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Smart Solar Hybrid Vehicle with Integrated Monitoring System

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Abstract: *This paper presents a smart solar hybrid vehicle that uses solar energy as its primary power source to reduce environmental impact, supported by a backup charging system for continuous operation. The vehicle includes real-time environmental monitoring, accident detection with alert notifications, and an alcohol detection system to enhance safety. Additionally, it features surveillance capabilities, making it suitable for applications in transportation and environmental monitoring.*

Keywords: Solar Hybrid Vehicle, Renewable Energy, Environmental Monitoring, Accident Detection, IoT, Surveillance System, Sustainable Mobility

I. INTRODUCTION

The rapid growth of the transportation sector, along with increasing environmental concerns, has created a strong demand for sustainable and intelligent mobility solutions. Conventional vehicles that rely on fossil fuels are major contributors to air pollution, greenhouse gas emissions, and rising energy consumption. As a result, researchers have focused on developing alternative technologies such as solar-powered and hybrid electric vehicles, which utilize renewable energy sources to reduce environmental impact and improve energy efficiency [1][2]. These systems not only help in minimizing carbon emissions but also reduce dependency on non-renewable energy resources.

In addition to sustainability, modern vehicles are expected to incorporate advanced safety and monitoring features. Recent developments in smart vehicle systems have introduced real-time environmental monitoring, enabling the measurement of parameters such as temperature, humidity, and air quality to enhance passenger comfort and health [3]. Furthermore, intelligent safety mechanisms such as accident detection and alert systems have been developed to provide immediate notifications during emergencies, improving response time and reducing fatalities [4]. Alcohol detection systems have also been integrated into vehicles to prevent unsafe driving conditions and enhance road safety [5].

The proposed smart solar hybrid vehicle combines renewable energy utilization with advanced monitoring and safety features into a single integrated system. By incorporating real-time sensing, automated alert mechanisms, and surveillance capabilities, the system aims to improve overall vehicle efficiency, safety, and functionality. This approach represents a significant step toward the development of intelligent, eco-friendly transportation systems suitable for modern societal needs.

The increasing demand for sustainable transportation and advanced vehicle safety has led to the development of smart solar hybrid systems that integrate renewable energy with intelligent monitoring technologies. Conventional vehicles contribute significantly to environmental pollution and energy consumption, which has encouraged the adoption of solar and hybrid electric vehicles as eco-friendly alternatives [1][2]. In addition to sustainability, modern vehicles are being enhanced with real-time environmental monitoring systems to track parameters such as temperature, humidity, and air quality, improving passenger comfort and operational efficiency [3]. Furthermore, safety features like accident

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detection with automatic alert notifications and alcohol detection systems help reduce road accidents and ensure responsible driving [4][5]. By combining these technologies, the proposed system offers an efficient, safe, and environmentally friendly solution for next-generation transportation.

II. LITERATURE REVIEW

Ref. No.	Author	Focus Area	Key Contribution	Limitation
1	Sharma et al. (2021)	Solar Powered Electric Vehicle	Developed a vehicle powered using rooftop solar panels to reduce fuel dependency and carbon emissions.	Limited power generation during cloudy weather and low speed performance.
2	Patel & Kumar (2020)	Hybrid Electric Vehicle System	Combined battery power with renewable energy sources for improved driving range.	High battery cost and complex energy management system.
3	Singh et al. (2019)	IoT Based Smart Vehicle Monitoring	Introduced real-time monitoring of temperature, humidity, and air quality using sensors and mobile app.	Depends on internet connectivity and sensor accuracy.
4	Mehta et al. (2022)	Accident Detection and Alert System	Used accelerometer + GPS + GSM to detect accidents and send emergency alerts instantly.	False alerts may occur during sudden braking or rough roads.
5	Gupta et al. (2022)	Smart Multi-Purpose Vehicle	Combined safety, surveillance, and environmental monitoring in one platform.	Increased system complexity and maintenance cost.

III. PROBLRM STATEMENT

Despite significant advancements in automotive technology, existing vehicle systems still face major challenges in terms of sustainability, safety, and intelligent monitoring. Most conventional vehicles depend on fossil fuels, leading to increased carbon emissions, environmental pollution, and high operating costs, while even electric vehicles rely heavily on grid-based energy sources [1][2]. Additionally, current vehicles lack integrated real-time environmental monitoring systems, which limits the ability to track important parameters such as temperature, humidity, and air quality for passenger comfort and safety [3]. Another critical issue is the absence of advanced safety mechanisms, including automatic accident detection and immediate alert systems, which can delay emergency response during critical situations [4]. Furthermore, the lack of inbuilt alcohol detection systems contributes to unsafe driving practices and increased road accidents [5]. These limitations highlight the need for a smart, energy-efficient, and safety-oriented vehicle that integrates renewable energy with intelligent monitoring and automated safety features to improve overall performance and reliability.

IV. METHODOLOGY / WORKING

The proposed smart solar hybrid vehicle system is designed by integrating renewable energy technology with embedded systems and IoT-based monitoring. The methodology begins with the utilization of photovoltaic (solar) panels to capture solar energy and convert it into electrical power. This energy is stored in rechargeable batteries and managed through a hybrid power system that ensures continuous operation even during low sunlight conditions [1][2]. The power management unit regulates energy distribution to different subsystems, improving efficiency and reducing dependency on conventional energy sources.

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The core control of the system is handled by an ESP32 microcontroller, which processes data collected from various sensors installed in the vehicle. Environmental monitoring is achieved using sensors such as DHT11 for temperature and humidity and MQ2 for gas detection, enabling real-time analysis of cabin conditions [3]. These sensors continuously transmit data to the controller, which can take automatic actions or send updates through IoT connectivity. Additionally, an ESP32-CAM module is integrated to provide real-time surveillance and visual monitoring, enhancing the overall security and functionality of the vehicle.

To improve safety, the system incorporates an accident detection mechanism that identifies sudden impacts using sensor data and automatically sends alert notifications to emergency contacts, ensuring quick response during critical situations [4]. An alcohol detection module is also included to prevent the vehicle from operating under unsafe conditions, promoting responsible driving [5]. All these subsystems are interconnected through IoT technology, allowing remote monitoring, data analysis, and control via wireless communication. This integrated methodology ensures that the vehicle operates efficiently while maintaining safety, sustainability, and intelligent functionality.

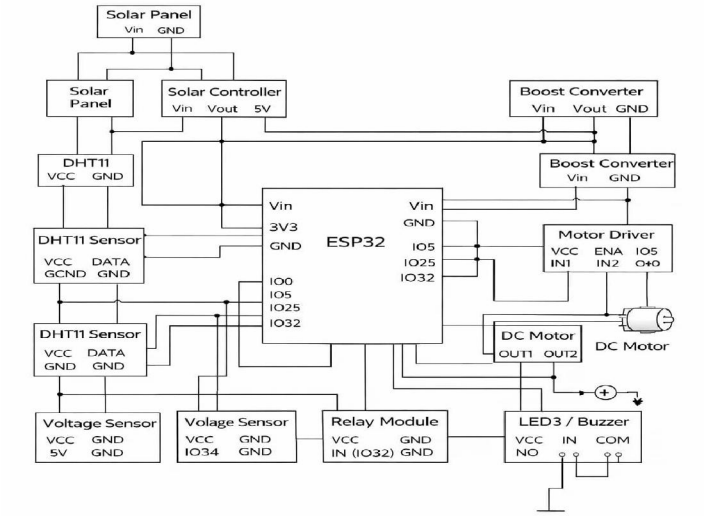

Figure 1: Block Diagram of Smart Solar Hybrid Vehicle with Integrated Monitoring System

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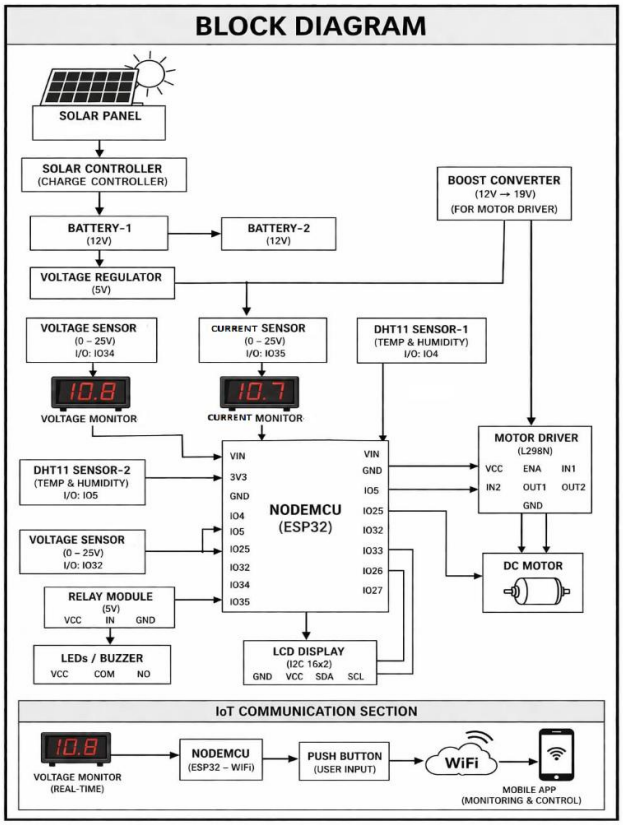

Figure 2: Circuit Diagram of **Smart Solar Hybrid Vehicle with Integrated Monitoring System**

V. CIRCUIT DIAGRAM

The circuit diagram represents a Smart Solar-Hybrid Vehicle with Integrated Monitoring System, designed to combine renewable energy, intelligent control, and real-time monitoring in a sustainable transportation system. In this setup, the solar panel generates electrical energy, which is regulated by the solar charge controller and boosted to the required level using a boost converter. The ESP32 microcontroller acts as the central control unit, receiving inputs from DHT11 sensors for temperature and humidity monitoring and voltage sensors for battery and power status measurement. Based on the sensor data, the ESP32 controls the motor driver to operate the DC motor for vehicle movement and manages the relay module for switching functions. The LED/buzzer provides visual and audible alerts for system conditions or faults. Overall, the circuit demonstrates an energy-efficient hybrid vehicle model that integrates solar charging, automated control, and smart monitoring features.

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VI. EXPERIMENTAL SETUP

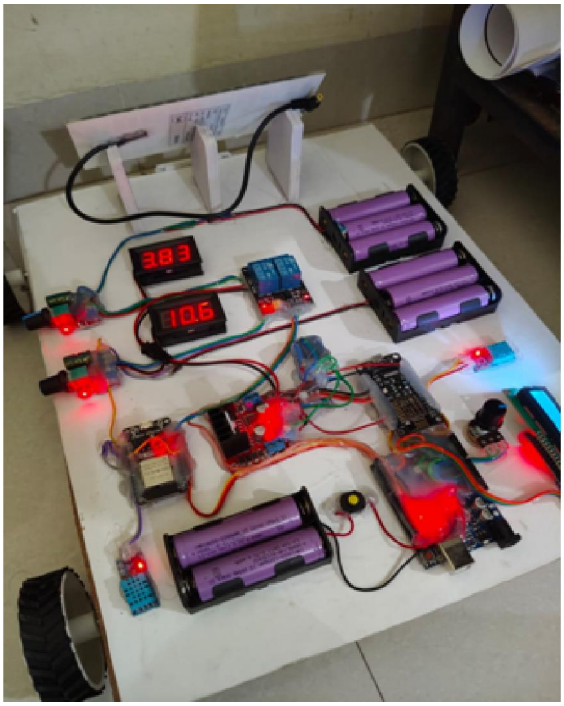

Figure 3: Experimental Setup Diagram of Smart Solar Hybrid Vehicle with Integrated Monitoring System

VII. HARDWARE TOOLS

1. SOLAR PANEL

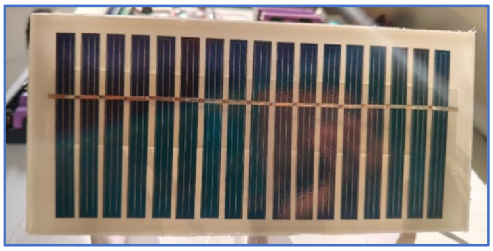

Fig. 4: Solar Panel

A solar panel generates DC power from sunlight using the photovoltaic effect. In this system, it acts as an additional energy source, charging the battery through a charge controller for safe storage. This helps ensure continuous power supply, reduces grid dependence, and enhances overall efficiency and reliability.

2. ARDUINO UNO

Fig. 5: Arduino Uno

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The Arduino Uno serves as the main controller of the system, monitoring battery voltage and making decisions based on preset thresholds. It controls the relay for automatic switching, displays system status on the LCD, and communicates with the ESP32 for remote monitoring.

3. 18650 BATTERY

Fig. 6 :18650 Battery

The 18650 lithium-ion battery is used for energy storage due to its high energy density and long lifespan. In this system, it supplies power when the grid is unavailable. Continuous monitoring ensures safe operation by preventing overcharging and deep discharge, thereby improving reliability and battery life.

4. VOLTAGE REGULATOR

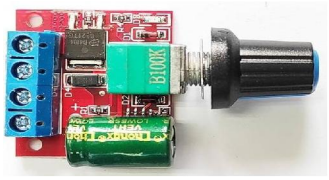

Fig. 7: Voltage Regulator

The voltage regulator ensures a constant output voltage for proper system operation. It provides stable power to components such as the Arduino, ESP32, and sensors, protecting them from voltage fluctuations and improving overall reliability and performance.

5.ESP32

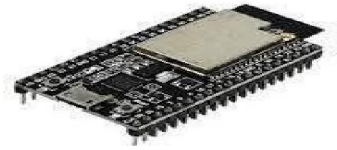

Fig. 8 : ESP32

The ESP32 is a microcontroller with built-in Wi-Fi and Bluetooth for IoT applications. In this system, it enables remote monitoring and control by sending data to a mobile application, allowing users to track system status and manage power sources in real time.

6. Digital Voltmeter Display

Fig. 9: Digital Voltmeter Display

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A digital voltmeter (DVM) is an electronic instrument used to measure electrical voltage and display the value in numeric form on a digital screen. Unlike analog voltmeters, which use a needle and scale, a digital voltmeter provides more accurate and easy-to-read results.

7. RELAY MODULE

Fig. 10 : Relay Module

The relay module acts as a switching device controlled by the microcontroller to select between different power sources. It enables automatic switching between batteries and the grid, while providing electrical isolation for safe and reliable operation.

8. DC Motor

Fig. 11:DC Motor

A DC motor (Direct Current motor) is an electrical machine that converts direct current electrical energy into mechanical energy. It works on the principle that when a current-carrying conductor is placed in a magnetic field, it experiences a force, causing rotation. This basic concept is related to the Lorentz force.

9. 16x12 LCD

Fig. 12 : 16x12 LCD

The 16×2 LCD display is used to show real-time system information. In this system, it displays temperature and humidity. It provides a simple user interface for easy monitoring and improves system usability.

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10. I2C MODULE

Fig. 13 : I2C Module

The I2C module is used for communication between the microcontroller and display using two wires (SDA and SCL). In this system, it connects the LCD with the Arduino and reduces wiring complexity. It ensures efficient communication and saves microcontroller pins.

11. CONNECTING WIRES

Fig. 14 : Connecting Wires

Connecting wires are used to establish electrical connections between system components. In this system, they ensure proper transmission of power and signals between devices. They support reliable operation and help in easy assembly and maintenance of the circuit.

VIII. ADVANTAGES

- Sustainability: Utilizes solar energy as the primary power source, reducing reliance on conventional fuels.
- Cost Efficiency: Reduces energy costs through solar power, lowering the overall cost of ownership.
- Environmental Impact: Significantly reduces carbon emissions, contributing to a cleaner environment.
- Energy Independence: The car can function independently of grid power, making it more reliable in remote areas.
- Real-Time Monitoring: Constantly tracks temperature, humidity, and air quality to ensure a safe and comfortable environment inside the car.
- Accident Detection: Provides real-time alerts in case of an accident, improving response time and safety.
- Alcohol Level Detection: Enhances driver safety by monitoring alcohol levels to prevent impaired driving.
- Safety Features: In case of an emergency, immediate notifications are sent to the owner's family, improving response time in critical situations.
- Solar Power Efficiency: Uses clean, renewable energy, helping reduce the overall carbon footprint of the vehicle.
- Dual Power Sources: Offers both solar energy and secondary charging options, ensuring continuous operation without dependency on one energy source.
- Military Application: The vehicle can be adapted for military and defense use, offering reliable transportation with integrated safety and surveillance features.
- Agricultural Use: Can be deployed in agriculture for tasks like surveillance, land monitoring, and even landmine detection, reducing human labor in dangerous areas.
- Remote Area Operation: Solar power allows the vehicle to operate in areas without access to grid electricity, ideal for off-grid locations.

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- Surveillance Capability: Equipped with a camera module, this car can be used for security and surveillance, ensuring safety in various environments.
- Robust in Harsh Conditions: Solar power makes it highly resilient in areas with limited access to traditional fuel sources, especially in harsh environments.

IX. DISADVANTAGES

- Weather Dependency: Solar energy generation can be inconsistent on cloudy or rainy days, reducing the car's efficiency.
- High Initial Cost: Solar-powered systems and advanced technology features could drive up the initial purchase price.
- Limited Power Storage: Solar panels may not generate enough energy to power the car for long trips, especially without adequate battery storage.
- Long Charging Time: Solar power alone can be slow to charge, especially if the car needs to be fully recharged.
- Limited Range: The car's range may be restricted in areas with low sunlight or poor infrastructure for secondary charging.
- Maintenance Requirements: Advanced features like sensors and cameras require regular maintenance and could result in high upkeep costs.

X. FUTURE SCOPE

- Improved Solar Efficiency: Advancements in solar panel technology could lead to higher energy conversion rates, enabling the vehicle to operate more efficiently in diverse weather conditions.
- Enhanced Energy Storage: Development of better batteries or energy storage systems could extend the car's range and reduce the reliance on secondary charging, making it more self-sufficient.
- Autonomous Driving Integration: The vehicle could be further developed with self-driving capabilities, allowing it to navigate without human intervention while maintaining its energy efficiency.
- Smart Traffic Integration: The vehicle could integrate with smart city infrastructure to optimize route planning based on real-time data like traffic, weather, and solar availability.
- AI-Driven Safety Features: Artificial intelligence could enhance accident detection, alcohol monitoring, and landmine detection, making the vehicle safer and more responsive to potential hazards.
- Global Expansion of Charging Networks: Expanding charging infrastructure tailored for solar hybrid vehicles could reduce charging times and increase adoption in different regions, including remote areas.
- Solar-Powered Fleet Integration: The car could be integrated into fleets for applications in sectors like agriculture, military, and industrial surveillance, maximizing energy use and reducing operational costs.
- Health Monitoring System: Adding features to monitor the health of passengers (e.g., heart rate, fatigue level) and integrate with emergency services could enhance safety for long trips.
- Customization for Specialized Use: The car could be adapted for specific industries, such as agriculture or military, with specialized tools and sensors for tasks like soil monitoring, crop irrigation, or security patrols.
- Global Environmental Impact: With more widespread adoption, solar hybrid cars could contribute to global efforts to reduce greenhouse gas emissions, supporting sustainable transportation initiatives worldwide.

XI. RESULT

The developed Solar Hybrid Car project successfully demonstrates the integration of renewable energy, intelligent safety systems, and smart monitoring features into a single vehicle platform. The system operates efficiently using solar energy as the primary power source with secondary charging support, ensuring continuous operation under different

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environmental conditions. Real-time monitoring of temperature, humidity, and air quality was achieved, enhancing passenger comfort and environmental awareness. The accident detection system successfully generated emergency alerts, while the alcohol detection feature improved driver safety by preventing impaired driving. The integrated camera module provided effective surveillance and security monitoring. The project also proved its potential applications in military, agriculture, and remote area operations due to its adaptability and self-sustaining power system. Overall, the prototype validates the feasibility of a cost-effective, eco-friendly, and multifunctional transportation solution for future smart mobility systems.

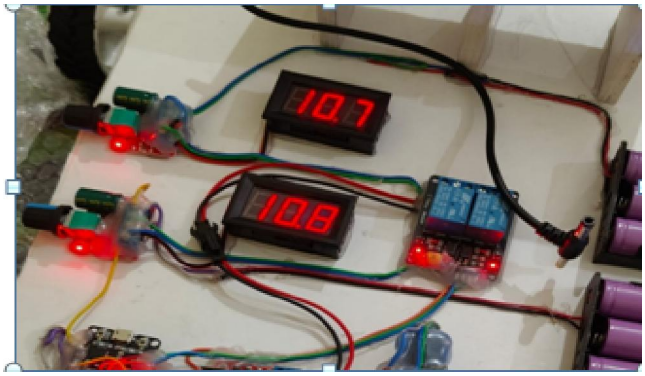

Fig. 15 Digital voltmeter showing battery voltage status

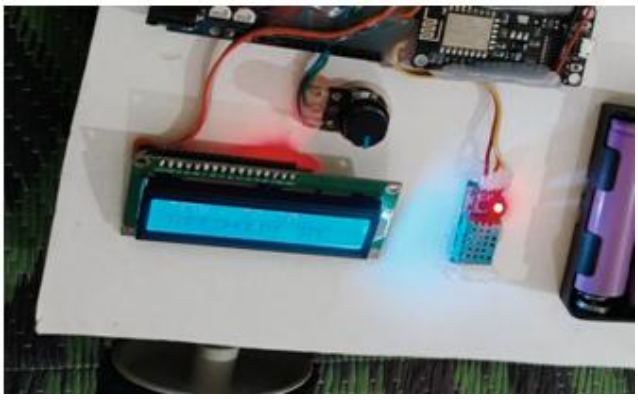

Fig.16Surrounding Temperature showing on LCD screen

Fig.17Real Time Temperature & Humidity value showing on device

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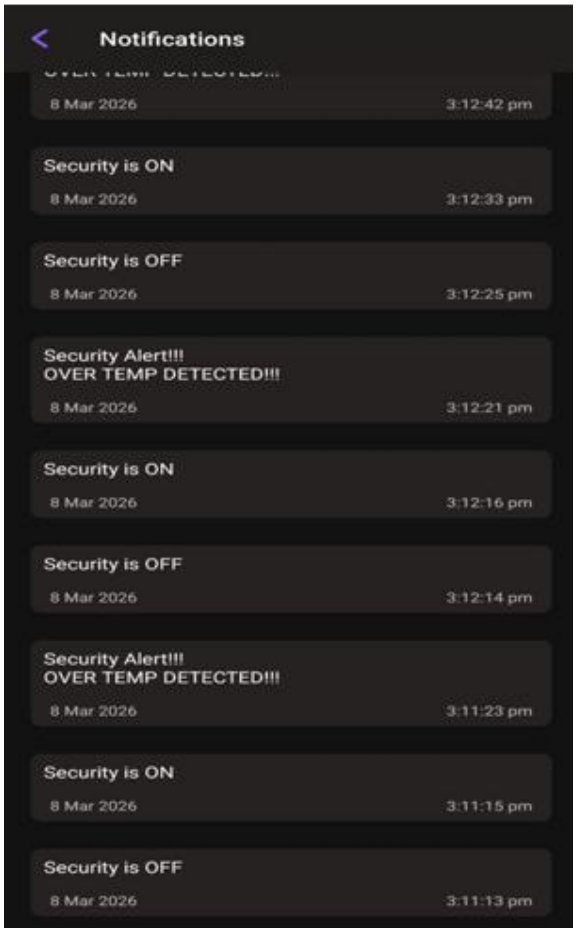

Fig.19 Real Time Notification

XII. CONCLUSION

The Solar Hybrid Car project offers a unique and sustainable solution to modern transportation challenges. By integrating advanced features such as real-time environmental monitoring, accident detection, alcohol level monitoring, and landmine detection, this vehicle provides a highly versatile and eco-friendly option for various sectors, including military, agriculture, and surveillance. With the power of solar energy, it not only reduces dependency on traditional fuel sources but also enhances safety and efficiency across different applications. This project highlights the potential for combining cutting-edge technology with sustainability to meet the growing demands of diverse industries

REFERENCES

[1]Sharma et al., "Solar Powered Electric Vehicle with Rooftop Solar Panel Integration," *International Journal of Renewable Energy and Vehicle Technology*, vol. 8, no. 2, pp. 45–52, 2021.
[2] Patel and Kumar, "Design and Performance Analysis of Hybrid Electric Vehicle System Using Renewable Energy Sources," *Journal of Sustainable Transportation Systems*, vol. 6, no. 4, pp. 112–119, 2020.
[3] Singh et al., "IoT Based Smart Vehicle Monitoring System for Environmental and Safety Parameters," *International Conference on Smart Computing and Communication Technologies*, pp. 210–215, 2019.

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[4] Mehta et al., "Accident Detection and Emergency Alert System Using GPS, GSM and Accelerometer," *International Journal of Advanced Electronics and Communication Engineering*, vol. 10, no. 1, pp. 33–39, 2022.
[5] Gupta et al., "Development of Smart Multi-Purpose Vehicle for Safety, Surveillance and Environmental Monitoring," *Journal of Intelligent Transportation and Automation*, vol. 5, no. 3, pp. 78–85, 2022.