

# Electric Power Generation From Solar Electric Vehicles

**Sakshi Chandrakant Kamble<sup>1</sup>, Prof. Dnyaneshwar Shivaji Waghmode<sup>2</sup>**

Student, Department of Electrical Engineering, Shree Siddheshwar Women's College of Engineering, Solapur, India<sup>1</sup>

HOD, Department of Electrical Engineering, Shree Siddheshwar Women's College of Engineering, Solapur, India<sup>2</sup>

**Abstract:** As the global demand for sustainable and renewable energy solutions increases, solar electric vehicles (SEVs) offer a promising innovation by integrating photovoltaic (PV) technology into electric mobility. This paper explores the concept of electric power generation from SEV highlighting how embedded solar panels can convert sunlight into usable electrical energy for vehicle propulsion, battery charging, and even grid support through bidirectional energy systems. While current technological limitations—such as low surface area, variable solar efficiency, and high costs—pose challenges to large-scale adoption, advancements in lightweight materials, high-efficiency PV cells, and intelligent energy management systems are steadily improving SEV viability. This study examines the design considerations, power output potential, and real-world implementations of solar-powered electric vehicles, including case studies like Lightyear, Aptera, and Sono Motors. The integration of SEVs into smart grids and decentralized energy systems represents a significant step toward reducing carbon emissions and enhancing energy resilience. Overall, this paper provides a comprehensive overview of the technical, environmental, and economic aspects of power generation from SEVs, highlighting their potential role in a sustainable transportation future.

**Keywords:** Solar Electric Vehicles (SEVs), Photovoltaic Systems, Renewable Energy, Electric Vehicle

## I. INTRODUCTION

The rapid growth of electric vehicles (evs) has been a key response to the rising concerns over climate change, fossil fuel depletion, and urban air pollution. While evs represent a cleaner alternative to conventional internal combustion engine vehicles, their widespread adoption brings challenges related to energy sourcing, grid load, and charging infrastructure. To further enhance the sustainability of electric mobility, solar electric vehicles (sevs) have emerged as a promising innovation that integrates photovoltaic (pv) technology directly into the vehicle structure. solar electric vehicles utilize solar panels installed on the vehicle & 39;s surface to harness sunlight and convert it into electrical energy through photovoltaic cells. This energy can be used to charge the vehicle's battery, extend its driving range, or supply power to the grid or other systems in vehicle-to-grid (v2g) and vehicle-to-home (v2h) applications. By generating power on-site, sevs reduce dependency on gridelectricity, much of which still comes from non-renewable sources. despite the clear environmental benefits, electric power generation from sevs faces limitations, including limited surface area for solar panels, variable solar irradiance, and the relatively low efficiency of current pv technology. However, ongoing research and technological improvements in solar cell efficiency, lightweight materials, and smart energy management systems are making sevs more practical and appealing.

Electric power generation from solar electric vehicles (SEVs) represents a promising convergence of renewable energy and sustainable transportation. By integrating photovoltaic (PV) technology directly into vehicles or their supporting infrastructure, SEVs harness solar energy to reduce dependence on fossil fuels, lower greenhouse gas emissions, and offer cost-effective mobility solutions.

### 1.1 What Are Solar Electric Vehicles?

Solar electric vehicles are a subset of electric vehicles (EVs) equipped with solar panels that convert sunlight into electricity. This energy can directly power the vehicle's electric motor or be stored in onboard batteries for later use. Unlike traditional EVs that rely solely on grid electricity, SEVs can generate a portion of their energy needs independently, enhancing their sustainability and reducing operational costs.[1]



## 1.2 How Do They Work?

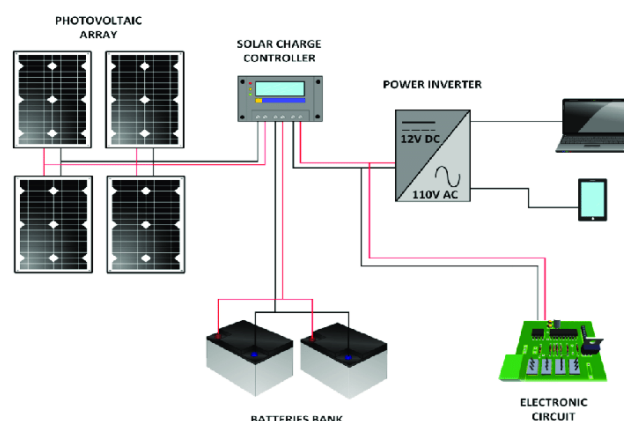
At the core of SEVs are photovoltaic cells, typically made from semiconductor materials like silicon. When sunlight strikes these cells, it excites electrons, generating direct current (DC) electricity. This electricity can either power the vehicle's motor directly or charge its batteries for future use. Some SEVs also feature advanced systems that allow excess energy to be fed back into the grid, a concept known as vehicle-to-grid (V2G) technology.

The architecture of solar electric vehicles (SEVs) integrates photovoltaic (PV) systems with electric vehicle (EV) technology to harness solar energy for propulsion. This integration involves several key components and subsystems working cohesively to optimize energy generation, storage, and utilization.

Solar electric vehicles (SEVs) are a marvel of modern engineering, combining the principles of photovoltaics, energy storage, and automotive design. The architecture of these vehicles is centered around three main components: the solar panels, the battery, and the electric motor.

Solar electric vehicles (SEVs), which combine the concepts of energy storage, photovoltaics, and automotive design, are a marvel of contemporary engineering. The three primary parts of these vehicles' architecture are the electric motor, battery, and solar panels.

- Solar panels:** The solar panels are the most noticeable component of the SEV's design. These are usually built into the vehicle's roof, though occasionally they are also incorporated into the body. They are composed of photovoltaic cells, which generate power from sunshine. Since it dictates the amount of power that may be produced, solar panels' efficiency is vital. [2]



- Power source:** A battery is used to store the electricity produced by the solar panels. This battery is comparable to those in conventional electric cars.[3]



**3. The electric motor:** The vehicle is propelled by an electric motor that is powered by the battery's stored energy. Because it impacts the vehicle's performance and range, this motor's efficiency is also crucial. Apart from these elements, a solar electric vehicle's architecture also comprises cooling, charging, and power distribution and management systems. The vehicle's actual design is also crucial since it must be lightweight to boost efficiency and aerodynamic to lower drag. [4]



#### 4. Essential Elements of the SEV Architecture Photovoltaic Panels (PV):

These panels, which are mounted on the outside of the car, use sunlight to create direct current (DC) electricity. Energy capture, structural integrity, and aerodynamic efficiency must all be balanced in the design. [2]

#### 5. MPPT, or Maximum Power Point Tracker:

By continuously modifying the electrical working point, this electronic technology makes sure the PV panels provide the most electricity possible. [5]



#### 6. DC-DC Conversion:

order to ensure effective energy transmission, it adjusts the voltage from the PV panels to match the battery's charging needs. [6]



### 7. Pack of Batteries:

When solar input is insufficient, the battery, which is usually made up of lithiumion cells, stores excess solar energy and powers the electric motor. System for Battery Management (BMS) This system keeps an eye on and controls the battery's health, safety, and charge level, maximizing [3]

### Aspects of Design:

**Weight and Space:** Including solar panels and related electronics increases weight and takes up space, hence small and light designs and lightweight materials are required.

**Efficiency:** For efficient solar energy use, it is essential to maximize the efficiency of every component, particularly the PV panels and power electronics. [macsphere.mcmaster.ca](https://macsphere.mcmaster.ca)

**Durability:** Elements need to be able to tolerate environmental elements like weather, vibrations, and temperature changes.

**Cost:** For a business to be viable, performance and affordability must be balanced.

### Procedure in Detail:

Solar panels provide DC electricity by absorbing sunlight.

To optimize power output, the MPPT controller modifies the electrical operating point.

Electricity can power the motor directly or charge the battery pack.

The vehicle is propelled by an electric motor that uses the energy that is supplied.

The car runs on battery energy that has been stored during periods of low sunshine.

The effectiveness of this system directly impacts the vehicle's overall performance and range.

## II. SOLAR POWER INPUT SYSTEM

The solar energy input system acts as the main power source for recharging the onboard power source arrangement. It supplies power for vehicle movement during daylight hours and helps to power the battery pack for utilization when sunlight is not present (e.g., during nighttime or overcast weather conditions).

### a) Solar Power (PV) Modules

- **Technology:** Monocrystalline silicon panels are the most prevalent because of their high efficiency.
- **Standard Efficiency:** 18%–22%
- **Location:** Roof, hood, or body-integrated panels on the automobile
- **Purpose:** Transform solar irradiance (sunlight) into direct current (DC) electricity by employing the solar energy effect.

### b) Cables and Connectors

- Created to manage low-current, high-voltage DC securely and with reduced power loss.
- Materials that are resistant to UV rays and weather conditions are frequently utilized for durability in automotive applications.

### c) Solar Analyzer (Optional Assessment Instrument)

- Instruments like the Amprobe Solar Analyzer are utilized during the configuration of the system to examine I-V (Current-Voltage) and P-V (Power-Voltage) graphs to evaluate and enhance panel efficiency across various circumstances.

The energy generated by a photovoltaic (PV) panel is influenced by multiple factors:

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$$P = A \times G \times \eta \quad P = A \times G \times \eta \quad P = A \times G \times \eta$$

Where:

- PPP = Output power (Watts)
- AAA = Area of surface panel (m<sup>2</sup>)
- GGG = Solar radiation (W/m<sup>2</sup>), usually 1000 W/m<sup>2</sup> in standard testing conditions.
- $\eta$  = Αποδοτικότητα πάνελ (δεκαδική μορφή)

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For a 1.5 m<sup>2</sup> panel operating at 20% efficiency in direct sunlight:

$$P = 1.5 \times 1000 \times 0.20 = 300 \text{ Watts} \quad P = 1.5 \times 1000 \times 0.20 = 300 \text{ \text{Watts}}$$

If the system obtains 5 peak sunlight hours daily:

$$E_{\text{daily}} = 300 \times 5 = 1500 \text{ Wh} = 1.5 \text{ kWh/day} \quad E_{\text{daily}} = 300 \times 5 = 1500 \text{ Wh} = 1.5 \text{ kWh/day}$$

### III. ADVANTAGES OF SOLAR ELECTRIC VEHICLES

- **Environmental Impact:** By utilizing solar energy, SEVs produce zero tailpipe emissions, contributing to improved air quality and reduced greenhouse gas emissions.
- **Cost Savings:** Harnessing free solar energy can significantly lower fuel and electricity costs over the vehicle's lifespan.
- **Energy Independence:** SEVs reduce reliance on external charging infrastructure, offering greater flexibility, especially in remote or off-grid areas.
- **Grid Support:** With V2G capabilities, SEVs can supply electricity back to the grid during peak demand periods, enhancing grid stability and efficiency.

### IV. CHALLENGES AND CONSIDERATIONS

- Despite their potential, SEVs face challenges such as limited energy generation capacity due to the surface area available for solar panels on vehicles, variability in solar energy availability, and the current cost of high-efficiency PV materials. Ongoing research aims to address these issues by developing more efficient solar cells and integrating energy storage solutions.
- The charge controller also serves to regulate the flow of power into the energy storage system, ensuring the batteries are charged efficiently and safely, while preventing overvoltage, overcurrent, or reverse polarity conditions.

### V. DISADVANTAGES OF SOLAR ELECTRIC VEHICLES (SEVS)

- 1. Limited Energy Generation:** The surface area available on vehicles restricts the number of solar panels that can be installed, leading to limited energy generation. This makes it challenging for SEVs to rely solely on solar power for propulsion, especially in less sunny regions. Motorway
- 2. High Initial Costs:** Integrating solar panels into vehicles involves advanced materials and manufacturing processes, increasing the overall cost of SEVs compared to conventional electric vehicles.
- 3. Weather Dependence:** Solar energy production is contingent on sunlight availability. Cloudy weather, shade, and nighttime conditions significantly reduce or halt energy generation, necessitating alternative charging methods.



**4. Design Constraints:** To maximize solar efficiency, SEVs often require specific design considerations, such as aerodynamic shapes and lightweight materials, which can compromise vehicle aesthetics and practicality.

**5. Energy Storage Challenges:** Storing solar energy efficiently requires large battery systems, which add weight and occupy space, potentially affecting vehicle performance and range.

**6. Infrastructure Limitations:** The current lack of widespread solar charging infrastructure limits the practicality of SEVs, especially for long-distance travel or in areas without adequate sunlight exposure.

## VI. CONCLUSION

The integration of solar power into electric vehicles is a significant step toward energy-independent and ecologically responsible transportation. This study has looked at the entire architecture of electrical power generation in Solar Electric Vehicles (SEVs) to gain a better understanding of the interactions between solar energy capture, energy storage, power regulation, and propulsion systems. Because of their efficient photovoltaic energy collection, reliable battery management, and intelligent power distribution, SEVs may reduce their dependency on fossil fuels, reduce greenhouse gas emissions, and operate with minimal environmental impact.

When building an efficient SEV, consideration must be given to a number of interrelated factors, including weight constraints, energy efficiency, system safety, solar irradiance variability, and real-time control. LiFePO<sub>4</sub> batteries, brushless DC motors, and highly effective MPPT controllers enhance system performance.

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**Prof. Dnyaneshwar Shivaji Waghmode.**

Professor, Dept. of Electrical Engineering, SSWCOE, Solapur, Maharashtra, India



**Sakshi Chandrakant kamble**

Pursuing the Bachelor degree in Electrical Engineering, SSWCOE Solapur