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Energy Conservation By Implementation Of Solar Photo Voltaic Modules in Indian Railway Linke Hofmann Busch Coaches

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Abstract- ***Lord "SUN" is being worshipped as a sole source of life on earth since ancient times. The estimated power released by the continuous fusion reactor is the order of 3.8*10^{26} watts out which mother earth intercepts 1.78*10^{17} watts. The rapid technology advancement literally ignores this purest form of energy due to easy availability of conventional fuels till 1973 when the first oil embargo shook the world. This oil crisis aided with increased awareness towards the new invention in renewable energy. In this study , a study was carried out to access the feasibility of installing solar photovoltaic modules at the top of Indian railway Linke Hofmann Busch coaches. This reduces the usage of diesel in trains and there is a significant reduction in CO_2 and NO_X emissions. Implementation of this scheme for all 178 trains running under Indian railway services there will be annual savings of 95000 crore rupees corresponding to 17361 kilometers of diesel and an annual reduction of 46129 tons of $C0_2$ AND 337.873 tons of NO_X emissions.***

Keywords: Carbon dioxide emissions, diesel, rail coaches, solar modules.

I. INTRODUCTION

In recent times, much research is being carried out to develop sustainable forms of transportation. This is necessary because transportation sector is a source of CO2 emissions and is a cause of global warming. Solar power cannot be relied upon to completely replace conventional fossil-fuel engines. It can only supplement the power generated by the engine and subsequently reduce CO2 emissions1. Buses and cars have been retro-fitted with solar panels on the roofs, hoods as well as the boot lids. The Adelaide City Council has introduced all-electric buses, with batteries being charged by solar panels mounted on top of the charging stations. Its operating cost is found to be less than conventional diesel powered buses2. Since the hybrid automobiles with solar technology have been realized, it would be logical to extend this idea to train coaches. The train coaches have a large roof area available for generation of energy using solar photo voltaic (PV) modules. The energy generated from this scheme in excess of the requirement in the coaches can be stored in batteries and used to supply electrical lighting loads even during night, thereby reducing the fossil fuel consumption. Prototype experimental airplanes have been made to fly on stored solar energy during the nights.

II. LITERATURE SURVEY

There have been a few recent papers that have deal with the application of previous sources to urban railway networks in that the authors investigated the performance of solar photo voltaic modules mounted on the roof of the rail coach to quantify the reduction in diesel consumption of the end on generation system that powered the electrical loading in new generation coaches. A roof coach installation of the panels was proposed which introduced a technical scheme for the auxiliary power system of passenger train based on photovoltaic and battery energy storage.

III. INSULATION OF PV CELL OVER LHB COACHES

One of the important constraints considered during the design of the SPV system and module mounting structure (MMS) was the 'Standard Dimensions'. The standard dimensions are declared by Research Design and Standards Organization (RDSO), Ministry of Railways, Govt. of India. According to the guidelines of RDSO, any moving body on the rails must not exceed the Maximum Moving Dimension (MMD). Hence, the SPV modules and MMS were installed such that it doesn't violate the MMD guidelines. The front- view of the roof-arch of the coach is as shown in fig. Since the roof of the coach was curved, poly-crystalline flexible SPV modules. Since the roof of the coach was corrugated, a flat surface was required to be created along the profile of the roof in order to facilitate stiff and easy mounting of the modules. Hence, a 2 mm thick stainless steel sheet was welded to the crests of corrugates and MMS was mounted on it. MMS was an assembly of Z-frames, rubber sheet, rubber gasket and copper strings. The module was housed inside the module mounting structure. Rubber sheet of the same dimension as the module was placed beneath the module to arrest vibrations of the train. Silica gel was used as an adhesive between the rubber sheet and the SPV modules. Rubber gasket was used to pack the gap between the SPV module and Z-frame. In order to ensure safety of the modules, copper strings fastened across the Z- frame. Hat-shaped conduits were welded to the roof for routing the cables emerging from the modules and these cables were drawn into the coach through the vents provided on the roof for ventilation.

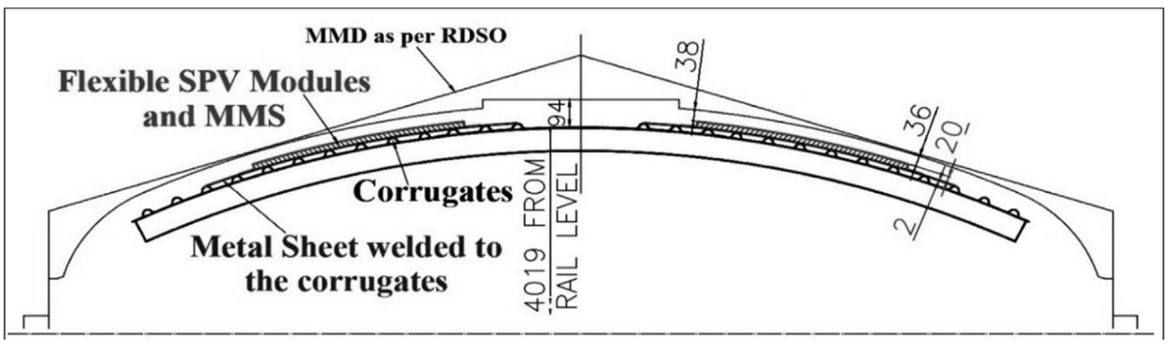

Figure.1 The front- view of the roof-arch of the coach

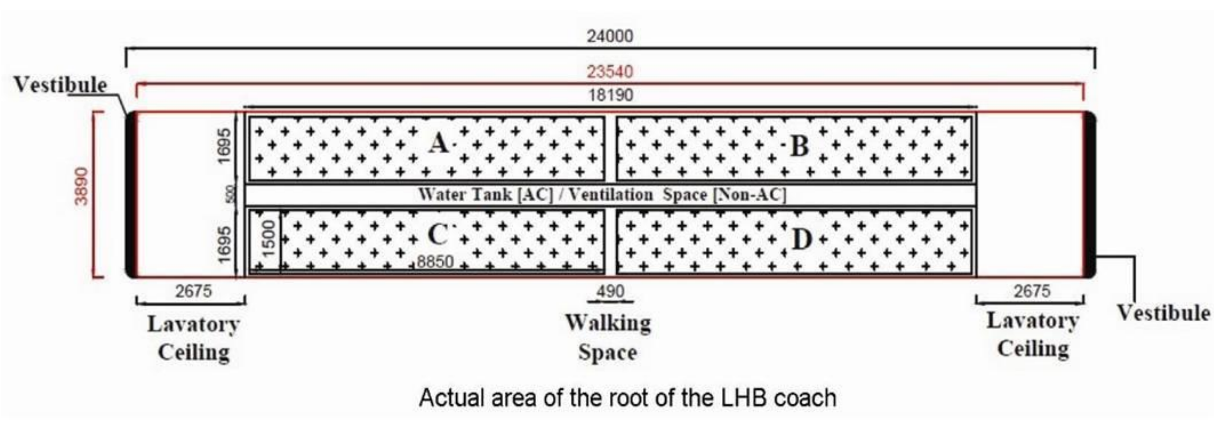

*Figure.**2** Schematic of the top view of a coach with the proposed design.*

To mount solar PV modules on the rooftops, it is vital to consider the dimensions of the coach. The entire area of roof surface cannot be used for installing solar PV modules; there have to be clearances that allow personnel to access the top easily for various purposes and associated auxiliary equipment on the rooftop. This would mean that the actual area that is available for fixing solar PV modules is much less than the total surface area of the roof. For the convenience of calculation, the entire area on the roof of a coach shall be divided into four equal parts separated by walkways, as shown in Figure.

*Figure.**3** Graphical representation of a LHB coach mounted with solar PV modules*

The power generation from solar modules in all the above shown sections are not be the same because it would depend on the time of travel and direction. Since the roof of the coach is curved, installing modules of standard sizes available in the market may not be feasible and would remain a constructional challenge. The power that can be generated from PV modules mounted in the area available on the rooftops is shown in Table. The installation of solar PV modules atop the roof of the LHB coaches would be similar to the representation in Figure.

Electrical loads in variants of LHB coach:

Connected electrical load in the AC coaches: 26 kW

Connected electrical load in the non-AC coaches: 4.6 kW

Connected electrical load in the pantry car: 10 kW

Net electrical load in the rake: 204.4 kW

Net lighting load in the rake (considering 19 coaches, including pantry car): 90kw

IV. CASE STUDY AND RESULTS

As discussed above mounting of pv cells over LHB coaches leads to many advantages. Here we present the case study regarding the theory we discussed by considering 2 train running under Indian railway service

TRAIN NO: 22120 TIRUPATHI DOUBLE DECKER KACHEGUDA-TIRUPATHI

Timing : 06:45-18:15 Distance: 678kms

Duration: 690min Sunshine period: 618min

Average trips of train/year: 104

COACH DETAILS:

Total number of AC coaches	09
Total number of Non-AC coaches	00
Total number of pantry coaches	00
Total	09

AREA:

Roof-top area available on an LHB coach	93.63m^2
Area occupied by air-conditioning units, lavatoryceiling,watertanks, walkways and ventilation vents	31.567m^2
Total available area for mounting SPV modules	61.793m^2
Solar power potential in an area of 1 m^2	154wp
Thus,solarpowerpotentialintheareaavailableontheroof-topofan coach	61.793 X 154 = 9.5KWP
Netsolar powerpotential assuming systemefficiency tobe80% and shaded region as 15%	6.5KWP
Area available on the rake	61.793X9=556.137m^2
Net capacity ofSPV system that canbeinstalled on the roof of the rake	6.5KWP X 9 = 58.5KWP
Yield of the SPV system when the monthly average daily GHI	5.95 X 556.13m^2 =3309.02KWhr
energy consumed by the net load of the rake during the sunshine period of 1 trip	(234 X 618)/60 = 2410.2KWhr
volume of diesel consumed by the load of the rake during the sunshine hours of 1 trip	1014.113liters
volume of diesel consumed by the load of the rake during the sunshine hours of 1 year	105467.5576liters

FUEL DETAIL:

Type of fuel used: HI-SPEED DIESEL

Cost: Rs55/lit

Fuel consumption for 1 trip: 1132.26liters

Cost of fuel consumed for 1 trip: 1132.26X55= Rs62274

Fuel consumed in sunshine period: (618X1132.26)/690= 1014.113liters.

Net load consumed in sunshine hours: (234X618)/60= 2410.2 kwhr

INVESTMENT AND MAINTAINENCE:

Price/watt prescribed by MNRE is Rs90

Net capacityof SPV canbe installedonthe roof-top 58.5KWp Investmenttobedone=58.5 X90X10^3 =Rs5265000

Investment to be done for the curved SPV panels = 30% of actual investment = Rs6844500

Annual O&M cost for a solar plant of 1 kW= Rs1163

AnnualO&Mcostfortheentirerake=1163X9X6.5=Rs68035 Netcashflow peryear=5800715-689035=Rs57326680.166

$$\text{ROI (return of investment)} = \frac{\textit{investment to be done}}{\textit{cash flow/year}} = \frac{6844500}{5732680} = 1.19\text{years}$$

CO_2 EMISSION:

Molecularweightof
CO_2=44 Molecular
weightofC=12

As per consideration 99% of C gets oxidized

CO_2 emissionfor1literofdiesel=733.9498X0.99X($\frac{44}{12}$) = 2664.2379 grams —

LIGHTNING SYSTEM:

In general consideration

Light Output	Light Emitting Diodes (LEDs)	Incandescent Light Bulbs	Compact Fluorescents (CFLs)
Lumens	Watts	Watts	Watts
450	4-5	40	9-13
800	6-8	60	13-15
1,100	9-13	75	18-25
1,600	16-20	100	23-30
2,600	25-28	150	30-55

Considering toreplace the present bulbs with LED bulbs then

Lightning system in AC coach

Total watts can be saved on entire rake= 2664W

Lightning system	Total number of Units	Present used CFC lights(watt)	Total wattage	Replacing with led light(watt)	Total wattage
Tube light	5	25	125	18	90
Tube light	10	40	400	27	270
Lavatory lamp	5	20	100	11	55
Emergency Lamp	6	20	120	11	66
Reservation chart lamp	4	15	60	7	28
		Total	805	Total	509

DESIGN CALCULATIONS:

Connected lighting load in the rake=26.64kw

Lighting load in each coach=26.64/9=2.96kw

Energy during the sunshine period=2.96*(618/60) = 30.488kwh

Multiplying the total appliances kWh for day times 1.3 (the energy lost in the system) to get the total kWh per day which must be delivered to the appliances

Total energy that could be supplied from PV panels = 30.486*1.3=39.63kWh/trip

Power generation factor is used while calculating the size of PV cells, it is varying factor depending up on the climatic condition

For INDIA PGF is 4.32

Total watt-peak ratios (W_P) of the PV panel capacity needed

$$= \frac{\frac{\text{Total watt hour per day needed}}{\text{generation from the PV module}}}{PGF} = \frac{39.63 \ X \ 1000}{4.32} = 9174W_P$$

The system is powered by 36volts, 290w, 72cell PV modules

Number of PV modules needed = 9174/290 = 31.33 (appro. 32)

V. CONCLUSION

In the present work, "ENERGY CONSERVATION BY IMPLEMENTATION OF SOLAR PV MODULES IN INDIAN RAILWAY LHB COACHES", following conclusions can be summarized from the results of study:

- Solar energy can be utilized successfully for the lighting load consumptions in trains
- From this process we can save 17361601.2 lit of diesel per year
- Rs.95.48 cr (954888066) per year that is used for the consumption of diesel can be saved
- CO_2 that is evolved from emission of diesel can be avoided up to 46129.1 tones (46129109.12) kg's and (1962.224676 kg's amount of NO_X can be prevented from emitting helps in contribution to reduce in global warming from our nation
- Wattage that is needed for the lightning loads can be minimized by replacing with LED bulbs

VI. REFERENCES

1. Arsie, I., Rizzo, G. and Sorrentino, M., A model for the optimal design of a hybrid solar vehicle. Rev. Automot. Eng., 2008, 29(3), 439–447.
2. Tindo the world's first solar bus. Adelaide City Council; http://www.adelaidecitycouncil.com/assets/acc/Environment/energy/docs/tindo_fact_sheet.pdf
3. Around the world in a solar air-plane–Solar Impulse, HB-SIA-solar impulse, 2009; http://www.solarimpulse.com/pdf/hb-sia/hb-sia_en.pdf
4. Shravanth Vasisht, M., Sridhar, B. S. and Dhanyavathi, A., Solar assisted power supply system for multi-services in railways. Electrical India, October 2011.
5. Shravanth Vasisht, M. et al., Project thesis on design and development of solar assisted power supply system for multi-services in railways, submitted to VTU, Belgaum, June 2011.
6. India solar resource maps, Ministry of New and Renewable Energy; http://mnre.gov.in/sec/solar-assmnt.html
7. Maintenance Manual for BG Coaches of LHB Design, Research Design & Standards Organization, Ministry of Indian Railway, New Delhi, 2010; www.rdso.indianrailways.gov.in
8. HHV solar 72 cell PV module, data sheet; http://www.hhvsolar.com/PDF/StandardModules/Multi/265_300_wp.pdf
9. Air-conditioning, Indian Railways Institute of Electrical Engineer-ing, Ministry of Railways, New Delhi, 2010; www.ireen.indian-railways.gov.in