DEVELOPING A SOLAR-POWERED ELECTRIC VEHICLES CHARGING SYSTEM UTILIZING VEHICLE -TO - GRID-ENABLED SMART TECHNOLOGY

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ABSTRACT

Two fundamental concerns have evolved in the global energy business during the past couple of decades. The first is the extensive use of fossil fuels, which causes their rapid depletion, and the second is carbon emission, which causes global warming. For energy, the majority of nations rely on fossil fuels and natural gas. Fossil fuels are not just nonrenewable, but also limited resources that will eventually run out and become too expensive and environmentally damaging to extract. However, distributed energy sources such as wind and solar energy are renewable, non-depleting, and environmentally friendly. Renewable energy is also dubbed "green energy" because it does not generate air pollution or carbon emissions. Transportation is one of the key industries that use fossil fuels. Battery Electric Vehicles (BEVs) were developed as an alternative to Internal Combustion Engines (ICEs) in an effort to reduce carbon dioxide (CO2) emissions and fossil fuel consumption (ICEs).

Keywords: Smart technology, V2G Technology, solar PV system, Battery.

1. INTRODUCTION

1.1 OVERVIEW

Globally, electric vehicles (EVs) are a novel concept in the transportation sector. In 2030, EVs are projected to make up 24% of the U.S. light vehicle fleet, compared to 64% of light vehicle sales in 2018. In this context, the battery charging process of EVs must be managed in order to maintain the power quality of the power grids. With the spread of Evs, however, a substantial quantity of energy will be stored in the batteries, hence increasing the likelihood of energy transfer in the other direction. Interaction with electric vehicles will be one of the important technologies in future smart grids, contributing to the autonomous functioning of the power grid. The notion of an on-board bidirectional charger utilising V2G and V2H technologies is presented. Due to lower carbon dioxide emissions and increasing fossil fuel prices, the electric vehicle has become more competitive than the conventional internal combustion engine vehicle. However, the EV was not generally embraced on the market due to restrictions such as expensive car costs; Limited charging infrastructure and limited all-electric driving range. EVs are cars that are partially or completely electric-powered. Electric vehicles offer minimal operating expenses since there are fewer moving parts that need to be maintained, and they are also very environmentally friendly because they consume little or no fossil fuel.

1.2 ELECTRIC VEHICLE

A vehicle that propels itself using one or more electric motors or traction motors is referred to as an electric vehicle (EV). Electric vehicles can be self-contained using a battery, solar panels, fuel cells, or an electric generator to convert gasoline to electricity, or they can be fueled by electricity from sources outside the vehicle through a collector system. Electric vehicles (EVs) include, but are not limited to, surface and underwater craft, electric Aeroplan's, and electric spaceships. EVs initially appeared in the middle of the 19th century, when electricity was one of the preferred forms of motor vehicle propulsion. At the time, gasoline-powered cars were unable to match the comfort and ease of operation that electric vehicles offered. While modern internal combustion engines have dominated motor vehicle propulsion for almost a century, electric power has remained prevalent in other vehicle types, such as railways and smaller vehicles of various kinds.

An electric motor replaces the internal combustion engine in all-electric vehicles, also known as battery electric vehicles (BEVs). The electric motor of the vehicle is powered by a sizable traction battery pack, which must be plugged into a wall outlet or charging apparatus, also known as electric vehicle supply apparatus (EVSE). The car does not have a tailpipe or any typical liquid fuel components like a fuel tank, fuel line, or fuel pump because it is an electric vehicle. Find out more about electric cars.

There are four types of electric vehicles available:

- **Battery Electric Vehicle (BEV)**

BEVs are also referred to as all-electric cars (AEV). Electric drivetrains powered solely by batteries are used in BEV-based electric vehicles. The large battery pack that houses the electricity needed to power the car can be charged by plugging it into the power grid. One or more electric motors are then powered by the fully charged battery pack to drive the electric vehicle. It is fully electrically powered. When compared to hybrid and plug-in hybrid vehicles, these are more efficient.

Main Components of BEV:

Electric motor, Inverter, Battery, Control Module, Drive train

- **Hybrid Electric Vehicle:**

HEVs are also referred to as parallel or series hybrids. HEVs have an electric motor in addition to an engine. Fuel powers the engine, while batteries provide electricity for the motor. Both the engine and the electric motor turn the transmission at the same time. Wheels are then propelled by this. Both the internal combustion (typically gasoline) engine and the battery-powered motor powertrain are utilised by the vehicle. When the battery is dead, the petrol engine is used to both propel and charge the vehicle. Compared to fully electric or plug-in hybrid vehicles, these cars are less efficient.

Main Components of HEV:

Engine, Electric motor, Battery pack with controller & inverter, Fuel tank, Control module

- **Plug-in Hybrid Electric Vehicle (PHEV)**

uses a battery that is charged by an external socket and an internal combustion engine (they have a plug). This implies that electricity, rather than the vehicle's engine, can be used to recharge the battery. While less efficient than BEVs, PHEVs are more efficient than HEVs.The term "series hybrid" also applies to PHEVs. Both an engine and a motor are present. You have a choice of two types of fuels: conventional fuel (like gasoline) and alternative fuel (such as bio-diesel). A battery pack that can be recharged can also power it. The battery can receive external charging.

Main Components of PHEV:

Electric motor, Engine, Inverter, Battery, Fuel tank, Control module, Battery Charger (if onboard model)

- **Fuel Cell Electric Vehicle (FCEV)**

Another name for FCEVs is zero-emission vehicles. To create the electricity needed to power the vehicle, they use "fuel cell technology." The fuel's chemical energy is directly converted into electric energy. Chemical energy is converted into electric energy. Consider an FCEV powered by hydrogen.

Main Components of FCEV:

Electric motor, Fuel-cell stack, Hydrogen storage tank, battery with converter and controller

1.3 SOLAR ENERGY

Solar energy, the sun's rays that can ignite chemical reactions, produces heat, or creates electricity. The total solar energy incident on Earth far exceeds both the present and future energy needs of the planet. This highly diffused source might potentially provide all of the energy required in the future if properly harnessed. Due to its limitless supply and lack of environmental impact compared to the finite fossil fuels coal, petroleum, and natural gas, solar energy is predicted to gain popularity as a renewable energy source in the twenty-first century.

Although the Sun is a very potent energy source and sunlight is by far the most abundant energy that Earth receives, the intensity of sunlight at the planet's surface is actually rather low. The massive radial radiation radiating from the far-off Sun is mostly to blame for this. Earth's atmosphere and clouds cause up to 54% of the incoming sunlight to be absorbed or scattered, which results in a relatively small additional loss. Nearly half of the sunlight that reaches the earth is composed of visible light, while the other half is made up of infrared radiation, with smaller amounts of ultraviolet and other electromagnetic radiation.

Since the Earth receives solar energy every day in the amount of nearly 200,000 times the world's daily electric generating capacity, the potential for solar energy is huge. Even though solar energy is free in itself, the high expense of gathering, converting, and storing it prevents widespread use of it. Although the former is simpler to achieve, solar radiation can be transformed into electrical energy as well as thermal energy (heat).

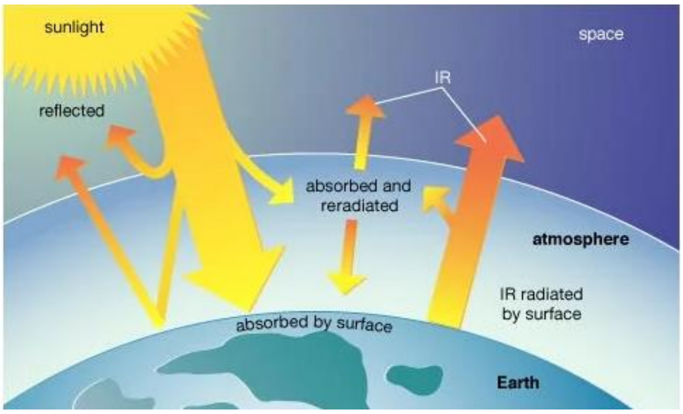


Figure 1: Solar Energy

Table 1: Advantages and Disadvantages of Solar Energy

Advantages of Solar Energy	**Disadvantages of Solar Energy**
Renewable Energy Source	Cost
Reduces Electricity Bills	Weather Dependent
Diverse Applications	Solar Energy Storage is Expensive
Low Maintenance Costs	Uses a Lot of Space
Technology Development	Associated with Pollution

1.4 SOLAR POWERED ELECTRIC VEHICLE CHARGING STATION

1.4.1 Meaning

One of the most effective ways to lessen India's reliance on fossil fuels for the powering of various modes of transportation is through solar charging stations for electric vehicles. This is because electric vehicles typically use electricity generated from fossil fuels, which is a major cause for concern.

It is essential to implement solar charging for electric cars and bikes as the popularity of electric vehicles rises. There are currently two types of solar charging stations for electric vehicles, depending on the configuration.

Figure 2: Solar Energy Charging for Electric Vehicles

We can investigate the viability of developing a PV-based infrastructure for electric vehicle charging. The technology is made to be used at workplaces to charge employees' electric vehicles while they are left parked during the day. The goal is to use PV energy as much as possible for EV charging while utilising the grid as little as possible. Such an EV-PV charger's benefits include:

- Because EV charging uses locally produced, environmentally friendly power from solar panels, there is a decreased need for energy from the grid.
- EV batteries also serve as energy storage for PV, which lessens the detrimental effects of integrating large amounts of PV into the distribution network.
- An extension of Vehicle-to-Grid (V2G) technology, in which an EV serves as a controllable spinning reserve for the smart grid, is made possible by the long parking times of EVs.

1.4.2 Types of Solar Based Electric Vehicle Charging Station

The key to significantly lowering our reliance on fossil fuels is the integration of solar energy and EV charging. There are many different ways to get electricity, so it's essential that electric vehicles run on renewable energy sources. A solar charging station will likely be installed at every home that has a solar energy system in the coming years as electric cars become increasingly popular. For this to happen, we will need to think about refuelling our cars differently and for our energy infrastructure to naturally evolve.

- ✓ **Off-grid Solar Based Electric Vehicle Charging Station**

The charging station is not connected to nearby utilities in this configuration. As a result, it is also known as an autonomous EV charger. Here, the battery storage system is fueled by the solar panel array. Additionally, this battery storage system meets the charger's entire power requirement. This kind of charging station can be installed almost anywhere because it doesn't require a connection to the grid. Additionally, they are simple to install because the majority of them have a sturdy steel foundation.

"Electric Vehicle Autonomous Renewable Charger" is another name for an off-grid auto charger. No local utility connection is necessary. The entire system's power requirements are met by this energy storage system, which is powered by the solar panel array. Since there is no requirement for a connection to the electrical grid, off-grid electrical car chargers can be installed almost anywhere. A sturdy foundation is necessary because the independent solar array canopy attracts a lot of wind. Some off-grid solar energy chargers have a large, ballast-serving base plate made of steel. Since there is no foundation or digging involved, installation of those is incredibly simple and quick.

- ✓ **On-grid Solar Powered Charging Stations for Electric Vehicles**

Because the energy produced by the solar array is stored in the grid rather than in batteries, the cost of an on-grid solar EV charger is unquestionably lower than that of the off-grid version. You receive credits from the utility provider when you feed the grid, which you can use to charge your electric vehicle. Your excess energy is sold to the utility company.

The simplest way to power your electric car with solar energy is with a grid-tied solar energy system. Whether or not your home requires the power at the time, a grid-tied solar energy system will feed the energy into the grid. Therefore, the electricity generated at home is sold to the utility company when your solar energy system is feeding the grid and you are at work. That power will be returned to you by the utility company in the form of a credit. You can use that credit to recharge your car at home after leaving work and leaving it parked there.

1.4.3 Components Needed for a Solar EV Charging Station

- an EV charger
- a strong base for a standalone solar charger
- Software that is sufficiently intelligent for billing and other tasks
- battery-based energy storage (exclusively for solar energy charging stations that are off grid)
- Solar panel array installed on the ground or roof for capturing solar energy

1.5 V2G "VEHICLE TO GRID"

V2G, which stands for "vehicle to grid," is a technology that allows energy to be returned from an electric car's battery to the electrical grid. A car battery can be charged and drained based on various signals, such as energy generation or consumption locally, with the use of electric vehicle to grid technology, sometimes referred to as car-to-grid.

Electric needs are steadily rising against the backdrop of the energy transition, in part because of the advancement of electric transportation. By 2040, 50% of all new automobiles sold will be electrified, predicts the BloombergNEF research. In a period of global turmoil, it will be necessary to power all of these cars in a smart and practical manner.

The electric car has the ability to store, distribute, or even produce power, much like a home with solar panels. A new generation of interactive cars known as Vehicle To Grid or V2G has replaced the passive electric vehicle, which does nothing except consume energy. V2G technology, as its name suggests, is the practise of feeding electricity stored in an electric car's batteries back into the electrical grid while it is parked. A smart grid is an electrical network system that employs information technology to regulate energy usage, and this technology is an element of it.

The smart grid, on a global scale, encourages data sharing between suppliers and consumers to address an important issue: energy storage. Large amounts of electricity are challenging to store. Real-time balance is required for management. Either not enough electricity is produced to power the network, or too much is produced and much of it is wasted. In this effort to modify the electrical flow, V2G may have a significant role.

The V2G battery functions as an extension of the electrical grid by storing energy produced when demand is lower and reintroducing it into the system when demand is higher thanks to bi-directional charging. As electric vehicles become increasingly common, it's simple to picture the benefits of this technology. With the use of Vehicle to Grid (V2G) technology, an electric vehicle might significantly contribute to a world free of emissions by using a big amount of renewable energy sources.

2. REVIEW OF LITERATURE

Ram Vara Prasad, Bugatha et. al (2022) This study outlines the concept of a solar-powered charging station for electric vehicles that eliminates the major drawbacks of fuel and air pollution. Globally, electric vehicles are currently on the road, and their number is gradually increasing. In addition to their positive effects on the environment, electric vehicles have been shown to reduce travel expenses by substituting petrol with energy, which is significantly less expensive. Consequently, we create an electric vehicle (EV) charging system that offers a novel and revolutionary solution. This method of recharging electric automobiles wirelessly, there is no need to stop for recharging, as the car charges while in motion. Solar energy is used to power the charging system; thus, no other power source is required. The system is constructed using a solar panel, battery, transformer, regulator circuitry, copper coils, an AC-to-DC converter, an at mega controller, and an LCD display. The device displays how electric vehicles may be charged while in motion, eliminating the need for charging stops. Consequently, the technology exhibits an integrated solar-powered wireless charging solution for electric automobiles.

Dighe, Amol & Rakesh et. al. (2022) the charging infrastructure for electric vehicles (EV) could be the most crucial aspect in ensuring a smooth transition to e-mobility. This study focuses on five developments that have the potential to play an alphabetical role in this regard: shrewd charging, vehicle-to-matrix (V2G), charging of electric vehicles using solar panels (PV), and. Contactless and on-street charging alternatives are available for EVs. Smart charging of EVs is anticipated to allow a large number of EVs to enter the market, supply environmentally friendly electricity, reduce the cost of charging, and provide more. The application of a lattice design; Bidirectional EV antennas will pave the way for the V2G era, in which EVs will be able to exchange energy and request future activities. Sun-oriented EV charging will have an effect on reasonable mobility and the use of EV batteries. Alternatively, the work area is constrained. Contactless and inductive charging of electric vehicles on the road will eliminate any strains and range tension; Concerns and preparations for updated application. This research examines the electromagnetic and energy engine strategy for contactless power move structures in future streets.

Sasikumar, Gnanasekaran & Sivasangari (2021) Renewable energy is a type of energy derived from a variety of sources, such as sunshine, wind, tides, geothermal, etc. It provides renewable energy derived from renewable natural resources. Increasing the use of renewable energy will reduce the demand for and price of fossil fuels. Solar photovoltaic energy is largely used for numerous uses, including heating, cooking, and electricity generating. Recent innovations contributed to the creation of solar-powered automobiles. This paper discusses the design and construction of a solar charging system for electric vehicles with a charge controller. Implementation of the proposed technology will decrease the cost of electricity and charging and discharging losses. In addition, the projected solar charging system will be one of the initiatives implemented to establish a "green campus." This article will analyze the system design and performance of a solar-powered electric vehicle system.

Sheeba, R., Mohammed Sulthan et al (2021) As a dependable alternative to gas-powered automobiles, electric vehicles are rapidly gaining popularity. For ongoing operation, these vehicles' batteries must be "refuelled." Solar-powered chargers have emerged as an intriguing alternative to the typical grid-based charging of electric vehicles. These chargers are pollution-free and supply electric automobiles with clean power. This paper describes the design of an intelligent hybrid electric vehicle charging station appropriate for both personal and commercial use.

Kumar, Rajan & Bharj et. al (2021) As part of their strategy to combat climate change and rising urban pollution, a developing nation such as India is rapidly adopting technologies connected to electric vehicles (EVs) and phasing out fossil fuel-powered vehicles. The Government of India (GoI) intended in April 2017 to have all EVs on the market by 2030. Also pursued is the promotion under the faster adoption and production of electric vehicles

(FAME) scheme. The infrastructure for electric charging is a crucial component of the electric mobility ecosystem. It is crucial for EV charging station markets to match the acceptance and expansion of EVs. Electric vehicles are limited in range and speed. The availability of charging stations and their network on the road is essential for facilitating the transition from fossil fuel vehicles to electric vehicles. Consequently, the accessibility of a plug points for charging remains an ongoing challenge for the majority of EV producers and users. Certainly, it is necessary to transition from grid-based charging stations to autonomous off-grid options for charging. Utilizing abundant renewable energy sources like solar energy is the key to resolving this issue. This chapter provides a comprehensive assessment of the infrastructure, technique, and implementation of EV charging systems and solar-based EV charging systems in India. Various obstacles and social obstacles to the adoption of electric vehicles are also explored.

Mehrjerdi, Hasan & Rakhshani, Elyas (2019) this article optimizes the operation of electric vehicle charging stations in electrical distribution networks. Instead of a single large-scale charging station, the grid is equipped with numerous small-scale charging stations. In addition, photovoltaic solar panels are installed on the grid in order to reap the benefits of renewable energy. The electric vehicles function in grid-to-vehicle mode. The suggested solution optimizes the charging and discharging behaviour of all electric vehicles on all buses. The offered technique optimizes the functioning of electric vehicles to mitigate the intermittent nature of renewable energy while simultaneously reducing energy costs. Moreover, it reduces the charging and discharging cycles of the vehicle's batteries to prevent battery degradation. The proposed challenge is treated as a nonlinear stochastic programming problem that incorporates the unpredictability of solar energy and is solved using the GAMS software. The results indicate that the proposed technology can charge and discharge the vehicle-to-grid system effectively. The vehicles are frequently charged during off-peak low-cost intervals and discharged during peak high-cost times. The intermittent nature of solar cells is mitigated by the established charging-discharging pattern for vehicle-to-grid systems, and energy shifting reduces the cost of consumed energy. The results demonstrate that the provided technique is capable of simultaneously achieving all planned goals.

Ahmad, Furkan & Shariff et. al. (2019) A high-power battery charger featuring PFC (power factor correction) and an AC/DC converter to adjust the charging current output ripple content, hence giving continuous DC to high-energy battery packs used in electric vehicles (EVs). This paper addresses the practical design and implementation features of an EV charger for charging the EV battery pack using a solar-assisted EV charging application. The operation of the circuit is analyzed, and a scientific model is developed to study the design aspect of circuit parameters. Finally, the framework's mathematical modelling is created in the MATLAB/Simulink environment to test the performance of the PFC under steady-state conditions with respect to load variation for a 3kW, 230Vrms input at a single phase 50 Hz rated supply to produce 48V DC EV battery charger buck converter output. The charging process is managed by Electric Vehicle Supply Equipment (EVSE) using a level 2 AC charging system based on SAE J1772. As a result, a simplified design on the system level will be explained, together with the whole set of functions of the integrated charging system. PROTEUS software has been used to simulate the communication and signaling circuit, and a prototype model has been implemented in the lab. A case study of a 6.4 kW solar photovoltaic charging station (SPVCS) placed in the Centre of Advanced Research in Electrified Transportation (CARET) building parking area on the Aligarh Muslim University (AMU) campus is used to describe the hardware model. The experiment is carried out on a 10-kWh lithium-ion battery pack on a bright sunny day under the solar panel's standard test conditions (STC).

Nair, Mohan, and Harin (2019) the solar-powered plug-in electric vehicle is a cost-effective vehicle that requires little maintenance. The biggest disadvantage of electric vehicles is their limited driving range. The vehicle battery can be charged while driving by installing a solar PV panel. Mechanical components such as the gearbox and differential are avoided. Direct drive to the wheels allows for more efficient driving.

John Kaldellis and Spyropoulos (2017) Improving transportation energy efficiency could help to reduce environmental deterioration and slow the depletion of existing fossil-fuel reserves. Adoption of eco-driving, particularly in metropolitan areas, the use of more efficient vehicles, and the transition to green public transportation are all effective techniques for enhancing energy efficiency. In any case, the usage of so-called clean new technology cars should be used in certain circumstances (e.g., smart cities) to establish a sustainable and efficient transportation strategy. The Piraeus University of Applied Sciences' Laboratory of Soft Energy Applications and Environmental Protection (SEALAB) has recently undertaken, as part of its innovative activities, the development, construction, and operation of the country's first stand-alone solar electric vehicle charging station (EVCS), CARPORT, monitoring all energy data and thus supporting and strengthening the country's efforts in infrastructure development. More particular, the novel initiative detailed in this chapter aims to speed the implementation of a European national electrification action plan through the development of EVCSs based on photovoltaic generators. The suggested solar EVCS is regarded as one of the most environmentally benign alternatives capable of assisting in the decarbonization of Europe's transportation industry.

Chandra Mouli & Gautam Ram (2016) This research analyses the possibilities of using solar energy to charge electric automobiles at the workplace in the Netherlands. The Dutch Meteorological Institute's data is utilized to estimate the ideal orientation of photovoltaic panels for maximum energy production in the Netherlands. Seasonal and diurnal variations in solar insolation are studied to assess the energy availability for EV charging and the need for grid connection. Due to Netherlands' relatively low solar insolation, it has been discovered that the power rating of the PV array can be 30% higher than the power rating of the converter. Various dynamic EV charging profiles are evaluated in an effort to reduce grid dependence and maximize the use of solar energy to directly charge the EV. Considered are two scenarios: one in which EVs must be charged exclusively on weekdays, and another in which they must be charged seven days per week. Proposed is a priority mechanism to permit the charging of numerous EVs from a single EV–PV charger. The viability of connecting a local storage with an EV–PV charger to make it grid-independent is assessed. The ideal storage size that lowers grid dependence by 25 percent is determined.

Yilmaz, M. & Krein, Philip (2013) the vehicle-to-grid (V2G) connection idea allows plug-in vehicles to function as either loads or as a dispersed energy and power supply. This article examines the current status and implementation impact of V2G/grid-to-vehicle (G2V) technologies on distributed systems, as well as the needs, benefits, obstacles, and strategies for V2G interfaces on both individual and fleet cars. The V2G idea can enhance the performance of the energy grid in areas like efficiency, stability, and dependability. A vehicle with V2G capabilities provides reactive power assistance, active power regulation, tracking of changeable renewable energy sources, load balancing, and current harmonic filtering. These technologies can provide auxiliary services such as voltage and frequency regulation and spinning reserve. V2G costs include battery degradation, the requirement for intensive communication between vehicles and the grid, effects on grid distribution equipment, infrastructure modifications, and social, political, cultural, and technical hurdles. Despite the fact that vehicle-to-grid (V2G) operation can shorten the lifespan of car batteries, it is expected to become cost-effective for vehicle owners and grid operators. Components and unidirectional/bidirectional power flow technologies of V2G systems, individual and aggregated architectures, and charging/recharging frequency and tactics (smart, uncoordinated/coordinated) are discussed. Successful V2G operation requires three elements: power connection to the grid, control and communication between vehicles and grid operator, and on-board/off-board intelligent metering. The success of the V2G concept is contingent upon the standardization of requirements and infrastructure decisions, battery technology, and the effective and judicious scheduling of limited fast-charge infrastructure. The deployment of a charging/discharging infrastructure is required. The economic benefits of vehicle-to-grid (V2G) technologies are contingent upon vehicle aggregation, charging/recharging frequency and methods. In the future, grid operators and car owners will give greater consideration to the advantages.

3. **RESEARCH METHODOLOGY**

3.1 PROBLEM STATEMENT

The government has outlined numerous strategies to address environmental issues. Electric mobility and renewable energy are two such priority sectors that has been identified. India has an energy shortage, and the majority of its cities frequently experience power outages. Therefore, in light of electricity fluctuations, the current plan to target EVs on a mass scale cannot be realized. Before EVs are widely adopted, additional issues like the lack of fast charging infrastructure, the higher price of EVs, the risk of energy theft, etc., must be resolved.

In addition, the government has established a lofty rooftop solar target. Rooftop solar energy is advantageous in many situations because it reduces AT&C losses, does not require additional land (if installed on existing structures), and does not require transmission infrastructure. Rooftop solar still faces challenges, however, from institutional inconsistencies to slow grant and funding processing to low consumer awareness. Furthermore, problems with power quality result from an increase in the generation of renewable energy at the grid distribution level. The distribution grid network needs to be strengthened for greater bidirectional power flow due to the future energy demand growth that will be exponential and the high penetration of RE.

Hence, the thesis entitled *"DEVELOPING A SOLAR-POWERED ELECTRIC VEHICLES CHARGING SYSTEM UTILIZING VEHICLE -TO - GRID-ENABLED SMART TECHNOLOGY"*develops a V2G-enabled smart charging solution for electric vehicles that is highly efficient. Charging electric vehicles with photovoltaic panels can make EVs completely sustainable and reduce the infrastructure's net cost. Three aspects are required to establish a solar-powered EV charging infrastructure: system-level design, the development of a solar EV charger, and the formulation of smart charging algorithms.

3.2 AIMS &OBJECTIVES

The objectives of the study are as follows:

1) To study the concept of solar energy, V2G technology and solar power electric vehicles.

2) To develop a highly efficientsolar-powered, V2G-enabled smart charging system for electric vehicles at workplaces

3) To discuss the system architecture and power converter topologies for three-port EV-PV- charging system using detailed modeling

4) To examine the smart EV charging algorithms to reduce the cost of charging EVs using the developed EV-PV converter

5) To conduct the experimental testing on the Two CHAdeMO and CCS compatible EVs with the implementation of smart charging and V2G,

6) To assess the ideal PV system and local storage for charging electric vehicles at offices building

3.3 RESEARCH DESIGN

The design of this research will be three-fold in nature means the analysis will be divided into 3 parts.For a solar powered EV charging infrastructure, three elements will be essential which is system-level design, development of a solar EV charger and formulation of smart charging algorithms.

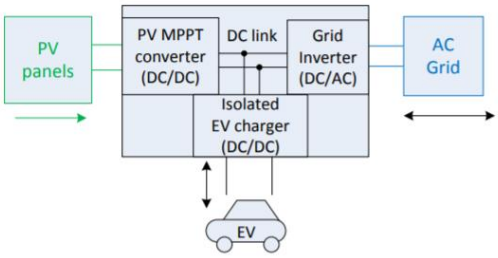
3.3.1 Experimental Setup on Topology for Three-Port EV-PV-Grid Converter

- **Loss Simulation and Converter Design**

In order to design a converter topology for maximum efficiency and power density, this section will discuss how to take into account a variety of design factors, including switching frequency, magnetic core, copper windings, semiconductor devices, capacitors, and heat sinks. This will require a number of iterations using an accurate loss model of the converter where the design parameters will be changed at each cycle, as shown in Fig. 4. The converter components, volume, and efficiency (i.e., losses) of the optimized design will be obtained at the end of the iterations.

Table 2. Specifications of EV-PV converter

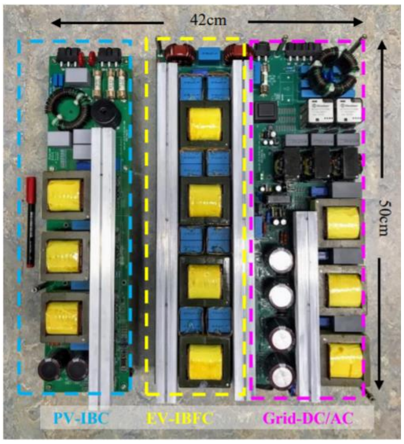
Parameter	Symbol	Value
Nominal power	P_{nom}	10kW
PV MPPT Voltage	V_{pv}	350-700V
PV MPPT Current	I_{pv}	0 - 30A
PV current ripple (peak-peak)	$\Delta I_{pv\%}$	< 10% of I_{pv}(max)
PV voltage ripple (peak-peak)	$\Delta V_{pv\%}$	< 0.5%
EV voltage	V_{ev}	200-500V
EV current (Bidirectional)	I_{ev}	-30A +30A
Internal DC-link voltage	V_{dc}	750V (for Arch. 1)
Total Harmonic Distortion		< 5%
AC grid connection		400V, 50Hz AC, 16A



Grid-connected, three-port, 10kW bidirectional EV-PV charger

3.3.2 Experimental Setup on Development of 10kw Bidirectional Solar EV Charger

- **EV-PV converter modular prototype**



Experimental 10kW three-port EV-PV converter prototype

The developed EV-PV converter prototype is shown above along with the grid inverter, PV IBC, and EV IBFC. The converter will be constructed modularly as two power modules to give the user flexibility and to improve the EV-PV charger's commercial viability. The PV IBC and its controller will each be built on two PCBs and make up the first power module. The IBFC, three-phase inverter, and their controllers will be located on one PCB and one PCB, respectively, in the second power module. The common DC-link and the communication port of the two controllers will be connected to join the two PCBs together. The DC-link will therefore be assessed from the outside and offers the opportunity to connect to additional PV power modules, EV charger power modules, and potential DC-grids. The control PCB will be located on the back of the power PCB on both power modules, giving the finished EV-PV converter its final dimensions of 50x42x12cm. The power density of the PV converter, EV+Grid converter, and full EV-PV converter will be 1380W/l, 555W/l, and 396W/l, respectively, based on cabinet dimensions.

- **Experimental waveforms**

When a PV emulator is used as input, Fig. 6(a) displays the operating waveforms of the PV IBC for continuous conduction mode (CCM), and Fig. as given below will display the waveforms for discontinuous conduction mode (DCM). The waveforms for the MOSFET drain-source voltage V_{ds}, inductor current I_L, and phase-shifted gate voltage VGS will be displayed in the figure. As shown in Fig. 6, the inductor current $I_{L\ (1)}$ rises during CCM when the gate voltage $V_{GS\ (1)}$ will be ON and then starts to fall when the gate will be turned off (a).

In DCM, the drain-source voltage $V_{ds(1)}$ oscillates as it will transition from $V_{ds(on)}$ to VPV because the inductor current $I_{L(1)}$ reaches zero prior to the end of the switching cycle (b).

(a)

(b)

Drain-source voltage V_{ds} and gate voltage V_{gs} for one phase of the IBFC for CH mode: (a) Quasi-resonant operation LVS for V_{ev}=250V, I_{ev}=5A (b) Valley skipping and DCM operation at low powers for V_{ev}=100V, I_{ev}=1A

3.4 SYSTEM DESIGN

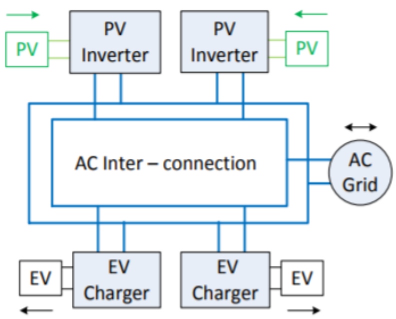
The system design of the solar EV charging station will examine the optimal design for the photovoltaic (PV) system to satisfy the EV charging requirements. Simple charging systems, such as Gaussian EV charging, will be developed to assist in synchronizing EV charging with PV generation and reducing grid dependence. The use of a local storage will be found to aid in regulating the diurnal solar variations, but will have a little effect on overcoming the seasonal solar variations. Despite the India's lower solar insolation, a 10kWp PV system will produce an average of 30kWh per day. This is enough for a Nissan Leaf EV to travel 55,000 km per year. Summer and winter energy yields will vary by up to five times, which is a phenomenon that cannot be fixed with a solar tracker. The PV converter rating will be 30% smaller than the PV array due to the lower insolation, with only a 3.2% energy loss.

Simple charging strategies, like Gaussian EV charging, will be suggested in order to better match EV charging to PV generation and lessen reliance on the grid. It will be discovered that using a local storage could manage the diurnal solar variations but will have a little impact on overcoming seasonal solar variation. Finally, various approaches to connecting a single EV-PV charger to a number of EVs at work will be suggested. The main advantage will be that it will make it possible to share the infrastructure for charging, which will lower the price and amount of space needed for EV charging stations in the parking lot.

3.4.1 PV System Design

The three-port 10kW converter connected to the 50Hz AC grid will be selected as the optimal system architecture. The grid-connected EV-PV charging system's major source of power is solar energy. A 10kWp photovoltaic (PV) array will be installed at the workplace to generate the solar energy. The panels would be positioned as a solar carport or on the roof of the building.

To enable solar charging of EVs, the power converter design will look into power converter topology, semiconductor device technology, power density, efficiency, closed-loop control, and EV charging standards. Simply put, it is the hardware that makes it possible to charge EVs using solar energy. The current methods for solar-powered EV charging will involve using a DC/AC solar inverter to draw power from a PV array and an AC/DC EV charger to recharge the vehicles. Figure 3 illustrates this using separate power converters for EV and PV.



The current method for solar-powering EVs uses a DC/AC solar inverter to extract PV power, followed by an AC/DC EV charger to recharge the EV

3.4.2 Smart charging algorithms

Smart charging is a technique that enables the charging of electric vehicles to be intelligently controlled and/or shifted in order to accomplish one or more useful goals in addition to having a fully charged EV battery. Smart charging will be used to schedule EV charging in the afternoon rather than the morning, for instance, if solar forecast data will indicate that it will be cloudy in the morning and sunny in the afternoon. As an alternative, the goal will be to lower the cost of charging using fluctuating energy prices. Electric vehicle fleet charging will be scheduled using a number of smart charging algorithms that take into account factors like EV user preferences, energy prices, the availability of ancillary services, and reactive power support. When compared to the uncontrolled charging of EVs, these algorithms will prove to significantly reduce the cost of charging.

The problem with the current strategy is that every one of these factors, such as EV user preferences, energy prices, or forecasts for renewable energy, will be treated as a separate input and will be optimized separately. One charging profile appears as a solution for each set of inputs, which results in a number of different EV charging profiles will be obtained as a result. This is not feasible because one EV cannot be controlled by multiple charging profiles at once. Second, the algorithms will not be tailored for a specific power electronic hardware, which will make it challenging to directly implement and use them on EV charging systems. Last but not least, the majority of charging algorithms will not be tested on real EVs, and their compliance with EV charging standards will not be confirmed.

Therefore, it will be crucial to create a single problem formulation that will combine various applications, allowing for the creation of an optimal EV charging profile that will be used to manage the EV. As a result, the advantages of each application will be added together, increasing the overall benefit to the point where it will support widespread adoption of smart charging. In order to maximize the use of PV energy and lower the cost of EV charging, a new set of intelligent charging algorithms will be developed in this work. Its six applications—EV user preferences, charging of EVs from solar panels, vehicle-to-grid, energy prices from the market, multiplexing of multiple EVs to a single charger, and provision of regulation services to the independent system operator—are combined into one formulation (ISO). Due to this, net costs will be reduced significantly more than they were previously. Additionally, the use of EVs compatible with CHAdeMO and CCS/Combo, the two international standards for DC charging of EVs, will be used to test the implementation of smart charging and V2G.

3.5 DATA COLLECTION

The data will be collected through the primary and secondary sources. In primary source, the data will be collected from the experimental values that help the design process to help electric vehicle companies to manufacture batteries for their vehicle will be collected. In secondary source the data will be collected through the internet, magazines, research papers, books, thesis, dissertation etc.

3.6 TOOLS AND TECHNIQUES USED FOR ANALYSIS

Inductor current and inductance will be estimated by the four methods such as No variation, peak current, Middle current and proposed model using MATLAB. PV array will be modeled in MATLAB using 30 modules of Sun power E20-327 modules rated at 327W. Further the irradiance on a panel with specific orientation (A_m, θ_m) will be estimated using the geometric models and the Isotropic sky diffused model.

4. WORK PLAN AND CHAPTERIZATION

The research plan includes a detailed timetable and structure for completing the research project, as detailed below:

Work Plan for Research:

Sr. No	Particulars	Time /Duration
1)	Submission of proposal and Pre-Presentation of Synopsis	3 Months
2)	Six Month Progress Report	Every Six Month
3)	Course Work-I	As per Schedule of University
4)	Course Work-II	After one year as per schedule of university

5)	Publication of Research paper-I based on Review of Literature	On or before Six Months from the submission of Synopsis to university
6)	Pilot Study Submission	After a year as per schedule of university
7)	Publication of Research paper-II based on Analysis and Inferences drawn from the selected poems	After one and half year as per schedule of university
8)	Pre-submission of Ph.D. Presentation and submission of Synopsis along with Pre-Ph.D. Report	After 2 Years as per rules of university
9)	Final Ph.D. Thesis submission along with Plagiarism Report	After 36 Months, as per given stipulated time frame and rules and regulations of university

Chapterization: The presentations of chapters of the research are as below:

Chapter No.	Name of Chapter/Particulars
Chapter 1	Introduction
Chapter 2	Literature Review
Chapter 3	Conceptual/ Theoretical framework
Chapter 4	Research Methodology
Chapter 5	Data analysis and results
Chapter 6	Conclusion and Future Scope
	Bibliography

5. EXPECTED OUTCOME

It will be concluded that the three sub-converters will be coupled on a 750V central DC-link as part of the converter's modular design: an interleaved boost converter for solar energy, a three-phase inverter for the AC grid and an interleaved flyback converter for electric vehicles. This will demonstrate how the use of SiC devices in a QR mode flyback converter can achieve excellent efficiency even at high powers, despite though the flyback will be typically thought to be only suited for low powers. For the three sub-converters that permit four power flows, three closed loop controls will be created and put through testing. A 10kW prototype that will be constructed and put through testing will show a peak efficiency of 96.4%. The designed prototype will outperform currently available alternatives in terms of peak efficiency and partial load efficiency. A Nissan Leaf EV equipped with a CHAdeMO charge controller will serve as the test vehicle for the charge and V2G operation at 10kW.

Due to the size of the impedance network needed to manage high currents at low ripple, it will be determined from the evaluation that impedance-based converters will not be suitable for high power solar EV charging. Due to direct DC charging of PV from EV, three port converters based on a DC-link will be preferred. The optimum architecture for the PV port will have a three-phase interleaved boost converter at 50 kHz, which will outperform the CIIBC and TLBC in terms of efficiency, controllability and component count. Due to fewer components and easier management while keeping a similar efficiency, the two-level converter at 50 kHz with SPWM will outperform the three-level topologies for the grid port.

The proposed MILP formulation for charging an EV fleet from solar energy will have several applications built into one, including charging an EV from solar energy, using time-of-use tariffs to sell PV power and charge an EV from the grid, implementing V2G for grid support, using an EV to provide ancillary services in the form of reserves, and taking distribution network capacity constraints into account. The formulation will be created with a three-port converter topology in mind. This configuration will enable bidirectional EV charging from solar panels on DC while also allowing for a link to the AC grid for power balance. The formulation will include a schedule for connecting a single EVSE to a number of EVs. This will enable the EVSE to be used by a large number of EVs, thus lowering the cost of EV infrastructure. The MILP optimization will run over a set time period and will be applied as a receding horizon model predictive control.

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