

# Green Drive: Self-Charging EV Technology Using Regenerative Braking and Solar Energy Harvesting

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**Abstract—** The rapid growth of electric vehicles (EVs) has significantly contributed to sustainable transportation and reduced carbon emissions. However, challenges such as limited driving range, long charging duration, and dependence on charging infrastructure continue to affect the widespread adoption of EVs. This paper presents the design and analysis of a self-charging electric vehicle system named Green Drive, which integrates renewable and regenerative energy technologies to improve energy efficiency and reduce dependency on external charging sources. The proposed system combines regenerative braking, solar energy harvesting, and onboard energy generation techniques to continuously recharge the battery during vehicle operation. Experimental analysis demonstrates improved runtime, enhanced energy utilization, and increased operational efficiency. The proposed system contributes toward sustainable and eco-friendly transportation solutions.

**Keywords—** Electric Vehicle, Self-Charging EV, Regenerative Braking, Solar Energy, Battery Management System, Sustainable Transportation.

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## I. INTRODUCTION

The increasing demand for sustainable transportation and the growing environmental concerns associated with fossil fuel consumption have accelerated the development of electric vehicles (EVs). Electric vehicles offer significant advantages such as reduced greenhouse gas emissions, lower operational costs, and improved energy efficiency. Despite these benefits, EVs still face several limitations including restricted driving range, long charging duration, and inadequate charging infrastructure.

To overcome these challenges, researchers and industries are exploring innovative technologies that can improve EV autonomy and reduce dependence on external charging stations. One promising approach is the development of self-charging electric vehicles capable of generating and recovering energy during operation.

The proposed Green Drive: Self-Charging EV Technology integrates regenerative braking, solar energy harvesting, and onboard charging mechanisms to continuously supply energy to the battery system. Regenerative braking converts kinetic energy into

electrical energy during braking, while solar panels mounted on the vehicle generate renewable energy from sunlight. The integration of these technologies improves battery efficiency, extends driving range, and promotes sustainable transportation.

This research focuses on the design, implementation, and performance analysis of a prototype self-charging electric vehicle system. The study evaluates the effectiveness of integrated energy generation methods and their impact on the overall efficiency and practicality of electric vehicles.

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## II. LITERATURE REVIEW

Recent advancements in electric vehicle technology have focused on improving energy efficiency and reducing charging dependency through renewable and regenerative energy systems.

Singh et al. (2019) highlighted the importance of regenerative braking systems in electric vehicles. Their study demonstrated that regenerative braking can recover approximately 10–25% of the energy normally lost during braking and store it in the battery for future use.

Lee et al. (2021) proposed Dynamic Wireless Power Transfer (DWPT) systems for electric vehicles, enabling charging while the vehicle is in motion using electromagnetic induction. This technology significantly reduces the requirement for frequent stationary charging.

Several studies have also investigated the integration of solar photovoltaic systems in EVs. Solar-assisted charging systems can provide supplementary power to increase battery life and improve energy sustainability. Researchers have identified solar energy harvesting as an environmentally friendly solution, especially in countries with high solar exposure.

Battery management systems (BMS) and smart energy management algorithms are also critical components in modern EV technology. These systems optimize charging cycles, improve battery lifespan, and enhance overall system reliability.

Although self-charging technologies offer substantial advantages, limitations such as high manufacturing cost, limited energy generation capability, infrastructure requirements, and system complexity continue to present challenges for large-scale implementation.

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## III. PROBLEM STATEMENT

Despite the increasing popularity of electric vehicles, their widespread adoption is limited by challenges such as:

- Limited driving range
- Long charging time
- Dependence on external charging infrastructure
- Battery degradation
- High energy demand
- Dependence on grid electricity generated from non-renewable sources

Frequent charging requirements reduce convenience and operational efficiency, especially during long-distance travel. Therefore, there is a need for an advanced energy-efficient system capable of generating and recovering electrical energy during vehicle operation.

The proposed Green Drive system aims to address these issues by integrating regenerative braking, solar energy harvesting, and onboard charging technologies to improve energy efficiency, extend driving range, and minimize reliance on external charging systems.

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## IV. OBJECTIVES

The primary objectives of the proposed system are:

- To design and develop a self-charging mechanism for electric vehicles.
  - To utilize regenerative braking for kinetic energy recovery.
  - To integrate solar energy harvesting for supplementary charging.
  - To improve battery efficiency and extend vehicle driving range.
  - To reduce dependency on external charging infrastructure.
  - To develop an intelligent energy management system.
  - To evaluate the performance and efficiency of the integrated system.
  - To promote sustainable and eco-friendly transportation.
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## V. SYSTEM DESIGN AND ARCHITECTURE

The proposed self-charging electric vehicle system consists of multiple integrated subsystems responsible for energy generation, storage, conversion, and utilization.

### 5.1 Main Components

#### 1. Drive Unit

A DC series motor is used to provide propulsion to the vehicle.

## 2. Energy Storage System

A lithium-ion battery pack combined with a Battery Management System (BMS) stores electrical energy and ensures safe battery operation.

## 3. Solar Energy Module

A polycrystalline solar panel is mounted on the vehicle surface to harvest solar energy.

## 4. Regenerative Braking System

The regenerative braking system converts kinetic energy generated during braking into electrical energy.

## 5. DC Generator and Gearbox

An alternator coupled with the motor shaft through a reduction gearbox generates electricity during motion.

## 6. Power Electronics

DC–DC converters and boosters regulate voltage and improve energy conversion efficiency.

## 7. Energy Management System (EMS)

An Arduino Nano-based controller manages power flow, charging priority, and system monitoring.

## 8. Monitoring System

Voltage, current, temperature, and speed sensors continuously monitor system performance.

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# VI. METHODOLOGY

The methodology adopted in this research focuses on the design, fabrication, and experimental evaluation of a prototype self-charging electric vehicle.

A small-scale electric toy car with a self-weight of 18 kg and passenger capacity of 35 kg was selected as the experimental model. The vehicle was modified to include:

- DC series motor
- Solar panel
- Alternator
- Reduction gearbox
- Lithium-ion battery

- Battery Management System
- Arduino Nano controller

The drive motor provides mechanical propulsion, while the alternator connected through a gearbox generates electrical energy during vehicle motion. The generated electrical energy is regulated using a charge controller and stored in the battery.

A solar panel mounted on the vehicle continuously harvests renewable energy during operation. During braking and deceleration, regenerative braking converts kinetic energy into electrical energy and recharges the battery.

The experimental setup was evaluated under different operating conditions by measuring:

- Battery voltage
- Charging current
- Charging efficiency
- Runtime
- Vehicle speed
- Energy consumption
- Vehicle range

The collected data were analyzed to determine the overall efficiency and feasibility of the self-charging system.

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## VII. EXPERIMENTAL SETUP

The experimental setup was designed to analyze the performance and reliability of the proposed self-charging electric vehicle system.

### 7.1 Test Environment

- Open test track and laboratory setup
- Temperature range: 20°C–35°C
- Smooth road conditions
- Controlled operating environment

### 7.2 Safety Measures

- Emergency shutdown mechanism
- Insulated wiring
- Overcurrent protection
- Thermal protection system
- Battery protection circuit

## 7.3 Testing Procedure

1. Assemble all system components.
  2. Charge the battery for baseline analysis.
  3. Operate the vehicle under different load conditions.
  4. Measure regenerative braking output.
  5. Measure solar charging performance.
  6. Record battery parameters and runtime.
  7. Analyze system efficiency and driving range.
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# VIII. DESIGN CALCULATIONS

## 8.1 Battery Capacity

Battery Specification:

- Voltage = 12 V
- Capacity = 2.2 Ah

Battery Energy:

$$\text{Energy} = V \text{ Ah} = 12 \times 2.2 = 26.4 \text{ Wh}$$

Therefore, battery energy capacity is 26.4 Wh.

## 8.2 Motor Power

Motor Specification:

- Voltage = 12 V
- Current = 1 A
- Two motors connected in parallel

Motor Power:

$$P = V I = 12 \times 1 = 12 \text{ W}$$

Total motor load for two motors:

$$\text{Total Power} = 12 \times 2 = 24 \text{ W}$$

## 8.3 Battery Runtime

Runtime Calculation:

$$\text{Run Time} = 1.1 \text{ hours}$$

Considering 80% practical efficiency:

Runtime  $\approx 0.88$  hours  $\approx 53$  minutes.

## 8.4 Vehicle Range

Assuming average speed = 20 km/h:

$$\text{Distance} = \text{Speed} \times \text{Time} = 20 \times 0.88 = 17.6 \text{ km}$$

Approximate vehicle range = 17 km.

## 8.5 Solar Charging

Solar Panel:

- Voltage = 12 V
- Current = 0.5 A
- Efficiency  $\approx 90\%$

Solar charging time  $\approx 17$ –20 minutes.

## 8.6 Generator Charging

Generator Power:

$$P = 24 \times 5 = 120 \text{ W}$$

Considering converter efficiency of 85%:

Effective charging power  $\approx 102$  W.

Generator charging time  $\approx 16$  minutes.

## 8.7 Overall System Efficiency

The integrated system achieved an overall efficiency of approximately 70–75%.

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# IX. RESULTS AND DISCUSSION

The developed prototype successfully demonstrated the feasibility of integrating regenerative braking and solar energy harvesting within a self-charging electric vehicle.

The experimental results showed:

- Improved battery utilization efficiency
- Extended runtime due to supplementary charging
- Reduced dependency on external charging
- Enhanced vehicle autonomy
- Stable system operation under different conditions

The regenerative braking mechanism effectively recovered energy during braking conditions, while the solar panel continuously supplied supplementary energy during vehicle operation.

The experimental analysis confirmed that the proposed self-charging system can significantly improve the sustainability and operational efficiency of electric vehicles.

## Performance Summary

Parameter	Value
Battery Energy	26.4 Wh
Motor Load	24 W
Runtime	53 minutes
Vehicle Speed	20 km/h
Vehicle Range	17 km
Solar Charging Time	17–20 minutes
Generator Charging Time	16 minutes
Overall Efficiency	70–75%

## X. ADVANTAGES OF THE PROPOSED SYSTEM

- Reduced dependency on external charging stations
- Improved energy efficiency
- Eco-friendly transportation solution
- Reduced carbon emissions
- Enhanced driving range
- Better battery utilization
- Renewable energy integration
- Lower operational cost
- Sustainable mobility solution

## XI. LIMITATIONS

Despite several advantages, the proposed system also has certain limitations:

- Limited solar energy generation capacity
  - Higher system complexity
  - Increased initial manufacturing cost
  - Dependence on environmental conditions
  - Additional weight due to multiple subsystems
  - Limited infrastructure for dynamic charging systems
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## XII. CONCLUSION

The proposed Green Drive: Self-Charging EV Technology presents an innovative approach toward sustainable electric mobility by integrating regenerative braking, solar energy harvesting, and onboard charging systems within an electric vehicle.

The experimental results demonstrate that the proposed system improves energy utilization, extends operational runtime, and reduces dependency on external charging infrastructure. The integration of renewable and regenerative energy systems contributes significantly toward improved vehicle efficiency and reduced environmental impact.

The developed prototype validates the feasibility of self-charging electric vehicle technology and highlights its potential for future transportation applications. With further improvements in battery technology, smart energy management systems, and renewable energy integration, self-charging EVs can become a practical and sustainable solution for modern transportation.

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## XIII. FUTURE SCOPE

Future developments in self-charging electric vehicle technology may include:

- Integration of solid-state batteries
- AI-based energy management systems
- Wireless dynamic charging roads
- Vehicle-to-Grid (V2G) integration
- Smart IoT-based monitoring systems
- Improved solar panel efficiency
- Advanced regenerative braking algorithms
- Autonomous self-charging mobility systems

These advancements can significantly improve the practicality, efficiency, and commercial viability of self-charging electric vehicles.

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## REFERENCES

1. K. Vignesh, P. Sakthi, A. Pugazhenthii, V. Karthikeyan, and C. Vinothkumar, "Free Energy Bicycle," International Journal of Innovative Science Engineering & Technology, vol. 2, issue 4, April 2015.
2. Prof. Kuseker S.K., Bandgar P.M., Andhale P.S., Adlinge G.H., Gaikawad V.V., and Dhekale S.P., "Design and Development of Electrical Car," International Journal of Emerging Technology and Advanced Engineering, vol. 5, issue 4, April 2015.
3. Awash Telde, "Renewable Energy Use for Continuous Electric Vehicles Battery Charging Capacity in Mobile," Innovative Systems Design and Engineering, vol. 5, issue 10, 2014.
4. Patel Vijaykumar V. and Prof. R.I. Patel, "Structural Analysis of Automotive Chassis Frame and Design Modification for Weight Reduction," International Journal of Scientific & Technology Research, vol. 1, issue 3, May 2012.
5. T. Allen Prasad and Lokesh Ramesh, "Powering the Electric Cars with Dynamos," IOSR Journal of Mechanical and Civil Engineering, vol. 3, issue 2, September 2012.
6. SM Ferdous, Walid Bin Khaled, Benzoir Ahmed, Sayedus Salehin, and Enaiyat Ghani Ovy, "Electric Vehicle with Charging Facility in Motion using Wind Energy," World Renewable Energy Congress, Sweden, 2011.
7. Dr. Kirpal Singh, Automobile Engineering, Standard Publishers.