ISETC2025

UNIVERSITI TEKNOLOGI MARA

ISETC2025

2 ND INTERNATIONAL SCIENCE, ENGINEERING AND TECHNOLOGY COLLOQUIUM



THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A SUSTAINABLE WORLD

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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

OPTIMIZING BLADE DESIGN FOR SMALL-SCALE WIND TURBINES: A COMPARATIVE STUDY OF 4-BLADE AND 6-BLADE PROTOTYPES

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Abstract: This research investigates the voltage performance of small-scale wind turbine prototypes with varying blade configurations and distances from a wind source. Using simple, cost-effective materials, 4-blade and 6-blade turbine models were constructed and tested under controlled conditions using a hair dryer as a consistent wind source. Voltage outputs were measured using a multimeter, and results show that both blade count and distance from the wind source significantly influence electricity generation. The study offers insights into the design optimization of wind turbine blades for renewable energy education and small-scale applications.

Keywords**:** *Wind turbine prototype, renewable energy, blade configuration, voltage output, small-scale wind generation*

INTRODUCTION

Renewable energy is a vital topic in addressing global sustainability challenges. Educating students about clean energy technologies is essential for shaping environmentally conscious citizens and future innovators. Wind energy is widely regarded as one of the most promising sources of renewable energy with blade design playing a critical role in determining the amount of energy that can be captured (Marimuthu & Kirubakaran, 2014). Nowadays, wind energy is given special attention because of its benefits, as it has been demonstrated to be a significant source of clean and renewable energy for generating electrical power (Al-Quraishi et al., 2022; Mahmoud et al., 2012).

Wind is generated by differences in atmospheric pressure, which cause air to move from high-pressure to low-pressure areas. The speed and behavior of wind vary globally, influenced by factors such as terrain, proximity to water bodies, and vegetation cover (Muhsen et al., 2020). The basic idea behind how wind turbines operate is that they use wind energy to spin their blades around a motor, producing electrical power (Patel, 1999). The wind turbine electricity production can be depending on the following factors, namely wind speed, air density, and area swept by the rotor blades (Marimuthu & Kirubakaran, 2014). There are two categories of wind turbines, Horizontal-Axis Wind Turbine (HAWT) and Vertical-Axis Wind Turbines (VAWT) (Mohd Farriz Basar, 2021). In a Horizontal-Axis Wind Turbine (HAWT), the main rotor shaft and the generator are installed on top of a tower (Deskos, 2019). Vertical-Axis Wind Turbines (VAWT) have a stationary design and can operate regardless of wind direction. Usually, the gearbox and electrical generator in VAWT are positioned at ground level (Dumitrescu et al., 2013).

Adding more blades increases the overall weight that the turbine must rotate. However, a higher number of blades also offers a larger surface area for the wind to act upon, resulting in greater rotational force. While turbines with fewer blades may be lighter and offer some advantages, they tend to be less efficient due to reduced turning power. Interestingly, some studies during the 80's found that two-blade configurations can achieve higher efficiency under certain conditions (Deraman, 2013). There are many studies proposed to optimize the wind turbine. Rector and Visser (2019), conducted an experimental study to examine how solidity, number of blades, and pitch angle affect a 2.5-meter HAWT operating under natural conditions. They tested turbine rotors with 3 and 6 blades. The results indicated that increasing the number of blades and solidity improved turbine performance at low wind speeds. However, at higher wind speeds, the 3-blade rotor outperformed the 6-blade design (Duquette & Visser, 2003). Eltayesh et al., (2021) studied experimental and numerical investigation for the effect of number of blade (solidity) on the power and thrust coefficients of a small-scale horizontal-axis wind turbine, HAWT. They found that decreasing the number of blades (which makes the turbine less sensitive to the change in tip speed ratio) the wind turbine with 3 blade

configurations has the maximum power coefficient in respect to 5 and 6 blade (Eltayesh et al., 2021). This study presents a hands-on exploration of wind turbine design, focusing on blade quantity and positioning relative to wind sources. The aim is to determine how these factors affect the electrical output of a prototype dynamo-based wind turbine, using low-cost materials and simple fabrication techniques.

MATERIALS AND METHODS

Prototype Fabrication

The fabrication process began with cutting and shaping plastic materials into blades, which were then affixed to bottle caps to serve as the turbine rotor. A central hole was drilled into each bottle cap to function as the hub, and the blades were symmetrically attached around the hub to maintain rotational balance. The rotor was connected to a dynamo that operated as the electrical generator. A PVC board was prepared to house the dynamo, exposing only the rotating shaft, while the output wires were routed through an opening in the board. A diorama setup was assembled to illustrate the flow of generated electricity. For wind simulation, a hair dryer was employed at controlled distances of 5 cm, 10 cm, and 15 cm from the turbine. The resulting voltage output was measured using a digital multimeter.

Testing Procedure

Voltage measurements were obtained in three independent trials for each turbine configuration and at each distance. Tests were performed under identical environmental conditions for both the 4-blade and 6-blade turbines to ensure comparability. The performance of each configuration was evaluated by calculating the average voltage output at the respective distances, thereby enabling a direct performance comparison between the two blade designs.

RESULTS AND DISCUSSION

Table 1. Voltage Performance of 4-Blade Turbine

Distance	First Attempt	Second Attempt	Third Attempt	Average
5 cm	2.70V (Very bright)	2.72V (Very bright)	2.70V (Very bright)	2.71V
10 cm	2.61V (Bright)	2.63V (Bright)	2.61V (Bright)	2.63V
15 cm	2.32V (Dim)	2.45V (Dim)	2.44V (Dim)	2.40V

Table 2. Voltage Performance of 6-Blade Turbine

Distance	First Attempt	Second Attempt	Third Attempt	Average
5 cm	2.73V (Very bright)	2.74V (Very bright)	2.70V (Very bright)	2.72V
10 cm	2.68V (Bright)	2.65V (Bright)	2.63V (Bright)	2.65V
15 cm	2.47V (Dim)	2.54V (Dim)	2.55V (Dim)	2.52V

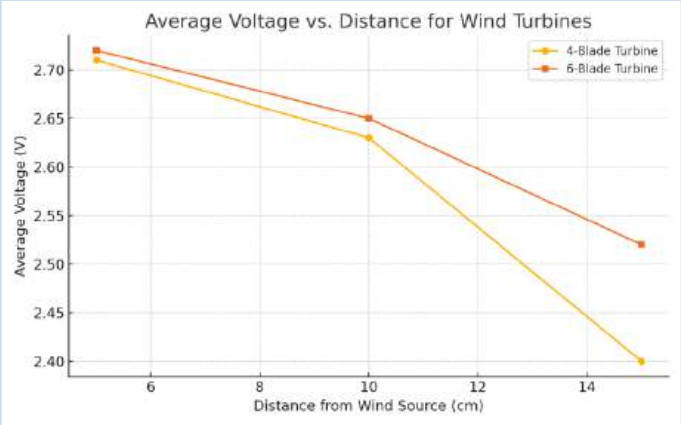


Figure 1. Comparison of average voltage output for 4-blade and 6-blade turbines at different distances

The experimental results demonstrate a clear relationship between the number of blades on a wind turbine and its electrical output. As listed in the table and shown in the graph, both the 4-blade and 6-blade prototypes exhibited a decrease in average voltage as the distance from the wind source increased. This trend is consistent with the reduction in wind velocity and energy intensity at greater distances, which reduces the kinetic energy available to drive the turbine.

However, the 6-blade turbine consistently outperformed the 4-blade turbine across all tested distances. At 6 cm, the 6-blade turbine generated a slightly higher average voltage compared to the 4-blade configuration, and this difference became more significant as the distance increased to 10 cm and 15 cm. The gentler decline in voltage for the 6-blade turbine suggests that it is better suited to operate efficiently even in lower wind conditions, likely due to its larger surface area and greater aerodynamic interaction with the airflow.

This finding aligns with previous studies, including those by Rector and Visser (2019) as well as Erich Hau, (2006) (Duquette & Visser, 2003; Hau & Von Renouard, 2006), which reported that increasing the blade number and solidity improves turbine performance, especially at lower wind speeds. The greater torque provided by additional blades contributes to more effective energy conversion, though it may also increase mechanical resistance.

In contrast, the 4-blade turbine showed a sharper voltage drop, indicating reduced efficiency as wind input decreases. While having fewer blades can reduce weight and cost, it may not be ideal for environments where wind speed fluctuates or where wind sources are not consistently strong.

CONCLUSIONS

This study demonstrates that blade number and wind source proximity significantly impact the performance of small-scale wind turbines. The 6-blade configuration, tested under short distances from a hair dryer wind source, produced higher average voltages than the 4-blade counterpart. These findings provide valuable insights for optimizing low-cost wind turbine models used in educational or prototype settings.

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Sekian, terima kasih.

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Timbalan Ketua Pustakawan

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