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Calculation of Lighting Capacity on The Pinisi Tourist Ship Using the Zonal Cavity Method

Suardi[1*], Wira Setiawan[1,3], Alamsyah[1],Amalia Ika Wulandari[1],Muhammad Uswah Pawara[1], Muhammad Yogi Raditya[2], Muhammad Rifai[1]
[1]Department of Naval Architecture, Kalimantan Institute of Technology, Balikpapan, 76127, Indonesia
[2]Architecture Department, Kalimantan Institute of Technology, Balikpapan, 76127, Indonesia
[3]Marine Technology, School of Engineering, Newcastle Upon Tyne, NE1 7RU, UK

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Abstract

The Pinisi tourist ship is one of the designs made to increase tourists' interest in Taka Bonerate National Park. This tourist destination presents excellent maritime beauty, especially its coral reefs. Just like ships in general, pinisi also requires electricity, especially for use in lighting on board. This research aims to analyze the need for lighting power on board, by carrying out the concept of a tourist ship, the lighting system is also made like in a hotel with the aim of pampering tourists. In planning, the lighting system is made into two conditions, namely conditions during sleep and normal conditions. The type of lamp used is an LED lamp which is proven to be better than other types of lamps. The method used is the zonal cavity method usually called the lumen method. The advantage of this method is that the power of the lights used in the room will be just right according to the needs of the room, neither more nor less, so it won't interfere with your eyesight because the lights don't feel dim or too bright. The results obtained were the following values for each Junction Lighting (JL), bottom deck (JL1) obtained a value of 0.419 kW, main deck (JL2) obtained a value of 1.058 kW, upper deck (JL3) obtained a value of 0.893 kW. The calculation value for the Junction Emergency (JE) was also obtained at 0.506 kW.

Keywords: Pinisi; lighting capacity; Zonal cavity method; LED Lamp; Junction Lighting.

1. Introduction

Taka bonerate is a tourist destination that presents underwater beauty located in the Selayar Islands, South Sulawesi Province. UNESCO has made this place one of Indonesia's biosphere reserves (TBKS) because of its abundant biodiversity and marine biota [1]. The impact of the COVID pandemic which paralyzed almost all economic sectors in several countries including Indonesia also weakened the attractiveness of tourists for vacations [2]. A study states that traveling to the beach, diving, and surfing are proven to be able to improve human mental health [3]. A breath of fresh air has come since the WHO decided that the world has entered a transitional phase towards the end of the pandemic and Indonesia has also lifted the Covid emergency so that the wheels of the economy and other sectors are slowly starting to grow again [4]. To grow the interest of tourists to be able to visit Taka Bonerate, it is necessary to have supporting facilities and infrastructure available at that place. If you take the example of Labuan Bajo, Bali, and Raja Ampat, the three destinations have been equipped with adequate supporting facilities so that they can attract foreign tourists to vacation there [5].

The concept of a tourist ship is not a new thing in ship design. Several studies have been carried out related to this matter such as the design of a tourist pinisi boat for the Taka Bonerate National Park area which is more into the design of the ship [6]. The concept of building tourist ships is not much different from ship designs in general. The stages that must be passed are the process of determining the main dimensions, the drawing of the lines plan and the last the drawing of the general arrangement as is done in the design of fishing vessels with a size of 70 GT. [7]. design of warships to maintain Indonesian territorial sovereignty in Natuna waters [8], and finally the design of generator ships for electricity supply on Kagean Island [9]. Because the concept being carried is a tourist ship, there are differences in terms of the ship's interior. Especially for the distribution of lighting is also made more attractive like a floating hotel. Similar research has also been carried out which has the same concept, namely the design of lighting distribution on the KMP Bambit ship which compares the power requirements when the ship uses two different types of lights [10]. The same thing will also be applied in this article, namely on the Ppinisi tour boat.

The type of lamp used in ship planning is an LED (Light Emitting Diode) type lamp which has been proven

*Corresponding author. Email: suardi@lecturer.itk.ac.id

to have many advantages over other types of lamps such as a longer lifespan and non-toxic so it is safe for the environment [11], other studies have also mentioned this. The same thing is that LED lamps are more economical than TL lamps (fluorescent lamps) [12] and LED lamps have lower levels of mercury compared to other lamps [13]. The use of this type of lamp has also been widely applied because basically, the concept of energy saving is very important to be applied on ships that only rely on power supply from generators. A study that examined the effect of using LED lights on fishing boats said that costs incurred for generator fuel could be reduced by up to 50% after using LED lights [14] and the same technology was also applied to tug boats which after a study on the use of lights LEDs to replace the TL lamps on the ship resulted in a relatively high reduction in generator power consumption [15].

Table 1. Main specifications of pinisi tourist ship.

Description of Pinisi Tourist Ship	Unit
Overall length of the ship (LOA)	26 meters
Ship width (BMLD)	6.10 meters
Ship draft (TMLD)	2.30 meters
Ship depth (HMLD)	1.6 meters
Speed Service (Vs)	10 knots
Number of crew	6 Persons
Main Engine	Caterpillar 533 kW [16]

Figure 1. 3D Image of the Pinisi Tourist Ship.

It has been mentioned above that the standard lighting rules on board are almost the same as buildings on land and this has been regulated in the American Bureau of Shipping (ABS) class regulations. The lighting level must be correct so that it is not too bright or too dim because this will affect the activities of the people on board. With all these considerations, the hypothesis in the article focuses more on the optimal level of lighting aboard the Pinisi tour, according to regulatory standards, and can be a reference in the ship's electrical installation process, especially the distribution of lighting on board.

2. Experimental/theoretical method

2.1. General Description of Pinisi Tourist Ship

This tourist ship pinisi is designed to follow the success of similar ships stationed in Labuan Bajo and Bali. The existence of the ship has proven to be very effective in increasing the interest of tourists to vacation there. The hope is that after this ship is designed, it will be able to increase the interest of tourists to tour the Taka Bonerate National Park. This wooden ship is powered by a 533 kW main engine with a mass of 1950 tons and a crew of 6 people. [16]. Ship specs in general can be seen in Table 1. For detailed ship design can be seen in Figure 1.

2.2. Electrical Installation (Pinisi Tourist Ship)

Ships are the same type of floating buildings as buildings on land because they require electrical installations for the needs inside the building [17]. The design of this pinisi ship also requires electrical installations to support operations on board. Generally, a ship requires a minimum of 2 main generators, 1 port generator, 1 emergency generator, MSB (Main Switchboard), ESB (Emergency Switchboard) and several Juntion boxes (Power Juntion, Lightning junction, Emergency Juntion, Juntion Monitoring, and Juntion Communication) to be placed on the ship deck. For a backup power source, the ship must also be equipped with a battery capable of providing power in emergency conditions. In Figure 2 you can see the distribution of power from the generator and battery to each junction.

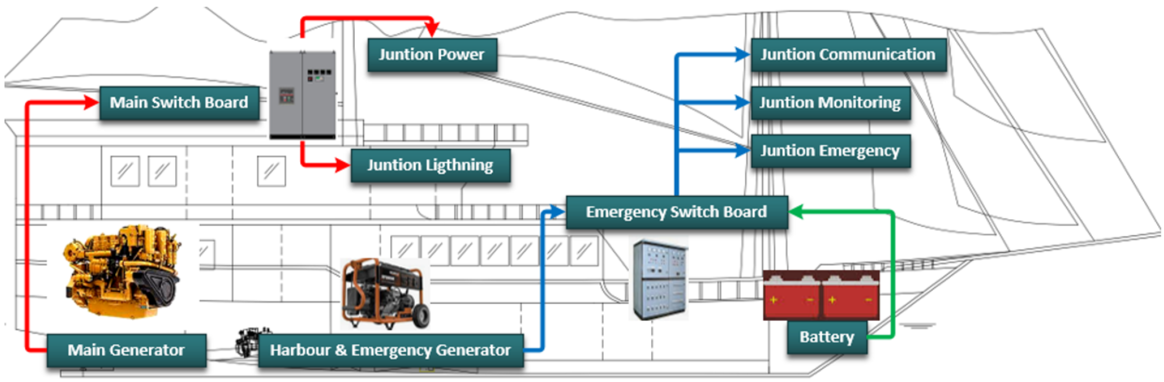

Figure 2. Electric power distribution on Pinisi tourist ship.

Table 2. Appropriate light-level criteria for Crew Accommodation Spaces

Space	Illuminance Level	Space	Illuminance Level
Cabins and Sanitary Spaces			
For the reading room in general	150 Lux		
Reading and Writing		Sanitary Spaces	
Desk	500 Lux	Lavatory/Toilet room	200 Lux
Bunk Light	200 Lux	Bath/shower area	150 Lux
Changing Room	200 Lux	Light During Sleep Period	<30 Lux
Dining Room			
Mess Room and Cafeteria	300 Lux	Snack or Coffee Area	150 Lux
Recreation Space			
Lounges	200 Lux	Gym Room	300 Lux
Library			
General Lighting	150 Lux	Bulletin Board	150 Lux
Reading Area	500 Lux		
Computer Room	300 Lux	Game Rooms	200 Lux
Movie room/Movie Theater	150 Lux	Reception Areas	300 Lux

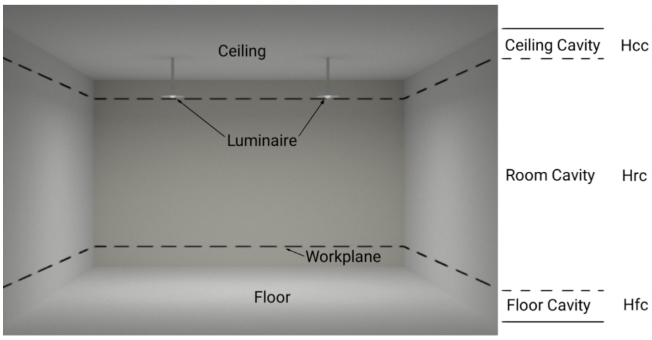

Figure 3. Cavity dimension illustration in a room.

2.3. Standard Illumination of the Room on the Ship

Illumination can be interpreted as the intensity level of the light flux emitted to a surface (floor, ceiling, wall) [18]. Previously it was mentioned that buildings such as buildings, houses, and other land structures have the same characteristics as ships so they require good lighting standards. The room above the ship must have sufficient lighting to facilitate the mobilization of crew & passengers and to facilitate every activity on board the ship. The level of lighting in the accommodation space on board can be seen in Table 2.

2.4. Zonal Cavity Method

Determining the number of lights in a room without proper calculations can cause two things to happen, namely, whether the light intensity produced by the lamp is greater or less. If the light produced is higher, it will have an impact on eye glare or can cause eye damage in the future, as well as the light is too dim, it will cause a lack of ability for the eyes to see an object. To find the right light intensity based on the dimensions of the room, the zonal cavity method can be used. This method is very familiar to be applied both for determining light over buildings and houses because it is considered accurate for indoor applications including rooms on ships because this method takes advantage of the ability of light reflection from walls, floors, and ceilings. In Figure 3 shows the cavity method which divides the dimensions of a room including the ceiling cavity, floor cavity, and room cavity [19] [20].

The first step in determining the level of lighting in the room is to first determine the Cavity Ratio, after that we calculate the reflectance factor, then the next step is to determine the utilization coefficient, and the last step is to calculate the average lighting level in the room. Room cavity ratio (RCR) is used to determine the optimal level of lighting required in each room according to regulatory standards by considering the room dimensions (ceiling, room/wall, and floor).

To get the value of the Room Cavity Ratio (RCR), the following formula can be used:

$$Room\ Cavity\ Ratio\ (RCR) = 5hrc\frac{L+W}{L\times W} \tag{1}$$

where:

hrc = distance from lighting to the work plane

L = length of a space (m)

W = Width of the room(m)

The amount of light flux required in a room is calculated by the following formula.

$$Room = \frac{E\ Room \times A}{CU \times LLF} \tag{2}$$

where:

Room = Flux of light produced in a room (Lumen)

E Room = Nominal lighting standards needed in a room (ABS standards for spaces on board ships as per table 2 with Lux unit)

A = Area of a room (m^2)

CU = Coefficient of Utilization (CU is obtained from RCR interpolation)

LLF = Light loss factor (Total)

Table 3. The ratio of Rooms on the Bottom Deck.

Lamps in Various Conditions	Illumination Standart (Lux)	Room Dimension (m)				RCR	CU
		Length	Width	Height	Area (m^2)		
Steering Engine Room	200	4.45	5.1	1.77	20.43	3.08	0.51
Engine Control Room	500	1.35	1.20	1.77	1.58	5.24	0.34
twin room 1 (PS)	150	6.50	2.33	1.77	11.23	1.94	0.59
Twin room 1 (PS) Sleeping Condition	30	6.50	2.33	1.77	11.23	1.94	0.59
Twin room 2 (SB)	150	6.50	2.33	1.77	11.23	1.94	0.59
Twin room 2 (SB) Sleeping Condition	30	6.50	2.33	1.77	11.23	1.94	0.59
Crew room 1 (PS)	150	2.50	2.33	1.77	5.70	2.76	0.54
Crew room 1 (PS) Sleeping Condition	30	2.50	2.33	1.77	5.70	2.76	0.54
Crew room 2 (SB)	150	2.50	2.33	1.77	5.70	2.76	0.54
Crew room 2 (SB) Sleeping Condition	30	2.50	2.33	1.77	5.70	2.76	0.54
Toilet twin room 1 (PS)	150	1.80	2.33	1.77	2.00	3.28	0.50
Toilet twin room 2 (SB)	150	1.80	2.33	1.77	2.00	3.28	0.50
Toilet Crew (PS)	150	1.50	2.33	1.77	3.32	3.65	0.48
Accommodation Stairs & Gangway	150	1.50	2.33	1.77	6.87	3.65	0.48
Void space	80	9.80	0.70	1.77	3.32	5.10	0.44
Lighting in an emergency							
Steering engine room	10	4.45	5.1	1.77	20.43	3.09	0.56
Engine Control Room	30	1.35	1.20	1.77	1.58	5.27	0.43
Twin room (1PS & 2SB) Generally	20	6.50	2.33	1.77	11.23	1.95	0.59
Crew room 1PS & 2SB	20	2.50	2.33	1.77	5.70	2.78	0.54
Accommodation Stairs & Alley Way	20	1.50	2.33	1.77	6.87	3.67	0.52
Void space	10	9.80	3.60	1.77	3.32	1.27	0.43

Table 4. Calculation of Luminous Flux and Total Lamp Requirement on Bottom Deck.

Lamps in Various Conditions	Min Flux (Lumen)	Flux Lamp (Lumen)	Planning	Total Flux (Lumen)	Lamp (Watt)	Total (Watt)	LED Lamp Type
Steering engine room	9306	4400	3	13200	42	126	Led E. R. Light 2' Erl
Engine Control Room	2699	1700	2	3400	17	34	Is Series 30
twin room 1 (PS)	3322	2100	2	4200	21	42	G. up Slim D. Light
Twin room 1 (PS) At Sleep	664	378	2	756	7.5	15	Berlin
Twin room 2 (SB)	3322	2100	2	4200	21	42	G. up Slim D. Light
Twin room 2 (SB) At Sleep	664	378	2	756	7.5	15	Berlin
Crew room 1 (PS)	1869	1000	2	2000	11	22	G. up Slim D. Light
Crew room 1 (PS) While sleeping	373	378	1	378	7.5	7.5	Berlin
Crew room 2 (SB)	1869	1000	2	2000	11	22	G. up Slim D. Light
Crew room 2 (SB) While Sleeping	373	650	1	650	7.5	7.5	Berlin
Toilet twin room 1 (PS)	699	1000	1	1000	15	15	G. up Slim D. Light
Toilet twin room 2 (SB)	699	1000	1	1000	15	15	
Toilet Crew (PS)	1215	1500	1	1500	15	15	
Accommodation Stairs & Gangway	2512	1500	2	3000	15	30	
Void space	716	1000	1	1000	11	11	G. up Slim D. Light
Lighting in an emergency							
Steering engine room	425	1000	1	1000	22	22	Keller Waterproof Led D. Light
Engine Control Room	130	1000	1	1000	22	22	
Twin room (1PS & 2SB) Generally	443	1000	1	1000	22	22	
Crew room 1PS & 2SB	249	1000	1	1000	22	22	
Accommodation Stairs & Alley Way	308	1000	1	1000	22	22	
Void space	91	1000	1	1000	22	22	

Table 5. Total power of the lights on the ship.

No.	In Normal Condition (JL)			In Emergency Condition (JE)	
	Deck	Power	Total	Power	Total
1	Bottom deck (JL 1)	0.419 kW	2.37 kW	0.132 kW	0.506 kW
2	Main Deck (JL 2)	1.058 kW		0.176 kW	
3	Upper Deck (JL 3)	0.893 kW		0.198 kW	

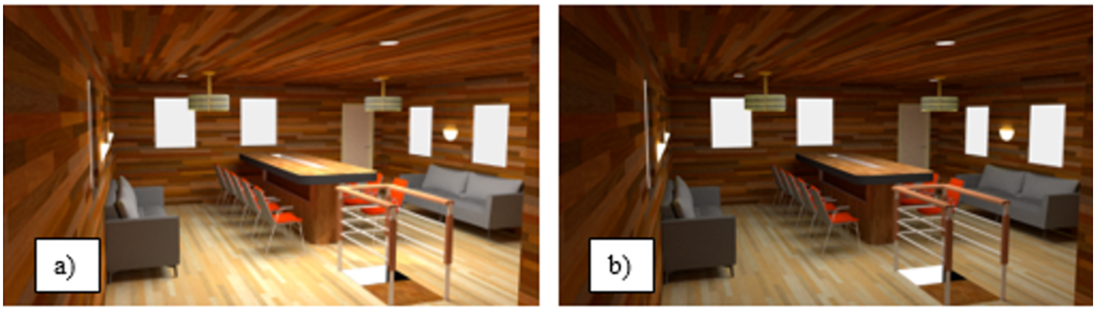

Figure 4. Lighting Conditions in the Mess Room, a) Under Normal Conditions, b) Under Emergency Conditions.

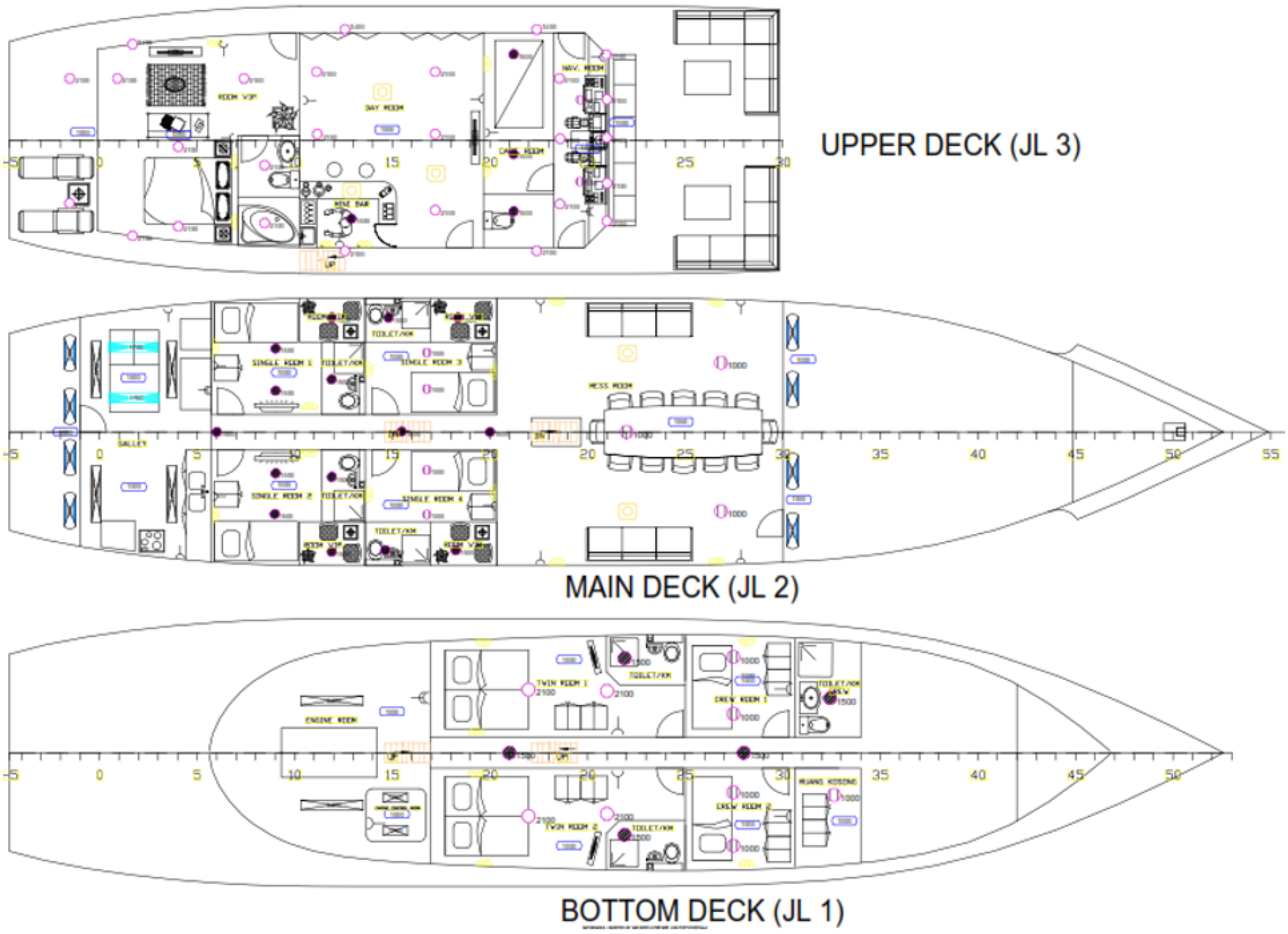

Figure 5. Plan of the Pinisi tourist ship decks using LED lights.

The total light loss factor (LLF) is composed of three basic factors: lamp lumen depreciation (LLD) and luminaire dirt depreciation (LDD). The light loss factor, along with the total lamp lumen output, varies with the manufacturer and type of lamp or luminaire and is determined by consulting the manufacturer's published data.

From this formula, we can calculate the number of lights needed in a room. The formula used is as follows.

$$N\ Room = \frac{Room}{Lamp} \quad (3)$$

where:

N space = Total lighting requirements in the room

Room = The resulting luminous flux (indoor case) (Lumen)

Lamp = Luminous flux on the lamp to be selected

3. Results and Discussion

Room conditions include the width of the room, the height of the room, the length of the room, and the area of the room as well as determining the illumination value of the room following the standards that have been set, especially regarding lighting. It is widely known that the generator power source onboard plays a role in supplying electricity for all needs on board which include lighting electricity, electricity for pumping installations, and electricity for telecommunications and monitoring (JP, JL, JM, JC, and JE). for the case of the pinisi tour ship, it is still within the limits of the ship design concept which is only limited to the shipbuilding design and general arrangement, while the installation of ship systems such as piping, machinery, propulsion, and electricity has not yet been designed, therefore, this pinisi tour ship will plan the distribution of lighting using LED lights based on lighting regulations issued by the ABS.

For the tabulation of lighting power requirements on tourist pinisi boats using LED lights, especially in the bottom deck area as shown in Table 3 and Table 4.

Tables 3 and 4 show the process of determining the number of lights used in each room on the bottom deck of the Pinisi ship. In the table you can also see the size of the room, minimum room illumination standards according to regulations, RCR and CU values, and the type of lamp used. For the bottom deck itself for lighting, it uses a total of 419 watts for normal conditions and 132 watts for lighting in emergency conditions. The total requirement for lighting power on board as a whole (all decks) can be seen in Table 5.

From Table 5 it can be seen that the total lighting power requirements for the room above the Pinisi tourism ship, there are three decks (Bottom deck, Main deck, and Upper deck) with variations in lighting, namely normal conditions and emergency conditions with each power of 2.37 kW under normal conditions (JL) and 0.506 kW in emergency ship conditions (JE).

In Figure 4, You can see 2 lighting conditions on the main deck, to be precise in the mess room section, namely normal conditions and emergency conditions. There are differences in lighting levels due to normal conditions, power is supplied from the main generator, while for emergency conditions, power is supplied from the emergency generator.

4. Conclusions

The results of the analysis using the cavity method on the tourist ship pinisi design using energy-saving lamps, namely LED lights, obtained the lighting load on the three decks of the ship, namely for the bottom deck (JL 1) of 0.419 kW in normal conditions and 0.132 in emergency conditions. For the main deck (JL 2) of 1.058 kW in normal conditions and 0,176 in emergency conditions. For the upper deck (JL 3) of 0.893 kW in normal conditions and 0.198 in emergency conditions. With that data, a conclusion can be drawn that the total electric power requirement for lighting on board is 2.37 kW in normal conditions and 0.506 kW in emergency conditions. In addition, based on a summary of other studies, LED lights have also been shown to not irritate the eyes compared to fluorescent lights. The results of this analysis illustrate that it is important to carry out simulation calculations in designing ship installations before the ship is made in its actual form so that errors do not occur in the process of determining the generator power used.

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