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Feasibility Report of Solar Powered Train

Pushpendra Chouhan[1], Dr. Pankaj Jain[2]
[1]*Research scholar, School of energy and environment management, RGPV, Bhopal.*
[2]*Associate professor, School of energy and environment management, RGPV, Bhopal.*

***Abstract:** In now days,we are facing various challenging global problems due to use of conventional source of energy(fossile fuel) in our transportation system.Solar energy is clean source of energy available in large amount and alternate option to fossile fuel.Indian Railway Endeavouring to use solar energy is for their versatile use in many aspects.currently Indian railway is running two trains one is in delhi from sarai ruhillah to farukh nagar in hariyana since July 14,2017. is first solar powered train.second one is "Himalaya queen" from kalka to Shimla.In these train static solar panels are mounted on rooftop to convert solar irradiation to electrical energy for giving needed power supply to run train.solar energy is clean source of energy helping us to alive in sustainable,ecofriendly manner.panel mounted on rooftop of these trains are static so that solar irradiation incident on them are not perpendicular all time with movement of train.therefore they generate less power than when panel mounted on rooftop are able to change direction in 2D manner with changing direction of solar irradiation so that incident irradiation are always perpendicular to them.*

***Keywords:** PV-photovoltaic panel, 2D- 2 diemensional,*

I. SOLAR TRAIN

A Solar train is a train that is run by electric power generated by photovoltaic panel in presence of solar irradiation.solar can be power from directly solar irradiation or by battery available for backup in case of emergency.these batteries can be charge by solar panels or by other source of supply.various research project are in development mode.UK's community energy south and network rail working together on world first solar powered track.which came alive in agust 2019.

A. Why to Going for Solar Powered train Instead of Fossile fuel Based Train

Todays all of trains are running by hydrocarbon base fuel or by power generated by coal based thermal power plant.these conventional scource of energy will end in coming days.so we need a alternative clean source of energy.solar energy are clean not have any pollutants emission and green house gases.so that it is not harmful to our health and helping us to fight against climate change globally.

II. LHB COACH DIEMENSIONS AND PV PANEL POWER RATING

1.2 OVERALL DIMENSIONS OF LHB COACH

Gauge	1676 mm
Length over body	23540 mm
Length over CBC	24000 mm
Wheel Base	2560 mm
Maximum width over body	3240 mm
Maximum distance between inner wheels	12345 mm
Window opening	1180x760 mm
Distance between centre pivots	14900 mm
Height of compartment floor from rail level under tare condition	1303 mm
Maximum CBC drop under gross load and worn conditions	75 mm
Minimum height from rail level	102 mm
Maximum height of centre line of side CBC above rail level for empty vehicle	1105 mm
Minimum height of centre line of CBC above rail level for loaded vehicle Maximum tare weight	1030 mm

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Panel Diemensions And Power Rating

Models	Pmax (W)	Vmp (V)	Imp (A)	Isc (A)	Voc (V)	Module Eff. (%)
WSD-400	400	40.68	9.85	10.06	49.47	20.17

MECHANICAL CHARACTERISTICS

Length x Width x Thickness (L x W x T) - mm	2009 mm (L) x 1003.5 mm (W) x 40 mm (T)
Weight (kg)	25.5
Solar Cells per Module (Units) / Arrangement	144 cells / (12*6 x 12*6)
Solar Cell Type	Mono Crystalline Silicon
Front Cover (Material / Thickness)	3.2/4 mm Tempered & Low Iron Glass with ARC
Encapsulate	PID Free Encapsulant, UV Resistant & Ultra Fast Cure
Junction Box (Protection degree/ Material)	Weatherproof PPO/ IP67 enclosure with bypass diodes
Cable & Connector (Protection degree / Type)	IP67 rated / MC4 compatible
Cable cross - section & Length	4 mm2 & 500mm

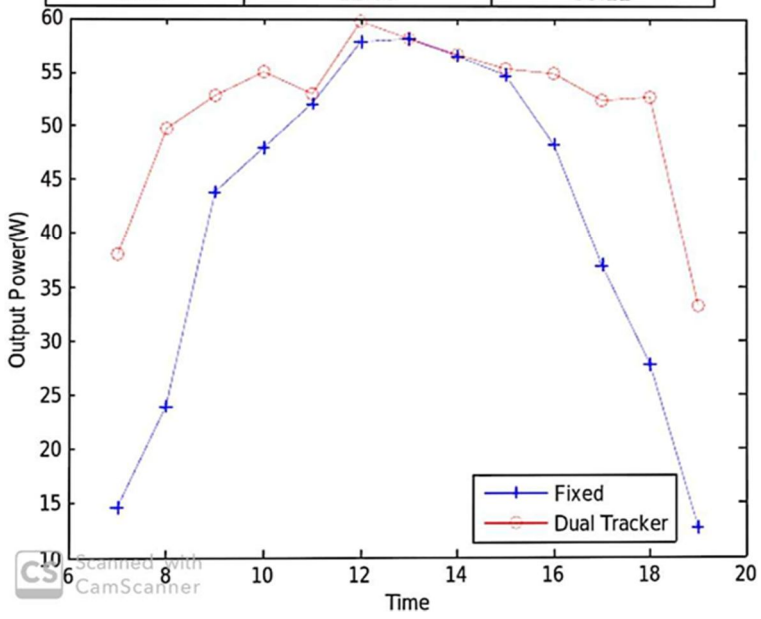
III. CALCULATION

Length of one LHB coach = 22 meter (aprxmt)
Width of one LHB coach = 3 meter (aprxmt)
Area available = 66 meter^2
Area of 21 LHB coach = 21×66
= 1386 meter^2
One panel area = length × width of panel
= 2.009 × 1.003
= 2.01 meter^2
Number of panels we can install on 21 coaches = 1386/2.01
= 689.55
Maximum power generation by these panels = 689 × peak power of panel
= 689 ×400 watt
= 275600 watt
= 275.6 kw
We know 820 kwhr energy is needed to cover distance of 100km so that 275.6 kwhr is very less.

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IV. POWER GENERATION (FIXED MOUNT VS DUAL MOUNT)

HOUR	POWER FOR FIXED MOUNT(W)	POWER FOR DUAL-AXIS(W)
0700	14.575	38
0800	23.987	49.728
0900	43.876	52.701
1000	47.94	54.9519
1100	52	52.974
1200	57.6666	59.6156
1300	57.96	58.0488
1400	56.412	56.5687
1500	54.6883	55.3151
1600	48.174	54.8562
1700	36.96	52.3698
1800	27.72	52.668
1900	12.69	33.22



From above data we can see by using dual axis tracker we can increase power generation approximately by 25%.so by calculation

275.6 +25% of 275.6 = 344.5 k watt

344.5 kwatt is also less from 821 kwatt which is needed to run 100 km.by using dual axis tracker generation is increased by not enough to run train independently.

V. EMBRYONIC DEVELOPMENT

From above calculation we can see that power generation is not sufficient to run train without using other source of power generation.we need to increase efiiciency of solar panel from present 17-20 % to 80-90 %.in present a lot of research work has been carried out to increase efficiency.but it may not become possible in near future to achieve it.

Efficiency of some most efiicient pv panel

Vikram somera p duplex = 19.76%

Waree arka series = 19.87%

From above calculation we know that we need more solar power with limitation of efficiency of solar panels.so we need to mount more panels to more power generation. limited space is available on coaches of train therefore we can not mount more panels on them. instead on roof of coaches we can mount on track. sleepers are use below of track they are made of concrete.

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if we can replace them by pv panels with make of same strength as concrete have we can generate sufficient amount of power.because Indian railway have 67,368 km length of railway line. Indian railway have asias largest railway network.and large length of railway remain always open so solar irradiation is always incident on it.we can use sleepers of track in this way to full capacity for needed power generation.these sleepers are horizolntal so that we will calculate solar irradiation on horizolntal surface.Type equation here.

A. Formula For Calculation Of Solar Irradiation

Solar beam flux incident angle is function of various solar geometric angle.

$$\Theta = f(\Theta_z, \phi, \Upsilon, \omega, \beta, \delta, a\ \Upsilon_s)$$Type equation here.

Where

Θ_z = zenith angle
Φ = latitude angle
Υ = surface azimuthal angle
$\Upsilon_{s=}$ solar azimuthal angle
ω = hour angle
β = slop tilt angle
δ = declination angle
a = altitude angle

$$\cos\theta = \sin\phi(\sin\delta\cos\beta + \cos\delta\cos\gamma\cos\omega\sin\beta) + \cos\phi(\cos\delta\cos\omega\cos\beta - \sin\delta\cos\gamma\sin\beta) + \cos\delta\sin\gamma\sin\omega\sin\beta$$

For horizontal surface = 0 , $\theta = \theta_z$

$$\cos\theta_z = \sin\phi\sin\delta + \cos\phi\cos\delta\cos\omega$$

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Relationship between hourly global,beam and diffuse radiation

$I_g = I_b + I_d$

$I_b = I_{bn} \cos\theta_z$

$I_g = I_{bn}\cos\theta_z + I_d$

Ashrae model it is postulated that

$I_{bn} = Ae^{-B/\cos\theta z}$

$I_d = CI_{bn}$

Where A,B and C are constants whose value are determined on month wise basis.

Values of the constants A, B, and C used for predicting hourly solar radiation on clear days

	A (W/m²)	B	C
January 21	1202	0.141	0.103
February 21	1187	0.142	0.104
March 21	1164	0.149	0.109
April 21	1130	0.164	0.120
May 21	1106	0.177	0.130
June 21	1092	0.185	0.137
July 21	1093	0.186	0.138
August 21	1107	0.182	0.134
September 21	1136	0.165	0.121
October 21	1136	0.152	0.111
November 21	1190	0.144	0.106
December 21	1204	0.141	0.103

We will calculate value of hourly global irradiation between 10:00 am to 14:00 pm on 21st April,2020 at Bhopal (23°12N,72°26S) location.

When we convert latitude in proper angle 12 minute will be = 12/60°

= .20°

So that 23°12N = 23.20°

And declination angle δ = 23.45sin[360/365(284+n)] where n is nth day in year

For 21st April 2020 its value is n = 112

So that δ = 11.91°

For horizontal $\cos\theta_z = \sin\emptyset\sin\delta + \cos\emptyset\cos\delta\cos\omega$

Where $\emptyset$ latitude angle = 23.20°

δ declination angle = 11.91°

So that $\cos\theta_z = \sin23.20°\sin11.91° + \cos23.20°\cos11.91°\cos\omega$

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At 12:00 noon,11:30am,10:30am,12:30pm,13:30pm ω = 0°,7.5°,22.5°,7.5°,22.5°

$\text{Cos}\theta_z$ = .39×.20 + .91×.97 cosω

= .078 + .88 cosω

Values of $\cos\theta_z$ at ω = 0,-7.5°,-22.5°,7.5°,22.5°

Respectively .958, .948, .878, .948, .878

At 21st April 2020 value of A,B,C respectively 1130 w/m^2 ,0.164 , 0.120

I_{bn} = Aexp(-B/cosθ_z)

I_{bn} = 1130 exp(-0.164/.958) = 951.46 w/m^2 at θz = 0°

I_{bn} = 1130 exp(-0.164/.948) = 950.3. w/m^2 at θ_z = -7.5°

I_{bn} = 1130 exp(-0.164/.878) = 937.9 w/m^2 at θ_z = -22.5°

Similarly at θ_z = 7.5° I_{bn} = 950.3 w/m^2

θ_z = 22.5° I_{bn} = 937.9 w/m^2

$I_g = I_{bn}\text{Cos}\theta_z + I_d$

$I_d = CI_{bn}$

I_d is 114.17,114.03,112.54,114.03,112.54 for values of θ_z

I_g = 1065.63 w/m^2 at θ_z =0°

= 1055.77 w/m^2 at θ_z = -7.5°

= 978.22 w/m^2 at θ_z = -22.5°

= 1055.77 w/m^2 at θ_z = 7.5°

= 978.22 w/m^2 at θ_z =22.5°

VI. METHODOLOGY

Previously we saw how i calculated generation from static solar panel mounted on train.they are generation enough power to run train.then a idea came to my mind why we can not mount solar panel on sleepers of track.they are all horizontal remain open to solar radiation all day time.by ASHRAE model I calculate hourly solar irradiance in Bhopal than by using these data I will calculate generation in particular length of track by considering each sleeper as photovoltaic panel.

VII. RESULT

Length of sleeper = 1.35 m

Width of sleeper = .25 m

Area of sleeper = 1.35m × .25m

= .3375 m^2

So total global radiation on 21 april 2020 from 10:00 am to 14:00 pm

=2(1055.77+978.22) w/m^2

= 4067.98 w/m^2

Solar irradiation on one sleeper = 4067.98w/m^2 × .3375 m^2

= 1372.94 w

Waaree solaar model wsd-400 have efficiency of solar panel = 20.17%

So that generation from sleeper from 10:00 am to 14:00 pm is

= 1372.94 × 20.17/100 w

= 276.92 w

1km length of Indian railway have approximate 1818 number of sleepers.

So that generation from sleepers of 1km length is = 1818 × 276.92w

= 503440.56 w

= 503.440 kw (10:00 am to 12:00 pm)

This power generation is enough to run train independently and surplus power can be store for dark hours to night.

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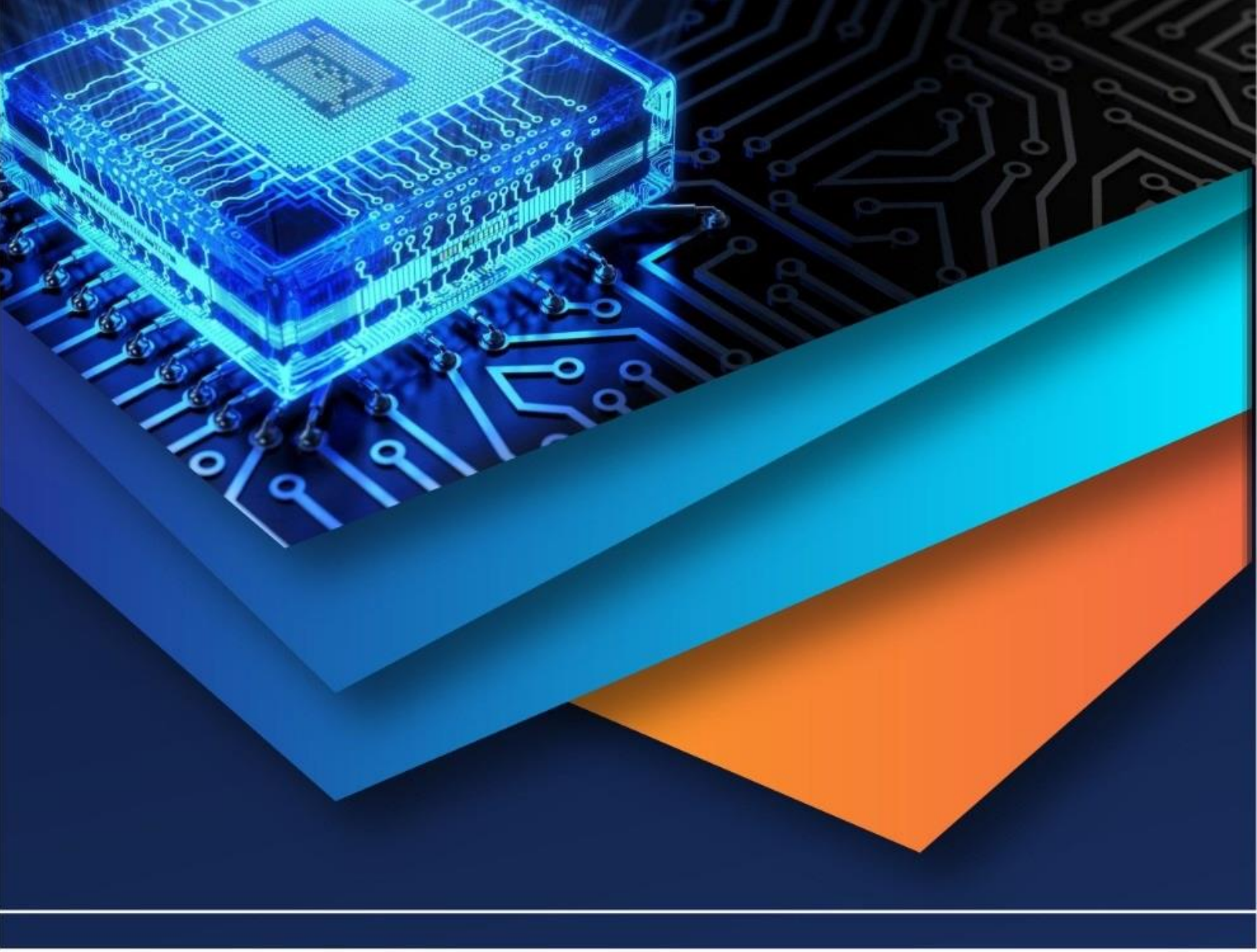
VIII. CONCLUSION

Our concept of solar train is good but power generation is not enough to run train completely without using other source of power. instead of it by setting up power plant on land we can generate enough power to run train and can store surplus generated power for dark hour duty. And sleepers of track are good to use them as source of generation of power by mounting pv panel on them.by this amount of power we can meet reduction in carbon footprint by reducing dependency on diesel for end on generation. today efficiency of solar panels are much less, hence this is our first step towards finding of full ecofriendly transportation system in future by scientific advancement in harnessing green energy. sustainable transport is a road for sustainable development and a means by which people can access what they need to live full and without affecting their fulfilled lives. All actors governments, business, civil society, and individuals must make a genuine, true commitment to transforming the transport system in terms of individual and collective travel and freight into one that is safe, affordable, accessible, efficient, and resilient, reliable , while minimizing carbon and other emissions and environmental impacts. This report explores needed actions that can effectively bring about these transformation.

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