Electric bicycles with solar panels

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Abstract. Solar energy is energy in the form of rays and heat from the sun. This energy can be harnessed by using a series of technologies such as solar panels. Solar panels are devices that consist of solar cells that convert light into electrical energy. The use of solar panels for battery charging on electric bicycles is the topic of this research. The process of developing an electric bicycle with solar power consists of several stages, starting from the preparation of the bicycle, the development design, the manufacture of the solar panel frame and holder, to the assembly and testing process. The result of this research is an electric bicycle uses a 24V, 12Ah battery with a charging time of 9 hours 33 minutes, using a 250 Watt DC motor. The maximum speed of an electric bicycle with solar panels is as expected, which is 20 km/hour with a distance of 16 km and a load of 89 kg. Mileage and travel time are affected by the weight of the rider.

1. Introduction
Solar energy is a very profitable source of energy for a country with a tropical climate such as Indonesia, given its sustainable nature and very large amounts. The enormous amount of energy produced from sunlight makes solar panels a reliable alternative source of energy for the future. [1]-[4] Electric bicycles have been widely circulating in Indonesia. However, charging the battery generally uses electricity power (PLN) so that the devotees only consist of certain groups. The development of a solar panel electric bicycle will charge the battery while driving and if there is no sunlight, the battery charging will come from electricity power using a battery charger through the controller. In addition, the solar panel electric bicycle also has lighting so it can be used at night. The solar panel also functions as the roof on an electric bicycle for comfort when riding during the day. [5]-[7]

2. Methodology
An electric bicycle is an alternative vehicle without fuel that is driven by a motorbike and accumulator. In general, electric bikes have the main components, namely: a motor, an accumulator and a controller. The type of motor used on an electric bicycle is a Direct Current (DC) electric motor with the Brushed type. Solar Panel is a device consisting of solar cells that convert light into electrical energy. The solar panel is a module consisting of several solar cells that are combined and connected in series and parallel depending on the size and capacity required. The solar cell module generates electrical energy which is proportional to the surface area of the panel that is exposed to sunlight. [8]-[9]
Figure 1. Solar Panel 20wp (2 Unit) [10]

Figure 2. Flowchart of Research
Figure 3. Block Diagram of Research.

Explanation and function of each block diagram:

a. The solar panel is a module consisting of several solar cells that are combined and connected in series and parallel depending on the size and capacity required.
b. Solar Charge Controller is one of the components in the solar power generation system, which functions as a regulator of electric current both for the incoming current from the Solar Panel and the outgoing load current. Works to keep the battery from overcharging.
c. The battery (accumulator) is a device that can store electrical energy in the form of chemical energy. An accumulator is an important element in an electric bike because the accumulator is the main drive source in electric bicycle motors.
d. The on / off key functions to disconnect and connect the current from the battery to the controller.
e. The controller is an electronic device that is on an electric bicycle. The controller functions to regulate the speed of the electric motor and divide the voltage to various sources such as electric motors, brake sensors, and indicators.
f. Throttle gas, is an electric bicycle speed control device. The throttle gas is connected to the controller.
g. DC motor is an electromechanical device that converts electrical energy into mechanical energy with a direct current as the supply of electrical energy. The DC motor is the prime mover on an electric bicycle.
h. The lighting lamp is an additional tool on the solar panel electric bicycle. Lighting functions to illuminate the road when driving at night.

3. Result and Discussion
The process of developing an electric bicycle consists of several stages, namely: bicycle preparation, development design, manufacturing of solar panel frames and mounts, painting of bicycle frames and solar panel frames, and the final stage is component assembly.
3.1 Electric bicycle development design
The following is a design of development an electric bicycle with solar panel shown in Figure 4 below:

![Figure 4](image1.png)

**Figure 4.** Design of Development an Electric Bicycle with Solar Panel

Caption:
- a. The length and width of the solar panel stand is 72 cm x 54 cm
- b. The thickness of the solar panel frame is 3.5 cm.
- c. The height of the solar panel frame is 135 cm.
- d. The height of the solar panel electric bike is 165 cm.

3.2 The Assembly Process of Electric Bicycles
The assembly process is the final part of making an electric bicycle. The assembly process is the combining of electric bicycle components and solar panels into one so that it becomes a form of a solar panel electric bicycle. The assembled components are:
- a. Solar Panel
- b. Solar charge controller
- c. DC Motor 250W
- d. Controller
- e. Battery
- f. Throttle gas
- g. Lighting

3.3 Results of Assembling an Electric Bicycle Solar Panel
The results of assembling a solar panel electric bicycle are shown in Figure 5, below:

![Figure 5](image2.png)

**Figure 5.** Results of Assembling an Electric Bicycle Solar Panel
Caption:
a. Solar Panel 2 unit, with capacity 20 Wp  
b. Solar charge controller 24V 20A  
c. Battery 2 unit, with a capacity 24V/12Ah  
d. DC Motor 24V/250W  
e. Controller 24V/250W

3.4 Testing of Solar Panel Electric Bike Charging  
This electric bicycle battery charging test aims to determine whether the solar panel electric bicycle battery charging process is going well and as expected. Testing the battery charging from solar panels do during the sun is shining to get maximum charging time.

3.5 Measurement of Battery Charging Time  
The electric bike is designed using 2 unit’s battery with a capacity of 12V/12Ah each. The battery is then assembled in a series that produces 24V/12Ah capacity. The measurement of battery charging time is shown in Table 1 as follows:

| No. | Battery Charging Source | Initial Battery Conditions | Charging Time, Beginning and End | Time To Full Battery Charging | Current (Ampere) | Explanation |
|-----|--------------------------|-----------------------------|----------------------------------|-------------------------------|-----------------|-------------|
| 1.  | Solar Panel              | Low Battery                 | 08.20-17.58                      | 9 hours 33 minutes            | 1.2 A           | Sun is shining |
| 2.  | Solar Panel              | Low Battery                 | 08.00-12.47                      | 14 hours 25 minutes           | 0.8 A           | Cloudy      |
| 3.  | Electricity Power (PLN)  | Low Battery                 | 12:20-18:15                      | 6 hours 5 minutes             | 1.9A            |             |

First test on Saturday, February 15, 2020, 08: 18-17: 51 when the sun is shining. The second test was on Saturday, March 14, 2020, in cloudy conditions. Charging uses two solar panels connected in series with a capacity of 20Wp. The use of a 20Wp solar panel to keep the battery from overcharging for long life. The weight of two units of solar panels 20Wp can be supported by an electric bicycle. The solar panel is installed horizontally on the bicycle to keep the bicycle stable while driving. The process of charging the battery must be observed at all times. Before charging the battery, the indicator must show that the battery is empty so that when making measurements an accurate time is obtained. Charging the battery from the solar panel goes well with the voltage and current of the solar panel, namely 24V / 1.2A with a charging time of 9 hours 33 minutes.

3.6 Measurement of Speed and Distance of Electric Bicycles  
Testing an electric bicycle with a weight of 39 kg and a load mass (person) of 50 kg, 55 kg, and 67 kg. The purpose of this test is to determine the maximum speed that can be achieved by an electric bicycle. The object under study is the travel time and the distance traveled. This test was carried out along Perumnas Telkomas Street, Makassar. Measurement of the speed and distance traveled by an electric bicycle is carried out using the GPS Speedometer application tool that has been installed on Android. Measurement of the speed and distance traveled by an electric bicycle is shown in Table 2 as follows:

| No. | Initial Battery Conditions | Current (Ampere) | Bike Weight (Kg) | Rider Weight (Kg) | Maximum speed (Km/hour) | Distance (Km) | Time (Minutes) |
|-----|----------------------------|------------------|------------------|-------------------|-------------------------|---------------|---------------|
| 1   | Full Battery               | 5.8              | 39               | 50                | 20                      | 16            | 48            |
Explanation:
The first test was conducted on Monday, February 25, 2020, at 17:00-17:42, with a bicycle mass of 94 Kg. The second test was conducted on Tuesday, February 26, 2020, at 21:00-21:48, with a bicycle mass of 89 Kg. The third test was carried out on Sunday, March 15, 2020, at 10:00-10:33 with a bicycle mass of 106 kg. The maximum speed of the solar panel electric bicycle is as expected, which is 20 km/hour with a distance of 16 km. Distance and travel time are affected by the weight of the rider. The average speed, maximum speed, and distance traveled by an electric bicycle can be seen on the screen display of the GPS Speedometer. Measuring the distance traveled by an electric bicycle is done by riding an electric bicycle until the indicator shows the condition of the battery is completely empty.

4. Conclusion
Based on the results of the discussion and testing of electric bicycles with solar panel, conclusions can be drawn including:

a. Electric bicycles that have been developed with the use of solar panels operate well.
b. The solar panels that are assembled can charge the battery in 9 hours 33 minutes with a current of 1.2A.
c. The maximum speed of an electric bicycle with solar panels is as expected, which is 20 km/hour with a distance of 16 km and a load of 89 kg. Mileage and travel time are affected by the weight of the rider.

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