Journal of Marine Electrical and Electronic Technology **Vol. …...., No. …….**

ISSN xxxxxx **Publication Periode**

E-COBRA: Integration of Wind Turbine Technology in Electric Car Power Banks for Sustainable Transportation

F.A.R. Puteri*, T.K. Hana, N.K. Novianto*****

* falishaazfa28@gmail.com

**ayyatsurayya16@gmail.com

*** nur.kholis@praditadirgantara.sch.id

Abstract

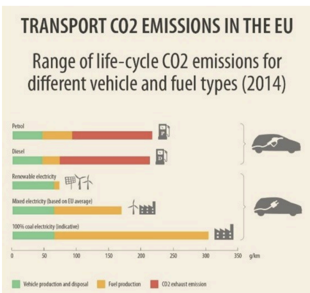
Dependence on non-renewable energy remains a major challenge, despite the growing popularity of electric cars, as most electricity sources come from coal. In response, this paper proposes E-COBRA, a wind turbine system with a magnetic rotor as a renewable electricity source that can extend the battery life of electric cars. Functioning as a power bank, E-COBRA utilizes wind energy while the car is moving and converts it into electricity to support the battery. The design of the E-COBRA follows the principles of aerodynamics, with an installation on the roof of the electric car to capitalize on the kinetic energy from the wind hitting the car. The lift generated by the air on the roof of the electric car turns a wind turbine. Inside the generator, the mechanical energy is used to spin a magnetic rotor inside a stationary coil of stator wire, changing the magnetic field and inducing electricity in the wire. This process generates electricity that is conducted through a cable and connected directly to the car's charging port. This paper compares the design of using a diffuser-increased wind turbine (DAWT) with a vertical axis wind turbine (VAWT) for the E-COBRA system. The comparison shows that the DAWT produces the largest energy, electrical power output of 2.2 kW at a car speed of 71.2 km/h. This technology not only reduces reliance on non-renewable energy but also offers a significant solution for increasing the efficiency and travel range of electric cars. As such, this approach represents a significant development in sustainable transportation solutions.

Keywords: DAWT, Electric car, Sustainable transportation, VAWT, Wind turbine

1. Introduction - please use 10pt Times New Roman bold for all headings

The lack of non-renewable energy is often the main focus and basis of many scientific innovations. Various efforts have been made to provide sustainable energy sources for daily life, including in the transportation field. Electric vehicles are an innovation that is considered the key to solving the problem of unsustainable transportation. According to the Ministry of Transportation of the Republic of Indonesia, the complete use of electric vehicles can increase energy efficiency, reduce dependence on carbon fuels, and improve Indonesia's air quality (Menhub, n.d.). This is because electric vehicles do not use fuel, so they do not produce pollution that is bad for the environment (Ramadhina & Najicha, 2022). Battery-based electric vehicles currently have the lowest life cycle greenhouse gas (GHG) emissions and have the potential to reach zero emissions in the future. Electric cars currently produce 47%-54% lower emissions than conventional cars (Mera & Bieker, 2023).

However, while electric cars do not produce the carbon emissions of burning fuel, they still contribute to Indonesia's carbon emissions, not from the mobility of the car, but from the electricity source that is the life of the car. In Indonesia, around 60% of electricity comes from coal-fired power plants (Winarto, 2015).



Source: Raksodewanto (2020)

Figure 1. Transport CO2 Emissions in the EU

Figure 1 shows the total carbon dioxide emissions of a vehicle, starting from the vehicle production process, fuel production, to fuel combustion. This data shows that carbon dioxide emissions per km of electric cars with a coal-fired power plant power source are greater than conventional petrol or diesel cars. This condition will only shift the air pollution problem from the city to the area around the power stations (Raksodewanto, 2020).

So, this shows that the environmentally friendly transportation goals of electric cars cannot be met without a renewable source of electricity.

On the other hand, electric cars also have several disadvantages compared to conventional cars that hinder the implementation of the renewable energy transition program. As the latest innovation, the availability of charging infrastructure, or public electric vehicle charging stations, is still very limited at 1,124 units (2024) compared to the number of public fuel filling stations of 14,400 (2023). In addition, the limited range of electric cars is due to battery capacity. These issues make electric cars unsuitable for long-distance travel.

Therefore, a solution is needed to utilize renewable energy as a power source for electric cars and maintain power stability for long-distance travel. This paper proposes the Electric Car Power Bank for Sustainable Transportation, or E-COBRA for short. E-COBRA is an innovative power bank for electric cars that utilizes wind power using a wind turbine equipped with a magnetic rotor to ensure stable energy output. This innovation is designed to support electric car batteries. When the electric car is moving, the E-COBRA, located on the roof of the car, will utilize the kinetic energy from the wind hitting the car. The wind turbine will utilize the wind to spin the motor and generate electricity which is then transmitted directly through a cable connected to the car's charging port, enabling continuous battery charging during the ride.

E-COBRA's ability to convert wind energy into electricity on the move solves three problems that electric cars face: limited battery range, lack of charging infrastructure, and dependence on non-renewable energy sources. By utilizing renewable energy sources, E-COBRA not only maximizes the range of electric cars. It also contributes to reducing carbon emissions.

This paper will review previous research to determine the E-COBRA design that can generate the most power and most efficiently. Furthermore, this paper will prove the power that the E-COBRA can generate with a simple experiment. This stage aims to ensure that the E-COBRA will function optimally and can be a feasible solution to be implemented in Indonesia.

2. Literature Review and Previous Research

2.1 Literature Review

2.1.1 Electric car

An electric car is an automobile vehicle operated by one or more electric systems. Electric cars utilize electrical energy to move, which is stored in a secondary battery that can be recharged with a charging system. Like cars in general, electric cars have four car wheels attached to each end of the car. the electrical energy used to operate the electric car helps the car wheels get balanced torque, giving the electric car smooth movement and acceleration (Dzaky, 2018).

2.1.2 Electric Car Charging System

Electric cars store electrical energy that will be used to operate the vehicle in the battery. The battery in an electric car can be recharged through the battery charging process, known as the charging process. In this process, the battery is supplied with electrical energy from a power source with a voltage that is adjusted to a certain battery capacity. The minimum power required to recharge an electric car is different depending on the desired time to fully charge the battery. If the user wants a faster charge, then the minimum power required for charging is also greater (Aswardi, Elfizon, & Warman, 2018).

2.1.3 Wind Turbine

Wind turbines are a windmill technology developed to create power plants that utilize the wind to provide torque to windmills. in wind turbines, the kinetic energy formed from the rotation of the wheel that drives the electric generator is utilized and converted into electrical energy (Brilliyanto, 2024). Wind turbines can process the creation of electrical energy when the wind blows the rotor blade or pinwheel. In this process, the generator, the machine used to produce electricity, also rotates as the rotor rotates. With the principle of electromagnetic fields, the generator converts the mechanical energy generated from the rotation into electrical energy which is then transmitted through cables (Prasetio, 2019).

2.1.4 DAWT

DAWT or diffuser augmented wind turbine is a designation used for wind turbines designed with a cone shape that is used to obtain high efficiency in wind turbines in converting kinetic energy into electrical energy at a lower cost. DAWT wind turbines are modified with a conical wind diffuser, causing a pressure drop at the diffuser outlet which helps increase the wind flow rate at the diffuser inlet to obtain the highest efficiency (Naji & Jabbar, 2024).

2.1.5 VAWT

DOI xxxxxx

VAWT or vertical axis wind turbine is a wind turbine whose axis of the wheel rotates with a vertical shaft. In VAWT, the direction of the wind blowing is parallel to the rotor which causes the wheel to rotate with the wind blowing from various directions. VAWTs require low torque to rotate which allows them to rotate even in low wind speeds. In addition, the generator in VAWT is installed under the pinwheel, making it easily accessible for maintenance (Maulana, 2019).

2.1.6 Linear Regression Analysis

Linear regression analysis is a statistical method used to analyze the relationship between one independent variable and a dependent variable. The statistical analysis will be expressed by the equation y = mx + c. The x values represent the independent variable while the y variable represents the dependent variable of the analysis. This equation is done by visualizing the collected data with a scatter plot graph, and then adding a trendline in it where the trendline has the equation y = mx + c (Ali & Younas, 2021).

2.2 Previous research

2.2.1 Numerical Simulation of Wind Speed Effect on Wind Turbine Performance Enhanced with Diffuser

Following the principles of aerodynamics, the shape of the wind turbine certainly affects the performance and efficiency of the wind turbine. Diffuser Augmented Wind Turbine (DAWT) is a wind turbine made with a cone shape that helps wind turbines optimize their performance and produce maximum power output. Referring to previous research with ANSYS Workbench 19 computer simulations, tests have been carried out on the performance of VAWT at different wind speeds with a blade length of 4.32 meters at wind speeds of 3 m/s, 5 m/s, and 8 m/s. The turbine was modified by adding a 9-meter-long diffuser. This study showed significant differences in performance percentage results, namely 115.6% at 3 m/s wind speed, 99.2% at 5 m/s wind speed, and 91.8% at 7 m/s wind speed.

The results of this study identified that the performance of the DAWT showed maximum results at a lower wind speed of 3 m/s, with a performance percentage of 115.6%. This study provides an important overview of the effects of wind speed on the performance of modified wind turbines to help consider determining the best operational conditions to innovate the best tools for power support in electric cars (Irawan & Harianto, 2019).

2.2.2 Research on Active Power Flow and Efficiency of a Single Vertical Axis Wind Turbine (VAWT)

Vertical axis wind turbines (VAWT) are often known as wind turbines that can rotate easily because they can be more sensitive to wind gusts from all directions (Naji & Jabbar, 2024). Referring to previous research, the power flow characteristics of a vertical axis wind turbine (VAWT) in a single system based on wind conditions in South Sulawesi have been investigated, especially in areas with high wind energy potential such as Jeneponto and Sidrap. This study shows that at a wind speed of 23 m/s, a single VAWT can generate an active wind power flow of 2,980.9 watts, with the highest voltage of 14.22 V and a current of 5.8 A. The efficiency of the single VAWT is highest at 0.165% for a wind speed of 10 m/s, although the efficiency decreases as the wind speed increases. These data demonstrate the direct relationship between wind speed and generator and turbine rotation, as well as the importance of wind conditions in determining the power output of VAWTs, which is relevant for the development of power generation for electric cars (Azis, Parawangsa, & Fitri, 2023).

2.2.3 Electric Power Generation by Wind Turbines to Charge a Mobile Electric Car

In other studies, theoretical calculations have been carried out regarding the estimated electrical power yield of a single DAWT mounted on an electric car as a battery support. Adjusting to the aerodynamic concept of the car, a single DAWT is placed above the windscreen of the car to get the maximum wind speed when the car starts moving. Through theoretical calculations, the electric power generated from the wind shows a figure of about 3.26 kW to be distributed to the battery at a car speed of 120 km/h (Quartey & Adzimah, 2014).

3. Methods

This paper is written to construct the working system of the E-COBRA product to achieve the ideal output target as a power bank for electric cars. The main consideration in the design of E-COBRA is the turbine used, which is between the use of a vertical axis wind turbine (VAWT) or a horizontal axis wind turbine with a diffuser (DAWT). In this consideration, calculations will be made to compare the efficiency of the two wind turbine models and find out the minimum and maximum speed of the car that must be considered by the driver when operating the E-COBRA while driving.

3.1 Independent Variables

DOI xxxxxx

Here are the independent variables of the study :

Table 1. Independent Variables in the Study

Independent Variable	Description
Efficient speed	Efficient speed is the wind speed on the roof of the car. In this study, calculations will be made from different efficient speeds to see the ideal speed that must be met when the car operates E-COBRA.

3.2 Dependent Variable

Here are the dependent variables of the study :

Table 2. Dependent Variables in the Study

Dependent Variable	Description
Output power with losses	Output power with losses is the power that can be distributed by the wind turbine in total.
Actual Efficiency	The Actual efficiency of the wind turbine will be given in the form of a percentage (%) to ensure the efficient performance of the machine.

3.3 Control Variables

Here are the control variables in the study :

Table 3. Control Variables in the Study

Control Variabel	Value (m)	
	DAWT	
Turbine Radius	0.09	0.09
Turbine height	0.3	0.3
Diffuser Inlet Diameter	0.2	-
Diffuser Exit Diameter	0.3	-

3.4 Apparatus

The apparatus needed for the experiment are :

Table 4. Apparatus

Name	Specification	Amount
Fan	5 wind speed levels	1
Anemometer	Benetech GM816	1
Wind turbine	9 cm in diameter	1
Dynamo	12 Volt	1
Cable	-	1
Multimeter	NJTY T21A Digital	1

DOI xxxxxx

3.5 Experiment Procedure

Here is the procedure of the experiment :

1. The anemometer is faced in front of the fan.
2. The fan is turned on at the lowest wind speed level and the wind speed is recorded.
3. The recording repeats at every different wind speed level.
4. Cable and wind turbine is connected to the dynamo.
5. The conductor part of the cable is connected to the test lead of the digital multimeter.
6. The wind turbine is faced in front of the same fan.
7. The fan is turned on at the lowest wind speed level.
8. The power output of the wind turbine is recorded.
9. The recording repeats at every different wind speed level.

4. Results and discussion

4.1 Calculations

In calculating the power output with losses produced by wind turbines, several fundamental concepts and equations must be addressed to ensure the necessary variables are accounted for in the calculations. In this study, the process to determine the efficiency and power output with losses for each turbine is carried out in the following sequence. First, the total power available in the wind must be determined. The power generated by a wind turbine is fundamentally derived from the kinetic energy of the wind. The basic formula to calculate the power available in the wind is

$$P_{wind} = \frac{1}{2} \times \rho \times A \times v_{eff}^3$$

Where,

P_{wind} = Power available in the wind (watt)

ρ = Air density (kg/m^3)

A = Swept Area of the turbine (m^2)

v_{eff} = Efficient speed (m/s)

Then, the total efficiency of the turbine will be calculated to determine the overall power output of the turbine,

$$\mu = (1 - k_m)\times(1 - k_t)\times(1 - k_{e,t})\times(1 - k_t)\times(1 - k_w)\times c_p$$

Where,

c_p = Efficiency of the wind turbine (must be lower than the Betz limit of 59.3% and is typically between 30% and 40%).

k_w = Losses due to terrain topography, usually 3%–10%.

k_m = Mechanical losses from the blades and gearbox, typically 0%–0.3%.

k_e = Electrical losses from the turbine, usually 1–1.5%

$k_{e,t}$ = Electrical losses from transmission to the grid, usually 3–10%

k_t = Percentage of downtime due to failure or maintenance, usually 2–3%

μ = Actual efficiency

The final stage of calculation for power output with losses or net power produced by a wind turbine is derived from multiplying the actual efficiency with the power available in the wind.

$$P_{output} = \mu \times P_{wind}$$

Where,

P_{output} = Output power with losses or total power produced by the wind turbine

μ = Actual efficiency

P_{wind} = Power available in the wind (watts)

This calculation applies to both machines—DAWT and VAWT—as generic wind turbines. However, due to their significantly different structures, the power output calculations for DAWT and VAWT differ. The following outlines these differences:

a. Difference in Turbine Swept Area (A)

As the name implies, VAWT (Vertical Axis Wind Turbine) is a vertical-axis wind turbine with blades facing upwards, while DAWT (Diffuser-Augmented Wind Turbine) is a horizontal-axis wind turbine with a cone-shaped diffuser surrounding it. Due to the structural differences between these turbines, their swept area calculations also differ. The formulas for turbine swept area (A) are as follows:

VAWT

$A = D \times H$

Where,

A = Turbine swept area (m^2)
D = Diameter (m)
H = Turbine height (m)

DAWT

$A = \pi \times L^2$

Where,

A = Turbine swept area (m^2)
L = Blade length (m)

b. Boost Factor of the Diffuser in DAWT

A diffuser is added to a DAWT to enhance the airflow passing through the turbine. The diffuser creates a low-pressure area behind the turbine. This pressure difference increases the wind speed passing through the blades, thereby improving efficiency. The formula used to calculate the power output of a DAWT differs from a normal turbine:

$$P_{output} = \frac{1}{2} \times \rho \times A \times v_{eff}^3 \times C_p \times K$$

Where,
K = The factor representing the increase in airflow velocity caused by the diffuser
Research by Phillips (2006) demonstrated that a diffuser with an Exit-Area-Ratio (EAR) of 2.62 has a K value of 2.2.

$$EAR = \frac{A_E}{A_I}$$

Where A_E $(= \frac{\pi D_E^2}{4})$ and A_I $(= \frac{\pi D_I^2}{4})$ are the exit and inlet areas of the diffuser respectively.
Using an inlet diffuser diameter (D_I) of 0,2 m;

$$A_I = \frac{\pi \times 0{,}2^2}{4} = 0.03141592654\ m^2$$

Then,

$$A_E = A_I \times EAR = 0{,}03141592654 \times 2{,}62 = 0{,}08230972752\ m^2$$

From this calculation, the diffuser's D_E is:

$$D_E = \sqrt{\frac{4 \times 0.08230972752}{\pi}} = 0.3237282811 = 0{,}3\ m$$

With this diameter, a K value of 2.22 can be used for turbine power calculations.

4.2 Experiment 1: Power Generated by DAWT and VAWT

This demonstration aims to collect primary data to determine the power output of each wind turbine (DAWT and VAWT) when subjected to a fan set at varying speed settings. The wind speed generated by each fan is measured using a Benetech GM816 Anemometer, and the power output of each turbine is calculated using an NJTY T21A Digital Multimeter.

Table 5. Power Output VAWT and HAWT

Wind speed (m/s)	Power output (watt)	
	VAWT	HAWT
1.5	11.0	20.0
3	9.0	40.0
3.9	13.0	42.0

DOI xxxxxx

4.8	11.0	57.0
5	12.0	65.0

Due to the limitations of the equipment used, the demonstration for DAWT was conducted using HAWT without a diffuser. The power output produced by DAWT can be determined by multiplying by K. Therefore, the power output of DAWT is calculated as follows:

Table 6. Power Output VAWT and DAWT

Wind speed (m/s)	Power output (watt)	
	VAWT	HAWT
1.5	11.0	44.0
3	9.0	88.0
3.9	13.0	92.4
4.8	11.0	125.4
5	12.0	143.0

The data obtained from the study shows that the results are consistent with existing secondary data, indicating that DAWT is capable of producing greater power output compared to VAWT. This highlights DAWT's advantage in wind energy conversion efficiency into electrical power. These findings form the reason for choosing DAWT in the design of E-COBRA.

4.3 Experiment 2: Wind Speed Compared to Vehicle Speed

This verification uses the Benetech GM816 Anemometer with a calculation standard of m/s to determine the average wind speed. The anemometer is operated while riding a motor vehicle at varying speeds to demonstrate that the wind speed received by E-COBRA is directly proportional to the speed of the electric car. Additionally, this experiment aims to prove that DAWT will be capable of generating sufficient power to charge an electric car.

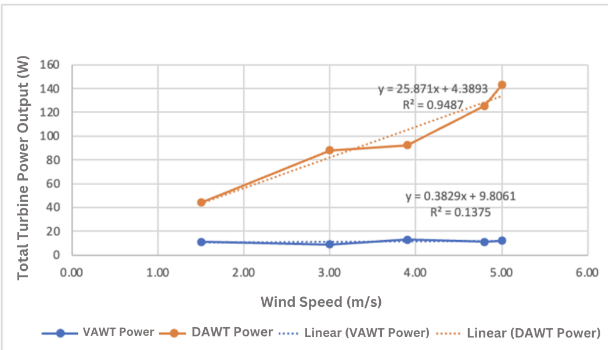


Figure 2. Graph of Wind Speed vs. Turbine Power Output

4.4 Data Processing

After plotting the experimental results on a graph, the trend of wind speed versus total turbine power output from experiments using the wind turbine prototype and multitester was analyzed. The graph in Figure 3 illustrates that the total power output of DAWT is significantly higher than VAWT. Linear trend lines were added to identify the correlation between increased wind speed and turbine power output. From these linear trend lines, the Pearson Correlation Coefficient (r) and the linear equations were calculated to describe the relationship of the correlation. The coefficients obtained were 0.9487 for DAWT and 0.1375 for VAWT. These values indicate that DAWT exhibits a strong positive correlation between wind speed and turbine power output $0.8 < r < 1$, whilst VAWT shows a very low correlation between the two variables $0 < r < 0.19$. Based on

DOI xxxxxx

these coefficients, the linear equation derived for DAWT is considered highly reliable for predicting the minimum vehicle speed required to achieve the power needed for charging an electric car, which is 2.200 kW. This prediction will be made using the linear equation derived from DAWT's correlation.

4.5 Equation Analysis

The linear regression analysis produced equations representing the trend between increasing wind speed and total turbine power output for VAWT and DAWT, respectively, as $y = 0.3829x + 9.8061$ and $y = 25,817x + 4,3893$. Given that DAWT generates higher power than VAWT, this study will focus on predicting the minimum vehicle speed required for charging, using DAWT's equation. To account for the difference in radius between the prototype turbine (4 cm) and the actual E-COBRA turbine (9 cm), scalability was applied based on the surface area ratio. The area ratio is calculated as follows:

$$Area\ ratio = \frac{\pi \times r^2_{actual\ turbine}}{\pi \times r^2_{prototype\ turbine}}$$

$$Area\ ratio = \frac{\pi \times 9^2}{\pi \times 4^2} = 5.0625$$

Since the power output with losses (p) is a function of wind speed and swept area, along with other coefficients, the actual turbine's power output is theoretically scaled by a factor of 5.0625 compared to the prototype's results. The estimated power output with losses for the actual turbine is given by:

$$P_{actual\ turbine} = P_{prototype\ turbine} \times 5.0625$$

Using this formula, the estimated power output with losses from the actual turbine is as follows,

Table 7. Estimated power output of DAWT $(P_{actual\ turbine})$

Wind speed (m/s)	DAWT Power output (watt)	
	Experiment Result	Scaled Calculation Estimation
1.5	44.0	222.75
3.0	88.0	445.50
3.9	92.4	467.78
4.8	125.4	634.84
5.0	143.0	723.94

Based on the calculation, an estimation of the power output of the E-COBRA DAWT at specific wind speeds has been obtained. Further adjustments will be made to the wind speed to predict the power output of the E-COBRA turbine when the wind speed corresponds to the wind speed of a moving vehicle. This adjustment will be carried out by deriving a linear equation from the correlation between wind speed and the estimated power output with losses of the actual turbine.

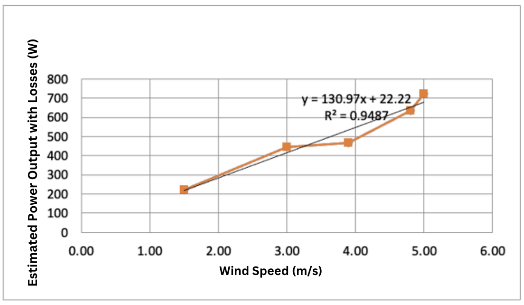


Figure 3. Graph of Wind Speed against Estimated Power Output with Losses

DOI xxxxxx

In the graph above, the function y representing the correlation between wind speed and the estimated power output with losses for the final E-COBRA design has been established. With a correlation coefficient of $r = 0.9487$, the derived equation, $y = 130.97x + 22.22$, can be used as a reference to determine the minimum vehicle speed required to achieve a power output of 2.2 kW for charging an electric car battery. To utilize this equation, information about the wind speed at the roof of the car, where the E-COBRA is installed, relative to the vehicle's speed is needed.

Given the equation $y = 130.97x + 22.22$, where y is the estimated power and x is the wind speed, the minimum power required to charge the electric vehicle battery is 2200 watts. By substituting y for 2200, the minimum wind speed can be calculated.

$$2200 = 130,97x + 22,22$$

$$x = \frac{2177,78}{130,97}$$

$$x = 16,63\ m/s$$

Thus, theoretically, for E-COBRA to effectively charge an electric car, a minimum wind speed of 16.63 m/s is required. To adjust wind speed measurements relative to the vehicle's movement, an experiment will be conducted to measure wind speed at an estimated height of 1.6 meters above ground level while the vehicle is in motion. This experiment will employ an Anemometer Benetech GM816 on top of a vehicle, which will record wind speed as the car travels at constant speeds. The experiment will vary the vehicle's speed at intervals of 10 km/h, 20 km/h, 30 km/h, 40 km/h, and 50 km/h as the independent variable. The dependent is the efficient speed on the wind speed measured at the rooftop of the vehicle. The results are as follows:

Table 8. Results of Wind Speed Against Vehicle Speed

Vehicle Speed (km/h)	Wind Speed (m/s)
10	2.1
20	6.5
30	7.1
40	10.5
50	11.2

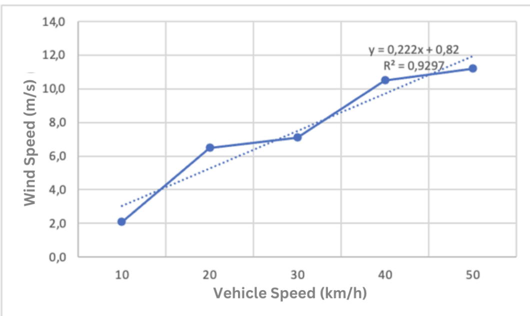


Figure 4. Graph of Vehicle Speed Versus Wind Speed

With a coefficient of $r = 0,9297$, this equation can serve as a basis for calculating the required vehicle speed. Thus, by substituting y to 16.63, the necessary vehicle speed is determined as follows:

$$16,63 = 0,222x + 0,82$$

$$x = \frac{15,81}{0,222}$$

$$x = 71,216\ km/h$$

Thus, the equation indicates that the minimum speed required for E-COBRA to charge an electric vehicle is 71.26 km/h. Given an average vehicle speed of 80 km/h, this equation demonstrates that E-COBRA is capable of generating sufficient power to charge the vehicle's battery.

DOI xxxxxx

4.6 Final Design of E-COBRA

The findings from the data analysis and both experiments serve as the foundation for the E-COBRA design. The dimensions of E-COBRA are determined based on the experimental data analysis from Phillips (2006). The choice of turbine is supported by the data analysis and Experiment 1, which demonstrated that DAWT can generate significantly more energy compared to VAWT. Meanwhile, Experiment 2 supports the design, as the derived equation proves that the E-COBRA design with these dimensions can theoretically generate sufficient power to charge an electric vehicle when exposed to the average wind speed in Indonesia.

The diffuser length is determined based on the turbine's divergence angle. According to the research by Li et al. (2020), divergence angles between 5° and 15° are considered optimal for diffuser geometry to achieve maximum pressure recovery. This is because larger angles can cause flow separation, while smaller angles fail to produce the desired diffuser effect. The diffuser length can be determined using the ratio of inlet to exit diameters and the divergence angle through the following formula:

$$L = \frac{D_E - D_I}{2 \times tan(\theta)}$$

$$L = \frac{0,3 - 0,2}{2 \times tan(10)}$$

$$L = \frac{0,1}{2 \times 0,1763} = 0,284\ m$$

Thus, to achieve optimal diffuser functionality, the E-COBRA will have a length of approximately 0.284 m, rounded up to 0.3 m.

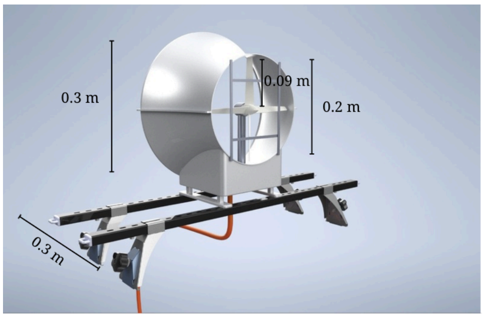


Figure 5. E-COBRA Final Design

Figure 6. E-COBRA Final Design on a Car

At the base of E-COBRA, there is a metal handle designed for easy installation and removal. This metal handle is attached to the roof rack component on the vehicle's roof, ensuring the E-COBRA can be easily mounted or detached. The DAWT turbine has a structural frame made of metal casing. This casing serves to protect the turbine from large foreign objects and creates a pressure difference as air enters and exits the E-COBRA. This pressure difference induces a temporary vacuum effect, drawing in more air and consequently generating greater energy output (Quartey & Adzimah, 2014).

5. Conclusion

Based on the required minimum vehicle speed and the power output achieved, E-COBRA with DAWT is theoretically effective as a supporting technology for electric vehicle batteries. At a minimum speed of 71.26 km/h, E-COBRA can produce 2200 watts of power, enough to charge electric vehicle batteries with power output comparable to public charging stations. This"power bank technology can address the challenges of long-distance travel faced by electric vehicles, ensuring the battery remains charged even during extended journeys. By utilizing wind turbines, E-COBRA generates electricity from renewable energy sources, thereby reducing dependency on coal-fired power plants. As a result, this innovation represents a significant step forward in sustainable transportation solutions.

Credit authorship contribution statement

Falisha Azfa Rania Puteri: Conceptualization, Writing – review & editing
Tsurayya Karima Hana: Conceptualization, Writing – review & editing
Nur Kholis Novianto M.Pd.:Supervision and review.

Declaration of Competing 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.

References

Dermawan, D., Febrianti, A.N., Setyawati, E.E.P., Pham, M.-T., Jiang, J.-J., You, S.-J., Wang, Y.-F., 2022a. The potential of transforming rice straw (Oryza sativa) and golden shower (Cassia fistula) seed waste into high-efficiency biochar by atmospheric pressure microwave plasma. Ind. Crops Prod. 185, 115122. https://doi.org/10.1016/j.indcrop.2022.115122

Dermawan, D., Wang, Y.F., You, S.J., Jiang, J.J., Hsieh, Y.K., 2022b. Impact of climatic and non-climatic stressors on ocean life and human health: A review. Sci. Total Environ. https://doi.org/10.1016/j.scitotenv.2022.153387

Kuo, T.C., Pacheco, A.M., Iswara, A.P., Dermawan, D., Andhikaputra, G., Hsieh, L.H.C., 2020. Sustainable ambient environment to prevent future outbreaks: How ambient environment relates to COVID-19 local transmission in Lima, Peru. Sustain. 12, 1–13. https://doi.org/10.3390/su12219277

Setiawan, A., Dianti, L.R., Mayangsari, N.E., Widiana, D.R., Dermawan, D., 2023. Removal of methylene blue using heterogeneous Fenton process with Fe-impregnated kepok banana (Musa acuminate L.) peel activated carbon as catalyst. Inorg. Chem. Commun. 152, 110715. https://doi.org/10.1016/j.inoche.2023.110715

Aswardi, Elfizon, & Warman. (2018). Sistem Pengisian Baterai pada Mobil Listrik. Seminar Nasional Teknik Elektro 2018. Retrieved from https://elektro.ub.ac.id/fortei/wp-content/uploads/2018/10/B-P012_FORTEI-141-145.pdf

Ali, P., Younas, A., Understanding and interpreting regression analysis. Correspondence to Ahtisham Younas, Memorial University of Newfoundland, St. John's, NL A1C 5S7, Canada. Correspondence to Ahtisham Younas, Memorial University of Newfoundland, St. John's, NL A1C 5S7, Canada

Azis, F., Parawangsa, A. N., & Fitri, N. S. N. (2023). Aliran Daya Aktif dan Efisiensi Vertical Axis Wind Turbine (VAWT) secara Stand Alone System. Jurnal Teknik AMATA, 4(1), 43–51. https://doi.org/10.55334/jtam.v4i1.90

Brilliyanto, R. (2024, February 23). Mengenal Turbin Angin: Energi Terbarukan yang Menyegarkan. Retrieved from https://amf.or.id/mengenal-turbin-angin-energi-terbarukan-yang-menyegarkan/

Dzaky, A. (2018, March 27). PENJELASAN MOBIL LISTRIK! Retrieved from https://student-activity.binus.ac.id/himtek/2018/03/27/1206/

Hu, X. and Wong, E. T. T. (2011), "A Numerical Study On Rear-spoiler Of Passenger Vehicle" World Academy of Science, Engineering and Technology, 637 pp.

Irawan, Y. H., & Harianto, H. (2019). Numerical simulation of the effect of wind velocity on the diffuser augmented wind turbines performance. Journal of Energy Mechanical Material and Manufacturing Engineering, 4(2), 73–82. https://doi.org/10.22219/jemmme.v4i2.9931

Li, Z., Moradi, I., Nguyen, Q., Karimipour, A., Afrand, M., Tlili, I., & Incecik, A. (2020). Three-dimensional simulation of wind tunnel diffuser to study the effects of different divergence angles on speed uniform distribution, pressure in outlet, and eddy flows formation in the corners. Physics of Fluids, 32(5). https://doi.org/10.1063/5.0006068

Maulana, Y. (2019). PERANCANGAN VERTICAL AXIS WIND TURBINE (VAWT) JENIS STRAIGHT BLADE. Journal of Industrial Engineering and Operation Management, 1(2), 347422. https://doi.org/10.31602/jieom.v1i2.2013

Menhub: Transportasi jadi fokus program transisi penggunaan energi terbarukan Kementerian Perhubungan Republik Indonesia. (n.d.). Retrieved from https://dephub.go.id/post/read/menhub--transportasi-jadi-fokus-program-transisi-penggunaan-energi-terbarukan

Mera, Z., & Bieker, G. (2023). PERBANDINGAN DAUR HIDUP EMISI GAS RUMAH KACA DARI KENDARAAN BERMOTOR MESIN BAKAR DENGAN KENDARAAN LISTRIK PADA KENDARAAN PENUMPANG DAN RODA DUA DI INDONESIA.

Mobil Listrik Tambah Banyak, PLN Siagakan 1.124 SPKLU Tersebar untuk Para Pemudik - PT PLN (Persero). (2024, April 1). Retrieved from https://web.pln.co.id/tidak-ada-kategori/2024/03/mobil-listrik-tambah-banyak-pln-siagakan-1-124-spklu-tersebar-untuk-para-pemudik#:~:text=%E2%80%9CPLN%20bersama%20mitra%20telah%20menyiapkan,dengan%20total%20sebanyak%201.124%20unit.

Mukaka MM. Statistics corner: A guide to appropriate use of correlation coefficient in medical research. Malawi Med J. 2012 Sep;24(3):69-71. PMID: 23638278; PMCID: PMC3576830.

Naji, M. M., & Jabbar, B. A. (2024). Diffuser augmented wind turbine: A review study. AIP Conference Proceedings. https://doi.org/10.1063/5.0191895

Philips, D. G. (2006), An Investigation on Diffuser Augmented wind Turbine Design, Unpublished PhD Thesis,The University of Auckland, pp. 1-334.

Prasetio, W. (2019). Prinsip kerja PLTB (Angin). Ugm. Retrieved from https://www.academia.edu/39024423/Prinsip_Kerja_PLTB_Angin_?auto=download

Quartey, G., & Adzimah, S. K. (2014). Generation of electrical power by a wind turbine for charging moving electric cars. Deleted Journal, 4(3), 19–29. Retrieved from https://www.iiste.org/Journals/index.php/JETP/article/download/11662/12007

Raksodewanto, A. A. (2020). MEMBANDINGKAN MOBIL LISTRIK DENGAN MOBIL KONVENSIONAL. TECHNOPEX-2020. Retrieved from http://technopex.iti.ac.id/ocs/index.php/tpx20/tpx20/paper/download/331/192

Ramadhina, N. A., & Najicha, N. F. U. (2022). Regulasi Kendaraan Listrik di Indonesia Sebagai Upaya Pengurangan Emisi Gas. Jurnal Hukum To-ra Hukum Untuk Mengatur Dan Melindungi Masyarakat, 8(2), 201–208. https://doi.org/10.55809/tora.v8i2.126

Schober P, Boer C, Schwarte LA. Correlation Coefficients: Appropriate Use and Interpretation. Anesth Analg. 2018 May;126(5):1763-1768. doi: 10.1213/ANE.0000000000002864. PMID: 29481436.

The International Council on Clean Transportation. Retrieved from https://theicct.org/wp-content/uploads/2023/09/ID-17-%E2%80%93-LCA-Indonesia_Bahasa_ES_final.pdf

Winarto, E. R. (2015). Evaluasi Dampak Lingkungan Siklus Hidup PLTU Batubara di Indonesia. Retrieved from https://etd.repository.ugm.ac.id/penelitian/detail/90323