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Relation between Wind energy & Metro Rails

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ABSTRACT

Renewable energy plays vital role to increase country's economy and growth. However, renewable energy will improve life performance of the living beings. As we have seen from last few decades environmental changes in India are increasing rapidly in different sectors. In particular coal and biogas are country's major source to generate electricity which releases dangerous gases into the atmosphere which is very harmful to living beings and atmosphere (1). This results the use of renewable energy resources (wind, solar, biomass and hydropower) energies are increasing gradually in India. In addition, India is the fourth largest country to generate the capacity of 34,293MV by wind energy which is around 10% of total energy installed in the country till 30thjune2018 (2). In this paper we will discuss about the relation of wind energy with metro by considering all the technological aspects with great technical details, and provide all the consideration factors, future extractions, recommendations to MNRE (ministry of new and renewable energy resources) and selection of turbine, generator & battery type which has to be used for installation of small vertical axis wind turbines to generate electricity through fast moving metros. in particular, this paper concentrates on two types of vertical axis wind turbines one is Enlil turbine and another is savonius type vertical axis wind turbine both of these turbines are very beneficial to generate electricity with calculations through metros.

Keywords:- *Wind energy, Metro Rail,* Renewable energy, toxic gasses, climate change, atmosphere, environmental problems, wind energy, wind speed, metro rails, small vertical axis wind turbine (SVAWT).

I. INTRODUCTION

There are numerous renewable energy resources (including fossil fuels, geothermal, tidal power, marine and ocean energy, hydropower, bio resources, nuclear, solar and wind) energies (4) are available to generate electricity in India. although, in India 60% of the electricity is generated by coal by violating all the APS (Air pollution standards) which releases harmful toxic gases into the atmosphere which results climate change and other environmental problems. Now government of India decided to close nearly 50MV of coal capacity by 2027 and convert them into wind and solar renewable energy resources which is growing rapidly than expected. According to IEEFA (Institute for Energy Economics and Financial Analysis) report India will generate more than 14GW renewable energy capacity in 2017-2018 which is more than doubled of 5.5GW energy generated by coal (3). Wind energy is renewable energy resource with no harmful emission and air pollution by any reaction. In addition its maintenance and operational cost is very low. However, wind speed fluctuates according to the place (5). As the renewable energy resources in India increasing rapidly with huge profit with changing ecosystem and environment in the country. This paper will provide one more research on wind energy with fast moving metros in the city of Hyderabad (India) which runs with their average speed of 35-40kmph (kilo meter per hour) and have its top speed 80kmph (6) which can easily rotate small vertical axis wind turbine which is installed between the two metro tracks. Where the wind speed increases and causes to rotate turbine blades which is mechanical kinetic energy further it converts into electrical energy by generator.

Objectives;

- Main purpose is to take advantage of renewable energy resources, in particular wind energy and utilize the maximum amount of energy from the fast running metros.
- Increasing awareness of wind energy industry by operating with most environmentally friendly ways.
- Improve the quality of life as no emission and exhaust.
- .
- To Increase the sustainability of the nation by providing green energy concepts which produce and preserving the environment.
- Harnessing Green energy for sustainable development.
- Power will be used for captive consumption.

II. LITRATURE REVIEW

There is a huge potential of wind energy in India, which should be given high priority by initiating new

policies and opening wind plants in the nation which has numerous advantages like, no carbon emission, global warming reduction, decrease of energy demands, clean & green energy. According to the ministry of new and renewable energy resources (MNRE) the states like Maharashtra, Gujarat & Tamil Nadu has been awarded for wind power capacity of 7.6 GW and expecting to get awarded for 10 GEW in 2019-2020 to achieve target 60GW till the end of 2022.(7) In particular the areas like Andhra Pradesh, Gujarat, Maharashtra and Rajasthan which has high potential of wind should be given high priority (9).

Due to the growing issues in the environmental pollution, depletion of fossil fuels and global warming in the nation Indian railways has taken very big step by initiating their first wind mill of capacity 10.5 MV on 2009 in Tamil Nadu. Moreover, the wind turbines has generated 100million units so far and registered in united nation frameworks convention on climate change (UNFCCC) which effects in reducing carbons by 20,000 Certified Emission Reductions (CERs) per annum. this initiatives from Tamil Nadu is appreciated no government in Indian railways has ever been started such green technological concepts in the state, Indian railways should concern more in such initiatives of green energy concepts which reduce the demand of energy and increase the go-green slogan internationally. Honorable minister of railways says that "railways are naturally a green mode of transport, further we are trying to improve more green energy technologies by using renewable energy resources for railways". (8)

In 2015 an aggregate Wind power capacity of 71MV has been installed in 33 locations of different states. In addition, 22,465MV has been established till the end of 2014 by using large size of wind electric generators units between 225KW to 2.1MV has been deployed in the nation under the state governments through ministry of new and renewable energy of India. (10) Furthermore, MNRE is planning for the first 1GW offshore wind project in India by aiming to establish 5GW by 2022 and 30GW by 2030 which will be beneficial response from the industry. (11)

Indian renewable industry is rapidly increasing. In spit, enable to achieve target 2022 with this pace. As the nations target is to achieve capacity of 1, 00,000MV by installing in solar, on the flip side 60,000MV capacity through wind till 2022. According to the Mercom India research forecasted solar industry in India is declined in the second half of this year in 2018 if we compared with 1st half due to improper project pipelines. Besides, India may achieve wind turbine installation as manufacturers of wind turbine have been installed at 34,393MV which is around 57% of target 60,000MV. (12)

III. MATERIALS & METHODS

3.1. Small Vertical axis wind turbines:

Vertical axis turbine (VAWT) consists of main shaft vertically and turbine does not need to be pointed into the wind to produce electricity in any wind direction, which is main advantage of this turbine. In addition the tower does not need to support the generator and turbine accessories which can be place near the ground which makes the maintenance of this turbine easy. (14)

3.1.2. Advantages;

- Electricity is generated through wind from any direction.
- Tower does not carry generator, as all the accessories are kept on the floor below turbine.
- Initial cost is very less compared to HAWTs.
- Installation & maintenance cost is very less.
- Can be installed in urban areas, due to low risk factor of human and birds' life as the turbine velocity is slow.
- SVAWT are suitable where space is limited and come with fewer challenges.

3.1.3 Selection priorities:

- Select small vertical axis wind turbine which has numerous advantages compares to horizontal axis wind turbine to generate electricity for small output power.
- Select modified savonius SVAWT or ENLIL which has good efficiency and power generation capacity. The main advantage of this selection is this required very less space.
- Choose turbine area which should be low-speed airfoil (cross-sectional shape of the blade) then we need to choose small blade angle (should be 8-10 degrees for better working) with suitable blade width and quantity (5 blades is best quantity).
- Socket structures are preferred for connection such that there should be less drag forces.
- To ovoid vibration in the turbine and increase the life expectancy of the wind turbine use co-axial structure for wind turbine and generator which reduces noises in the turbine, increases life, safety and stability.

- ❖ Automatic break system should be used as small vertical axis wind turbines may wear and tear if wind speed exceeds 25m/s.
- ❖ A permanent magnet synchronous generator is preferred to increase the output with same size rotor.
- ❖ A good designed vertical axis turbine provides good torque in the rotor to calculate at different wind speeds.

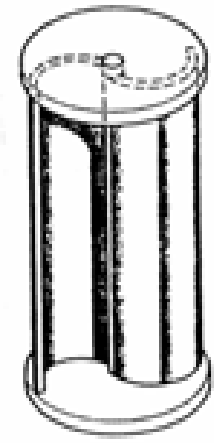
3.1.4. ENLIL TURBINE:

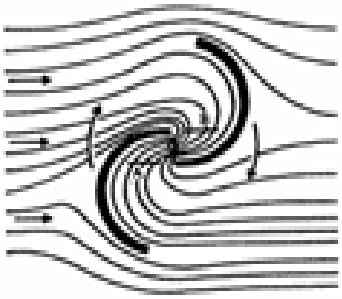
ENLIL wind turbine is new invention from Deveci Tech Company from Istanbul turkey; this unique innovation makes the country smart and renewable in future. (13) Enlil turbine consists of vertical blades which rotates acceding to the speed of the wind. Enlil is a vertical turbine which designed to capture one of the important renewable resources, wind power by using the dynamic of modern cities. In addition to commonly known turbines "Enlil" is designed to capture the flow of continuous traffic on the road. Moreover, solar panel is located at the top of the turbine through which extra electricity to be captured. Turbine will generate 1KW of energy per hour which can easily be used for single household in a day. besides all these advantages it also provide level of carbon dioxide (CO2) in the atmosphere by carbon foot print sensors, forecasting earthquake (or) definition, structure can be assembled and dissembled within a few minutes. (15) in particular the places like metro trains where the trains flows constantly and rapidly with the speed of 40-50 kmph, highways & city main roads where traffic is consistent Enlil strives to produce green energy all around the world.

Fig; 4.1.1(b); Enlil turbine

3.1.5 Small vertical axis wind turbine of savonius type;

This is savonius type of small vertical axis wind turbine shown in figure (20) is also known as s-rotor and invented by Finnish engineer r, Sigurd & J. Savonius in the year 1931. This is one of the simplest forms of turbines; consist of blades or scopes connected to its shaft which is curved, at any time the front of one of the blade will be facing into the wind, while the remaining two blades will be back on to the wind. As the back of each blade is rounded, they experience much less drag than the front of the blade which is facing into the wind. Which causes the drag is more when it is moving against the wind than when it is moving with wind. This unique phenomenon of blades of the turbine causes to spin. The efficiency of this type of turbines is high and as they required very less wind velocity to rotate.





Parts;

The base of the turbine should be strong as it holds complete turbine and should have good reliability so as to face high and low velocity of the wind. It should be designed in such a way to reduce vibrations of the turbine which occurs when the velocity of the wind increases.

Enlil turbine;

Enlil turbine consists 3 vertical wings which rotate according to the speed of the wind. Enlil is a vertical turbine which designed to capture one of the important renewable resources, wind power by using the dynamic of modern cities. In addition to commonly known turbines "Enlil" is designed to capture the flow of continuous traffic on the road. Moreover, solar panel is located at the top of the turbine through which extra electricity to be captured.

Generator;

Generator is one of the most important device which converts mechanical energy into electrical energy by the principle of electromagnetic induction to produce electric voltage it was originally designed by Nikola Tesla. Voltage is an electrical force which moves electricity from one point to another, further generation of voltage effects to generate current. The working of an ac generator will works on electromagnetic induction that is whenever the flux passing through the circuit changes an E.M.F will induce in it and the current begins to flow. The direction of the current can be given by using Fleming's right hand rule or LENZ'S law. wind turbine generators (WTG's) is the electrical machine used to generate the electricity, which is an electromagnetic device. Use of 12v dynamo is preferred as the turbine speed is low. However, a dynamo is an electrical generator that creates direct current using a commutator.

Solar panel;

A panel designed to absorb the sun's rays as a source of energy for generating electricity or heating. In this project solar panel is helpful to increase the wind speed by keeping the solar panel besides the SVAWT at an angle 30-40. When wind hits the panel will provide the direction onto the turbine which cause to increase the rotation of the turbine further increases the output in the farm of power.

Battery;

Batteries are used to store electricity when turbine or solar panel is not producing electricity. Lead-acid batteries are preferred as it can last up to 10 years, in addition 80% of the energy channeled into them. These batteries are designed in such a way that to provide electricity for long period of time can be charge and discharge up to its 80% capacity. However, automotive batteries should not be used which are shallow-cycle and therefore prone to damage if they discharge more than 20% of their capacity.

3.2; Working principle:

The fast moving metros which speed varies from 40-80kmph from both the sides, as most of the Indian metro lanes are double tracks. Whenever the metro

moves with the velocity of an average 45kmph which causes to release some pressurized air due to its speed. This pressurized air is hits top the vertical axis wind turbine it might be enlil/savonius small vertical axis wind turbine then the wing of the turbine makes rotation which makes mechanical kinetic energy, as the shaft of the turbine is connected to the generator with the help of gear mechanism to convert kinetic energy of the blade into electrical energy. Though, the generated electricity will be in alternating quantity, as the output of the 12v dynamo/generator is rectified by rectifier and the energy is stored in Lead-acid battery. If we consider Enlil turbine which consist of solar panel which is mounted at the top of the turbine will also generate the electricity with consistently provides air flow towards the blade of the vertical turbine as Solar cell is used to convert the sun light energy into electricity by photo voltaic effect. While, in case of savonius turbine the position of the solar panel is inclined at 30 degrees with the horizontal which helps to increase the velocity of the wind as the wind is first hits to solar panel then to turbine which increases the velocity of the turbine.

IV. FEATURE EXTRACTION

India has one of the highest installed power generation capacities in renewable energy resources. In particular, wind energy account for about 34.977GW till October 2018 which is 48.54% of the total renewable energy and forth largest installed wind capacity in the world. The installation of wind turbines are rapidly increasing, though wind power cost decreases (16). However, the installed wind capacity of Telangana state is negligible as it is 101MW the number is very less compared to Tamil Nadu and Gujarat 8,197 & 5, 613. (17) India's renewable energy targets are to generate 60GW till 2022 which can be achieved by good government schemes and increase the manufacturing of SVAWT with skilled operators (19). According to government scheme of renewable energy resources foreign direct investment and independent power producers (FDI & IPPs) could not participate due to less/no depreciation by government (18). Government department MNRI should take certain steps for FDI & IPPs to increase high quality SVAWT production. As small wind turbines has very helpful in different scenarios, particularly in our project it is very useful to generate electricity in metro cities where the velocity wind increased due to rapid motion of metro rails on the flyovers. Designing of the flyovers by considering installation space for SVAWT and provision should be given for under construction railway bridges, highways & flyovers through which huge output of electricity can be obtained which can be used in numerous ways.

V. CALCULATIONS

Calculative values are obtained when we consider all the scenarios with savonius vertical axis wind turbine with 12v dynamo, lead-acid battery and area of A=L*B= 1*0.5 = 1.5 without considering solar panel.

The calculation of vertical axis wind turbines is depends on the principle of conversion of kinetic energy of the wind into mechanical energy.
As we know that
Kinetic energy (K.E) =½ mv2
Where;
m = mass
v = velocity,
We also have the relation of mass with velocity and density
Mass (m) = ρ AV
Where;
A= area
v= velocity.
If we solve these above equations
We get,
K.E= ½ (m) V2
K.E= ½ (ρ AV) V2
K.E = ½ ρ AV3 watts,
ρ = density of air
(The density of the air is constant = 1.2754 kg/m3),
A be the swept area of the turbine = length*breadth = diameter of the rotor* height of the blade
Where l be the length of the blade take (l=h= 1meter),
(diameter o the rotor= 0.5 meter)
Then the area will become; A= 1*0.5 = 1.5
A=1.5 m2
Formula to determine the output power:
$P= \rho * ½ * A*V^3$

Trail 1
When wind speed is 5m/s
$P= \rho * ½ * A*V^3$
P=1/2*1.2754*1.5*7 (3)
Input power is obtained as
P= 328.09watts
(Gear ratio from the generator N1/N2=1/10) then,
P= 32.809 watts (output power)
Similarly,
Trail-2
$P= \rho * ½ * A*V^3$
P=1/2*1.2754*1.5*10 (3)
P= 956.55watts (input power)
P= 956.55*0.1

P=95.65 watts (output power)
Trail-3
P= ρ* ½* A*V³
P=1/2*1.2754*1.5*12 (3)
P= 1,652.91watts (input power)
P= 165.29watts (output power)
Trail-4
P= ρ* ½* A*V³
P=1/2*1.2754*1.5*15 (3)
P= 3,228.35 watts (input power)
P= 3,228.35 *0.1
P=322.835 watts (output power)

Trail-5
P= ρ* ½* A*V³
P=1/2*1.2754*1.5*18 (3)
P= 3,719watts (input power)
P= 3,719*0.1
P=371.90 watts (output power)
Trail-6
P= ρ* ½* A*V³
P=1/2*1.2754*1.5*20 (3)
P= 5,106.03watts (input power)
P= 5,106.03*0.1
P=510.6watts (output power)

S.NO	WIND SPEED (I) m/s	Area (l*b) In meters	Density of air (ρ) kg/m3	Power (P) P= ρ* ½* A*V³ in watts
1.	7m/s	0.75	1.2754	**32.809**
2.	10m/s	0.75	1.2754	**95.65**
3.	12m/s	0.75	1.2754	**165.29**
4.	15m/s	0.75	1.2754	**322.835**
5.	18m/s	0.75	1.2754	**371.90**
6.	20m/s	0.75	1.2754	**510.61**

VI. CONCLUSION

There are numerous ways to generate electricity. Although, wind energy resource is highly recommended due to its clean and non-polluting fuel sources with no water resources required to generate electricity. In addition, in this case vertical axis wind turbine is the best option to generate electricity due to its advantages over SHAVT. As the calculated values shown above at minimum wind velocity of 7m/s (25.2kmph) is producing 32.8 watts of output power. Output of the turbine increases when wind velocity increases to 15m/s (54kmph) which (is an average velocity of metro i.e. 40kmph) producing output as 322.83 watts. Moreover, when velocity reaches to 20m/s then the output power is 510 watts. However, the output power of the turbine can be increases practically by applying solar panel as it increases the wind speed and further increases power. If the savonius SVAWT is located in medians of the metro track it will produce good output, which can be increases by installing more number of the turbines in series with solar panels besides them. the output power can be used for metro inside lights, metro substation lights and maintenance, street and signal lights as metro runs medians to the city by covering all the main roads of the city & running of metro itself. While, use of Enlil turbine has more advantages like weather quality, earthquake definition, carbon footprint and Wi-Fi facility. Company claims that the single turbine will generate

1kwatts of energy ph which provide the average daily electricity needs of two households. Installing these turbines in series has numerous advantages like, the clean energy of the city increases which leads the city to become smart that run on renewable. This idea of installing turbines medians is very simple with no ground breaking technology with huge profit of output in the farm of power which minimizes the demands of fossil fuels. These installations of the turbine would change the nation's economy with decrease in level of co2 in the atmosphere & increasing green energy.

Limitations; (disadvantages)

- ✓ It required high initial cost.
- ✓ Installation required high skilled labors and operators.
- ✓ All the blades do not produce torque at the same time.
- ✓ Drags on the blades are more when they rotate.
- ✓ Vibration can be an issue at times & increase the noise produced by the turbine.
- ✓ Air flow at ground level may cause to increase turbulence, which further increases vibration.

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