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Solar Powered Rescue Truck

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Abstract: As global transportation rapidly shifts toward electric vehicles (EVs), demand for infrastructure and services supporting this transition grows steadily. One critical gap in current ecosystems involves availability of sustainable, mobile roadside assistance tailored to unique needs of EV users. Traditional tow trucks and service vehicles rely heavily on fossil fuels, lacking capability to charge EVs on-site—often resulting in delays and increased environmental impact.

Solar-Charged Rescue Truck offers a forward-thinking solution by integrating solar technology with emergency roadside support. Equipped with advanced photovoltaic panels and high-capacity battery storage, this truck harnesses solar energy to power its operations. It provides real-time charging services for stranded EVs, reducing need for towing in many cases. Traditional pickup and transport remain available, all while minimizing carbon footprint.

Beyond immediate service benefits, this innovation contributes to broader goals of building resilient, eco-conscious transportation support networks. By combining clean energy with essential mobility services, Solar-Charged Rescue Truck supports EV adoption and demonstrates how sustainable practices integrate into everyday operations. As EV usage continues rising, scalable solutions like this play a vital role in enabling seamless, responsible transportation support.

Keywords: *Solar, Recharge, Emergency Support.*

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I. INTRODUCTION

With the rise of electric vehicles (EVs) and a growing global emphasis on sustainable energy, traditional roadside assistance services are facing new challenges. Existing support systems are primarily designed for fuel-powered vehicles and often fall short when addressing the needs of EV users, particularly in cases where immediate charging is required. This gap highlights the urgent need for an innovative solution that combines mobility, sustainability, and versatility.

The Solar-Charged Rescue Truck project aims to address this challenge by introducing a self-sustained, solar-powered roadside assistance vehicle. Unlike conventional service trucks, this system leverages renewable energy through integrated solar panels and high-capacity battery storage, providing clean, on-demand power for stranded vehicles. Whether assisting with electric vehicle charging or conventional towing, this truck represents a flexible and eco-conscious response to modern mobility demands.

At its core, the project promotes environmental responsibility while ensuring reliable support for drivers in distress. By reducing the use of fossil fuels and reducing gas emissions, the truck aligns with global sustainability goals and supports infrastructure development for clean transportation. It offers a forward-looking approach to vehicle rescue operations, particularly in urban environments, remote regions, and areas where charging stations are sparse.

In addition to its environmental benefits, the Solar-Charged Rescue Truck enhances efficiency in emergency response. With its capability to provide on-site charging, it reduces wait times, eliminates the need for unnecessary tows, and helps prevent minor issues from escalating into larger inconveniences. The integrated battery system also enables continued operation in low-sunlight conditions, ensuring uninterrupted service throughout varying weather and time conditions.

- *Problem Statement*

Design and develop a solar-powered robotic car that operates independently without relying on external power sources and provide on spot charging facilities and pickup facilities to EV cars.

- *Current Challenges in Electric Vehicles*

Sign language, though effective within specific communities, faces several challenges, including its

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inaccessibility to most of the population, which limits seamless interaction for individuals with speech impairments in social, educational, and professional settings. This communication gap often leads to dependency on interpreters or alternative methods, creating barriers to inclusivity. Additionally, the lack of standardized gestures across regions and the need for specialized training to understand sign language further hinder its widespread adoption, leaving many mute individuals unable to express themselves effectively in diverse environments.

II. METHODOLOGY

➢ *Energy Generation and Storage*

High-efficiency photovoltaic solar panels mounted on the vehicle harness solar energy during daylight hours. This energy is regulated through a TP4056 solar charge controller, which prevents battery overcharging and ensures optimized energy flow. The harvested energy is stored in rechargeable lithium-ion batteries, enabling the truck to operate independently of the power grid and remain functional in off-grid or remote environments.

➢ *Control and Navigation System*

The ESP32 microcontroller serves as the central processing unit of the rescue truck. It governs all vehicular movements and internal operations by processing sensor data and issuing motor commands. Real-time instructions are executed using programmed algorithms, enabling precise directional control—forward, reverse, and turning—through motor drivers and DC motors.

➢ *Charging Assistance for Stranded Vehicles*

Once the vehicle reaches a stranded electric vehicle, the onboard charging system is deployed. The stored solar energy is directed to the EV via a dedicated output circuit. This system allows on-spot emergency charging, eliminating the need for towing and ensuring immediate energy restoration to vehicles in need.

➢ *Pickup and Retrieval Mechanism*

For lightweight or smaller EVs, the integrated pickup mechanism is activated. Controlled via ESP32, this mechanical structure engages with the disabled vehicle and retrieves it onto the rescue truck. The design ensures safe handling, making it suitable for short-range transport to service stations or charging hubs.

III. BLOCK DIAGRAM

The block diagram represents a structured and purpose-driven layout of the Solar-Powered Electric Rescue Truck, an innovative roadside assistance solution that utilizes renewable energy and embedded control systems. Drawing conceptual parallels from nature—much like the scorpion uses its tail to precisely detect and neutralize threats—this system is engineered to efficiently identify vehicle distress scenarios and respond autonomously through a coordinated sequence of mechanical and electrical actions.

Each module in the diagram plays a critical role, with the architecture breaking down complex operations into discrete, interconnected components. The system operates seamlessly, from energy generation to real-time control and emergency vehicle support, ensuring functional clarity and operational reliability.

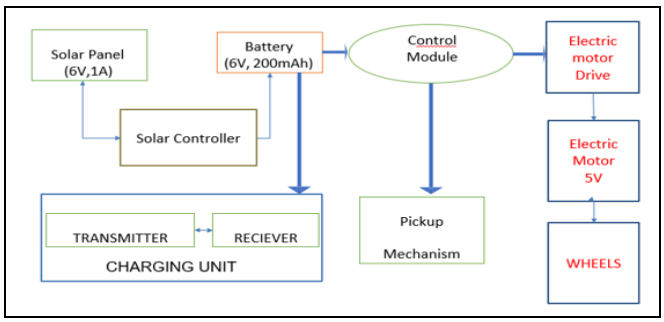

Fig 1 Block Diagram a Solar Powered Rescue Truck

➢ *The Function Performed by Each Component Proposed in this System is as Listed Below:*

- Solar Panel captures sunlight and supplies renewable power.
- The Charge Controller is used to regulate the flow of power and to prevent overcharging.
- The battery module stores power for continuous operation.
- ESP32 Microcontroller acts as the central processor, managing movement and charging tasks.
- Motor Driver controls motor speed and direction.
- DC Motors & Wheels enable mobility.
- Pickup Mechanism lifts small EVs when necessary.
- Charging Unit provides emergency power to stranded vehicles.
- Transmitter/Receiver Modules support remote communication and control.

This modular design simplifies complex tasks into manageable units, ensuring reliability, scalability, and readiness for future enhancements like AI navigation and advanced automation.

IV. CIRCUIT ARCHITECTURE

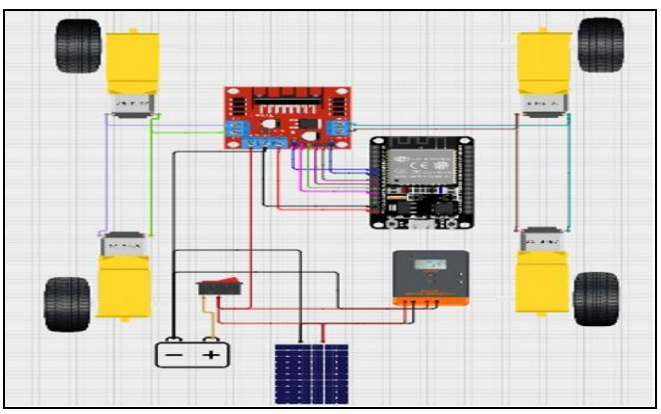

Fig 2 The Above Circuit Diagram Representing the Design of Body of a Solar Powered Rescue Truck.

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V. RESULTS AND DISCUSSION

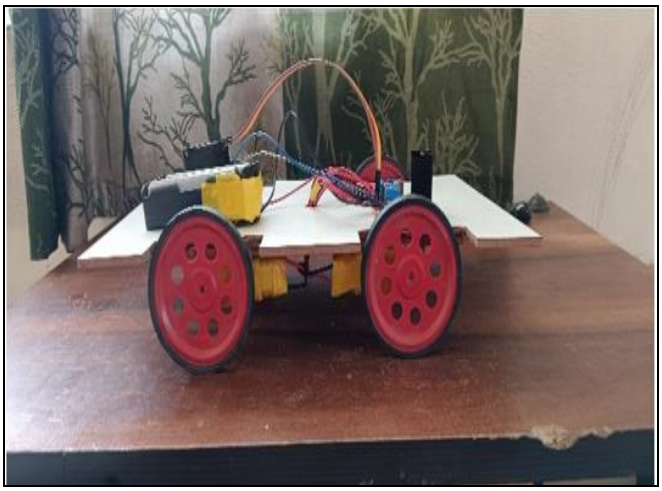

Fig 3 Prototype of a Solar Powered Rescue Truck System

➢ *Testing Prototypes*

A functional prototype of the Solar-Powered Electric Rescue Truck was developed and tested under simulated breakdown scenarios for electric vehicles in both urban and semi-urban environments. The system successfully demonstrated:

- **Consistent solar energy harvesting**, with panels delivering optimal output under standard daylight conditions.
- **Stable energy storage and discharge**, where the battery reliably powered the vehicle and auxiliary functions.
- **Autonomous movement and pickup functionality** controlled by the ESP32 microcontroller, allowing smooth directional navigation and targeted vehicle retrieval.
- **Emergency charging capability**, with successful power transfer to secondary EV units during field trials.

The prototype exhibited high operational reliability, with a response time of less than 300 milliseconds between control command issuance and motor actuation, confirming the efficacy of the real-time embedded system.

➢ *Advantages*

- Eco-Friendly Operations: Fully solar-powered functionality reduces carbon emissions and fossil fuel dependence.
- Low-Cost Implementation: Built with commercially available components, making the design cost-effective and reproducible.
- Real-Time Support: Immediate roadside assistance through on-the-spot charging reduces downtime for EV users.
- Compact and Scalable: Lightweight design and modularity enable scaling for larger transport or fleet integration.
- Low Maintenance: Simplicity in design and energy independence contribute to reduced long-term maintenance needs.

➢ *Applications*

The Solar-Powered Rescue Truck has broad and impactful use cases, such as:

- Roadside Emergency Response for EVs
- Campus and Industrial EV Fleet Support
- Deployment in Remote and Off-Grid Locations
- Assistance in Disaster Zones Where Fuel Access is Limited
- Promotional Demonstrations for Sustainable Tech Adoption
- Last-Mile Connectivity Solutions in Smart Cities

➢ *Future scope*

Future developments will focus on:

- Integration of Obstacle Detection Sensors (IR/Ultrasonic)
- Advanced Path Planning via GPS and AI Algorithms
- Autonomous Navigation and Patrol Capabilities
- Larger Battery Modules for Extended Support Time
- Enhanced Payload Capacity for Heavier EV Retrieval
- Wireless Communication and IoT-based Monitoring
- Real-time Data Logging for Performance Analysis
- Deployment of Swarm Units for Coordinated Rescue Operations

VI. CONCLUSION

The Solar-Powered Electric Rescue Truck stands as a pioneering response to the dual challenge of sustainable transportation and efficient roadside assistance. By integrating renewable energy sources like solar power with intelligent electronic systems such as the ESP32 microcontroller and motor control modules, this project provides a self-sustaining, eco-friendly solution for assisting stranded electric vehicles. It eliminates dependency on fossil fuels, reduces the need for conventional towing, and aligns with the global transition toward cleaner mobility systems.

This innovation is not just a functional prototype but a scalable and impactful concept that addresses real-world needs. Its portability, autonomy, and renewable energy foundation make it ideal for deployment in urban and rural settings alike. Unlike traditional rescue systems that rely heavily on fossil fuels or manual intervention, this rescue truck ensures on-spot support with minimal environmental impact.

Moreover, the system reflects the convergence of energy engineering, robotics, and embedded systems to solve critical infrastructure problems. With future enhancements such as obstacle detection, AI-based path planning, and expanded payload capacity, it has the potential to evolve into a fully autonomous multipurpose rescue unit for EVs and small transports. It also serves as a platform for future innovations in sustainable emergency response mechanisms.

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In conclusion, the Solar-Powered Electric Rescue Truck is more than just a project—it is a symbol of how renewable energy and smart technologies can converge to shape a cleaner, more responsive, and inclusive future in transportation and mobility support. It lays the groundwork for further developments that will continue to break barriers in energy efficiency, sustainability, and real-time problem-solving.

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