International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 06 | June - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Design and Development of Solar Smart Flower Based E- Vehicle Wireless Charging Station

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ABSTRACT

Public charging networks for Electrical Vehicles (EV) is on the rise, with more than 1.3 million EVs deployed worldwide. Whether for economic benefits (higher price per KWh for a faster charging) or for the sole purpose of priority, it has become a point of interest to set a strategy on how to prioritize EVs charging from a single network, especially if the power source is limited as in the case of renewable energy. Our dependence on fossil fuels is drastically reduced by the combined use of solar energy and Electric Vehicle (EV) charging. In this system, a solar charger for electric vehicle is designed and developed. This paper presents the design and implementation of a solar-based charging station for electric vehicles using an innovative smart solar flower system. Unlike conventional solar panels, the smart solar flower is equipped with photovoltaic petals that track the sun's movement, ensuring maximum energy absorption throughout the day. This system enhances the energy efficiency of the charging station by optimizing the angle of solar incidence. The smart solar flower's tracking mechanism integrates advanced sensors and actuators that adjust the panel's orientation based on real-time solar position. The design also incorporates energy storage in the form of high-capacity batteries, which store excess energy produced during peak sunlight hours for use during periods of low sunlight or high charging demand.

INTRODUCTION

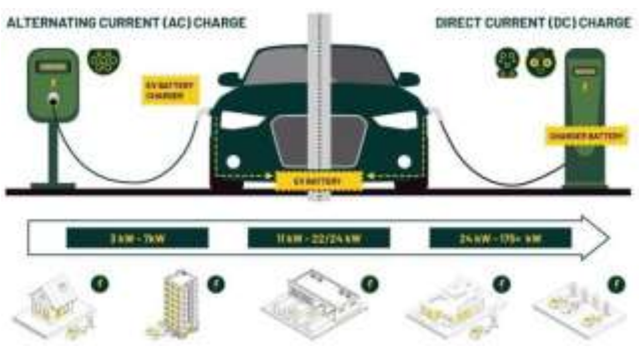
By 2030, India is expected to have 102 million EVs, which would need 2.9 million public charging stations. Solar-powered EV charging stations are a promising, eco-friendly and costeffective solution, with many benefits for the consumer, economy and India's climate goals. With India's potential to generate 749 GW of solar power, which is more than the country's current installed capacity, this is an untapped opportunity which is slowly gaining momentum. Here has been a rapid growth in the use of Electric Vehicles as an alternative to gas powered vehicles due to the increase in awareness towards a sustainable lifestyle. Traditionally, the Electric Vehicle charging has been grid-based but the technological advancement in the field of solar energy has led to the use of solar powered chargers for the Electric Vehicle charging. These pollution free solar chargers provide clean electricity to the Electric Vehicles and additionally results in a green environmental effect. Furthermore, the introduction of these charging stations would enable the people to rethink their means of transportation choices and thus switching to zero-emission vehicles.

By every year Electric Vehicles are becoming more and more affordable this leads the investors to start investing on charging station due to its increasing demand. At present, Electric grids are more dependent on fossil fuels than that of the renewable energy. Though EV's are electrically driven, they also will contribute to harmful emissions as electrical energy production for charging stations should also be taken into consideration are going to be additional generation from fossil fuels. Thus, in order to reduce the impact of the harmful emissions; renewable energy particularly solar energy based electric vehicle charging stations can be built. This project provide the design of a charging station that uses conventional grid supply for commonly available vehicles, to design and develop a solar fed charging station, to collect power details of electric vehicles, to implement the charging station that has the capability to utilize solar energy when it is available and switch to grid supply otherwise. A charging station powered by the conventional grid supply has got many limitations and disadvantages and hence we use solar energy for the charging purposes. The switching circuit enables the switching of circuits and the implementation of MPPT (maximum power point tracking) enables the tracking of maximum solar energy.

EV charging infrastructure refers to the systems and equipment that provide electric power to charge electric vehicles. There are three main types of EV charging infrastructure:

Which uses an in-car inverter to convert AC to DC and charges the battery at level 1 or level 2. the electric power coming from the standard grid is always in AC form, so it means that most of the chargers you will find around the city, parking lots of the shopping centers, and homes will provide your EV with this form of electricity. However, even though the power is delivered in AC form, the energy stored in your battery pack is always in DC. That means every electric car has an on-board converter that converts AC to DC to fill your battery. The converter is an essential part of any electric car since it is crucial for the charging process. This principle is used in any battery-powered device, which we can see in smartphones, consumer electronics, and electric vehicles.

However, there are also DC-only chargers for electric vehicles, also known as "fast chargers." They are located near industrial compounds or along the highways and use direct current instead of alternate current. Since feeding the battery directly with the same type of electricity and bypassing the AC/DC converter, the DC or rapid chargers are known to fill the battery much faster than regular AC or home chargers.



The long charging times are one of the biggest concerns of any EV owner. Although the DC chargers are known to fill 80% of your battery in about half an hour (depending on the vehicle and the charger), the AC chargers are much slower. There are several types of chargers available to the general public. Called **Mode 1, Mode 2, or Mode 3** in Europe or **Level 1 or Level 2** in the United States, you can find them practically everywhere.

The Mode 1 AC charger has a power output of 1-2 kW (plugging the EV in a plain socket at home), while the Mode 2 or 3 AC charger's typical output is between 7 and 22 kW. It is a standard home charger with 120 volts (US) and 230-240 volts (Europe) of power and longer charging times. Depending on the size of your battery but fully charging using the Mode 1 home charger can take up to 24 hours.

Mode 2 AC chargers are found in public places and have 240 volts of power. In most cases, a standard car battery can be fully charged in about 8 to 10 hours. Recently, many EV owners decided to purchase AC Chargers with charging boxes (Mode 3 chargers) for home use to shorten the process and have their cars fully charged overnight. It raises the electricity bill but lowers the charging times, which is more important.

1. DC charging,

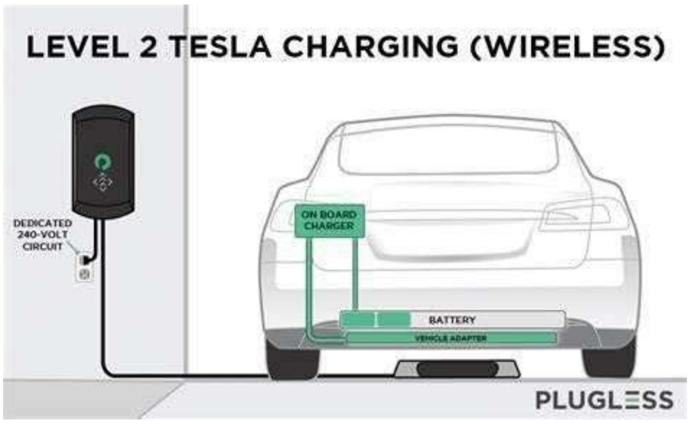
Which directly charges the battery at level 3 or DC fast charging, using ultra high-power circuits. Direct current fast charging, commonly referred to as DC fast charging or DCFC, is the fastest available manner for charging electric vehicles. There are three levels of EV charging:

Level 1 charging operates at 120V AC, supplying between 1.2 – 1.8 kW. This is the level provided by a standard household outlet and can provide approximately 40–50 miles of range overnight.

Level 2 charging operates at 240V AC, supplying between 3.6 – 22 kW. This level includes charging stations that are commonly installed in homes, workplaces, and public locations and can provide approximately 25 miles of range per hour of charging.

Level 3 (or DCFC for our purposes) operates between 400 – 1000V AC, **supplying 50kW and above**. DCFC, generally only available in public locations, can typically charge a vehicle to 80% in approximately 20-30 minutes.

Wireless charging



Which uses electromagnetic induction to transfer power without cords or plugs. Wireless charging is made possible by the principle of 'magnetic resonant coupling'. This allows for the transmission of electricity without wires or cables by creating a magnetic field between two electrical circuits: the transmitter and receiver. Although wireless electricity transmission can in theory work over long distances (as proposed by the 19th-century scientist Nikola Tesla), most current systems work over a few feet at most. The most commonly seen application is a charging pad – a flat surface onto which a device such as a smartphone or electric toothbrush can be placed to draw charge.

Benefits:

Sustainable Energy Generation: The solar-powered charging station reduces carbon emissions and reliance on fossil fuels.

Efficient Charging: The smart flower system optimizes charging speed and power based on vehicle type and battery capacity.

User Convenience: The user-friendly interface allows for easy payment and vehicle charging.

Remote Monitoring: IoT technology enables real-time monitoring and control of the charging station.

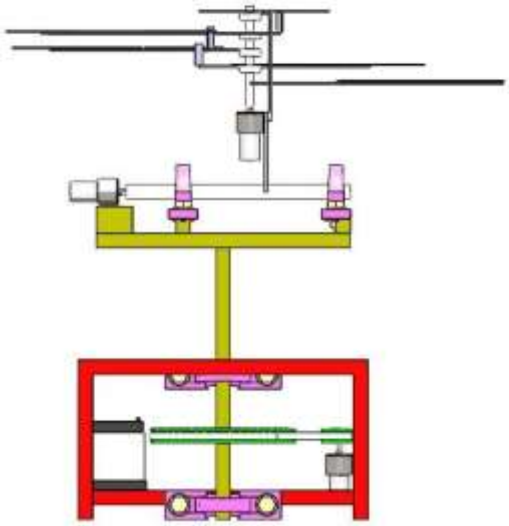
Cost Savings: The solar-powered system reduces energy costs and increases energy independence

Geometric Modeling:

Figure 1. Designed full assembly of the solar smartflower

Solar smartflower is designed to have six main parts consist of fin diesel nine units, body battery, hinge buffer, base, hinge base, and fin with hinge 1 unit. This Smartflower can open and close focus horizontally 360 degrees, you can move up and down vertically 270 degrees vertically. Figure 1 shows parts designed of the solar smartflower, and Figure 1 shows designed full assembly of the solar smartflower.

Figure 2. Design of parts of the solar smartflower



Result and Discussion:

Figure 3 shows the static simulation performed on the full assembly of the fan part solar smartflower.
Can be interpreted stress on all surfaces occurs in all directions. The occurrence of blue colour on the surface is due to receive a static minimum load permanently, and the part is not changed shape. Figure 4 shows silicon material properties, and Figure 5 shows load and fixtures.

Stress simulation result of the fan part solar smartflower designed is shown in Figure 4. Figure 5 and

Figure 6 show displacement and strain simulation results of the fan part solar smartflower designed. If

seen in the simulation results contained in Figure 4, shows the blue colour, meaning that the material

used can withstand the stress load given, as well as the load displacement and strain. This can be seen

in the simulation results shown in Figure 5 and Figure 6.

EV charger specifications

Charger Type	Charger Connector	Rated Output Voltage (V)	No. of Connector Guns	Charging Vehicle Type (W-Wheeler)
Fast	Combined charging system (CCS) (Min 50 kW)	200-750 or higher	1	4W
	Charge de move (CHAdeMO) (Min 50 kW)	200-500 or higher	1	4W
	Type-2 alternating current (AC) (Min 22 kW)	380-415	1	4W, 3W, 2W
Slow / moderate	BHARAT DC-001 (15 kW)	48	1	4W, 3W, 2W
	BHARAT DC-001 (15 kW)	72 or higher	1	4W
	BHARAT AC-001 (10 kW)	230	3 of 3.3 kW each	4W, 3W, 2W

India is located in the northern hemisphere, with the Tropic of Cancer (23.5_ N) passing through it. According to the National Building Code (NBC), India is majorly divided into five major climatic zones: cold, composite, hot & dry, warm & humid, and temperate [25]. For this analysis, six Indian cities have been selected, each featuring a different region and belonging to one of these climatic zones. The coordinates and altitudes for each of these cities are given in Figure

All these cities experience different weather conditions throughout the year. This mainly depends on the latitude and altitude of a place and its distance from the sea. The significant parameters that indicate a location's weather condition, pertinent to solar PV, are maximum & minimum ambient temperatures, cloud cover, total day length, number of actual sunshine hours, atmospheric turbidity, global radiation, and the number of 'full Sun hours.' These factors vary for each city throughout the year, depending on the city's geography and population. Some of these critical parameters have been tabulated for these six cities.

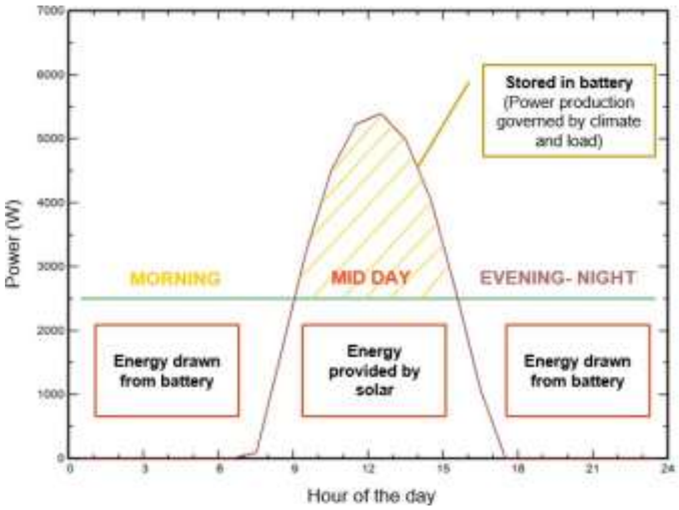


Figure 7. Generation vs. requirement profile of the charging station for a day

The selection of the station structure is another important criterion that depends on the soler PV application. A carport structure is preferred for the concerned design since this integrates the parking area with the array installation area. The array also acts as the roof for the parking zone and the battery room. Since most carport structure manufacturers allow only a 5–10 degree tilt, a south-facing roof with a 10 Degree tilt is opted for the charging station. The azimuth angle of the solar array is entirely subject to the available space. Figure 8 shows a carport integrated charging station.

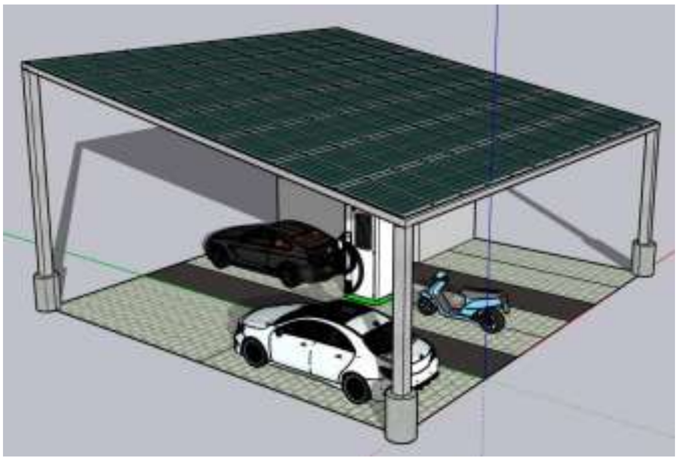


Figure 8. Schematic representation of carport charging infrastructure

The determination of the charging criteria is crucial, as it directly affects the system sizing and economics. Therefore, the system voltages and the charging conditions are governed by the codes and standards mentioned in Section 2.1. Here, the station design has been carried out according to Level-2 charging with a BHARAT DC-001 15 kW (240 V) GB/T connector. Following this, the major components of the charging station are selected, such as the PV array, battery bank, charge controller, EV charger, cabling, accessories, fasteners, and carport structure. The PV module, charge controller, and battery are the key elements of any off-grid solar PV plant.

The results generated found that the PR was extremely low for the 35.8 kWp system in all six cities, and the percentage losses due to full batteries were high. The PR shows how much energy is practically supplied to the consumers compared to what the system would have generated if it had worked under ideal STC conditions. When the array's energy production exceeds the combined load requirement of the station battery bank and the EV, the charge controller prevents the array from generating more energy. These losses are considered as unused energy losses. Unused energy is the difference between the plant's actual energy generation and the plant's energy generation potential under STC conditions. The array size is gradually decreased to optimize the system, simulations are done for all the iterations, and the PR and losses due to unused energy are recorded. The values obtained for all the cities have been mentioned in Figures 9 and 10.

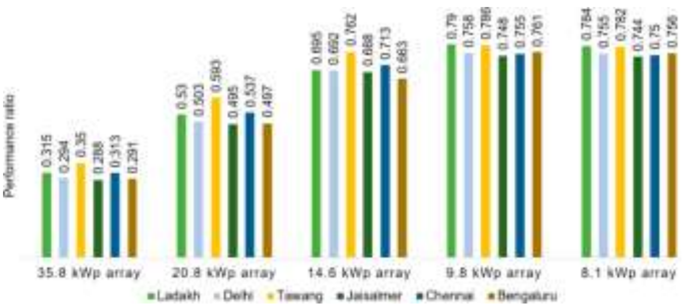


Figure 9. Performance ratio (PR) for different array sizes in all six cities.

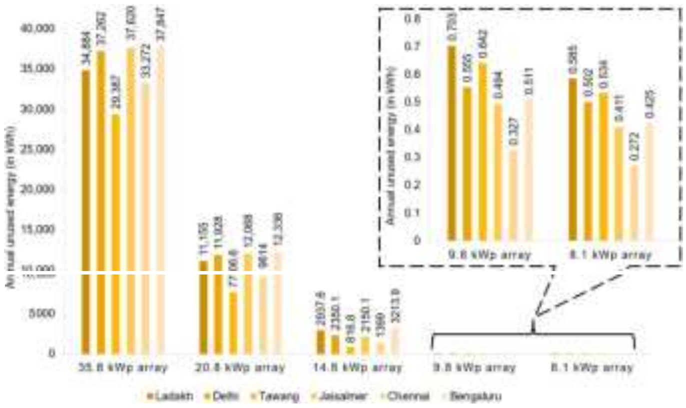


Figure 10. Annual unused energy for different array capacities in all six cities.

Conclusion

Based on fan static and body battery drop test simulations it can be concluded that the solar smartflower designed can be forwarded to the fabrication stage. This fact is reinforced by the simulation results that show despite the static or drop test loads but parts of the solar smartflower designed does not change shape.

Out of all the array sizes selected, the 8.1 kWp solar PV system with two days of battery autonomy (129.6 kWh battery capacity) has the fewest unused energy losses and a good PR in all six of the cities: Delhi, Chennai, Jaisalmer, Tawang, Ladakh, and Bengaluru.

An annual average of 12,428.8 kWh of energy can be generated from this system, which is sufficient to charge 414 vehicles with a battery capacity of 30 kWh. This would help in decreasing CO2 emissions by around 7950 kg per year.

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