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POTENTIAL FOR SOLAR PV ALONG ELECTRIFIED RAILWAY TRACKS IN INDIA

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ABSTRACT

The 100GW Solar Power capacity (by year 2022) target set by Govt. of India needs optimum utilisation of available area for deployment of Solar PV panels. Though land & roof tops are considered as focus areas, area along Electrified Railway Tracks also offer significant potential. This paper tries to assess the potential of Solar PV with solar panels mounted along both sides of electrified railway tracks in India for use as source of power for traction. It also studies the advantages & challenges related to the concept.

1. Introduction (1,2,3,4,13,14,19)

"Railway is naturally a Green mode of transport. We want to make it further Greener by adopting Renewable Energy as a major source of energy for Railways". Shri Suresh Prabhakar Prabhu, Minister of Railways, Govt. of India, said while addressing a conference on Solar Energy opportunities in the Rail Sector.

Indian Railways consumes about 18 billion units of electrical energy per annum for its traction and non-traction applications. Indian Railways, in its endeavour to counter the menace of global warming has targeted large scale harnessing of renewable energy, mainly solar and wind energy, in addition to adoption of energy efficient technologies. Vision 2020 document of the Indian Railways states that a key target is to utilize at least 10% of its energy requirement from renewable sources. Further, in the Rail Budget 2015-16, it has been announced that: "To reduce dependence on fossil fuels, it is intended to expand sourcing of Solar Power as part of the Solar Mission of Railways. Further, 1000 MW solar plants will be set up by the developers on Railway/private land and on rooftop of Railway buildings at their own cost with subsidy/viability gap funding support of Ministry of Non- Renewable Energy in next five years. This initiative of the Indian Railways would go a long way in contributing towards India's 100 GW solar targets under the National Solar Mission.

As per a recent study, following can be possible Solar PV sites for non-traction requirement of energy in Indian Railways

a) 49 diesel locomotive sheds could contribute to a cumulative installed capacity of 26 – 36 MW
b) 40 railway workshops could contribute to a total installed capacity in the range of 175-245 MW.
c) 79.7 MW of solar PV can be installed across 7970 railway stations under the Indian Railways,
d) Capacity of 6.1 MW of solar PV can be achieved across the identified Level Crossing Gates.

The Indian Railways has a large amount of land spread across the various zones. As per the Ministry of Railways, a total of 110935 acres (about 44894 hectares) is currently lying vacant. It is possible that some of this land could be diverted for purposes of setting up solar PV. The Rail Budget 2015-16 indicates that use of railway land is possible for solar PV installations. The Ministry of Railways in a recent report has notified that 100% FDI will be permissible for all solar PV projects installed on railway land. It is understood that Nagpur Metro Rail will also be using solar energy.

This paper tries to assess the potential of Solar PV with solar panels mounted along both sides of electrified railway tracks for use as source of power for traction. It also studies the advantages & challenges related to the concept.

2. **The concept** (11,12)

Indian Railways has been using electric traction fed by 25kV, 50Hz single-phase AC supply fed from the state utilities. The traction sub-stations feeding power to the contact wire are generally spaced 30-40 km apart and they take power from any two phases of the power utility transmission lines. They have an input voltage of 220/166/132/110 kV, which is step down to single phase 25kV using traction transformers. The 25kV is fed to the locomotive through the pantograph fitted on the locomotive.

The Solar PV Power can be utilised for traction as per arrangement shown in block diagram & location drawing given below.

Fig. 1 -Block diagram of Solar PV Power for Traction

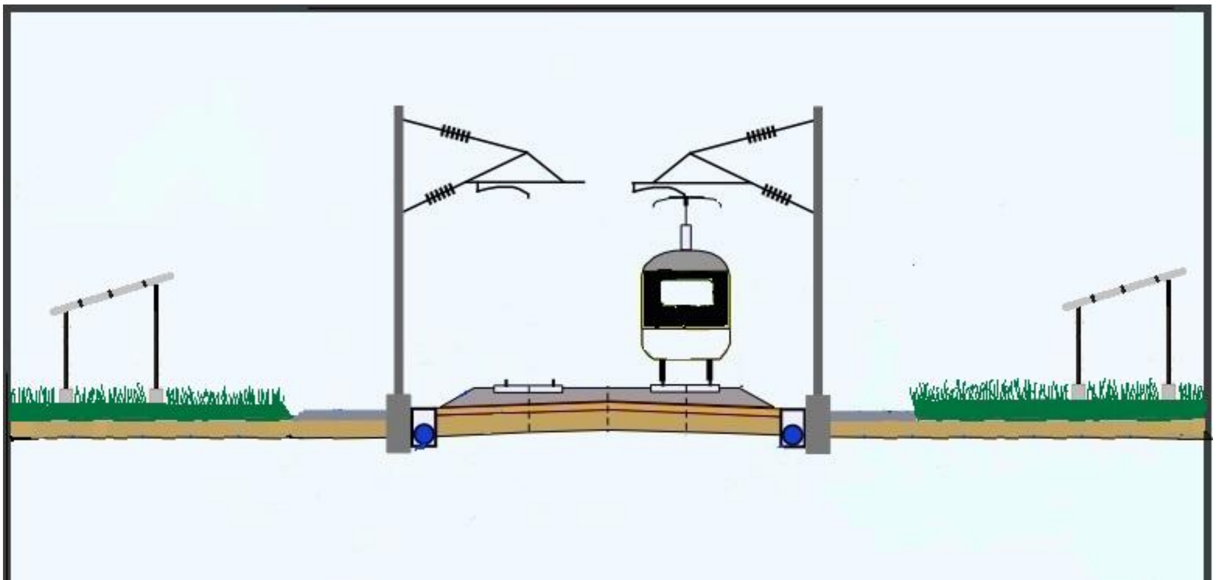

Fig. 2 - Arrangement of Solar PV modules along sides of electrified railway tracks

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The Solar PV modules are mounted on elevated structures along sides of electrified railway tracks & are connected to combiner boxes. The DC power from combiner boxes is fed to Central Inverter & the 380V, 3 phase AC output is fed to the transformer. The 25KV single phase AC output of the transformer is connected to the traction system. Suitable switchgear & protection is employed at each stage as needed. The modules need to be facing south, accordingly their mounting may be parallel or perpendicular to the railway track depending on its direction.

3. Estimate of potential (6,7,8,9)

Considering the space needed by a 300W rated polycrystalline solar pv module to be 2m lengthwise & 1m width wise, a landscape arrangement of 4 up modules gives the number of modules per km on one side of railway track as

(1000 ÷ 2) x 4 = 2000 modules

The wattage per km is 2000 x 300 = 600000 watts = 600 KW

Considering modules installed on both sides as given in the figure above

KW per km route length = 600 x 2 = 1200 KW = 1.2 MW

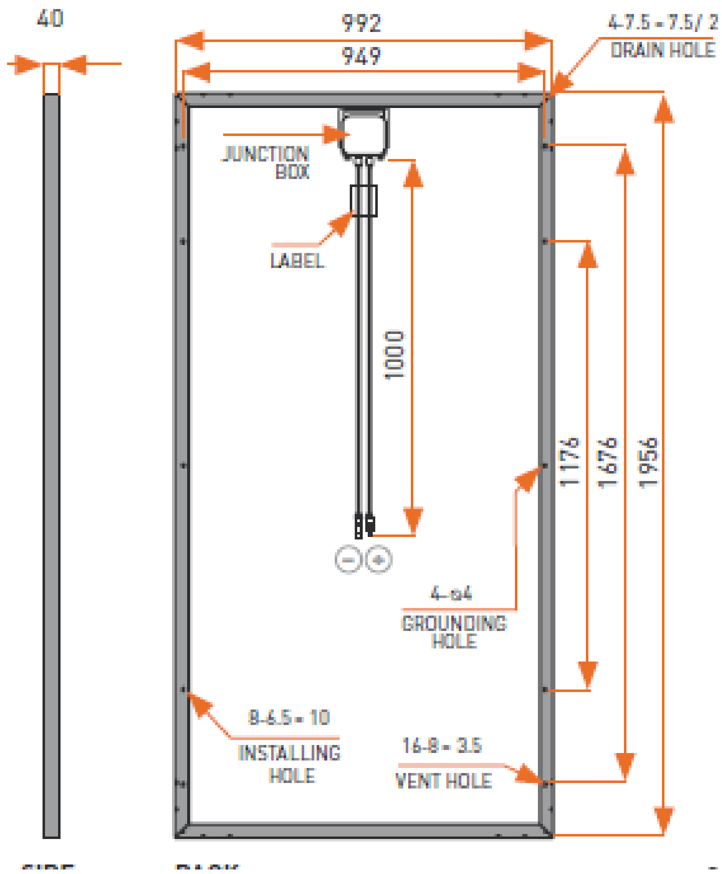
Considering total electrified railway track route length of 26000 km, the MW potential is

26000 x 1.2 = 31200 MW = 31.2 Gigawatt

Since this is DC installed capacity, the AC capacity can be taken as approx 27 Gigawatt considering losses of connected components for evacuation.

As present Solar PV Power Plants in India are generating around 1.5 million units per MW per annum, 27 Gigawatt capacity can generate 27000 x 1.5 = 40500 million units or 40.5 billion units per annum. As railways own consumption is 18 billion units per annum, the excess energy can be fed to the grid & can be a source of revenue. If total route length of Indian Railways of 65000 km is electrified in future, it may have Solar PV potential of more than 60 Gigawatt .

Fig. 3 - Dimensions in mm of a typical 300W Polycrystalline Solar PV Module



4. **Power evacuation** (11,15)

The best way to evacuate the power from solar pv modules on sides of electrified railway tracks is by utilising it for traction as shown in block diagram above. The choice of rating of central inverter can be 600 KW or higher depending on local terrain & existing power supply arrangement. The 600 KW central inverter may cover modules for a length of 600m on one side of track, connected to modules for 300m on either sides of its location. The rating of transformer connected to each central inverter can be selected matching the inverter rating. The DC combiner boxes, switchgear, protection, DC & AC cabling, grounding & remote monitoring will be needed to complete the evacuation system.

Other options for power evacuation may also be considered as per design & safety requirements of the railways with due consideration to AC & DC losses.

Fig 4 - A typical Outdoor Central Inverter

5. Advantages (10,16,17,18)

The advantages of concept of Solar PV on sides of electrified railway tracks are as follows -

1. As per experts in USA indicate "Electric trains are so efficient that a single 300-watt solar panel (about 4x6 feet) can provide up to 7,000 miles of an individual's commuting miles per year, or 5 to 20 miles per day. The national average, based on National Transportation Database data on the efficiency of the various U.S. electric train systems, is about 4,000 miles per year for each 300-watt solar panel." Solar PV for railway traction is one the greenest uses of renewable energy as efficiency of electric trains is much higher than that of electric vehicles on road.
2. It helps railways reduce their carbon footprint as presently power is sourced from coal based power plants.
3. It helps prevent trespass & encroachment near railway tracks. Supporting structure can be fitted with wire mesh.
4. It is a source of power with no threat of increase in input fuel prices in future.
5. Vegetables can be grown on land under the solar panels & water drained from cleaning the panels gets used for their irrigation. Railway land is presently licensed to Group 'C' and 'D' categories of railway employees and weaker sections under 'Grow More Food' scheme, for growing vegetables, crops, etc.

6. Transmission infrastructure & losses are avoided as the power is used for traction at the site of generation.
7. It helps in sound attenuation.
8. It helps in preventing soil erosion near railway tracks.
9. The system requires minimum maintenance.
10. Excess power can be fed to utility grid using net metering.
11. Integration with wind power is easy.
12. Can be expanded to multiple rows where more land is available.

6. Challenges(6,7,11)

1. The system needs to be designed & configured for proper coordination with traction power supply.
2. The supporting structures need to be designed to withstand impact of air draft from passing trains & isolate solar panels from vibration caused by the train.
3. The location of modules needs to be in line with railway safety & operational norms.
4. Combiner boxes & Central inverter need to be selected to ensure minimum ac & dc cable length & related losses while ensuring least number of components.
5. The railway workers who are allocated land under the solar panels must be trained & held responsible for regular cleaning of solar panels with water.

7. Conclusion

Indian Railway has already taken steps towards encouraging Solar PV for its non-traction energy needs. It should also utilise the potential of Solar PV for traction requirement .This potential is at present 27 Gigawatt as estimated above. With increasing electrification of tracks, this potential will grow further in future.. With no requirement for extra land, Solar PV can help railways meet its own requirement of energy as well as feed excess energy to the grid. Even if 50% of this potential is exploited(as found easily possible in a study in UK) , the gains are substantial.

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