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Savonius Turbine Suitability Analysis Based on Low Wind Speed Characteristics

Adi Nugraha[1,*], Fajar Ramadhan[1], Muhammad Fathurrizki[1], Reza Abdillah Prastian[1], Muhamad Khadavy[1], Muhammad Ilham Daifullah[1]

[1] Laboratory of Electrical Engineering Study Program, Department of Electrical Engineering, Sultan Ageng Tirtayasa University, Cilegon, Indonesia
**Corresponding author email: adi.n@untirta.ac.id*

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ABSTRACT

Wind energy is one of the renewable energy sources with significant potential to be developed as an environmentally friendly power generation alternative. However, the selection of wind turbine types must be adjusted to the wind speed characteristics of the implementation area to ensure optimal performance. This study aims to analyze the suitability of the Savonius turbine based on low wind speed characteristics. The research was conducted at the Faculty of Engineering, Universitas Sultan Ageng Tirtayasa (FT UNTIRTA), by measuring wind speed at three different locations using an anemometer. The measurement locations included an open sports field, a building rooftop, and a green open space area. The measurement results showed that the wind speed ranged from 1.5 m/s to 3.2 m/s, categorized as low wind speed below 4 m/s. The obtained data were analyzed and compared with the wind turbine performance characteristic graph based on the relationship between power coefficient (Cp) and turbine tip speed ratio (TSR). The analysis results indicate that the Savonius turbine has the most suitable characteristics for low wind speed conditions because it can operate at low TSR values and has good self-starting capability and high starting torque. In addition, the Savonius turbine offers simple construction, ease of manufacturing, and the ability to operate under varying wind directions. Based on the research results, the Savonius turbine is recommended as an alternative small-scale wind power generation system for areas with low wind speed characteristics.

1. Introduction

The increasing development of electrical energy needs encourages the use of renewable energy sources as an alternative to fossil energy [1]. One of the renewable energy sources that has great potential to be developed is wind energy [2]. The use of wind energy is considered environmentally friendly, sustainable, and able to be a solution for providing electrical energy in open areas that have the potential for natural wind flow [3]. Various open areas such as research areas, conservation areas, technology development land, and public facilities areas are beginning to consider the application of wind power plants as part of an independent energy system [4].

At the research site, there is a large open area that has the potential to be developed as a location for small-scale wind power plants. However, one of the main problems in the design of a wind power system is the selection of turbine types that match the characteristics of wind speed in the location [5]. Each type of wind turbine has different performance characteristics to certain wind speed conditions [6]. Propeller-type wind turbines or horizontal axis wind turbines (HAWT) generally have high efficiency, but require a relatively larger wind speed to operate optimally [7]. In contrast, Savonius-type vertical turbines are known to have good self-starting capabilities, high starting torque, and are able to work in low wind speed conditions [8].

Based on the results of initial measurements carried out at the research site, it was obtained that the average wind speed was in the low range, which was around 3 m/s or below 4 m/s. This condition caused the selection of turbine type to be an important aspect so that the planned generation system could work effectively [9]. In low wind conditions, the use of turbines with high initial rotation requirements has the potential to result in suboptimal performance. Therefore, it is necessary to analyze the suitability of wind turbine types based on the characteristics of wind speed available at the research site [9].

Savonius turbines are one of the alternatives that are considered suitable for low wind speed conditions because they have the ability to operate at a low tip speed ratio and are able to produce better initial rotations than some other types of turbines [10]. In addition, the construction of the Savonius turbine is relatively simple, easy to manufacture, and has low maintenance costs, making it suitable for application to small-scale generation systems [11].

Based on these problems, this study was conducted with the title "Analysis of the Suitability of Savonius Turbines Based on Low Wind Speed Characteristics". This study aims to analyze the characteristics of wind speed at the research site and determine the suitability of using Savonius turbines as an alternative to wind power generation in low wind speed conditions.

2. Methods

This study uses a quantitative descriptive method with a field observation approach. The study was conducted to analyze the suitability of the use of Savonius type wind turbines based on the characteristics of low wind speed in the area of the Faculty of Engineering, Sultan Ageng Tirtayasa University (FT UNTIRTA). This research was conducted on May 26, 2026. The method is can be seen in figure 2.

The initial stage of the research was carried out by studying the literature on the characteristics of various types of wind turbines, especially Savonius turbines, as well as theories about the relationship between tip speed ratio (TSR) and power coefficient on wind turbine performance. Literature studies are also used as a basis for determining turbine characteristics that are suitable for low wind speed conditions.

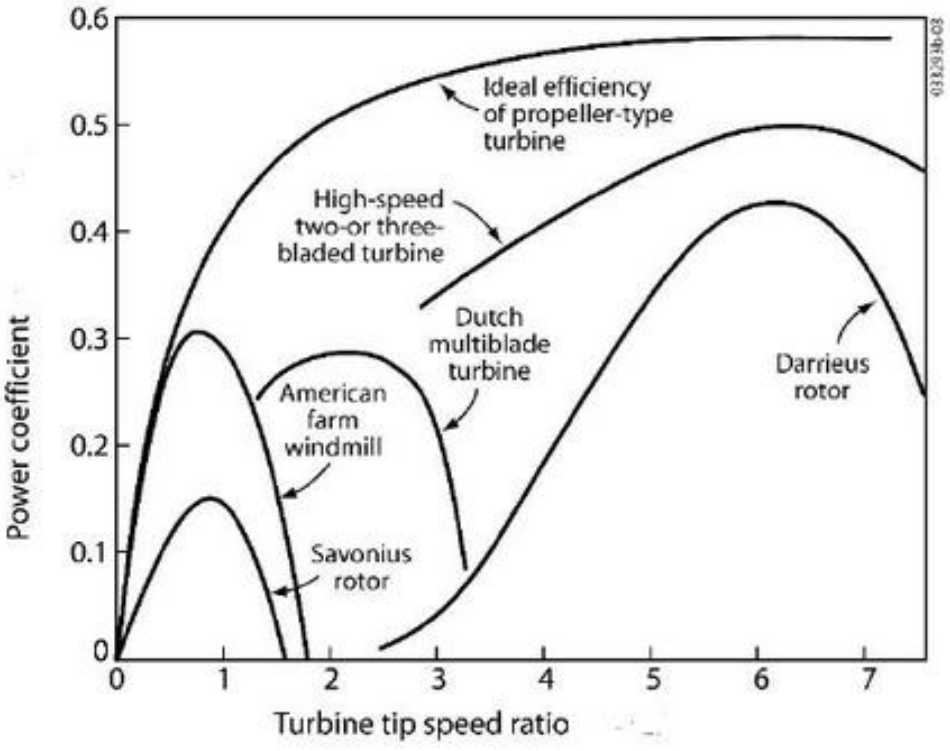

Figure 1: Types of turbines suitable for each wind speed [12].

Furthermore, a survey of the research location was carried out to determine several wind speed measurement points in open areas in the FT UNTIRTA environment. Measurements were made using an anemometer to obtain wind speed data at several observation points. The measurement data is then recorded and the average value of the wind speed is calculated.

Based on the measurement results, it was obtained that the average wind speed characteristics at the research site were in the category of low wind speed, which was around 3 m/s or below 4 m/s. The

data was then analyzed by comparing the characteristics of wind speed to the graph of the relationship between power coefficient and turbine tip speed ratio in several types of wind turbines.

The analysis was carried out to determine the type of turbine that is most suitable for low wind speed conditions. Based on the characteristics of the turbine performance graph, the Savonius turbine has good self-starting capability, high starting torque, and is able to work at a low tip speed ratio, so it is considered more suitable for application at the research site than several other types of turbines.

The final stage of the study was carried out by drawing conclusions regarding the suitability of using Savonius turbines as an alternative to wind power plants in low wind speed conditions in the research area.

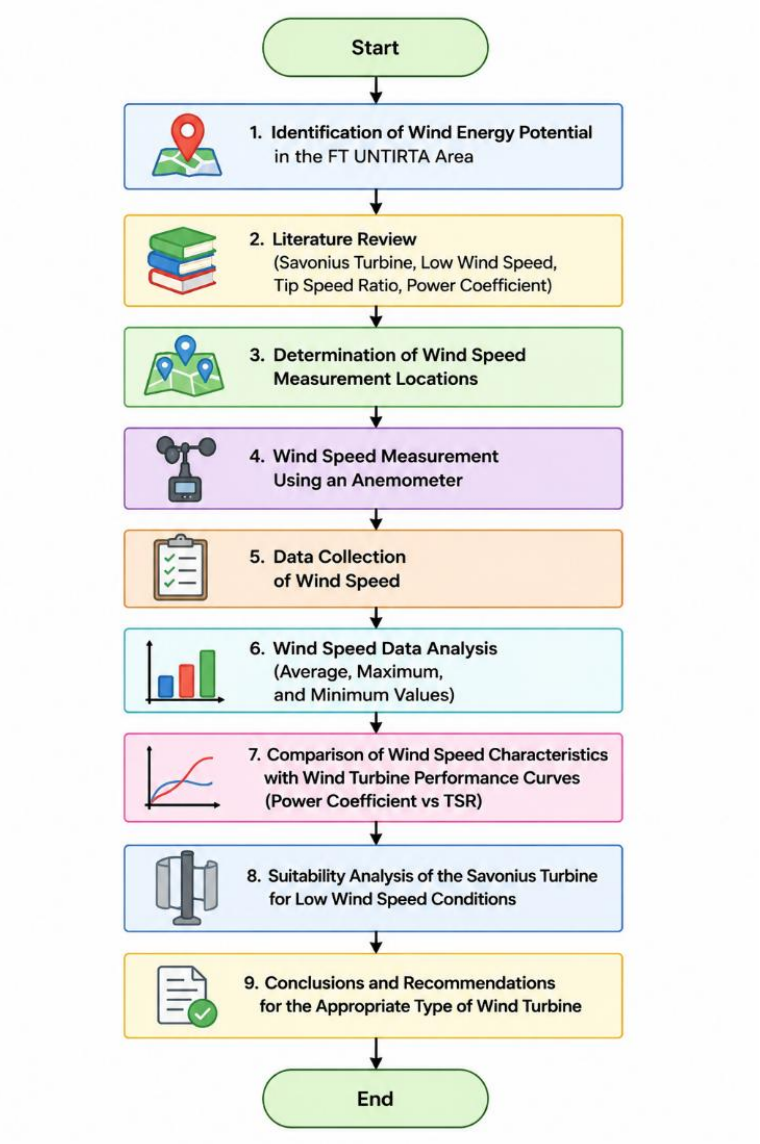

Figure 2: Flowchart of Research Design.

3. Results and Discussion

3.1. Results

Wind speed measurements were carried out at three different locations within the Faculty of Engineering, Sultan Ageng Tirtayasa University (FT UNTIRTA) using an anemometer. The selection of the location was made based on the characteristics of open areas that have the potential to be used as locations for the implementation of small-scale wind power plants. The first location is in the open sports field area near the Hijrah Canteen (figure 3).

Figure 3: Open sports field area.

Based on the measurement results, it was obtained that the wind speed ranged from 1.5 to 2 m/s. This value indicates that the field area has relatively low wind potential. This condition is influenced by the presence of buildings around the area and unstable wind flow patterns.

The second location is on the rooftop of the CoE (Center of Excellence) FT UNTIRTA building (figure 4). The measurement results showed a higher wind speed than other locations, ranging from 2 to 3.2 m/s. This condition occurs because the rooftop area has less wind resistance so that the wind flow can move more freely. Based on the measurement results, the rooftop of the building is the location with the best wind potential among the three observation points.

Figure 4: Rooftop of the CoE (Center of Excellence) FT UNTIRTA building.

Figure 5: Green open garden near the Hijrah Canteen.

The third location is in a green open park near the Hijrah Canteen (figure 5). At this location, wind speeds range from 1.5 to 2.2 m/s. This value is still included in the category of low wind speed. The presence of vegetation and trees around the park causes some of the wind flow to be obstructed, thus affecting the value of the wind speed obtained.

Table 1: Average Wind Speed in the Untirta campus area.

No	Place Name	Average Wind Speed
1	An open-air sports field area near the Hijrah Canteen	1,5 – 2 m/s
2	Rooftop CoE (Center of Excellence) FT UNTIRTA building	2 - 3,2 m/s
3	green open garden near Hijrah Canteen	1,5 - 2,2 m/s

Overall, the measurement results showed that the average wind speed characteristics at the study site were in the low category, which was below 4 m/s. These conditions are the basis for determining the type of wind turbine that is suitable to be applied in the research area. The measurement data was then compared with a graph of the performance characteristics of several types of wind turbines based on the relationship between the power coefficient (Cp) and the turbine tip speed ratio (TSR). Based on the graph, a propeller type turbine or horizontal axis wind turbine (HAWT) has high efficiency but requires a greater wind speed to produce optimal rotation. Meanwhile, Darrieus-type turbines perform well at high TSR but are less than optimal in low wind conditions because they have low self-starting capabilities.

Unlike the two types of turbines, the Savonius turbine has characteristics that are more suitable for low wind speed conditions. The Savonius turbine is able to operate at low TSR values and has a high initial torque so that it is easier to rotate in low wind conditions of around 1.5–3.2 m/s as obtained at the research site. In addition to being able to work at low wind speeds, Savonius turbines also have a simple construction, are easy to manufacture, and have relatively low maintenance costs. This turbine is also not too affected by changes in wind direction, making it suitable for use in areas with changing wind patterns.

Based on the results of the analysis that has been carried out, it can be concluded that the Savonius turbine is the most suitable type of wind turbine to be applied to research sites with low wind speed characteristics below 4 m/s. Of the three measurement locations, the rooftop area of the building has the best wind potential for the development of a small-scale wind power plant using Savonius turbines

3.2. Discussion

Based on the results of measurements carried out at three location points in the FT UNTIRTA environment, the characteristics of wind speed were obtained which were relatively low, which was in the range of 1.5–3.2 m/s. The rooftop area of the building shows the highest wind speed value compared to other locations with a range of 2–3.2 m/s, while the open sports field area and green open garden have wind speeds ranging from 1.5–2.2 m/s. In general, all research sites have wind speed characteristics below 4 m/s so they are included in the low wind speed category.

In this study, the analysis was carried out by comparing the results of wind speed measurement to the graph of wind turbine performance characteristics based on the relationship between power coefficient (Cp) and turbine tip speed ratio (TSR). The focus of the analysis was directed to the characteristics of the Savonius turbine as a prime candidate for low wind speed conditions. Based on the performance characteristics graph, the Savonius turbine works in a low TSR range, which is about 0 to 2. This shows that the Savonius turbine is capable of generating rotation even in low wind speed conditions. This characteristic is different from some other types of turbines that require a higher TSR value in order to work optimally.

In figure 1, it can also be seen that the Savonius turbine has a lower power coefficient value than the propeller and Darrieus turbines. However, in low wind speed conditions, self-starting capability and high starting torque are more important factors than maximum efficiency. With these characteristics, the Savonius turbine is easier to start spinning at a low wind speed of about 1.5–3.2 m/s as obtained at the research site. In addition, Savonius turbines have the ability to receive wind direction from various sides without the need for a wind direction mechanism. This characteristic is very suitable to be applied to open environments with variable wind direction patterns such as in the research area of FT UNTIRTA. The simple construction of the Savonius turbine also provides advantages in manufacturing, installation and maintenance processes.

The results of the analysis showed that the wind speed characteristics at the research site were in accordance with the optimal working area of the Savonius turbine on the wind turbine performance graph. Therefore, the Savonius turbine is considered the most suitable type of turbine to be applied to research sites with low wind speed characteristics below 4 m/s. Of the three measurement points, the rooftop area of the building has the best potential for the implementation of the Savonius turbine because it has the highest wind speed value and a smaller wind flow barrier compared to other locations.

4. Conclusion

Based on the results of wind speed measurements carried out at three different locations in the FT UNTIRTA environment, wind speed characteristics were obtained that were relatively low with a range of between 1.5 m/s to 3.2 m/s. The rooftop area of the building shows the highest potential wind speed compared to other locations, while the open sports field area and green open garden have relatively lower wind speed values.

The results of the analysis based on the comparison of wind speed characteristics to the wind turbine performance graph in relation to the power coefficient (Cp) and turbine tip speed ratio (TSR) showed that the Savonius turbine is the most suitable type of turbine for low wind speed conditions below 4 m/s.

Savonius turbines are able to work at low TSR values and have good self-starting and starting torque capabilities so that they are able to operate in low wind speed conditions.

Savonius has the advantages of simple construction, easy to manufacture, relatively low maintenance costs, and being able to work in changing wind directions. These characteristics make the Savonius turbine suitable for application as an alternative to small-scale wind power plants in the research area. Based on the results of the research that has been conducted, the Savonius turbine is recommended as the most suitable type of wind turbine to be applied in areas with low wind speed characteristics such as in the FT UNTIRTA environment

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