HYBRID ROAD RAIL POWER GENERATOR

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Abstract - *Energy demand is increasing day by day and until now its major source is fossil fuel urning for electricity generation is responsible for pollution and climate change etc. Therefore, many countries are getting shifted towards renewable energy sources for fulfilling our countries whole electricity demand by using clean energy sources we require huge landmass. If we can innovatively manage various renewable energy sources on our highway and rail network, we can solve the problem by greater extent. It can be done about the land availability for renewable energy sources.*

It's a hybrid energy generation system which includes photovoltaic solar, wind turbines and piezoelectric energy harvester. In that same system we also carry large scale rain water harvesting practices. This system has so many advantages. First is clean energy generation without occupying additional land, also it is beneficial for road itself, road users and vehicles also. When EV's get generalized this system plays a very vital role for providing energy for on-road charging station.

Key Words: Renewable Energy, solar panel, vertical axis wind turbine, rain water harvesting.

1.INTRODUCTION

In the present era pollution and climate change are major threats for today's generation. Many studies show that fossil fuel burning for electricity generation and vehicles s the main reason of pollution and climate change. Therefore, many countries got shifted towards renewable energy and biofuels. Also, India takes impressive steps in renewable energy, in the recent years our renewable energy sector gets matured. But some countries like Iceland, costa Rica, UK, Sweden fulfill their whole electricity demand by using renewable energy sources. But the countries like India, USA have enormous energy demand.

According to IEEA (Institute for Energy Economics and Financial Analysis) India requires 1.97%-2.88% land nearly 65000 to 95000 sq.km. for achieving Net Zero Targets by 2050. This is such a huge number. Today our population is 139.66 crore and our annual growth of population is 1%. Our present scenario about population is very bad and in upcoming years there is possibility of food scarcity and problem about residence. If we get trouble in fulfilling our essential demands then our renewable energy targets and our ambitious sustainable development goal face a lot of problems.

Hybrid Road-Rail Power Generation system will able to give solution for that problem. It uses one of the most readily available sources in the nature known as, solar energy. Also it uses wasted energy to generate the electricity which includes force generated by moving of vehicles in terms of wind disturbance and vehicles kinetic energy.

According to WHO's recent reports India get polluted. To counter that situation, we need carbon mitigation and also sequestration carbon. One of the simplest and economical sequestration carbon technique is 'Reforestation'. Then we are able to carry reforestation practices on that remaining land. This slashes the carbon in the atmosphere. Roofs are able to plays another most significant role of 'Large scale Rain Water Harvesting'.

2. METHODOLOGY

It is a hybrid electricity generation system on highways and railways which includes solar panels as top, Vertical Axis Wind Turbines and Piezoelectric Pavement as base. India has second largest road network in the world after USA which contains:

- 1,51,019 km National Highway
- 5,846 km Golden Quadrilateral
- 20,000 km operational and proposed Expressway
- 1,86,0000 km State Highway

Also, our country have one of the largest rail network. Which have route length of 67,956 km and total trackage is 1,26,366 km.

1. Solar Photovoltaics

India is located to the north of the equator, which receives yearly mean solar irradiation of 6.5 KWh/m2 day. It is very good solar photovoltaic system. Solar panels are mounted on the roof of highways. This structure is supported by steel structure frame around the cross section of the road length which includes the total width of the road and railway.

Figure 1: Solar Panels on Roofs

2. Road side Vertical Axis Wind Turbine

Wind turbines are installing by number of ways. Roadside Vertical axis wind turbines is got power by specially designed supporting structure, this accelerates the air movement. And its installed capacity is 3KW.

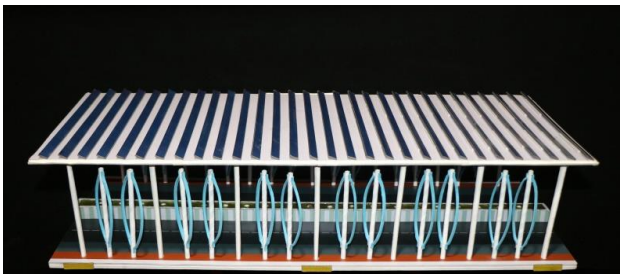

Figure 2: Vertical Axis Wind Turbines

3. Vehicle Powered Vertical Axis Wind Turbine

Wind turbulence is created by speedily moving vehicles. On the other hand, if it moves, it would create low wind pressure field. Wind turbulence direction is moving along the vehicles to the center of low pressure field. This energy gets captured by installing vertical axis wind turbines along the highways.

Figure 3: Vehicle Powered V.A.W.T.

4. Piezoelectric Pavement

This system is discovered by 'Innowatech' an Israel based company. They're tested reports said that for 1 Km piezoelectric roads single lane can generates 44,000 KWh/year, where 600 vehicles are passing during one hour.

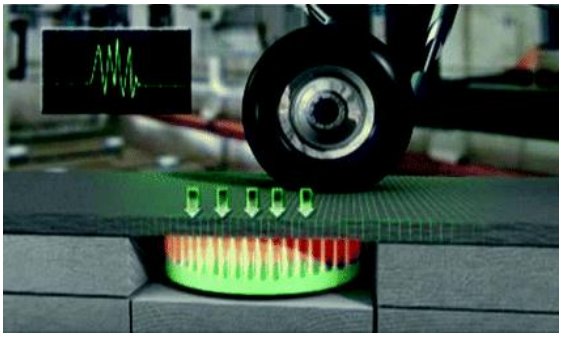

Figure 4: Piezoelectric Pavement

5. Rain Water Harvesting

Roofs are also carrying the rain water harvesting activity. Slope is provided for roof like a camber provision and at both ends pipes are installed which will carry water.

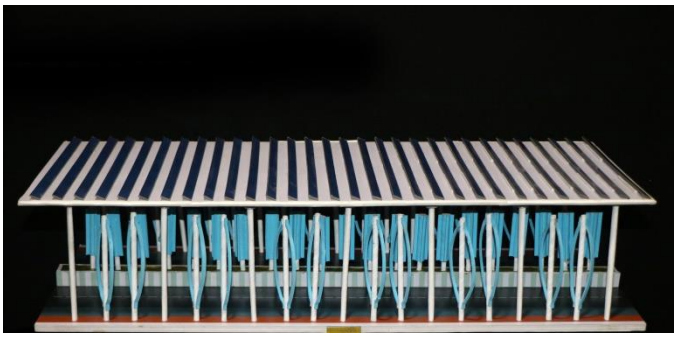

Figure 5: Rain Water Harvesting

2.1 MODELING AND ANALYSIS

It is a general calculation; it should be varied location to location. (For 1Km road stretch)

1. **National Highways: -**

1. Roof Mounted Photovoltaics-

- Total area=25m*1000m
- Solar panels= Monocrystalline, 540 Watt and 1.1m*2.1m in size of each panel
- Angle of tilt=45 degree

Sin(45)=h/1.1=0.78 m

Cos(45)=x/1.1=0.78 m

D=3h=3*0.78=2.34

L=D+x=2.34+0.78=3.12m

Panels along length=1000/3.12=320 Nos

Panels along length=25/2.1 =11 Nos

- No. of panels=320*11=3520 Nos
- Electricity generation=3520/2=1760 Kw
- 1Kw generates 4 units

Daily electricity generation=1760*4=7.04 MW/day/km

2. Roadside Vertical Axis Wind Turbines (V.A.W.T.)-

- Type of turbine=Darrieus Wind Turbine
- Installed Capacity=3 KWh
- Efficiency=25%
- No. of turbines=360 Nos.
- Output= (3*0.25)*24*360=6.48 MW/day/km

3. Vehicle motion powered v.A.W.T.-

- Installed Capacity= 2.5 KWh
- No. of Turbines=250 Nos.

Each turbine can generate 6KW/day, according tested results in U.K. by G311 turbine

Outout= 6*250= 1500 KWh says 1.5 MW/day/km

4. Piezoelectric Pavement (Road Base)-

- Each lane of 1Km generates 44 MW per year, tested by Israel based Innowatech company.
- Output=44/365*4 Lane= 0.482 MW/day

Total Daily Output of 1Km=7.04+6.48+1.5+0.482= 15.502 MW/Day/Km

- Output per year-

i. Solar Panels=7.04*335*151019=356.163 TWh/year

ii. Road side V.A.W.T.=6.48*365*10000 =23.652 TWh/year (For only 10000 Km)

iii. Vehicle powered V.A.W.T.=1.5*365*151019=82.683 TWh/year

iv. Piezoelectric Panels=44*4*151019=26.579 TWh/year

Total Generation by N.H. annually=356.163+23.652+82.683+26.579=489.077 TWh/year

2. **Expressway:-**

1. Roof Mounted Photovoltaics-

- Total area=35m*1000m
- Solar panels= Monocrystalline, 540 Watt and 1.1m*2.1m in size of each panel
- Angle of tilt=45 degree

Sin(45)=h/1.1=0.78 m

Cos(45)=x/1.1=0.78 m

D=3h=3*0.78=2.34

L=D+x=2.34+0.78=3.12m

Panels along length=1000/3.12=320 Nos

Panels along length=30/2.1 =14 Nos

- No. of panels=320*14=4480 Nos
- Electricity generation=4480/2=2240 Kw
- 1Kw generates 4 units

Daily electricity generation=2240*4=8.96 MW/day/km

2. Roadside Vertical Axis Wind Turbines (V.A.W.T.)-

- Type of turbine=Darrieus Wind Turbine
- Installed Capacity=3 KWh
- Efficiency=25%
- No. of turbines=360 Nos.

- Output= (3*0.25)*24*360=6.48 MW/day/km

3. Vehicle motion powered v.A.W.T.-

- Installed Capacity= 2.5 KWh
- No. of Turbines=250 Nos.

Each turbine can generate 6KW/day, according tested results in U.K. by G311 turbine

Outout= 8*250= 2000 KWh says 2 MW/day/km

4. Piezoelectric Pavement (Road Base)-

- Each lane of 1Km generates 44 MW per year, tested by Israel based Innowatech company.
- Output=44/365*4 Lane= 0.482 MW/day

Total Daily Output of 1Km=8.96+6.48+2+0.482= 17.922 MW/Day/Km

- Output per year-

i. Solar Panels=8.96*335*20000=60.032 TWh/year

ii. Road side V.A.W.T.=6.48*365*5000 =11.826 TWh/year (For only 5000 Km)

iii. Vehicle powered V.A.W.T.=2*365*20000=14.6 TWh/year

iv. Piezoelectric Panels=44*4*20000=3.52 TWh/year

Total Generation by Expressway annually=60.032+11.826+14.6+3.52=89.978 TWh/year

3. Golden Quadrilateral: -

1. Roof Mounted Photovoltaics-

- Total area=25m*1000m
- Solar panels= Monocrystalline, 540 Watt and 1.1m*2.1m in size of each panel
- Angle of tilt=45 degree

Sin(45)=h/1.1=0.78 m

Cos(45)=x/1.1=0.78 m

D=3h=3*0.78=2.34

L=D+x=2.34+0.78=3.12m

Panels along length=1000/3.12=320 Nos

Panels along length=30/2.1 =14 Nos

- No. of panels=320*14=4480 Nos
- Electricity generation=4480/2=2240 Kw
- 1Kw generates 4 units

Daily electricity generation=2240*4=8.96 MW/day/km

2. Roadside Vertical Axis Wind Turbines (V.A.W.T.)-

- Type of turbine=Darrieus Wind Turbine
- Installed Capacity=3 KWh
- Efficiency=25%
- No. of turbines=360 Nos.
- Output= (3*0.25)*24*360=6.48 MW/day/km

3. Vehicle motion powered v.A.W.T.-

- Installed Capacity= 2.5 KWh
- No. of Turbines=250 Nos.

Each turbine can generate 6KW/day, according tested results in U.K. by G311 turbine

Outout= 6*250= 1500 KWh says 1.5 MW/day/km

4. Piezoelectric Pavement (Road Base)-

- Each lane of 1Km generates 44 MW per year, tested by Israel based Innowatech company.
- Output=44/365*4 Lane= 0.482 MW/day

Total Daily Output of 1Km=8.96+6.48+1.5+0.482= 17.422 MW/Day/Km

- Output per year-

i. Solar Panels=8.96*335*5846=17.547 TWh/year

ii. Road side V.A.W.T.=6.48*365*500 =1.183 TWh/year (For only 500 Km)

iii. Vehicle powered V.A.W.T.=1.5*365*5846=3.2 TWh/year

iv. Piezoelectric Panels=44*4*5846=1.029 TWh/year

Total Generation by Golden Quadrilateral annually=17.547+1.183+3.2+1.029=22.959 TWh/year

4. State Highways: -

1. Roof Mounted Photovoltaics-

- Total area=7m*1000m

- Solar panels= Monocrystalline, 540 Watt and 1.1m*2.1m in size of each panel
- Angle of tilt=45 degree

Sin(45)=h/1.1=0.78 m

Cos(45)=x/1.1=0.78 m

D=3h=3*0.78=2.34

L=D+x=2.34+0.78=3.12m

Panels along length=1000/3.12=320 Nos

Panels along length=5/2.1 =2 Nos

- No. of panels=320*2=640Nos
- Electricity generation=640/2=320 Kw
- 1Kw generates 4 units

Daily electricity generation=320*4=1.28 MW/day/km

Total Daily Output of 1Km=1.28 MW/Day/Km

- Output per year-

Total Generation by S.H. annually=1.28*335*186000=79.757 TWh/year

5. Railways: -

1. Roof Mounted Photovoltaics-

- Total area=25m*1000m
- Solar panels= Monocrystalline, 540 Watt and 1.1m*2.1m in size of each panel
- Angle of tilt=45 degree

Sin(45)=h/1.1=0.78 m

Cos(45)=x/1.1=0.78 m

D=3h=3*0.78=2.34

L=D+x=2.34+0.78=3.12m

Panels along length=1000/3.12=320 Nos

Panels along length=7/2.1 =3 Nos

- No. of panels=320*3=960 Nos
- Electricity generation=960/2=480 Kw
- 1Kw generates 4 units

Daily electricity generation=480*4=1.92 MW/day/km

Total Daily Output of 1Km=1.92 MW/Day/Km

- Output per year-

Total Generation by Railways annually=1.92*335*126000=81.043 TWh/year

Total highway and rail network able generates= 762.632 TWh/year

2.2 RESULTS AND DISCUSSION

This system can generate the mass electricity without giving any adverse effect on the environment. It can eliminate major drawback of large-scale electricity generation project in terms of, 'Change in Land Use' which lead in ecological imbalance. Additional land is not required for installing new electricity generation project. In that system we can carry, 'Large scale Rain Water Harvesting', which collects the water on the on the solar roof. It also provides job opportunities. We know that, pot holes are formed during rainy days it is the mainly because of road deteoration, it can be eliminated by provision of roof on the road top. Which will save repairing and maintenance cost, therefore life span of road increases. Roofs can eliminate the direct contact between solar radiation and vehicles which will minimizes the vehicles heating, it saves the fuel. Also, it improves the life of tyre. Roof can eliminate glare effects. Also, it gives comfort during summer and rainy season. When EV's get generalized, then supporting structure plays the role of charging station which uses generated at that particular location which eliminate the transmission losses.

3. CONCLUSIONS

Now a days, many countries give priority to clean energy and sustainable development. Larger electricity generation projects require acres of land. The land will get saved by using Hybrid Road Rail Power Generator. Land saved during electricity generation system gets used reforestation and for Green Field.

In India, solar radiation is available in abundance. By installing solar panels on the highway and railway roof we generate mass electricity. Wind disturbance due to the vehicle movement have good potential for electricity generation. The energy may be used by using extra sensitive vertical axis wind turbines along the road side. Piezoelectric energy harvesters capture the kinetic energy of vehicles to generate the electricity. This hybrid electricity generation system increases the power output. In that system we can utilize the waste energy in order to generate electricity. Water conservation practices are also carried out by using rain water harvesting system.

When EV's get generalized, now a days India's rail network gets electrified their energy demand will get fulfilled by electricity generated on transportation network particularly roadways and railways. It would save the electricity wastage during long distance transmission.

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