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Design and Fabrication of Traffic Turbine (Free Energy Generation Application)

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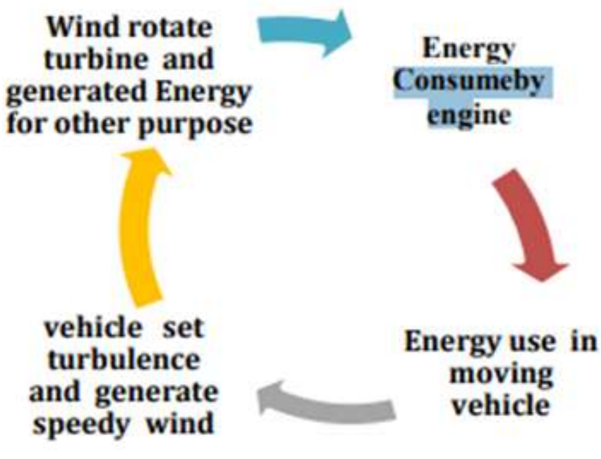
ABSTRACT

The project's goal is to create a wind turbine that can harness wind energy from passing cars. Although wind energy is thought to be the clean energy source with the quickest rate of growth, it is constrained by erratic wind conditions. Highways may produce a significant amount of wind to power a turbine because of the volume of traffic they see. This power is wasted. To establish the average wind speed caused by approaching cars, extensive research on wind patterns is needed. Since the wind turbines will be situated on the medians, the design will take into account fluid movement from both sides of the road. These wind turbines can be added to the current lamps in the medians using the information gathered. As the wind source will fluctuate a storage system for the power produced will also be created in order to distribute and maintain a continuous source of power. The turbine should be able to supply streetlights and other public amenities with limitless power on a worldwide scale.

Keywords: Traffic vehicle, Highway, VAWT Self-powered applications, Wind energy

1. INTRODUCTION

The majority of developed and emerging nations are working to build more wind farms around the world since everyone likes clean electricity production and because electricity consumption is rising daily. The concept of increasing the transferable energy from the availability of the wind internationally is now being found by numerous studies. We took into account the wind energy that nature provides for free. We can transform wind kinetic energy into mechanical energy, which can then be converted to electrical energy, by employing a wind turbine. The two types of wind turbines are horizontal axis and vertical axis wind turbines, as is common knowledge. We choose a vertical axis wind turbine because it requires less maintenance, has a simpler design, and is less expensive.



The amount of kinetic energy that can be converted mostly depends on the wind speed that is approaching the turbine and the turbine's swept area. Up until now, energy has been produced through wind. Only in coastal areas and high-altitude places where there is a strong natural breeze. Our strategy in this effort is to increase the production of wind energy in areas with low wind speeds.

The best chance of rotating a turbine is when high-speed, continuous turbulence is produced by moving automobiles on highways. After burning gasoline, a vehicle's kinetic motion produces air turbulence on the road, which can be caught by wind turbines and used to generate electricity.

The study found that the car's average speed on roadways where wind turbines will produce practically constant wind waves is between 60 and 90 km/h.

Fig. 1. Schematic of the highway with VAWT

Table 1 Parameters of the vehicle traffic according to research

Vehicle Type	***Observed speed (km/h)***			***Average vehicle dimension (m)***	
	Max Speed	**Min Speed**	**Mean Speed**	**Length**	**Width**
Small Car	**110**	**55**	**82.5**	**3.72**	**1.44**
Big Car	**125**	**59**	**92**	**4.58**	**1.77**
Lcv	**70**	**46**	**75**	**6.1**	**2.1**
Bus	**103**	**53**	**75**	**10.1**	**2.43**
Truck	**74**	**35**	**53**	**9.75**	**2.35**

Note: LCV: Light Commercial Vehicle

Illustrations

Adapted research on energy production from the trail left by moving automobiles on the roadway by a variety .The flowchart or research approach for low economic VAWT is displayed in Fig. 3. First, we concentrated on the availability of wind sources, either force wind generated by a highway vehicle's wake or local, prevailing wind. Then we employ VAWT produced from plastic drums that, after being divided into four halves, resembles Savonius type VAWT. We have already addressed the fact that we use waste products like bicycle rims and plastic drums. The blade is connected to the bicycle rim for vertical alignment, and the pulley system additionally utilised the bicycle rim's backside. A wind turbine's pulley system links an AC generator to it, and the generator is connected to a supercapacitor for energy storage. The generated electricity is then used for self-powered applications like street lights, traffic signals, and other things load where there is less power distribution.

Site Selection

Considering VAWT's improved performance because we use both force wind and natural wind to increase the effectiveness of the anticipated system, site selection was crucial. Therefore, factors at that location must be taken into account such as the number of passing vehicles, the absence of obstructions for the natural wind to blow, and the correct maintenance of the turbine testing and commissioning.

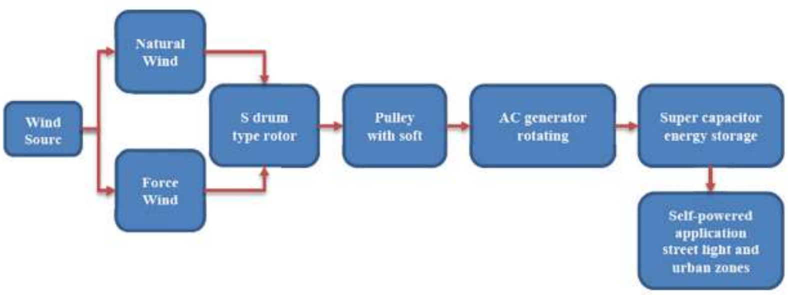


Fig 2. Design Process Flow Chart

Design Challenge

In line with the rising cost of commodities and energy, turbine prices are rising. It is necessary to recoup the cost of designing the turbine in a fair amount of time, measured in energy savings.On the highway, every moving object provides a variable, erratic source of wind energy. Power storage and a means to efficiently distribute the generated power must be included in the wind turbine's design.Some crucial design factors include the amount of space and operational noise. The placement site of the wind turbines should not be negatively impacted at all.

Traditionally, distant areas have been where wind turbines are deployed. Due to the need to transmit the power produced to the intended site, this presents an extra hurdle. Fortunately, the wind turbine used in this project is made for usage in locations with significant traffic and a strong demand for electricity. Another important design factor is safety. Since the turbines must be installed in busy regions, the design includes a number of safety features. These safety precautions include warning signs and stationary highway guards that surround the spinning turbine blades.

Global Application

Any city in the globe could use the design. It must respect the environment. There will be manuals and labels in a variety of languages available for each individual city. Figure 3 depicts a sharp increase in the e power in 2012, when it reached a new height of 282 GW. Organizations like the World Wind Energy Council also demonstrate the use of wind energy.Any city in the globe could use the design. It must respect the environment. There will be manuals and labels in a variety of languages available for each individual city.Figure 3 depicts a substantial rise in the use of wind energy worldwide.2012 saw a rise in ower of about 20%, reaching a new peak of Various sources such as the global wind energy council show china as the leading country in the employment of wind energy.

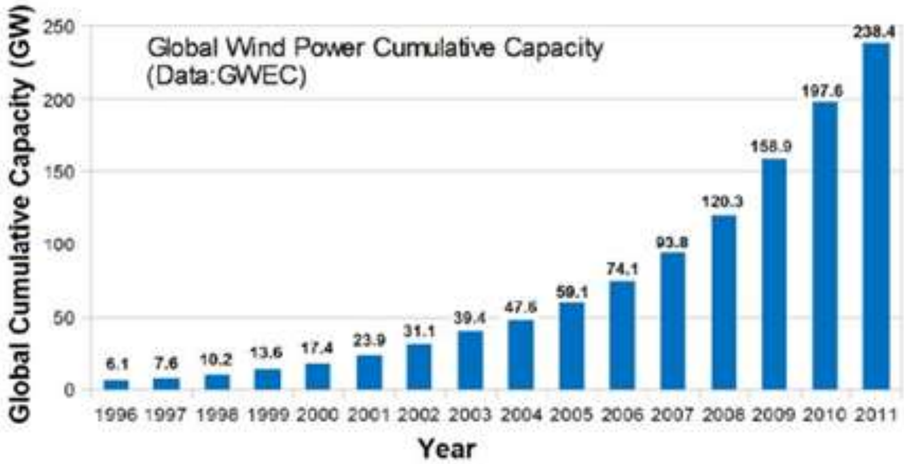


Fig 3. Global trend in wind energy, data from the global wind energy council.

Problem Statement and Solution

The variability of the wind's sources is a significant barrier to the expansion of wind energy. A sufficient source of potential wind energy seems to be provided by highways. It is necessary to conduct a thorough investigation of the fluid flow caused by vehicles on roadways to obtain boundaries for the design of a wind turbine. The turbine must have the capacity to store energy for use during periods of low, heavy, or stop-and-go traffic. The architecture must be environmentally responsible and sustainable. Horizontal axis wind turbines make up the majority of the conventional turbines we use in various applications. The biggest issue with this type of turbine is that it cannot capture wind from all directions. Vertical axis wind turbines are another form of wind turbine. The primary benefit of this sort of turbine is that it can gather wind energy from all directions. We chose these turbines because of this type's advantage.

Vertical Axis Wind Turbine

There are different types of vertical turbine 1. Savonius 2.Darrieus 3. Giromill 4. Gorlav Helical all turbine from this types have their own advantages and disadvantages because of their constructional features. But all from above the turbines from all kind of prospects helical turbine seems to be fit because of it's better efficiency, higher wind collecting capacity.

Firstly,here we considered the shape of savonius and find the efficiency of wind speed of the turbine and then for better efficiency and all throughtout research, we came to know Gorlav Helical is best for bringing the better efficiency.

MOTIVATION AND OBJECTIVE

The goal of developing a roadway wind turbine is to make a workable contribution to the global trend of wind energy production. This project aims to design a wind turbine that can be utilised in cities because wind turbines are often used in rural areas. In particular, the wind turbines will produce power using the wind draught produced by moving automobiles on the highway. The goal is to introduce a potential source of clean energy in order to reduce the amount of pollution produced by burning fossil fuels.

PROJECT TIMELINE

The project is divided into several major tasks. Research is a significant portion of this project because collecting our own data requires special permissions and maybe a bit hazardous. All of the team members are expected to research the pros and cons of the different design options to ensure the most efficient design. All team members are expected to participate in the research and design of the highway wind turbine. Team meetings are frequently held atleast once a week.

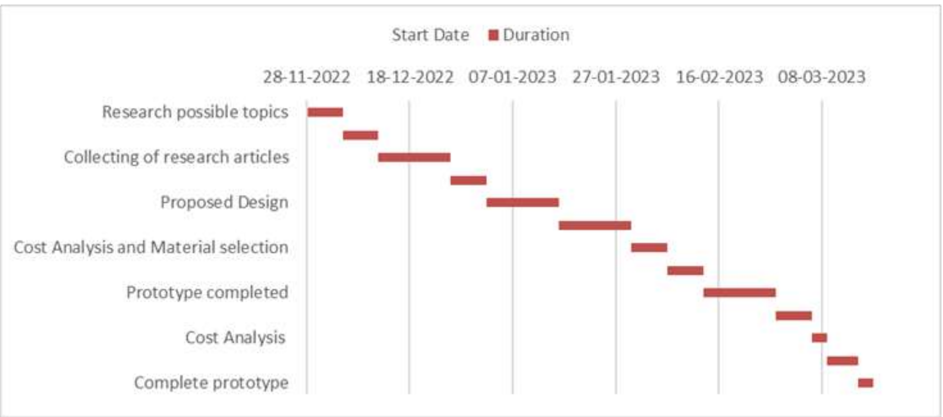


Fig.4. project timeline

Task	**Start Date**	**End Date**	**Duration**
Research possible topics	28-11-2022	05-12-2022	7
Project overview	05-12-2022	12-12-2022	7
Collecting of research articles	12-12-2022	26-12-2022	14
Design Survey	26-12-2022	02-01-2023	7
Proposed Design	02-01-2023	16-01-2023	14
Research and Data Analysis	16-01-2023	30-01-2023	14
Cost Analysis and Material selection	30-01-2023	06-02-2023	7
Simulations	06-02-2023	13-02-2023	7
Prototype completed	13-02-2023	27-02-2023	14
Test prototype and compare Theoretical vs Experimental	27-02-2023	06-03-2023	7
Cost Analysis	06-03-2023	09-03-2023	3
Optimize prototype	09-03-2023	15-03-2023	6
Complete prototype	15-03-2023	18-03-2023	3

Table.2. Breakdown of tasks

LITERATURE SURVEY

The idea to utilize wind turbines on the highway is not entirely unique. There have been attempts by several individuals and groups to recycle energy from highways. The most impressive is a design displayed on a YouTube video entitled “Highway Helical Wind Turbine Project (Next Generation Highway's Potential For Wind Power).” A wind turbine is designed to be placed on the medians of the highway. Although one turbine may not provide adequate power generation, a collective of turbines on a long strip of highway has potential to generate a large amount of energy that can be used to power streetlights, other public amenities or even generate profits by selling the power back to the grid. This design concept is meant to be sustainable and environmentally friendly. The highway wind turbine can be used to provide power in any city around the globe where there is high vehicle traffic.The generating high and continuous turbulence at high-speed vehicles on the highways can have an optimum potential to rotate a turbine. So a vehicle kinetic motion after consumption of fuel creates air turbulence on the road which can be captured by using wind turbines and electric energy can be generated.

CONCEPTUAL DESIGN (DESIGN ALTERNATIVES)

There are several ways to approach this particular design problem. Inliterature surveys, we discovered different features of wind turbines which were appealing for different reasons. For example, the gear turbines in China were very inexpensive and the modular sections could easily be snapped together to form a bigger system. That particular design did not seem as environmentally friendly as the designs with larger propellers. Other designs include turbines built into highway dividers or on overhead poles as seen in the design by the Arizona State Student Joe (last name not provided) (Joe, 2007). Joe calculated that with cars moving at 70 mph, 9,600 kilowatts of electricity could be produced per year using his design.

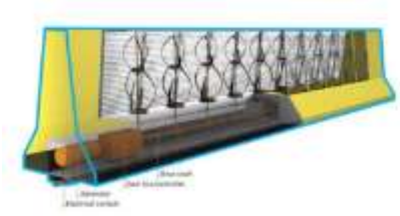


Fig.5. MARK OBERHOLZER, GUARDRAIL WIND TURBINE DESIGN

Fig.6.ARIZONA STATE UNIVERSITY STUDENT DESIGN

Figures 5-6 show various designs for wind turbines on the highway. Each design has positive and negative aspects. For example, in figure 5, the turbines are built into guardrails. This design is particularly complex because the guardrails must be fitted with vanes in order for the wind produced by vehicles to reach the turbines inside. Fig.6. show wind turbines proposed by an Arizona State University student. This design rejected because it requires the construction of custom support posts.

ANALYTICAL ANALYSIS

The following formulas are utilized to design the most efficient turbine.

Power available = 1/2ρAV^3

The power coefficient (C_P) is the power extracted divided by the power available

$$Cp = \frac{Power\ extracted}{1/2\rho AV\text{^}3}$$

The maximum value for the power coefficient is called the Betz limit

$$Cp\max = \frac{\frac{8}{27}\rho AV^3}{\frac{1}{2}\rho C^3} = \frac{16}{27} = 0.5926$$

If there is no wind profile variation perpendicular to the direction of motion of the vehicle, then all air turbulence goes directly or indirectly along the column height h. Under this ideal condition, all air turbulence reaches the wind turbine. This turbulence absorption results in rotational kinetic energy to the blades of the turbine. This follows in accordance with the Bernoulli theorem for the fluid motion i.e.

$$P1 + \frac{1}{2}\rho_1 v_1^2 = P2 + \frac{1}{2}\rho_2 v_2^2$$

The air turbulence speed change for v_1 to v_2 creates a pressure difference dP = P2 - P1 at two face of the imaginary cylinder. It has significance value before of velocity variation and it also depends on size of air column. This pressure variation produced a drag force. The net drag force on the wind turbine is easily correlated with air column pressures difference as

$$F = dP\ \pi R_2$$
$$or\ \ F = ½\ d\rho\ v_a^2\ \pi R^2$$

This drag force actually does work in displacing air column or setting vibration in air column. There will be more air horizontal propagation as compared to vertical as vehicle having horizontal motion. Indirectly drag forces work done is equal to the decrease in kinetic energy of wind column between two end of imaginary cylinder i.e.

$$F.h = \frac{1}{2}\left(m_v v_v^2 - m_w v_w^2\right)$$

where h is high of air column.

From law of conservation of energy in situation of no wind energy loss , we have

$$\frac{1}{2}\left(m_v v_v^2 - m_w v_w^2\right) = \frac{1}{2}\ d\rho v_w^2\ \pi R^2 . h$$

$$\text{or } v_w = \left[\frac{m_v}{m_{w+d\rho\ \pi R^2 h}}\right]^{\frac{1}{2}} v_v$$

The multiplying factor $M = \frac{mv}{(\text{mw+d}\rho\pi\text{R 2 h})}$ > 1 because an increase of mass ratio is counter cannot balance by larger value of cylinder volume and so almost all the vehicle velocity is transferred to air velocity near wind turbine in ideal situations. But in the real situation there exist an another dynamical correlation, coefficient K related to various loss factors like loss of wind motion or energy due to diffusion, collision loss, air resistance, the location of the turbine, vehicle size & shape and volume available for expansion etc. The value of the dynamical correlation constant K lie between 0 to 1 and have a different value for different vehicle or wind turbine. The K=0 value corresponds to no velocity transfer and 1 for 100% velocity transfer. Therefore, wind turbulence speed is related to vehicle speed as

$$or\ v_w = K\left[\frac{m_v}{(m_w + d\rho\pi R^2 h}\right]^{\frac{1}{2}} v_v$$

The resultant wind velocity v_w can rotate turbine or kinetic energy of wind is transfer to rotational energy of turbine. The rotational speed of turbine having radius R is given by

$$\omega = \frac{MK\ v_w}{R}$$

So from wind power P harnessed by wind turbine is given by related to wind velocity v_w and is given by

$$P = \frac{1}{2} K C_p \rho A\left[\frac{m_v}{(m_w + d\rho\pi R^2 h)}\right]^{\frac{3}{2}} v_w^3$$

PROPOSED DESIGN

Our group is proposing to design a vertical axis wind turbine to utilize the wind produced by moving vehicles to generate electricity. These turbines will be placed along roadways that have high volume of fast moving traffic. The electricity generated will then be the stored in batteries. Since the electricity produced will be direct current (DC) it must be converted to alternating current (AC) before it can be used for lighting the street lamps, sold to the grid or any of the man ways we use electricity today. This means that the DC current must be pasted through an inverter first.

Fig.7.Vertical Axis Wind Turbine of savonius shape

FRONT VIEW

TOP VIEW

Fig.8. Modified Vertical Axis Wind Turbine(Gorlav Helical Shape)

There are several advantages and disadvantages to using a vertical wind turbine design. A vertical wind turbine design is selected because vertical turbines are capable of capturing wind in any direction, whereas, horizontal turbines need to be pointed in the direction .

RESULTS AND DISCUSSION

Above analysis show that wind speed approaches at turbine are directly proportional to square root of vehicle mass and velocity of the vehicle. If we assume the following data: R =0.5m , mv=1200 kg, mw=1.3 kg /m3 , $d\rho$ = 0.01 kg /m3 and h=3 m The value of multiplying factor M is found to be an order of 389. The variation of wind velocity approaches at turbine for different values of R is shown in Table 2. The wind power P harnessed by wind turbine due to wind velocity v_w with same set of data can be calculated with the help of above equations. It is found to be vary cubically with wind speed but limited by the value of Betz limit C_p and correlation constant K as shown in Table 2.

Table 2 : Table for Vehicle Speed vs Wind speed & Power generated

v_v (Km/h)	v_w (Km/h)	Power (kW)	v_w (Km/h)	Power (kW)	v_w (Km/h)	Power (kW)
Value of K→ K=0.1 K=0.01 K=0.001						
0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	19.72	232.09	1.97	23.21	0.20	2.32
20.00	39.44	1856.69	3.94	185.67	0.39	18.57
30.00	59.17	6266.33	5.92	626.63	0.59	62.66
40.00	78.89	14853.53	7.89	1485.35	0.79	148.54
50.00	98.61	29010.81	9.86	2901.08	0.99	290.11
60.00	118.33	50130.67	11.83	5013.07	1.18	501.31
70.00	138.05	79605.65	13.81	7960.57	1.38	796.06
80.00	157.78	118828.2 6	15.78	11882.83	1.58	1188.28
90.00	177.50	169191.02	17.75	16919.10	1.77	1691.91
100.00	197.22	232086.4 5	19.72	23208.64	1.97	2320.86

This is maximum power value as we have assumed that no wind variation along the column height and complete air turbulence effect the wind turbine. But in actual practice most of wind variation go useless due to wide angle. If one can use and does not include energy loss factors like air resistance, friction factor etc and a minimum of 0.1 % of maximum value is available for power generation then still some significance value can be generated as shown in Table 2.

This can be increased if we place of small circular turbines or a series of small circular turbines at proper placed or at regular intervals , reduces mass and friction of wind turbine and use of high-quality piezo sensor.

Conclusion

In conclusion, a lot of information about the wind patterns caused by traffic on both sides of the roadway is gathered. A wind turbine is created to be installed on the highway medians using the data gathered. Even if one turbine might not supply enough, a group of wind turbines along a lengthy stretch of highway have the potential to produce a lot of energy that might be used to run street lights and other public facilities or even be sold back to the grid for a profit. This architectural style aims to be environmentally responsible and sustainable. A wind turbine that uses manufactured wind also has a wide range of uses.

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References

[1] Kumar, M., Kumar, K., & Rana, R. (2016). Wind Energy Generation from Traffic Movement. *DU Journal of Undergraduate Research and Innovation*, *2*(1), 116.

[2] Malave, S. N., & Bhosale, S. P. (2013). Highway wind turbine (quite revolution turbine). *Int. J. Eng. Res. Technol*, *6*(6), 789-794.

[3] Bani-Hani, E. H., Sedaghat, A., Al-Shemmary, M., Hussain, A., Alshaieb, A., & Kakoli, H. (2018). Feasibility of highway energy harvesting using a vertical axis wind turbine. *Energy Engineering*, *115*(2), 61-74.

[4] Burtnick, J., Fairbanks, R., Gross, F., Lin, E., McCrone, B., & Osmond, J. (2015). *Placement of Small Vertical Axis Wind Turbine to Maximize Power Generation Influenced by Architectural and Geographic Interfaces in Urban Areas* (Doctoral dissertation).

[5] Dai, K., Bergot, A., Liang, C., Xiang, W. N., & Huang, Z. (2015). Environmental issues associated with wind energy–A review. *Renewable energy*, *75*, 911-921.

[6] Dhar, A., Naeth, M. A., Jennings, P. D., & El-Din, M. G. (2020). Perspectives on environmental impacts and a land reclamation strategy for solar and wind energy systems. *Science of the total environment*, *718*, 134602.

[7] Premalatha, M., Abbasi, T., & Abbasi, S. A. (2014). Wind energy: Increasing deployment, rising environmental concerns. *Renewable and Sustainable Energy Reviews*, *31*, 270-288.

[8] Abohela, I., Hamza, N., & Dudek, S. (2013). Effect of roof shape, wind direction, building height and urban configuration on the energy yield and positioning of roof mounted wind turbines. *Renewable energy*, *50*, 1106-1118.

[9] Wang, S., & Wang, S. (2015). Impacts of wind energy on environment: A review. *Renewable and Sustainable Energy Reviews*, *49*, 437-443.

[10] Bakker, R. H., Pedersen, E., van den Berg, G. P., Stewart, R. E., Lok, W., & Bouma, J. (2012). Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress. *Science of the total environment*, *425*, 42-51.

[11] Radun, J., Maula, H., Saarinen, P., Keränen, J., Alakoivu, R., & Hongisto, V. (2022). Health effects of wind turbine noise and road traffic noise on people living near wind turbines. *Renewable and Sustainable Energy Reviews*, *157*, 112040.

[12] Zerrahn, A. (2017). Wind power and externalities. *Ecological Economics*, *141*, 245-260.

[13] Radun, J., Maula, H., Saarinen, P., Keränen, J., Alakoivu, R., & Hongisto, V. (2022). Health effects of wind turbine noise and road traffic noise on people living near wind turbines. *Renewable and Sustainable Energy Reviews*, *157*, 112040.

[14] Freiberg, A., Schefter, C., Girbig, M., Murta, V. C., & Seidler, A. (2019). Health effects of wind turbines on humans in residential settings: Results of a scoping review. *Environmental research*, *169*, 446-463.

[15] Hübner, G., Pohl, J., Hoen, B., Firestone, J., Rand, J., Elliott, D., & Haac, R. (2019). Monitoring annoyance and stress effects of wind turbines on nearby residents: A comparison of US and European samples. *Environment international*, *132*, 105090.

[16] Rathore, M. K., Agrawal, M., & Baredar, P. (2021). Energy production potential from the wake of moving traffic vehicles on a highway by the array of low economic VAWT. *Materials Today: Proceedings*, *46*, 5272-5277.

[17] Pohl, J., Gabriel, J., & Hübner, G. (2018). Understanding stress effects of wind turbine noise–The integrated approach. *Energy Policy*, *112*, 119-128.

[18] Malave, S. N., & Bhosale, S. P. (2013). Highway wind turbine (quite revolution turbine). *Int. J. Eng. Res. Technol*, *6*(6), 789-794.

[19] Apeksha, M., Purohit, A. J., Ashalatha, A., & Khanum, K. (2019). Development and Implementation of Highway Electric Power Generation using Wind Turbine for Smart Traffic and Light Control System. *i-Manager's Journal on Embedded Systems*, *7*(2), 28.

[20] Speksnijder, S. (2018). Reuse of wind turbine blades in a slow traffic bridge.

[21] Mendel, B., Schwemmer, P., Peschko, V., Müller, S., Schwemmer, H., Mercker, M., & Garthe, S. (2019). Operational offshore wind farms and associated ship traffic cause profound changes in distribution patterns of Loons (Gavia spp.). *Journal of environmental management*, *231*, 429-438.

[22] de la Vega, D., Jenn, D., Angulo, I., & Guerra, D. (2016, April). Simplified characterization of Radar Cross Section of wind turbines in the air surveillance radars band. In *2016 10th European Conference on Antennas and Propagation (EuCAP)* (pp. 1-5). IEEE.

[23] Knopper, L. D., Ollson, C. A., McCallum, L. C., Whitfield Aslund, M. L., Berger, R. G., Souweine, K., & McDaniel, M. (2014). Wind turbines and human health. *Frontiers in public health*, *2*, 63.

[24] Seltenrich, N. (2014). Wind turbines: a different breed of noise?.

[25] Michaud, D. S., Feder, K., Keith, S. E., Voicescu, S. A., Marro, L., Than, J., ... & van den Berg, F. (2016). Exposure to wind turbine noise: Perceptual responses and reported health effects. *The Journal of the Acoustical Society of America*, *139*(3), 1443-1454.

[26] Mane, V. R., Kadam, A. S., Sawant, S. J., Patil, V. A., Ganesh, B., & Suryawanshi, A. A. (2015). Power generation by vertical axis wind turbine. *J. Analog Digit. Devices*, *9359*(7), 1-7.

[27] Pawlaczyk-Łuszczyńska, M., Dudarewicz, A., Zaborowski, K., Zamojska-Daniszewska, M., & Waszkowska, M. (2014). Evaluation of annoyance from the wind turbine noise: a pilot study. *International journal of occupational medicine and environmental health*, *27*, 364-388.

[28] Saad, M. M. M., & Asmuin, N. (2014). Comparison of horizontal axis wind turbines and vertical axis wind turbines. *IOSR Journal of Engineering (IOSRJEN)*, *4*(08), 27-30.

[29] Dogan, B., Özer, S., & Erol, D. Sustainable Energy Technologies and Assessments.

[30] GANESH, R. (2013). *DESIGN AND FABRICATE A SAVONIUS WIND TURBINE* (Doctoral dissertation, SRM University).

[31] Haque, M. (2013). Design of a Self-sufficient Micro-Grid with Renewable Energy Production.

[32] Kothari, D. P. (2013). *Wind energy systems and applications*. ALPHA SCIENCE INTERNATIONAL LIMITED.