

A DEMONSTRATING MODEL OF SMART SOLAR EV CHARGING STATION

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Abstract: *The Smart Solar EV Charging Station is a cutting-edge technology that integrates solar energy with electric vehicle (EV) charging capabilities. This system uses solar panels to generate electricity that can be used to power the charging station, reducing the reliance on the grid and providing a sustainable and cost-effective solution for EV charging.*

Key words: *Smart solar, Electrical vehicle, Charging station, Cost-effective, Grid*

I. INTRODUCTION

This paper discusses the concept and advantages of a Smart Solar EV Charging Station, which combines solar energy and electric vehicle (EV) charging technology for eco-friendly and sustainable charging. The aim is to promote renewable energy adoption, reduce carbon emissions, and support widespread EV adoption. This innovative system utilizes solar panels to generate electricity for charging, reducing grid reliance. It offers smart features like remote monitoring, real-time data analysis, and user-friendly interfaces for efficient EV charging. The Smart Solar EV Charging Station addresses the growing need for sustainable and efficient EV charging infrastructure as more people switch to electric vehicles [1].

II. PROCEDURE

The Smart Solar EV Charging Station is a complex system that involves the integration of several technologies, including solar energy generation, energy storage, electric vehicle charging, and smart features such as remote monitoring and control. The following is a general methodology of how the Smart Solar EV Charging Station operates:

- 1) **Solar Energy Generation:** The charging station is equipped with solar panels that generate electricity from sunlight. The solar panels are connected to a solar inverter that converts the DC power generated by the solar panels into AC power that can be used to charge electric vehicles [2].
- 2) **Energy Storage:** The charging station may also be equipped with a battery storage system that can store excess solar energy for later use. The energy storage system ensures that the charging station can operate even when there is no sunlight or during peak demand periods.
- 3) **Electric Vehicle Charging:** The charging station is equipped with electric vehicle charging equipment, including charging cables, connectors, and charge controllers. When an electric vehicle is plugged into the charging station, the charging equipment communicates with the vehicle to determine the optimal charging rate and manages the flow of electricity to the vehicle [3].

4) Smart Features: The Smart Solar EV Charging Station is equipped with smart features such as remote monitoring and control, real-time data collection and analysis, and user-friendly interface. These features enable the charging station to be monitored and managed remotely, ensuring optimal performance, and minimizing downtime.

5) Grid Connection: In some cases, the charging station may be connected to the grid, allowing it to draw power from the grid during periods of low solar energy generation or high demand. However, the charging station is designed to operate with minimal or no grid dependence, relying primarily on solar energy generation and energy storage.

6) Overall, the methodology of the Smart Solar EV Charging Station involves the integration of solar energy generation, energy storage, electric vehicle charging, and smart features to provide a sustainable, efficient, and user-friendly charging solution for EV drivers.

III. SECTION

3.1 Basic circuit diagram of Solar EV Charging station.

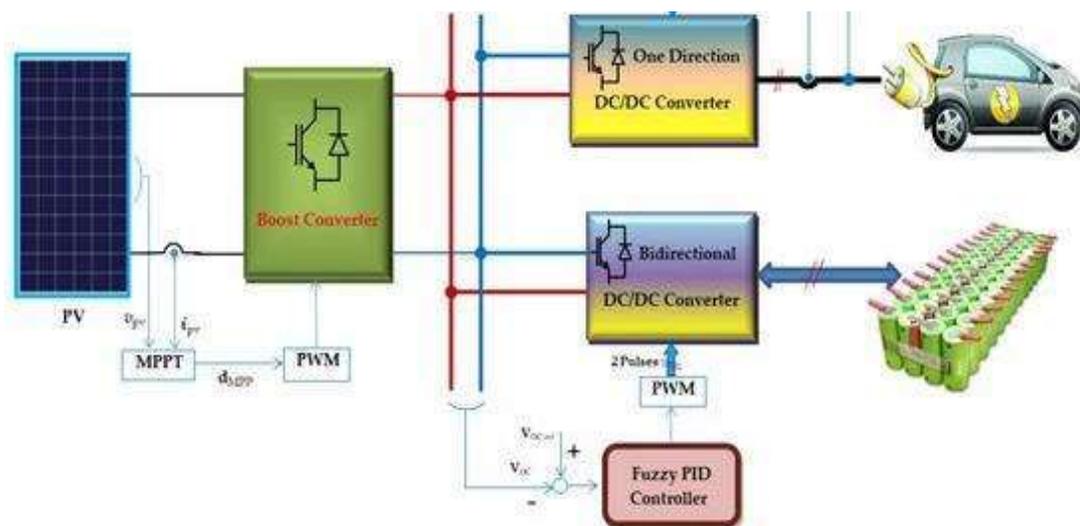


Figure 1 Basic circuit diagram of Solar EV Charging station

3.2 Various components used in our project including its function and circuit diagram.

3.2.1 Solar Panel - A solar panel is a device that converts sunlight into electricity using photovoltaic cells. These cells absorb photons from the sun and convert them into an electric current. Solar panels are used in various applications, including residential, commercial, off-grid, and portable systems. They can also charge batteries, power small devices, and provide remote lighting. Most solar panels are made of silicon, although other materials like cadmium telluride or copper indium gallium selenide can be used. Panel efficiency depends on material, size, and sunlight exposure [4].

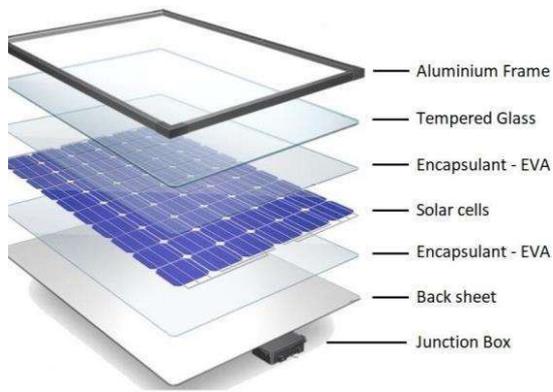


Figure 2 Solar Panel

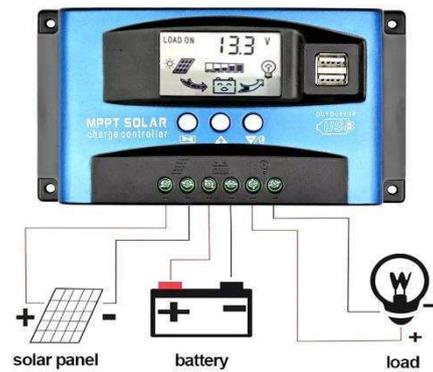


Figure 3 Solar charge controller



Figure 4 Rechargeable Battery

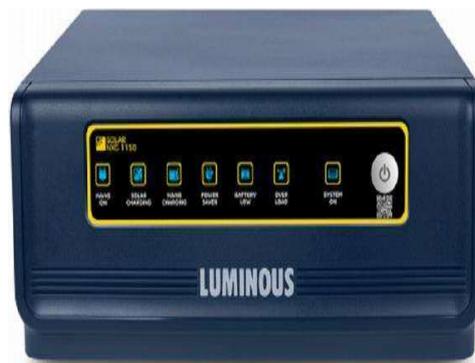


Figure 5 Inverter

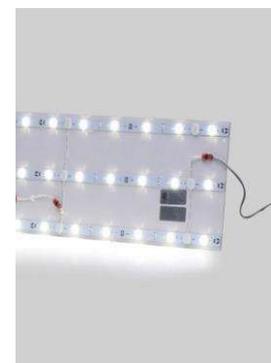


Figure 6 LED panel

3.2.2 Solar charge controller - A solar charge controller is a crucial component in a solar power system, responsible for regulating the voltage and current between solar panels and batteries. Its primary role is to ensure efficient and safe battery charging by preventing overcharging or undercharging. There are two types of controllers: PWM, which is cost-effective but less efficient, and MPPT, which is more efficient and can maximize energy conversion from solar panels. These controllers come in various sizes and include features like overcharge protection, battery temperature sensing, and load control to enhance the longevity and performance of solar power systems [5].

3.2.3 Rechargeable Battery (Lead Acid) - A 12V lead-acid rechargeable battery is widely used in vehicles, boats, and backup power systems. It consists of lead plates in a sulfuric acid and water solution. Charging it requires a specific lead-acid battery charger with settings for the battery type. Safety precautions are crucial, including well-ventilated charging areas, disconnecting from devices, and avoiding overcharging to prevent overheating or explosions. A fully charged battery should read around 12.6V, which can be monitored with a voltmeter or battery tester.

3.2.4. Inverter - An inverter is an electronic device that transforms DC electricity into AC electricity. It is frequently used in off-grid solar power setups, where solar panels generate DC electricity that must be converted into AC for household appliances and devices. Inverters vary in size and capacity, serving small portable needs or large-scale applications. They often feature safety mechanisms like overvoltage, overload, and ground fault protection. Some include charge controllers for battery regulation. Inverters may also have added functions like grid-tie capability, enabling excess power to be sold back to the utility grid, and battery backup for uninterrupted power during grid outages. Overall, inverters are a crucial element in off-grid solar systems, facilitating the conversion of solar-generated DC electricity into usable AC power for various purposes.

3.2.5 LED panel - An LED panel is a lighting fixture that uses energy-efficient LEDs to produce bright light. It's commonly used in both commercial and residential spaces, replacing traditional lighting like fluorescent or incandescent bulbs. LED panels consist of a flat grid of LEDs on a PCB, covered with a diffuser and housed in an aluminum or plastic frame. They offer advantages such as energy efficiency, longer lifespan (typically 50,000+ hours), and low maintenance. LED panels come in various sizes and shapes for different applications, including ceiling grid, suspension, surface-mounting, or recessed installation, making them a versatile and efficient lighting choice.

3.2.6 Arduino uno - The Arduino Uno is a widely used microcontroller board based on the ATmega328P chip. It's known for its simplicity, making it accessible to beginners. With an open-source development environment, users can easily write and upload code using the Arduino IDE. The board offers various input and output options, including digital and analog pins and communication interfaces like I2C, SPI, and UART, allowing users to connect sensors and devices. It also features a USB port for code upload and power, and it can be powered externally. Its versatility has made it popular for various projects, fostering a large supportive online community [6].

3.2.7 A.C to D.C converter- An AC to DC converter, also known as a rectifier, transforms alternating current (AC) from the electrical grid into direct current (DC) used by electronic devices. The conversion involves two key steps: rectification, which uses diodes to create pulsating DC, and filtering, which smooths the signal with capacitors. Two main types exist: half-wave and full-wave converters, with the latter producing a smoother output. AC to DC converters are crucial in various applications, including powering electronics, battery chargers, and renewable energy systems like solar and wind power, enabling the use of DC power in modern electronics and electrical systems.

3.2.8 USB data cable - A USB data cable is a versatile cable used for data transfer and device charging between electronic devices with USB ports. It typically has a USB Type-A connector on one end and either a Type-B or Type-C connector on the other. USB data cables work with computers, smartphones, tablets, cameras, printers, and more. They come in various lengths, may be shielded for signal quality, and may have gold-plated connectors for durability. Different USB standards like USB 2.0 (480 Mbps) and USB 3.0 (5 Gbps) determine data transfer rates and power capabilities. In summary, USB data cables are crucial for modern electronics, facilitating fast and reliable data transfer and device charging.

IV. CIRCUIT DIAGRAM

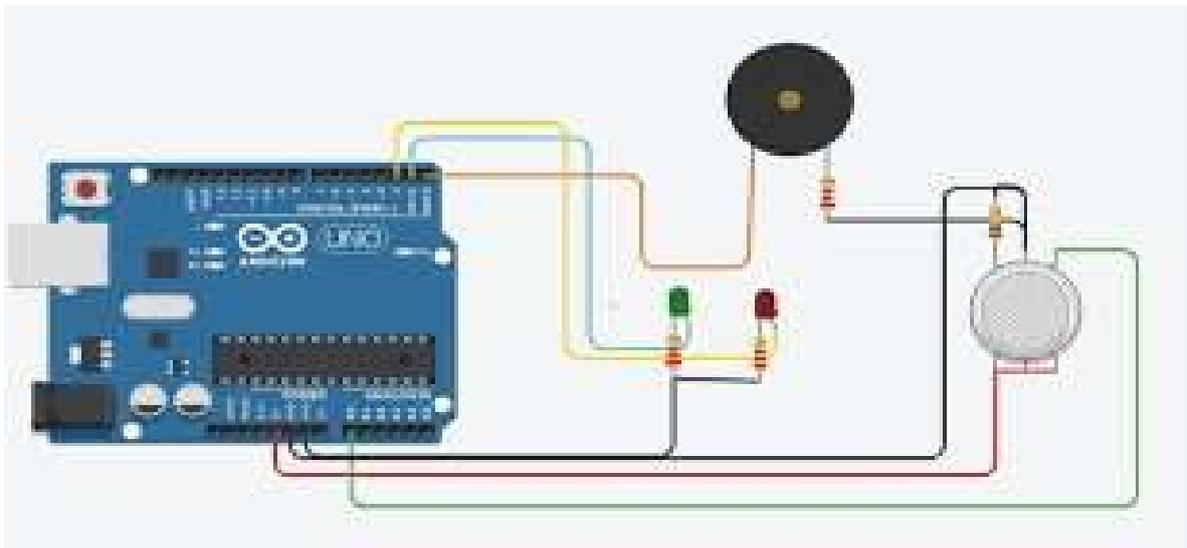


Figure 7 Circuit diagram of Smoke detection in the smart canteen

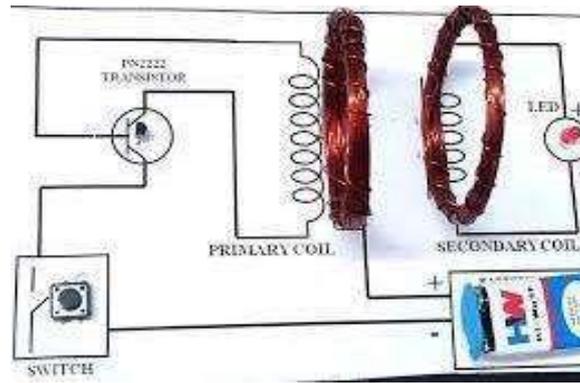


Figure 8 Circuit diagram of wireless power transamination

V. GRAPH FOR SALES OF EV VEHICLES IN INDIA IN THE YEAR OF 2023



Figure 9 Proposed Model of the EV Station

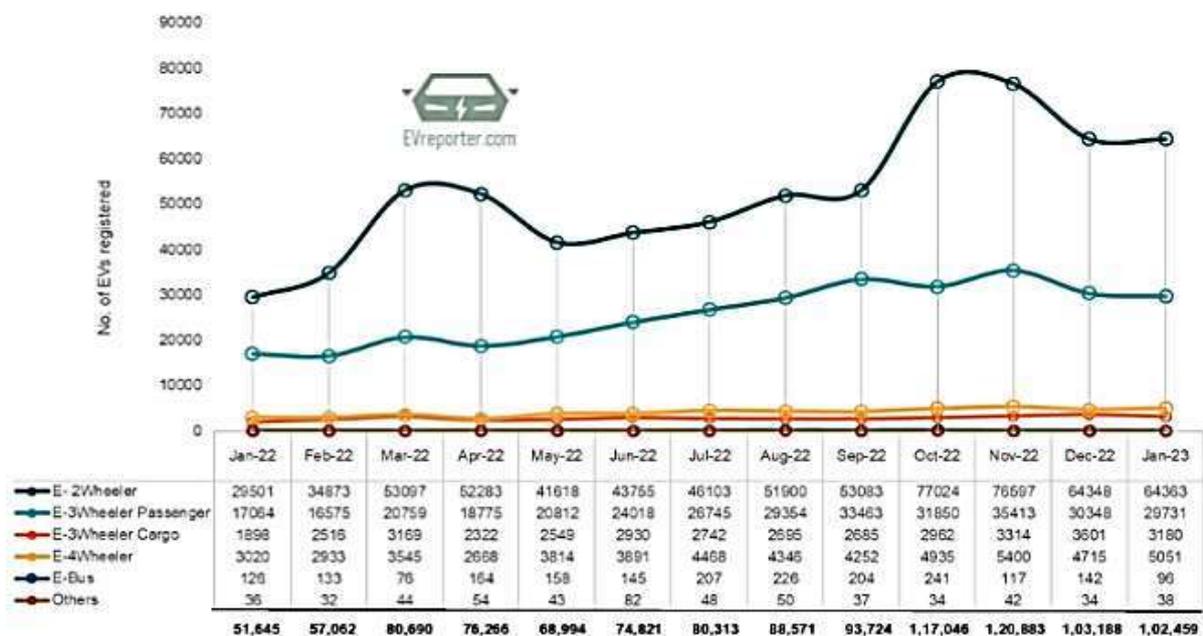


Figure 10 Sales of EV in India (Jan, 2022-2023)

VI. RESULTS AND DISCUSSION

Sample Calculations are done considering Tata Nexon EV car model as an example to understand the complete system Calculation for solar system [at 1000W/m² of solar irradiance at 25 °C.] Consider, 50 KW of solar system [i.e., daily output] Average sunshine in hours in India = 5 Hours. (50 KW-hr)/5 hrs = 10 KW 10 KW system will be needed. ∴ 10 KW * 5 hours = 50 KW daily output. Considering, solar panel with peak power = 385 Watts with, Maximum voltage = 40.3 V.

Maximum current = 9.56 Amp.

$$P = V * I$$

∴ No. of panels required for 10 KW system is, ((10 * 10)

3 Watts)/385 Watts = 25.97 = 26 panels.

Panels are connected in series to increase voltage output & connected in parallel to increase current output.

Solar panel dimensions are:

Length = 197.6 cm, Width = 99.1 cm,

Thickness = 3.5 cm.

∴ Area of Solar Panel = Length * Width

$$= 19582.16 \text{ cm}^2. = 1.95 \text{ m}^2.$$

∴ Area for 26 panels = 26 * 1.95 = 51 m².

Calculation for solar panel - area

Dimensions of Tata Nexon EV are:

Length = 3.99 m, Width = 1.811 m,

∴ Area of Tata Nexon EV = Length * Width

$$= 3.99 * 1.811 = 7.233 \text{ m}^2.$$

∴ Total Plant Area = Area for 26 panels + Area of Tata Nexon EV.

$$= 51 + 7.22 = 58.23 \text{ m}^2.$$

∴ Minimum Area required for Solar Charging Station is 60 m²

Calculation for batteries

The nominal voltage of Lithium-ion battery is 3.60V/cell and current is 2600mah.

$$P = V * I$$

$$P = 3.60 * 2.6$$

$$P = 9.36 \text{ Watt [For one cell]}$$

We considered the Lithium polymer battery of Tata Nexon EV with following specifications:

Capacity: - 30.2 KW-hr & 320 V Lithium polymer battery.

To get the no. of cells in a battery pack,

Total output power = 30.2 KW

Output power of one cell = 9.36 Watts

∴ No. of cells = $((30.2 * 10)$

3 Watts)/9.36 Watts = 3226.49 cells

No. of cells \approx 3227 cells.

Battery of Tata Nexon EV: -

Calculating ampere output of battery

$P = V * I = (30.2 * 10)$

$3 = 320 * I$

∴ $I = 94.375$ Amps.

∴ To calculate no. of cells in series / parallel.

$(P(\text{Battery}))/P(\text{cell}) = (V(\text{Battery}))/V(\text{Cell})$

$(I(\text{Battery}))/I(\text{Cell})$

$(30.2 * 10)$

$3/9.36 = 320/3.6 * 94.375/2.6$

$3227 = 88.88 * 36.29$

$3227 = 89 * 36$

∴ 89 cells are connected in series & 36 cells are connected in parallel to meet the battery capacity.

Operating voltage for batteries

∴ Lithium-ion will operate safely within the designed operating voltages.

Normal cell voltage = 3.6 V

Typical end of discharge = 2.8V – 3.0V

Maximum Charge Voltage = 4.2 V.

As 89 cells are connected in series,

∴ $[89 * 4.2 = 373.8$ Volt] is the maximum charge voltage of a battery pack.

Voltage should not exceed this value; it may lead to temperature rise & battery damage.

∴ $[89 * 2.8 = 249.2$ Volt]

i.e., when voltage reaches 249.2 Volt hence, battery will be in discharged state.

SI No.	List of materials	Quantity	Specification
1	Solar Panel	2	12v,6v DC
2	Solar charge controller	1	20v DC
3	Rechargeable Battery (Lead Acid)	1	12v DC
4	Inverter	1	12DC to 220v AC 200W
5	Non rechargeable battery	3	9v DC
6	LED panel	1	12vdc
7	Arduino uno	2	AT Mega 328 PU
8	A.C to D.C converter	2	220VAC to 12v DC
9	USB data cable	1	Data and power
10	Smoke sensor	1	MQ3 (smoke, fire)
11	LED light	5	5v DC
12	LED strip light	5	12v DC
13	DC fan	1	12v DC
14	Bluetooth module	1	5v DC
15	A.C bulb	1	220V AC 50Hz
16	Bulb holder	1	Plastic
17	2 channel relays	1	5v-12v DC
18	Alarm	1	5v DC
19	Toy car	1	Without remote control
20	Included copper wire ring	2	25 gauge
21	Switch	8	30v DC
22	Connecting wire	10	Multicolor packet
23	Digital voltage indicator	2	100v DC
24	Aux cable	2	3.5 mm audio jack

Table 1 List of Materials

VII. CONCLUSION

In conclusion, solar EV charging stations are a promising solution for sustainable transportation and reducing carbon emissions by using solar energy to charge electric vehicles. They offer benefits like cost savings, grid stability, and environmental advantages, but there are challenges such as consumer behaviour and scalability. Nevertheless, their deployment is a crucial step towards a sustainable energy system and wider electric vehicle adoption, achieved through public-private partnerships, innovation, and addressing challenges.

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