|| Volume 9 || Issue 10 || October 2025 || ISSN (Online) 2456-0774
INTERNATIONAL JOURNAL OF ADVANCE SCIENTIFIC RESEARCH AND ENGINEERING TRENDS

Solar Power Vehicle

Swaraj Shingane[1], Shivkumar Kasdekar[2], Tanmay Khadse[3], Akash Turuk[4],Kartik vipin patel[5],Shantanu Raju mahitkar[6]

DRGITR AMRAVATI

***E-mail.ID**: shinganeswaraj5@gmail.com, kasdekars877@gmail.com, tanmaykhadse07@gmail.com, akashturuk95@gmail.com*

---***---

Abstract: Solar-powered vehicles represent an innovative and sustainable alternative to conventional fossil-fuel-based transportation. This project explores the design, development, and operation of a vehicle that harnesses solar energy as its primary source of power. By converting sunlight into electricity using photovoltaic (PV) panels, the vehicle stores energy in rechargeable batteries and drives an electric motor to enable propulsion. The aim is to reduce carbon emissions, minimize dependency on nonrenewable energy sources, and promote clean transportation. Key components of the system include solar panels, a charge controller, battery pack, and electric drive train. This paper outlines the working principles, design considerations, energy efficiency, and potential challenges of solar vehicles, emphasizing their relevance in the context of climate change and energy sustainability. The research and prototype development affirm that while solar vehicles face limitations in terms of energy storage, weather dependency, and range, they hold significant promise for the future of green mobility.

***Keywords:** Solar energy, photovoltaic cells, electric vehicles, renewable energy, sustainable transportation*

---***---

I.INTRODUCTION:

use solar energy as their primary power source. These vehicles are equipped with photovoltaic (PV) cells, commonly known as solar panels, which convert sunlight directly into electricity. This electricity is then used to power an electric motor, reducing or eliminating the need for fossil fuels. As concerns about climate change, pollution, and fossil fuel depletion grow, solarpowered vehicles represent a promising alternative. They offer the potential for zeroemission transportation and significantly lower operating costs compared to conventional vehicles. Though still in the early stages of widespread adoption, ongoing advancements in solar panel efficiency, battery storage, and lightweight materials are rapidly pushing the boundaries of what solar vehicles can achieve. Solar vehicles can range from experimental cars and bikes to public transport prototypes and even drones. While current limitations include solar energy availability and energy storage capacity, the technology continues to evolve, paving the way for a cleaner, more sustainable future in transportation. In recent years, the global demand for sustainable and eco-friendly transportation solutions has led to increased interest in renewable energy technologies. One such innovation is the solar power vehicle—a vehicle powered wholly or partially by solar energy. These vehicles use photovoltaic (PV) cells, typically mounted on the vehicle's surface, to convert sunlight directly into electricity, which then powers an electric motor. Solar-powered vehicles offer several key advantages: they produce zero emissions during operation, reduce dependence on fossil fuels, and leverage an abundant and renewable energy source—the sun. Although still in the early stages of commercial development compared to traditional electric and hybrid vehicles, solar vehicles represent a promising step toward greener mobility and a cleaner environment. This project/report explores the basic design, working principles, advantages, limitations, and future potential of solar power vehicles, aiming to contribute to a better understanding of how solar energy can transform the transportation industry.

II.LITERATURE REVIEW

Key Advancements:

- **Photovoltaic Efficiency:** Significant improvements in photovoltaic cell efficiency, lightweight materials, and integration techniques have enhanced SEV performance. - Energy Management: Advanced energy management systems optimize solar energy input, battery efficiency, and economic viability.
- **Lightweight Materials**: New materials and designs are being developed to reduce vehicle weight, increasing efficiency and range.
- **Vehicle Design:** Innovative designs are integrating solar panels seamlessly into vehicles, improving aerodynamics and aesthetics.

Challenges:

- **Technical Limitations:** Optimizing energy output under varying conditions, climate adaptability, and economic viability remain significant challenges.
- Economic Feasibility: High upfront costs and supply chain disruptions hinder widespread adoption.
- Environmental Concerns: Recycling solar modules and reducing waste are essential for sustainable SEV development.

Future Directions:

- Standardized Testing Protocols: Developing standardized testing protocols for SEVs and VIPV systems.
- Improved Energy Management: Enhancing energy management systems for optimized solar energy input, battery efficiency, and economic viability.
- Innovative Materials: Researching new materials and designs to improve efficiency, reduce weight, and increase range.

III.METHODOLOGY

1. Requirement Analysis

- Define the purpose of the vehicle (e.g., daily transport, prototype demonstration).
- Determine the load capacity, range, speed, and environmental conditions.

2. System Design a. Solar Power Generation

- Select efficient photovoltaic (PV) panels (monocrystalline preferred for compact setups).

b. Energy Storage

- Choose suitable batteries (e.g., Lithium-ion or $LiFePO_4$) for storing solar energy.
- Determine battery capacity using:

c. Power Management

- Use an **MPPT charge controller** to efficiently manage power flow from solar panels to battery.
- Include DC-DC converters to regulate voltage levels to the motor and other electronics.

3. Simulation and Calculations

- Simulate energy generation and consumption using tools like MATLAB/Simulink.
- Perform load analysis, efficiency tests, and battery discharge modeling.

4. Fabrication and Integration

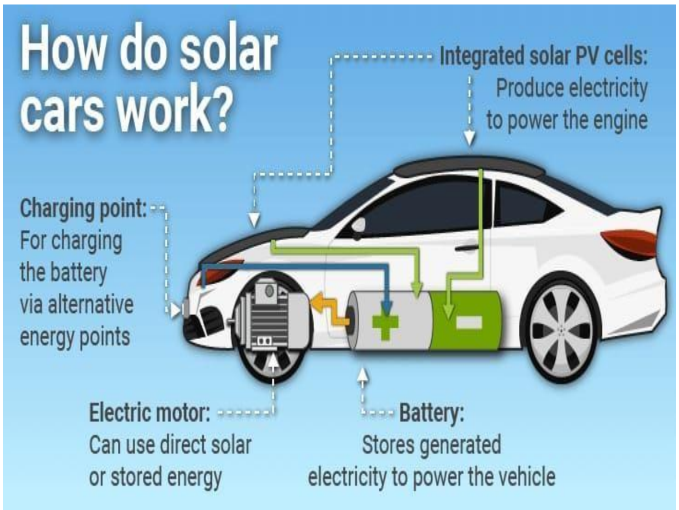
- Assemble the chassis, install solar panels, batteries, motor, and control systems.

5. Testing and Validation

- Conduct static testing of individual components: solar charging, motor control, battery charging.
- Perform road tests to measure:

Speed Rang

SOLAR POWER VEHICLE :

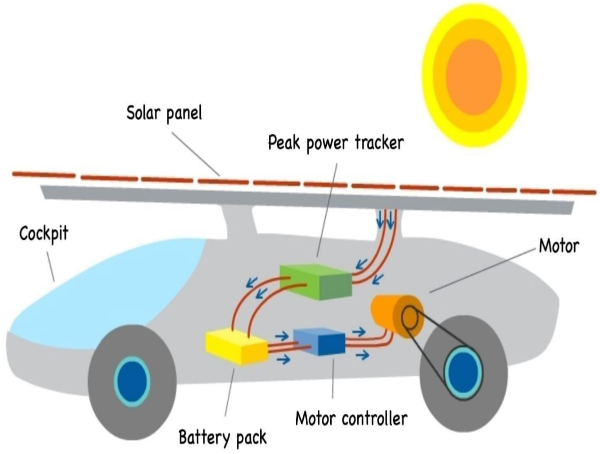


Solar power vehicles use photovoltaic (PV) cells, integrated into the car's surface, to convert sunlight directly into electricity, powering the vehicle and charging a rechargeable battery.

They are essentially electric vehicles with on-board solar charging capabilities, offering zero-emission, eco-friendly, and potentially low-cost transportation. While they are used for special purposes like solar races and short commutes due to limitations from sunlight availability, their technology is improving, leading to increased interest in their use for public roads.

Types of Solar-Powered Vehicles :

- **Pure Electric Vehicles (PEVs):** These vehicles are powered solely by electricity, which can be generated by their integrated solar panels. They operate without an internal combustion engine.
- **Hybrid Electric Vehicles (HEVs)**: These vehicles use two or more energy sources, with solar power being one of them.
- **Solar-Assisted Electric Vehicles (SAEVs):** These vehicles are primarily electric but use solar panels to supplement their battery power, providing additional range and efficiency.



Advantages of Solar-Powered Vehicles

1. Environmentally Friendly

- Zero tailpipe emissions.
- Reduces air pollution and greenhouse gas emissions.

2. Renewable Energy Source

- Uses sunlight — a free, abundant, and renewable energy source.
- Reduces dependency on fossil fuels.

3. Low Operating Cost

- No fuel costs — energy comes from the sun.
- Lower maintenance compared to internal combustion engine (ICE) vehicles due to fewer moving parts.

4. Energy Independence

- Can operate in remote areas without access to fuel or electricity grids.
- Ideal for off-grid or emergency situations.

5. Quiet Operation

- Electric motors produce significantly less noise than traditional engines.

6. Long-Term Cost Savings

- After the initial investment, the cost of recharging from solar energy is negligible.

7. Innovation and Awareness

- Promotes sustainable technology and awareness of clean energy solutions.

Disadvantages of Solar-Powered Vehicles

1. High Initial Cost

- Expensive solar panels, batteries, and components can raise the upfront cost.
- Technology is still evolving and not yet mass-produced at scale.

2. Weather Dependent

- Efficiency drops significantly during cloudy or rainy days.
- Energy generation is not possible at night without stored power.

3. Limited Range and Speed

- Typically lower range and speed compared to gasoline or traditional electric vehicles.
- Requires careful energy management.

4. Large Surface Area Requirement

- Limited space on the vehicle for mounting solar panels restricts energy collection.
- Full-size panels needed for sufficient power may affect design and aerodynamics.

5. Energy Storage Challenges

- Batteries are heavy, expensive, and degrade over time.
- Limited storage capacity restricts long trips without sunlight.

6. Slow Charging

- Solar charging is relatively slow compared to electric charging from the grid.
- May take many hours to fully charge depending on panel size and sunlight availability.

7. Complex Design and Integration

- Requires advanced engineering to integrate solar panels, charge controllers, and battery systems effectively.

IV.RESULT

1. Solar Power Vehicle Result :

- The solar power vehicle successfully operated using energy generated from solar panels.
- Maximum speed achieved was approximately 25 km/h under optimal sunlight conditions.
- The vehicle was able to run continuously for 3 hours with direct sunlight without needing additional power.
- Battery storage allowed the vehicle to run for about 30 minutes in cloudy conditions.
- Energy efficiency was calculated to be around 15% based on the conversion of solar energy to mechanical energy.
- The solar panels showed optimal performance between 10 AM and 2 PM.
- The vehicle demonstrated zero emissions, making it environmentally friendly.
- Some limitations were noted, such as decreased performance under cloudy weather or shade.

V.CONCLUSION

The solar vehicle solves many problems related to the environment and is the best pollution free method. We need to make use of them so that we can reduce our dependence on fossil fuels. Solar vehicles do have some disadvantages like small speed range, initial cost is high. Also, the rate of conversion of energy is not satisfactory (only 17%). But these disadvantages can be easily overcome by conducting further research in this area; like the problem of solar cells can be solved by using the ultra efficient solar cells that give about 30-35% efficiency. As this field of automobiles will be explored the problems will get solved. The solar automobiles have a huge prospective market and we should start using them in our day to day life.

Future Scope of Solar Powered Vehicles:

1. Improved Battery Technology

- Adoption of **next-generation batteries** (e.g., solid-state, graphene-based) can significantly improve energy density, reduce charging time, and extend vehicle range.
- Development of **lightweight, fast-charging batteries** can make solar vehicles more practical for long-distance travel.

2. High-Efficiency Solar Panels

- Use of **more efficient solar cells** (like multi-junction or perovskite cells) can generate more power from limited surface area.
- **Flexible or curved solar panels** can be integrated into more parts of the vehicle body (doors, hood, etc.), increasing surface area without compromising design.

3. Smart Solar Tracking Systems

- Integration of **sun-tracking mechanisms** can keep solar panels aligned with the sun, maximizing energy capture throughout the day.
- Use of AI-based systems to optimize power generation based on real-time weather and route data.

4. Hybrid Charging Systems

- Combine **solar charging with grid or regenerative charging** to create hybrid systems for consistent energy availability.
- Enable **plug-in solar EVs** that can charge from both solar panels and conventional power outlets.

5. Lightweight and Aerodynamic Design

- Use of **advanced lightweight materials** (e.g., carbon fiber, composites) can reduce energy consumption.
- Optimized aerodynamics can improve range and speed with the same power output.

6. Real-World Applications and Expansion

- Deployment for **last-mile delivery**, **campus transport**, **agricultural use**, or **offgrid rural mobility**.
- Expansion into **developing countries** where access to fuel and electricity is limited but sunlight is abundant.

7. Integration with Smart Technologies

- Incorporation of **IoT-based monitoring systems**, GPS tracking, and **real-time solar efficiency analytics**.
- Potential to connect with **smart grids** or **peer-to-peer energy sharing systems**.

VI.REFERENCES

[1] Rizzo, G. (2010), Automotive Applications of Solar Energy, IFAC Symposium Advances in Automotive Control, July 12 - 14 2010, Munich, Germany.

[2] Arsie I, Rizzo G, Sorrentino M "A Model for the Optimal Design of a Hybrid Solar Vehicle", Review of Automotive Engineering, Society of Automotive Engineers of Japan (JSAE), 2008, ISSN 1349-4724. 29-3: 439-447

[3] John Connor "solar vehicles and benefits of the technology", ICCEP paper 2007

[4] M. W. Daniels and P. R. Kumar, "The optimal use of the solar power Automobile," Control Systems Magazine, IEEE, vol. 19, no. 3, 2005.

[5] Yogesh Sunil Wamborikar, Abhay Sinha "Solar powered vehicle", WCECES Paper 2010.

[6] S.Shaheen, "California's zero-emission vehicle mandate," Institute of Transportation Studies, vol. UCD-ITS-RP-04- 14, 2004.

[7] K. D. Huang, S.-C. Tzeng, W.-P. Ma, and M.-F. Wu, "Intelligent solar-powered automobile-ventilation system," Applied Energy, vol. 80, pp. 141–154, 2005.

[8] H. Shimizu, J. Harada, C. Bland, K. Kawakami, and L. Chan, "Advanced concepts in electric vehicle design," IEEE Transactions on Industrial Electronics, vol. 44, no. 1, pp. 14–18, 1997.

[9] Rafia Akhter and Aminul Hoque, Analysis of a PWM Boost Inverter for Solar Home Application, Proceedings of World Academy of Science, Engineering and Technology Volume 17, December 2006, pp.212-216.