Salud, Ciencia y Tecnología - Serie de Conferencias. 2024; 3:615
doi: 10.56294/sctconf2024615

Categoría: STEM (Science, Technology, Engineering and Mathematics)

ORIGINAL

A Novel Vertical Axis Wind Turbine to Provide Green Energy for Coastal Area

Un novedoso aerogenerador de eje vertical para suministrar energía verde a las zonas costeras

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Cite as: Sriman B, Silviya S H A, Sampath N, A. Beneta M, R. Vanitha M, Jayalakshmi P. A Novel Vertical Axis Wind Turbine to Provide Green Energy for Coastal Area. Salud, Ciencia y Tecnología - Serie de Conferencias. 2024;3:615.https://doi.org/10.56294/sctconf2024615

Submitted: 07-12-2023 **Revised:** 09-03-2024 **Accepted:** 16-05-2024 **Published:** 17-05-2024

Editor: Dr. William Castillo-González

ABSTRACT

The goal of this project was to create a wind turbine that could power little street lights. Considering the typical wind speeds in chennai India and ease of construction the design of the wind turbine chosen to be sea hawk/enlil design from vertical axis wind turbine category.The VAWT is coupled to a disc type alternator and mounted on the road dividers of a highway. The wind speed on the median of highway roads will be significantly higher than at the pedestrian walking lane as it is propelled by passing traffic from both sides. The power generated can be stored in a battery bank which is placed under the windmill and utilized at night time for lighting purposes on the highway.

Keywords: VAWT; Highways; ENLIL; Renewable Energy; Street Lights; Power Generation.

RESUMEN

El objetivo de este proyecto era crear un aerogenerador que pudiera alimentar pequeñas farolas. Teniendo en cuenta las velocidades del viento típicas de la India y la facilidad de construcción, se optó por un aerogenerador de eje vertical (VAWT) acoplado a un alternador de disco y montado en la mediana de una autopista. La velocidad del viento en la mediana de la autopista será significativamente mayor que en el carril peatonal, ya que es impulsado por el tráfico de ambos lados. La energía generada puede almacenarse en un banco de baterías situado bajo el molino y utilizarse por la noche para iluminar la autopista.

Palabras clave: VAWT; Autopistas; ENLIL; Energía Renovable; Alumbrado Público; Generación de Energía.

INTRODUCTION

India has the second-largest road network in the world, with 33 lakh kms (approximately), of which 96 260,72 kms include national highways, 131 899 kms state highways, 467 763 kms district highways, and 2 650 000 kms rural and other roads.[1,2,3]

Our objective is to make the light systems in the highway self-sufficient by generating energy from VAWT rather than requiring a separate source of electricity which is generated by burning coal/fossil fuels and simultaneously saving energy which can be used for alternative purposes.

The goal of the article is to develop an extremely efficient and environmentally beneficial method of power generation using renewable energy sources, specifically wind energy.

Using the existing vertical axis turbine method and customizing the blade configuration for an effective energy generation system regardless of the direction of the wind leading to more power being generated at the output terminal. This energy could be used at night to illuminate the roads.

In this work, the drawback may be overcome by utilizing a VAWT (Vertical Axis Wind Turbine). The VAWT is coupled to a disc type alternator and mounted on the road dividers of a highway. The wind speed on the median of highway roads will be significantly higher than at the pedestrian walking lane as it is propelled by passing traffic from both sides. The VAWT is forcefully propelled by this wind from two directions, anyway it harnesses both of the wind directions and spins in one direction only.If the turbine's speed rises, the alternator's speed goes up as well, withdrawing from a battery bank that's also installed underneath the turbine. The enlil design that we are employing here can provide the average electrical needs of two households (i.e) approximately 100 watts per hour of electricity.

Literature survey

In this section, a literature review is conducted to look into the many forms of VAWT, compare the effectiveness of the different VAWT designs, comprehend its use, and examine experimental research that has used VAWT. The straight blade is the least efficient, and the twisted blade produces the best performance compared to other models, according to a comparative analysis of Savonius rotor blade types, such as curved, straight, aero-foil, and twisted blade design for VAWT carried out in (Shah et al., 2018). The plan to harvest wind energy from a Darrieus type VAWT for a Martian use is described in (Kumar et al., 2010).

A specially created lift-based VAWT's performance is contrasted with that of a multi-blade wind turbine in (Chiarelli et al., 2013).Damages to the blades resulting from varying torque during operation are one of the reasons VAWT has not been adopted on a commercial basis. There is a design that uses pitching optimization to lessen this variability (Erfort et al., 2020). According to an experimental investigation by Eriksson and Bernhoff (2005), when torsional vibrations in the design of the VAWT are taken into account, a directly driven synchronous generator is favored over a geared induction generator. In a study published in (Kang et al., 2010), a spiral rotor Savonius turbine design is contrasted with a traditional Savonius design. The findings show that when the entire rotation cycle is taken into account, the torque performance of the spiral Savonius turbine is improved. The maximum torque coefficient of a turbine is related to its stability of operation, and according to a comparison between a conventional and spiral Savonius turbine published in (Kang et al., 2013), the spiral rotor's maximum torque coefficient is higher than that of the conventional rotor. An examination of the fluid dynamics of several rotor designs, including the spiral Savonius turbine seen in (Kang et al., 2014).[5]

Objective analysis

The objective of the paper is to develop an extremely efficient and environmentally beneficial method of power generation using renewable energy sources, specifically wind energy. By utilizing the latest vertical axis turbine approach and customizing the blade design, we can create a reliable energy-generating system that operates in and around our residential area regardless of the direction of the wind. The goal of this essay is to lessen the effects of global warming.[3]

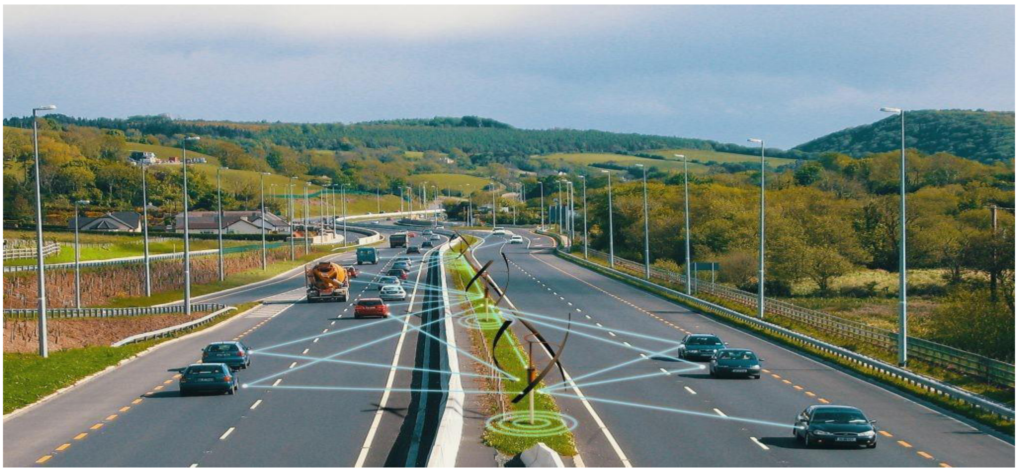

Figure 1. ENLIL in highways

The key benefit of employing VAWT is that as the wind direction changes, they do not need to be turned into the wind stream. Additional benefits include lower fabrication and maintenance costs due to the accessibility of large, high-maintenance goods. A straightforward, inexpensive tower is also used in vertical-axis design.

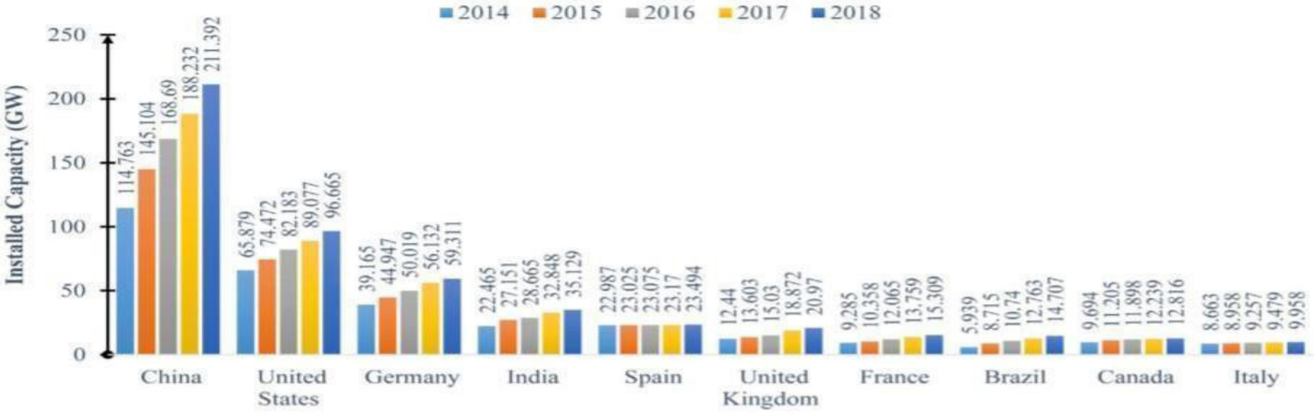

Figure 2. Country wise installed wind energy capacity from 2014-2018

The bar graph is referred from a survey taken by a number of universities from the middle east and Pakistan which is published in ain shams engineering journal, the bar graph represents the wind energy capacity recorded from different countries over the time period 2014 - 2018.[4]

Existing syste

Typically, we produce renewable electricity using a variety of methods, including solar, wind, and hybrid energy,but it can't be placed everywhere because there will be a maintenance issue due to the enormous overall size of the plant. Existing techniques have some drawbacks, including high maintenance and repair costs, transportation issues, greater blade sizes, and demands for high beginning torque.[2]

Figure 3. ENLIL Execution

The above picture is an ingenious turbine system that was installed in Istanbul with the support of the city metropolis. The project was developed by a young entrepreneur, Kerem Deveci, who is the founder of Diversitech together with researchers from Istanbul Technical University. The project is closely watched not only by Turkey, but also by other countries that want to use the technology to produce clean and cheap energy.

The system includes an intelligent vertical-axis ENLIL wind turbine that generates electricity from the wind generated by buses and highway traffic. It also has solar panels that use solar energy and measure the temperature at the same time. The system's sensors measure humidity, wind and carbon dioxide, while a smart IoT platform connects it to the rest of the infrastructure Because the device is relatively small in size, it can be installed in many places that are not suitable for traditional turbines, such as walkways, roofs of tall buildings, parks, beaches and private houses. The produced energy can be transferred elsewhere or used for road maintenance. Apart from all this this also has a earthquake monitoring station

This study examines potential locations for wind turbines along Pakistan's southern coastline (figure 4).

Pakistan's coastal regions produce a considerable amount of wind energy potential that is evaluated carefully taking into account wind power density, wind roses, wind, and frequency functions. There are four zones along the coastline (1–4). Zone 1 is symbolized by Karachi, Zone 2 by Ormara, Zone 3 by Pasni, which sits between Zones 2 and 4, and Zone 4 is symbolized by Gwadar, which is located along the western portion of the coastline.

Since these locations are near the coast, they exhibit powerful wind currents that are present all year round. At the relevant zone's focus location, each zone covering many cities and villages with the major city is marked.[4]

Figure 4. Zones where the survey is conducted in Pakistan

Proposed solution

Due to its compact size and the fact that it is a permanent magnet synchronous machine, the generator employed in the suggested method only requires a tiny starting torque. The location of this turbine is not limited to wind-proximity regions, such as seashores or buildings. The wind generated by moving automobiles is used to power the proposed turbine, which is mounted on coastal highways

METHODOLOGY

By active driving mode, a technique for VAWT wind tunnel testing is established. Small-scale and self-starting challenges are resolved by the developed technique.

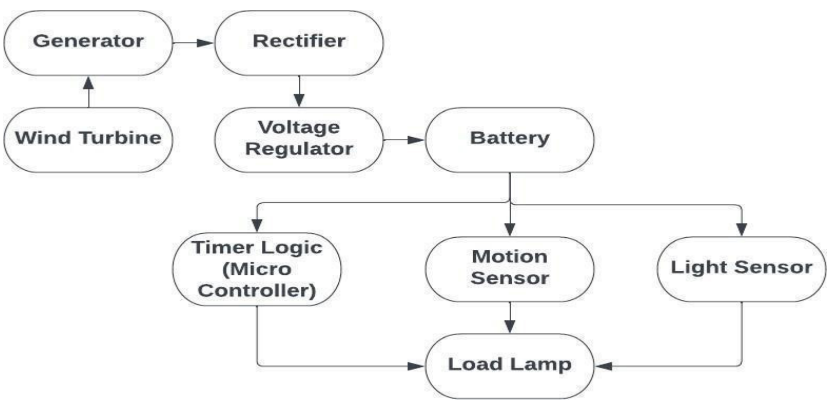

Figure 5. ENLIL schematic representation

The quantification of strut drag and the isolation of mechanical losses are crucial areas.The windmill's efficiency has been increased by using the Enlil design paradigm.[5]

https://doi.org/10.56294/sctconf2024615

These are the basic variables which we have considered while designing. The variables considered are:

Vertical axis wind turbines

A wind turbine with a vertical axis has its main rotor shaft oriented transverse to the wind and its primary components at the base of the turbine. This configuration makes it possible for the generator and casing to be situated near to the ground, making maintenance and repairs easier. In order to avoid the need for wind detection and orientation systems, VAWTs shouldn't be aimed into the wind.

Generator

A generator that uses a permanent magnet as its own excitation field rather than a coil is known as a permanent magnet synchronous generator. As the magnetic field is created by a shaft-mounted permanent magnet mechanism and current is induced into the stationary coil, the term "synchronous" here refers to the real fact that the rotor and magnetic field revolve at the same speed.

Rectifier

A rectifier is a piece of electrical equipment that changes alternating current into direct current, which only flows in one direction.Rectification, which "straightens" the current's direction, is the name given to this process. Rectifiers come in many different physical configurations, such as vacuum tube diodes, mercury-arc valves, stacks of copper and selenium oxide plates, semiconductor diodes, silicon-controlled rectifiers, and various silicon-based semiconductor switches.

Voltage regulator

A mechanism called a voltage regulator is made to automatically maintain a constant voltage level. It could feature a straightforward pellet architecture or might incorporate negative feedback. It may be used to control one or perhaps more AC or DC voltages depending on the design. Power electronics regulators are used to control the DC voltages required by the processors and other components in devices like computer power supply.

Battery

A battery is an electric device made up of one or more electrochemical cells. Its positive terminal acts as the cathode and its negative terminal as the anode when supplying electricity. The negative terminal serves as the origin of the electrons that travel from the positive terminal to an external electric circuit. Redox reactions change high-energy reactants into lower-energy products when a battery is connected to an external electric load, and the free energy difference is transferred to the external circuit as electrical energy.

Motion Sensor

A motion sensor is a device that locates moving objects, particularly people. A system that automatically completes a task or notifies the user of motion in a certain region frequently includes such a device as a component. They are an essential part of security systems, automated lighting control systems, home management systems, energy-efficient systems, and other helpful systems.

Light sensor

Light sensors, also known as photo sensors, are devices that detect light or other electromagnetic radiation. A p-n junction in a photo detector turns photons into current. In the depletion region, the absorbed photons from electron-hole pairs. Photo detectors include photodiodes and phototransistors.

ARCHITECTURE FLOW

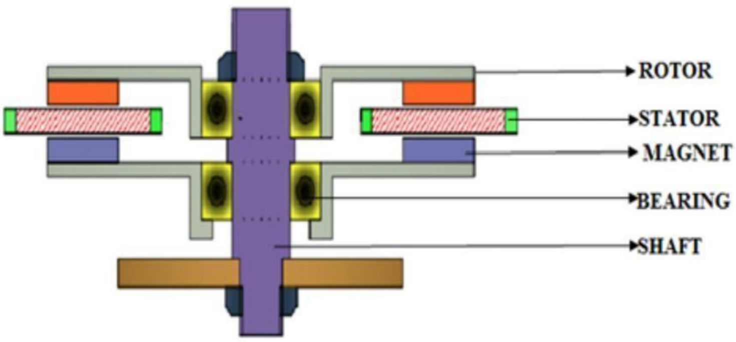

Figure 6. Layout of a Wind turbine

https://doi.org/10.56294/sctconf2024615

Rotor

The most crucial and under constant stress part of any wind turbine is its rotor blades. It is their responsibility to take the kinetic energy of the wind and transform it into a rotating motion around a central hub. The tips of the blades are turning considerably faster than the centre hub of the blades, especially for propeller-type blade designs, and the longer the blade, the quicker it rotates relative to the wind.[2]

Stator

The wind turbine's stator is its most important electrical component. It contains all of the wire coils that will experience an induced voltage as the magnets move over them. Because it is stationary, it is referred to as a stator. We will be making a three-phase alternator for this project, and the stator will have nine coils. Three coils will be arranged in series. The markings on the bottom of the stator moulds will help you determine whether the coils are the right size and are positioned appropriately when you assemble this.

Magnet

Permanent magnets must be quite powerful for wind turbines and generators. In some of the largest wind turbines in the world, rare earth magnets, such as neodymium magnets, are used. These magnets are the strongest permanent magnets currently on the market since they are made of neodymium, iron, and boron. Powerful electricity generation is achieved by neodymium magnets. They are incorporated into wind-turbine designs to minimize costs, increase dependability, and lessen the need for expensive maintenance.

Bearing

Bearing mechanism is implemented to ensure the Shaft operates without interruption. The bearing has a 1 cm diameter. In general, bearings are offered to support the shaft and maintain its smooth operation.

Shaft

The shaft should be properly fitted to the blade while it is being constructed. The shaft has a 10mm diameter so that it can be installed into the disc with ease, and 2mm thick mild metal sheets are coupled to the top and bottom ends.

VAWT mechanism

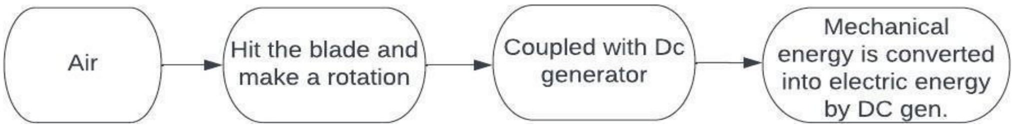

Figure 7. Flow chart of VAWT mechanism

The following steps illustrate the energy conversion process in more detail:

Step 1: In the first step, strong wind in the middle part of the highway hits the wind turbine blades and makes it rotate in clockwise direction even when the vehicles are moving on any side of the highway. Because the arrangement of the wind turbine blades are in that manner.

Step 2: The vertical axis wind turbine in the highway is linked with two generators ,one at the top and the other at the bottom of the turbine blades. When the blades rotate, energy is produced by the generators.

Step 3: Thus, using a dc generator, mechanical energy is transformed into electrical energy, and the generated power is then stored in a battery and utilised to power the street lights in the highway.[12]

RESULT

The Power in the Wind

Using kinetics concepts, it is possible to calculate the power of the wind. The idea behind how the wind turbine operates is to transform the kinetic energy of the wind into mechanical energy.Any particle's kinetic energy, or 1/2 mv2, is determined by multiplying its mass by the square of its velocity.[13] The amount of air moving across an area A at a speed V equals A. V, and its mass M is equal to the volume of the region times the air density, or

m = AV (1)

(m is the area-transferring air mass. A windmill-style generator's brushed by its whirling blades In the K.E. equation, substituting this mass value. In the formula K.E.= 1/2, this mass value is substituted.)

AV.V2 watts= 1/2

AV3 watt (2)

According to the second equation, the available power is inversely proportional to the intercept area and to the air density (1,225 kg/m3). In horizontal axis aero turbines, the region is typically circular and has a diameter of D.

A= (π/4) D2 **(Sq.m)**

Wind velocity vs. power output

Power output= (1/2) Av^3

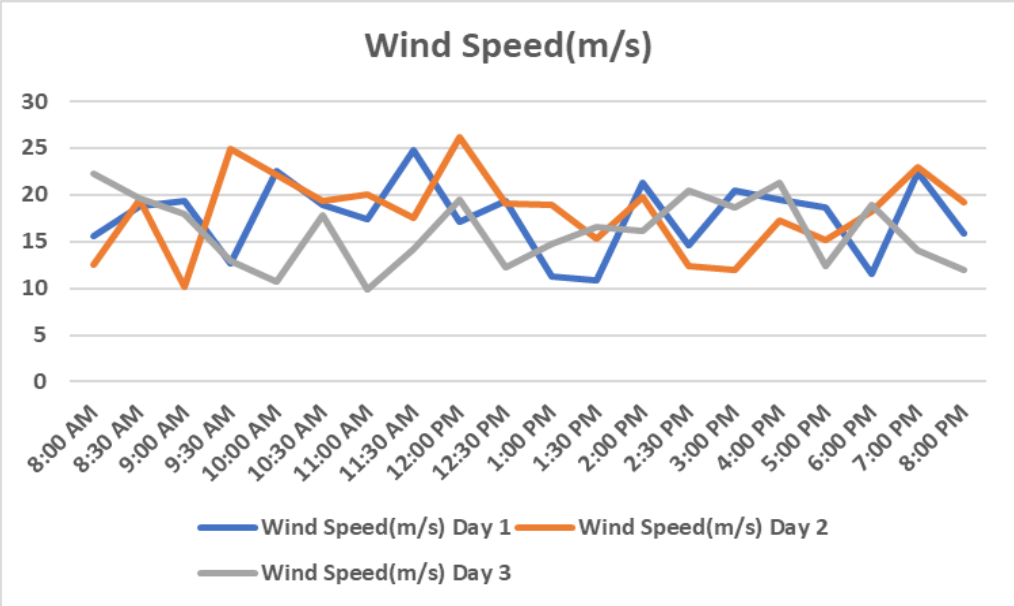

Figure 8. Wind readings from Coastal highway

-At that height and location, the air density (typically 1,225 kg/m3) Each blade's swept area is 3,33, and the wind speed is measured in m/s.

The table given below represents the average wind speeds in and around coastal areas and we have calculated the output using the formulas mentioned in the Vth section.

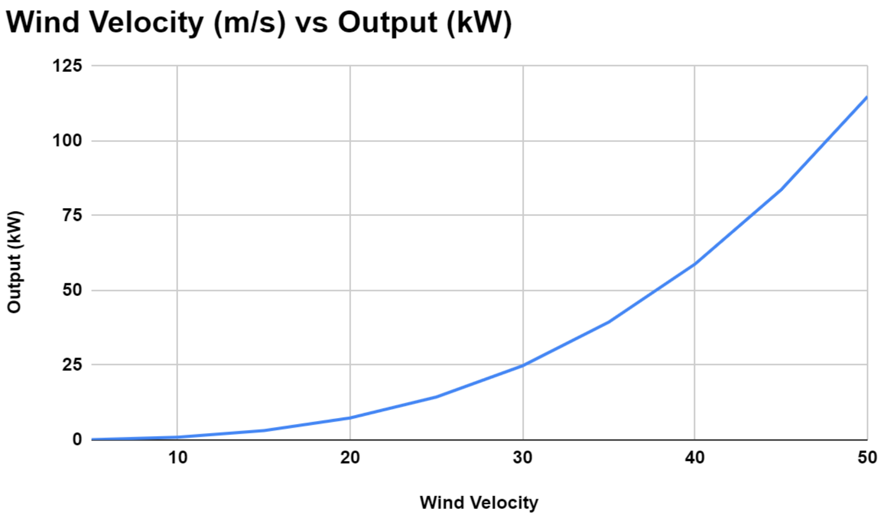

Figure 9. Wind Velocity

The vertical axis wind turbine is designed and fabricated in such a way that it can be able to capture wind from all the directions,power developed from the project is 0,11 kW for a speed of 5m/s, the efficiency of VAWT can be increased by changing the shape and size of the blade, the theoretical and experimental result is varying because in the theoretical calculation we consider the wind is hitting all the three turbine blades, practically it is hitting only one turbine at a time.[13]

Predictions and Forecasting

To make accurate forecasts and predictions, the following factors should be considered:

- Wind speed and direction: The amount of energy generated by the VAWT depends on the wind speed and direction. WInd speed and direction can be determined using an anemometer, while wind direction can be determined using a wind vane.
- Turbine efficiency: The efficiency of the VAWT is another important factor to consider. The efficiency can be influenced by the design of the turbine and the material used to build it.
- Solar radiation: The amount of solar radiation received by the solar panel (if any) used in conjunction with the VAWT can affect the amount of energy generated.
- Time of day: The amount generated by VAWT can vary throughout the day, depending on the wind speed and direction.
- Weather Conditions: Weather conditions such as rain, snow, or extreme temperatures. Can affect the amount of energy generated by VAWT.

To predict the amount of energy that will be generated by the VAWT, data can be collected and analyzed using the machine learning algorithms. This data can include historical wind speed and direction data, turbine efficiency data, and weather data. The machine learning algorithms can then be used to create a model that predicts the amount of energy that will be generated by the VAWT based on the current weather conditions.

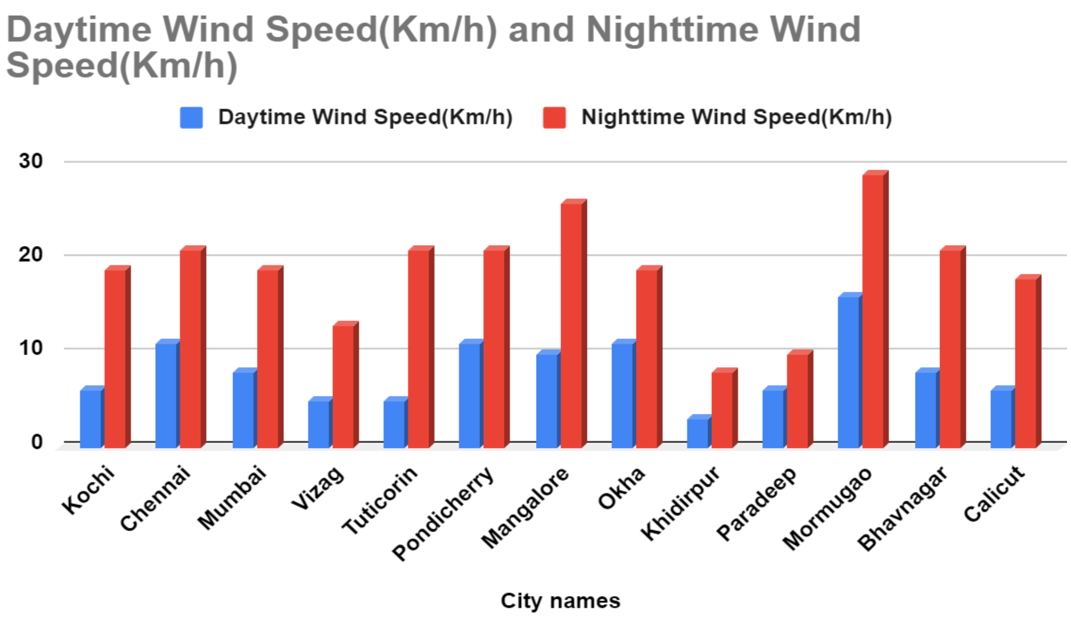

Figure 10. Wind speed in various coastal regions of india

Once the amount of energy that will be generated by the VAWT has been predicted , it can be determined how much of that energy can be used to power the street light.This can be done by calculating the power consumption of the street light and comparing it to the predicted energy output of the VAWT. If the predicted energy output is greater than the power consumption of the street light, the excess energy can be stored in batteries for later use.[14,15,16,17]

CONCLUSION

The study and creation of a novel design for an urban Enlil VAWT technology that doesn't require additional parts or external energy feed-in to assure enough starting torque was the main emphasis of this article. To accelerate the evaluation of complex shaped VAWT designs, a new model for predicting aerodynamic performance is applied. The creation of a brand-new urban Enlil VAWT unique design serves as an illustration of this model's utilization.[18,19]

To evaluate the behavior of the design, a prototype is put together for outside testing. The field testing is conducted in a controlled wind tunnel environment and an urban setting. The results of the field testing support the design, demonstrating that the new urban Enlil VAWT can self-start at wind speeds.

Future works

More efficient wind turbines can be developed by enhancing the blade's design for better aerodynamics. Using an alternator that is more effective and offers higher voltage at less rpm and increasing the alternator's input rpm through a gear mechanism will lead to greater alternator output power.

For a windmill to function effectively, structural fabrication needs to be more precise and the turbine can also be installed next to high-speed railway lines to increase energy output.There is always room for improvement in the design

of the blades, reducing noise and increasing the power output.This can be achieved through computational simulation, wind Tunnel tests and field experiments.

Energy storage can help VAWT- powered street lights to continue functioning during periods of low wind speed or no wind at all integrating a battery or other energy storage system can increase the reliability and efficiency of the street light.Field tests can provide valuable data on the performance of VAWT-powered street lights under real-world conditions. This can help to expand the market for VAWT technology and increase its adoption.

VAWTs can also be used to power other types of infrastructure, such as bus shelters, park benches and information kiosks.

Exploring alternative applications can help to expand the market for VAWT technology and increase its adoption.

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FINANCING
No external financing.

CONFLICT OF INTEREST
No conflict of interest.

AUTHORSHIP CONTRIBUTION
Conceptualization: B. Sriman, Annie Silviya, Nithya Sampath, A. Beneta Mary, R. Vanitha Mani, P Jayalakshmi.
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Writing - proofreading and editing: B. Sriman, Annie Silviya, Nithya Sampath, A. Beneta Mary, R. Vanitha Mani, P Jayalakshmi.