Tourist Boat Electrification

By Basuki Rahmat

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Tourist Boat Electrification

Hendro Agus Widodo[1], Joesianto Eko Poetro[2], M. Basuki Rahmat[3], Purwidi Asri[5], Edy Prasetya H[6], Catur Rahmat H[7],
Marine Electrical Engineering, Shipbuilding Institute of Polytechnic Surabaya, Indonesia
mbasuki.rahmat@ppns.ac.id[3*]

Abstract; As a city crossed by rivers, Surabaya has the potential for attractive water tourism. Kalimas is one of them. Kalimas is a river that divides Surabaya. Kali Mas is a tributary of the Brantas River. This main river flows from Mojokerto as its headwaters, then flows to the northeast, empties into Surabaya, and ends in the Madura Strait. Muara Kali Mas has been Surabaya's traditional port for centuries. This port became the gateway to the capital of the Majapahit Kingdom (in Trowulan), and became part of the Surabaya people's battle against the allies before November 10, 1945. In various countries, river tourism has developed. Not only for city residents, but has become part of the State's tourism. One example is in Italy, namely tracing the river canals in Venice in Italy. Everything is described so well that everyone who comes wants to try it. Experiences and interesting photo documentation make river tourism an opportunity to develop. River tourism can be a potential alternative for Surabaya residents. Become a means of recreation or further developed into a tourist vehicle of national and even international standards. An important means of water tourism is a boat. Tour boats were developed to support the success of this tour. This article discusses the electrical installation for tourist boats that will be used on the Kali Mas River. Its power source is taken from diesel engines and also from solar panels that are capable of generating electricity.

Keywords: Tourist Boat, Electricity, River

INTRODUCTION

Surabaya as a city of heroes has many historical locations. Some of them are related or located in water areas (city's rivers area). One of the most historical and importance river in Surabaya is Kali Mas, which is a part of the Brantas river. The river is also a borderline between Surabaya City and Sidoarjo Regency and Gresik Regency. In the past and even centuries ago, Kali Mas as the wheel of economic and trade cycles even in historical records at that time became the gateway to the capital of the Majapahit Kingdom in Trowulan Mojokerto, as well as witnessing the history of the heroic battle between Raden Wijaya, the founder of the Majapahit empire and the troops. Tartars during the Mongol rule in the 13th century. During the Dutch colonial period, Kali Mas became one of the most vital means of water transportation, several modes of water transportation, both canoes, boats transporting commodities and fish caught by fishermen from the port of Tanjung Perak to the interior of the city, from Kembang Jepun to the Chinatown area to other areas. Kayun once operated a suspension bridge that could be lifted when a commodity ship passed into this area. Kalimas River is the main priority that is planned to develop river transportation, tourism transportation and goods logistics. This is considering the characteristics of the Kali Mas River with a length of about 18 KM, a width of between 20-35 meters and a depth of about 50 centimeters to six meters. One of the tourist boat models used can be seen in Figure 1. This tourist boat is very simple. Driven by a diesel outboard engine. Tour boats are operated during the day. Standard requirements for safety and operational feasibility have not been met. Therefore, it is very necessary to make tourist boats operated at night with the eligibility requirements and passenger safety a priority.

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Figure 1. The existing Tourist Boat
(https://surabaya.liputan6.com/read/4097038/pemkot-surabaya-identifikasi-4-sungai-untuk-transportasi-air)

METHODOLOGY

Research activities begin with the preliminary stages, namely literature study, data collection of load and electricity demand and analysis of demand data.

A literature study

A literature study was conducted to study the latest developments related to solar panel technology, battery technology and the utilization of solar power generation systems used as ship propulsion.

Data collection on electricity demand

At this stage, both qualitative and quantitative data were obtained from a survey conducted with the Surabaya State Shipping Polytechnic tourism ship design team. The qualitative data obtained include:

- The ship will be operated on the river in Surabaya (Kalimas River)
- The ship is only operated during the day
- Should the ship use the main source of solar panels as a source of energy
- Passenger capacity 10 people

From this data, it is known that the load includes Outboard Machines, Lighting Lamps, Decorative Lights, Remote Lights, and Sound Systems.

Calculation and Analysis

At this stage, calculations and analysis are carried out to get a complete picture of the ship's electrical needs, for tourist ships that you want to design and build in the future.

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RESULTS AND DISCUSSION

Tourist Boat Specifications

The designed tourist ship has the following specifications:

- LoA : 8.00 m
- B : 3.00 m
- H : 1.50 m
- T : 0.6 m
- CB : 0.46
- Roaming duration: 2 hours (temporary)
- Maximum speed: 5 knots (~9 km/h)
- Cruising speed: 4 knots (~8 km/h)

Figure 2 is the roof design that the plan is to use. The roof of the ship will be given 41 solar panels which will be channeled to the battery to be stored and used properly.

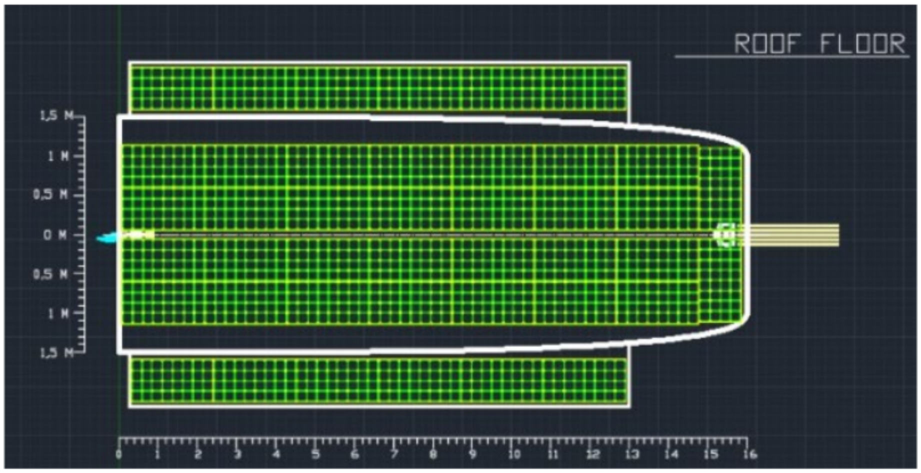

Figure 2. Solar Roof

The design of the roof of the ship is made as if there are additional areas such as two fins on the right and left. This area can be tucked under the roof if not needed. The roof is given solar panels as much as 2 x 6 cells can be added to increase input. Figure 2, is the specification of Flexible Solar Panel used in this study.

The solar panel used is a flexible Jskye model ST44M 140-FLP; each panel has dimensions of 1,435 mm x 540 mm x 15 mm, maximum power voltage (Vmp) 24.2 V, maximum power current (Imp) 5.8 A, with maximum output power (WPmax) 140 W. The picture 3, shows the general arrangement. For a schematic diagram of the electrical system shown in Figure 4.

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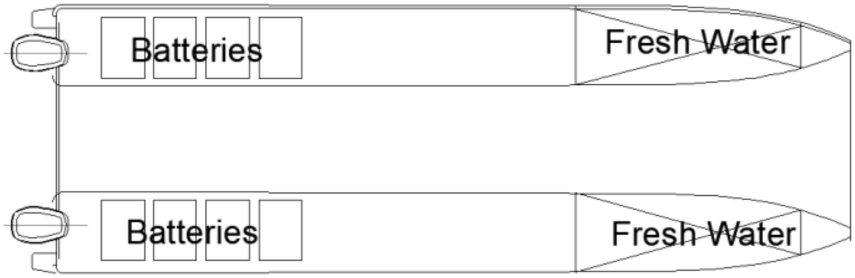

Figure 3. General Arrangement for Placement of Batteries and Fresh Water

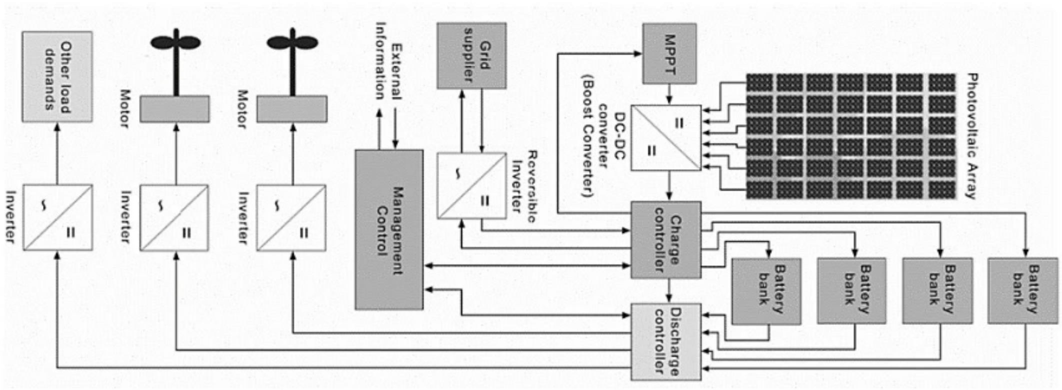

Figure 4. Electrical Schematic Diagram

Electrical Equipment Needs

The need for electrical equipment is very necessary for the convenience of passengers. For this reason, it is necessary to regulate the electrical loads, in such a way that they meet the technical requirements of the ship, including those related to heavy loads (in kg). The need for electrical equipment is shown in Table 1 below.

Table 1. Electrical Equipment

No	Part	Weight (kg)	Note
1	Hull	1560	
2	Superstructure	800	
3	Outboard Engine	180	2 unit
4	Batteries	480	8 unit; 20.6X9.4X8.8 In
5	Passenger & Crews	750	10 person
6	Solar Panel 200WP	1.5	40 unit

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From the analysis carried out, the following data were obtained. With parameter LCG = 3.6 m; TCG = 0 M; and KG = 0.55m. The Outboard Machine includes:

- Lighting
- Decorative lights
- Remote light
- Sound System (communication tools, navigation lights, AC power balance).

To calculate the load, the following equation is provided.

$P_T = P \times t$ ....(1)

$P_T = V \times C$ ....(2)

In the equation, P_T is the electrical load in a certain time (Wh), P is the wattage of the tool (W), t is the operating time (h), V is the rated voltage of the tool (V), and C is the capacity (Ah). The 15% correction factor is also important to include in the calculations. Estimated load for each equipment on board identified in Table 2.

Table 2. Electric Load

No	KOMPONEN	DAYA (WATT)	TEGANGAN (V)	QUANTITY (Unit)	TOTAL BEBAN (WATT)
1	Lampu Penerangan	10	12	4	40
2	Lampu Hias	10	12	10	100
3	Lampu jauh	30	220	2	60
4	Sound System	50	12	1	50
5	Motor Listrik Penggerak	5000	48	2	10000
				Total	10250

Electrical load balance (Power Balance) is a balance between the load and the power plant. Because not all the equipment on the ship is fully operational. The boat's electrical load is very important under certain conditions, such as when the ship is docked, sailing, and in maximum conditions. Based on the results of table 5.2, the maximum load conditions are:

10.25 kW x 2 hours of cruising x 1.15 (correction factor) = 23.5 kWh.

Batteries are used to store electricity generated by photovoltaic panels. Serves to supply ship equipment. The battery system consists of several batteries connected in series and/or parallel. The total voltage of the battery packs connected in series will be the sum of each battery pack voltage. While the total capacity of parallel connected batteries (Ah) provided will be the sum of the respective battery pack capacities. Batteries can be combined with multiple battery connections to achieve the required voltage or capacity, like 2S2P meaning that 2 batteries are connected in parallel then connected to another 2 batteries connected in parallel through a series connection. The battery type is shown in the table 3.

Based on the calculation of the electrical load, a maximum energy of 23.5 kWh is required for the remaining cruising time (2 hours). To achieve the required power, it is necessary to consider the efficiency and Depth of Discharge (about 80%) of the battery system. The required voltage is 48 V, according to the voltage of the DC motor and bilge pump. Table 4, shows the calculations that determine the battery system, which consists of 4 battery banks (parallel) with each bank consisting of 4 series of connected battery packs, to achieve load requirements of 48 V and 31 kWh.

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Table 3. The battery type

Kapasitas Normal	200 Ah
Nominal Tegangan	12,8 V.
Bobot	26 kg
Dimensi	500 x 235 x 225 mm
Pelepasan Standar (Vco, Id)	8 V, 50 A
Biaya Standar (Vc)	14.6 V.
Resistensi internal DC	50 mΩ

Table 4. Battery System Calculation

Properti	Nilai	Satuan
Muatan maksimum	23.5	kWh
Daya (Efisiensi 10%)	25.8	kWh
Total Daya (DoD)	31	kWh
Voltase yang Dibutuhkan	48	Volt
n Seri	4	pcs
n Paralel	4	pcs
Kapasitas baterai	800	ah
	38.400	Wh
Kapasitas total	38,4	kWh
Baterai Dibutuhkan	16	unit
	416	kg
Berat Sistem	00.04	ton

Photovoltaic Power Generation System

To measure the potential of photovoltaic power plants, information on the available space for the arrangement of solar arrays on the ship's roof is needed. The flexible solar module used is Skye model ST44M 140-FLP, which has dimensions of 1,435 mm x 540 mm x 15 mm, maximum power voltage (Vmp) 24.2 V, maximum power current (Imp) 5.8 A, with maximum output power (WPmax) 140 W. Based on the design of the ship and the available space, the solar modules that are possible to be installed on the roof are 40 units, with a series configuration.

The energy output of the photovoltaic array can be estimated at standard radiation using the following equation:

WN = WPmax x np ………………………………………………………………………………..(3)

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WPmax is the maximum peak wattage the panel produces and np is the number of panels installed. To produce 40x140=5.6 kWPmax. The average annual electrical energy of the photovoltaic array can be estimated by the following equation (Saputra, et al., 2019).

PDC = Qm x WN x K1 x K2 x K3 x K4

Where:

- PDC is photovoltaic energy (kWh/year)
- WN is the photovoltaic array energy output at standard radiation (kWPmax)
- Qm is the average annual flux of solar radiation; in this paper we consider a global horizontal irradiation of 1500 kWh/m2/year.
- K1 is the coefficient for temperature effect compensation. The operating temperature increases when the solar panel array is placed under the Sun. When the operating temperature rises, the power output drops (due to the characteristics of the panel material). Our estimate is K1 0.9.
- K2 is the coefficient for the stain and wear compensation coefficient in the circuit. Our estimate is K2 0.9.
- K3 is the coefficient of energy loss in the DC circuit. Solar panel systems generally have several wires to connect to each module, and that number of connections creates some constraints in the flow of electricity, which reduces the total power output of the system. Our estimate of K3 0.95.
- K4 is the energy loss coefficient in the DC-DC converter, this tool is used to convert the solar panel voltage to a battery that will be used by ship equipment. Our estimate is K4 0.95.

The table 5 shows the required photovoltaic system.

Table 5. Photovoltaic system.

Properti	Nilai	Satuan
Total Panel Surya	40	unit
Output Daya Tahunan	6.14	MWh
Output Daya Harian	16.8	kWh

Based on the calculations in table 3, the Skye ST 44 M 140-FLP solar array will be able to produce electricity of 6.14 MWh per year, and around 16.8 kWh per day.

CONCLUSION

1. The need for machinery and electrical equipment on a tour boat with a capacity of 10 people that can meet the needs on the ship is 10.5 kW.
2. It takes more than 40 units of solar panels to meet the power balance requirements of the ship's daily maximum power requirements.
3. The number of batteries required is 16 units. To meet maximum power requirements for 2 hours of roaming time

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