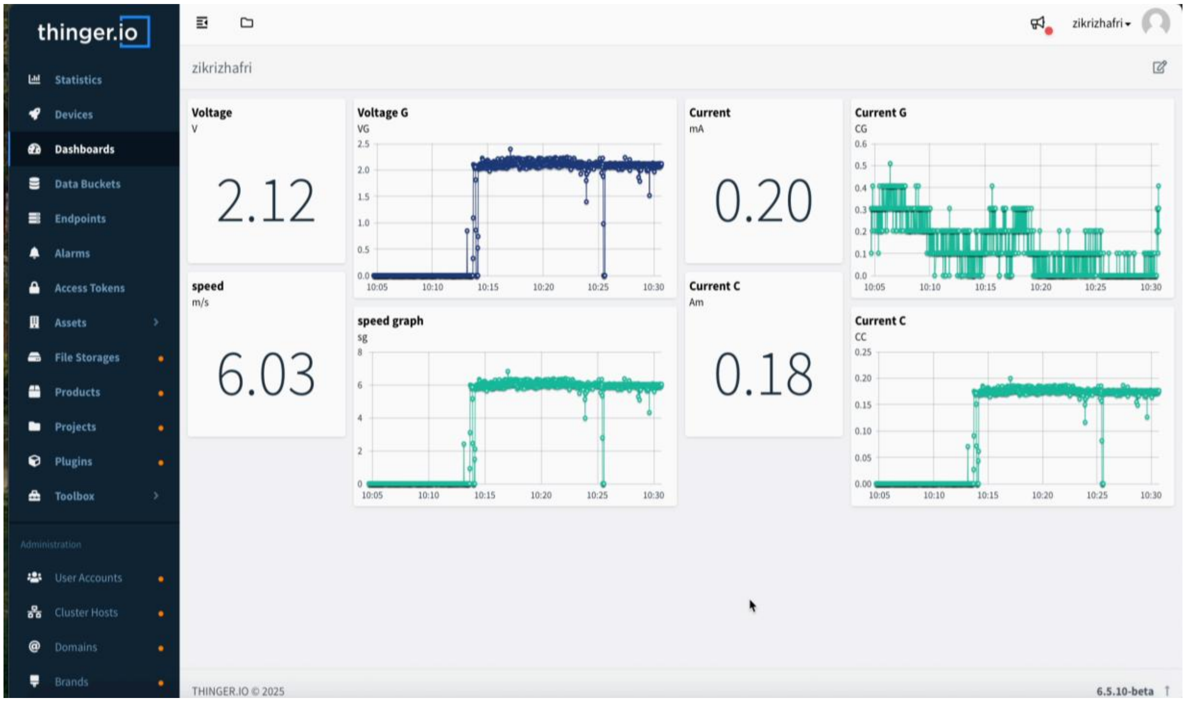


Figure 5: Schematic Design.

b. WEHSS Thinger IO Platform.

The integration of Thinger.io with the wind turbine monitoring system enables real-time tracking and visualization of crucial parameters such as voltage, current, and wind speed. The Thinger.io dashboard presents these key metrics in a clear and organized manner, allowing users to monitor the turbine's electrical output and environmental conditions simultaneously. Voltage readings are displayed alongside a graph that tracks their fluctuations over time, providing insights into the generator's performance stability. Current values are shown with a corresponding graph, illustrating how the electrical load varies as wind conditions change. Wind speed data is also visualized with a real-time graph, helping users correlate wind conditions with electrical output. Figure 6 show the

Thinger.io dashboard layout, where all these parameters are combined into a single interface. This comprehensive data visualization supports efficient energy management by enabling remote monitoring, timely detection of anomalies, and informed decision making to optimize the wind energy harvesting system's performance.



Voltage V 2.12

speed m/s 6.03

Current mA 0.20

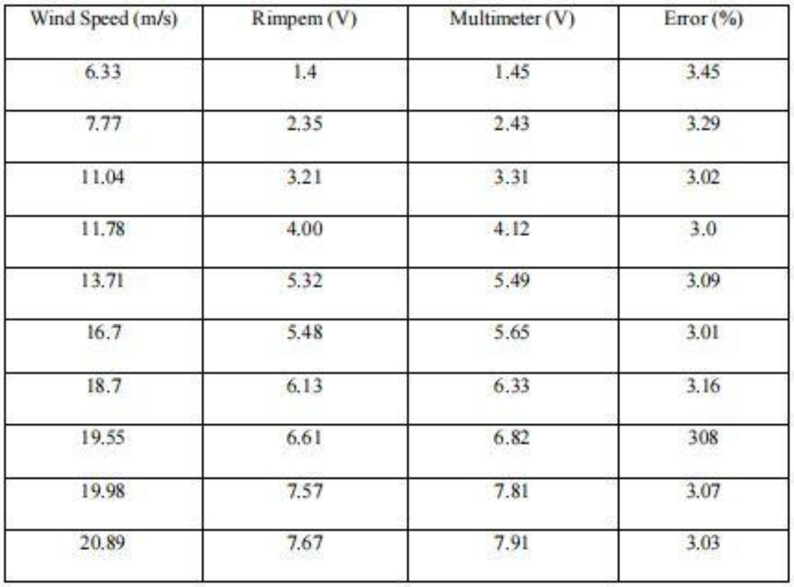
Current C Am 0.18

Figure 6: Thinger.io Dashboard

3.0 RESULTS AND DISCUSSION

The voltage readings obtained from the WEHSS system show a consistent increase in response to rising wind speeds, which aligns with the expected performance of a wind driven DC generator. When compared to a standard multimeter, WEHSS consistently records slightly lower voltage values across all wind speed levels. The percentage error between the two readings remains relatively stable, averaging around 3%. For example, at a wind speed of 6.33 m/s, the WEHSS reading is 1.40 V compared to 1.45 V from the multimeter, resulting in a 3.45% error. At higher wind speeds, such as 20.89 m/s, the readings are 7.67 V and 7.91 V respectively, with a 3.03% error. This consistent margin suggests that WEHSS, although slightly underestimating voltage, performs reliably and proportionally across varying wind conditions. the WEHSS system demonstrates stable and repeatable voltage measurement behaviour, making it suitable for wind speed and power monitoring in small scale renewable energy applications. The detailed comparison between WEHSS and multimeter readings is provided in Table 2.

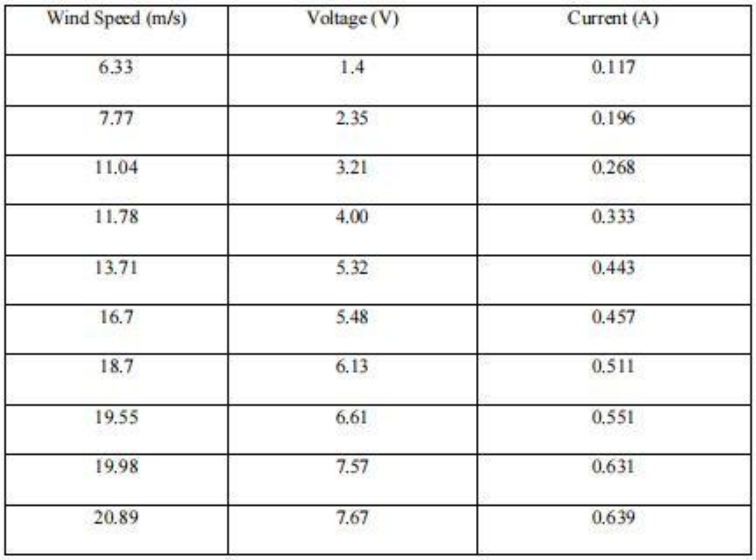
Table 2: Comparison Between WEHSS and Multimeter Readings



Wind Speed (m/s)	Rimpem (V)	Multimeter (V)	Error (%)
6.33	1.4	1.45	3.45
7.77	2.35	2.43	3.29
11.04	3.21	3.31	3.02
11.78	4.00	4.12	3.0
13.71	5.32	5.49	3.09
16.7	5.48	5.65	3.01
18.7	6.13	6.33	3.16
19.55	6.61	6.82	308
19.98	7.57	7.81	3.07
20.89	7.67	7.91	3.03

This monitoring section show the relationship between wind speed, voltage, and current generated by the wind turbine system. At a wind speed of 6.33 m/s, the voltage produced is 1.4 V with a current of 0.117 A. As the wind speed increases to 7.77 m/s, the voltage rises to 2.35 V and current to 0.196 A. Further increases in wind speed to 11.04 m/s and 11.78 m/s correspond to voltages of 3.21 V and 4.00 V, with currents of 0.268 A and 0.333 A, respectively. At higher wind speeds such as 13.71 m/s and 16.7 m/s, the voltage reaches 5.32 V and 5.48 V, with currents of 0.443 A and 0.457 A. Near the upper range, wind speeds of 18.7 m/s, 19.55 m/s, 19.98 m/s, and 20.89 m/s generate voltages of 6.13 V, 6.61 V, 7.57 V, and 7.67 V with corresponding currents of 0.511 A, 0.551 A, 32 0.631 A, and 0.639 A. This clear trend shows that as wind speed increases, the turbine produces higher voltage and current output, which is critical for assessing the turbine's power generation performance and optimizing energy harvesting in real-time. Table 3 illustrates the graph between wind speed and voltage.

Table 3: Wind Speed, Voltage and Current Reading

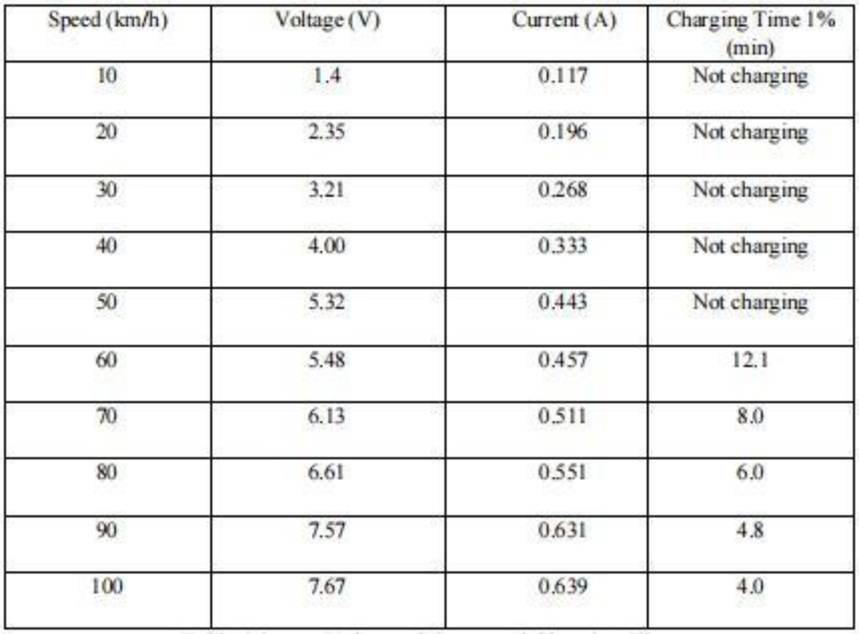


Wind Speed (m/s)	Voltage (V)	Current (A)
6.33	1.4	0.117
7.77	2.35	0.196
11.04	3.21	0.268
11.78	4.00	0.333
13.71	5.32	0.443
16.7	5.48	0.457
18.7	6.13	0.511
19.55	6.61	0.551
19.98	7.57	0.631
20.89	7.67	0.639

The table 4 shows the relationship between wind speed, voltage, current, and the estimated time to charge 1% of a 5000mAh battery using a wind turbine system. At lower wind speeds ranging from 10 km/h to 50 km/h, although the system generates increasing voltage and current—from 1.4V and 0.117A at 10 km/h to 5.32V and 0.443A at 50 km/h—the output is still insufficient to begin charging the battery effectively.

This indicates that the turbine's output at these speeds does not meet the minimum charging threshold, either due to insufficient voltage, current, or both. Once the wind speed reaches 60 km/h, charging begins with a time of approximately 12.1 minutes to add 1% (50mAh) to the battery, corresponding to a modest output of 5.48V and 0.457A. As wind speed continues to increase, both voltage and current rise, resulting in faster charging times. For instance, at 70 km/h, the system produces 6.13V and 0.511A, reducing the charging time to 8 minutes per 1%. At 80 km/h, this improves to 6.61V and 0.551A with a 6-minute charging time, and further to 7.57V and 0.631A at 90 km/h, with a time of just 4.8 minutes. At the highest speed tested, 100 km/h, the turbine delivers 7.67V and 0.639A, bringing the charging time for 1% down to 4 minutes. This data clearly demonstrates a positive correlation between wind speed and the efficiency of power generation, with both voltage and current contributing to reduced charging times as speed increases.

Table 4: Voltage, Current and Charging Time



Speed (km/h)	Voltage (V)	Current (A)	Charging Time 1% (min)
10	1.4	0.117	Not charging
20	2.35	0.196	Not charging
30	3.21	0.268	Not charging
40	4.00	0.333	Not charging
50	5.32	0.443	Not charging
60	5.48	0.457	12.1
70	6.13	0.511	8.0
80	6.61	0.551	6.0
90	7.57	0.631	4.8
100	7.67	0.639	4.0

The ANOVA table for the quadratic model evaluates the effect of Motorcycle Speed and its squared term on the response variable, which in this case is voltage. The linear term of Motorcycle Speed explains a significant portion of the variation, with a sum of squares of 4.9008, an F-value of 101.19, and a highly significant p-value of 0, indicating a strong linear relationship between motorcycle speed and voltage. Additionally, the quadratic term (Motorcycle Speed^2) also significantly influences the model, with a sum of squares of 0.6343, an F-value of 13.1, and a p-value of 0.0085, demonstrating that the relationship is not purely linear but has a curved component. The residual sum of squares is relatively low at 0.339, suggesting that the model explains most of the variation in the data. The quadratic model is expressed by the equation 1:

$$Voltage = -16.27 + (0.254 \times Motorcycle\_Speed) + (1.34 \times Anemometer) - (0.00144 \times Motorcycle\_Speed^2) - (0.0347 \times Anemometer^2) - (0.0128 \times Motorcycle\_Speed \times Anemometer) \ldots \text{Eqn. (1)}$$

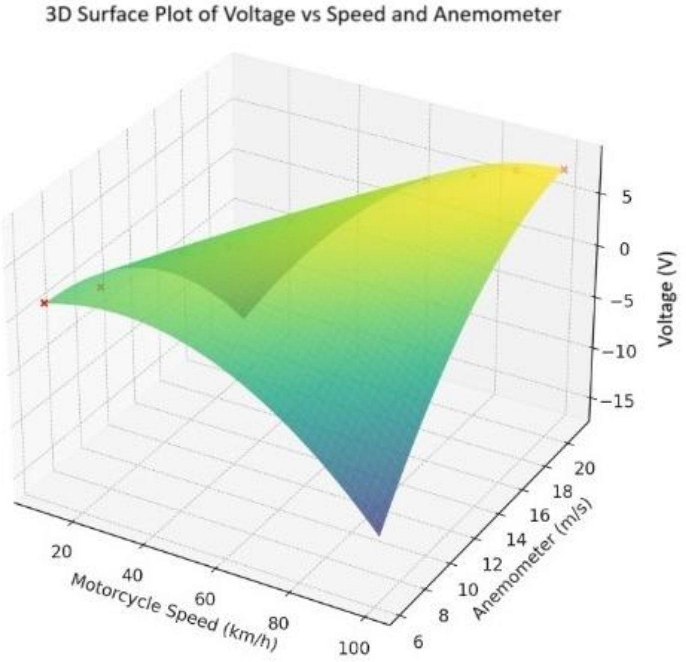
Figure 7 (a) shows this quadratic model with motorcycle speed as the predictor, while (b) illustrates a 3D surface plot depicting the voltage response as a function of both motorcycle speed and anemometer readings. This visualization highlights the complex interaction between these variables and their combined effect on voltage generation.

ANOVA (Analysis of Variance) Table for the quadratic model using

Motorcycle Speed as the predictor:

Source	Sum of Squares	DF	F-value	p-value	
Motorcycle Speed	4.9008	1	101.19	0	
Motorcycle Speed²	0.6343	1	13.1	0.0085	significant
Residual (Error)	0.339	7	—	—	

(a)



(b)

Figure 7: (a) Quadratic Model with Motorcycle Speed, (b) 3D Surface Plot of Voltage Vs Speed and Anemometer

4.0 CONCLUSIONS

This paper shows a strong link between motorcycle speed, wind speed, and the voltage output of the WEHSS system. The data fits a second-order polynomial model, where higher motorcycle speeds lead to higher wind speed and voltage. A peak of 7.67 Vdc is reached at 100 km/h. Analysis confirms speed and speed^2 are reliable predictors of voltage. The system works efficiently above 50 km/h, producing over 5 Vdc, enough for low-power devices. Although voltage increases slow down at very high speeds, the system proves effective for small-scale energy harvesting, making it a potential sustainable solution for mobile use.

Despite its contributions, the research presents several limitations that should be acknowledged. The experimental setup, which used motorcycle-induced wind to simulate varying wind speeds, does not fully capture the complexity and unpredictability of natural wind conditions, limiting the generalizability of the results to real-world environments. While the WEHSS system proved consistent, its tendency to slightly underestimate voltage readings suggests a need for periodic calibration to maintain accuracy over time. The battery charging analysis focused solely on the time required to charge 1% of a 5000mAh battery, omitting broader evaluations such as full charging cycles, the impact on battery longevity, and overall system efficiency.

Furthermore, the testing was conducted under a fixed electrical load, whereas actual applications may involve dynamic load variations that could significantly influence system performance. Lastly, the scalability of the system remains uncertain, as the current prototype may require substantial modification to be viable for larger-scale wind energy installations. Therefore, while the findings are valuable, they are most applicable to micro-generation systems and controlled research contexts. To improve the reliability and applicability of the wind turbine monitoring system, future research should prioritize conducting experiments in natural wind environments. Unlike the controlled motorcycle-induced airflow used in this study, real-world wind conditions include variability in speed, turbulence, and direction. Testing the system in such conditions would provide more accurate data on its performance and allow for better understanding of how environmental factors affect power generation. This would also help validate the system’s resilience and adaptability under fluctuating weather patterns.

Finally, efforts should be made to enhance the scalability and technical capabilities of the system. This includes upgrading the wind turbine and electrical components to handle higher power outputs, as well as improving the RIMPEM measurement system for greater accuracy and expanded parameter monitoring. Integrating advanced control features, such as adaptive load balancing or predictive algorithms, would further improve system performance. These enhancements would not only increase the system's potential for real-world deployment but also open the door for applications in larger-scale or hybrid renewable energy systems.

Author Contribution

Kharudin Ali: Conceptualization, writing and editing and Main Supervisor. M. Zikri Zhafri Darobi: Developer, writing and editing and investigation. Afidatul Nadia Mok Hat: Methodology and Co-Supervisor. Zulkifli Abd Rahman and Damhuji Rifai: Visualisation and monitoring system. M. Redwan Abd Aziz, Ahmad Joraimee Mohamad, Wan Zulkarnain Othman: Project Designer. Johnny Koh Siaw Paw, Yaw Chong Tak: Analysing and identify the limitation. Ahmed N Abdalla: Gap and Problem Statement.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors acknowledge the financial support of the Geran Penyelidikan Jangka Pendek UC TATI (GPJP/ fasa 1/2026/9001-2603) which makes this work possible.

References

1. Ali K, Mohamad AJ, Rifai D, Besar MB, Ikhmal MA, Mamat NH, et al. IoT System Design of Thermoelectric Generator for Harvesting Motorcycle Exhaust Heat Energy. Lect Notes Electr Eng [Internet]. 2022;921(1):213–26. Available from: https://link.springer.com/chapter/10.1007/978-981-19-3923-5_19
2. Pazikadin AR, Rifai D, Ali K, Mamat NH, Khamsah N. Design and implementation of fuzzy compensation scheme for temperature and solar irradiance wireless sensor network (Wsn) on solar photovoltaic (pv) system. Sensors (Switzerland). 2020;20(23):1–37.
3. Abouelfadl S. Global Warming – Causes, Effects and Solution'S Trials. JES J Eng Sci. 2012;40(4):1233–54.
4. Qamar S, Irshad I, Shahzad R, Ali E. Fuel Cells and Their Role in Sustainable Energy Transition: A Review. J Res Nanosci Nanotechnol. 2025;16(1):38–59.
5. Wibowo C, Hasudungan H, Panalili OS, Setiawan D, Dewadi FM, Tantular UM, et al. Optimization and Efficiency of Energy Conversion Technology Integration in Hygiene Systems. Public Heal Saf Int J. 2025;5(1):2715–5854.
6. Sayed ET, Olabi AG, Alami AH, Radwan A, Mdallal A, Rezk A, et al. Renewable Energy and Energy Storage Systems. Energies. 2023;16(3):1–26.
7. Aghmadi A, Mohammed OA. Energy Storage Systems: Technologies and High-Power Applications. Batteries. 2024;10(4).
8. Vaishnavi R, Athira C, Pradeep C, Prasanna E, Srikanth V. International Journal of Research Publication and Reviews Energy Efficiency in Blockchain Social Networks . 2024;5(3):819–25.
9. Sumit J. Utilizing Kinetic Energy of Wind as a Source of Power in Commercial Vehicles. Int J Renew Sustain Energy. 2013;2(6):198.
10. Zishan S, Molla AH, Rashid H, Wong KH, Fazlizan A, Lipu MSH, et al. Comprehensive Analysis of Kinetic Energy Recovery Systems for Efficient Energy Harnessing from Unnaturally Generated Wind Sources. Sustain. 2023;15(21):1–18.
11. Ali K, Wan Mohd WS, Rifai D, Ahmed MI, Muzzakir A, Asyraf TA. Design and implementation of portable mobile phone charger using multi directional wind turbine extract. Indian J Sci Technol. 2016;9(9).
12. MAMUR H. Design, application, and power performance analyses of a micro wind turbine. Turkish J Electr Eng Comput Sci. 2015;23:1619–37.
13. Jaikanth MC, Jaivignesh S, Jaikumar J. Adaptive Wind Turbine With Modified Blade And Compressed Cone Structure. 2013;2(7):683–8.
14. Mezaal J, Whale J, Schlunke K, Bahri PA, Parlevliet D. Design of an Active Axis Wind Turbine (AAWT) That Can Balance Centrifugal and Aerodynamic Forces to Reduce Support Infrastructure While Maintaining a Stable Flight Path. Energies. 2024;17(22).
15. Santoso AD, Daulay H, Priyanti A, Silalahi VMM, Yaumidin UK, Irawati N, et al. Conversion of motorcycles to electric vehicles towards sustainable mobility. Glob J Environ Sci Manag. 2024;10(SI):181–200.
16. Manousakis NM, Karagiannopoulos PS, Tsekouras GJ, Kanellos FD. Integration of Renewable Energy and Electric Vehicles in Power Systems: A Review. Processes. 2023;11(5):1–27.
17. Schlichting AD, Anton SR, Inman DJ. Motorcycle waste heat energy harvesting. Ind Commer Appl Smart Struct Technol 2008. 2008;6930(April):69300B.
18. Pance S, Piskac D, et al. Evaluation of Motorcycle Energy Consumption in Urban Traffic. Int J Sustain Transp Technol. 2019;2(1):27–31.
19. fiyad H, Mokhtar W, Ali E. DC Motor Emulation of Wind Energy Conversion System. Int J Telecommun. 2021;01(01):1–8.
20. Mahmuddin F, Sitepu H, Pawara MU. Analysis Performance of DC Motor as Generator in The Horizontal Axis Wind Turbine. 2015;2:31–7.
21. MARUMO Y, KATAYAMA T. Analysis of Motorcycle Weave Mode by using Energy Flow Method. J Mech Syst Transp Logist. 2009;2(2):157–69.

22. Ambulkar SS, Langdapure V, Shaik F, Khillare S, Sahare RM. Electricity Generation from Heat Exhaust of Motorcycle. Int J Nov Res Dev. 2024;9(3):305–12.
23. Hussian AH, Ali K, Hat ANM, Atan F, Mohd WSW, Ayub MAM, et al. Smart Control Led Downlight, Socket and Switch Using IOT with QR Security. J Phys Conf Ser. 2021;1874(1).
24. Ismat U, Nasri M, Ali K, Rifai D, Abdalla AN, Faraj MA. Design of Adaptive RFID on IoT Platform with Passive Tag Based on Laboratory Management System (LMS). 2023;4(2):105–18.
25. Ali K, M. Sokri MSA, Rifai D, Raja Aris RSNA, Besar MB, Abdul Halim MZ, et al. LOW POWER CONSUMPTION FOR O2 AND CO GASES MEASURING BASED IoT SYSTEM AT CONFINED SPACE AREA. Int J Innov Ind Revolut. 2025;7(20):302–16.
26. Syafiq MA, Ali K, Rahman NA, Rifai D, Salleh Z, Faraj MA. IoT System for Distance and Battery Usage for Mobile Lawn Mower Machine. Int J Synerg Eng Technol [Internet]. 2024;5(2):33–9. Available from: https://doi.xxxxx.xx
27. Naim Mohamad S, Ali K, Huda Mat Tahir N, Nasri Razali M, Hanan Azimi F, Ridzwan Aw S. IOT-Based Control System for Forward and Reverse Mechanism of Automatic Livestock Gate. Int J Synerg Eng Technol [Internet]. 2024;5(2):62–70. Available from: https://doi.xxxxx.xx
28. Muhammad W, Wan F, Ali K, Muhammad W, Syahmi A, Mohd W, et al. SMART IoT Network System on PV Outdoor Lamp with Camera Recording Integrated (SINOPOL). 2024;5(2):23–32.
29. Wahab MA, Ali K, Azman MA, Rahman NA, Aris RSNABR, Saleh Z, et al. Wireless Control Buoy Boat for Water Rescue Operation. Int J Synerg Eng Technol [Internet]. 2024;5(2):53–61. Available from: https://doi.xxxxx.xx
30. Li S, Patnaik S, Li J. IoT-Based Technologies for Wind Energy Microgrids Management and Control. Electron. 2023;12(7):1–7.