



Solar based Electric Vehicles Fast Charging Station

Nirala Kumar and Prof. Manish Kethoriya

*Department of Electrical Engineering
School of Research and Technology, People' University, Bhopal [MP], India*

ABSTRACT

Electric vehicles are a brand-new, rapidly-evolving energy and transportation technology with numerous financial and environmental advantages. The various types of electric vehicles and the associated hardware, in particular battery chargers and quick charging stations, are examined and evaluated in this study. The various kinds of electric vehicle charging stations and industry standards, as well as how they affect the electricity distribution system, have all been detailed. The characteristics of electric vehicles, the protocols currently in use for charging battery systems, the battery management system (BMS), the various international standards in use, the infrastructure required to charge electric vehicles, as well as the different charging modes, have also been covered. Electric vehicles (EVs) are swiftly establishing themselves as vital players in the transportation and electricity sectors. They consequently need a suitable charging infrastructure at the same time. This work study includes a literature analysis on solar charging stations, information on managing maximum power points, and information on solar panels and the charging grid. Electric vehicle (EV)-PV) charging system architecture. Additionally, use MATLAB/SIMULINK to construct and simulate a 35 kW EV charging station based on R-2023a. In order to enhance the effectiveness of the solar panels, the charger can be charged in Fast charging mode using solar energy as a stand-alone system using Perturb and Observe MPPT. In order to circumvent the problem of power disconnecting when the grid went down while utilizing a PV on-grid system, this system utilised EVs as well as fast charging to shorten charging time and a PV off-grid system. The simulation was run at a temperature of 40° C with an illumination of 1000 W/m². The charging time is considerably less than the database time, the results show. Actual line voltage is 415 volts, and the grid's frequency is 50 hertz, with a voltage fluctuation of 10 volts. Grid voltage V_{dc} is 415 volts according to the results of the simulation, but after a brief period of time, the voltage lowers to 320 to 338 volts, where it stays constant for the duration of the testing, which is 10 seconds. From grid Menten, current flows between 126 and 132 A until sample time 7. Within 10 seconds, the output voltages of Battery 1 are 535 to 538 volts, Battery 2 is 502 to 504 volts, and Battery 3 is 494 to 495 volts. Similar to this, for a total of 10 seconds, the output current of Battery 1 is 31 A, Battery 2 is 27 A, and Battery 3 is 25 A. As a reference value, the SOC of Batteries 1, 2, and 3 is constant.

Keywords: Battery Charger, Charging Station, Electric Vehicle, DC-DC Fast Charging, li-ion battery

1. Introduction

The current reliance on Internal Combustion Engine (ICE) technology, which is responsible for high energy consumption, environmental pollution, and rising fossil fuel prices, must be reduced, and alternative fuels with the potential to solve environmental pollution, global warming, and energy sustainability concerns must be investigated. Considering danger, pollution, availability, maintainability, and efficiency, and reliability, electricity is the most suited energy for transportation in the next 30 years. Since the invention of automobiles with ICE in the late nineteenth century, the automotive industry has witnessed only modest changes. With fossil fuel as the primary fuel, ICE remains the primary mover for autos. With growing worries about the depletion of natural resources (such as oil and gas) and air pollution, governments, automakers, and consumers throughout the world have been collaborating to adapt to a shift to green mobility. This has resulted in fierce rivalry and a continuing revolution in the development of electric cars (EVs) and hybrid electric vehicles (HEVs), which offer better efficiency and fewer CO₂ emissions than internal combustion engine (ICE) vehicles. Electrochemical batteries, like the gasoline tank in ICE vehicles, are essential components for energy storage in all EVs and HEVs. Nowadays, EVs provide an intriguing answer to the growing reliance on fossil fuels, as they allow for significant reductions in air pollution. However, the adoption of EVs is still hampered by a number of challenges, the majority of which stem from the interaction and integration of these cars with the existing power grid. Furthermore, in order for zero-emission vehicles to be widely distributed on the market, they must have travel ranges and charging periods equivalent to typical oil-based fuel vehicles. As a result, EVs require battery packs with high values for both energy storage capacity and charging rates. In this regard, lithium-ion batteries are a highly attractive choice, as they have shown a significant potential in recent years to equip electric vehicles with good acceleration and driving range. New lithium compound technologies are now available, allowing for specific energy of up to 180 Wh/kg and a maximum

* Corresponding author. Tel.: +91 78698 26079.

E-mail address: er.niralapcrt@gmail.com

charging rate of 6 C, lowering charging periods to as little as 10 minutes. Typically, low-power charging modes are appropriate for charging battery packs throughout the night for 7-8 hours, assuring low power requirements for the grid. Indeed, current research show that in 80% of cases, the daily trip range is less than 50 km. As a result, such sluggish recharging would be acceptable for most users, ensuring a travel range of 100 to 150 kilometers during daylight hours. Electric vehicles (EVs) are seen as the means of transportation of the future. The Paris Declaration and Call to Action on Electromobility and Climate Change aims for the global deployment of 100 million electric vehicles by 2030. EVs are far more energy efficient than gasoline/diesel vehicles, and they emit no exhaust emissions. They feature a considerably simpler drivetrain, are much quieter, and require much less maintenance. EVs, on the other hand, are only sustainable if the electricity required to charge them is generated from renewable sources rather than fossil fuel-based power plants. It is obvious that any type of electric vehicle, whether a HEV, PHEV, or PEV, has lower well-to-wheel emissions than a comparable gasoline vehicle. At the same time, the emissions of an electric vehicle are reliant on the quality of the fuel mix. Contrary to common assumption, when EVs are charged from a grid that is primarily fueled by fossil fuels such as coal or natural gas, the emissions are significant rather than zero. However, if EVs are charged from a system that is primarily fueled by renewable energy, the net emissions are close to zero. The problem, then, is to power EVs in the future with renewable energy sources.



Figure Error! No text of specified style in document..1 A rendering of a solar-powered EV charging station

As a result, charging electric vehicles with photovoltaic panels can make EVs completely sustainable while simultaneously lowering the net cost of charging infrastructure. This is the vision and motive for the thesis. If PV generation is insufficient, an alternating current (AC) grid link is provided to provide any excess PV electricity or draw power for EV charging. This ensures that if either PV generation or EV charging is insufficient or unavailable, neither is impeded.

1.1. System Level Design

The goal of system level design is to create a PV and EV system that matches solar energy with EV charging needs. The problem is that solar generation is location dependent and subject to seasonal and diurnal changes. Traditionally, the design of the PV system and the EV charging infrastructure have been studied separately, without regard for their critical interdependence. In this thesis, an integrated system design that considers both EV and PV is thus contrasted in terms of quick charging. In the case of the Netherlands, extensive modelling of meteorological data such as sun irradiation and temperature is required, as well as an analysis of EV users' daily commuting requirements. The effect of a PV tracking system and the installation of a lower rated power converter on the PV system rating is also investigated.

Second, basic smart charging strategies, such as a Gaussian EV charging profile, can assist EV charging in closely tracking fluctuating PV generation. Simultaneously, local storage offers the capacity to regulate solar variations by storing energy during surplus generation and providing power when it is low. While both strategies have been demonstrated to aid in sun charging of EVs, they have not been examined simultaneously. Furthermore, in the case of office charging, EV charging demand is typically 5 days per week on weekdays, whereas PV generates power 7 days per week. The critical influence of this mismatch in supply and demand on system design has not before been studied.

1.2. Power Converter Design

To enable solar charging of EVs, the power converter design studies power converter architecture, semiconductor device technology, power density, efficiency, closed-loop control, and EV charging standards. Simply said, it is the hardware that makes it possible to charge EVs from PV.

Existing solutions for charging EVs with solar energy include employing a DC/AC solar inverter to extract electricity from a PV array and then charging the EVs with an AC/DC EV charger. Figure 1.3 depicts this with independent power converters for PV and EV. As a result, the power exchange medium between EV and PV is the AC grid. However, this solution is inefficient and rigid for a variety of reasons:

1. Because EV and PV are primarily direct current (DC), exchanging power through alternating current (AC) involves more power conversion and is less efficient than DC power exchange. This is due to the fact that high power inverters/rectifiers for EV and PV often contain a two-step power conversion, a DC/DC stage, and a DC/AC stage. The DC/AC stage can be bypassed using DC power exchange between EV and PV.
2. The conventional solution requires two DC/AC inverters, one in the PV converter and one in the EV converter, increasing the system's cost and complexity.
3. Currently, solar inverters and EV chargers are built as distinct equipment with no shared control interface. This makes it difficult to design charging algorithms to manage EV charging based on PV generation in practice.
4. EV batteries can be charged from the grid as well as discharged back to the grid. This phenomenon is known as Vehicle-to-grid (V2G), and it necessitates the use of a bidirectional EV charger (charge and discharge). With V2G, the EV can function as a grid-controllable electrical

generator. This would be much more helpful if solar energy could be stored in the EV during the day and extracted at night. Commercially accessible EV chargers are currently not bidirectional, and so do not support V2G technology.

- Finally, the current generation of power converters are constructed utilizing standard silicon semiconductor technology, which limits the switching frequency to 30kHz. Lower switching frequencies result in bigger passive components in converters, increasing converter volume and decreasing power density.

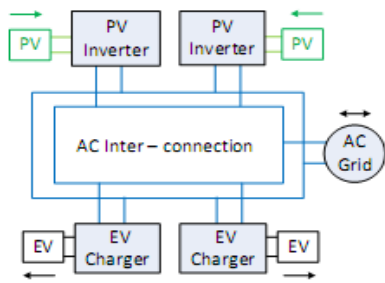


Figure Error! No text of specified style in document..2 Existing EV solar charging systems use a DC/AC solar inverter

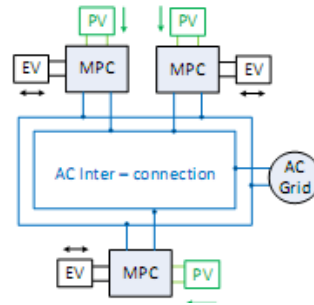
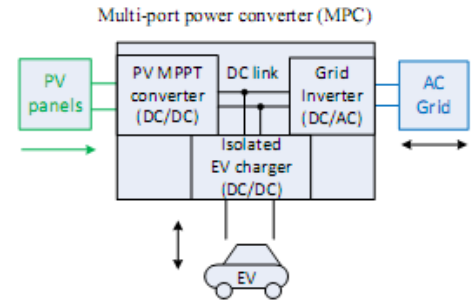


Figure Error! No text of specified style in document..3 Integrated multi-port power converter



To address these shortcomings, a possible approach would be to create a dedicated multi-port power converter (MPC) capable of connecting to PV, EV, and grid, as shown in Figure 1.4. It would be more efficient to connect EV and PV on DC rather than AC in the integrated converter.

1.3. Smart Charging Algorithms

Smart charging is a means of intelligently controlling and/or shifting EV charging in order to achieve one or more meaningful goals other than attaining a completely charged EV battery. For example, if solar forecast data indicates that it will be an overcast morning followed by a sunny afternoon, smart charging can assist in scheduling EV charging in the afternoon rather than the morning. Alternatively, the goal could be to reduce charging costs depending on dynamic energy prices. Several smart charging algorithms for electric vehicles have been developed, which schedule EV fleet charging depending on inputs such as EV user preferences, energy pricing, the provision of ancillary services, or reactive power support. When compared to uncontrolled charging of EVs, these algorithms have proved to dramatically cut charging costs.

The disadvantage of the present technique is that each of these characteristics, such as EV user preferences, energy pricing, or renewable energy prediction, is treated as a distinct input and addressed as a separate Optimisation problem. As a result, multiple alternative EV charging profiles are acquired as a solution, with one charging profile providing a solution for each combination of inputs. This is not feasible because a single EV cannot be handled with many charging profiles at the same time. Second, as previously said, the algorithms are not customized for a certain power electronic hardware, making it difficult to directly build and use them on EV charging stations. Finally, most charging algorithms have not been tested with actual EVs, and their compliance with EV charging regulations has not been confirmed.

As a result, it is critical to provide a single problem formulation that combines many applications so that one optimal EV charging profile may be obtained to control the EV. This results in the addition of benefits from each application, resulting in a net benefit big enough to drive large-scale smart charging implementation. A new set of smart charging algorithms is being developed to maximize the usage of PV energy while lowering the cost of EV charging. The important characteristic is that it incorporates six applications into one formulation: EV user preferences, EV charging from PV, vehicle-to-grid, market energy prices, multiplexing of many EVs to a single charger, and provision of regulation services to the independent system operator (ISO). This results in a significant reduction in net costs, far greater than previously realized. Furthermore, smart charging and V2G are tested using EVs that are compatible with CHAdeMO and CCS/Combo, which are the two global standards for DC charging of EVs.

1.4. Photovoltaic Array

A PV array is defined as a collection of parallelly connected strings. Strings: certain PV modules are linked in series. The following is the mathematical model of PV cell group output current for one PV module.

$$I_A = N_p I_{ph} - N_p I_0 \left[\exp \left(\frac{q \left(\frac{V}{N_s} + I \frac{R_s}{N_p} \right)}{n K T} \right) - 1 \right] - \left(\frac{V \left(\frac{N_s}{N_s} \right) + I R_s}{R_{sh}} \right)$$

Eqn. Error! No text of specified style in document..1

Where N_p denotes the number of cells linked in parallel. N_s is the number of cells connected in series. I_{ph} is a solar cell photocurrent. The saturation current of the diode is equal to $3.5075e-11$ A. The ideality factor n is equal to 0.96299. K is the Boltzmann constant, which equals $1.380658e^{-23}$ J/K. T is the working temperature of a solar cell (in Kelvin). V is the volt equivalent, and R_s is the series resistance, which equals 0.32702. The current generated by photovoltaic cells is denoted by I_A . R_{sh} is the shunt resistance, which is 597.8018. Q is the charge of an electron, and it is equivalent to 1.6022×10^{-19} C. The PV group's maximum current, maximum voltage, and maximum power are all indicated as I_m , V_m , and P_m , respectively.

$$P_m = V_m I_m$$

Eqn. Error! No text of specified style in document..2

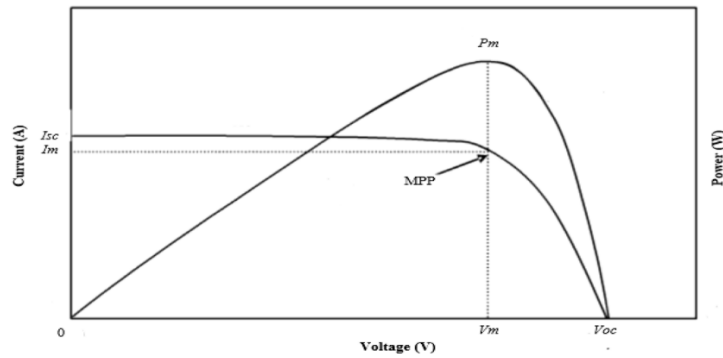


Figure Error! No text of specified style in document..4 I-V and P-V properties of a PV array

1.5. Li-Ion Battery

Batteries are one of the most common methods of storing electrical energy. As a load, this article advocated electric car batteries. Among the existing rechargeable batteries, this work is relevant to EVs, namely li-ion batteries, which are now recognized as the ideal answer for EVs. In terms of energy effectiveness and power concentration, lithium-ion batteries are superior. Li-ion batteries have high volumetric (energy density) and specific energy densities, as well as smaller diameters and lighter weight cells (Manufacturing That Reduces Risk and Improves Reliability). A battery's energy density is proportional to its weight, whereas its volumetric density is proportional to its volume (Manufacturing That Eliminates Risk and Improves Reliability). The energy in a battery is proposed as WH, which is written in the following equation as the energy in any group of batteries or one battery.

$$WH = V \times AH$$

Eqn. Error! No text of specified style in document..3

Where V is the battery system volt. The capacity of batteries is measured in AH. Figure 5 compares the energy densities of lead acid, nickel-cadmium, nickel-metal-hydride, and lithium-ion batteries.

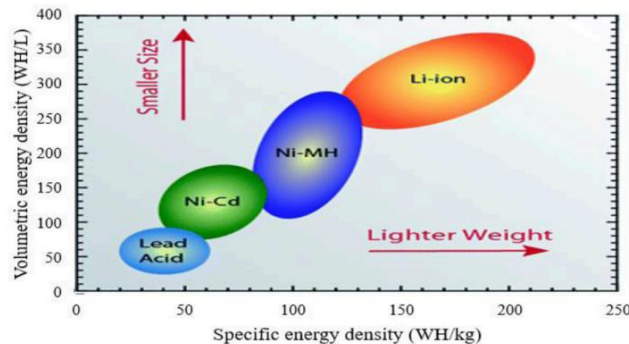


Figure Error! No text of specified style in document..5 Energy densities in batteries

1.6. Objective of the Work

Some object of this dissertation work has to studied and some objective to simulate using MATLAB/SIMULINK. The details of this dissertation work object as:

1. To study about smart charging station for EV-PV.
2. To study about Multi port power management.
3. To study architecture of power flow of EV-PV.
4. To study about fast charging of DC/DC EV-PV.

2. Research Methodology

There are two major advantages to charging electric vehicles using solar PV systems, sustainability and economy. From well-to-wheel, fuel usage, and life cycle assessment standpoints, charging electric vehicles with solar energy results in significantly improved energy efficiency, as well as significantly reduced net emissions and environmental effect. Second, thanks to dropping PV system prices, solar PV electricity is now cheaper than traditional electricity in many regions of the world. Furthermore, depending on the automotive category, an electric car's total cost of ownership is already cheaper than that of a comparable internal combustion engine vehicle. Finally, with the elimination of net metering and the possibility of future feed-in tariff reductions, charging EVs from PV promotes PV self-consumption while ensuring a return on investment for the PV system. All of these characteristics make solar EV charging appealing in terms of the environment, sustainability, and economics.

2.1. EV Charging System for PV

As previously stated, the charging system extensively used in Europe for alternating current charging is based on the Type 2 Mennekes connector. At the Level 2 charging power level, it enables both single and three phase AC charging. However, in the future, DC charging via CHAdeMO and the Combined Charging option (CCS) will be the most recommended charging option for charging EVs from solar panels at work. This is due to the following reasons:

1. Both EV and PV are inherently DC by nature.
2. Smart charging of EV is possible, where the EV charging power can be varied with time.
3. DC charging facilitates V2G protocol.

As a result, the focus of this dissertation will be on EV DC charging. While high-power DC charging on the order of 50kW is common, the focus here is on low-power DC charging. This is because, as previously said, cars are frequently parked at the workplace for 8 hours per day. Because of the long parking times, the same energy can be given to the EV at a lower charging power. For example, 80kWh energy can be provided in 8h using the 10kW charger, which allows 666 km distance for a 2016. This is more than sufficient for the daily driving requirements for 6 to 10 employees.

2.2. System Architecture for the EV-PV System

Various system architectures can be utilised to charge EVs using solar energy. The EV-PV charging system incorporates the PV array, the electric vehicle supply equipment (EVSE), and the AC grid in all instances, with the primary goal of charging the EVs directly from the PV electricity. To integrate the PV, EV, and grid, two types of power converters can be employed:

- A single multi-port converter (MPC) that combines grid, PV, and EV power.
- Separate power converters for grid, PV, and EV interconnected via a common interconnection.

The power converters can be linked together using either an AC or DC interface. The converter interconnection is used to share PV electricity across several EVs and interchange power between the EV and the grid. The system architecture can be of four sorts using the two power converter types indicated above, depending on whether the interlinking bus is AC (1Φ 230V 50Hz or 3Φ 400V, 50Hz grid) or DC.

Architecture 1 - Separate converter for PV, EV interlinked on AC

Figure 2.1(a) depicts the Architecture 1 schematic. PV panels and EV charging/discharging are powered by separate converters. The PV converter is a DC/AC inverter with maximum power point tracking (MPPT), while the EV charger is an AC/DC converter. The existing 50Hz AC grid serves as the architecture's backbone, and all power is routed through it. The downside is that the PV power cannot be used directly to charge the EV in DC form. This causes needless conversions from DC to AC in the PV inverter and back to DC in the EV charger.

Architecture 2 - Separate converters for PV, EV interlinked on DC

Figure 2.1(b) depicts the Architecture 2 design, which employs a DC interface to connect the converters for the PV panels, EV, and grid. Both the PV and EV converters are DC/DC converters with MPPT and charge management, respectively. The DC interface enables the direct use of PV DC electricity for EV charging, resulting in improved efficiency. The DC connector is linked to the AC grid via a central inverter. The central inverter is critical for V2G functioning because it allows electricity to be fed/drawn according to the differential between PV generation and EV charging needs. The DC interconnection can be enlarged to a DC micro-grid depending on its power rating, size, and the number of sources and loads linked to it. The downside of Architecture 2 is that the DC interconnection must be established independently rather than using existing AC grid infrastructure. Control and protection of the DC connector must be provided based on the size, power handled, and anticipated power changes.

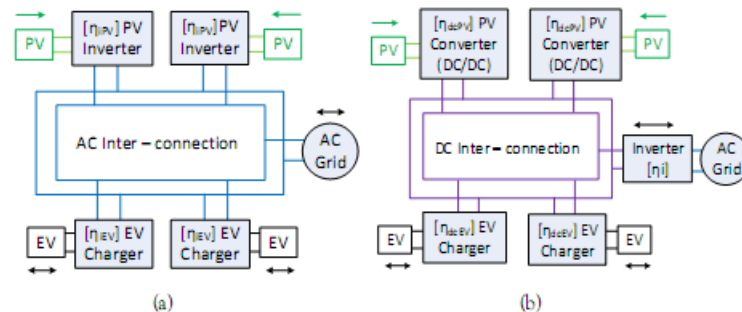


Figure 2.1 (a) System Architecture 1 and (b) System Architecture 2 for the EV-PV charger

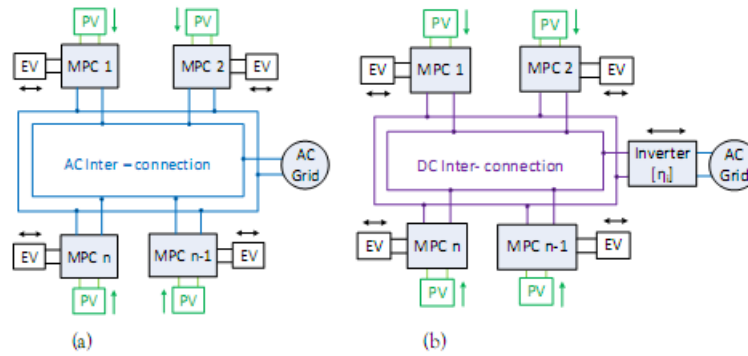


Figure 2.2 (a) System Architecture 3 and (b) System Architecture 4 for the EV-PV charger using multiport converters

Architecture 3 - Multiport converter for PV, EV, grid interlinked on AC

Using a central DC-link, the multi-port converter connects the converters for the PV array, the EV, and the AC grid. Multiple MPC are linked together via the AC grid. As demonstrated in Figure 3.2 (a), integrating power electronic converters for PV, EV, and grid into a single MPC results in improved power density, lower component count, cost savings, and ease of control. The MPC controller can control EV charging from PV, but in the previous two architectures, communication must be established between the separate PV and EV converters. The main problem is that without conversion to AC, the DC PV output from one MPC cannot be utilised to charge the EV of another MPC.

Architecture 4 - Multiport converter for PV, EV, grid interlinked on DC

Figure 2.2 (b) depicts the architecture 4 schematic, which is a hybrid of Architectures 2 and 3. It integrates the converters for the PV array and EV using a multi-port converter, as shown in Figure 2.2 (b). Many MPCs are linked together via a DC connector. To connect to the AC grid, a high-power central inverter is used. This central inverter outperforms architecture 3's use of multiple mini inverters embedded within the MPC. Similarly, to Architecture 2, the DC interconnection can be expanded to a DC microgrid depending on the amount of power handled and other sources and loads linked.

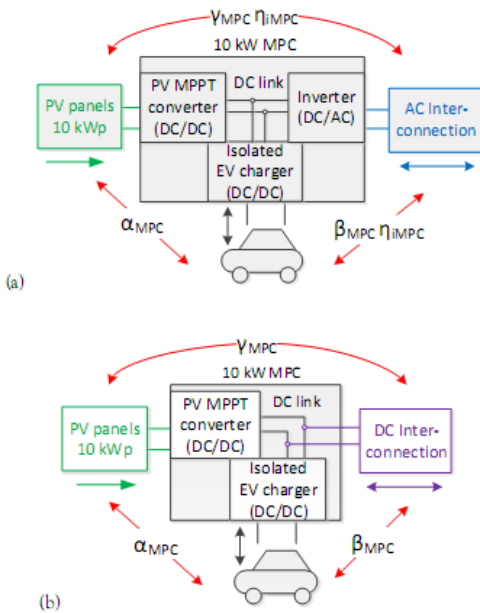


Figure 2.3 Block diagram of multi-port converter for (a) Architecture 3, (b) Architecture 4

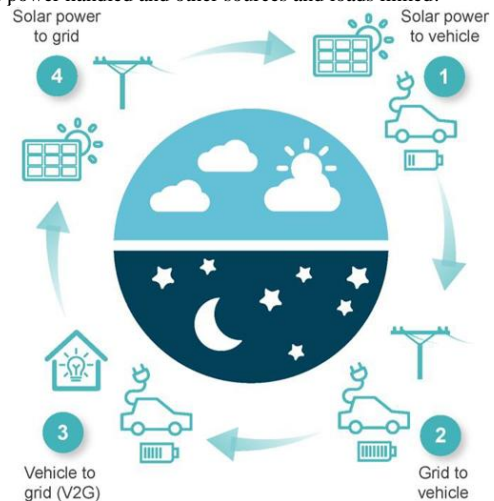


Figure 2.4 Four possible power flow mode in an EV-PV system

2.3. EV-PV Power Flows

There are four possible power flows in an EV-PV charging system when using multiport or separate converters, named as EVPV Mode 1 to 4 as shown in Figure 2.4.

- EVPV Mode 1**-EVPV Mode 1 is the direct use of PV power for EV charging, which is the charging system's primary goal. Mode 1a charging is a subset of Mode 1 charging that is suited to architectures 3 and 4 that use an MPC. The power exchange from the PV panel linked to one EV-PV MPC to the EV connected to another EV-PV MPC was represented by Mode 1a. This could happen in a workplace where EVs are not connected to all EV-PV chargers.

- **EVPV Mode 2**-The power flow from the grid to the EV for EV charging is represented by EVPV Mode 2. When solar energy is insufficient to meet the EV charging requirements, Mode 2 is used.
- **EVPV Mode 3**-EVPV Mode 3 is the power exchange from EV to grid for V2G.
- **EVPV Mode 4**-EVPV Mode 4 is used to directly feed PV power to the grid. This mode is enabled when there is no EV for charging or when the EV battery is full.

2.4. Comparison of System Architectures

Direct DC charging of EVs from PV without conversion to AC results in fewer conversion stages and associated losses. This is a significant advantage of Architecture 2,3,4 over Architecture 1. When using an MPC, a single inverter is used for both the EV and PV, either within the MPC (Architecture 3) or for the complete DC interconnection (Architecture 4). When compared to separate converters as in Architecture 1,2, the common inverter results in a lower component count, higher power density, and lower losses. Another advantage of the MPC is the ease with which individual EV, PV, and grid converters may be controlled, as opposed to operating separate power converters via a communication infrastructure. Finally, Architecture 2 and 4's DC interconnection does not use the current AC grid infrastructure. As a result, Architectures 2 and 4 face a disadvantage in the development of a separate DC interconnection with its own control and protection. This work have architecture 3 EV-PV system.

2.5. 35 kW DC Fast Charging Station Designing

Here 35kW DC fast charging station with solar cogeneration connected with the three battery packs of electric vehicles (EV).This is comprising four main components as show in Figure 2.5:

- Grid: AC supply voltage as a three-phase constant voltage source.
- Solar Generation: solar pack as parallel strings of series connected cells.
- DC Fast Charging Station: the power electronic circuits to convert the AC supply voltage from the grid to the DC voltage level that the EV battery pack requires.
- EV battery pack: the battery pack as series of battery cells.

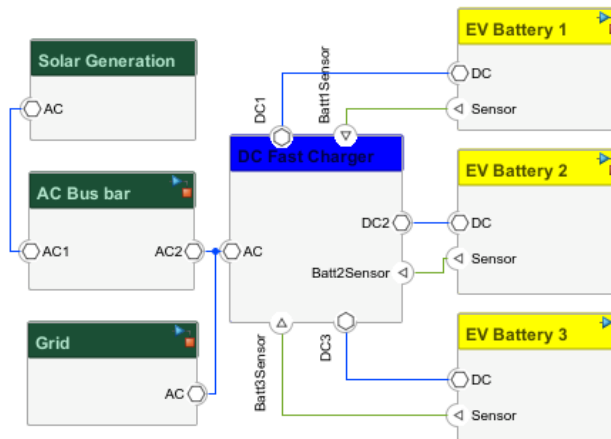


Figure 2.5 A 35 kW Fast charging EV-PV Station

Solar Generation

Solar generation is the combination of two section solar plant and inverter circuit section. The solar generation schematic diagram by using MATLAB is shown in Figure 2.6.

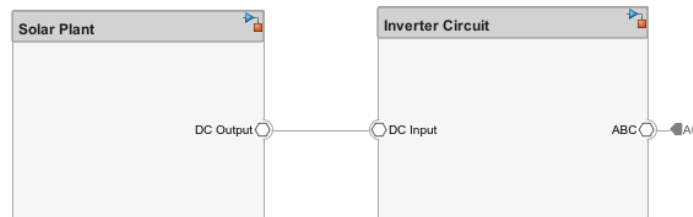


Figure 2.6 Schematic diagram of Solar Generation

Solar Plant

Solar plant made by solar panel and some circuits. The solar plant shown in Figure 2.7 and Figure 2.8. Data for solar photovoltaic panel manufacturer datasheet based on standard test condition as shown in Table

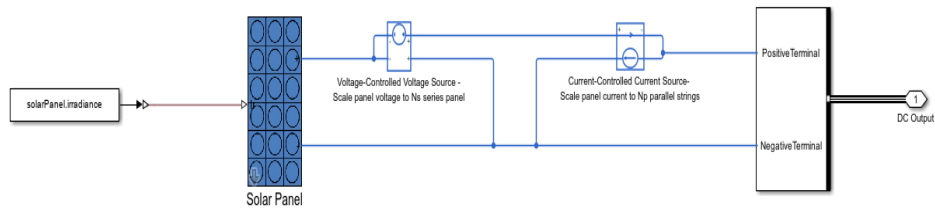


Figure 2.7 Solar Plant

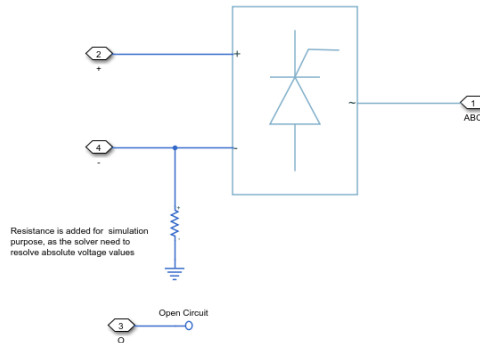


Figure 2.8 Inverter Circuit

Table 2.1 Specification of Solar panel

Parameter	Value
Short Circuit Current	8.18 A
Open Circuit Voltage	36.7 V
Maximum Power Voltage	29.9 V
Maximum Power Current	7.53 A
Number of Solar Cell connected in series	60
Solar panel current temperature coefficient	-0.04/100
Solar panel voltage temperature coefficient	-0.32/100
Temperature Measurement	25 °C
Irradiance Measurement	1000 W/m ²
Maximum system voltage	1500 V
Nominal operating cell temperature	45 °C
Area of the panel	1.652*1.000 m ²
Solar panel per square meter capacitance	13*10 ⁻⁹ F
Quality factor	1.5
Series resistance	0
Temperature exponent for diode saturation current	3

Maximum power of solar panel =maximum PV*maximum Power Current*1e-3 kW

AC Bus bar

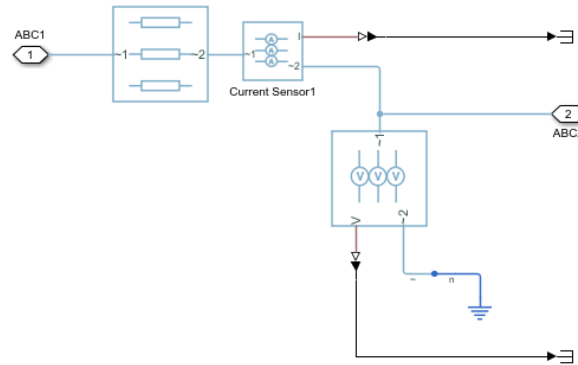


Figure 2.9 AC Bar

DC fast Charger

DC fast charging is the combination of FEC and DC-DC converter section as shown in Figure 2.10. Here 3 DC-DC converters used.

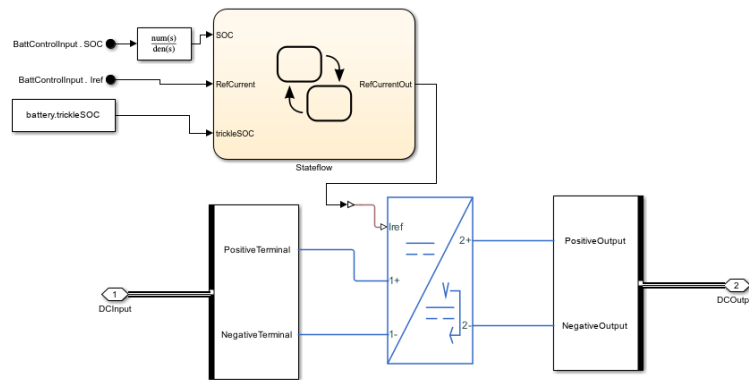


Figure 2.10 DC-DC Converter

Table 2.2 Plant Specification

Parameter	Value
Plant Power	35 kW
Operating Temperature	40 °C
System Voltage drop	8 V
Switching frequency	10000 Hz

Table 2.3 Three phase grid Parameter

Parameter	Value
Supply Line Voltage	415 V
Actual Line Voltage	415 V
Frequency	50Hz
Voltage Fluctuation	10

Grid Supply voltage = Grid Supply line voltage/sqrt(3) Volt

Actual Grid Supply voltage = Actual Grid Supply line voltage/sqrt(3) Volt

Table 2.4 Environmental Simulation parameter

Parameter	Value
Solar panel irradiance	1000 W/m ²
Solar Panel Temperature	25 °C
Number of cycles simulated	500

Solar PV plant design

Solar Plant temperature Voltage Reduction=solar Panel voltage Temperature Coefficient*solar Panel open Circuit Voltage of PV*(solar Plant operating Temperature+(solar Panel cell NOCT Temperature-20) *1000/800-25)

Estimated Number of PV Panels

solarPlant.voltagePerPenal=solarPanel.maxPowerVoltagePV+solarPlant.temperatureVoltageReduction

Operating voltage per panel in V

solarPlant.numSeriesPanelReq=ceil(2*(1+solarPlant.approximateSystemVoltageDrop/100)*grid.supplyVoltage*sqrt(2)*... (1+grid.voltageFluctuation/100)/solarPlant.voltagePerPenal);

Battery Design

Here three battery used. The parameters for all batteries as shown in Table 2.5 and Specification of Battery shown in Table 2.6. In this design Panasonic NCR 18650 PF model battery are used.

Table 2.5 Parameters common to all batteries

Parameter	Value
Cells in Series	100
Cells in Parallel	1
Trickle SOC	0.8

Table 2.6 Battery Specification

Battery	Current Reference	Initial SOC
Battery 1	27	0.2
Battery 2	31	0.78
Battery 3	25	0.62

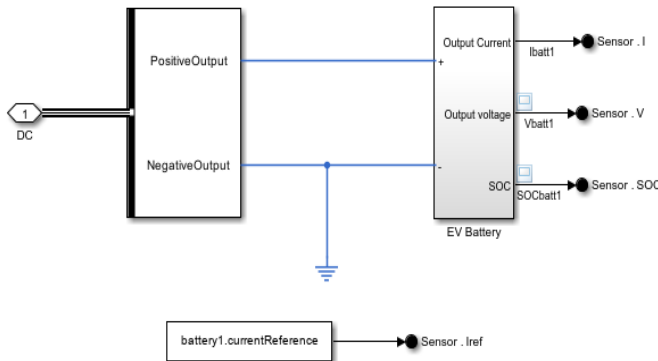


Figure 2.11 Battery_1

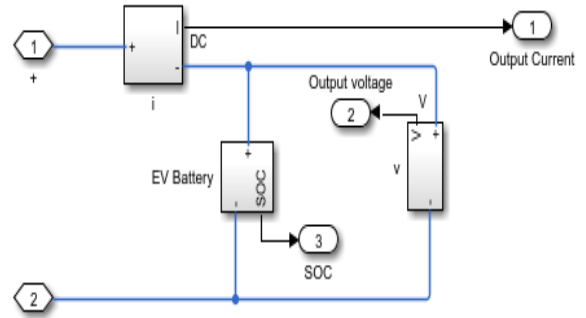


Figure 2.12 Battery connection

2.6. Maximum Power Point Tracking

This method employs Perturb and Observe (MPPT) to maximize output power. Figure 2.13 displays a PV module's output power curve as a function of (P-V) with constant irradiance and constant cell temperature, with the PV module working away from the MPPT. A slight increase in this method disrupts the PV module's working voltage, and the resulting change in power, P, is monitored. If P is positive, it is assumed that the operating point has moved closer to the MPP. The operating point should be closest to the MPP as a result of higher voltage disturbances along a comparable path. If P is negative, the operational point deviates from MPP, and the perturbation path must be reversed to return it to MPP.

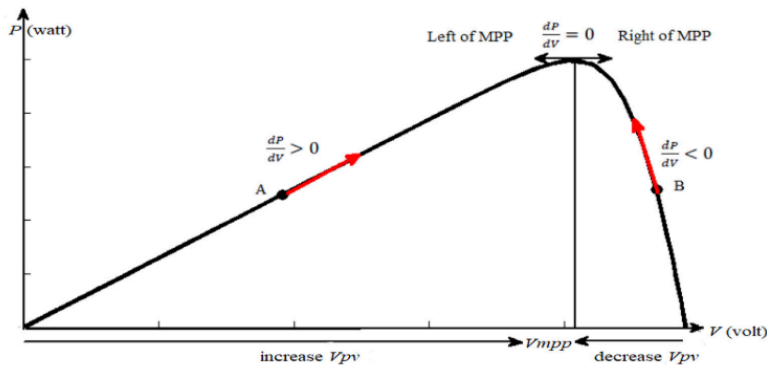


Figure 2.13 Perturb and Observe on the P-V curve

Although it has a slower dynamic reaction than fuzzy logic control (FLC), the Perturb and Observe strategy is utilized to extract the most power feasible from solar energy. As a result, we used smaller increments to achieve a successful steady-state inaccuracy.

3. Resultand Discussion

This section discussed the outcome of the Fast Charging Solar Power Station. MATLAB SIMULINK release 2023a was used to simulate the results. All of the parameters utilized were based on the chapter 3, table presented in the section Designing a 35 kW Solar Fast charging Station Using Solar Energy. To determine the parameters of the fast charging station, MATLAB Simulink was utilized. The MATLAB PV system simulation model, which used the Perturb and Observe MPPT controller. The temperature is maintained at 40° C, and the irradiance is maintained at 1,000 W/m2. This work simulated the power of an input and output MPPT controller, as well as its efficiency, charging time, and voltage and current level characteristics for each model of

these electric vehicles. To obtain and calculate MPPT efficiency based on input and output power for each system, a MATLAB SIMULINK platform is used in this work.

3.1. Grid Voltage and Current

Supply Line Voltage 415 V used, Actual Line Voltage 415 V, frequency of grid is 50Hz where voltage fluctuation 10. According to simulation result grid voltage Vdc is 415 volts but after fraction of second the voltage drops to 320 to 338 volts constant up to testing time 10 second which is shown in Figure 3.1. Current passes from grid Menten from 126 A to 132 A as shown in Figure 3.2 up to sample time 7.

3.2. Battery Voltage and Current

The output of batteries voltage and current as well as SOC after the simulation result as shown in Figure 3.3, Figure 3.4 and Figure 3.5. The Output Voltage of Battery 1 is 535 Volt to 538 Volt, Voltage of Battery 2 is 502 Volt to 504 Volt and Voltage of Battery 3 is 494 Volt to 495 Volt within 10 second. Similarly, the output Current of Battery 1 is 31 A, Current of Battery 2 is 27 A and Current of Battery 3 is 25 A for all time that is 10 second as shown in Figure 3.3 and Figure 3.4. The SOC of Battery 1,2 and 3 are constant as reference value.

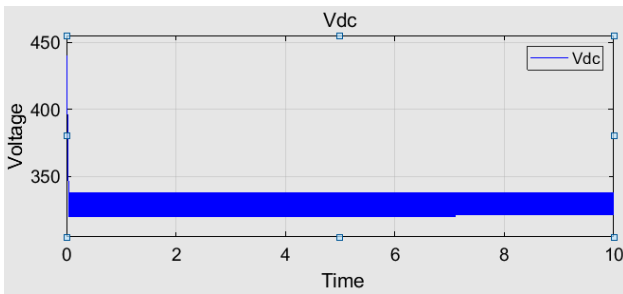


Figure 3.10 Grid Voltage

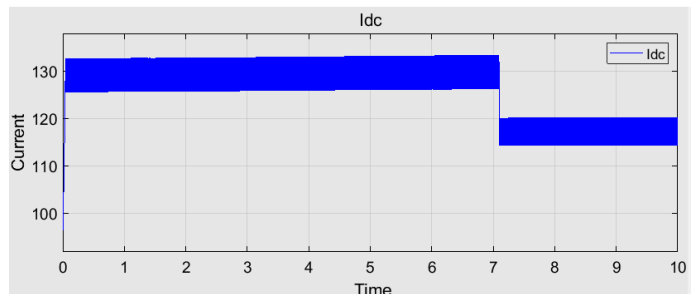


Figure 3.11 Grid current

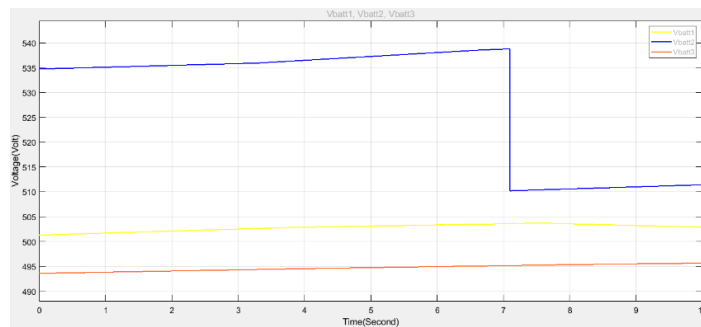


Figure 3.12 Batteries Voltage

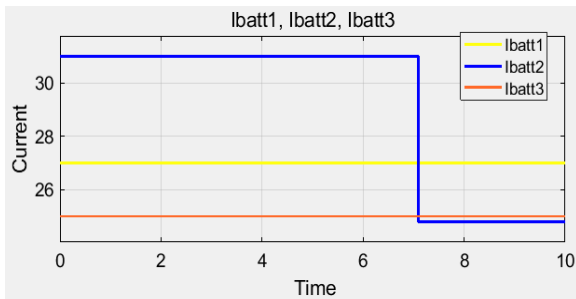


Figure 3.13 Batteries Current

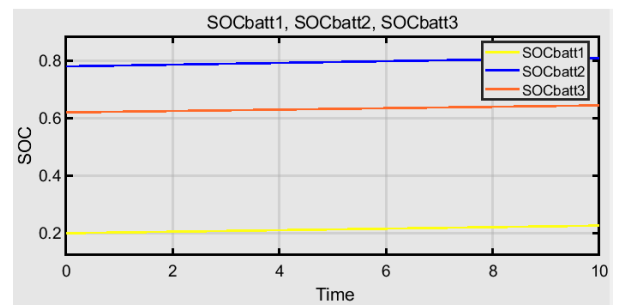


Figure 3.14 SOC of Batteries

4. Conclusions and Future Scope

4.1. Conclusion

In this work study about the solar panel and charging grid, maximum power management, literature review related to solar charging station. System architecture of EV-PV Charging system. Also design and simulate a 35 kW EVs charging station using MATLAB/SIMULINK based on R-2023a. The charger can be charged in Fast charging mode utilizing solar energy as a stand-alone system with Perturb and Observe MPPT to maximize solar panel efficiency. This system used EVs as a Fast charging to reduce charging time, as well as a PV off-grid system to avoid the issue of power disconnecting when the grid went down when using a PV on-grid system. This simulation was done with an irradiation 1000 W/m² and temperature between 40° C and applied in MATLAB software. According to the results, the charge time is much shorter than the database time.

Supply Line Voltage 415 V used, Actual Line Voltage 415 V, frequency of grid is 50Hz where voltage fluctuation 10. According to simulation result grid voltage Vdc is 415 volts but after fraction of second the voltage drops to 320 to 338 volts constant up to testing time 10 second. Current passes from grid Menten from 126 A to 132 A up to sample time 7. The Output Voltage of Battery 1 is 535 Volt to 538 Volt, Voltage of Battery 2 is 502 Volt to 504 Volt and Voltage of Battery 3 is 494 Volt to 495 Volt within 10 second. Similarly, the output Current of Battery 1 is 31 A, Current of Battery 2 is 27 A and Current of Battery 3 is 25 A for all time that is 10 second. The SOC of Battery 1,2 and 3 are constant as reference value.

4.2. Future Scope

To ensure that charging is always available, future work will focus on charging electric vehicles using a hybrid system that includes PV systems, wind turbines, and fuel cell (FC) technology. It is expected to be efficient and economically feasible to address the problem of the changing intensity of the sun for the solar system and the erratic wind speed for wind stations, in addition to the use of hydrogen technology as an energy storage method. Furthermore, how to boost the efficiency of PV modules to provide more electricity in the same size is already available. In addition, how to adapt battery production to become more energy-dense to get more energy in the same size.

REFERENCES

- [1] R. Bhatti, Z. Salam, M. J. B. A. Aziz, K. P. Yee, and R. H. Ashique, "Electric vehicles charging using photovoltaic: Status and technological review," *Renewable and Sustainable Energy Reviews*, vol. 54, pp. 34-47, 2016.
- [2] Al-Gabalawy, M., Elmetwaly, A. H., Younis, R. A., and Omar, A. I., "Temperature prediction for electric vehicles of permanent magnet synchronous motor using robust machine learning tools," *J. Ambient. Intell. Humaniz. Comput.*, 2022. doi:10.1007/S12652-022-03888-9
- [3] Aqib Shafiq, Sheeraz Iqbal, Salman Habib, Atiq ur Rehman, Anis ur Rehman, Ali Selim, Emad M. Ahmed and Salah Kamel, "Solar PV-Based Electric Vehicle Charging Station for Security Bikes: A Techno-Economic and Environmental Analysis," *Sustainability*, 14, 13767. pp. 2-18, 2022. <https://doi.org/10.3390/su14211376>
- [4] B. Revathi, A. Ramesh, S. Sivanandhan, T. B. Isha, V. Prakash and S. G., "Solar Charger for Electric Vehicles," 2018 International Conference on Emerging Trends and Innovations in Engineering and Technological Research (ICETIETR), Ernakulam, India, 2018, pp. 1-4, doi: 10.1109/ICETIETR.2018.8529129.
- [5] C. Capasso and O. Veneri, "Experimental study of a DC charging station for full electric and plug in hybrid vehicles," *Appl. Energy*, vol. 152, pp. 131-142, 2015.
- [6] Chandra Mouli, G. R., Schijffelen, J., Van Den Heuvel, M., Kardolus, M., and Bauer, P., "A 10 kW solar-powered bidirectional EV charger compatible with chademo and COMBO," *IEEE Trans. Power Electron.* Vol. 34, pp. 1082-1098, 2019. doi:10.1109/TPEL.2018.2829211
- [7] Dacombe, D., & German, M., "Solar Energy for Electric Vehicle Charging: An Analysis of Solar Impacts and Cost Savings," *Renewable Energy*, 92, 568-577, 2016.
- [8] Emeter, G., "Solar-Powered Electric Vehicle Charging Stations," *IEEE Power and Energy Magazine*, 14(2), 34-41, 2016.
- [9] F. Fattori, N. Anglani, and G. Muliere, "Combining photovoltaic energy with electric vehicles, smart charging and vehicle-to-grid," *Sol. Energy*, vol. 110, pp. 438-451, 2014.
- [10] G. R. Chandra Mouli, P. Bauer, and M. Zeman, "Comparison of system architecture and converter topology for a solar powered electric vehicle charging station," 9th International Conference on Power Electronics and ECCE Asia (ICPE-ECCE Asia), pp. 1908-1915, 2015.
- [11] Gao, F., Liu, Y., & Wang, Y., "A Review on Solar Energy- Powered Electric Vehicle Charging Station," *Energies*, 11(7), 1710, 2018.
- [12] Gao, F., Wang, Y., & Liu, Y., "The Development of Solar Energy-Powered Electric Vehicle Charging Station," *IEEE Transactions on Smart Grid*, 7(6), pp.4228-4237, 2017.
- [13] Gong, X., Dong, F., Mohamed, M. A., Abdalla, O. M., and Ali, Z. M.' "A secured energy management architecture for smart hybrid microgrids considering PEM-Fuel cell and electric vehicles," *IEEE Access* 8, pp. 47807-47823, 2020. doi:10.1109/ACCESS.2020.2978789
- [14] Helgason, B., & Jonsson, F., "The Cost of Solar Electric Vehicle Charging Station in Different Locations," *Renewable and Sustainable Energy Reviews*, 68, 697-709, 2017.
- [15] Ibrahim, A., & Goh, B., "A review of solar-powered electric vehicle charging stations," *Renewable and Sustainable Energy Reviews*, 43, 670-683, 2015.
- [16] K. S. Vikas, B. Raviteja Reddy, S. G. Abijith and M. R. Sindhu, "Controller for Charging Electric Vehicles at Workplaces using Solar Energy," 2019 International Conference on Communication and Signal Processing (ICCSP), Chennai, India, 2019, pp. 0862-0866, doi: 10.1109/ICCSP.2019.8697992.
- [17] Khatri, S., & Kaur, A., "A Review on Solar Powered Electric Vehicle Charging Station," *International Journal of Recent Technology and Engineering*, 7(4), 726-733, 2018.

-
- [18] Krishnan Nair D, Prasad K, Lie TT. "Design of a PV-fed electric vehicle charging station with a combination of droop and master-slave control strategy," *Energy Storage*. 2023;5(5): e442. doi:10.1002/est2.442
- [19] Li, Y., & Zhu, Z., "Review of solar-powered electric vehicle charging stations," *Renewable and Sustainable Energy Reviews*, 73, 693- 706, 2017.
- [20] Lin, H., & Chen, Y., "Solar-Based Electric Vehicle Charging Station: An Overview," *Renewable and Sustainable Energy Reviews*, 81, pp.1441-1451,2018.
- [21] Liu, Y., & Yu, J., "Solar powered electric vehicle charging stations: A review of technological advancements and challenges," *Renewable and Sustainable Energy Reviews*, 95, pp.1028-1042,2018.
- [22] M. van der Kam and W. van Sark, "Smart charging of electric vehicles with photovoltaic power and vehicle-to-grid technology in a microgrid; a case study," *Appl. Energy*, vol. 152, pp. 20-30, 2015.
- [23] Makwana, B., & Bhut, M., "Solar powered electric vehicle charging station: A review. *Renewable and Sustainable Energy Reviews*, 59, 1130-1137, 2016.
- [24] Mishra, S., Dwivedi, G., Upadhyay, S., and Chauhan, A. "Modelling of standalone solar photovoltaic based electric bike charging," *Mater. Today Proc.* vol. 49, pp. 473-480, 2021. doi:10.1016/j.matpr.2021.02.738
- [25] O. Isabella, G. G. Nair, A. Tozzi, J. H. Castro Barreto, G. R. Chandra Mouli, F. Lantsheer, S. van Berkel, and M. Zeman, "Comprehensive modelling and sizing of PV systems from location to load," *MRS Proc.*, vol. 1771, pp. 1-7, 2015.
- [26] P. Nunes, T. Farias, and M. C. Brito, "Day charging electric vehicles with excess solar electricity for a sustainable energy system," *Energy*, vol. 80, pp. 263-274, 2015.
- [27] Shariff, S. M., Iqbal, D., Saad Alam, M., and Ahmad, F. "A state of the art review of electric vehicle to grid (V2G) technology," *IOP Conf. Ser. Mat. Sci. Eng.* 561, 012103, 2019. doi:10.1088/1757-899X/561/1/012103
- [28] T. S. Biya and M. R. Sindhu, "Design and Power Management of Solar Powered Electric Vehicle Charging Station with Energy Storage System," 2019 3rd International conference on Electronics, Communication and Aerospace Technology (ICECA), Coimbatore, India, 2019, pp. 815-820, doi: 10.1109/ICECA.2019.8821896.
- [29] V Kareem, Z., & Karp, A., Review of Solar Energy Powered Electric Vehicle Charging Stations. *Renewable and Sustainable Energy Reviews*, 103, pp.621-630, 2019.
- [30] Wang, D., Sechilariu, M., and Locment, F. "PV-powered charging station for electric vehicles: Power management with integrated V2G," *Appl. Sci. Switz.* 10, 6500, 2020. doi:10.3390/APP10186500.