

## Design of Catamaran Ship Using Solar Power

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### ABSTRACT

Solar power is a renewable energy that can replace oil fuel as the main energy of the ship. The use of fuel oil can worsen the environment in the Maninjau lake tourism area. This paper aims to develop a ship propulsion design using solar power with the main size of the WL bilge Length 367.33 cm, Width (B) 170 cm, Height (H) 70 cm, Draught (T) 30.7 cm. To produce the power needed at a speed of 6 knots, using the method of theoretical analysis by counting, total energy and solar panels to convert sunlight into electrical energy. The result of calculating the total energy needed to reach 6 knots is 0.932 kW. The solar panels needed to produce the power are 4 pieces with a capacity of 100 Wp. This system does not use an inverter because it uses a DC electric motor as a vessel driver. The design of a solar-powered boat can be an option for the community as an environmentally friendly tourist ship without fuel.

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## 1. INTRODUCTION

The ship is a complex vehicle that is required to be able to operate and survive with high durability over a long period of time in a changing environment. Tourist boats are vessels used to support tourism activities for tourists [1]. On the Maninjau lake tour boat uses fossil fuels as the main energy driving fuel motor. As stated [2] Dependence on fossil fuels can cause a serious threat, namely: (1) depleted petroleum reserves (2) unstable oil production causes oil prices to change frequently. This causes the environment to be worse due to air pollution caused by the fuel from the motorbike. The ship that will be planned uses the drive of solar power as the main energy. Solar power is a renewable energy that can replace oil fuel as the main energy of the ship. The advantages of this system are that the energy obtained is free, does not cause pollution, does not require fuel to move the ship, easier maintenance. According to [3] "This can overcome the scarcity of fossil fuel energy and reduce air pollution, besides that also to provide added value to the tourist area".

The area of Indonesia has daily solar rays of 4,000-5,000 Wj / m<sup>2</sup>, while the average number of hours of irradiation is between 4 and 8 hours [4]. Electricity generation can be used in two ways, directly with photovoltaic and indirectly by concentrating solar energy. In this study using solar energy with photovoltaics. The following is an overview of the structure of solar panels:

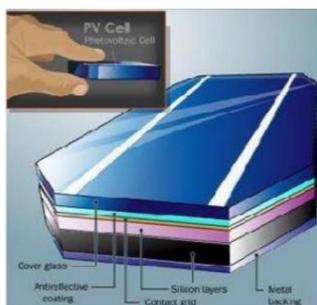


Figure 2 : Solar Cell Structure [5]

In sunlight there are various electromagnetic waves, it is expected that solar panels can absorb as much radiation as possible from sunlight [6]. When the solar cell absorbs sunlight, free electrons and holes make a positive/negative connection, and when connected to a DC load, the electric current will flow to that load.

## 2. METHOD

This paper is the development of ship propulsion that uses solar power. Obstacle value produced at a speed of 6 knots is obtained 301, 08 N. The speed of 6 knots is taken because considering the energy to be produced by the solar cell system is not constant and also the surface area needed for solar panels also needs to be considered. So with variable speed and obstacles, it can be seen the amount of energy needed to move the ship. The power output needed as vessel propulsion will be used as a parameter in calculating the number of solar panels and supporting components used in this system.

### 2.1 Research Objects

The research object used is a ship with a flat catamaran hull inside. The following is the gastric form that will be used as the object of research.

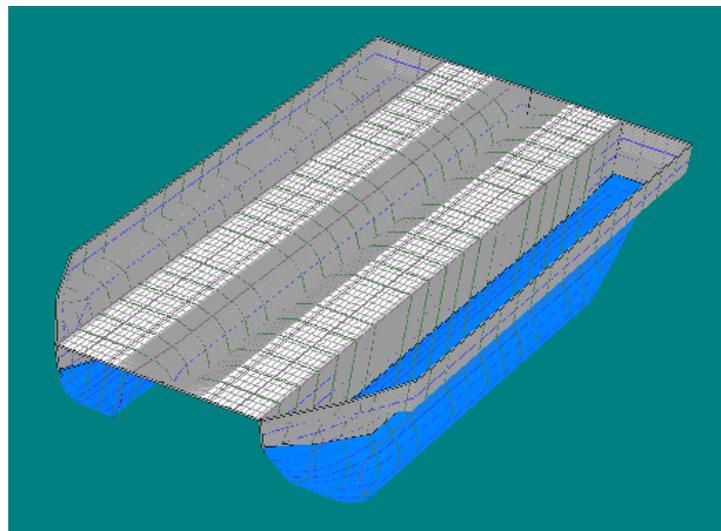


Fig. 3. Flat Inside Inside Catamaran

The following are the dimensions of a flat inside catamaran ship as follows:

Table 1. The dimension of Gastric Katamaran

No	Parameter	Value	Unit
1	Displaced	448679,63	cm <sup>3</sup>
2	WL Length	367,33	cm
3	Beam (B)	170	cm
4	Drought (H)	70	cm
5	Draft (T)	30,7	cm
10	Prismatic Coeff. (Cp)	0,805	-
11	Block Coeff. (Cb)	0,779	-
12	Max Sect. Area Coeff. (Cm)	0,967	-
13	Water. Area Coeff. (Cup)	0,939	-

### 2.2 Data Analysis Techniques

#### 2.2.1 Need Power

The total energy is the power needed to move the ship with engine capacity according to the size of the ship. To calculate total energy you can use the formula from [7] as follows:

$$EHP = Rt \times Vs \quad (1)$$

### 2.2.2 Machine Selection

The driving motor is the engine which is the main driving source of the booster system [8]. In the selection of machines used as propulsion of the ship is an electric outboard engine with a capacity that will be determined from the results of the calculation of total energy.

### 2.2.3 Calculating the Number of Panels

The number of panels referred to here is the amount of use of solar panels needed to be able to drive the electric drive engine. for the number of solar panels can be determined by equation [4]:

$$\text{Number of Solar Panels} = \frac{\text{Total Power Requirement (Watts/Hours)}}{\text{Solar Cell Panel Capacity (Watts) x Solar Radiation (Hours)}} \quad (2)$$

### 2.2.4 Determination of component types

The components used in the design of the propulsion of this ship are:

#### 2.2.4.1 Combiner

Combiner functions as a safety PV that contains CB, fuse and as a place for combining electric current from PV before continuing to the charge controller and battery [9]. This will save the use of cable components. Because the cable that is usually used as an intermediary from the panel to the Solar charge controller can be reduced by using a combiner.

#### 2.2.4.2 Solar charge controller

This tool serves to regulate the voltage and current released from the solar module, do the battery charging process, prevent the battery from overcharging, also control the discharge process [10].

#### 2.2.4.3 Battery

Battery functions as a storage of energy produced from solar panels. The energy produced by solar panels will be stored before use. This avoids power shortages when the system is used and can damage the battery when the battery empties during operation. So this can be anticipated by calculating the number of batteries used by the formula [4] as follows:

$$\text{Minimum battery amount} = \frac{2 \times \text{Total power needed}}{\text{the battery used (Volt x Ah)}} \quad (3)$$

To determine the battery charging rate the time needed to fill the battery in an empty state until it is fully charged can be calculated by equation [11] as follows:

$$T = \frac{2 \times \text{battery used (Volt x Ah)}}{\text{Solar Cell Panel Capacity (Watt)}} \quad (4)$$

## 2.3 Draft scheme for a solar-powered ship propulsion system

The ship's propulsion system uses solar power in the form of a series of images in which all the components have been combined into a series.

## 3. RESULTS AND DISCUSSION

### 3.1 The power needed to move the ship

The theoretical calculation results of the required power are 0.932 kWatt. The results of the power obtained will be a reference as the engine selection will be used to drive the ship. In the selection of the engine, the required power is needed because the engine capacity used will have an impact on the engine's thrust against the ship.

### 3.2 Determining the Machine Type

The machine that is used as the propulsion of the ship is an electric outboard engine with a capacity of 2 hp. On this machine, there are 5 advanced modes and 2 reverse modes so you can choose the speed as desired. Equipped with a battery indicator so you can set the route correctly. The rotor support pole is made of stainless steel material so it is very strong. This type of machine has become an option as a driver of the ship because with the specifications as in table 2 this machine can produce thrust with a capacity of 2 HP. Then this machine will be used as much as 1 piece as the driver of the ship. The following machine specifications are used:

Table 2. Specifications of Electric Vessel Machines

Type	Dc – Electric
Power	540-660 Watt
Voltage	12 Voltage
Height	15gr

### 3.3 Number of Solar Panels

The calculation results can be the number of panels 3, 728. So, the solar panels to be used will have 4 solar panels with a capacity of 100 WP. The type of solar panel used is the type of polycrystal. In this calculation, the researchers assume the duration of use of this system is 2 hours. This type of panel is used because the type of polycrystal has the advantage of being able to absorb light when it is cloudy. This is a consideration in the selection of solar panels. Solar panels besides absorbing sunlight can also be used as a protective/roofing vessel. The total area of the solar panel is 4.2 m<sup>2</sup>. This area can be determined by the length of the solar panel 2.4 m and the width of 1.5 m as shown in Figure 4.

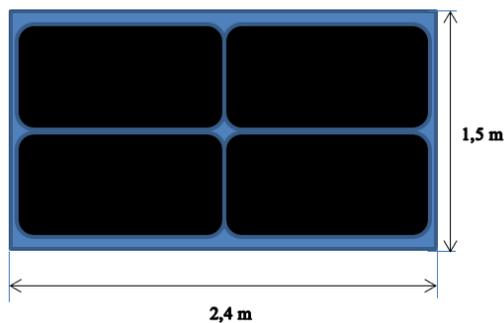


Fig. 4. Solar Panel Area

Table 3. Solar Panel Specifications

Specification	Information
Max. Power (Pmax)	100W
Max. Power Voltage (Vmp)	17.6V
Max. Power Current (Imp)	5.69A
Open Circuit Voltage (Voc)	22.0V
Short Circuit Current (Isc)	6.11A
Tolerance	± 3%
Nominal Operating Cell Temp (NOCT)	45°C
Max. System Voltage	1000VDC
Max. Series Fuse	10A
Cell Technology	Poly-Si
Weight	7.7Kg
Dimension	1021 x 70 x 30 mm

### 3.4 Components used in solar drive systems

#### 3.4.1 Combiner

In this series use the type of 4 in 1 out Quatplexser Combiner. The choice of the combiner is based on the number of panels to be combined, there are 4 solar panels, so combiner with 4 inputs is used. This can also reduce the use of connecting cables from solar panels to the solar charge controller. Because by using a combiner, the 4 panels used will be connected to the combiner and will be forwarded to the solar charge controller with 1 cable out. So it can minimize the use of cables. The following combiner specifications are used:

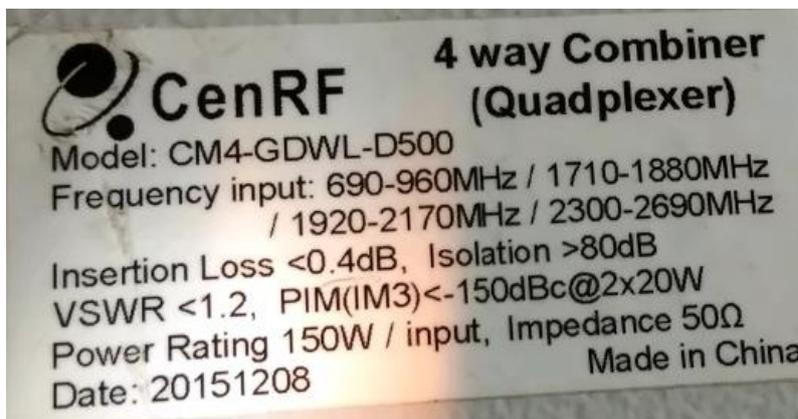


Fig. 4. Combiner specifications

#### 3.4.2 Battery

The battery used is 2 YUASA N 70Z-75D31R battery. The use of 2 pieces of battery with a capacity of 12 v 75 Ah because the motor that is driven requires considerable power. It also functions as a backup energy that needs to be in an emergency. The amount of battery charging rate in an empty state takes 4.5 hours until it is fully loaded. The following battery specifications are used:

Table 5. Battery specifications

Specification	YUASA N 70Z – 75D31R,
<b>Volt</b>	12 V
<b>Capacity</b>	75 Ah
<b>Dimension</b>	173 x 202 mm

#### 3.4.3 Solar Charge Controller

This circuit uses one BCU with the following specifications:

Table 5. Epsolar LS1024R BCU Specifications

<i>Nominal System Voltage</i>	12 / 24VDC
<i>Rated Battery Current</i>	10A
<i>Max. Battery Voltage</i>	32V
<i>Charge Circuit Voltage Drop</i>	≤0.26V
<i>Discharge Circuit Voltage Drop</i>	≤0.15V
<i>Overall dimension</i>	140x65x34mm
<i>Net weight</i>	0.15kg

### 3.5 Draft scheme for a solar power ship propulsion system

This system uses solar panels with a capacity of 100 WP, with the meaning that solar panels will be able to produce 100 watts per hour in maximum conditions. With the power needed by a motor of 0.932 kWatt,

four solar panels are needed. The total area of solar panels needed is 4.2 m<sup>2</sup>. So that solar panels can be used requires a combiner and solar charge controller as a regulator of the incoming flow to the battery. After the energy is stored by the new battery, it is distributed to the motor. Charging 2 batteries with a capacity of 12 v 75Ah can be filled from empty until fully charged takes 4.5 hours.

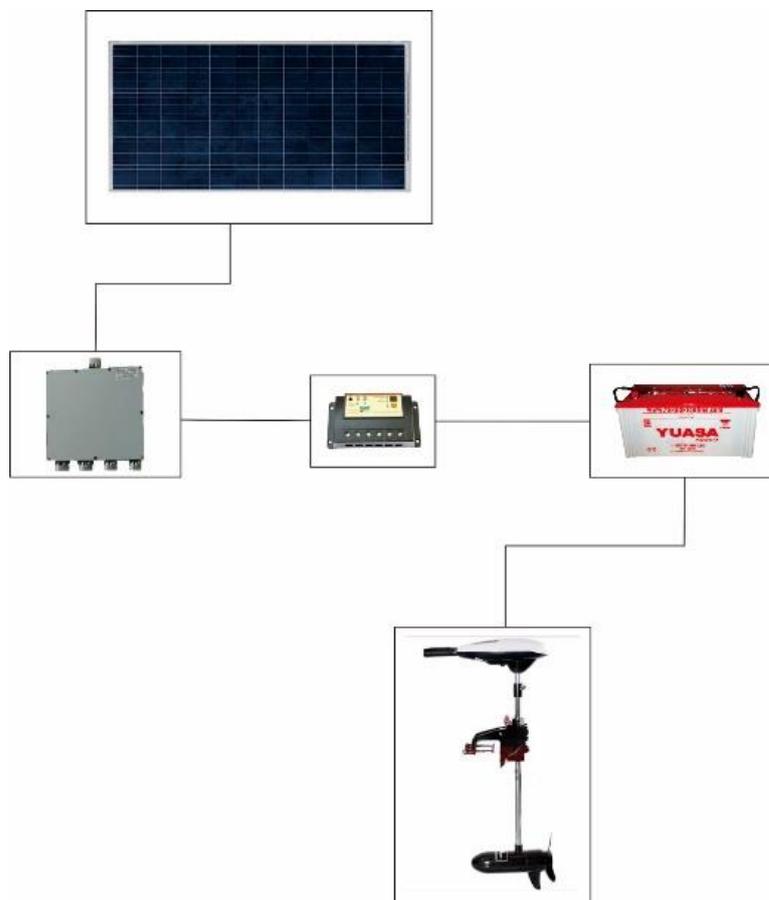


Fig. 5. Schematic of a Solar Drive System

#### 4. CONCLUSION

The development of solar-powered propulsion of ships can be concluded that using the scheme will help in designing shipbuilders. This is seen from the use of energy on ships that they no longer use fossil fuels but with solar power. In this design do not use an inverter because the energy from solar panels that have a DC current can be channelled directly to the motor with a DC current. This drive system also does not require many cables because 4-panel currents can be combined with combiner and output into 1 output after which it can proceed to the solar charge controller.

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## NOMENCLATURE

EHP	= Energy Hourse Power
Rt	= Resistance total
Vs	= Speed
T	= Time