Vertical Wind Turbines as Power Plants at the Railroad Tracks

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***Abstract*—Wind speed is caused by the movement of the Railway saves kinetic energy which can be used as an alternative wind energy. Based on the data from the Indonesian Central Bureau of Statistics, the average wind speed on the island of Java is 7.5 m / s. The wind speed can produce a power capacity of electrical energy that has been converted, which is equal to 50 watt. With the design of a wind turbine that has a height of 50 cm and a cross-sectional area of 0.047 m2. The capacity of electric power is very potential in terms of the use of renewable wind energy. Placement of wind turbines around the railroad track area, the other objective is as a security tool or called a guardrail which is an effort to prevent and reduce the level of accidents around the area.**

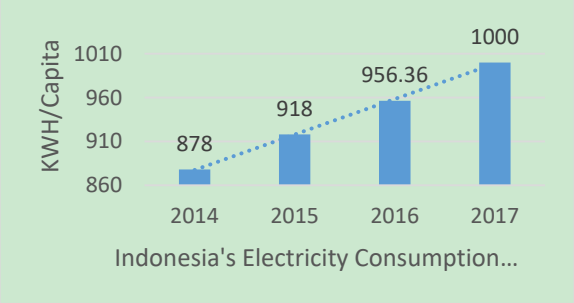
***Index Terms*—wind, turbines, train, energy**

I. Introduction

Energy has an important role in achieving social, economic and environmental goals for sustainable development and is a support for national and international economic activities. Energy use is currently increasing rapidly along with economic growth and population growth. Especially the concern is the use of electrical energy. Electricity needs in Indonesia are currently increasing because the number of people in Indonesia is increasing. almost all human activities in every day require electrical energy which is certainly needed by a power plant to be able to meet these needs. Ironically, the increase in the number of electrical energy needs is not balanced with adequate energy supply and at this time in Indonesia the increase in electricity demand is increasing every year [1].

However, the phenomena that occur at this time actually indicate the existence of an electrical energy crisis which is evidenced by rotating blackouts and campaigns for efficient use of electricity to the public. As a consequence of human need for electricity, a solution must be sought for the fulfilment of electricity with the use of renewable alternative energy.

The mode of rail transport has been widely applied in several countries in the world, both developed and developing countries, since 1930. Trains have a high speed, the wind generated from the speed of railroad movement can be used as a source of alternative energy use from the wind. Therefore, innovation can be made for alternative energy for wind power plants, namely making turbines around the area of the railroad tracks. Aside from being an effort to innovate alternative energy wind power plants the function of the turbine can be used as safety and security around the railroad area, namely as a guardrail.



(Source : Ministry of Energy and Mineral Resources, 2017)

Figure 1. In this graph illustrates the increase in elecricity consumption in Indonesia since 2014 to 2017. [2]

A. Trains

A train is a form of rail transportation that consists of a series of vehicles drawn along a railroad line to transport cargo or passengers. Motion styles are provided by separate locomotives or individual motors in several units. Railroads usually consist of two, three or four rails, with a number of monorails and mixed maglev guideways. PT KAI Indonesia along the island of Java is 5,042 km with the speed at which trains travel 105 km / h, with regular motion

According to the Data from the Central Statistics Agency and BMKG, Indonesia's average wind speed during the day is 1-7 km / hr, and at night it is 4-7 km / hr. The followings are the wind speed data in Indonesia:

TABLE I. In This Table, Exlplained Average Wind Speed of Several Island in Indonesia. Java Island Get the Highest of Wind Speed

Island	Average Wind Speed (m/s)
Sumatera	4,9
Java	7,5
Bali	6
Nusa Tenggara	7
Sulawesi	4
Bangka Belitung	3,5
Kalimantan	4,5
Maluku	4,2
Papua	3,7

(Source: Data from the Indonesian Central Bureau of Statistics, 2018)

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B. Renewable Energy

Renewable energy is derived from the "sustainable natural processes", such as solar power, wind power, biological process water flows, and geothermal energy. Temperature differences in two different places produce different air pressures, resulting in wind. Wind is the movement of matter (air) and it has been known for a long time to be able to drive a turbine. Wind turbines are used to produce kinetic energy and electrical energy. Energy available from wind is a function of wind speed; when the wind speed increases, the output energy also increases to the maximum energy that the turbine can produce. innovation can be done for alternative energy for wind power plants, namely making turbines around the railroad area. Aside from being an effort to innovate alternative energy wind power plants, the turbine function can be used as safety and security around the railroad tracks [3]

II. Literature Review

Dragomirescu (2010) develops new wind turbines that can harvest wind even in low wind conditions. The turbine is the same crossflow turbine as the Banki turbine. Analysis of turbine performance is carried out in numerical simulations. Based on the simulation results, turbines with an outer diameter size of 1 m produce a maximum tip speed ratio (TSR) of less than 0.6, the resulting torque coefficient is close to 3.6 and the power coefficient reaches around 0.45 [4]

III. Basic Theory

A. Wind Turbine

A wind turbine is a driving machine whose driving energy comes from the wind. The wind turbine functions to convert the kinetic energy of the wind into motion energy in the form of rotor rotation and shaft, the energy of motion that comes from the wind is then forwarded to the force of motion and torque on the generator shaft which is then generated by electrical energy. Based on the direction of the axis of motion, the wind turbine is divided into two, namely: horizontal and vertical axis wind turbines. While based on the principle of aerodynamic forces that occur, wind turbines are divided into two, namely types: lift and drag. Type of lift for low wind rotation and type of drag for high wind rotation [5].

B. Vertical Axis Wind Turbine

The vertical axis wind turbine is a wind turbine whose rotor rotation axis is perpendicular to the ground surface. The advantage of the vertical axis wind turbine concept is simple in its planning. The design allows placing in the mechanical components, electronic components, transmission of gears and generators at ground level and it is easy to process. Currently, vertical axis wind turbines have been developed which can utilize aerodynamic forces. The Crossflow turbine is one of them. Crossflow turbines are turbines that work by means of air pressure and then is converted into kinetic energy. A Crossflow turbine has advantages in simple, cost effective and easy maintenance structures [6]

C. Power Coefficient

Power coefficient is important in designing a wind turbine because it shows how much wind energy can be converted from wind kinetic energy through the rotor cross section. The power coefficient greatly influences the performance of wind turbines and is influenced by the wind turbine construction and its energy conversion principle. The power output of the rotor is stated by:

$$P = \frac{1}{4}\rho A (V_1^2 - V_2^2) (V_1 + V_2) \quad (1)$$

while the power passing through the rotor cross section is:

$$P_0 = \frac{1}{2}\rho A V_1^3 \quad (2)$$

The ratio between the output power of the rotor to the total power through the rotor cross section called the Cp power coefficient is formulated with

$$CP = \frac{P}{P0} \quad (3)$$

D. Security Level on the Railroad Track

In Law Number 23 of 2007, concerning Railways to facilitate the transfer of mass and / or goods safely, comfortably, in an orderly manner, it often results in events that are contrary to the Railway Law. The level of accidents in these transportation equipment's is fairly high. This can be caused by accidents involving the train itself or accidents at railroad crossings that harm public transport or public road users that cross the railroad. Currently the security equipment in the railroad track is only a crossing railroad door that serves as a symbol that the train will cross the railroad and the drivers have to stop because the train will pass and protect and provide a warning that there will be a passing train. According to the survey, in reality there were many motorists who violated the rules so that they broke through the railroad barriers so that the accident rate increased. Some reasons motorists break through the crossbar because the crossbar itself is not fully closed, and then it takes a long time to wait for the train to pass and most drivers don't want to wait.

IV. Research Methods

This research method is to develop the idea of wind turbines and the placement of wind turbines on railroad lines, then literature studies include renewable energy, wind turbines, and wind potential in the Indonesian region.

A. Discussion of Result

Based on data from Table 1, it is known that the average wind speed on the Java Island region is 7.5 m / s. The known wind speed is the normal speed of the land. Then the cross section of the turbine can be calculated as follows:

Known:
Expected P_0 = 50 watt

ρ = 1,25

V = 7,5 m/s

$$P_0 = \frac{1}{2}\rho A V_1^3 \quad (4)$$

$$50 = \frac{1}{2} 1{,}25 A (7{,}5)^3 \quad (5)$$

$$50 = 1054{,}7 A \quad (6)$$

$$A = \frac{50}{1054{,}7} \quad (7)$$

$$= 0{,}047 m^2 \quad (8)$$

B. Turbin Design

Based on the calculation of the power capacity, the wind turbine is designed with a height of 100 cm, and the cross-sectional area of the turbine is 0.047 cm. A Turbine is designed in the form of a vertical turbine with a crossflow blade type. Turbines are designed using 20 blades. [7]

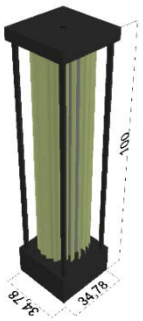

Figure 2. In this figure, based on expected energy, the turbine design height is 100 cm, and 34,78 cm for width and length.

C. Placement of Wind Turbines

Based on wind speed data in Table 1, the greatest wind potential is on Java. So, the location for the placement of the turbine locations on the railroad tracks is Java island especially on the Jakarta City Line. Remembering the density of the population of Jakarta City and there are 25 stations and the intensity of the use of trains and accidents on high railway lines. This wind turbine can be integrated as a railroad guardrail for security equipment around the railroad area.

Figure 3. In this figure explained about placement at the railroads tracks, also 2 – 3 meters placement form the tracks. So, the turbine will be catched the wind easily.

V. SWOT Analysis

A. Strength

Wind renewable energy is unlimited in number and is renewable and does not pose a risk of scarcity. The energy that can be produced by one wind turbine planned for this is 50 watts. This wind turbine can be used as a sustainable integrated system, and the function of both is as a security tool, which is a guardrail around the railroad area. In terms of cost, of course this integrated tool can provide high profits, considering this tool is a long-term project and can save conventional energy.

B. Weekness

Strong licensing is needed to implement this project. And to implement it requires a high cost at the beginning

C. Opportunity

Can help drive the country's economy and open up many new employment opportunities, can reduce the greenhouse effect, can be used as an integrated system to help safeguard railroad area roads.

D. Threat

The threat that can be felt is when developing this renewable energy, namely the difficulty of licensing from the ruling party.

VI. Conclusion

We present and design a crossflow type wind turbine as a reference wind turbine that can be placed in the area around the railroad which aims to produce wind energy that can be converted as an alternative energy with a 50 watt power capacity with a 100 cm turbine height and turbine cross-section 0.047 cm2. Another purpose of this research is to gain insight into wind turbines that are placed in the accident-prone areas as one of the efforts to make integrated innovations. The integration of this wind turbine can be used as a security tool in the railroad area. And this innovation presentation can be developed for other goals of renewable alternative development, especially wind utilizationn.

References

[1] D. Caesaron and M. Yona, "Evaluasi dan Usulan Pengembangan Energi Terbarukan Untuk Keberlangsungan Energi Nasional," *JIEMS*, 2014.

[2] I. Nurjanah, B. Winardi, and A. Nugroho, "Prakiraan kebutuhan energi listrik tahun 2016 – 2020 pada Pt. Pln (persero) unit area pelayanan dan jaringan (APJ) tegal dengan metode gabungan," *Transient*, vol. 5, no. 1, 2016.

[3] J. F. Manwell, *Wind Energy Explained Theory, Design and Application*, Amherst: John Wiley and Sons, Ltd, 2002.

[4] Dragomirescu, *Performance Assessment of a Small Wind Turbine with Crossflow Runner by Numerical Simulations*, Bucharest: Elsevier, 2010.

[5] E. Hau, *Wind Turbine*, 2nd ed. New York: Springer, 2005.

[6] U. K. Sahaa, S. Thotlaa, and D. Maityb, "Optimum design configuration of savonius rotor through wind tunnel experiments," *Journal of Wind Engineering and Industrial Aerodynamics*, vol. 96, no. 8-9, pp. 1359-1375, 2008.

[7] W. B. Pramono and A. H. Warindi, *Perancangan Mini Generator Turbin Angin 200 Watt Untuk Energi Angin Kecepatan Rendah*, 2015.

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