Case study: Solar electric vehicles in India.

Mamta L Prajapati¹, Prof. (Dr.) P J Gundaliya², Dr. Anal Sheth³

¹T.F.G.Polytechnic Adipur Kutch, 370205, India
²L.D.Engg. Ahmadabad, 380015, India
³CEPT University, Ahmadabad, 380009 India

Email id: mistrymamta23@gmail.com
Email id: pjgundaliya@ldce.ac.in
Email id: anal.sheth@gmail.com

Abstract. Over exploitation of fossils fuel to meet humans luxurious in present day life has created imbalance in the ecosystem so to have a balance “Green revolution” is required. It means that there is need of using renewable energy resources instead of non-renewable energy which do not harm the environment and also does not contribute in increasing carbon footprint. In context to this each and every sector in the world is adopting alternative resources (renewable energy) to reduce somehow the degradation of environment so that the ecosystem can be balanced and healthy livelihood is achieved. Seeing the condition of the global environment many researchers are attempting to find technological advances which can efficiently transform this renewable energy into mechanical energy in that they have succeeded India has abundance of resource of renewable energy; amongst them solar energy is available with minimum limitation and in abundance. If transportation sector shifts to renewable energy utilization, a good amount of greenhouse gases(GHG) can be minimized. This paper exemplifies the cases of solar electric vehicles including solar cars, solar e–rickshaws, solar tricycles, solar buses and solar vans, that have been successfully implemented in India. These examples demonstrate that the solar electric vehicles can transform a future scenario on a larger scale for India and also other countries.

Keywords: Renewable Energy, Solar Energy, Eco-System, Electric vehicles

1. Introduction

Our existence depends on energy; without which our sustainability might not exist. Energy is an essential view to individuals’ life and is also a key requirement for various sectors, including agribusiness, transportation as well as for industrial exercises that are imperative to the social and financial development of each nation (F.M.Uhammad-Sukkiet al., 2012). A country’s development is directly related to its transportation infrastructure. A majority share of the world's oil request is for transit (Richardson, 2013). With ever increasing population, transportation demand in India has also increased. The demand for energy is growing day by day world-over. After the oil crisis in 1973, there is a global movement to resort to alternative sources of renewable resource apart from conventional resources such as coal, gas and petroleum (Salunke et al., 2017). Due to good earning, comfort, door to door facility and
user friendliness, many people choose private transport mode which has resulted into increase in numbers of vehicles that are driven by fossil fuels. The move towards privatization of transport mode has resulted in increase in air and noise pollution in India. Even when considering public transport, present day in India it utilizes petrol, diesel, etc which cause a worry for unclean natural and energy security (Sheth and Sarkar, 2017).

2. **Renewable energy and Environment**

The government bodies’ panel on climate change has predicted that the GHG emission could ascend by 25–90% by 2030 in contrast with the year 2000, and the Earth could get hotter by 3°C this century. Indeed, even with a little ascent in temperature of 1–2.5°C, it could actuate genuine impacts, incorporating diminished harvest yields in tropical territories prompting expanded danger of craving and spread of different diseases (Adheesh, 2016). Solar based Electric vehicles (E Vs) are one of the most encouraging innovations in the transportation division to decrease GHG outflows in the post-2020 time period (IPCC 2012; IEA 2013). Further, according to the IPCC the transportation division is blameworthy for roughly 23% of CO₂ emission on the planet. Every single area has utilized electricity as the principle wellspring of energy. As indicated by the focal electrical position 2014, Service of intensity, GOI, India lattice is profoundly dirtied with 950 Gco₂/Kwh contrasted with different nations on the planet (Sheth and Sarkar, 2017). Thus it is being realized that the consumption of renewable energy is vital and necessary. Researchers have found out various new technologies to deal with it and many positive findings have been revealed. India's GHG emission from transportation has ascend from roughly 80 million tons for every year in 1994 to around 119 million tons for every year in 2000. In 2004, the transportation sector in India contributed around 8 percent of the nation's energy based GHG emission. Around 90 percent of these were from street transport, contrasted with a worldwide normal of 72 percent. As compared to other countries, India is far away in utilizing renewable energy. To reduce the pollution level and to balance our ecosystem, there is need to prioritize renewable energy, especially in public transportation sector. India's promise under the Paris Understanding is to decrease the carbon impression of its economy by 33-35% by 2030, when contrasted with the 2005 levels (www.investindia.gov.in). Different positive effects can be expected from the presentation of EVs, including proprietor vehicles working costs, decreased CO₂ discharges.

India was the primary nation on the world to set up a Service of renewable power source asset in mid 1980. Various renewable energy resources available are solar energy, wind energy, hydropower energy, geothermal energy, biomass energy, etc. From point view of renewable energy resources, India has vast energy resource potential especially that of solar energy. Conversely, hydropower, biomass and geothermal energy have been developed for a considerable length of time, and five year development plan for these inexhaustible renewable solar energy were equivalent with traditional energy (fossil fuels). Smart grid technologies have proved a cleaner energy flexibly that is progressively effective, affordable and increasingly feasible (Ellaben et al, 2014). Conventional energy is popular because of ease of utilization and availability. Exploitation of conventional energy resources has come to that extent that these are getting scarce and on verge of extinction. But recent developments in replacing conventional energy by renewable energy are gaining importance. For example, in a small scale to investigate maintainability through utilization of renewable energy source in the vehicle division demonstrates that solar energy based electric transports can give as equivalent to diesel based transport with help from GOI in type of subsidy. (Sheth and Sarkar, 2017)

3. **Innovative developments in solar transport**

Alternative vehicles advances, for example, electric vehicles (EVs), are being acquainted with diminish the world's reliance on oil for transportation and breaking point transportation related CO₂ emanations. Richardson (2013) has likewise noticed that the non conventional energy sources are being created and to
replace petroleum based vehicles, reducing ozone depleting substance emission just as the outflow of different toxins, for example, nitrous oxides (NOx) and sulfur dioxide (SO2). In future, upgradation of technology may reveal more efficient and economical technique in the market which may be more appropriate in terms of techno-commercial feasibility.

Rand (2009) observed that innovation in solar car have done a lot and now it is no longer a curiosity. As encounters and results of the World Sun powered Test, the vehicles are assuming a significant job in spreading out the advancement of battery-powered battery innovation, and in giving both a feature and a proving ground for the most recent advances. Rose (2011) observed that E-bike innovation is developing and there is proof that an expanding scope of light electric vehicles will challenge the obstructions which are utilized to define vehicles that are classified as 'bikes'. While the heft of the current market for these vehicles is ruled by China, there are indications of developing deals in different nations. Improving battery innovation, alongside creative item configuration, is probably going to bring about a progressively different scope of vehicles, with lower weight and improved execution. A study by Devan et al (2020) dwells upon a tricycle used by physically challenged persons. A tricycle is a three-wheeled vehicle driven by human-powered. Discussing of this work, an eco-friendly motorized tricycle operated by solar cells was developed for disabled people to enable them to drive without much effort. As a result of this, the GHG radiation is also get rid of and the operational cost is minimized. Thus, the solar-powered tricycle is both eco-friendly and advisable. Across the world countries such as Malaysia, America, UK and Malta are giving huge subsidy to individuals when they register for electric vehicles (EVs). Many cities in India like Ahmadabad and Hyderabad have also successfully implemented EVs.

4. Developments in solar transport in India

Similarly, there have been many innovative developments in the sector of solar transport in India as well. This section illustrates some case studies of such developments in India.

(a) Solar buses:
According to study by Naiket al (2019), the capa-buses (super capacitor), the electric vehicles have been worked alongside the electric transports to investigate the electrified transportation structure in the Guwahati city. The proposed framework is reasonable for different circumstances in all the periods of a year. The benefits that the Guwahati city gains, by the usage of the proposed framework are (a) the diminished activity of inside burning motor vehicles in urban areas and therefore the improved air quality in city district and (b) the advantage to the basic resident to participate in decreasing carbon impression based transportation framework in the city.

Students at Lovely Professional University have developed India’s first driverless, solar-powered bus. The vehicle was showcased at the 106th edition of the Indian Science Congress (INC). The driverless bus uses renewable energy that is delivered with an electric motor and solar power. With this set up, the bus can manage to reach a top speed of 30kmph and can transit up to 70 km per single full energy. The bus has a capacity to seat 10 to 30 people. (Source: https://www.financialexpress.com)

(b) Solar train:
Indian Railroads on July 14, 2017 started first solar based fuelled DEMU (diesel electrical numerous unit) train from the Safdarjung rail line station in Delhi. The train runs from SaraiRohilla in Delhi to Farukh Nagar in Haryana. A total of 16 sunlight based boards, each creating 300 Wp, are fitted in six mentors. The sunlight based boards achieve out 17 units of intensity in a day which empowers the lighting framework in the mentor. As of now solar oriented boards are introduced on non-air conditioning mentors as it were. By sparing an approximated 1.2 lakh kilo liter of diesel consistently, the railroads spare a use of INR 672 crore for each year. The sunlight based force likewise helps in limiting 2.7 lakh huge amounts of carbon dioxide outflow every year. (Source: https://economictimes.indiatimes.com)

(c) Solar e-rickshaw:
“ElecRic”, an electric rickshaw model launched in Bangalore in 2016, runs on solar power, has zero-tailpipe emissions and is available at a nominal price of INR 2 lakh. The model has a range of 110 km with one full charge that takes about five hours for charging. The maintenance cost of the solar electric rickshaw is estimated to be INR 1 to INR 5 per km. (source: https://economictimes.indiatimes.com/)

(d) Solar car:
In 2013, the “e20” model of electric car has been launched by Mahindra group in India in order to meet the company’s “5es” framework: Clean, convenient, connective, clever, and cost effective. The car can be charged via a common 15 ampere outlet, or using solar panels. Many other electric car models from various manufacturers have entered the market to boost sustainability benefits.( source: https://www.businessinsider.in)

(e) Solar van/taxi:
Individual small scale efforts have also been recorded such as attempts by Chitre (year) from Nagpur to convert his regular car to a solar-powered one. With 25 years efforts to perfect the innovation, the e-vehicle has so far travelled a distance of 3,500 kilometres hassle-free. (Source: https://www.thebetterindia.com)

In context to promote, the government of India is launching many schemes to promote use of non-conventional energy. Seeing the vulnerable condition MHRD has announced extensive use of solar energy (to an extent of 100 GW) and has declared various subsidy in residential, agricultural and industrial sectors; as a response of which good initiatives are being taken by various private companies to use solar energy resulting into good saving in sense of economy as well as environment. Jawaharlal Nehru national solar mission (JNNSM) launched in 2010 is one of the promotional policies, under nationwide action plan on climate change (NAPCC-2008). Until today, under the spotless advancement system, nine tasks were started in India's transportation area concentrating on the development of new patterns in transport including the electrical vehicles, mode shift transportation, and clean petroleum derivative based, and so on. (Nallapaneni et al, 2007)

5. Conclusion
India has abundant potential for solar energy due to its tropical region that is why the concept of solar based electric vehicles can be optimistically taken forward for wider implementation. This paper exemplifies the cases of solar electric vehicles including solar cars, solar e–rickshaws, solar tricycles, solar buses and solar vans, that have been successfully implemented in India. These examples demonstrate that the solar electric vehicles can be a future scenario on a larger scale for India and also other countries. The innovative use of solar energy in transportation can lead to socially, eco-friendly and many other benefits thus leading to a sustainable system.

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