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30GT Fishing Vessel Electrical System Design

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Abstract: The ship electrification process is the process of installing or providing electric power to supply all the electrical power needs for ships. In general, main electricity supply will be provided, and emergency supplies in the form of batteries or emergency generators that are able to survive supplying emergency loads such as navigation equipment, navigation lights, and emergency lighting for about 3 hours. Another consideration in the electrification process on fishing vessels is also aimed at reducing dependence or even replacing conventional fuel. Of course, not all machines or equipment that are usually operated with conventional fuel can be directly replaced with electrical energy. The implementation of electrification on fishing boats takes into account the technological and cultural aspects of fishermen so that not all of them will be directly replaced by electrical energy.

Keywords: ship; electrification; fishing vessels

INTRODUCTION

Indonesia is the largest archipelagic country in the world, has a total of 13,466 islands, a land area of 1,922,570 km2 and a water area of 3,257,483 km2. The data is based on data from the Geospatial Information Agency (BIG). Indonesia's marine area reaches 63% of the total area of the Republic of Indonesia which is one of the potential fields for capture fisheries (S. Irianto et al., 2021). To support the increase in marine capture fisheries, it is necessary to fulfill adequate facilities and infrastructure, such as ships, fishing gear, fishing ports, supporting industries and the big role of various parties to develop it.

The State Fisheries Management Area of the Republic of Indonesia or often abbreviated as WPP NRI is a fishery management area for fishing, conservation, research, and fishery development which includes inland waters, archipelagic waters, territorial sea, additional zones, and the Indonesian exclusive economic zone (ZEEI).

Several studies have conducted studies on activities in fishing ports. According to (Suherman & Dault, 2009) PPN Brondong has a strategic role in the development of fisheries and marine affairs, namely as a center or center for marine fisheries activities, especially those in the Lamongan Regency, East Java. PPN Brondong, apart from being a liaison between fishermen and users of the catch, both direct and indirect users such as: traders, processing factories, restaurants and others, is also a place for interaction of various interests of the coastal community located around PPN Brondong. Brondong PPN that functions properly will be a beneficial meeting point (terminal point) between economic activities at sea and economic activities on land. While fishing areas by fishermen are mostly in the Masalembu, Makasiri, Kramean and around Bawean areas. The length of the day at sea is 7-12 days, apart from one day fishing (Mahulette & Widodo, 2011).

In this study, a study of electrification was conducted. Where the consideration in the electrification process on fishing vessels is aimed at reducing dependence or even replacing conventional fuel. The implementation of electrification on fishing boats takes into account the technological and cultural aspects of fishermen so that not all of them will be directly replaced by electrical energy figures should be cited in numerical order.

METHODOLOGY

This research method was prepared by considering several previous studies with the following steps (Cadick et al., 2012; Lee et al., 2014; Lim et al., 2019; Zahedi & Norum, 2013):

First time doing Needs Identification. The occurrence of overfishing (fully-exploited and over-exploited) in the majority of WPPNRI makes the first step to conduct electrification studies on fishing gear so that they are able to explore areas that are still moderately-exploited or towards the open sea. Based on the roaming area and the appropriate design category, the technology needed for fishing, exploration and safety aids will be determined, and then the electricity needs will be calculated. The next step is mapping. This activity was started by conducting field surveys and interviews at one of the fishing ports in East Java to better map out the types of vessels and fishing gear used. This information will be useful for consideration of the placement and size of the module/prototype designed according to the general dimensions of the ship. The next stage is design and prototype.

From the data collection in the 2 steps above, the design and prototype of the required electrification system will then be made with a possible combination of alternative energy uses. The final step is to do the analysis. The analysis is carried out on the principle of benefits, advantages and disadvantages of the electrification system compared to the conventional system. Including consideration of the weight and size of the installed module/prototype as input regarding reduction of catch and safe installation.

RESULT AND DISCUSSION

The object of research is a fishing vessel with the following specifications:

- Length overall (LOA): 21.00 m
- Length waterline (LWL): 18.95 m
- Breadth (B): 4.10 m
- Draft (T): 1.60 m
- Speed: 7 – 10 knots
- Main Motor:170 HP/1500 rpm
- Fuel tank : 3500 ltr
- Fresh Water Tank : 2500 ltr

Ships with the above specifications are designed to sail (fish) for 3-5 days with a crew of 16 people.

1. Load Identification
   The load/equipment that uses electrical energy is shown in table 1 and table 2. The equipment installed on this ship does not operate simultaneously. some equipment operate continuously (continuous) and some operate temporarily (intermittent). From this loading data, it will be used in determining the power supply capacity requirements that must be able to supply the installed equipment.
2. Loading Balance Calculation
   Load calculation is carried out by considering the loading characteristics of each equipment. There are equipments that operate continuously (continuous) and there are those that operate temporarily

(intermittent). This data is used to determine the capacity requirements of all power sources that must be able to supply the installed equipment. Calculation of the need for power sources refers to the terminology of the rules of the Indonesian Classification regarding the need for electrical power (Rules For Classification And Construction Part 1 Vol. IV Rules For Electrical Installation, 2022), chapter 3. The power balance of electrical equipment must be carried out to ensure the adequacy of power generating units, storage units and units that transform electrical energy. The power balance calculation is done by detailing which loads operate continuously and which operate intermittently, as well as considering the diversity factor for intermittent loads.

Table 1. DC power load data

No	Items	Vol (unit)	Power/Unit (W)	Voltage(V)
1	Emergency Lamp	3	15	12
2	Mast light	2	40	12
3	Side light	2	40	12
4	Stern light	1	40	12
5	Anchor light	1	40	12
6	Red light	1	40	12
7	HF radio	1	75	12
8	GPS Map + Fish Finder	1	75	12
9	Radar	1	75	12
10	SSB Radio	1	100	12
11	Wiper	1	45	12
12	Clear View Screen (CVS)	1	45	12
13	Horn	1	25	12
14	Bilge Pump	2	150	12

Table 2. DC power load data

No	Item	Vol(unit)	Power/Unit (W)	Voltage (V)
1	Wheel House Lamp	1	20	220
2	Lampu Crew room atas	1	20	220
3	Captain room Lamp	1	15	220
4	Lampu Crew Room bawah	2	15	220
5	Gang Way Lamp	2	15	220
6	Canopy Lamp	1	15	220
7	Stering gear Lamp	1	15	220
8	Crew Store Lamp	1	15	220
9	Lampu sorot AC	2	100	220
10	Engine room Lamp	1	15	220
11	Pompa Dinas Umum	1	750	220

12	Blower Kamar mesin	2	250	220
13	Bilga Pump AC	1	550	220
14	Fresh Water Pump	1	300	220

The power balance calculation is expressed in tabular form and is called the Electric Power Consumption Table (Sakai et al., 1989). In this calculation, the first step is to separate the use of loads into continuous and intermittent categories. After being separated, for each category, the load power is added up. Especially for intermittent loads, after meeting the total load power value, it is then multiplied by the diversity factor. The value of the diversity factor based on discussions with the engineering department is given a value of 0.8 which indicates a safe and realistic number from the experience of the engineering department. So at the time of sailing the total power is:

$$P_{T=} P_{cont.} + (KxP_{int.})$$

$$P_{T=} 525 + (0{,}8\ x\ 540)$$

$$P_{T=} 957\ W$$

When this power is supplied by a battery that has a voltage of 12 V, the current that flows is:

$$I = \frac{P}{V}$$

$$I = \frac{957}{12}$$

$$I = 79{,}75\ A$$

The complete results of power balance calculations for DC loads are summarized in table 3 and for AC loads in table 4. With a calculated current value of 79.75 A, the battery with a capacity approaching is a battery with a capacity of 100 Ah. This 100 Ah battery when used to supply a current of 79.75 A will be able to last for 1 hour 15 minutes. Batteries with a capacity of 100 Ah can use dry or wet types. Based on the two tables (table 1 dan 2), the generator needs to supply both AC and DC loads can be calculated. The calculation of the generator power requirement is to consider the optimal power that is usually used by the generator for operation of 0.8 of its maximum power so that the generator power is obtained:

$$P_{GENSET} = (P_{beban\text{-}DC} + P_{beban\text{-}AC})/0{,}8$$

$$= (957 + 2140)/0{,}8$$

$$= 3097/8\ W$$

$$= 3871{,}25\ W$$

Table 3. DC load power balance

APPARATUS		No.	LOAD		DEMAND FACTOR (%) CONSUMPTION POWER (WATT)								
					Going Harbour In & Out						REST IN PORT		
		Offset	Output	Input	%	Cont.	Intermi.	%	Cont.	Intermi.	%	Cont.	Intermi.
No.	*Item*		*(W)*	*(W)*		*(W)*	*(W)*		*(W)*	*(W)*		*(W)*	*(W)*
1	Emergency Lamp	3	15	15	100		45	100		45	100		45
	Total	3					45			45			45
II.	**NAVIGATION LIGHT**												
1	Mast light	2	40	40	100	80	-	100	80	-	100	-	80
2	Side light	2	40	40	100	80	-	100	80	-	100	-	80
3	Stern light	1	40	40	100	40	-	100	40	-	100	-	40
4	Anchor light	1	40	40	100	-	40	100	-	40	100	40	-
5	Red light	1	40	40	100	-	40	100	-	40	100	40	-
	T o t a l	7				200	80		200	80		80	200
	COMMUNICATION & NAVIGATION EQUIP.												
1	HF radio	1	75	75	100	75	-	100	75	-	100	-	75
2	GPS Map + Fish Finder	1	75	75	100	75	-	100	75		100	-	75
3	Radar	1	75	75	100	75	-	100	75		100	-	75
4	Wiper	1	45	45	100	-	45	100	-	45	100	-	45
5	CVS	1	45	45	100	-	45	100	-	45	100	-	45
6	Horn	1	25	25	100	-	25	100	-	25	100	-	25
7	SSB Radio	1	100	100	100	100	-	100	100	-	100	-	100
	T o t a l	7				325	115		325	115			440
IV.	**PUMP, VENT, ETC**												
1	Bilga Pump	2	150	300	100	-	300	100	-	300	100	300	-
	T o t a l	2					300			300		300	
	Continuous Load	Total *(W)*				525			525			380	
	Intermitten load	Total *(W)*					540			540			685
		Devercity factor					0,8			0,8			0,8
		Equivalent cont power *(W)*					432			432			548
	TOTAL REQUIRED POWER *(Watt)*					957			957			928	
	TOTAL REQUIRED POWER *(Ampere)*					79,75			79,75			77,33	

Table 4. DC load power balance

APPARATUS		No.	LOAD		DEMAND FACTOR (%) CONSUMPTION POWER (WATT)								
					A Going Harbour In & Out						Rest In Port		
		Offset	Output	Input	%	Cont.	Intermit.	%	Cont.	Intermit.	%	Cont.	Intermit.
No	*Item*		*(W)*	*(W)*		*(W)*	*(W)*		*(W)*	*(W)*		*(W)*	*(W)*
I	GENERAL LIGHT												
1	Wheel House	1	20	20	100		20	100	-	20	100		20
2	Crew room atas	1	20	20	100		20	100		20	100		20
3	Captain room	1	15	15	100		15	100		15	100		15
4	Crew Room Bawah	2	15	30	100		30	100		30	100		30
5	Gang Way	2	15	30	100		30	100		30	100		30
6	Kanopi	1	15	15	100		15	100		15	100		15
7	Stering gear	1	15	15	100		15	100		15	100		15
8	Crew Store	1	15	15	100		15	100		15	100		15
9	Lampu sorot AC	2	100	200	100		200	100		200	100		200
10	Engine room	1	15	15	100		15	100		15	100		15
	Total						375			375			375
II	GENERAL EQUIPMENT												
1	Pompa Dinas Umum	1	750	750	100	-	750	100	-	750	100	-	750
2	Blower Kamar mesin	2	250	250	100	500		100	500		100		500
3	Bilga Pump AC	1	550	550	100	550		100	550	-	100	550	
4	Fresh Water Pump	1	300	300	100	-	300	100	-	300	100	-	300
	Total					1050	1050		1050	1050		550	1550
	Continuous Load	Total *(W)*				1050			1050			550	
	Intermitten load	Total *(W)*					1425			1425			1925
		Deversity factor					0,80			0,80			0,80
		Equivalent Cont. Power *(W)*					1140			1140			1540
	TOTAL REQUIRED POWER (Watt)					2140			2140			2090	

3. Determination of Delivery and Security

   Determination of the conductor of the electric power system begins with calculating the current absorbed by each load. Results From the table above, the current required load is calculated and is shown in table 5.

The total amount of current that must be supplied by the battery is 88.75 A, so the base/mains safety that must be used is a fuse with a capacity of 100 A. With this fuse capacity, based on the BKI regulation (Rules For Classification And Construction Part 1 Vol. IV Rules For Electrical Installation, 2022), parts 5, copper conductors used is a cross-sectional area of 50 mm2 which has a current-carrying capability of 133 A when arranged with other measuring cables/control cables, 104 A when arranged with other power lines, and 157 A when separated from other wiring. While the busbar used to divide the load is 15 mm x 3 mm which has the ability to carry a current of 200 A. The conductor and safety values above are installed for each battery, if the number of batteries is added to increase capacity

Table 5. Calculation of Current Value at DC Load Voltage 12 V

No	Items	Vol(unit)	Power/Unit (W)	Current (A)
1	Emergency Lamp	3	15	3,75
2	Mast light	2	40	6,67
3	Side light	2	40	6,67
4	Stern light	1	40	3,33
5	Anchor light	1	40	3,33
6	Red light	1	40	3,33
7	HF radio	1	75	6,25
8	GPS Map + Fish Finder	1	75	6,25
9	Radar	1	75	6,25
10	SSB Radio	1	100	8,33
11	Wiper	1	45	3,75
12	Clear View Screen (CVS)	1	45	3,75
13	Horn	1	25	2,08
14	Bilge Pump	2	150	25,00
	TOTAL			88,75

The total amount of current that must be supplied by the battery is 88.75 A, so the base/mains safety that must be used is a fuse with a capacity of 100 A. With the capacity of the fuse, based on the BKI regulation, (Rules For Classification And Construction Part 1 Vol. IV Rules For Electrical Installation, 2022) parts 5, copper conductors used is a cross-sectional area of 50 mm^2 which has a current-carrying capability of 133 A when arranged with other measuring cables/control cables, 104 A when arranged with other power lines, and 157 A when separated from other wiring. While the busbar used to divide the load is 15 mm x 3 mm which has the ability to carry a current of 200 A. The conductor and safety values above are installed for each battery, if the number of batteries is added to increase the capacity (ampere-hour, Ah) it must be installed safety and delivery.

Table 6. Determination of Safety and Conductor For DC Load Voltage 12 V

No	Nama peralatan	Jumlah (unit)	Daya/ Unit (W)	Arus (A)	Rating Fuse (A)	Penghantar (mm^2)
1	Emergency Lamp	3	15	3,75	4	1,5

2	Mast light	2	40	6,67	8	1,5
3	Side light	2	40	6,67	8	1,5
4	Stern light	1	40	3,33	4	1,5
5	Anchor light	1	40	3,33	4	1,5
6	Red light	1	40	3,33	4	1,5
7	HF radio	1	75	6,25	8	1,5
8	GPS Map + Fish Finder	1	75	6,25	8	1,5
9	Radar	1	75	6,25	8	1,5
10	SSB Radio	1	100	8,33	10	1,5

At the load supplied by the AC generator, for wiring efficiency it is necessary to group the load on the conductor group. The conveying group is intended to supply loads from adjacent conveyance locations and lines. Based on the load grouping based on the conductor that supplies it in the table 6, it can then be determined the size of the conductor and the required safety. For alternating current (AC) loads, the conductors installed for each group use a minimum cross-sectional area of 1.5 mm^2 which has a maximum current carrying strength of 12 A when several conductors are installed close together. Based on the total value of the secured current of 14.72 A, the generator set outgoing safety is 16 A. While the busbar as a load divider is used which is 15 mm x 3 mm which has a maximum current carrying strength of 200 A. To connect the output a generator with a busbar is used as a conductor with a cross-sectional area of 2.5 mm2 which has a maximum current carrying strength of 25 A. With a current of 14.72 A and a load voltage of 220 V, the generator needs as a power supplier are:

$$P = V\ x\ I\ x\ \cos\varphi$$

$$P = 220\ x\ 14{,}72$$

$$P = 3238{,}4\ Watt$$

Gensets, under normal operating conditions are usually operated at 80% of their capacity. Overhead 20% is used as a backup to anticipate loads which in their starting conditions require relatively high starting currents, usually motor loads. Thus, the capacity of the generator required is equal to.

$$P = 3238{,}4/0{,}8\ Watt$$

$$P = 3238{,}4/0{,}8\ Watt$$

$$P = 4048\ Watt$$

With this power requirement, generators with a power range of 5000 Watt are widely available in the market, both premium and gas fueled.

Table 7. the summary result of the electrical design

No	Nama peralatan (Grup Penghantar)	Jumlah (unit)	Daya/Unit (W)	Arus/beban (A)	Arus Beban (A)
1	Wheel House Lamp (1)	1	20	0,09	0,09
2	Lampu Crew room atas (1)	1	20	0,09	0,09

3	Captain room Lamp (2)	1	15	0,07	0,07
4	Lampu Crew Room Bawah (2)	2	15	0,14	0,28
5	Gang Way Lamp (1)	2	15	0,14	0,28
6	Canopy Lamp (1)	1	15	0,07	0,07
7	Stering gear Lamp (3)	1	15	0,07	0,07
8	Crew Store Lamp (3)	1	15	0,07	0,07
9	Lampu sorot AC (4)	2	100	0,91	1,82
10	Engine room Lamp (3)	1	15	0,07	0,07
11	Pompa Dinas Umum (5)	1	750	3,41	3,41
12	Blower Kamar mesin (6)	2	250	2,27	4,54
13	Bilga Pump AC (7)	1	550	2,50	2,50
14	Fresh Water Pump (8)	1	300	1,36	1,36
	TOTAL				14,72

CONCLUSIONS

In planning the electrical system, it is very important to pay attention to AC loads and DC loads. DC load, namely navigation and safety equipment, is supplied by a battery with a capacity of 100 AH with a duration of 1 hour 15 minutes. While the AC load is supplied by a generator set with a capacity of 5000 Watt. Meanwhile, an AC load will receive a supply from a generator with a capacity of 5000 Watt. Where there are several equipment whose wiring is combined. The conductors used have a cross-sectional area of 1.5 mm^2 except for the DC bilge pump which requires a conductor with a cross-sectional area of 2.5 mm^2.

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REFERENCES

Rules For Classification And Construction Part 1 Vol. IV Rules For Electrical Installation, IV (2022). www.bki.co.id

Cadick, J., Capelli-Schellpfeffer, M., Neitzel, D., & Winfield, A. (2012). *Electrical Safety Handbook, 4th Edition*. McGraw-Hill Professional. https://doi.org/doi:10.1036/9780071745147

Lee, D. K., Jeong, Y. K., Shin, J. G., & Oh, D. K. (2014). Optimized design of electric propulsion system for small crafts using the differential evolution algorithm. *International Journal of Precision Engineering and Manufacturing - Green Technology*. https://doi.org/10.1007/s40684-014-0029-9

Lim, C. og, Park, B. cheol, Lee, J. chul, Kim, E. S., & Shin, S. chul. (2019). Electric power consumption predictive modeling of an electric propulsion ship considering the marine environment. *International Journal of Naval Architecture and Ocean Engineering*. https://doi.org/10.1016/j.ijnaoe.2019.02.011

Mahulette, R. T., & Widodo, A. A. (2011). POTENSI TANGKAPAN IKAN LAUT PADA TEMPAT

PELELANGAN IKAN DI PULAU JAWA, BALI DAN NUSA TENGGARA BARAT. *Jurnal Kebijakan Perikanan Indonesia*. https://doi.org/10.15578/jkpi.3.2.2011.159-168

S. Irianto, B., Warka, M., & Yudianto, O. (2021). Law Enforcement in Indonesia's Exclusive Economic Zone in the Framework of Indonesia's National Interest in the Marine Sector. *International Journal of Multicultural and Multireligious Understanding*. https://doi.org/10.18415/ijmmu.v8i9.3010

Sakai, H., Akizawa, H., Kitano, Y., & Yamane, K. (1989). Study on Electric Power Consumption Table for Fishing and Training Vessel. *JOURNAL OF THE MARINE ENGINEERING SOCIETY IN JAPAN*. https://doi.org/10.5988/jime1966.24.10_436

Suherman, A., & Dault, A. (2009). Pengembangan Pelabuhan Perikanan Nusantara (PPN) Pengambengan Jembrana Bali. *J Saintek Perikanan*.

Zahedi, B., & Norum, L. E. (2013). Modeling and simulation of all-electric ships with low-voltage DC hybrid power systems. *IEEE Transactions on Power Electronics*. https://doi.org/10.1109/TPEL.2012.2231884