iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** V **Month of publication:** May 2026

DOI: https://doi.org/10.22214/ijraset.2026.83022

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

PV-Based Off Grid Charging Station for Electric Vehicle

Ms. Ashvini Tagde, Dr. Nilesh Bodhne, Prof. Uttara Dudhpachare
Department of Electrical Engineering Vidarbha Institute of Technology, Nagpur, Maharashtra, India

Abstract: The quick rise of electric mobility has kinda boosted the need for dependable and eco friendly charging solutions. In this work, we show a PV based off grid charging station for electric vehicles, it's meant to run on its own, so it doesn't really rely on the traditional grid network. At the same time it keeps power available in a continuous, greener way. Basically the setup uses a solar photovoltaic PV array as the main energy source, then it's backed by a solar charge controller, battery storage, an inverter module, plus a voltage sensing unit, and there can also be an optional grid backup if needed. The solar energy collected during daylight hours is pushed into the battery, and later that stored energy is used for EV charging or it can run AC loads through the inverter. With real time monitoring of voltage and other system parameters, the controller can handle power in a more efficient manner, and it also guards the battery against overcharging, or getting dragged into deep discharge. The proposed model, shows steady behavior even when the solar conditions shift, and it points to how practical renewable powered charging can be in rural, remote, or grid scarce areas. Overall this hardware prototype helps reduce carbon emissions, reduces our dependency on fossil fuels, and supports clean energy adoption in the transportation sector.
Keywords: Solar Photovoltaic (PV) System, Off-Grid Charging, Electric Vehicle (EV), Battery Energy Storage, Inverter Module etc.

I. INTRODUCTION

Renewable energy sources provide clean energy that is sufficient on earth. These renewable sources are obtained from land, water, sun, plants, etc. These sources are widely used in the production of electricity. Solar and wind power generation are attractive sources because they are environmentally friendly. A hybrid system is a mixture of different renewable energy sources such as solar energy, biomass electricity, wind energy, etc. In hybrid energy production, the produced power is first stored in the battery and then used to meet the energy demand. Today, the wind and solar energy system is growing rapidly, and the traditional energy source is depleting every day and disappearing in the coming years. So we must look for a new source of energy that is non-polluting and easily accessible. On sunny days you get energy from the sun and on cloudy days from the wind system.

A growing global problem related to rapid economic development and a relative lack of energy, because we all do not know that renewable energy sources are quickly running out. So it is time for us to use both conventional and non-conventional sources of energy to generate electricity. Today,

Supercapacitors are widely used. These high pressure and efficient energy storage devices are also known as ultracapacitors or electrochemical double layer capacitors (EDLC). Their favorable properties make them ideal for use in energy storage systems, including the ability to charge and discharge quickly without losing efficiency in the long term. The supercapacitor package can be used in a HESS (battery-supercapacitor system), which integrates various energy storage technologies with a specific control strategy that maximizes the benefits of each energy source used for overall efficiency.

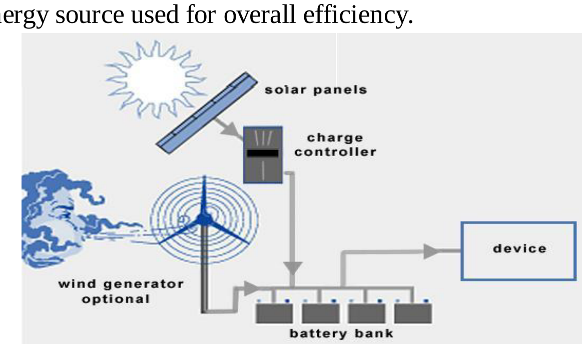


Fig. 1 Schematic of a conventional photovoltaic Hybrid System.

II. PROBLEM STATEMENT

The use of renewable energy as a source of energy is expanding as the price of petroleum fluctuates. Therefore, it is crucial that engineering and technological students have a grasp of and awareness of technology related to renewable energy at the educational level. Solar energy is one of the most popular renewable energy sources. There is a lot of research being done to develop alternatives to improve the efficiency of photovoltaic systems (solar panels). One such method is to employ a solar panel tracking system.

Key Statement:

- Install sources such as horizontal axis wind turbines to increase power outages.
- Also add a solar system to generate electricity.
- Create a similar model that will be able to reflect system features and functionality as needed.

III. BEHIND RESEARCH

Fast charging as an indoor electric vehicle board is hindered by the cost of the electronic components needed to convert the electricity, which increases the overall cost of the electric car. However, built-in chargers cannot ensure fast EV charging due to the high cost of EV-related electronics and increasing the charging capacity of the car.

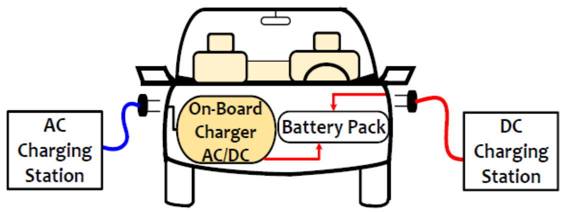


Fig.1. Hybrid EV Charging Station

To ensure faster charging of electric vehicles, external chargers are used that provide high direct current. It is worth noting that in external chargers, the entire conversion from AC/DC is done by an independent inverter. That is why it is important to increase the power of the converters to ensure faster charging of the car. The results of several published studies have been used in the design and development of efficient and reliable electric vehicle charging systems at electric vehicle charging stations.

1) Hybrid Power :

A hybrid power tool combines two energy sources to supply electricity efficiently. It is a system designed to generate power using multiple sources, ensuring reliability, efficiency, and low emissions at a minimal cost. In the proposed system, solar and wind energy are utilized for electricity generation. These renewable sources offer significant advantages over conventional power, providing a sustainable and cost-effective solution. The system requires minimal investment and can be installed anywhere without location constraints. By integrating solar and wind power, the hybrid system ensures continuous energy availability, making it an ideal choice for various applications.

In this proposed gadget, solar and wind power are employed to generate electricity. Sun and wind strength have distinct advantages as compared to all other unconventional electricity sources. Each power asset is required in all areas. It desires a low fee. There is no need to identify a specific area to put in this gadget.

2) Solar Power :

Solar energy is power generated by the sun's radiation, which is constantly and readily available on the earth. It is freely accessible, does not emit pollutants, has minimal upkeep expenses, and is cost-effective. However, it has difficulty producing power in bad weather conditions. Solar energy is more efficient than conventional sources, requiring an upfront investment but having a longer lifespan and lower emissions.

IV. PROJECT DESCRIPTION

1) Block Diagram

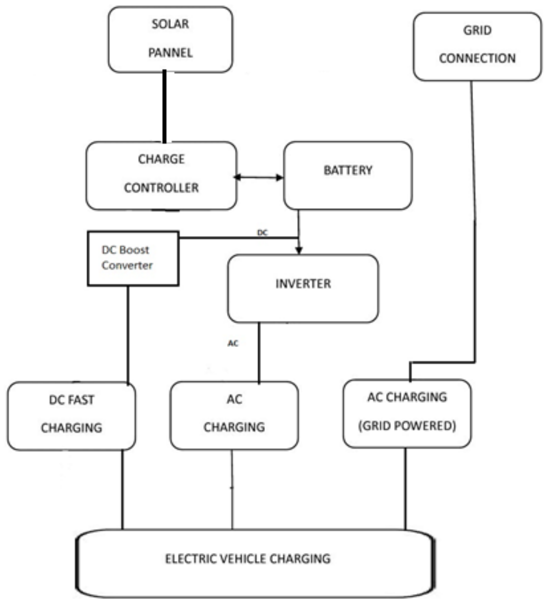


Fig. 2. Block Diagram of system

V. WORKING

1) The system begins with a solar panel, which captures sunlight and converts it into DC electrical energy for charging and storage.
2) This power is regulated by the solar charge controller, which prevents battery overcharging and manages optimal charging conditions.
3) The battery stores the regulated DC energy, ensuring continuous EV charging even during night or low-sunlight periods.
4) A DC boost converter is used to step up the DC voltage when higher voltage levels are required for DC fast charging.
5) The boosted DC power is supplied directly to the DC fast charging unit, enabling quick charging of electric vehicles.
6) The stored DC power from the battery is also fed into an inverter, which converts DC energy into AC power for AC charging loads.
7) The AC charging unit supplies regulated AC output for standard EV charging modes.
8) The system also includes a grid connection as an emergency or backup power source, enabling AC grid-powered charging when solar or battery energy is insufficient.
9) All charging pathways—DC fast charging, AC charging, and AC grid charging—integrate into the final Electric Vehicle Charging output.

VI. COMPONENTS

1) Solar Panel
2) Solar Charge Controller
3) LCD Display
4) Development Board
5) Inverter Module
6) Voltage Sensor
7) AC Load
8) Charging Socket
9) Adapter
10) LED Indicator
11) Others

VII. COMPONENTS SPECIFICATION

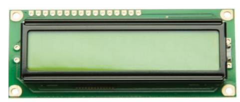
1) Solar Panel (12v25w)

Solar energy is that energy which we get from the sun in form of radiation. It does not cause any kind of pollution, it is inexhaustible. It is available free of cost. A solar cell is used to convert solar energy into electric energy, it is also known as photovoltaic cell.

2) LCD Display (5v)

A liquid crystal display (LCD) is a thin, flat panel used for electronically displaying information such as text, images, and moving pictures.

LCD stands for **L**iquid **C**rystal **D**isplay. LCD is finding wide spread use replacing LEDs (seven segment LEDs or other multi segment LEDs)

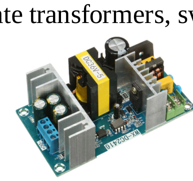


3) DC to DC boost Converter (Regulated 12v)

A boost converter (step-up converter) is a DC-to-DC power converter that steps up voltage (while stepping down current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element: a capacitor, inductor, or the two in combination.

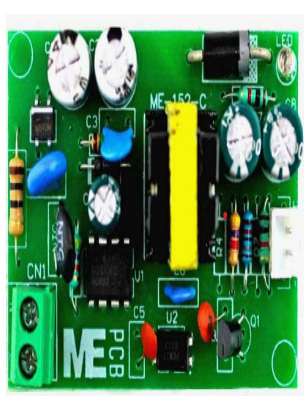
4) Inverter

An inverter is an electrical device that converts direct current (DC) to alternating current (AC); the converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits.

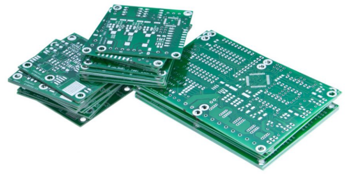


5) SMPS Unit (220v AC to 12v DC)

SMPS is an electronic power supply system that makes use of a switching regulator to transfer electrical power effectively. It is a PSU (power supply unit)



6) PCB's Board



A printed circuit board (PCB) mechanically supports and electrically connects electrical or electronic components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a non-conductive substrate.

VIII. PROPOSED CALCULATIONS

Total energy generated by the system is the total energy generated by the solar PV panel and the power generated by the wind turbine. According to statistics, it can be represented by,

PT = NW * Pw + Ns * PS
There,
Total energy generated = PT
Power generated by wind turbines = PW
Energy produced by solar panels = PS
Wind turbine number = NW
Number of solar panels used = NS

Calculations for solar energy
To determine the size of the PV modules, the required power consumption should be measured. Therefore, power is calculated as
PS = Ins (t) * AS * Eff (pv)

There,
Ins (t) = separation at t (kw / m2)
AS = one PV panel area (m2)
Effpv = full efficiency of PV panels and dc / dc converters.
The overall efficiency is provided by,
Eff (pv) = H * PR
There,
H = Annual rate of solar radiation on oblique panels.
PR = Performance rate, loss coefficient.

C. Cost
The total cost of a solar-wind energy system depends on the total number of wind turbines used and the total number of solar panels used. The total cost is therefore provided as follows
Total Cost = (Wind Turbine Number * Cost of One Wind Turbine) + (Solar Panel Number * Cost of One Solar Panel) + (Number of Batteries Used in Battery Bank * Cost of One Battery)
CT = (NW * CWT) + (NS * CSP) + (NB * CB)
There,
CT is the total cost per Rs
CWT is the cost of a single wind turbine
CSP costs one day panel per Rs
CB One Battery Cost Rs
NW is the amount of wind turbine used
NS is the number of solar panels used

NB is the number of batteries used in the Battery Bank.

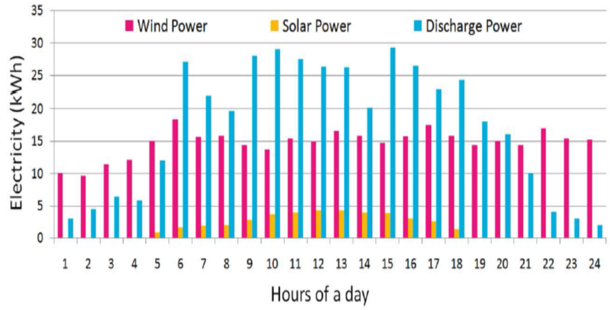


Fig. 4 Hourly generated electricity by both wind and solar from the proposed method.

The hourly required load, the total power generated by the recharging station, and the power supplied to the grid are shown in Fig. 5. In some cases such as hour 1-3.5 and 12-16.5 the station supplies few kilowatt of power to the grid.

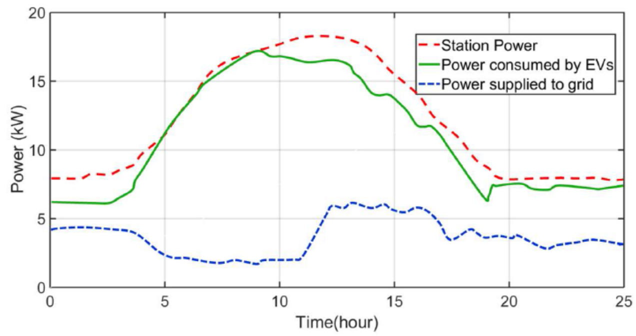


Fig. 5 Hourly power measured during a day.

IX. ADVANTAGES WITH HYBRID SYSTEM

1) During the rainy season and winter the amount of sunlight is insufficient as this season energy is complemented by the wind energy system.
2) Due to climate change when there is a lack of wind power beyond the power provided by solar panels.
3) Low operating costs and maintenance costs make you a savings.
4) Used in any place whether it is remote or crowded.
5) Efficient power generation
6) Solar and wind sites benefit the environment as they will reduce carbon and other harmful pollutants by about 90% in the area.

X. APPLICATIONS

1) Distributed electricity generation
2) Hospital, Hotels, Guest House etc.
3) Electricity installation in remote and rural areas.
4) Street lighting.
5) Transfer and contact Tower with multiple application.

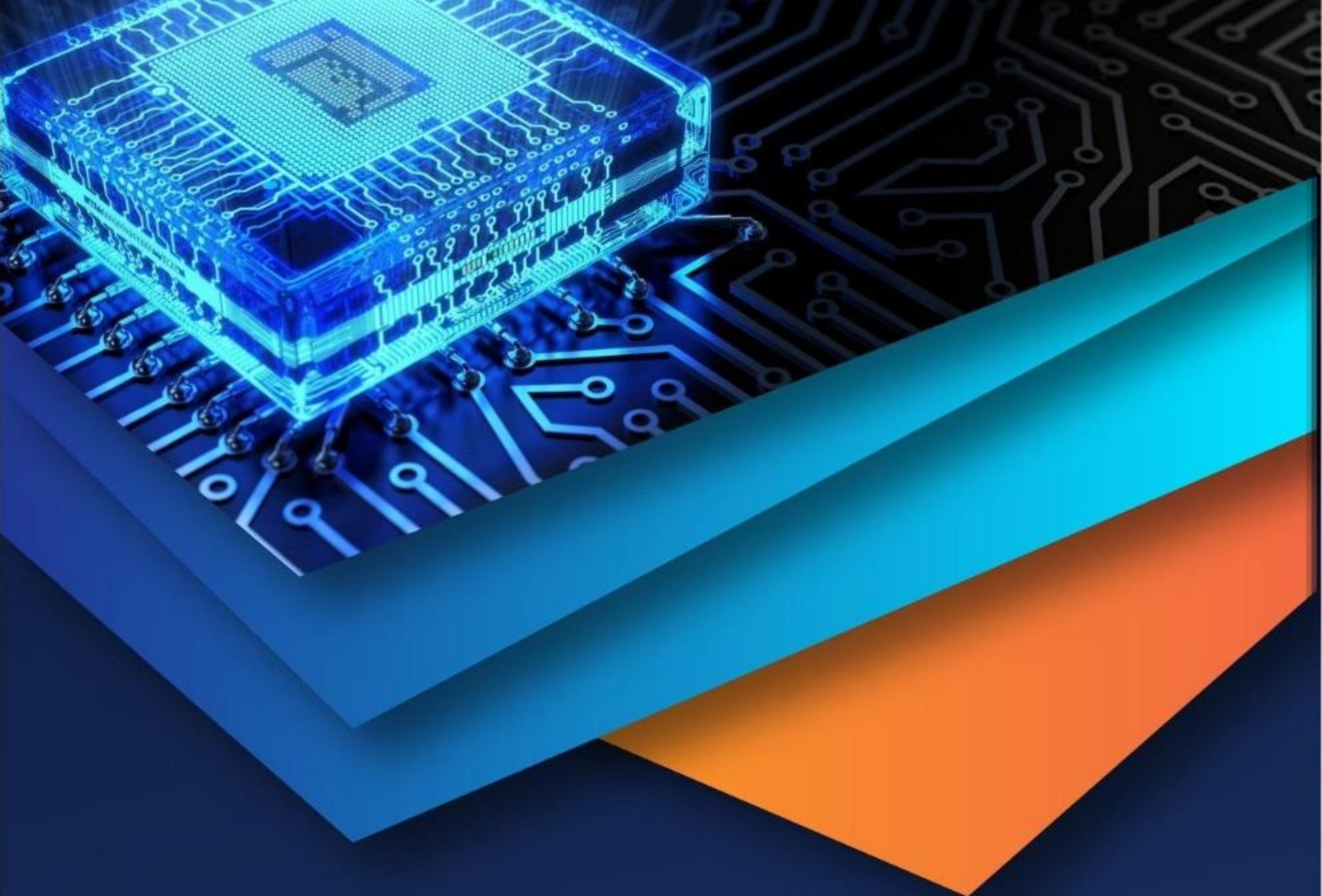
XI. CONCLUSION

The proposed PV-based off-grid charging station is expected to demonstrate a reliable, sustainable, and cost-effective solution for electric vehicle charging. By integrating solar panels, a charge controller, battery storage, and an inverter system, the model ensures uninterrupted charging even in the absence of grid power. The inclusion of both DC fast charging and AC charging modes enhances flexibility and supports various EV requirements. The system utilizes renewable energy, reducing dependency on conventional electricity and minimizing environmental impact.

Real-time monitoring and efficient energy management further improve system performance and battery life. Overall, the project is anticipated to validate the feasibility of solar-powered EV charging and promote cleaner, decentralized charging infrastructure for future mobility.

REFERENCES

[1] A. J. Alrubaie, "A comprehensive review of electric vehicle charging methods," Sustainability, 2023.
[2] IEA-PVPS Task 17, "PV-powered electric vehicle charging stations," IEA-PVPS Report, 2021.
[3] V. N. Saraswathi, "A comprehensive review on charger technologies, types, and standards," Journal (PMC), 2024.
[4] A. Borhani, "PV and energy-storage management for EV charging in residential areas," Solar Energy, 2024.
[5] K. Pal, "Electric vehicle fast-charging station energy management," Energy Systems, 2024.
[6] M. Kumar, "Comprehensive review of electric vehicle technology and integration with renewables," Applied Sciences, 2023.
[7] G. Bhutkar, "Energy management system for EV charging infrastructure," E3S Web of Conferences (ICRERA), 2024.
[8] A. K. Tripathi, "Integration of solar PV panels in electric vehicle charging infrastructure," Energy Science & Engineering, 2025.
[9] J. Olano, "Development of energy management systems for electric vehicle charging stations," Applied Sciences, 2025.
[10] J. S. Tamba II, "Solar-powered electric vehicle charging systems: A comprehensive review," Renewable & Sustainable Energy Reviews, 2025.
[11] A. Adejumobi,S.G. Oyagbinrin, F. G. Akinboro & M.B. Olajide, "Hybrid Solar and Wind Power: An Essential for Information Communication Technology Infrastructure and people in rural communities", IJRRAS, Volume 9, Issue1, October 2011, pp 130-138.
[12] Kavita Sharma, Prateek Haksar "Designing of Hybrid Power Generation System using Wind Energy- Photovoltaic Solar Energy- Solar Energy with Nanoantenna" Internationa Journal of Engineering Research And Applications (IJERA) Vol. 2, Issue 1,Jan-Feb 2012, pp.812-815 .
[13] Sandeep Kumar, Vijay Kumar Garg, "A Hybrid model of Solar-Wind Power Generation System", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), Vol. 2, Issue 8, August 2013, pp. 4107-4016.
[14] International Journal of Electronic and Electrical Engineering. ISSN 0974-2174, Volume 7, Number 5 (2014), pp. 535542 © International Research Publication House http://www.irphouse.com Hybrid Renewable Energy System: A
[15] Arjun A. K., Athul S., Mohamed Ayub, Neethu Ramesh, and Anith Krishnan," Micro-Hybrid Power Systems – A Feasibility Study", Journal of Clean Energy Technologies, Vol. 1, No. 1, January 2013,pp27-32.



10.22214/IJRASET

INDEX COPERNICUS 45.98

ISRA JIF IMPACT FACTOR: 7.129

SJIFactor TOGETHER WE REACH THE GOAL IMPACT FACTOR: 7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY