The Utilization of Solar Cell System Design in the Ship

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Abstract: Utilization of solar energy as solar photovoltaic plant in the engineering as a source of electrical energy to produce no pollution, air pollution and pollution on the surrounding environment. The basic ingredients of photovoltaics is solar cell. The use of solar cell on a vessel can be used as energy in a variety of electrical equipment on the ship, due to the relative abundance of Sun energy and never run out because the Sun bathes the territory Indonesia 10-12 hours a day. In this case the solar cell used to meet the needs of the mechanical cooling equipment on board the ferry that sails around the region of Indonesia. Expected usage of this solar energy can reduce the use of fossil fuels oil and can save on operational costs. In this paper will show the usage of solar cell in the ship for mechanical cooling system and for lighting equipment. All the needs of electrical power in supply from batteries being replenished by solar panels. Solar power become one of alternative energy to overcome the presence of the energy crisis especially a reduction in the availability of petroleum and the more expensive world oil prices. Major problems focused on design of electric system as power plant resources in the ship. We will see the calculation for solar cell system design for mechanical that the investment for purchase a solar cell will be more efficient than motor diesel and also that solar cell also can be used for power lighting in the ship and can saving almost 52.5% by 52.5 % of the generator burden.

1 INTRODUCTION

Be advised that papers in a technically unsuitable form will be returned for retyping. After returned the manuscript must be appropriately modified.

There are a variety of alternative energy could be developed include coal, natural gas, geothermal, biomass, hydro, wind, wave, solar and nuclear. From some of the alternative energy, are classified into two groups, the energy is not renewable and renewable energy. Renewable energy not including consists of petroleum, coal, nuclear and gas. While including the kind of renewable energy include geothermal, biomass, water, wind, solar, wave and others that are still open. Renewable energy has the potential to be superior in comparison to fossil energy. There are several underlying reasons among others due to the build-up of the infinite, renewable and environmentally friendly. Solar energy, water, wind, biomass, Ocean and other alternative energy sources are available in abundance in nature, whereas it is used still little. Remember the sunshine all year round for availability, then it is right if the solar energy is harnessed as a provider of electrical energy. With the layout of the equatorial regions are on Indonesia, which is at a latitude of 60 North Latitude and 110 South Latitude and 950 East Longitude and 1410 East Longitude and having regard to the circulation of the Sun in a year in the area of 23.50 North Latitude and 23.50 South Latitude and the territory of Indonesia will always in sunlight for 10 until 12 hours in a day. Because of the layout of Indonesia are on the Equator then Indonesia has solar radiation level that falls on the surface of the Earth Indonesia (especially the West part of Indonesia) averaged approximately 4.5 kWh/m2 monthly variation of about 10% (Faturachman, et.al, 2013).

The need for increasing energy and depleting reserves of oil, forcing people to look for alternative energy sources. Developed countries have also competed and raced the latest breakthroughs to search a creating new technologies that can replace petroleum as an energy source. Depleting his supplies of energy and also the dependence on one type of energy in which the fuel oil is very huge and almost all sectors of life using this fuel, while fuel oil Is a commodity exports dominant to state revenues. In the utilization solar energy in Indonesia as an equatorial and tropical areas with the land area of almost 2 million sq km, endowed with irradiating the sun more than six hours a day or about 2,400 hours in a year. Solar energy on Indonesia have intensity between 0.6

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- 0.7 kW / m2 how its abundance of energy most wasted this. For solar energy utilization attempts Indonesia has various advantages such as:

- The energy is available with large numbers in Indonesia.
- Strongly support the national energy policy of austerity.
- Verified and equitable energy.
- Allow built in remote areas because it does not require the transmission of energy or transportation of energy resources.
- Solar energy is an environmentally friendly energy source.

While in Indonesia should actually solar cells get special attention, this because indonesia which is the tropics and is in the equatorial region and indonesia has the characteristics of the wind to a less well (very fluctuates) in an appeal with the characteristics of the wind in the western countries but it was very profitable to solar energy average get a sunburn six hours a day on the weat. An effort to search for new energy sources should meet requirement that produce the amount of energy quite strong the cost of economical and not have a negative impact on the environment. Hence search- are in direct in the use of solar energy either directly or indirectly by the use of a panel that solar cell that can change solar energy into electrical energy in call of solar cell are very supportive (Shariman, et. all, 2014).

Solar cells or in the international world is more known as a solar cell or photovoltaic cell, is a semiconductor that has a surface of divasi and consists of a series of p and n type diodes, which able to convert the energy of sunlight into electrical energy.

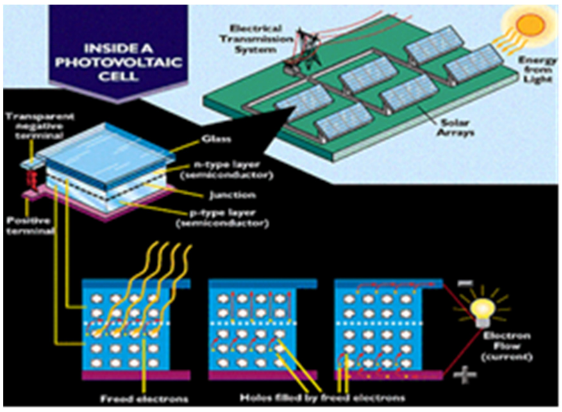

Figure 1. Solar Cell

Solar Cell application in Marine Engineering:

1. The use of solar cells on a supertanker.
2. Solar boat.
3. Japan first cargo ship sets.

Figure 2. Solar Cell in Tanker

To build a solar energy system (photovoltaic) that can operate properly then needed some major constituent components are: a. the Solar Panel, b. Charge controller, c. Inverter, d. Battery.

Photovoltaic (PV) is the technology that serves to change or convert solar radiation into electrical energy directly. The word is derived from the language of Greece, photos which means light and volt mean voltage. PV is usually packaged in a unit called the module. In a solar module consists of many solar cells that can be arranged series or parallel. Whereas the definition of solar is a semiconductor element that can convert solar energy into an electric photovoltaic effect on the ground. The core of PV job is edit or convert energy from solar radiation into electrical energy. Some of the components used is a semiconductor element called solar cells, and then organized into a solar module.

Solar systems photovoltaic common worn for lighting is a system individuals or that more often known as the solar home system (SHS). This system has voltage 12 V dc, consisting of one module photovoltaic, batteries, instrument controller and 3 lamp and a stop contact. (Abu Bakar, 2006).

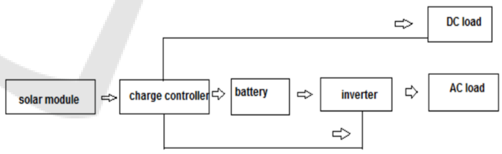

Figure 3. Module Solar Cell System Block Diagram

From the diagram above can explain that the energy in sunlight into electrical energy by the convert module will be channeled to a charge controller to adjust the charging electrical energy in the battery. From this controller charger can also directly use to load DC or go directly to the inverter to change the current air conditioning Next electrical energy in the battery will generate in convert by direct current (DC) to alternating current (AC) so it can be used in the load.

Charge of controller on the system (solar power stations) can as a brain because of their functions as officers electric current good against the current enters or current out / used.

Inverters in principle, photovoltaic generates a current of DC (unidirectional). When the required AC currents (alternating), then it can be met by installing a tool modifiers, electronic equipment that works very efficiently is called an inverter. Inverter specification is not the same i.e., depending on the extent of the power consumption of the entire electrical equipment. The greater the need for power, then the power inverter capacity also grew.

Battery is a device that converts the chemical energy directly into electrical energy. A battery consisting of voltaic one or more cells and every voltaic cell consisting of two half cells connected in series by electrolyte conductive containing the anion (negative ions) and cation (positive ions). In oxidation reaction reduction, battery power reaction reduction (the addition of electrons) to cation happens, at the cathode while oxidation reaction (electrons deleted) to anion happening anode. Electrodes not interconnected, but connected electrically by an electrolyte which may be either solid or liquid. Battery is a source of electricity obtained through a chemical process to get electrical energy by long time it takes plate positive and negative plate enough. Positive and negative plate prepared gregarious then sealed each other and made no relation one against another.

2 PROBLEM STATEMENT

In the utilization of solar energy photovoltaic are used to directly convert solar energy into electrical energy. The use of photovoltaic energy plants as a source of electricity can be said to produce no pollution, air pollution and noise pollution to the surrounding environment. Based on these considerations, it appears that photovoltaic conversion of sunlight into electrical energy will be the main energy source in the future. In addition, the price of conventional energy sources will continue to be higher and its preparation is also very limited, while photovoltaic prices gradually going down as a raw material abundant on the Earth. Electrical energy is generated from photovoltaic can be used for a variety of uses. And to ensure the continuous provision of energy is then used as energy storage batteries. Electric motors become increasingly practical and economically after the number of discoveries on the technology of solar panels, battery and charger are better. Electric motor maintenance and cost effective in the work.

For solar panel treatment more easily enough cleaned once a week. Installation of electric motors is simpler and also does not require refrigeration. All electrical power needs in the supply from the battery is recharged by solar panels. With this system is expected to reduce fossil fuels. But now the problem is confined to the ship, and to apply this system needed a place. In this final project will examine the effectiveness of solar cells. Where the obtained results expected are references to the ability of solar cells in generating electrical energy where the final result is expected to be aware concerning the efficiency of solar cells.

The need for electricity in a ship must provide by the generator and its immense power available is very dependent on operational the ship. The generator choices is specialized of idealizing systems in this role for planning because it involves tecno-economy problem. The requirement or common rules electricity a ship between other:

1. Supply electricity to vessels needs. System neutral body of ship grounded on may not except:
   - Zinc anode protection system must be a cathode or the outer part body of ship;
   - System limited or local ground as system starting and starting motor in motor fuel combustion;
   - A measuring monitor insulator instrument to the current that circulated no more than 30 mA in the worst of conditions;
   - High voltage neutral ground to avoid dangerous areas were defined in requirements.
2. Power supply and distribution.
   - Generator, switch board and battery must be in a separate location from the fuel tank and oil pump, with a cofferdam or with sufficient distance.
   - Cable that may be open to steam and gas needs to be protect with insulation in accordance, with the possibility of reducing corrosion.

Some requirements in the form of cable for installation on board based on the position where the cables will be placed, adapted to the structure of the ship so that the installation and buffer plate avoid of strains/stresses possibility. Stages of electricity ship system from the genset generator with his drive that serves as power plants that supply all the needs of electric power on board. Then the flows in the channel generate main switch board (the main liaison panel) which is a main panel that combines the power of some existing genset for distributed the junction was then in the forward to all components of each junction. Junction power is a terminal of some existing equipment on board that require a three-phase electric power:

a) Junction lighting is a terminal for the power supply to be used as a means of lighting (lights) on the ship.
b) the Junction is a communication terminal for the power supply being used as communication tools on board.
c) Monitoring the terminal Junction is to supply electric power to be used as a monitoring tool.

After using the genset, ships can use the power of the land through shore connection which is usually in use at the time of the ship's docking. If the genset is not active then the emergency source of electrical power (power source) is usually in the form of battery. Due to the nature of the emergency then only certain equipment and very important in the supply by the emergency source of electric power for example his lights, lamps, navigation, gangway lighting appliances, and others. Emergency power source will be stored automatically through the emergency switch board if all the genset is not active.

3 RESULT

3.1 For Power Lightning Equipment

The following are the main data from the main Ferry Ro-Ro 500 GRT:

Length Over All LOA = 45,05 m
Length between Perpendicular LPP = 40,15 m
Length of Water Line LWL = 42,00 m
Breadth B = 12,00 m
Height H = 3,20 m
Draft T = 2,15 m
Velocity Vs = 11 knot
Main Engine = 2 × 800 HP
Auxiliary Engine = 2 × 80 kVA
Gen set emergency = 25 kVA
Power lighting needs:

a) For the main lighting lights used fluorescent and neon lights.
b) For emergency lighting lamps mounted at the steering wheel, desk maps, alleys, stairs, engine room, and locations that are considered important or in accordance with the requirements of the BKI.
c) Lighting lights for engine room, bathroom/toilet, kitchen and rooms open from types that are waterproof (water tight).

Table 1. Power lighting needs

Bottom Deck	Total (unit)	Load (watt)	Used (hour/day)	Power (Kwh/day)	Description (hour used)
Steering engine room	2	20	12	0,48	conditional
Void room (4 rooms)	1	20	12	0,96	conditional
Emergency light (signal)	5	5	12	0,3	conditional
Vehicle Deck					
Emergency generator room	1	20	12	0,24	18.00-06.00
Stairs to engine room	2	10	12	0,24	18.00-06.00
Crew room (6 rooms)	1	20	12	1,44	18.00-06.00
Stairs to void room	2	20	12	0,48	conditional
Engine room stairs	2	20	12	0,48	conditional
Toilet (4 rooms)	1	10	12	0,48	conditional
Vehicle load room	16	20	12	3,84	18.00-06.00
Lifeboat	2	40	12	0,96	18.00-06.00
Store	1	20	12	0,24	conditional
Emergency Light (signal)	16	5	12	0,96	conditional
Passenger Deck					
VIP passenger outside light	2	40	12	0,96	18.00-06.00
VIP passenger room	8	20	12	1,92	18.00-06.00
Ornament room (2 rooms)	1	10	12	0,12	conditional
Toilet/bath room (10 rooms)	1	10	12	1,2	conditional
Economy passenger room	22	20	12	5,28	18.00-06.00
Economy passenger outside light	2	40	12	0,96	18.00-06.00
Cafeteria	1	20	12	0,24	18.00-06.00
Tatami room	2	20	12	0,48	18.00-06.00
Masjid	2	20	12	0,48	18.00-06.00
Urinary	1	20	12	0,24	18.00-06.00
Wudhu (ablution) space	1	20	12	0,24	18.00-06.00
Emergency lamp (signal)	10	5	12	0,6	conditional
Navigation Deck					
Steering room	5	20	12	1,2	18.00-06.00
Chief Engine room	1	20	12	0,24	18.00-06.00
Master room	1	20	12	0,24	18.00-06.00

Solar cell specification:
FV Energy, FVG 240P – MC:
Power peak : 240 W
Efficiency : 14,6 %
Tension module : 30,50 V
Current module : 7,88 A
Open circuit tension : 37,60 V
Short circuit current : 8,28 A

From the selection of the solar panels, it can be calculated how many pieces of solar panels needed to meet the needs of power for lighting load. For conditions in Indonesia, even though the duration of the sun shines for 8 hours/day (08.00-16.00), but the effectiveness of the photon beam obtained solar panels during the day is 5 hours. Thus the number of panels to meet the needs of power of 33600 W_h as much:

$$\frac{33600\ W_h}{240\ W \times 5\ hr} = 28 \text{ solar cell}$$

In this case will be installed as many as 35 solar panels, where the addition of a number of solar panels as much as 7 units as backup power when the solar intensity less than 1000 W/m2. With extensive consideration of the deck platform is still able to accommodate the number of solar panels, in addition to the power generated will be greater or in other words the addition of solar panels directly also adds to the amount of power generated. The amount of power generated by the solar panels in one hour: 35 hours x 240 Watt = 8400 Watt hour. The amount of power generated by the solar panels is in 5 hours is: 8400 W x 5 hours = 42000 Watt hour = 40 kWh of solar panel quantity, then solar panels chosen is FV energy, FVG 240P-MC model with consideration to address the needs of the power load of information. It has solar panels power largest so enough to area on the bridge deck 20 m x 8 m = 160 m^2 and is installed with a slope of 150.

From the regulator or charge controller specification that is, the maximum current that can be issued charge controller is 60.0 Ampere. Whereas current generated by a solar panel voltage with a 30.50 volt is 7,88 Ampere, so one charge controller is used only for: 60/7.88 = 7 units of solar panels. Total charge (n) = total amount solar panel/7 = 5 units.

Output current for 1 charge controller:
I = 7,88 A × 7 solar panel
= 55,16 A (maximum current released by charge controller 60,0 A)

Output for 6 charge controller:
I_{output} = I × (n)charge
= 60 A × 5
= 300 A

Charger capacity = output charge current × total charger × used time
= 60 A × 5 × 12 hours
= 3600 Ah

Power produced for 5 chargers :
I_{output} = 300 A
V_{output} = 12 V
Power = $I_{output} \times V_{output}$
= 300 A × 12 V
= 3600 Watt = 3,6 kW

To ensure that the system can operate properly and in accordance with good and suits the needs of load need planned design of the battery system. Note the overall burden of the solar panels of 42 kW_h battery planned to use Marine Batteries, Rolls Series 5000 type with a capacity of 370 A_h (according to spec). The resulting power battery:

Battery power = battery capacity × battery voltage
= 357 A_h × 12 V
= 4284 W_h
= 4,284 kW_h

Total battery for needed the total power 42 kW_h :
Total battery (n) = total power / power battery
Total battery (n) = 42 kWh / 4,284 kWh = 9,80 ≈ 10 units

Battery capacity for 8 units :
Q_{total} battery = 357 Ah × 10 units
= 3570 Ah

Battery power :
Battery power = 3570 A_h × 12 V
= 42840 W_h
= 42,84 kW_h

After determining the number of batteries required, the next step is to calculate the length of use of the battery. Where known:
Battery capacity = 357 A_h
Battery voltage = 12 Volt
Long Used = 12 hours
So:
Power per hour = battery power / long used
$= \frac{357\ A_h \times 12\ V}{12\ hours}$
= 357 W_h

Battery used = power battery / power per hour
$= \frac{357\ A_h \times 12\ v}{357\ W_h}$
= 12 hours

Battery charge = $\frac{\text{battery power x total battery}}{\text{solar cell over all power}}$
$= \frac{357\ A_h \times 13\ V \times 10\ batteries}{42000\ watt}$
= 1.02 hour

In the design of this solar panel system, the current is generated from solar panels is direct current or DC (Direct Current). While the current required for the lighting system is current on his boat back and forth turning or AC (Alternating Current). To change the DC to AC inverter needed inverter. Planned use of Xantrex inverter sine wave type, then the number of inverters needed is:

Number inverter = solar cell overall power/ power output inverter
= (42000 W)/(4000 W) = 10, 5 ≈ 11 units

In the plan the placement of solar panels on the deck of the bridge and the solar panel system components in the void or empty space under the deck of the vehicle with a total area of 12.4 m x 12 m = 148,8 m^2. As for the number of each component and its size:

a) Charger controller, amount: 5 unit, dimensions: 37 cm x 15 cm x 15 cm, weight: 0.45 Kg/unit
b) Battery (12 Volt 74 A_h), amount: 10 unit, dimensions: 55.9 cm x 17.8 cm x 6 cm, weight: 123.4 Kg/unit
c) Inverter amount: 11 unit, dimension: 53.4 cm x 38,1 cm x 22,86 cm, weight : 16 Kg/unit

Then the total weight of the whole solar system of solar panels and other components in the completeness of 2054.75 Kg.

3.2 Power Need Analysis for Cooling System

Words like “is”, “or”, “then”, etc. should not be capitalized unless they are the first word of the title.

Power need for the ship's cooling system Ro-Ro ferry is used for Steering Room, Passenger Rooms, Cabin Crew Rooms and the Control Room, installed air conditioning (AC) machine in the form of AC

Split in each room. AC Blower must be arranged so that every part of the room to get the same temperature influence. Engine/generator AC should be placed outdoors and protected from direct weather influences and the sea air or given a construction for protection against the weather. For AC generators placed on vehicle load space must be given a protective fender, or construction to protect the generator from the possibility of a collision with a vehicle.

Specifications for AC and its placement are:

- The engine control room : 1 x ½ PK
- Medical Room : 1 x ½ PK
- Mess Room : 1 x ½ PK
- Captain and Engine Room Operators : 1 x ½ PK
- Mosque Room : 1 x ½ PK
- Passenger Executive Room : 4 x 1½ PK

There are 3 factors to consider when determining the need for PK of AC power conditioners, namely AC power (BTU/hour), electrical power (Watts), and PK of the AC compressor. Actually number PK on AC power is a unit on the AC compressor, not AC cooling power, so to decide on the power need, we must look from the specification of AC.

Table 2. Power Need

Room's Name	Unit	AC Power (PK)	AC Power (BTU/h)	AC Power (Watt)
Engine Room	1	1/2	± 5000	220
Captain & Engine Room Operator	1	1/2	± 5000	220
Passenger Executive Room	4	11/2	± 12000	1560
Medical Room	1	1/2	± 5000	220
Mosque Room	1	1/2	± 5000	220
Mess Room	1	1/2	± 5000	220
			Total	2660

According to the table 2, it needs power for air conditioner on board during the cruise of 10 hours is 2660 x 10 = 26,600 W ≈ 26.6 Kwh.

In determination of solar panels which will be used, there are parameters that serve as a reference. The parameters in selection solar panels are:

- General rule in passenger vessels. It is used as a reference by which solar panels this can be mounted on board, because not all parts of a passenger ship can be mounted by solar panels.
- Room available on a passenger ship. Solar panels selected for planning power plant will be adjusted with a common plan (general arrangement) a vessel ferry Ro-Ro, so they will be known how many panel that can be attached on board.

Based on data of the irradiating sun from several locations in Indonesia, solar radiation in Indonesia can be classified as follows [9]:

- to western region Indonesia around 4.5 kwh/m^2 day with variations monthly about 10%.
- to eastern Indonesia around 5.1 kwh/m^2 day with variations monthly about 9 %.
- wind speed average in Indonesia about 4.8 kwh/m^2 day with variations monthly 9 %.

From calculation of the total solar module above then we chosen brands of solar cell to be used is type FVG 240P – MC with the specifications:

- Power peak : 240 watt peak
- Efficiency : 14.6 %
- Voltage of module (max) : 30.50 V
- Current of module (max) : 7.88 A
- Current of short circuit : 8.28 A
- Voltage open circuit : 37.60 V
- Dimension : l × b × h (1650 × 990 × 35) mm

From selection of the solar panels, it can be calculated how many pieces of solar panels needed to meet the power for cooling load. For conditions in Indonesia, even though the duration of the sun shines is 8 hours/day, but the effectiveness of the photon beam obtained solar panels during the day is only 5 hours.

With so many panel to meet the needs of power equal to 26600 watt as many as the efficiency of solar panel hence: 240 x 14.6 % = 204.96 W.

The number of panel = (26.600 Wh) / (204.96 W x 5 hour) = 25,956 ≈ 26 solar panels. This solar panel will be installed as many as 26 solar panels with consideration of the bridge deck is still able to accommodate the number of solar panels, Besides all the power produced will be higher than or in other words the number of solar panels directly also increased the amount of resources resulting.

The amount of power generated by the solar panel in 1 hour is: 26 x 204.96 Watts = 5328.96 Wh. The magnitude of the power generated by the solar panels all over in 5 hours is: 5328.96 x 5 = 26644.8 Wh.

Then solar panels chosen is FVG 240P-MC model with consideration to address the needs of load power lighting. It has solar panels, power and sufficient for the largest area on the deck of the bridge 20 x 8 = 160 m^2.

For the placement of solar cell will be placed on deck wheel house and the installation is done in parallel in order to optimize the absorption of solar energy.

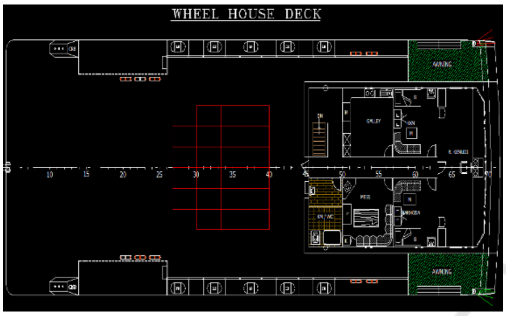

Figure 4. The Placement of Solar Panel in Deck House

From the existing controller charger specifications, the maximum current that can be issued charger controller is of 60 A. Whereas current generated by a solar module with voltage of 30.5 V is 7.88 A. So that one charger controller was only able to be used for 7 pieces of solar modules.

The number modules of 1 charger = (charger power) / (power module) = 60/7.88 = 7.61 ≈ 7 pieces, so for 1 charger controller accommodates up to 7 panels.

To determine the amount of controller charger:
charger = (number of modules) / 7 = 1/7 = 3.28 ≈ 4 controller charger.

Current output for 1 charger controller:
l = 7.88 x 7 = 55.16 A (the current maximum of 60 A controller charger issued)
Current output 4 controller charger for 10 hours :
o_{utput} = l x (n) charger = 60 x 4 x 10 = 2400 A
The Total power generated by charger controller: 60 × 4 × 24 V = 5760 Watt

To determine the battery used:
Battery capacity = 1104 Watt, battery voltage = 4 Volt.
Battery current: 1104 x 4 = 4416 Wh ≈ 4,416 Kwh
Then the number of batteries needed to load total:
Number of the battery = (total load needs) / (battery power) = 26600/4416 = 6.023 ≈ 6 battery
Battery capacity for 6 units is: Q_{batt} = 1104 x 6 = 6624 Ah

Total battery capacity is: Q_{tot} = 6624 bat x 4 = 26496 Wh = 26.496 KWh
Battery charging time = (battery power) / (power solar cell)
= (1104 x 4 x 6)/(26 x 204,96) = 4.97 hour.

Battery operating Time = (operational length of battery power)/(total load power that needs)
= (26496 x 10)/26600 = 9.96 h.

In designing this solar cell system, the current resulting from the solar module is the current DC. While the current that is used to drive the compressor using the flow of AC current to change DC, needs inverter current. Planned use type XANTREX model SW3024E with the specification:
- Power : 3300 watt
- Voltage : 24 V
- Efficiency: 94%, so 94% x 3300 watt = 3102 watt

The amount of inverter need:
Total inverter = Inverter produced / Inverter power
= 26644.8 / 3102
= 8.59 ≈ 9 inverter

The amount of resources which are borne generator is:
VA = 80,000 – 26,496 = 53,504 the amount of power and the savings could be done is:
Saving energy = (the load early - the load after) / (the load early) x 100 %
= 80,000 / 53,504 x 100 % = 1.49 %
Analysis of driving force system between diesel engine and solar cell:
Ship propulsion system component:
- ♦ with motor diesel:

- 1 unit auxiliary 80 kVA
- Tool kit engine

- ♦ with solar cell:

- Use solar cell 26
- 4 controller charger
- 6 battery
- 9 inverter

The calculation of fuel consumption using generator power planned 80 kVA, for 10 hours cruise:
W_{fo}: 80 x 210 x 10 x 10^{-6} x 0.6 = 0.1008 tons
The volume of fuel:
$W_{fo} / \gamma_{fo} =$ 0.10 / 0,85 = 0.11 m^3 = 110 liter
The price of diesel fuel for the total fuel shipping is 110 liter and the price of 1 liter of marine diesel is Rp 8,500,-
The calculation for motor diesel:
Investment for the purchase of diesel
- Generator 1 unit: Rp. 43.000.000,
- Tool kit-engine 1 set: Rp. 2,000,000,-

Operations:
The fuel for the 5 trip for 1 day needs 110 liters.
- 1 day cruise 110 liters x Rp 8,500 = Rp 935,000
- For a year Rp 935,000 x 365 days = Rp. 341,275,000
- For 5 years Rp. 341,275,000 x 5 =: Rp. 1,706,375,000,-
- For 10 years = Rp. 1.706.375.000,-
For 10 years usage performed 4 times engine maintenance and costs Rp 6,000,000 x 10 : Rp 60,000,000.-
Investment for the purchase of solar cell:

- Using 26 units solar cell @ Rp. 3,139,500- = Rp. 81,627,000,-
- 4 pieces charger controller @ Rp. 6,490,000,- = Rp. 25,960,000,-

- 6 batteries @ Rp. 9,093,500,- = Rp. 54,561,000,-
- 9 inverter @ Rp. 34,950,000 = Rp. 314,550,000,-
- 1 tool kit set engine: Rp. 2,000,000,
Operational battery backup 6 pieces @ Rp. 9,093,500,- = Rp. 54,561,000,-
Maintenance costs for 10 years @ Rp. 2,000,000/yrs = Rp. 20,000,000,-

Table 3. Total Investment

Year	Generator	Solar cell
1	Rp. 341,275,000,-	Rp. 434,329,500,-
5	Rp.1,706,375,000,-	Rp. 10,000,000,-
10	Rp.1.706.375.000,-	Rp. 20,000,000,-
After 10 years	Rp. 60.000.000,-	Rp. 54,561,000,-
Total	Rp. 3,814,025,000,-	Rp. 553,259,000,-

4 CONCLUSIONS

1. From an analysis of existing loads needs, the design of utilization of power lighting equipment on the 500 GRT Ferry needs:
   a) Early loads generator = 80 kVA
   b) Necessity after loads = in because of loads 42000 VA supplied by solar system, that generator load is:
   80000 - 42000 = 38000 VA = 38 kVA
   c) Energy savings can be done is:
   = early load – after loads × 100 %
   = × 100 %
   = 52,5 %
   d) The amount of a solar panel that can be mounted on the deck of the bridge with a total area of 160 m2 as much as 35 solar panel considering the rules applicable to the Ro-Ro Ferry ships.
   e) The other amounts is: 5 unit charger controller, 10 unit batteries, and 11 unit inverter.

2. Total overall resources for 5 trips Merak-Bakaheuni cruise trip is 26.6 kWh. This value is calculated based on 1 trip cruise for 2 hours. Based on the data above, the planning of solar cell for the cooling system are as follows: The module used is type FVG 240 P-MC with:
   a) Power peak specifications: 250 Watts
   b) Efficiency: 14.6%
   c) Voltage module (max): 30.50 V
   d) Flow module (max): 7,88 A
   e) Short circuit Currents: 8,28 A
   f) Open circuit Voltage: 37,60 V
   g) Dimensions: p l t (1650 x 990 x 35) mm
   h) Output power panel : 204,96 Watts

The amount of the planned solar cell is 26 units with the effectiveness of the Sun for about 5 hours, so that the total power output is obtained by 26,496 kWh. The overall surface area of panels for installation planning 37,57 m^2 solar cell placed on the wheel house decks with a total area of 160 m2.

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If any, should be placed before the references section without numbering.

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