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DESIGN AND DEVELOPMENT OF COST-EFFECTIVE SOLAR POWERED ELECTRIC BIKE.

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ABSTRACT:

The design and development of a Solar Powered Electric Bike that uses solar energy along with battery power to drive the vehicle. Solar energy is a renewable, clean, and freely available energy source. By integrating a solar panel with an electric bike, the dependency on conventional charging methods can be reduced. The solar panel helps in charging the battery either partially or fully, depending on sunlight availability, thereby increasing the overall efficiency and sustainability of the vehicle.

The proposed system mainly consists of a solar panel, rechargeable battery, PMDC motor, motor controller, throttle control, mechanical frame, wheels, and electrical wiring. The solar panel converts sunlight into electrical energy, which is used to charge the battery. The battery stores this energy and supplies power to the PMDC motor through the motor controller. The controller regulates the speed and torque of the motor based on the throttle input provided by the rider. A Permanent Magnet DC (PMDC) motor is used in this project due to its simple construction, high efficiency, good torque characteristics, and ease of speed control. PMDC motors are well suited for electric bike applications because they provide high starting torque and smooth operation at low speeds. The speed of the motor can be easily controlled by varying the voltage using the controller, which improves rider comfort and safety. The mechanical structure of the bike is designed to be strong, lightweight, and cost-effective.

A metal frame is fabricated using welding techniques to provide proper support for the rider, battery, motor, and other components. The solar powered electric bike is also economical compared to conventional vehicles. The running cost is very low because sunlight is free and electricity consumption is minimal. Maintenance costs are reduced due to fewer moving parts compared to internal combustion engine vehicles. This makes the system suitable for students, daily commuters, and people living in rural and urban areas.

INTRODUCTION

The design and development of a Solar Powered Electric Bike that uses solar energy along with battery power to drive the vehicle. Solar energy is a renewable, clean, and freely available energy source. By integrating a solar panel with an electric bike, the dependency on conventional charging methods can be reduced. The solar panel helps in charging the battery either partially or fully, depending on sunlight availability, thereby increasing the overall efficiency and sustainability of the vehicle. The proposed system mainly consists of a solar panel, rechargeable battery, PMDC motor, motor controller, throttle control, mechanical frame, wheels, and electrical wiring. The solar panel converts sunlight into electrical energy, which is used to charge the battery. The battery stores this energy and supplies power to the PMDC motor through the motor controller.

The controller regulates the speed and torque of the motor based on the throttle input provided by the rider. A Permanent Magnet DC (PMDC) motor is used in this project due to its simple construction, high efficiency, good torque characteristics, and ease of speed control. PMDC motors are well suited for electric bike applications because they provide high starting torque and smooth operation at low speeds. The speed of the motor can be easily controlled by varying the voltage using the controller, which improves rider comfort and safety. The mechanical structure of the bike is designed to be strong, lightweight, and cost-effective. A metal frame is fabricated using welding techniques to provide proper support for the rider, battery, motor, and other components. The solar powered electric bike is also economical compared to conventional vehicles. The running cost is very low because sunlight is free and electricity consumption is minimal. Maintenance costs are reduced due to fewer moving parts compared to internal combustion engine vehicles. This makes the system suitable for students, daily commuters, and people living in rural and urban areas.

A Solar Powered Electric Vehicle (SPEV) is a modern transportation system that utilizes solar radiation as a primary source of energy to operate an electric motor for vehicle propulsion. In recent years, the rapid depletion of fossil fuel reserves, increasing fuel prices, and rising environmental concerns have created a strong demand for clean and sustainable mobility solutions. Traditional internal combustion engine (ICE) vehicles are major contributors to air pollution and greenhouse gas emissions, which lead to climate change and global warming. Electric vehicles (EVs) were introduced to reduce pollution, but they still depend largely on electricity generated from coal-

based power plants, making them not fully eco-friendly. A solar powered electric vehicle overcomes this drawback by using renewable solar energy, which is freely available, abundant, and environmentally friendly. Solar photovoltaic (PV) panels mounted on the vehicle convert sunlight directly into electrical energy through the photovoltaic effect. This energy is either stored in a rechargeable battery or directly supplied to the motor through a charge controller. The stored energy is later used to run a DC or BLDC motor that drives the wheels, providing smooth and silent transportation.

The combination of solar energy and electric mobility makes SPEVs highly efficient, cost-effective, and sustainable. They require minimal maintenance, have fewer moving parts, and significantly reduce operating costs, making them ideal for both urban and rural transportation. As solar technology becomes more efficient and battery technology continues to advance, solar electric vehicles have the potential to revolutionize the future of transportation. This project focuses on designing, developing, and analysing a prototype of a solar-powered electric vehicle that demonstrates the feasibility and benefits of using solar energy for green mobility. The world is experiencing an increasing need for clean energy, and the transportation sector is a major contributor to carbon emissions. Therefore, it is necessary to explore environmentally friendly, cost-effective, and sustainable alternatives for transportation. Currently, global warming and air pollution, particularly in urban areas, pose significant challenges worldwide.

I. LITERATURE REVIEW

Several researchers have studied the concept of solar powered electric bikes as an alternative to conventional fuel-based and battery-only electric vehicles. Early studies mainly focused on converting normal bicycles into electric bikes by integrating a DC motor, rechargeable battery, and solar panel. These studies proved that solar energy can be effectively used to charge the battery either partially or fully, thereby reducing dependence on grid electricity. The results showed that solar powered e-bikes are feasible for short-distance travel, especially in urban and semi-urban areas with good sunlight availability.

Many research works emphasize the design and development aspects of solar electric bikes. These studies discuss the selection of lightweight bicycle frames, hub motors, lithium-ion or lead-acid batteries, and rooftop-mounted solar panels. Researchers highlighted that proper integration of electrical and mechanical components plays a major role in improving performance and safety. Some designs also allow dual charging options, where the battery can be charged using both solar energy and conventional electric supply, ensuring uninterrupted operation even during low sunlight conditions.

Energy efficiency and performance analysis form an important part of the literature. Several studies evaluated parameters such as speed, range, charging time, and power consumption. It was observed that solar panels help extend the riding range by continuously charging the battery during daytime travel. However, most researchers concluded that on-board solar panels alone cannot fully power the bike for long distances and high speeds. Therefore, solar energy mainly acts as a supporting energy source rather than the primary source.

Cost effectiveness is another major focus in the reviewed literature. Many researchers aimed to develop low-cost solar powered electric bikes using easily available components to make them affordable for students, daily commuters, and rural users. Comparative studies showed that solar e-bikes have lower operating costs compared to petrol bikes, as they eliminate fuel expenses and reduce electricity consumption. However, initial costs increase slightly due to solar panels, which researchers suggest can be recovered over long-term usage.

Environmental benefits are strongly highlighted in most studies. Researchers agree that solar powered electric bikes are eco-friendly as they produce zero tailpipe emissions, reduce air pollution, and help conserve fossil fuels. Literature also points out the social benefits of solar e-bikes in developing countries, where they can provide an economical and sustainable mode of transportation for short-distance travel.

Despite these advantages, the literature identifies certain research gaps**.** Limited work has been done on real-time performance testing under varying weather conditions. Long-term durability, battery degradation, and optimized power management systems such as MPPT controllers are not widely explored. Additionally, there is a lack of detailed cost–benefit analysis comparing solar e-bikes with conventional electric bikes. These gaps provide scope for further research and improvement in the design and development of cost-effective solar powered electric bikes.

II. LITERATURE REVIEW

In recent years, many researchers have focused on solar powered electric bikes as a solution to increasing fuel costs and environmental pollution. Studies indicate that combining solar energy with electric propulsion can significantly reduce dependency on fossil fuels. Early research demonstrated that a bicycle fitted with a small solar panel, battery, and DC motor can operate efficiently for short-distance travel, making it suitable for daily commuting.

Several research works concentrate on the design methodology of solar powered electric bikes. These studies explain the importance of selecting appropriate components such as lightweight frames, efficient hub motors, charge controllers, and energy storage systems. Researchers emphasized that the placement of solar panels plays a crucial role in maximizing sunlight absorption while maintaining vehicle balance and rider comfort. Proper mechanical and electrical integration improves overall system reliability and performance.

Performance evaluation is widely discussed in the literature. Researchers analyzed parameters such as speed, torque, battery charging rate, and riding range. The findings show that solar assistance increases battery life and reduces frequent charging from the grid. However, due to limited panel area and varying sunlight conditions, solar power alone is not sufficient to continuously run the bike at higher speeds. Hence, solar energy is mainly used as a supplementary power source to improve efficiency.

Many studies also focus on the economic feasibility of solar powered electric bikes. Researchers compared manufacturing cost, operating cost, and maintenance cost with conventional two-wheelers. The results revealed that although the initial investment is slightly higher due to solar panels, the running cost is very low because there is no fuel consumption. This makes solar e-bikes cost effective in the long run, especially for regular users.

Environmental impact analysis forms an important part of the literature. Most studies highlight that solar powered electric bikes produce zero emissions during operation and help in reducing greenhouse gases and noise pollution. Researchers also point out that promoting solar e-bikes can contribute to sustainable transportation and support government initiatives for renewable energy adoption.

The literature also identifies certain limitations and future research needs. Most existing studies are based on small-scale prototypes with limited real-world testing. There is a lack of advanced energy management systems, such as intelligent controllers and regenerative braking. Additionally, optimization of battery size, solar panel efficiency, and overall weight reduction has not been fully explored. These gaps create opportunities for further improvement in the design and development of cost-effective solar powered electric bikes.

III. SYSTEM OVERVIEW

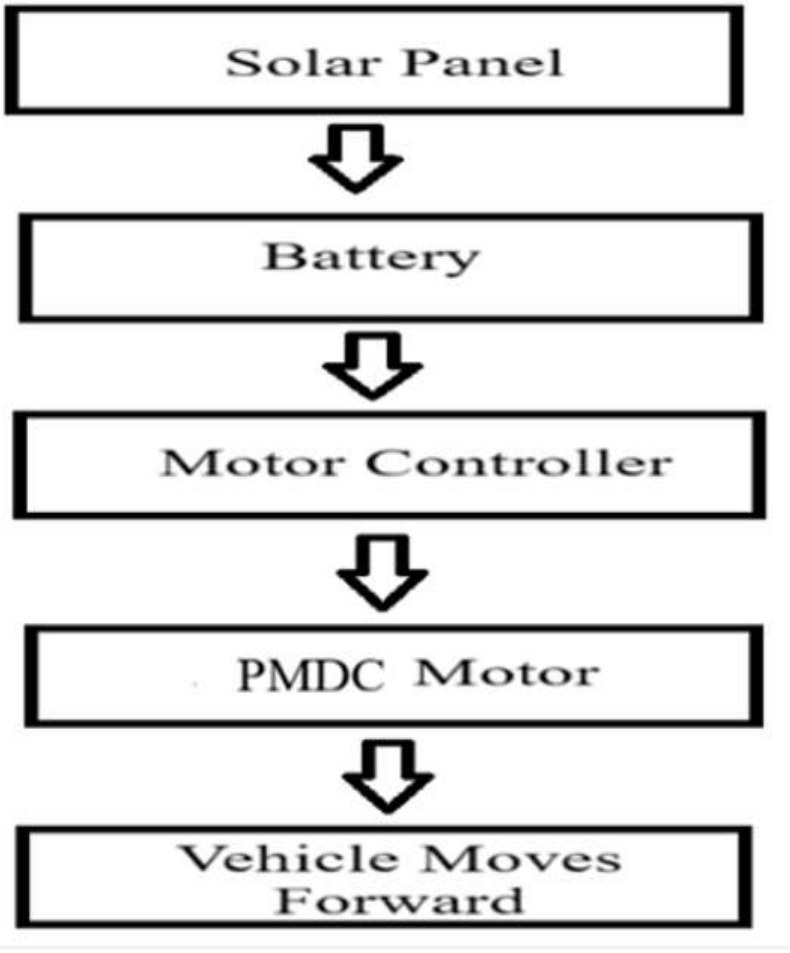


Fig : - Block diagram of solar powered Electric Bike.

Solar Panel: The solar panel is the main source of energy in this system. It absorbs sunlight and converts it into electrical energy using the photovoltaic effect. The output of the solar panel is DC power, which is suitable for charging batteries. The amount of power generated depends on sunlight intensity, panel area, and efficiency. Using a solar panel reduces dependency on conventional electricity and makes the vehicle eco-friendly.

Battery: The battery stores the electrical energy produced by the solar panel. It supplies power to the system when sunlight is not available, such as during night or cloudy conditions. The battery ensures continuous operation of the vehicle. Commonly used batteries include lead-acid or lithium-ion batteries. It acts as a backup power source and helps in maintaining a steady supply of energy to the motor controller.

Motor Controller: The motor controller is an important control unit between the battery and the motor. It regulates the amount of voltage and current supplied to the PMDC motor based on the rider's input. By controlling the electrical power, it helps in smooth starting, speed control, and safe operation of the motor. It also protects the motor and battery from overload and short-circuit conditions.

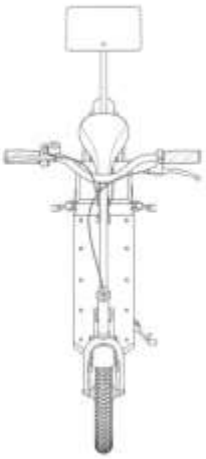
PMDC Motor: The Permanent Magnet DC (PMDC) motor converts electrical energy into mechanical energy. It uses permanent magnets instead of field windings, which improves efficiency and reduces size. When current flows through the armature, a magnetic force is produced that causes the motor shaft to rotate. PMDC motors are commonly used in electric vehicles due to their simple construction, good torque characteristics, and ease of control.

Vehicle Movement: The rotational motion of the PMDC motor is transmitted to the wheels using mechanical arrangements such as a chain drive, belt drive, or gears. This mechanical power causes the wheels to rotate, resulting in forward movement of the vehicle. The speed of the vehicle depends on the motor speed, controller settings, and load conditions. Thus, the coordinated operation of all components enables smooth and efficient vehicle motion.

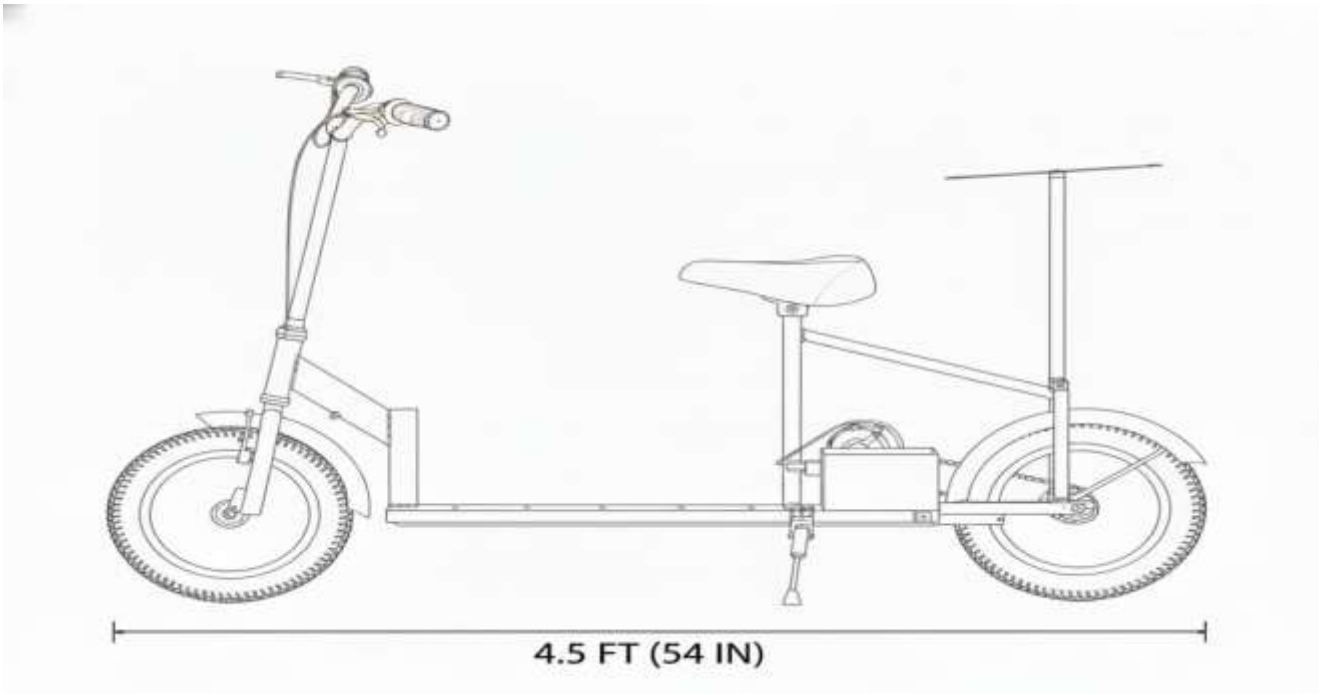
IV. EXPERIMENTAL SETUP

CAD Modelling and Engineering Drawing

Fig(a)



Fig(b)



Fig(c)

Fig 1 : Fig(a) , Fig(b) and Fig(c) are represents Front View, Top view and side view

The scooter uses a two-wheel configuration, with a smaller front wheel connected to a long steering column and handlebar for smooth control, and a larger rear wheel that supports the drive system. The handlebar assembly is ergonomically designed to provide comfortable steering and balance during riding. A flat footboard platform is provided at the centre of the chassis, allowing the rider to stand or rest their feet securely. Above the rear section, a single seat is mounted to offer riding comfort for longer distances. The seat height and placement are designed to maintain proper riding posture. The rear section accommodates the electric drive system, including the motor, battery box, and transmission components. These are placed close to the rear wheel to ensure better weight distribution and efficient power transfer. A side stand is included to allow stable parking when the scooter is not in use. The design also shows clear dimensional views (front, side, and isometric), indicating attention to proper proportions, ground clearance, wheel alignment, and overall balance.

The chassis of the scooter is designed to be lightweight yet strong, ensuring durability while reducing overall vehicle weight. Mild steel

tubing is commonly used for the frame due to its good strength, ease of fabrication, and cost effectiveness. Proper welding techniques are applied to maintain structural integrity and rider safety. The frame geometry is planned to support both static and dynamic loads during riding, braking, and turning. The front steering system is designed to provide stable handling and smooth manoeuvrability at low and moderate speeds. The steering column angle and handlebar width are selected to reduce rider fatigue and improve control. The front wheel size helps in absorbing minor road irregularities, contributing to better ride comfort.

The rear wheel plays a crucial role in propulsion and load carrying. Mounting the electric motor near the rear wheel reduces power loss and improves efficiency. The battery box is positioned low and close to the centre of gravity, which enhances vehicle stability and prevents imbalance during acceleration or cornering. Adequate space is provided for ventilation and easy maintenance of electrical components. The vertical support behind the seat can be used for mounting accessories such as a solar panel, luggage rack, or safety elements in future upgrades. Overall, this design focuses on a cost-effective, lightweight, and practical electric scooter, suitable for short-distance urban travel and educational or prototype-level projects.

FABRICATIONS

This project involves the fabrication of a cost-effective electric vehicle by following a systematic design and manufacturing process. Initially, detailed drawings were prepared to finalize the dimensions and layout of the vehicle. The structure consists of a front wheel and two rear wheels, providing good balance and stability. A hub motor is mounted on the wheel, and the steering handle is connected to the front wheel for smooth control. The vehicle is designed with a comfortable seat and sufficient space for the rider. The fabrication process includes material selection for the chassis, mainly using mild steel due to its strength and availability. Cutting, welding, and joining operations are carried out to form the frame. Bearings are used to support wheel rotation, and a front fork is installed for steering. After completing the mechanical assembly, electrical components such as the motor, controller, battery, and wiring are installed properly. Finally, all connections are checked, and the vehicle is tested to ensure safe and efficient operation.

Frame

This frame is the basic structural backbone of the electric scooter, fabricated using metal sections to provide strength, stability, and ease of assembly. The design is simple and practical, suitable for a prototype or student project. The front portion of the frame consists of a flat rectangular metal plate that acts as the footrest platform for the rider. This plate is wide enough to support body weight comfortably and is reinforced to prevent bending during riding. A vertical hollow pipe is welded at the front end, which is intended for mounting the steering column and handlebar assembly. The middle section of the frame houses a rectangular box structure, which is designed to accommodate important components such as the battery, motor controller, or electrical wiring. This box also helps in improving weight distribution by keeping heavy components close to the centre of the frame. At the rear side, a welded triangular and vertical support structure is provided to mount the seat post. This arrangement ensures proper rider posture and transfers the rider's load safely to the main frame. The angled supports increase rigidity and reduce vibrations during operation.

Fig(a) Fig(b)

Fig.2: Fig(a) and Fig(b) Shows Bike Frame.

The frame serves as the main support structure of the electric scooter and is made from metal to ensure strength and stability. The front section includes a rigid footrest platform for the rider, along with a vertical pipe used to mount the steering and handlebar assembly. The centre of the frame contains a box-like compartment for placing electrical components such as the battery and controller, helping in proper weight balance. At the rear, reinforced supports are provided for seat mounting, ensuring safe load transfer and improved riding comfort with reduced vibrations.

RESULT

A fully working of a low-cost solar-powered electric bike that can run using both battery and solar energy. Reduced dependency on grid electricity, as the bike charges itself through the mounted solar panel. Lower daily travel cost, making the bike affordable for students, workers, and rural users. Environment-friendly transportation that reduces carbon emissions

The result of this project shows that the designed and developed solar powered electric bike works successfully as planned. All major components such as the PMDC motor, battery, motor controller, frame, wheels, and solar panel were properly assembled and tested. The vehicle was able to run smoothly using electrical energy stored in the battery.

The PMDC motor provided sufficient torque to move the bike at a safe and stable speed. Speed control was achieved using the motor controller, allowing smooth acceleration and deceleration. The mechanical structure and frame were strong enough to support the rider's wight and ensure stability during movement.

The solar panel was able to charge the battery when exposed to sunlight, reducing dependency on external electrical charging. This proves that the system can support renewable energy usage and improve overall energy efficiency. The battery provided adequate backup power, allowing the bike to operate even when solar energy was not available.

During testing, the bike showed low noise, zero exhaust emission, and reduced running cost, making it eco-friendly and suitable for short-distance transportation. The project result confirms that the proposed system is technically feasible, economical, and environmentally friendly.

Fig(a)_

Fig (b)

Fig (c)

Fig.8.1: Fig(a),Fig(b),Fig(c) Shows Result of Solar Powered Electric Vehicle.

V. CONCLUSION

The Solar-Powered Electric Bike project successfully illustrates the application of renewable energy in modern transportation. By integrating solar panels with an electric bike, the system efficiently converts sunlight into electrical energy, enabling the bike to operate with minimal reliance on conventional power sources. This not only reduces fuel costs but also contributes significantly to lowering

carbon emissions, promoting a cleaner and greener.

The solar powered electric bike demonstrates that solar energy can be effectively harnessed for short-distance commuting, making transportation more sustainable and eco-friendly. It also provides insights into battery management, motor efficiency, and solar energy optimization, offering valuable learning for future advancements in electric vehicle technology. The bike is designed to be low-cost and user-friendly, making it accessible to a wider range of users.

Overall, this project proves that integrating renewable energy with electric mobility is both feasible and beneficial. It encourages the adoption of green technologies and highlights the potential of solar power in reducing dependence on non-renewable energy, paving the way for environmentally responsible transportation solutions.

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