



Analysis of Indian Scenario of Solar Powered Electrical Vehicle Charging Stations.

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ABSTRACT

In India the electrical vehicles are booming due the government agendas toward the sustainable solution for the current power generation. At the current state the most of the vehicles are charged in the house through the grid but if EVs are looking for the more reliability the range of the must be very long. For this situation the EV charging stations must be developed in the India. Currently the demand of the charging stations is increasing as the EVs are rapidly increasing. At the other hand the Indian Government is pushing the policy of green energy and the look forward to the reduce the energy dependency on the fossil fuels. Solar powered EV charging stations are be the solution for the increased electricity demand for the EV charging Stations. The solar powered EV charging stations infrastructure presents a promising solution for the sustainable transportation. This study presents the current scenario of the charging stations which are solar powered.

Keywords: Electrical Vehicle, Solar Generation Technology, Charging Station Infrastructure.

1. Introduction

As we aiming to reduce the greenhouse gas emissions, we must reduce the usage of the gas or fuel based automotives. The solar powered Charging stations not either the reduce the greenhouse gas emissions by increasing the reliability on the EV, but also reduce the fuel which required for the generation of the power using conventional methods. Currently the global energy sector is witnessing a revolution towards renewable energy sources, Solar power is leading in this transformation [1]. By 2030, India is expected to have 102 million EVs, which would need 2.9 million public charging stations. Solar-powered EV charging stations are a promising, eco-friendly and cost-effective solution, with many benefits for the consumer, economy and India's climate goals. With India's potential to generate 749 GW of solar power [2], which is more than the country's current installed capacity, this is an untapped opportunity which is slowly gaining momentum. A study by The Energy and Resources Institute (TERI) shows that the per-unit cost of electricity generated from solar panels ranges between Rs 2.50 to Rs 3.50, (which will be significantly lower by 2030) whereas the per-unit cost of electricity from grid power ranges between Rs 6 to Rs 7. So, the Solar powered charging points are way more economical and environment friendly than the grid powered charging stations.

2. EV adoption in India

The Indian EV market stands between the top ten EV markets in the world. The government of India is Promoting the Electric vehicles by introducing the various schemes. Subsidies under the FAME scheme, tax exemptions, and the increasing awareness of the need to reduce air pollution are some of the factors that are making people shift to EVs. The overall efficiency of EVs is six times more than ICE vehicles [3]. Therefore, the adoption of EVs for transportation as a mainstream could create a great positive impact on the environment. EVs accounted for about 5% of total vehicle sales between October 2022 and September 2023—and could reach more than 40% penetration by 2030 [4]. The automobile makers in India such as Tata Motors, Mahindra and Mahindra Ltd., have recently launched their EV segments into the Indian market [5]. Apart from the EV sales for 2022, it is forecasted for the upcoming decades. From this we can say that the India required a large EV charging infrastructure.

3. Current Scenario in India

The government has taken several initiatives to promote the adoption of solar-powered EV charging stations. In March 2021, the Ministry of Power issued [guidelines](#) for the development of public EV charging infrastructure that mandates all public charging stations to install solar panels with a capacity of at least 10% of the total charging station capacity. Additionally, the government has also announced several incentives and subsidies to encourage the adoption of EVs and solar-powered charging infrastructure. [7]. According to the Ministry of Power, India as of February 2024 there are 12146 operational EV charging stations in the country [8]. The Indias first solar-based electrical charging facility is under construction near Kempegowda International Airport in Devanahalli, Bengaluru. There are currently two Charge Point Operators (CPOs) in India which are offering solar EV charging stations --

ElectriVa and Atum Charge. [ElectriVa](#), which at present has five solar EV charging stations, aims to build the fastest and largest EV CP network with advanced state-of-the-art infrastructure, operated through IoT based unmanned and automated systems, powered by sustainable energy sources and data analytic tools, driving the growth of clean mobility [9]. In India the solar powered Charging Stations are still in the establishing phase, while in the countries like Germany has 60% dependable on the solar based charge stations [10].

4. Future Developments and Industry Leaders

The history of electric vehicle (EV) charging stations is closely tied to the development and evolution of electric vehicles themselves. As of now the ElectriVa and Atum has established their charge stations but the more private players are also showing interest in this sector. They have recognized potential of this sector and have taken several initiatives to promote its adoption. Delhi, Bengaluru, and Pune are some of the cities that are already in the process of implementing the installation of solar charging stations in parking lots, shopping malls, and highways. Further, there are a few Indian startups that are in the process of designing and implementing cost effective and sustainable solar charging solutions across the country. Solar-powered EV charging solutions provider ATUM Charge has completed installation of 250 Universal Electric Vehicle charging stations across the country, with the maximum 48 in Telangana. Tata Power announced that it would set up 150 EV charging stations across the city of Mumbai. The company has also partnered with several state governments and public sector undertakings to set up EV charging infrastructure in the country. EV manufacturer Hero Electric has also announced that it would set up a network of 10,000 EV charging stations across the country over the next five years [11]. Additionally, the government has also announced several incentives and subsidies to encourage the adoption of EVs and solar-powered charging infrastructure.

In Ether Energies EV ecosystem plan their charging infrastructure initiative, includes solar-powered charging stations in various cities. Hence, placed in the list of Top Solar EV Charging Operators in India. Fortum Charge & Drive is a global leader in EV charging solutions, and their presence in India is making a significant impact. Thus, counted in the list of Top Solar EV Charging Operators in India. ReNew Power, another major player in India's renewable energy sector is actively diversifying its portfolio by investing in solar EV charging infrastructure. SUN Mobility is revolutionizing electric mobility by introducing an innovative and scalable battery-swapping solution. Their Smart Batteries can be rapidly exchanged at charging stations, reducing charging time to just a few minutes. While not directly solar-powered, SUN Mobility's approach enhances the sustainability of EVs by enabling quick and efficient charging, furthering the cause of green mobility [12].

5. Advantages

5.1. Intermittency and Reliability

The implementation of solar energy into the EV charging stations shows the immediate and long-term financial impact on the overall system. Despite the high upfront costs, these systems offer significant long-term savings by reducing reliance on grid electricity [13]. The use of solar power can reduce the operating costs of the EV charging station and increase the return on investment. According to The Energy and Resources Institute (TERI) that the cost of solar generated power is ranges between the Rs 2.50 to Rs 3.50 meanwhile the grid energy is cost between Rs 6 to Rs 7. And the solar energy will be more cost effective by the 2030 [14]. Means the per unit charges will be reduced which is beneficial for the consumer as well as charge provider.

5.2. Efficient and Reliable

The grid connected charge points may be subjected to the stability issues due to the varying load demand on the grid, but the solar charge points can be operated isolated so there are minimum losses are the stable demand is present, although the smart energy monitoring system can be integrated in it, which helps to optimized energy management, load scheduling and the real-time monitoring. Which can make the system more reliable and can provide a stable supply toward the charge points, the generation is also monitored with help of this system. The charging scheduling module also provides real-time updates to the users about the charging status, estimated time of completion, and charging costs [15].

5.3. Scalable and Flexible

This system can be expanded in its capacity as the future requirements. Since the generating Solar panels can be increased according to the need and the generation is also increases. The traditional EV chargers have different types of the operating modes like AC-DC chargers and DC-DC chargers. So, it is more flexible to charge the EV in both the operations.

5.4. Fast Charging and Efficient

The conventional grid systems are transmitting the energy in the form of AC supply but the batteries stored the energy in the form the DC. At this time the converters are used to convert the AC-DC which has the losses which affects the efficiency of the overall system which is also time consuming. Meanwhile the Solar PV cells generate the energy in the form of DC power which bypasses the need of the converter hence the DC power is directly stored in the battery by adjusting the power levels [16]. The converter losses are drastically reduced in this method, which improves the overall efficiency of the Charge point. This results to the charge the battery in very fast manner.

5.5. Hybrid Approach

Since in the India the rooftop solar system is already have good implementation, it can possible to add the same approach in the Charging stations. India has existing 12146 EV charging stations which are the grid based [17], so it can easily to be converted into the solar powered spots by integrating the PV cells in the system. In this approach the need of the energy storing facility is can be optional, which has the major cost percentage in the overall system which reduces the cost of the system. This system works same as the existing rooftop systems using the concept of the net metering.

6. Challenges and Barriers for Expansion

However, the solar integration has significant benefits for the total economic and environmental conditions and it can provide the solution for sustainable energy generation and consumption, whereas this integration is fraught with technical challenges that span across the disciplines of power electronics, energy management, and grid infrastructure [13]. Addressing these challenges is crucial for the development of a reliable, efficient, and scalable solar-powered EV charging system. The variability of solar energy, dictated by diurnal cycles and weather conditions, poses a significant challenge to the deployment of solar-powered EV charging stations. The intermittent nature of solar power can lead to inconsistencies in the charging process, potentially affecting the performance and longevity of EV batteries [14].

The integration of solar energy into electric vehicle (EV) charging stations presents several challenges, including:

1. **Intermittency and Reliability** –In India there are different weather conditions and sunlight availability which makes difficulties to produce stable power and making it unreliable for continuous EV charging without energy storage solutions.
2. **Energy Storage and Battery Costs** – To ensure uninterrupted power supply, battery storage systems (such as lithium-ion or flow batteries) are required, but these add significant costs and maintenance concerns [15].
3. **Grid Stability and Load Management** – Integrating solar-powered charging stations into the grid can lead to voltage fluctuations and instability, especially during peak charging times. Advanced load management and grid synchronization are necessary.
4. **Space Constraints** –Installing solar panels require large space. To generate a large-scale electricity the large solar arrays must be installed with some distance to avoid the shadow interference which increases the space need. In urban or high-traffic areas, finding adequate space for large solar arrays can be a challenge.
5. **High Initial Investment** – Setting up solar-powered charging stations involves high upfront costs for solar panels, inverters, energy storage systems, and infrastructure.
6. **Efficiency and Conversion Losses** – The efficiency of solar panels and power conversion systems affects overall energy availability. Energy losses during conversion, storage, and distribution can reduce effectiveness [16].
7. **Scalability and Expansion Issues** – Expanding solar-powered EV charging infrastructure requires extensive planning and investment, along with advancements in technology to improve efficiency.
8. **Weather and Seasonal Variability** – Cloudy days, monsoons, or winter months reduce solar power generation, necessitating alternative power sources or hybrid charging solutions.
9. **Public Awareness and Adoption** – Limited awareness and acceptance of solar-powered EV charging stations can slow down investment and development.

7. Conclusion

As the Electrical vehicles are increasing in India the fuel consumption will reduce but in other hand the demand of electrical charging centres and the electricity will also shoot up. Indian electricity demand is fulfilled by almost 75% by using the conventional energy generation methods which is major barrier for Indias clean energy program so implementation of renewable sources is important, by integrating the solar generation technology in the charging spots can be a major step towards the green mobility. As the electricity demand of the automotive industry will be fulfilled by itself then the dependency on the fuel-based generation also reduced. whereas the total integration has some major barriers but the developing technology will definitely find the solution on it and clears the way for fully green Mobility.

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