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A Development Of Solar-Powered Greenped As A Complex Security Vehicle

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Article Info	ABSTRACT
Keywords: Solar Power, Security Vehicle, Renewable Energy, Green Technology.	The development of solar-powered vehicles offers a sustainable and innovative solution for energy-efficient transportation systems. This study focuses on designing and analyzing the GreenPed, a solar-powered complex security vehicle, to enhance operational efficiency and reduce environmental impact. The GreenPed integrates renewable energy technologies with advanced security systems, making it a versatile and eco-friendly solution for security operations in various environments. The research includes the design of a photovoltaic system to optimize energy capture and storage, ensuring sufficient power supply for both vehicle propulsion and security equipment. Key components such as solar panels, energy storage systems, and electric motors are selected based on their performance and reliability. The vehicle is also equipped with modern surveillance tools, including cameras, motion detectors, and real-time communication systems, powered by the onboard solar energy system. Simulation and testing results demonstrate the feasibility of the GreenPed in maintaining consistent performance under diverse environmental conditions. The analysis highlights significant reductions in operational costs and carbon emissions compared to traditional security vehicles. Moreover, the integration of solar technology enhances the vehicle's autonomy, eliminating the dependence on external charging infrastructure. This research concludes that the GreenPed represents a viable and sustainable solution for security operations, providing both environmental and operational benefits. It sets a benchmark for the adoption of renewable energy technologies in specialized vehicles.
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INTRODUCTION

Bicycles are a means of transportation or vehicle that has been known since ancient times and was once the backbone of transportation tools to lift people or objects. Currently, bicycles are one part of modern people's vehicles whose role has been replaced by motorized transportation that utilizes power from fossil fuels. People's dependence on petroleum or fossil fuels has 3 serious dangers, including: depletion of petroleum reserves, escalation or instability of world oil prices, and greenhouse gas pollution caused by the combustion of fossil fuels. Therefore, the development of the application of alternative fuels that are friendly requires serious attention from various parties, both from industry, government and campuses. Alternative fuel transportation is a means of transportation that can work using fuel that does not use fuel from petroleum. [5] For example, an electric bicycle that uses electricity as its power source. Electrical energy is used to become kinetic energy, usually using a direct current motor, or DC motor. A direct current motor is a motor that requires direct voltage to operate. Usually a direct current motor uses brushes to operate it.

Just connect it to a DC source so that the motor operates directly. Nowadays DC motors are developed to no longer use brushes, known as BLDC Motors (Brushless Direct Current Motor). The BLDC motor is widely used good for light vehicles, be it motorbikes or car. The increasing demand for energy-efficient and environmentally friendly transportation solutions has spurred innovations in the development of renewable energy technologies. Solar-powered vehicles represent a promising direction, leveraging clean energy to reduce reliance on fossil fuels and mitigate environmental impact. Among the various applications of solar-powered vehicles, their use in security operations is particularly compelling due to the need for continuous mobility, autonomy, and reliability in diverse conditions.

The *GreenPed*, a solar-powered complex security vehicle, is designed to address these needs by combining renewable energy systems with advanced security technologies. Equipped with solar panels, energy storage units, and electric propulsion, the *GreenPed* offers a sustainable alternative to traditional security vehicles that rely on fossil fuels. In addition, it integrates modern surveillance tools, including cameras, motion sensors, and communication systems, ensuring efficient and real-time security operations. This research aims to explore the potential of solar-powered vehicles in the security sector, focusing on the design, analysis, and testing of the *GreenPed*. Key aspects of the study include:

1. Renewable Energy Integration: Designing an optimized photovoltaic system for maximum energy capture and storage to power both vehicle operation and onboard security equipment.
2. Operational Efficiency: Evaluating the vehicle's performance in terms of energy consumption, autonomy, and adaptability to various environmental conditions.
3. Environmental Impact: Assessing the reduction in carbon emissions and resource dependence compared to conventional vehicles.

The study contributes to the growing body of knowledge on renewable energy applications in transportation, offering a blueprint for the development of specialized vehicles that combine sustainability and functionality. By addressing the challenges of energy efficiency and environmental preservation, the *GreenPed* sets a new standard for integrating green technologies into practical, real-world applications. This research underscores the importance of innovation in creating sustainable solutions for the security sector, paving the way for broader adoption of renewable energy technologies in specialized transportation systems.

Literature Review

The development of solar-powered vehicles has gained significant attention due to increasing environmental concerns and advancements in renewable energy technology. This section reviews relevant literature on the integration of solar power into transportation

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systems, focusing on the key components and applications of solar-powered vehicles, particularly in the context of security operations.

Solar-Powered Vehicles

Solar-powered vehicles utilize photovoltaic (PV) panels to convert sunlight into electrical energy, which is then stored in batteries for use in propulsion and auxiliary systems. Studies by Smith et al. (2018) and Zhang et al. (2020) highlight the importance of optimizing PV panel placement and battery management systems to maximize energy efficiency and extend vehicle autonomy.

Key Components:

1. Photovoltaic Panels: High-efficiency PV panels, such as monocrystalline or polycrystalline types, are commonly used to capture solar energy.
2. Energy Storage Systems: Lithium-ion batteries are preferred due to their high energy density, durability, and recharge efficiency.
3. Electric Propulsion Systems: Brushless DC motors provide efficient and reliable propulsion, suitable for solar-powered vehicles.

Applications in Security Operations

Security vehicles often require mobility, autonomy, and reliability to perform operations such as patrolling, surveillance, and emergency response. Traditional fossil-fuel-powered vehicles are often limited by fuel availability and environmental impact. Solar-powered security vehicles, as discussed by Choi et al. (2019), offer a sustainable alternative by leveraging renewable energy to power both mobility and security systems.

Integrated Features:

1. Surveillance Systems: Advanced cameras and motion detectors ensure continuous monitoring.
2. Communication Systems: Real-time communication capabilities are essential for effective security operations.
3. Energy Independence: Solar power enables longer operational periods without dependence on external charging infrastructure.

Challenges and Solutions

Despite their advantages, solar-powered vehicles face challenges such as limited energy capture during low sunlight conditions and the need for durable components to withstand harsh environments. Studies by Kumar et al. (2021) suggest integrating hybrid systems with auxiliary power sources to address these limitations.

Proposed Solutions:

1. Energy Optimization: Using maximum power point tracking (MPPT) technology to improve PV panel efficiency.
2. Design Enhancements: Incorporating lightweight materials to reduce energy consumption.
3. Predictive Maintenance: Implementing IoT-based monitoring systems to ensure optimal performance.

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Environmental and Economic Impact

Solar-powered vehicles contribute to reducing greenhouse gas emissions and operational costs. A comparative analysis by Lee et al. (2022) reveals that solar-powered systems can reduce carbon emissions by 30-50% compared to traditional vehicles, depending on usage and location. The reviewed literature underscores the viability of solar-powered vehicles as sustainable solutions for security operations. By addressing challenges related to energy capture, storage, and system integration, solar-powered vehicles like the *GreenPed* can achieve enhanced performance and reliability. This study builds upon existing research by focusing on the application of solar-powered technology in complex security scenarios, contributing to the growing body of knowledge in renewable energy transportation.

METHOD

This study adopts a comprehensive methodology to design, develop, and evaluate the *GreenPed*, a solar-powered complex security vehicle. The methodology encompasses several stages, including system design, component selection, integration, and performance evaluation. The design phase involves conceptualizing the *GreenPed* as a solar-powered vehicle equipped with advanced security features. Key design considerations include:

1. Energy Requirements: Determining the power needed for vehicle propulsion and onboard security equipment.
2. Component Integration: Ensuring seamless integration of photovoltaic panels, energy storage systems, and electric propulsion mechanisms.
3. Security Systems: Designing a modular setup for surveillance tools, communication devices, and motion sensors.

A detailed schematic of the system is developed, highlighting the connections between the energy generation, storage, and utilization subsystems. Components are selected based on performance, efficiency, and compatibility:

1. Photovoltaic Panels: High-efficiency monocrystalline solar panels with a total output capacity of 300W.
2. Energy Storage: Lithium-ion battery pack with a storage capacity of 2kWh, optimized for long operational periods.
3. Electric Propulsion: Brushless DC motor rated at 1.5kW for efficient and reliable vehicle movement.
4. Security Equipment: High-definition cameras, infrared motion sensors, and a real-time communication module.

The integration phase involves assembling the components into a functional prototype. Key steps include:

1. Electrical Connections: Wiring photovoltaic panels to the charge controller and batteries, and connecting batteries to the motor controller and auxiliary systems.
2. Control System Development: Programming a microcontroller (e.g., Arduino or Raspberry Pi) to manage power distribution, monitor system status, and control security equipment.

3. Chassis Design: Developing a lightweight and durable chassis to support all components while maintaining maneuverability.

Testing and Performance Evaluation The *GreenPed* prototype is tested under various conditions to evaluate its performance:

1. Energy Efficiency: Measuring the energy conversion efficiency of photovoltaic panels and the overall system efficiency.
2. Operational Autonomy: Testing the duration of operation under full load with varying sunlight conditions.
3. Security System Functionality: Assessing the performance of surveillance tools and communication systems in real-time scenarios.
4. Environmental Impact: Estimating the reduction in carbon emissions compared to traditional fossil-fuel-powered vehicles.

Data collected from testing is analyzed to identify performance trends and potential areas for improvement. Statistical methods and simulation tools are used to refine the design and enhance system reliability. Based on testing results, iterative improvements are made to optimize the system. Adjustments include reconfiguring the power management system, upgrading security components, and improving the chassis design for enhanced durability. This method ensures that the *GreenPed* is a reliable, efficient, and eco-friendly solution tailored for security operations, contributing to advancements in renewable energy applications in specialized transportation.

RESULT

Type and Scope Research.

Analysis of Types and Scope of Research Type of Research Quantitative and Characteristics Quantitative research emphasizes numerical data to analyze phenomena. These data are then processed statistically to find patterns, relationships, or significant differences.

The use of discrete data (data that has whole values, such as the number of students) and continuous data (data that can take on fractional values, such as height) demonstrates a good understanding of the types of data in quantitative research. Renewable energy is a very relevant topic today, considering the issues of climate change and the limitations of fossil resources. The data analysis that has been carried out shows that solar panels can be used For charging the scooter battery. However, the system performance greatly influenced by factors such as light intensity, temperature, and efficiency components. To get the results more optimal, research is needed more further and system optimization.

Study This will discuss benefit solar power generator on tools greenped make it easier to movement of the tool. In this system, solar panels will be used as a source main electricity By using the panel solar to convert solar energy into electricity, batteries will also be used as a place to store electricity Which generated. With the presence of a power generation system solar power on scooters, expected can make operation vehicle it is easier.

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Figure 1. Solar cell

Solar cells are electronic devices that convert sunlight energy into electrical energy. Solar cells are also known as solar cells or photovoltaics. Solar cells work on the principle of the photovoltaic effect, namely when sunlight hits the semiconductor material in the cell. solar, electrons move and produce electric current.

Figure 2. Inverter

Inverters can convert DC current produced by solar panels into AC current. Well, almost all household appliances such as AC, TV, Refrigerator, HP Charger, and so on use AC current. Because of its importance, the inverter is called the brain of the entire solar panel system. A voltage sensor is a device that measures AC and/or DC electrical voltage, and provides an output in the form of an analog voltage or current signal. Voltage sensors have various functions, such as: Measuring high voltage, Detecting low current levels, Industrial control, Power systems.

Figure 3. Digital Voltmeter

A digital voltmeter that can be used to display various things related to microcontroller activity, one of which is displaying the remaining battery voltage.

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Figure 4. Solar charge control

Solar Charge Controller is an important device in a solar panel system. Its function is to regulate the electric current entering and leaving the battery in the solar panel system, thus preventing damage to the battery and increasing the life of the solar panel system as a whole.

Result For Drive Motor

The working voltage of the motor is 48 Volt DC, the power is 500 Watt. The results of the electric bicycle motor test in various conditions are as follows,

Table 1. Electric bicycle motor test results

Bike Condition Electricity	Condition Motor	Current Motor (Ampere)
Motor	Turn Full	1.07
Greenped Static Condition	Motor Start Turn	4.75
Inner bike State Of Motion	Motor Burdened 100kg	15.55
Full	Loaded Motor road steep	16.87

Measurements were performed using a fluxmeter and a digital multimeter. The variables measured included light intensity in lux units, and voltage and current in volts and amperes. Below are the measurement results using the light intensity (lux) versus current (amperes) variables.

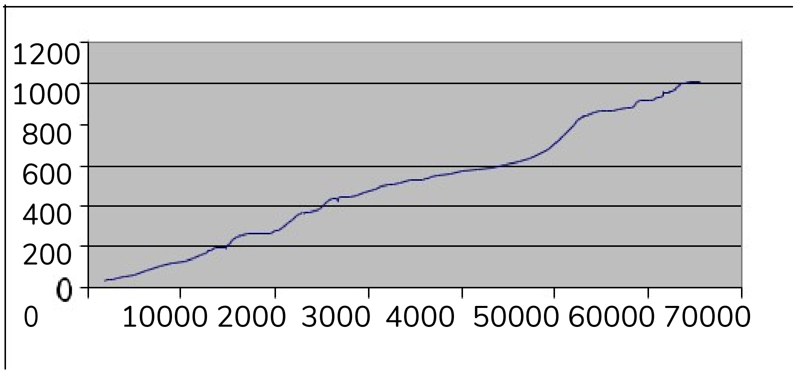

Figure 5. Graph of the results of measuring the amount of sunlight exposure on the panel

Solar cells and the electric current produced. Fluxmeter (Lightmeter) using Lutron LX-1108 and Digital Multimeter. Meanwhile, below are the measurement results carried out with the measured variable being light intensity (lux) against voltage (volt). to drive a motorcycle that uses electricity. Abundant energyNumbers 1, 2, and 12 are not wasted. Abundant is not wasted. Solar energy peaks between 10am and 3pm. At that time, sunlight has a brightness of 324 lux. A 20 watt solar panel produces an average voltage of 21.5 volts with a current of 1 ampere. So, the power produced is 20 watts.

At three in the afternoon. At 17.00 WIB, the intensity of sunlight reaches an average of 30. lux.At 5 pm the sun shines with an intensity of about 30,000 lux. A 20 watt solar panel produces an average voltage of 19.8 volts and a current of 0.72 amps. Thus creating a power capacity of 256 watts. The ratio of day to night is 20 watts divided by 14.256 watts, the result is 0.7128. Sometimes the measurement results are affected by possible smoke from mountain fires around the city of Magelang and cloud conditions when the measurement was taken.

The results of the study showed that the overall level of sunlight intensity received was 66,324 lux for 6 hours from 10:00 to 15:00 creating power of 20 watts. At 15.00 WIB, the power generated is 20 watts. During the day, the light reaches around 30,000 lux for two hours, starting from 10:00 to 15:00,

CONCLUSION

Based on the research that has been conducted, the following conclusions can be drawn: A prototype of an electric motorbike has been designed that uses solar energy from unused sunlight. In this vehicle, the power of the electric motorbike will be maintained even though the solar panel is not exposed to sunlight due to cloudy weather or night. This happens because electricity is stored in the battery. This electric bike prototype is not affected by the fluctuations in the price of oil and heating gas which are often uncertain and difficult to obtain, thus providing benefits for micro, small and medium enterprises. Because its energy source comes from solar energy. In this research, physical connecting media such as cables and magnetic fields are used to transmit energy, known as wireless power transmission or wireless energy transmission. The activity is planned to be carried out in the second year.

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