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Comprehensive Analysis of Electric Train Energy Consumption Modeling to Ensure Environmental Sustainability

Rudra Bhanu Satpathy[1], Subhrajyoti Ranjan Sahu[2]

[1]M. Tech, ECE, St. Peter's University Chennai.
[2]B. Tech, ECE, Nalanda Institute of Technology, Bhubaneswar.

[1]rudra@gmail.com, [2]subhrajyotiranjan@hotmail.com

Abstract **- The energy consumption of electric trains is considering the efficiency of regenerative braking for the support of the system of rail simulation. Furthermore, the energy recovery reduces the overall consumption of power, and the railway department is trying to capture the energy consumption that is totally associated with the operational parameters, train routes and several trains. The railway department is transiting the overall backbone of transportation systems that are sustainable in nature that can be necessary for limiting the effects of global warming. The railways' department is also trying to establish the renewable resources such as solar panels, electric power plants and many more. The methods of energy consumption within the railway transportation are compared to other systems for the cost and the precisions. Therefore, the main use of the energy consumption is totally associated with the department of the railway for maintaining the overall sustainability-related with eco-friendly environment.**

Keywords— Solar panels, electric power plants, eco-friendly environment, sustainability

Introduction

Environment sustainability is aiming at enhancing the quality of people's life without providing unnecessary strain upon the supporting ecosystems of earth. It can be considered as the creation of equilibrium among consumerist culture of people along with the living world. Environmental sustainability provides several advantages to the globe, and it also diminishes energy-oriented prices, attracts the latest consumers, and enhances sales rate, boost innovations including that it also puts greater impact in society. Utilizing and consumption of electric trains can be considered as environment friendly rather than diesel powered trains. In this research paper, in case consumption of electric train energy is effectively providing environmental sustainability or not, this will be critically discussed.

Advantages of electric train energy consumption

Electric trains have the ability to diminish carbon emissions in comparison to diesel powering trains, though only in case power generation mixture is not dependable upon fuels with higher carbon content, basically that is known as coal. This overall research paper is trying to develop an electric train-oriented energy consumption modeling structure in consideration of instant regeneration decelerating efficiency in terms of supporting a railing stimulation system (Wang and Rakha, 2017). The transportation sectors have become the main customer of energy along with that developer of ***GHG emissions***. More specifically, transportation-oriented energy utilization has estimated for ***27% of the overall globe basic energy consumption*** including that generated 34% of greenhouse gas that is CO_2. The increasing attention in terms of environmental sustainability regarding transportation systems created significant opportunities to investigate the chances of energy optimization more in these sectors particularly characterized through an already ***higher level of sustainability***, more particularly in railway stations.

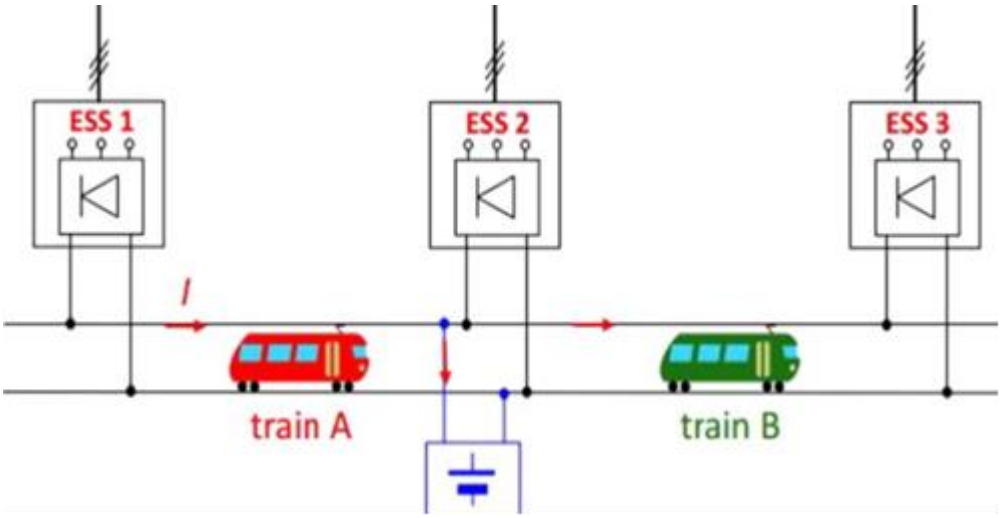

Figure 1: Model of electric train

(Source: Wang and Rakha, 2017)

Electric power trains are having a great estimation of benefits over those diesel engines. Electric trains provide more environmental sustainability, quicker acceleration, ***generate less CO_2 emissions*** including that they are lighter, and lower fuel prices as it explains that it generates less wear upon tracks. As including several of electric conveyances, there are several important cuts in the ***CO_2 emissions*** at the time of utilizing electric trains systems as opposed to that diesel ***or else steam driving trains pollution*** through the trains itself is mainly zero (Al-Thawadi*et al.* 2019).

Moreover, electric trains' consumption would be beneficial as it has less energy efficiency including lower maintenance prices that in turn might lead to less expensive train tickets (Shinde *et al.* 2018). Consumption of electric trains can be beneficial as electric trains naturally emit ***20 to 35% lower carbon*** than other diesel trains and an electric train is more environment friendly, basically electric trains that are powered through ***renewable energy*** including that it offers ***free carbon journey.***

Challenges faced by railway department in maintaining sustainability

In the current scenario, the railway system is playing an important role in the transportation system of India. In addition, there are advanced and interesting developments in the railway departments. It is much more justified because the railway ministry is trying to develop the transportation system by using battery or hydrogen trains and start the main art of digitalisation. The transport planners and decision-makers can be the more effective craft for the strategic decision and several priorities that provide sustainability to railway departments (Shinde *et al.* 2018). For the upcoming future, technology is becoming a significant part of sustainable and better railway systems.

Furthermore, the most significant role of the railway system in rural, suburban, and urban passenger transport is the overall sustainability of the total transport system. Apart from that, as the greenest and cleanest high-volume transport, the railway system is playing a vital role in creating economies and sustainable lifestyles. Sustainable development is the most important factor for the economic growth of the railway ministry and this ministry should take employment opportunities and best initiatives for maintaining sustainability (Ramya and Devadas, 2019).

The main challenges that are faced by the railway department such as the operation and construction of the railway department have degraded, destroyed, and fragmented the overall ecosystems. In addition, it also destroyed the habitat; land degradation occurred and increased soil erosion during construction.

It also affects the wildlife movement, water bodies and many more. The railway department is having a sustainability management-based life cycle for the turnout system of railways and they are trying to maintain the effectiveness and efficiency for improving the overall sustainability (Kaewunruen and Lian, 2019). Therefore, the department of railways to sustainability is it provides several efficient services, transfer the traffic from the roadways and offer the real alternatives for fewer modes of sustainable transport.

Advantages and impacts of electric train energy on environment sustainability

The system of the railway is dynamic and complex, and they are part of the broader and larger transportation system. The environmental impact of the railway transportation system is always compared with the roadway and also with air transport. In addition, the main environmental impact of several trains is totally compared by summarising the analysis of life cycle. On average, the railroads are much more fuel efficient than the roadways vehicles such as trucks. The most important technology of railway systems comes from the recovery of braking energy and the braking energy of the railway system is then recovered

within the storage systems for maintaining sustainability (Ceraolo *et al.* 2018). The movement of freight by the railways instead of the trucks can lower the emissions of greenhouse gas and that is also up to 75%. The railway transportation is an environmentally friendly transportation system as it is easier to travel from one place to another. Furthermore, for this, the emissions of greenhouse gases per kilometre on the railway transport are about 80% less than the roadways transportation.

Sustainable development can be increased in the railway department by planting more and more trees, nurturing the biodiversity on the rail land, reducing several wastes within the supply chains of railway networks. In addition, developing the long-term strategies for improving the resilience of the railway network within the face of the climate change and by this, the department is trying to maximise the overall contribution of the railway passengers. The environmental impacts are much higher for the fuel technology and for that the powertrain technology is used to reduce the emissions of greenhouse gases (Sharma and Strezov, 2017). The economic cost of the electric vehicles is much higher while the technology of the powertrain cost is lower as they are eco-friendly.

Materials and methods

The energy consumption of electric trains can be done by establishing sustainable energy resources such as solar panels, by establishing electric power plants on the trains. Furthermore, the electric locomotives that are having higher efficiency from the electric motors are helping in the consumption of energy resources. In addition, the power might also come from renewable and clean resources such as geothermal energy, solar power, hydroelectric power and many more. The comparative analysis is done for the environmental impact that is affecting the eco-friendly environment and a recovery period is taken to improve the overall impact (Gao *et al.* 2019). The trains are using steam power, electric and diesel fuel and the electric power is mainly utilised for maintaining the sustainable development. The trains that have the electric propulsion usually consume the energy that is being produced as several kinds of electric power plants. For determining the overall pollution through the air, the production of electric power and the overall energy consumption is done and by this, the production of electric power is much more decisive in nature.

Result and discussions

In this overall research process, major benefits and impact of utilizing electric train energy consumption modeling and in case it is providing environmental sustainability or not is a major part of discussion. Ultimately, through the overall research discussion it can be stated that electric train consumption is more beneficial than using diesel trains. Environment sustainability is the major concern of people and consumers are more concerned about the transportation that is environment friendly (Ceraolo *et al.* 2018). Throughout Indian railway transport, it can be recognized that electric trains are more environmentally friendly forms of transport. In addition, GHG emissions per traveler kilometer for railway transport are normally up to five consecutive times less than that of car conveyances. Deduction in fossil fuel-oriented dependency has been continuously an issue globally for numerous years (Balali and Stegen, 2021). On the other hand, results naturally show that railways have a significantly less energy footprint than passenger cars along with trucks. Passenger railway is basically three times greater efficient rather than a car upon a passenger mile basis at recent occupancy levels.

The less energy consumption of electric trains is leading towards a less greenhouse gas emissions. In the year of 2017, numerous measures have been taken in terms of becoming more sustainable, environment friendly and efficient. Utilization of solar powered oriented diesel electric trains would be beneficial in terms of becoming more environmentally sustainable. Few years ago, railway departments launched a solar powering diesel electric train, through the Safdarjung station that is situated in Delhi (Vujanović*et al.* 2021). Railway sectors have utilized 16 solar panels, separate of them generated 300Wp and this is included in the portion of planning of the Indian railways in terms of promoting renewable and clean energy. This overall process supported the Indian railway to save the Indian railways up to 5.25 lakh liters of diesel per each train in later 25 years including those three crores each train in the equal time frame. Consumption of this is equally environmentally sustainable as it supports the reduction of 1,350 CO_2 emissions from each train in the next 25 years. In Indian railway electric train consumption rate is high as it generates low carbon emissions.

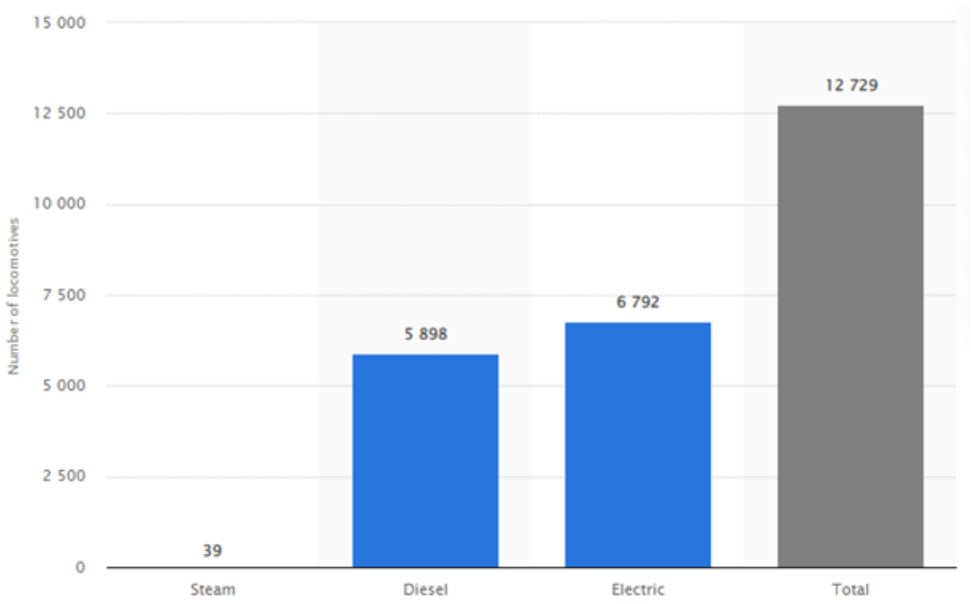

Figure 2: Electric train in India

(Source: Sun, 2021)

Future scope

The Indian Government needs to take numerous measures in terms of making electric trains more sustainable. Consumption of Solar power facilities would be beneficial in terms of making electric train more sustainable. In order to make electric trains more sustainable it is necessary to adopt practices of energy conserving and installing new forms of green technology can help in making the environment more sustainable (Liu *et al.* 2018). The Indian Government needs to provide more money and take measures in terms of reducing carbon emissions. The Indian railway minister is primarily planning to have 1000MW solar powering procedures by 20250 and 2021. This move would support Indian railways in sourcing nearly 10% of electrical energy through renewable sources. Indian railways are continuously trying to take green initiative and the Minister is trying to provide 71.19MW of solar plants that have already been installed (Nag, 2019).

Conclusion

Environment sustainability is the major concern of every passenger along with that the Indian Government is continuously trying to take better effective measures in order to make electric trains more sustainable. The Indian government has also taken several measures such as electric power plants and solar panels in terms of making electric trains more sustainable. Electric trains generate lower CO_2 emissions than diesel trains and it also produces less pollution therefore, it can be stated that electric train consumption would be beneficial for environmental sustainability.

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