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Analysis Of The Efficiency Of Using Solar Cells In The Electrical System Of Non-Conventional Ship

*Tasdik Tona, Capt. Nurwahidah, Dr. Nurwahidah
Makassar Maritime Polytechnic
Makassar State University
E-mail:tasdiktona123@gmail.com

Abstract

This research aims to determine the efficiency of using solar cells in non-conventional ship electrical systems. The method that will be used in the research is the use of primary data and secondary data which will provide a comprehensive approach in this research. Based on the analysis above, a system with solar cells can produce Wh of energy per day, to meet daily energy needs with Wh of the Watts used every day. By using the battery capacity, the system has very large energy reserves, allowing the system to be used every day and will be very efficient in meeting load needs, with excess energy capacity. With a generator capacity with more than enough Wattage to meet the daily energy needs of the existing load, this means there is excess energy that can be stored in the generator.
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Keywords: Ship Electrical Systems, Non-Conventional Ship Solar Cells.

1. INTRODUCTION

Regulation of the Minister of Transportation Number KM 65 of 2OO9 concerning the Standard of Non-Convention Vessels (Non Convention Vessel Standard) Flying the Indonesian Flag, Jakarta concerning the Standard of non-convention vessels flying the Indonesian flag is a standard that applies to domestic vessels sailing in Indonesian waters. This standard is compiled and developed through studies and discussions involving government agencies, and stakeholders in the shipping sector, shipping industry and ports on selected materials from the requirements and specifications of the standard. One of the scopes of this standard is in Chapter V - Machinery and Electricity, this Standard is applied to all Non-Convention Vessels Flying the Indonesian Flag, both old and new vessels that are not regulated by international conventions.

In simple terms, NCVS regulates ships up to 500 gross tons sailing domestically. Meanwhile, ships above 500 GT are required to comply with Safety of Life at Sea (Solas) regulations.

Previous research results show that several non-conventional ships have electrical power sources consisting of generators and solar cells that are managed simply with various limitations in the use of installation materials that do not yet have standards issued by BKI or general policies.

Renewable energy is the main focus in the development of electrical systems, especially on non-conventional ships. This type of ship requires a reliable and efficient source of electricity to run various equipment that supports its operations. Solar energy is one of the renewable energy sources that can answer the need for alternative energy. The geographical conditions of Indonesia, which is an archipelagic country with a long coastline and vast oceans, are an added value for the use of solar energy (Shanty, M., Ayom, B., & Muhammad, A. 2021.).

Non-renewable sources of electrical energy are increasingly depleted, so that the continuity of electricity distribution will be hampered, and the costs required to generate electrical energy will increase. To overcome this difficulty, it is necessary to find alternative sources of electrical energy. One of these alternative sources of electrical energy is using sunlight. A tool that can convert sunlight into electrical energy is a solar cell (Adelia, AZ 2017). The application of solar cells to non-conventional ships can make a positive contribution to environmental sustainability and reduce dependence on fossil energy resources. However, to optimize its use, an in-depth analysis of a number of technical, operational, and economic factors is needed.

From the design of solar cells for electricity needs on fishing boats that have been carried out on miniature ships with a solar panel size of 10 wp, a 150 watt inverter and a 10 Ah/12 volt battery, with a weather temperature of 30o C it can fully charge the battery for 8 hours, with the power on the battery can light a 15 watt lamp for 5 hours 20 minutes. With this design, fishing boats can use solar cells. Non Convention Vessel Standard ("NCVS") is a safety standard given to ships that are not regulated in any international convention (non-convention). Regarding NCVS, it has basically been widely used by several countries, one of which is Japan (Raihan, A 2023). By understanding the potential use of solar cells and their constraints, it is hoped that it can make a significant contribution to designing an efficient, environmentally friendly and reliable electrical system. In addition, the findings of this study can also provide practical guidance for ship designers, operators and other stakeholders in selecting and implementing solar cell technology optimally in the context of non-convention ships.

Electricity on a ship can be divided into four specific systems including the Generation System, Main Switchboard System, Emergency Switchboard System, and Distribution System (European Maritime Safety Agency. 2020). The ability of an object to conduct electricity is generated from the presence of an electric charge (Julianto, T. S 2019). The electrical power installation system is the process of distributing electrical power generated from an electric power source to electrical equipment or loads that are adjusted to the provisions stipulated in electrical regulations and standards (International Electrotechnical Commission), PUIL (General Requirements for Electrical Installations), IEEE, SPLN and so on (PUIL, 2011).

Solar panels convert sunlight intensity into electrical energy through the photovoltaic process, using semi-conductor components (Dzulfikar, D,. & Wisnu, B 2016). Photovoltaic solar energy is a technology used to utilize solar energy into direct current with semiconductor devices that we commonly call solar panels (solar cells) (Purwoto, BH, et al 2018).

Solar power plants are a power generation system that uses solar energy to generate electricity (Rifaldi, M., et al 2023). Solar energy is one of the renewable energies. Solar energy is used in solar power plants to generate electricity. Solar cells will be arranged in such a way as to form solar panels (Hasrul, R). For the benefit of the solar cell system, this type of battery can still be used but is not ideal, because it uses thin plate material so that its resistance is low and has a large surface (Siagian, P., et al)

According to data from the Ministry of Energy and Mineral Resources in 2019, solar energy is one of the largest potential uses of renewable energy in Indonesia, with a potential of 207.8 gigawatts (GW). This potential shows that Indonesia has abundant solar resources, especially considering its geographical location in the tropics.

This research focuses on the analysis of the efficiency of using solar cells in the electrical system of non-conventional ships. In today's era, the development of solar cell technology has made rapid progress, and its application in the marine transportation sector, especially on non-conventional ships, is an interesting challenge and opportunity.

The use of solar cells on non-conventional ships has a positive impact on energy efficiency and emission reduction. The state of the art in this study includes increasing the efficiency of solar cells, integrating with energy storage systems, and optimizing power regulators to ensure stable electrical power availability. Several studies have shown that the integration of this technology can minimize dependence on fossil fuels.

The main references in this study include leading scientific journals that discuss solar cells, ship energy efficiency, and the latest technology in ship electrical systems. Other references include research related to the application of solar cells in marine transportation.

The research results of Ramanan, CJ (2024) show that Floating solar photovoltaic systems are rapidly gaining attention because of their potential to produce higher energy and efficiency compared to conventional land-based solar photovoltaic systems. Recent studies have shown that this technology produces 0.6% to 4.4% more energy and shows efficiency improvements ranging from 0.1% to 4.45% compared to land-based systems. Recent research also highlights innovations in the design of solar cells that are more efficient and resistant to marine environmental conditions.

From the results of previous research with the research title Implementation of Electrical Standards for Non-Convention Ships Flying the Indonesian Flag (GT 7-35) at Pelabuhan Rakyat, it shows that several non-convention ships have electrical power sources consisting of generators and solar cells that are managed simply with various limitations in the use of installation materials that do not yet have standards issued by BKI or general policies. Therefore, further research is needed to optimize the design of a more efficient solar cell system in increasing the availability of electrical power.

On this basis, this research is expected to provide a significant contribution in developing sustainable solutions for non-conventional ship electricity through an in-depth analysis of the efficiency of solar cell usage.

2. METHOD

The method that will be used in the research is the use of primary data and secondary data will provide a comprehensive approach in this research. Primary data will provide specific and relevant information obtained directly from stakeholders, while secondary data will provide context and references from existing sources. By combining the two types of data, a more complete understanding of the efficiency of solar cell use on non-conventional ships will be obtained.

The population in this study includes all non-conventional ships that have implemented solar cell technology as a source of electrical energy. This population can include various types of ships, such as passenger ships and cargo ships.

Sample selection was carried out randomly, and the sampling technique used was accidental sampling, namely taking samples that were found by chance in the research area.

3. RESULTS AND DISCUSSION

This study was conducted to analyze the efficiency of solar cell usage in the electrical system on non-conventional ships operating in Paotere Port and Majene Port. With the increasing awareness of the importance of renewable energy, solar cell technology is considered as one of the solutions to reduce dependence on fossil fuels and reduce carbon emissions in the maritime sector. The results of the analysis of survey data in the field are as follows:

Table 2. Results of Field Survey Data Analysis

No	Ship Name	Amount and Energy Produced by Solar Cells	Total Battery Capacity	Total Daily Energy Consumption	Efficient Use of Solar Cells	Battery Usage Efficiency
1	KLM HERI JAYA 02	500 Wh per day	2400Wh	250 Wh per day	50%	9.6 days
2	KM DAYA ALAM BEAUTIFUL	1000 Wh per day	3000Wh	120 Wh per day	12%	25 days
3	KLM ARCHIPELAGO WORKS	1000 Wh per day	3000Wh	180 Wh per day	18 %	16.6 days
4	KLM SINGLE JAYA	500 Wh per day	1200Wh	72 Wh per day	14 %	16.6 days
5	KLM BEAUTIFUL AIRLINES 01	250 Wh per day	2400Wh	240 Wh per day	96%	10 days
6	KLM RAINBOW 37	500 Wh per day	2400Wh	552 Wh per day	110.4%	4.34 days
7	KLM FAITHFUL HOPE 888	500 Wh per day	1200Wh	54 Wh per day	10.8%	22.2 days
8	KM Rismanas Beautiful	1500 Wh per day	2400Wh	580Wh per day	36.6%	4.13 days
9	KLM Main Masni	500 Wh per day	2400Wh	195 Wh per day	39%	12.30 days
10	KLM Masterpiece	1250 Wh per day	2400Wh	240 Wh per day	19.2%	8.8 days
11	KLM Thanks to Friends	1250 Wh per day	2400Wh	135 Wh per day	10.8%	17.7 days
12	KLM 03	500 Wh per day	2400Wh	720 Wh per day	144 %	3.3 days

Source: Processed Data (2024)

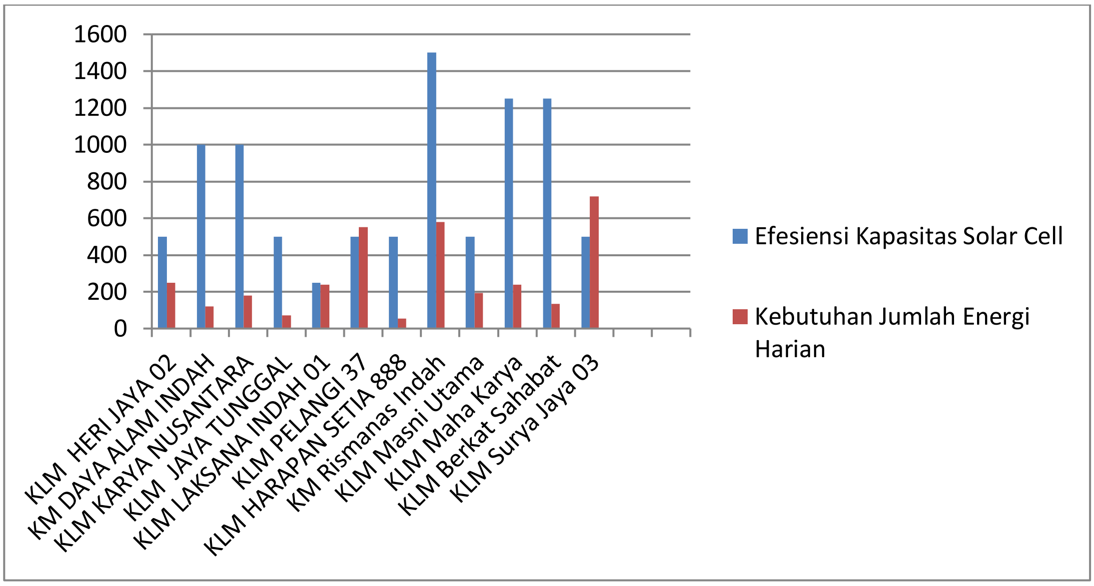

Figure 1. Graph of Battery Capacity Against Daily Energy Needs

Based onanalysis on the ship named KLM Heri Jaya 02 the use of a system with two 50 Wp solar cells can produce energy of 500 Wh per day, which is more than enough to meet the daily energy needs of 250 Wh from the existing load. Based on the analysis above the ship named KM Daya Alam Indah the use of a system with one 100 Wp solar cell can produce energy of 1000 Wh per day, which is much more than enough to meet the daily energy needs of 120 Wh from two 10 Watt lamps used for 12 hours per day.

Based on the analysis above, the ship named KLM Karya Nusantara uses a system with two 100 Wp solar cells that can produce 1000 Wh of energy per day, which is more than enough to meet the daily energy needs of 180 Wh from two 15 Watt lamps used for 12 hours per day. Based on the analysis above, the ship named KLM Jaya Tunggal uses a system with one 100 Wp solar cell that can produce 500 Wh of energy per day, which is more than enough to meet the daily energy needs of 72 Wh from two 3 Watt lamps used for 12 hours per day. Based on the analysis above, the ship named KLM Laksana Indah 01 uses a system with one 50 Wp solar cell that can produce 250 Wh of energy per day, which is more than enough to meet the daily energy needs of 240 Wh from two 10 Watt lamps used for 12 hours per day. Based on the analysis above, the ship named KLM Pelangi 37 using a system with one 100 Wp solar cell can produce 500 Wh of energy per day, which is not enough to meet the daily energy needs of 552 Wh from the existing load. Based on the analysis above, the ship named KLM Harapan Setia 888 using a system with one 100 Wp solar cell can produce 500 Wh of energy per day, which is more than enough to meet the daily energy needs of 54 Wh from the existing load. Based on the analysis above, the ship named KM Rismanas Indah using a system with one 300 Wp solar cell can produce 1500 Wh of energy per day, which is more than enough to meet the daily energy needs of 580 Wh from the existing load. Based on the analysis above, the ship named KLM Masni Utama using a system with two 50 Wp solar cells can produce 500 Wh of energy per day, which is more than enough to meet the daily energy needs of 195 Wh from the existing load. Based on the analysis above, the ship named KLM Maha Karya uses a system with one 250 Wp solar cell that can produce 1250 Wh of energy per day, which is more than enough to meet the daily energy needs of 240 Wh from the existing load. Based on the analysis above, the ship named KLM Berkat Sahabat uses a system with one 250 Wp solar cell that can produce 1250 Wh of energy per day, which is more than enough to meet the daily energy needs of 135 Wh from the existing load. Based on the analysis above, the ship named KLM Surya Jaya 03 uses a system with two 100 Wp solar cells that can produce 500 Wh of energy per day, which is not enough to meet the daily energy needs of 720 Wh from the existing load.

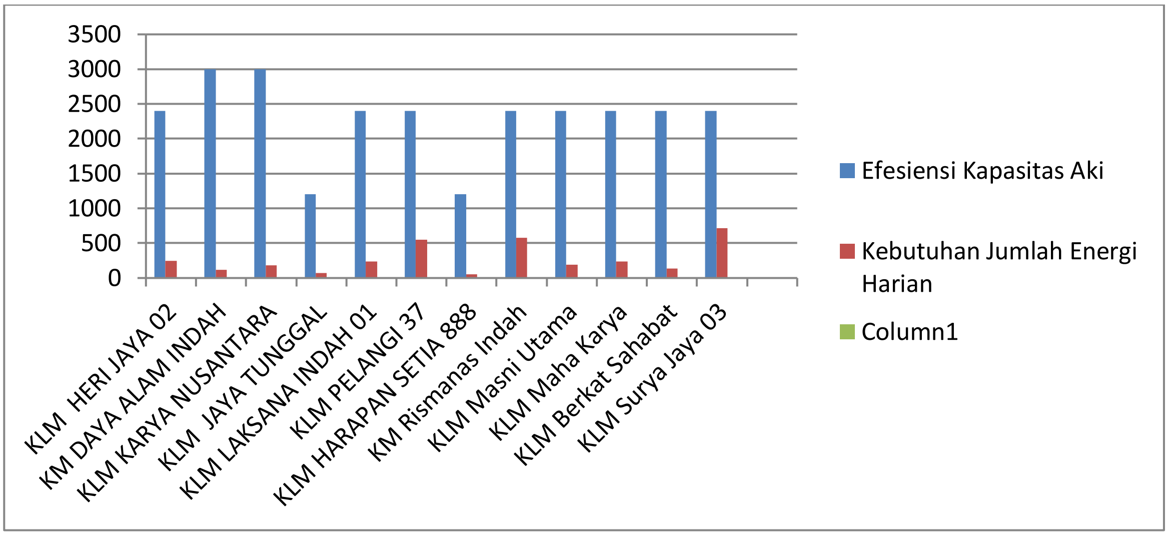

Figure 2. Graph of Battery Capacity Against Daily Energy Needs

Based on the analysis above, the ship with the name KLM Heri Jaya 02 has a battery capacity of 2400 Wh, which is more thanenough to meet the daily energy needs of 250 Wh from the existing load, this system has enough energy reserves to be used for several days without any input from solar cells, making it very efficient and reliable for use on non-conventional ships. Based on the analysis above, the ship named KM Daya Alam Indah with a battery capacity of 3000 Wh, this system has a very large energy reserve, which is more than enough to meet the daily energy needs of 120 Wh from two 10 Watt lamps used for 12 hours per day. The system efficiency is around 12%, indicating that this system is very efficient in meeting the load needs, with excess energy capacity. Based on the analysis above, the ship named KLM Karya Nusantara with a battery capacity of 3000 Wh, this system has a very large energy reserve, which is more than enough to meet the daily energy needs of 180 Wh from two 15 Watt lamps used for 12 hours per day, indicating that this system is very efficient in meeting the load needs with excess energy capacity. Based on the analysis above, the ship named KLM Jaya Tunggal with a battery capacity of 1200 Wh, this system has a very large energy reserve, which is more than enough to meet the daily energy needs of 72 Wh from two 3 Watt lamps used for 12 hours per day. The system efficiency is around 14%, indicating that this system is very efficient in meeting load needs, with excess energy capacity. Based on the analysis above, the ship named KLM Laksana Indah 01 with a battery capacity of 2400 Wh, this system has a very large energy reserve, which is more than enough to meet the daily energy needs of 240 Wh from two 10 Watt lamps used for 12 hours per day indicating that this system is very efficient in meeting load needs, with excess energy capacity. Based on the analysis above, the ship named KLM Pelangi 37 with a battery capacity of 2400 Wh, this system has enough energy reserves to be used for several days without any input from solar cells to meet the daily energy needs of 552 Wh from the existing load which makes it very efficient and reliable for use on non-conventional ships. Based on the analysis above, the ship named KLM Harapan Setia 888 with a battery capacity of 1200 Wh, this system has enough energy reserves to meet the daily energy needs of 54 Wh from the existing load used for several days without any input from solar cells, which makes it very efficient and reliable for use on non-conventional ships.

Based on the analysis above, the ship named KM Rismanas Indah with a battery capacity of 2400 Wh, this system has enough energy reserves to meet the daily energy needs of 580 Wh from the existing load used for several days without any input from solar cells, which makes it very efficient and reliable for use on non-conventional ships. Based on the analysis above, the ship named KLM Masni Utama with a battery capacity of 2400 Wh, this system has more than enough to meet the daily energy needs of 195 Wh from the existing load used for several days without any input from solar cells, which makes it very efficient and reliable for use on non-conventional ships. Based on the analysis above, the ship named KLM Maha Karya with a battery capacity of 2400 Wh, this system has more than enough to meet the daily energy needs of 240 Wh from the existing load used for several days without any input from solar cells, which makes it very efficient and reliable for use on non-conventional ships. Based on the analysis above, the ship named KLM Berkat Sahabat with a battery capacity of 2400 Wh, this system has more than enough to meet the daily energy needs of 135 Wh from the existing load used for several days without any input from solar cells, which makes it very efficient and reliable for use on non-conventional ships. Based on the analysis above, the ship named KLM Surya Jaya 03 with a battery capacity of 2400 Wh, this system has enough reserves to meet the daily energy needs of 720 Wh from the existing load used for several days without any input from solar cells, which makes it very efficient and reliable for use on non-conventional vessels so as to optimize the use of surplus energy or expand the system to support additional loads and measure the actual efficiency of system components to obtain more accurate data and understand the potential energy losses in the system.

4. CONCLUSION

The system with solar cells can produce energy of Wh per day, to meet daily energy needs with Wh from the large Watts used every day. By using the battery capacity, the system has a very large energy reserve, allowing the system to be used every day will be very efficient in meeting load needs, with excess energy capacity. With a generator capacity with Watts that are more than enough to meet daily energy needs from the existing load, this means that there is surplus energy that can be stored in the generator.

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