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Solar Energy Based EV Charging Station with An Added Battery Storage System

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ABSTRACT: This paper extends the application of Renewable Energy by integrating it with grid supply. Solar based EV charging station is a project where solar energy is converted into electrical energy with the help of photovoltaic cell for charging of the EV's. Vehicles are usually charged from normal grid supply but it leads to various disadvantages because most of the electricity is generated by conventional sources which is proven harmful for environment. It also leads to depletion of the fossil fuels. To address this issues use of renewable energy is very important. Solar based EV charging station does not solely rely on the solar power generation but it also uses the added battery storage system which can be used for charging the EV in case of poor weather conditions, etc. The output of solar panel is given to charge controller which is then given to buck converter to reduce the voltage to 5V and then directly fed to charging port. In case of battery storage system, stored energy from battery is fed to buck converter for reducing voltage level and then directly supplied to charging port. While in the third case where power is taken from grid a step down transformer is used to convert 230V to 12 V after that it is fed to charging port. In this way by providing 3 options for charging of EV the system is made more efficient and reliable.

I. INTRODUCTION

The urgent need to address environmental pollution has catalyzed a shift towards electrification in the transportation sector. While electric vehicles (EVs) offer promise in reducing emissions, the source of electricity powering these vehicles is crucial. Simply converting fossil fuels to electric energy does not alleviate pollution; instead, it necessitates a transition to sustainable and renewable energy sources. This proposal advocates for the integration of solar photovoltaic (PV) panels to harness solar energy and power DC microgrid-based EV charging stations. An additional battery serves as a buffer to store or deliver generated energy, enhancing system reliability. The envisaged charging stations will be grid-connected, enabling seamless energy import or export to accommodate fluctuating demand, especially in regions with intermittent sunlight. The escalating concerns regarding fossil fuel depletion, rising costs, and environmental degradation have propelled the popularity of EVs. Consequently, governments and organizations are prioritizing charging infrastructure development. Solar energy-based EV charging stations offer a viable solution, applicable in corporate sites, parking areas, or remote locations with limited access to conventional electricity sources. This integrated system not only addresses environmental concerns but also optimizes energy costs and power demand. By leveraging renewable solar resources and employing efficient control techniques, the aim is to maximize energy extraction and utilization within the DC microgrid. The proposed model emphasizes profitability, fast-charging capabilities, and grid independence through renewable generation and storage solutions, while mathematical models and simulations have been explored extensively, practical implementation strategies remain pivotal. This paper seeks to bridge this gap by presenting a holistic approach to solar-powered EV charging stations, integrating insights from existing research on renewable energy systems and control algorithms.

II. NEED OF SOLAR BASED EV CHARGING STATION

Solar energy-based electric vehicle (EV) charging stations with backup battery storage systems address critical needs in our quest for sustainable transportation and energy independence. As the world moves towards reducing carbon emissions and combating climate change, the transportation sector plays a pivotal role due to its significant contribution to greenhouse gas emissions. Integrating renewable energy sources like solar power into EV charging infrastructure not only reduces reliance on fossil fuels but also promotes cleaner and more sustainable transportation solutions.

One of the key advantages of solar energy-based EV charging stations is their ability to harness abundant sunlight, which is a virtually unlimited and renewable resource. By utilizing solar panels to capture sunlight and convert it into electricity, these charging stations can provide clean and green energy to power electric vehicles, thereby reducing reliance on traditional grid electricity generated from fossil fuels. This not only helps in reducing greenhouse gas emissions but also mitigates the environmental impact associated with the extraction and combustion of fossil fuels. Moreover, solar energy-based EV charging stations offer greater energy resilience and independence. With a backup battery storage system, these charging stations can store excess solar energy generated during the day and use it to charge EVs during periods of low sunlight or at night. This ensures a reliable and uninterrupted supply of clean energy for EV charging, even during grid outages or disruptions. Additionally, by reducing dependence on the grid for electricity, solar-powered EV charging stations contribute to greater energy security and resilience in the face of natural disasters or other emergencies.

Furthermore, solar energy-based EV charging stations offer economic benefits by reducing electricity costs and promoting local job creation. By generating electricity on-site from solar panels, these charging stations can lower operational costs associated with purchasing electricity from the grid. Additionally, the installation and maintenance of solar panels and battery storage systems create opportunities for job growth in the renewable energy sector, supporting local economies and communities.

In conclusion, the need for solar energy-based EV charging stations with backup battery storage systems is evident in their ability to provide clean, resilient, and cost-effective energy for electric vehicles. By harnessing the power of the sun, these charging stations not only help reduce greenhouse gas emissions and combat climate change but also promote energy independence, security, and economic prosperity. Embracing solar energy-based EV charging infrastructure is essential for building a sustainable and resilient transportation system for the future.

III. OBJECTIVES OF BATTERY STORAGE SYSTEM

Ensure reliability: By integrating a backup battery storage system into the solar-based EV charging station, reliability is enhanced. Solar energy generation is subject to variability due to weather conditions and time of day. With battery storage, excess solar energy can be stored during periods of high generation and utilized during low generation or high demand periods. This ensures a consistent power supply for EV charging, reducing reliance on intermittent solar energy and mitigating the risk of power outages.
Enhance sustainability: The combination of solar power and battery storage minimizes reliance on fossil fuels, thereby reducing greenhouse gas emissions and environmental impact. EV charging stations powered by renewable energy sources contribute to the transition towards a greener transportation sector, aligning with global efforts to combat climate change. By reducing dependence on traditional grid electricity, the system promotes sustainable energy practices and environmental stewardship.
Optimize efficiency: The integration of backup battery storage optimizes the efficiency of the charging station. Excess solar energy can be stored in the battery during periods of high generation, allowing the system to operate more efficiently by maximizing the utilization of renewable resources and minimizing waste. This not only benefits the environment but also improves the economic viability of the charging station by reducing operational costs associated with grid electricity usage.
Improve resilience: The backup battery storage system enhances resilience against grid disruptions and fluctuations. In areas prone to blackouts or grid instability, the battery serves as a reliable backup power source, ensuring uninterrupted EV charging services. This is particularly important in emergency situations or during peak demand periods when grid infrastructure may be strained. By providing a reliable backup power source, the system enhances the overall reliability and resilience of the charging station.
Enable demand management: The integration of battery storage enables demand management and load balancing. By strategically discharging stored energy during peak demand periods, the charging station can reduce strain on the grid and potentially benefit from demand response programs. This not only optimizes energy usage but also enhances cost-effectiveness by minimizing peak demand charges. Overall, the integration of battery storage facilitates efficient energy management, ensuring reliable and sustainable operation of the solar-based EV charging station.

Table 1: Comparison of Conventional and Non-Conventional station

Points	**Conventional Charging Station**	**Non-Conventional Charging Station**
Grid Dependence	Rely Entirely on the Grid	Can Operate Off-Grid
Operating Cost	Quite Expensive Comparatively	Less (Cost Effective for Long Term)
Environmental Impact	Contribute to Carbon Emission and Pollution	Reduces Green House Gas Emissions
Initial Cost	Low	Comparatively High
Energy Prices	Variable	Fixed

IV. PROPOSED WORK

As shown in Fig 1 circuit consist of Solar PV System, Power Grid System, Bridge Rectifier, Buck Converter, Battery Storage System, Automated Switching System and Load (EV).

Solar PV System:
Solar PV Cell generates 2 Volt 5-watt peak Dc which is further step down by Buck Converter (12v DC to 5v DC) and fed to automated switching system.

Power Grid System:
The 230 Volt AC supply of power grid is Step downed to 12 Volt by stepdown transformer and it is converted to DC supply by Bridge Rectifier i.e. 5 Volt DC which is further fed to Automated Switching System.

Bridge Rectifier:
It is used to convert AC supply into DC supply. The 230 Volt power supply of power grid is converted to 12 Volt AC by stepdown transformer and by Bridge Rectifier 12 Volt AC is converted to 12 Volt DC supply.

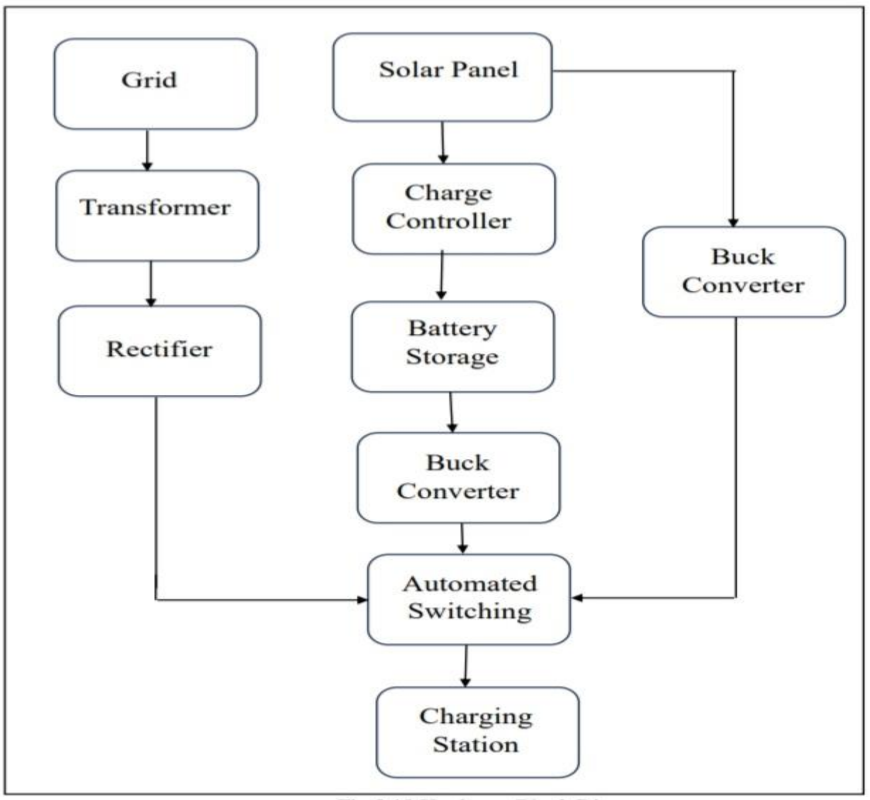

Fig 1: Block Diagram of Hardware

Charge Controller:
It is used to maintain the output voltage of solar PV cell constant. The charge controller is used to avoid sudden charging and discharging of batteries and it also plays important role to avoid flow of reverse current in the system.

Battery Storage System:
Battery Storage system is charged by charge controller and it consist of set of 3 lithium-ion batteries which are connected in series having the rating of 3.7volt, 2.2amp each.

Automated Switching System:
This system Consist of two types of switches which are normally open (NO) and normally closed (NC). Normally closed switch is used in association with primary supply line and for backup system Normally Open switches are implemented which is done on the priority basis.

V. HARDWARE IMPLEMENTATION

In the given system as shown in Fig 2 three energy sources are integrated such as to make the system more reliable and renewable. In project first source of energy is the solar PV system which contains the solar PV panel, Charge In the given system three energy sources are integrated such as to make the system more reliable and renewable. In project first source of Controller, Buck converter, Additional battery storage system. second source of energy is from the grid system which provide the 230v ac supply to the Ev charging station which includes the various components such as Step Down transformer, Buck converter. The third and final source of energy is the directly from solar PV panel which includes the buck converter, there is no intermediate battery storage system is not used to shift the channel of energy towards the Ev charging station two automated switching system are provided to make the interrelation between the three interconnected systems.

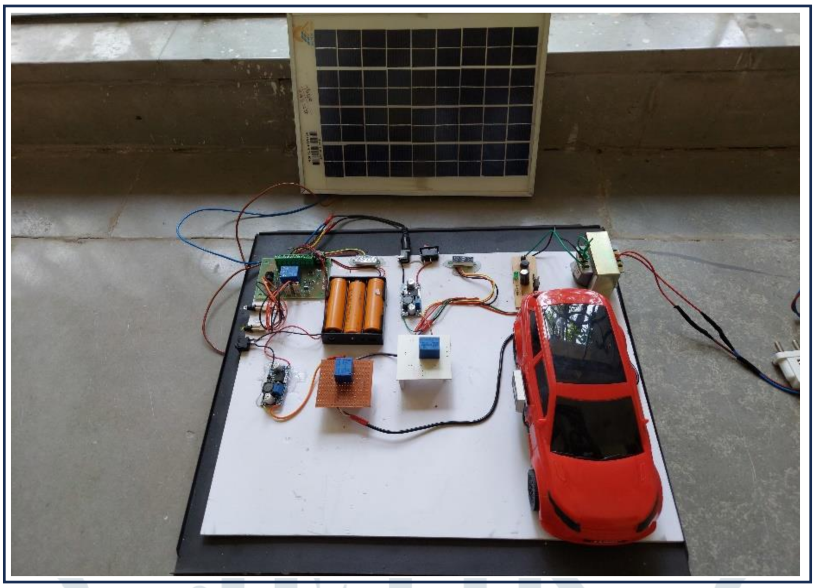

Fig 2: Hardware

In the first system, solar energy is collected from the sun and it converts in to electrical dc electrical energy by solar panel having the rating of 5watt peak,18 volt after that charge controller is provided to avoid the sudden charging and discharging of the battery .it also avoid the reverse flow of current in the system .the output of the charge controller is collectively provided to the battery storage system which includes the set of three lithium ion batteries which are connected in the series having the rating of 3.7 volt & 2.2amp each now the output of the battery storage system is provided to the Buck converter which is also called as the DC-DC converter which steps down the approximate 12 volt dc voltage in to 5 volt dc voltage. after that Automated switch is provided between the buck converter and main plug of Ev charging system.

Now the second system includes the main source of energy is the supply from the main Grid system of 230 volt AC this supply is step down to 12 volt AC by the step down transformer having the rating of 230v/12volt,1Amp.after that the secondary voltage of the transformer is given to Rectifier unit which converts the 12 volt ac supply in to the 12 volt dc supply here another Buck converter is also provided which step down the 12 volt dc into 5 volt dc supply which is given to the Ev charging station.

The final source of energy directly from the solar PV panel there is no intermediate battery storage system is provided after this one buck converter is provide which step down the DC voltage up to the 5 Volt dc which is provided to the EV charging station through the automated switching unit.

In our charging station, we prioritize three energy sources: solar panels, battery storage systems, and the grid. Our automated switching system ensures optimal utilization based on availability. First and foremost, when solar energy is available, it takes precedence. Solar panels convert sunlight into electricity, providing the primary power source for the charging station.

If solar power alone cannot meet demand, the system seamlessly switches to the grid. This ensures continuous charging, especially during periods of low solar generation or high demand.

Lastly, if neither solar nor grid power is sufficient, our battery storage system comes into play. Stored energy serves as a reliable backup, ensuring uninterrupted operation of the charging station.

This hierarchical approach optimizes energy usage, prioritizing renewable sources while maintaining reliability. Welcome to our charging station, where sustainability and efficiency are paramount.

In conclusion, our integrated charging station represents the epitome of sustainable technology, seamlessly blending solar power, grid connectivity, and advanced battery storage. With a commitment to efficiency and reliability, we pave the way towards a greener future for electric vehicle infrastructure. Welcome to the forefront of innovation, where every charge signifies a step towards a cleaner, brighter tomorrow.

VI. RESULTS

In hardware electric vehicle load consist of two batteries (Lithium Ion) in series having theequivalent voltage of 7.4 V, 2.2 A.

Method 1: By Using Grid

Battery Ah requirement is 2Ah having charging current of 1 A which is the secondary current of Transformer.

So, Charging Time is Calculated using given formula:

Charging Time = Ah of battery/ Charging Current

= 2/1
= 2 hours (120 Minutes)

In our case two batteries are connected in series so it will take 4 hours to get fully charged.

Method 2: By Using Solar PV Panel

Battery Ah requirement is 2Ah having charging current of 2.2 A which is the output current of Battery Storage System.

So, Charging Time is Calculated using given formula:

Charging Time = Ah of battery/ Charging Current
= 2/2.2
= 0.909 hours (54 Minutes)

Method 3: By Using Battery Storage System

Battery Ah requirement is 2Ah having charging current of 1.5 A which is the output current of Charge Controller.

So, Charging Time is Calculated using given formula:

Charging Time = Ah of battery/ Charging Current
= 2/1.5
= 1.33 hours (79.8 Minutes)

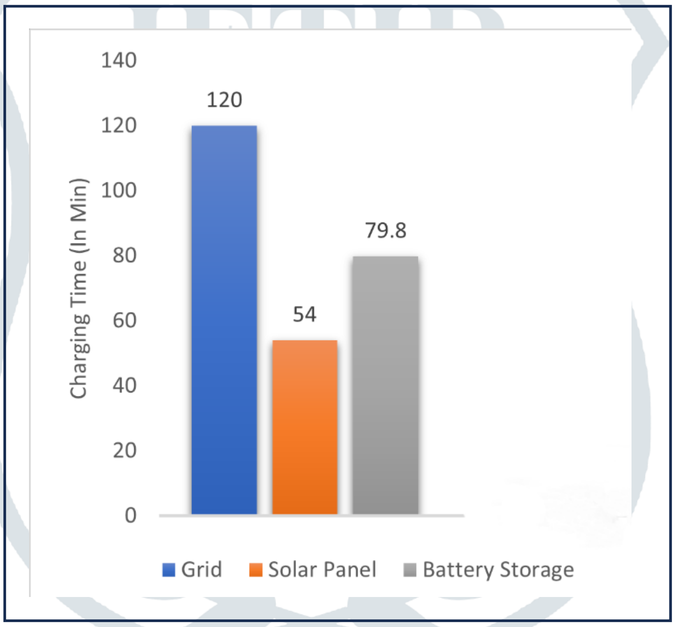

Fig 3: Graph of Charging Time

VII. CONCLUSION

This paper explains about the development and observation of solar based EV charging station with added battery storage system. In this paper the time taken by the vehicle to get fully charged is calculated with all three methods in which it concludes that vehicle will get charged faster by using solar panel output, comparatively slower by using battery storage system and slower but using grid supply. This paper is the utilising and promoting the use of renewable technology since it offers various advantages like less running cost, environment safety, etc.

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