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RESEARCH PAPER

Solar grass cutter: design to fabrication

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Abstract

The present paper focuses on the design, modeling, and fabrication of a solar-powered grass cutter aimed at achieving uniform grass cutting with minimal physical effort. The system integrates essential components efficiently, resulting in a compact and eco-friendly solution for lawn maintenance. Unlike conventional manual or electrically powered grass cutters, this model operates entirely on solar energy, eliminating the need for grid electricity and significantly reducing both noise and air pollution. The solar grass cutter is particularly beneficial for users who rely on manual tools, offering a user-friendly alternative that conserves time and energy. By harnessing renewable energy, the device also contributes to environmental sustainability and promotes green technology in everyday applications. The fabrication process emphasizes cost-effectiveness and ease of use, making it suitable for domestic as well as small-scale commercial applications. Overall, the developed model not only improves operational efficiency but also supports cleaner and quieter operation compared to traditional systems.

1. Introduction

The grass cutter is a mechanical device used for trimming grass evenly across a range of locations such as cricket fields, institutional premises, public parks, and residential lawns. Grass cutting is essential not only for aesthetic purposes but also for maintaining safety, particularly in agricultural areas where overgrown vegetation can attract pests or obstruct movement. Traditionally, grass was cut manually, a method that demanded significant labor and time, making it inefficient and costly. To address these challenges, the first lawn mower was invented by Edwin Beard Budding in 1830, marking a significant milestone in lawn maintenance technology. Since then, the evolution of lawn mowers has led to the development of various types powered by gasoline, petrol, and even steam. While these machines improved operational efficiency, they introduced new problems such as excessive noise, vibration, air pollution, and reliance on fossil fuels. In response to these drawbacks, recent studies and innovations have focused on alternative, environmentally friendly solutions. Venkatesh et al. [1] fabricated a lawn mower and evaluated its performance using CATIA software for analysis. Their work emphasized the need for technical validation in the design stage to enhance functionality. Vanishree et al. [2] presented the design and analysis of a manual grass cutter, studying its various components to optimize cutter performance. Their work focused on mechanical robustness and ergonomic use. Ulhe et al. [3] introduced a modified solar grass cutter with the added benefit of remote operation, allowing even unskilled users to operate the machine effectively. Their model aimed at ease of use while ensuring uniform grass trimming. Similarly, Sujendran and Vanitha [4] developed a hybrid grass trimmer using sensors and designed it to function both on battery and solar energy. This dual-mode operation improved flexibility and operational hours. Amrutesh et al. [5] employed a Scotch yoke mechanism in the design of an electric grass cutter. Their results showed a significant reduction in power consumption compared to traditional mechanisms. Mia et al. [6] focused on developing a user-friendly solar-powered grass

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cutter to reduce the dependency on conventional electricity and decrease the overall load on the power grid. Jain et al. [7] advanced this concept further by incorporating Arduino-based controls into a wireless solar grass cutter, enhancing automation and precision. The integration of microcontroller-based systems has enabled more intelligent and efficient operations. Despite the progress in the field, most of the earlier solutions still relied partially on fossil fuels or manual input. Many conventional grass cutting machines are internal combustion (IC) engine-based, which contributes to environmental degradation through carbon emissions and high operational costs. Additionally, these systems are generally labor-intensive and not economically viable for small-scale users. To overcome these limitations, this paper presents a solar-powered grass cutter design. The proposed model aims to minimize human effort, reduce environmental impact, and ensure consistent performance. Key design factors such as energy efficiency, ease of operation, and low maintenance have been considered, as illustrated in Figure 1. The solar grass cutter harnesses renewable energy, making it both cost-effective and sustainable for long-term use. With solar energy becoming more accessible, such innovations can revolutionize lawn maintenance, especially in rural and remote areas where electricity access is limited.

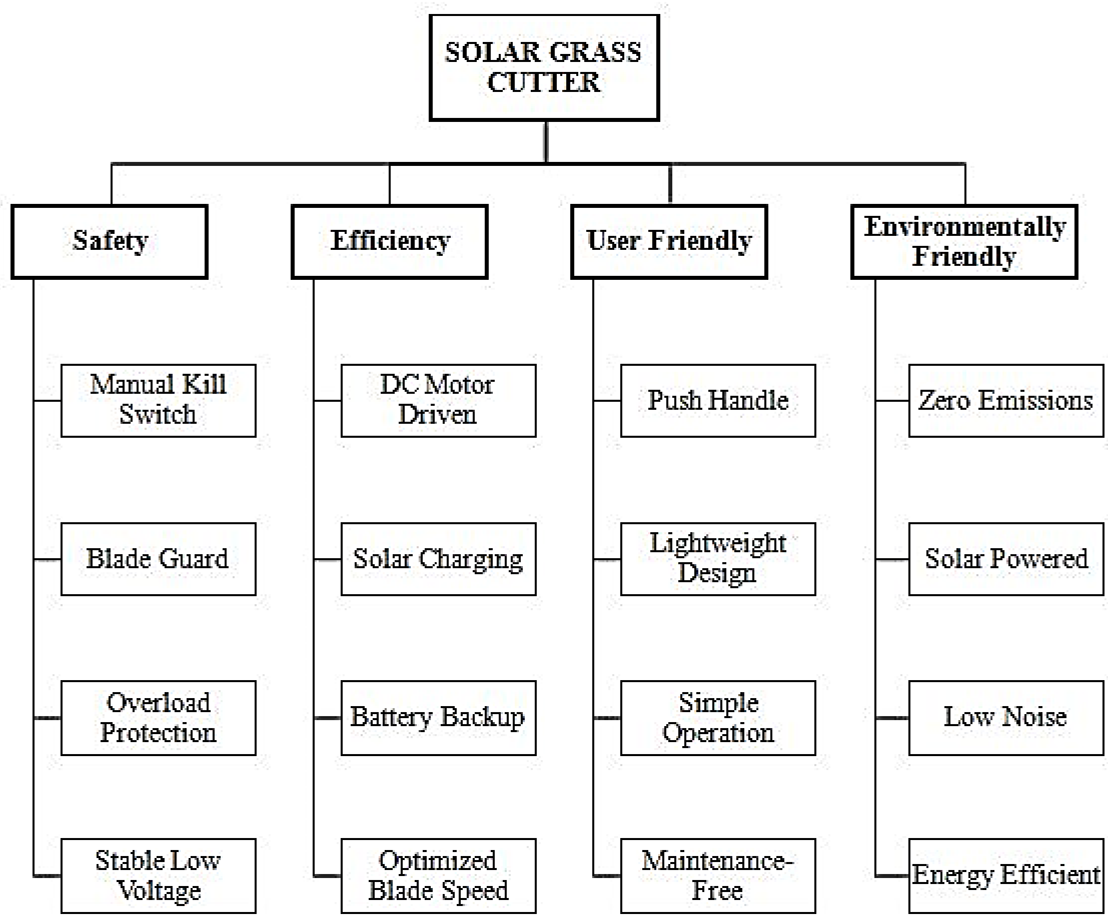

Figure 1. Research Analysis Chart.

2. Methodology

The present work focuses on the design and development of a solar-powered grass cutter with the primary objective of reducing the electricity load on the power grid. By utilizing solar energy, this system offers an eco-friendly and cost-effective alternative to conventional grass cutting machines that typically rely on fossil fuels or electric power. The project integrates a combination of mechanical, electrical, and electronic components, all carefully assembled to ensure efficient performance and reliable operation. A systematic approach has been followed in the development process, starting from conceptual design, component selection, mechanical layout, and electrical integration, to testing and performance evaluation. This structured methodology is illustrated in Figure 2, which outlines each phase of the project, ensuring clarity and precision in execution. The mechanical components include the cutting blades, frame structure, wheels, and drive mechanism, while the electrical and electronic sections comprise the solar panel, battery, DC motor, control circuitry, and switches. These components are detailed in Table 1, highlighting their specifications and roles within the system. The overall system is designed for ease of operation, low maintenance, and minimal environmental impact, making it suitable for residential, institutional, and agricultural lawn maintenance. This solar grass cutter represents a sustainable solution aligned with modern green energy initiatives. Table 1 outlines the essential components used in the design of the solar-powered grass cutter, each chosen for its specific function to ensure efficient operation. The system utilizes a 150 W solar panel to harness solar energy, which is then regulated by a 10 A, 300 W solar charge controller to prevent overcharging or deep discharge of the battery. The 80 Ah, 12 V battery stores the energy and delivers power to the motor and other components, offering sufficient capacity for extended use. To convert stored DC power into AC when required, a 600 W inverter is integrated into the system. Additionally, a 12 V, 8 A battery charger is provided for direct charging from the grid during cloudy days or low sunlight conditions. Proper electrical connectivity is ensured using standard gauge wires suitable for the expected load. The cutting mechanism features a rotary stainless-steel blade known for durability and effective performance. The structural framework consists of a PVC chassis with a metal base and a handle for user control. Mobility is achieved using two fixed and two caster wheels for smooth and flexible movement. Bearings are incorporated to support both the wheels and the blade shaft, reducing friction. A standard 12V DC battery connector ensures safe and secure connections.

Table 1. Components used in Solar Grass cutter.

S.N.	Component	Specification
1	Solar Panel	150 W
2	Solar Charge Controller	10 A, 300 W
3	Inverter	600 W
4	Battery	80 Ah, 12 V, C-rate: 8
5	Battery Charger	12 V, 8 A
6	Wire	Standard gauge for load
7	Blade	Stainless steel, rotary
8	Chassis with Handle	PVC frame with metal base
9	Wheels	2 fixed + 2 caster wheels
10	Bearings	For wheel and blade support
11	Battery Connector	Standard 12V DC connector

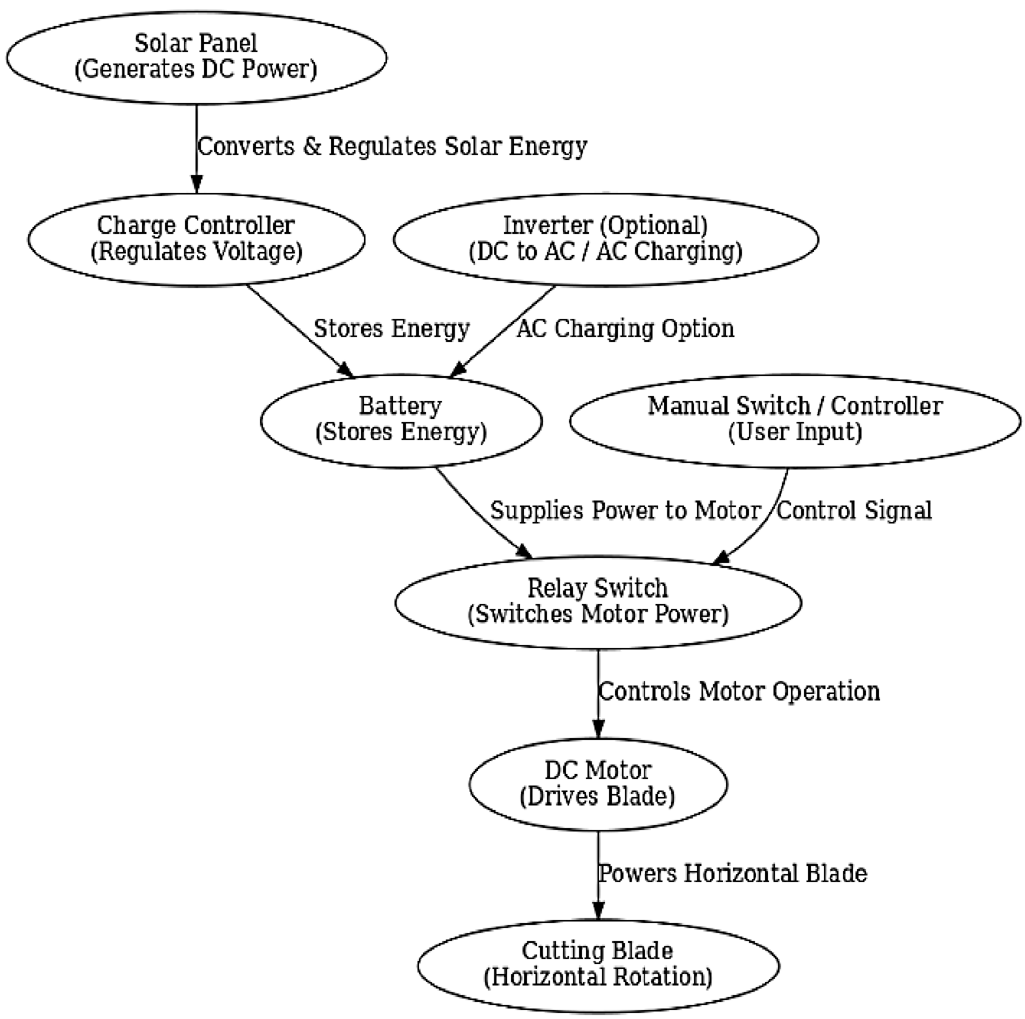

Figure 2. Flow chart of methodology adopted.

Fig. 2 illustrates the functional block diagram of the solar-powered grass cutter, showcasing the energy flow and control mechanism. The system begins with a solar panel, which captures sunlight and converts it into DC electrical power. This power is then passed through a charge controller that regulates the voltage to ensure safe and efficient charging of the battery. An optional inverter is included in the setup to convert DC to AC power, allowing alternative grid-based charging when solar energy is insufficient. The battery acts as the primary energy storage unit, supplying power to the motor when required. A manual switch or controller, operated by the user, sends control signals to a relay switch that governs the power delivery to the motor. The relay switch plays a crucial role in toggling the motor operation based on user input. Once the relay switch activates the circuit, power is directed to the DC motor, which drives the cutting blade. The motor converts electrical energy into mechanical rotation, causing the blade to spin horizontally. This rotary cutting blade trims the grass evenly and efficiently. Overall, the diagram highlights a closed-loop system integrating solar energy harvesting, electrical regulation, user control, and mechanical operation to power an eco-friendly grass cutting machine.

3. Working Principle and System Overview

The proposed solar grass cutter system integrates both mechanical and electrical components to deliver an efficient, eco-friendly grass cutting solution for lawn maintenance, particularly suited for large open fields such as cricket grounds. The system is powered by a 150W solar photovoltaic panel that captures sunlight and converts it into electrical energy. This energy is then regulated by a solar charge controller and stored in a rechargeable 12V battery. A relay switch acts as an intermediary control mechanism between the battery and the DC motor, enabling safe operation and power modulation. The cutting mechanism involves a rotary blade mounted on the shaft of the DC motor. Once the motor is powered through the battery via the relay, it generates the necessary torque to rotate the blade at high speeds, in a horizontal plane, effectively slicing through grass with a shearing action. This configuration is particularly advantageous for achieving a uniform cut across flat surfaces, such as cricket fields, as the horizontal motion allows for broad coverage in each pass. A well-balanced and sharpened blade reduces the amount of force needed, thereby enhancing energy efficiency and ensuring smoother operation. The model can be viewed in two primary segments: the control section and the design (mechanical) section. The control section comprises the solar panel, charging circuit, battery, relay switch, and wiring, all of which ensure that energy is harvested and utilized efficiently. The design section includes the wheels, motor, horizontally oriented blade and supporting frame. The structural framework consists of a chassis supported by four wheels, with front caster wheels enabling easy mobility and rear wheels providing stability. The developed model is shown in Fig. 3. Fig. 3 shows the fabricated prototype of the solar-powered grass cutter, designed to function efficiently using renewable solar energy. The setup prominently features a solar panel mounted on the top frame, which harnesses sunlight and converts it into electrical energy for powering the system. The supporting structure is built using PVC pipes, providing a lightweight yet sturdy chassis that houses all essential components in a compact arrangement. Beneath the solar panel, a battery unit is securely installed to store the converted solar energy. This stored energy is later used to drive the motor and cutting blade. Visible electrical wiring connects the solar charge controller, battery, and manual switches, indicating an integrated control circuit to regulate voltage and manage power flow within the system. The presence of manual switches on the front panel allows the user to control the motor operation conveniently. The prototype includes two fixed rear wheels and two front caster wheels, ensuring smooth maneuverability across various terrains. The overall design reflects simplicity, portability, and functional integration, making it suitable for small to medium-scale grass cutting tasks. This real-time implementation validates the proposed system's viability in utilizing clean solar energy for efficient, eco-friendly lawn maintenance.

Figure 3: Solar Grass Cutter.

The performance evaluation of the solar-powered grass cutter system involves systematic calculations to verify the efficiency, energy usage, and mechanical compatibility of its components. The system is primarily powered by a 12-volt, 80-ampere-hour (Ah) battery, which serves as the energy storage unit. To begin with, the total energy storage of the battery is determined by multiplying the voltage (V) with the capacity (Ah), yielding:

Battery Energy Capacity

Battery Voltage = 12 V
Battery Capacity = 80 Ah
Battery Energy (Wh) = V×C = 12 V × 80 Ah = 960 Wh

This indicates the system has a total energy storage of 960 watt-hours, which is a measure of the total energy available for motor operation.

To estimate how long the grass cutter can operate on a fully charged battery, we consider the power requirement of the motor driving the cutting blade. Assuming the blade motor consumes 150 watts, the expected runtime is calculated as:

Motor Runtime

Blade Motor Power P=150 W
Runtime (hours) = Battery Energy (Wh)/Motor Power (W) = 960/150 = 6.4 hours

This result shows that the system can operate continuously for approximately 6.4 hours under ideal conditions, which is sufficient for medium-scale lawn mowing tasks.

Next, we assess the torque produced by the motor, which is essential for determining whether the motor can handle the mechanical load of rotating the blade. The torque TTT is derived from the power-torque-speed relationship:

Torque on Blade Motor

$P = 2\pi NT/60 \Rightarrow T = P \times 60 / 2\pi N$
where, P = 150
N = 3000 RPM
$T = 150 \times 60 / 2\pi \times 3000 = 9000/18849.56 = 0.477$ Nm

This torque value of 0.477 newton-meters (Nm) is adequate for rotating lightweight stainless-steel blades used in domestic and institutional grass cutters.

To analyze the cutting efficiency, we also calculate the tip speed of the blade, which influences cutting performance.

Tip Speed of Blade

$\Omega = 2\pi N/60 = 2\pi \times 3000/60 = 314.16$ rad/s
blade radius r=0.11 m
$V = \omega \times r = 314.16 \times 0.11 = 34.56$ m/s

This high-speed rotation ensures a clean and uniform grass cut. Additionally, to account for motor efficiency, the actual input power required is calculated considering an efficiency of 85%:

Input Power Accounting for Efficiency
Motor Efficiency η = 85% = 0.85
Input Power = P/η = 150/0.85=176.47 W

This means that while the motor delivers 150 W of usable mechanical power, it draws about 176.47 W from the battery. Finally, the total energy consumed over the operational period remains:

Energy Used (Wh) = P × Runtime = 150 × 6.4 = 960 Wh

These calculations confirm that the solar-powered grass cutter is energy-efficient, has sufficient runtime, and possesses the mechanical strength to perform the intended lawn maintenance tasks, all while relying on clean, renewable energy.

Table 2. Calculated Parameters

Parameter	Value	Description
Motor Runtime	6.4 hours	Operating time on a full 12V, 80Ah battery using a 150W motor
Blade Motor Torque	0.48 Nm	Sufficient to rotate the blade for grass cutting (rotary motion)
Blade Tip Speed	34.56 m/s	High enough for clean, effective cutting (typical: 30–50 m/s)
Input Power Required	176.47 W	Total power needed, accounting for 85% motor efficiency
Total Energy Used per Cycle	960 Wh	Energy consumed during full battery usage
System Efficiency	85%	Assumed motor and transmission efficiency

Table 3 summarizes the key performance parameters of the solar-powered grass cutter system, offering insights into its energy efficiency, mechanical effectiveness, and operational feasibility. The motor runtime is calculated to be 6.4 hours, which reflects the total continuous operation time achievable using a fully charged 12V, 80Ah battery when powering a 150W DC motor. This is adequate for most small to medium lawn mowing tasks without the need for frequent recharging.

The blade motor torque is measured at 0.48 Nm, indicating the rotational force available to drive the cutting blade. This value is sufficient to handle typical grass cutting loads and ensures consistent rotary motion of the blade during operation. The blade tip speed is calculated as 34.56 meters per second (m/s). This falls within the generally accepted optimal range of 30–50 m/s for effective grass cutting. Such a speed ensures that the blade can shear grass cleanly without pulling or damaging the lawn, resulting in a well-maintained and aesthetically pleasing cut. The input power required is estimated at 176.47 watts, which accounts for the motor efficiency of 85%. This means that although the motor delivers 150 W of mechanical power, it consumes slightly more electrical energy due to losses in the motor and transmission system.

The total energy used per cycle is 960 watt-hours (Wh), equivalent to the full energy capacity of the battery. This value confirms the energy demand for one full operation cycle of the cutter. Lastly, the system efficiency is assumed to be 85%, representing the combined efficiency of the motor and drive system. This figure is important for evaluating overall performance and ensuring that the power conversion from the battery to blade rotation remains within acceptable efficiency limits.

4. Interpretation of Results

The performance metrics of the solar-powered grass cutter highlight its suitability for extended and efficient outdoor use, especially in large open fields such as cricket grounds or institutional lawns. The blade tip speed, calculated at 34.56 meters per second, falls well within the optimal operational range of 30 to 50 m/s. This speed ensures clean and effective grass cutting without tearing or damaging the turf, which is essential for maintaining a healthy and visually uniform lawn surface. The torque output of the motor is measured at 0.48 Newton-meters (Nm). This value is particularly appropriate for a lightweight, horizontally-mounted rotary blade. It provides enough rotational force to overcome the resistance posed by typical grass density, ensuring a smooth and uninterrupted cutting action. Such torque levels promote stable performance even when the blade encounters uneven patches or denser growth. A notable strength of the system is its runtime of 6.4 hours on a single full battery charge. This extended operational time is especially beneficial for large-scale applications such as cricket fields or parks, where long durations of uninterrupted grass cutting are required. The user can perform daily maintenance or scheduled trimming operations without the need for frequent recharging or mid-task interruptions. The system's input power requirement, estimated at 176 watts, remains within practical limits for energy sourcing. This demand is manageable by a 150-watt solar panel, especially under full sunlight conditions over an average 8-hour day. During peak sun hours, the solar panel can recharge the 12V, 80Ah battery completely, replenishing the energy used during the previous operation cycle. An important advantage of this setup is its sustainable, self-contained energy model. Since the system can be fully recharged using solar energy alone each day, it eliminates the need for external electrical sources or fuel, significantly reducing operational costs and environmental impact. This makes the grass cutter an ideal solution for eco-conscious applications, supporting green energy adoption while maintaining functionality and efficiency.

5. Conclusion

The solar-powered grass cutter designed and evaluated in this study demonstrates a practical, efficient, and environmentally friendly solution for lawn maintenance, particularly in large open spaces such as cricket fields, institutional grounds, and public parks. By integrating solar energy with mechanical and electrical systems, the cutter eliminates dependence on fossil fuels and reduces noise and air pollution typically associated with conventional internal combustion engine-based mowers.

Key performance metrics—including a blade tip speed of 34.56 m/s, a torque output of 0.48 Nm, and a runtime of 6.4 hours—show that the system operates within optimal parameters for effective and consistent grass cutting. The power input of 176 W, matched with a 150 W solar panel and an 80 Ah battery, ensures that the system can be fully recharged within a single sunny day, enabling daily, self-sustaining operation without reliance on the electric grid.

Overall, this solar grass cutter offers a promising alternative to traditional mowers, combining low operational costs, reduced maintenance, and zero emissions. It is especially suitable for applications where power access is limited or where sustainability is a priority. Future improvements could include automation, enhanced battery storage, or IoT-based monitoring to further boost efficiency and user convenience.

6. Future scope

While the current solar-powered grass cutter presents an efficient and eco-friendly alternative to conventional systems, there remains considerable potential for further development and optimization. Future research can focus on several key areas to enhance the performance, automation, and usability of the system:

- Incorporating sensors, GPS, and artificial intelligence (AI) can transform the grass cutter into an autonomous system. Future models can be designed to detect grass height, avoid obstacles, and navigate specific paths without human intervention, improving safety and operational efficiency.
- Research can be directed toward integrating advanced battery technologies such as lithium-ion or solid-state batteries, which offer higher energy density, faster charging, and longer life cycles compared to traditional lead-acid batteries. This would increase the runtime and reduce weight.
- The use of high-efficiency solar panels (e.g., monocrystalline or bifacial panels) and solar tracking systems can be explored to maximize solar energy capture throughout the day, especially in regions with variable sunlight.
- Future designs can incorporate lightweight composite materials or biodegradable components to reduce overall weight, enhance portability, and improve environmental sustainability.
- Developing modular attachments for different lawn maintenance tasks—such as trimming, fertilizing, or soil aeration—can broaden the functionality of the machine and reduce equipment redundancy.
- Adding wireless communication (e.g., Bluetooth, Wi-Fi) and IoT integration can allow users to monitor battery status, runtime, location, and maintenance alerts remotely via smartphones or cloud-based platforms.
- Extensive field testing under various terrain types, weather conditions, and grass densities can help optimize blade design, wheel traction, and energy management for real-world reliability and versatility.
- Future studies can explore low-cost component alternatives and scalable manufacturing processes to make the system more accessible for large-scale deployment, particularly in rural or developing regions.

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