BUDUĆNOST OBNOVLJIVIH IZVORA ENERGIJE NA ŽELEZNICI

THE FUTURE OF RENEWABLE ENERGY IN RAILWAYS

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Železnice su pomerile granice očekivanog i ušle u opseg velikog razvoja uz konstatno povećanje kapaciteta, mogućnosti, brzine i pouzdanosti, sa jasnom opredeljenošću da ostave što manji ugljenični otisak. Za krutu železničku strukturu oslonjenu na sisteme koji obezbeđuju vitalno preživljavanje osnovnih funkcija neophodni su stabilni izvori napajanja.

Rad proučava koliko su železnice spremne da se priključe trenutnim trendovima u korišćenju obnovljivih izvora energije kao što su energija sunca i vetra, razmatra kurs razvoja i ukazuje na napore koji se čine da se usvoje principi čistijeg transporta.

Ključne reči: *obnovljiva energija na železnici; energija sunca; energija vetra; čistiji transport*

Railways have shifted the boundaries of expected and entered the scope of great development with a constant increase in capacity, capabilities, speed and reliability, with a clear determination to leave as little carbon footprint as possible. A rigid railway structure relying on systems that ensure the vital survival of essential functions requires stable power sources.

The paper studies how ready the railways are to join trends in the use of renewable energy sources such as solar and wind energy, considering the course of development and emhasises the efforts done to adopt the principles of cleaner transport.

Key words: *renewable energy railway; sun energy; wind power; cleaner transport*

1 Introduction

The main advantage of railways in the emerging new world leaning towards green, sustainable and renewable is its comparatively small CO2 emission. The transportation sector while increasing in capacity is strongly advised to migrate towards rail, governments advising even passengers to use mostly rail transportation. However, this is only valid for electrified rail lines and it still raises the question where did the energy for it came from? If this energy is not clean could the electrified rail transport really be considered as clean, also?

In order to avoid ambiguities, several approaches are made to make rail greener and even the smallest changes made these days are sifted through the green approach principles. Saving of kW even are not neglected, thus contributing to lasting effects [1-4].

The directions being set for the future involve primarily the source of energy itself, migrating to solar power, wind generated power even hydrogen. Second direction is based on multiple small changes amounting to decrease of used energy, reuse of it and perhaps effects that are not seen at the first glimpse. Third direction will be the last to catchup this *green train* and is related to storing of energy, relaying on technology currently being developed.

2 Energy sources and storage

International Union of Railways (UIC) is aiming for sustainable mobility [4]. One of the most interesting projects worldwide using renewable energy sources in rail transport are perhaps Netherlands Railways project providing all-electric trains with 100% renewable energy (RE) achieved in 2017 before its due date [1], also India using solar power for rail transport, even planning to generate that way up to 266 GW [2]. But what will make the main changes are correlation within the government mindset changing the national regulations and bylaws, making RE and Energy efficiency (EE) a must and coupling various sectors to make it happen quickly and reliably.

Mostly the energy is expected from solar power plants and wind power plant, with the main issue being the instability of the power generation. This calls for energy storage as a backup in cases when RE do not provide enough for current need of the system. Storage units mostly used are batteries, flywheels and electric double—capacitors [3].

2.1 Renewable energy systems and elements

Solar power is widely recognized approach and it spans from rooftops, to areas around rail line being covered with photovoltaic (PV) systems. Solar and wind power plants depend on climate and region and are not always an acceptable solution. But these are still the number one solution because of its harvesting power. As mentioned before India is doing the major turn by covering so many stations (some 900). The India is covering its unused land with PV systems increasing the part of RE energy consumption. Not stopping there, they also use wind energy.

The positions of solar and wind plants could be in some way constrained by area of installation. Over the years many variants of RE elements appeared: RE on buildings, on rolling stock, etc. So, since the number of these plants and elements is increasing the UIC proposed some options for classification of renewable energy systems (fig.1).

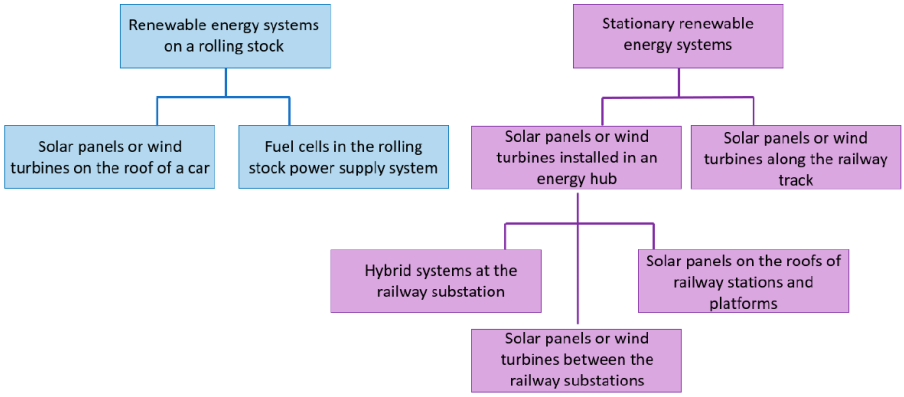

Figure 1. Rolling stock and building RE elements [3].

One of the solutions currently being used utilize the solar panels on the roof of the train, so the energy is provided in situ. The countries with high insolation could benefit from this solution [5]. Compared to India case [5] our country has smaller GHI (Global Horizontal Irradiance) index – 1.1 kWh/m^2 in the north and to 1.7 kWh/m^2 in the south during January and from 5.9 to 6.6 kWh/m^2 during July [6] figure 2. This implies that during reconstruction of railway lines roof solar panels for the stations could be a good start for a turn towards RE.

Here is a simple example of calculation for such roof solar panels production of clean energy – if a railway line has some 20 stations, with the average of 10 hours of sufficient sunlight (H), some 10 solar panels (N) per roof and 300W of power per panel (P_P) it amounts for: $H \times N \times P_P \times 0.75$=10h × 10 × 300W=22.5kWh daily. The ratio of 75% is taken to make it more realistic (if not all standard conditions have been met). Of course, the sufficient number of sunlight hours is also for discussion and could vary. But even half of the number calculated for 20 stations is not neglectable, and in some cases stations having additional buildings this number could increase. The same could be met for newly build green field locations along the track accommodating various equipment. Since the latitude of building doesn't vary much along the lines the major influence on efficiency

could be related to surrounding objects (buildings, trees, etc) and the overall position of roofs. One of the obstacles are the mindset of people setting the design prerequisites (terms of reference). For all the reconstructed lines designs lean towards the well thought out solutions, which doesn't change much from station to station, or along the line. The true impact on efficiency in these cases could be the shift to a green mindset that would establish the point of view through which all the solutions could be sifted. Since the aim is to generate and not to only be a passive user of power perhaps the multiple test sites could be set, for solutions' tryouts. Railway certainly don't lack in areas it could test such solutions.

Figure 2. Serbia's Global Horizontal Irradiation (GHI), average annual sum, period 1994-2013 [6]

Wind plants could be found in various sizes but perhaps the most interesting is a variant on cars (figure 1). Wind turbine system on rail coach for electricity generation [7] include one or more open source wind turbines coupled to one or more coaches of the train. Wind turbines generate mechanical energy when the train is moving. System also include generator(s) to convert mechanical to electrical energy, as well as storage devices [7].

Besides solar and wind the true new renewable is a system proposed by Greenrail [8]. The sleepers made by Greenrail are acting as energy generators. Since sleepers are unavoidable part of the track their overall presence is a nice solution for distributed source. Sleepers are usually made by concrete, but in this case the sleeper is made from recycled materials including even a mini solar panel. The pressure made by passing trains is also converted into electric energy and thus the company claims it could provide some 70kW/km for 20 trains (per hour). It is jet to discover how much impact this solution could have but knowing that there are some 1600 sleepers per km it is worth a try. Another good angle is that this sleeper is made of end of life tires meeting the sustainability axioma. The number of years is 50 for these sleepers and another good fact is that even then it could be recycled again. Perhaps the best of all is that they will cost 15-20% less (per km of rail track) than traditional sleepers [9].

3 Small changes make a big impact

Sometimes a change could seem redundant or insignificant but in the long run a pool of such changes could amount for a great impact. Here just a few will be presented. Even these do not seem so small to Railway managements during various procurement processes since these changes usually mean greater prices. However, the green statements should be the integral part of all terms of reference, stating clearly mission statements of railway and commitments made [10].

Regenerative breaking is a braking process used by electric motor, acting as a generator during speed decrease. Kinetic energy transforming to electric thus a new source of energy (not just dissipated) could be used as an addition returning to the power distribution system. But, not just electric but hybrid trains could benefit from regenerative braking systems. This system is used in both metro and major national lines and is a standard in new trains, also included in new high-speed trains. This is especially interesting because now most cars have their own electric motors, not only the locomotive. The best impact of regenerative braking is expected on air quality (i.e. diesel locomotives, marshaling yards,..), but only limited in longer freight trains. New Delhi is now famous in rail circles because of its earned *carbon credits* for regenerative braking system, cutting back on energy use of the trains by about 30% [11].

The eddy current breaks also could have some environmental impact since they need no interaction between the braking elements thus prolonging the lifecycle of brakes. This is a way to reduce wear and tear and potentially some CO_2 in production.

The digitalization brought reduction in paper use, but the true aim is to achieve net zero (CO2 emission). The digital sector with such increase and 4% of global greenhouse emission must be a part of rail RE pathway. The use of digital technologies could bring the 20% reduction of the 2050 projection (to achieve net-zero for energy, materials and mobility). This implies that the percent of digital in overall emission will rise. Since the speed in railways brought distributed data centers and various equipment along the tracks this means that telecommunication systems are an issue to be rethought.

IT data centers, a massive energy consumption points, with ever changing structures and devices need to be sustainable. The equipment which is intensively used and changed fast must be chosen wisely and with energy efficiency in mind. Virtualization and the use of SSDs (solid state devices) cut down the power consumption (approximately by half) in currently reconstructed data center of Infrastructure of Serbian railways, in Belgrade. The fast-growing data centers will be able to provide heating, thus using the dissipation as a benefit [12].

4 Conclusion

Energy efficient entity such as railway could only be made with good and principled planning. Some of the long existing sectors will be reinvented trough this EE revolution. Railways are lucky having different aspects that could help. The solid and significant infrastructure, different professions and fields that could benefit new approaches, and head start being the low CO_2 emission solution. Solar, wind generated power, stationary or dynamic, distributed or located in smaller areas, all could benefit the net sum of railways.

Since more than 10m left and right from the tracks is railway property testing more than one possible solution could provide a right direction suiting our country. Greening the designs and seeing them trough to implementation and commissioning is a first step for increasing the efficiency and sustainability (providing increase in efficiency by considering microlocation solutions). Only the operation could provide additional information for setting the right systems, but to get there perhaps the right course is to try as much as possible systems. This will involve people on maintenance and implementation to learn through various tryouts, providing empirical data. Current reconstructions are happening too fast for a true feedback providing reliable information about adequate solutions.

In the end it is necessary to remind that the true changes begin in the minds of people. Beside the management processes, technical development and research the true power is provided with training and motivation of people. So, including the new RE processes in railway, generating the needed power in desired way and empowering people is a trio that is expected to provide the best outcome.

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