Redesigning Generator of Landing Craft Tank 1500 DWT by Considering Technical and Economic Factors

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Abstract. The electrical system is very important thing on a ship, where the tool that functions as power to meet the electricity needs on the ship is a generator. In some cases, generator planning does not pay attention to technical and economic factors that have an impact on operations cost. The technical factor will be adjusted to the standard and regulations of the classification board, while the economic factor will be planning an efficient electrical installation and power installation system. The results obtained from this paper show the operational needs of the ship based on the condition when harbour, sailing, loading and unloading, and emergency during the day with total intermittent load of 110.6 KW and total continuous load of 130.6 KW while the operational needs of the ship at night with total intermittent load is 98.2 KW and total continuous load is 181.5 KW. Then it was found that the largest operational power requirement of the ship in an emergency at night was 38.5 KW and the largest power was in the condition of the ship at night of 102.5 KW. Then we get 3 generators with 2 sets of 60 KW power capacity and 1 set of 45 KW.

Keywords: Redesigning, Operations Cost, Landing Craft Tank

1 Introduction

The electrical system on the ship is an important thing in designing a ship. Generator is one of the equipment on the ship that is useful to meet all the power needs on the ship. In determining the capacity of the generator that will be used to meet the power needs of the ship, a load calculation will be carried out to determine the power capacity and changes in use for each operating condition. The goal is to find the minimum and maximum power required [1]. In some cases, Landing Craft Tank (LCT) 1500 DWT ship at Dok dan Perkapalan Kodja Bahari Jakarta Shipyard Unit III has a very large generator power so that it becomes inefficient for planning generator power requirements. Therefore, this paper aims to redesigning generator of LCT 1500 DWT by considering technical and economic factors. The technical factor in question is in accordance with the regulations that have been issued by a class, which in this case is the Indonesian Classification Bureau (BKI). Meanwhile, the economic factor in question is the efficiency of calculations regarding the determination of power installations and lighting installations. The author will calculate the load factor and the diversity factor on the ship. The load factor will be calculated conditions when harbour, sailing, loading and unloading and emergency. To calculate the generator capacity, first requires secondary power balance data from the installed pumps, then calculates all electric motors from the winch, lamps and other electrical equipment installed according to technical factors and economic factors. According to the Indonesian Classification Bureau (BKI) listed in Volume 4 Chapter 1 of 2004, all electrical equipment on board and the capacity of each equipment must be listed in the table.

2 Generator Capacity

The generator output power required during sea voyages must be greater than 15% of the power requirements specified in the power balance [3].

3 Ship Electrical and Equipment

The electrical components contained in the ship are divided into several parts, as follows:

3.1 Electric motor and Winch

According to (Hartono, 1988) winch or a tool commonly called a crane is a tool that needs to be able to rotate slowly to lift or extend the tros and anchors.
3.1.1 Windlass and anchor motor power

Included in the Indonesian Classification Bureau (BKl) volume 2 of 2018, regarding the calculation of the anchor plan, the following formula can be used to calculate the anchor plan:

\[ Z = \frac{D^2}{2} + 2. h \cdot B + \frac{A}{10} \]  

where \( D \) = Displacement of the ship [m³], \( h = fb + hi \) [m], \( B \) = Width of the ship [m], \( A = \) Area in side view of the hull, superstructure, and deckhouse [m²]

3.1.2 Winch and Lifeboat Electric Motor Power

According to the book "Ship Equipment and Supplies" written by Sukarsono N.A. On page 75, the motor power of the lifeboat can be calculated using the following formula:

\[ N = \frac{W \cdot t \cdot \eta}{60 \times 75 \times \eta} \quad (kw) \]  

where \( W \) = weight of lifeboat + weight of equipment + weight of crew [kg], \( t = \) motor efficiency, i.e. 0, 98 (for new motorcycle)

3.1.3 Winch and Ramp Door Motor Power

According to the book "Merchant Ship Design Hand Book Volume 5" page 58, calculating the winch drum can use the formula:

\[ I = \frac{k \cdot d \cdot L}{\pi \cdot N \cdot (D + n \cdot d)} \quad (kw) \]  

where \( k = \) provisions for wire rope 1.2, \( d = \) Steel rope 3/4 inch [m], \( L = \) Length of rolled steel rope, \( n = \) standard roll rope maximum 7, \( D = \) Diameter of drum

Then perform Hydraulic calculations based on "Maker Bosch Rexroth Hydraulics, Theory and Applications" using the formula:

\[ M = F \times r \quad (Nm) \]  

where \( F = \) Load on winch drum 9810 N, \( r = \) radius of winch drum [m]

Then calculate the flow rate of the electric motor using the formula:

\[ Q = \frac{v \cdot n}{(n \cdot \% \cdot 10^{-4})} \quad (lt/min) \]  

Then the calculation of the power input from the electric motor will be obtained using the formula:

\[ P = \frac{Q \cdot p}{6 \times 10^{-4}} \quad (kw) \]  

where \( Q = \) Flow rate pump [lt/min], \( p = \) 207 bar (existing), \( t = v \cdot h \cdot m = 0.85 \times 0.98 = 0.765 \)

The last step is to calculate the power output of the electric motor using the formula:

\[ P = \frac{Q \cdot p \cdot \%}{6 \times 10^{-4}} \quad (kw) \]  

where \( Q = \) Flow rate motor [lt/min], \( p = \) 207 bar (existing), \( t = v \cdot h \cdot m = 0.85 \times 0.98 = 0.765 \)

From the calculation above, the power from the electric motor using the formula:

\[ N = \frac{3.8 \times V}{100} \quad (kw) \]  

where \( V = \) Room volume [m³]

3.1.4 Air Conditioner (AC)

According to the book "Ship Equipment and Supplies" written by Sukarsono N.A. On page 75, the AC motor power can use the following formula:

\[ Z = \frac{D^2}{2} + 2. h \cdot B + \frac{A}{10} \]  

where \( D = \) Displacement of the ship [m³], \( h = fb + hi \) [m], \( B = \) Width of the ship [m], \( A = \) Area in side view of the hull, superstructure, and deckhouse [m²]

3.1.5 Lighting Equipment

Determination of lighting equipment on the ship in accordance with the book "Merchant Ship Design Hand Book Volume 5" is divided into 3 parts of lighting. First, inside Lighting (a), includes interior lighting covers rooms such as rooms on the main deck, poop deck, and wheel house deck. Second, external lighting (b), includes aisles on the outside of the ship, as well as places for lowering lifeboats. Third, navigation lighting (c), includes lights used by ships when sailing, loading and unloading or leaning, and so on. So from the three parts of the lighting, the total lighting on the ship can be calculated with the following formula:

\[ \Sigma = Total \; a + Total \; b + Total \; c \]  

3.1.6 Other Electrical Equipment

The electrical equipment in question is equipment that can support the completeness of the ship, such as equipment in the kitchen (a), washing equipment (b) and navigation and communication equipment (c), the following formula is:

\[ \Sigma = Total \; a + Total \; b + Total \; c \]  

3.2 Generator Power Capacity Calculation

In this case it will be explained about the calculations in analyzing the power capacity of the generator, as follows:

3.2.1 Load Factor

The load factor is very important when planning the generator capacity to distribute all the electrical power requirements on the ship. The load factor is defined as the ratio of the working time of the equipment under certain conditions to the total working time under these conditions [3].

3.2.2 Continuous Load (CL)

Equipment that operates continuously under normal operating conditions. Here is the equation formula

\[ CL = Input \times Total \; Work \times LF \quad (kw) \]  

where \( CL = \) Continuous Load [kw], \( LF = \) Load Factor, \( Input = \) Data Power Balance using Open Source software

3.2.3 Intermittent Load (IL)

Equipment that operates intermittently (periodically) in normal sailing conditions with an indefinite period of time. Here is the equation formula:

\[ IL = Input \times Total \; Work \times LF \quad (kw) \]  

where \( IL = \) Intermittent Load [kw], \( LF = \) Load Factor, \( Input = \) Data Power Balance using Open Source software
3.2.4 Diversity Factor

In short, the diversity factor is the operating load in determining the total load on the generator. Where the value of the diversity factor according to the Indonesian Classification Bureau (BKI) should not be below 0.5. So the author uses a reference from the energy and electricity journal STT-PLN Vol.9 No.6 regarding "Electrical System on the Frosch-class Navy Warship KRI Teluk Celukan Bawang 532" which uses 0.6 for the diversity factor value. The following is the equation formula for calculating the diversity factor, as follows:

\[ e = \frac{\text{Total Load}}{\text{Total Power}} \]  

(13)

where \( e \) = Diversity Factor [kw], IL = Intermittent Load [kw]

3.2.5 Power Requirement

The following is the formula for calculating the electric power capacity (power requirement), as follows:

\[ \text{Power Requirement} = \text{Total IL x e}; \ (kw) \]  

(14)

where IL = intermittent load [kw], e = Diversity Factor [kw]

3.2.6 Total Load Power Calculation

The following is the formula for calculating the total load power, as follows:

\[ P_B = \text{CL} + e \times IL; \ (kw) \]  

(15)

where CL = Continous Load [kw], e = Diversity Factor, IL = Intermittent Load [kw]

4 Analysis

4.1 Main Properties

Main properties is obtained from secondary data collection from Dok dan Perkapalan Kodja Bahari Shipyard Unit III. This data will be used as a reference for generator calculations, it can be seen in table 1, as follows:

| Parameter                  | Properties          |
|----------------------------|---------------------|
| Name                       | MV Alfa Trans Dua  |
| Length Overall (LOA)       | 64 m                |
| Length Between Perpendicular (LPP) | 56.7 m            |
| Breadth (B)                | 14 m                |
| Height (H)                 | 4.5 m               |
| Draught (T)                | 3 m                 |
| Coefficient Block (C\text{B}) | 0.76 m         |
| Speed (Vs)                 | 9 knots             |
| Displacement               | 1950 ton            |
| Crew                       | 19 Person           |

4.2 Windlass and Anchor Power

The first thing to do is to calculate the anchor plan, based on BKI volume 2 can use the following formula:

\[ Z = \frac{d_2}{3} + 2 \cdot h \cdot B + 4 \cdot \frac{A}{10} \]

Where:
- \( h = f_b + h_i \)
- \( f_b = 1.5 + 6.5 \)
- \( h_i = 8 \)
- \( A = \text{The area of the walls of the superstructure} \)
  
\[ = A1 + A2 + A3 + A4 \]
\[ = 96 \text{m}^2 + 92 \text{m}^2 + 15 \text{m}^2 + 41 \text{m}^2 \]
\[ = 172 \text{m}^2 \]

So,

\[ Z = \frac{19502}{3} + 2.8.14 + \frac{172}{10} \]
\[ Z = 156 + 224 + 17.2 \]
\[ = 397.2 \]

So from the BKI table in section 7 regarding "ship equipment" regarding anchors, anchor chains and rigging based on the \( Z \) value obtained, it can be seen in table 2, as follows:

| Item                                      | Anchor Requirement |
|-------------------------------------------|--------------------|
| Number of Anchor                          | 2                  |
| Weight 1 Anchor                           | 1140 kg            |
| Diameter 1 (d1)                           | 34 mm              |
| Diameter 2 (d2)                           | 30 mm              |
| Diameter 3 (d3)                           | 26 mm              |
| Tail chain length for bow anchor (l)      | 385 m              |
| pull rope length                          | 180 m              |
| Mooring rope length                       | 140 m              |
| Number of mooring ropes                   | 4                  |

Table 2. Data on anchor, anchor chain and rope – rigging

Calculation of 1, Anchor Electric Motor Power

- Diameter : 34mm
- Brand : Data
- Type : DZC 12001/12002
- Tensile Force : 12000 kg
- Motor Speed : 12m/min
- Motor Power : 22 kW

Then, calculation of 2 and 3, Anchor Electric Motor Power

- Diameter : 30 mm and 26 mm
- Brand : Data
- Type : DZC 7001/7002
- Tensile Force : 7500 kg
- Motor Speed : 13m/min
- Motor Power : 15 kW

4.3 Winch and Lifeboat Electric Motor Power

Based on "Ship System and Equipment" by Sukarsono, you can use the formula:
Then perform the Hydraulic calculations, as follows:

\[ M = 9810 \times 0.14 \]
\[ M = 1373.4 \text{ Nm} \]

Then calculate the flow rate of the electric motor, based on “Hydraulics. Theory and Applications, Bosch Rexroth p. 30”, using the formula:

\[ Q = \frac{n \times \pi \times r \times \eta}{288 \times 913.4} \text{ (l/min)} \]
\[ Q = 26.1 \text{ l/min} \]

Then the calculation of the power input from the electric motor will be obtained using the formula:

\[ P = Q \cdot p \text{ (kw)} \]
\[ P = 66.5 \% \text{ (kw)} \]
\[ P = 65 \text{ (kw)} \]

Then we get a winch ramp door with the following capacities:

- **Brand**: Jiangsu Jiaoyan
- **Type**: JYR14
- **Slewing Load**: 14 KN
- **Suits**: 14 people

### 4.4 Winch and Electric Motor Power Ramp Door

To calculate the winch and electric motor power, a list of materials used in the ramp door is required, the material list is obtained from secondary data collection, below is a list of materials that can be seen in table 3, as follows:

#### Table 3. Rampdoor materials

| NO | Type of Materials        | Size              | Total |
|----|--------------------------|-------------------|-------|
| 1  | Stay rampdoor plate      | 12mm x 1550 x 4500 | 4 Sh  |
| 2  | Angle profile            | 12mm x 4000 x 300  | 2 Sh  |
| 3  | Angle profile            | 12mm x 4500 x 300  | 2 Sh  |
| 4  | Engsel                   | 25mm x 350 x 450   | 18 Sh |
| 5  | Bracket                  | 30mm x 300 x 450   | 9 Sh  |
| 6  | House Roll Plate         | 12mm x 150 x 150   | 18 Sh |
| 7  | House Roll Plate         | 12mm x 300 x 300   | 2 Sh  |
| 8  | House Roll Plate         | 12mm x 110 x 300   | 4 Sh  |
| 9  | Roll bearing             | Dia. 280           | 2 Sh  |
| 10 | House Roll Plate         | 12mm x 1614 x 180  | 2 Sh  |
| 11 | Bracket                  | 12mm x 300 x 300   | 2 Sh  |
| 12 | Roll bearing             | Dia. 280           | 2 Sh  |
| 13 | Roll bearing             | 12mm x 804 x 180   | 2 Sh  |
| 14 | Roll bearing             | 12mm x 918 x 150   | 2 Sh  |
| 15 | Roll bearing             | Dia. 280           | 2 Sh  |
| 16 | Bracket Karet             | 12mm x 15 x 15     | 9 Sh  |
| 17 | Plate strip              | 10mm x 34 x 10000  | 4 Sh  |
| 18 | Rubber                   | 80 x 40 x 10000    | 2 Sh  |
| 19 | Wire rope                | Dia. 16 mm         | 100 M |
| 20 | Chain                    | Dia. 25 mm         | 20 M  |
| 21 | Seal                     | Dia. 25 mm         | 4 Bl  |
| 22 | Spanscrap                | Dia. 25 mm         | 2 Bl  |
| 23 | sch bu pipe              | Dia. 4 mm          | 2 mtr |
| 24 | Clamp                    | Dia. 16 mm         | 4 Sh  |
| 25 | tongueike                |                    |       |
| 26 | Plate                    | 12mm x 1500 x 6000 | 1 Sh  |
| 27 | RB                       | Dia. 1" (88 = 12 m)| 12 Sh |

First, by calculating the drum winch, based on the "Merchant Ship Design book 5 outfitting" as follows:

\[ l = \frac{k \times x \times L}{\pi \times N \times (D + nx)} \text{ (kw)} \]
\[ l = \frac{3 \times 14 \times 7 \times (280 + 7 \times 16)}{1.2 \times 16 \times 100000} \text{ (kw)} \]
\[ l = 222 \text{ mm} \approx 230 \text{ mm} \]

Then perform the Hydraulic calculations, as follows:

\[ M = F \times r \text{ (Nm)} \]
Table 5. Volume and ac power requirement on poop deck

| Room                | Total | Volume m³ | Power Needs (KW) |
|---------------------|-------|-----------|------------------|
| Captain Room        | 1     | 105,3     | 3,0              |
| Crew 1 Room         | 1     | 78,0      | 2,2              |
| Crew 1 Room         | 1     | 76,3      | 2,2              |
| Owner Room          | 1     | 69,3      | 2,0              |
| Engineering Room    | 1     | 105,3     | 3,0              |
| **Total**           |       | 434,2     | 12,4             |

In this case, a measurement of the volume of the room contained in the wheel house deck as follows:

Table 6. Volume and ac power requirement on wheel house deck

| Room                   | Total | Volume m³ | Power Needs (KW) |
|------------------------|-------|-----------|------------------|
| Chart Space            | 1     | 30,6      | 0,9              |
| Radio & Navigation Space | 1     | 344,1     | 9,8              |
| **Total**              |       | 374,7     | 10,7             |

Then the total power requirement is obtained according to the calculation for the entire deck of 49.3 KW.

4.6 Pumps

The data on the power requirements of the pumps are obtained from secondary data collection, as follows:

Table 7. Pump power requirement

| No | ITEM                              | No. of | Power (KW) | set | output | input |
|----|-----------------------------------|--------|------------|-----|--------|-------|
| 1  | Bilge Pump / Fire Pump            | 1      | 7,5        | 9   |        |       |
| 2  | General Service & Ballast Pump    | 2      | 7,5        | 18  |        |       |
| 3  | Sea Water Hydropathosome Pump     | 1      | 2,2        | 2,6 |        |       |
| 4  | Fresh Water Hydropathosome Pump   | 1      | 2,2        | 2,6 |        |       |
| 5  | Fuel Oil Transfer Pump            | 1      | 1,5        | 1,8 |        |       |
| 6  | Working Air Compressor            | 1      | 1,5        | 1,8 |        |       |
| 7  | Lub Oil Transfer Pump             | 1      | 1,5        | 1,8 |        |       |
| 8  | Fuel Oil Purifier                 | 1      | 2,2        | 2,6 |        |       |
| 9  | Sludge Transfer Pump              | 1      | 1,5        | 1,8 |        |       |
| 10 | Sewage Treatment Plant            | 1      | 2,5        | 3   |        |       |
| 11 | Oil Water Separator               | 1      | 0,4        | 0,5 |        |       |

4.7 Calculation of Lights on The Ship

The planning of lighting on the ship is based on the book "Merchant Ship Handbook Vol 5", as follows:

Table 8. Ship navigation lightning

| No. | Item                     | Power (KW) | Jumlah | Total Power (KW) |
|-----|--------------------------|------------|--------|------------------|
| 1   | Main Light               | 500        | 1      | 500              |
| 2   | Side Light               |            |        |                  |
|     | a. Starboard Side        | 50         | 1      | 50               |
|     | b. Port side             | 50         | 1      | 50               |
| 3   | Morse lamp               | 100        | 1      | 100              |
| 4   | Anchor Lamp              |            |        |                  |
|     | a. Bow Anchor Light      | 40         | 2      | 80               |
|     | b. Stern Anchor Light    | 40         | 1      | 40               |
| 5   | Stern Light              | 75         | 1      | 75               |
| 6   | Loading and Unloading Lights | 500   | 1      | 500              |
| 7   | Sailing Lights           | 40         | 1      | 40               |
| 8   | Lifeboat Lamp            | 75         | 1      | 75               |
| 9   | Spotlights               | 1000       | 1      | 1000             |
|     | **Total**                |            |        | 2510             |

Then the planning for lighting power requirements on the wheel house deck is carried out based on table 11, as follows:

Table 9. Poop deck lighting power requirements

| No. | Room                  | Dimension (m³) | W/m² | Power Needs (KW) |
|-----|-----------------------|----------------|------|------------------|
| 1   | Captain Room          | 1              | 3.85 | 2.74             |
| 2   | Crew 1 Room           | 1              | 3.50 | 2.55             |
| 3   | Crew 1 Room           | 1              | 3.50 | 2.50             |
| 4   | Owner Room            | 1              | 3.50 | 2.55             |
| 5   | Toilets               | 1              | 1.65 | 1.96             |
| 6   | Toilets               | 1              | 1.50 | 1.30             |
| 7   | Toilets               | 1              | 1.33 | 1.34             |
| 8   | Toilets               | 1              | 1.65 | 1.96             |
| 9   | Engineering Room      | 1              | 3.85 | 2.74             |
|     | **Total**             |                |      | 1751.28           |

Then the planning for lighting power requirements on the main deck is carried out based on table 11, as follows:

Table 10. Main deck lighting power requirements

| No. | Room                  | Dimension (m³) | W/m² | Power Needs (KW) |
|-----|-----------------------|----------------|------|------------------|
| 1   | CO2 Room              | 1              | 1.5  | 3.34             |
| 2   | Provision Store       | 1              | 2.04 | 3.39             |
| 3   | Toilets               | 1              | 2.60 | 3.34             |
| 4   | Crew 1 Room           | 1              | 3.30 | 3.00             |
| 5   | Crew 2 Room           | 1              | 3.30 | 3.00             |
| 6   | Crew 3 Room           | 1              | 3.30 | 3.00             |
| 7   | Office                | 1              | 3.50 | 2.60             |
| 8   | Mess Room             | 1              | 6.60 | 4.80             |
| 9   | Galley                | 1              | 3.30 | 3.33             |
|     | **Total**             |                |      | 3069.83           |

Then do the lighting planning for the poop, the power requirements are obtained as follows:

Table 11. Wheel house deck lighting power requirements

| No. | Room                  | Dimension (m³) | W/m² | Power Needs (KW) |
|-----|-----------------------|----------------|------|------------------|
| 1   | Chart Space           | 1              | 1.58 | 1.93             |
| 2   | Radio & Navigation Space | 2              | 5.50 | 7.60             |
|     | **Total**             |                |      | 2599.86           |
So, 

\[ \Sigma = \text{Total lights inside the ship} + \text{Total lights outside the ship} + \text{Total navigation lights} \]

\[ = 14405.27 + 3120 + 2510 \]

\[ = 20035.27 \text{ Watt} \]

It can be concluded that the need for lighting on the ship is 20.04 Kw.

### 4.8 Other Electrical Equipment Calculation

The following are the power requirements of other installed electrical equipment, based on the book “Merchant Ship Handbook Vol 6”, namely: In this case, the power used in kitchen equipment will be determined, as follows:

#### Table 14. Kitchen equipment power requirements

| No. | Item                          | Power (KW) |
|-----|-------------------------------|------------|
| 1   | Exhaust For Galley           | 1.5        |
| 2   | Waste Food Grinder           | 0.75       |
| 3   | Rice Cooker                  | 1.5        |
| 4   | Freezer                      | 0.5        |
| 5   | Water Boiler                 | 1.5        |
| 6   | Electric cooking range       | 2.5        |
| 7   | Electric universal cooking machine | 0.75 |
| 8   | Electric Coffee Burn         | 0.1        |
| 9   | Electric Fryer               | 5          |
| 10  | Refrigerator                 | 2.5        |
| 11  | Baking Oven                  | 10         |
| 12  | Hot Plate                    | 4          |
| 13  | Soup Boiler                  | 9          |
| 14  | Rice Washer                  | 0.4        |
| 15  | Others                       | 15         |
|     | Total                         | 77.5       |

In this case, the power used in washing equipment will be determined which can be seen in Table 15, as follows:

#### Table 15. Washing equipment power requirements

| No. | Item                          | Power (KW) |
|-----|-------------------------------|------------|
| 1   | Dishwasher                    | 0.5        |
| 2   | Laundry (2 x 8 kW)            | 1.6        |
|     | Total                         | 2.1        |

In this case, the determination of the power used in navigation and communication equipment can be seen in Table 16, as follows:

#### Table 16. Power requirements for navigation and communication equipment

| No. | Item                          | Power (KW) |
|-----|-------------------------------|------------|
| 1   | Marine Radar                  | 0.5        |
| 2   | Echo Sounder                  | 0.3        |
| 3   | Radio                         | 0.3        |
| 4   | Telephone                     | 0.08       |
| 5   | GPS                           | 1          |
| 6   | Telegraph                     | 0.08       |
| 7   | Others                        | 3.5        |
|     | Total                         | 6          |

In this case, the power used in other equipment will be determined which can be seen in Table 17, as follows:

#### Table 17. Power requirements for other equipment

| No. | Item                          | Power (KW) |
|-----|-------------------------------|------------|
| 1   | Power pack for steering gear  | 2          |
| 2   | Power pack for bow thruster   | 1          |
| 3   | Exhaust fan for engine room   | 2          |
| 4   | Exhaust fan for emergency generator | 1 |
| 5   | Battery Charger               | 1          |
| 6   | Exhaust fan for toilet        | 5          |
|     | Total                         | 15.7       |

### 4.9 Analysis of Generator Power Capacity Calculation during the Day

At this stage, calculations will be made during daytime conditions, as follows:
### Table 18. Harbour condition in day

| No | Item                               | Set | Power | Day | Power | Harbour |
|----|------------------------------------|-----|-------|-----|-------|---------|
|    |                                     |     |       |     |       | Generator Output |
| 1  | 1 6 6 100 1 6                       |     |       |     |       | 38,2305 |

### Table 19. Sailing condition in day

| No | Item                               | Set | Power | Day | Power | Sailing |
|----|------------------------------------|-----|-------|-----|-------|---------|
|    |                                     |     |       |     |       | Generator Output |
| 1  | 1 6 6 100 1 6                       |     |       |     |       | 31,7789 |

### Table 20. Loading and unloading condition in day

| No | Item                               | Set | Power | Day | Power | Loading&Unloading |
|----|------------------------------------|-----|-------|-----|-------|------------------|
|    |                                     |     |       |     |       | Generator Output |
| 1  | 1 6 6 100 1 6                       |     |       |     |       | 36,2058 |

### Table 21. Emergency condition in day

| No | Item                               | Set | Power | Day | Power | Emergency |
|----|------------------------------------|-----|-------|-----|-------|-----------|
|    |                                     |     |       |     |       | Generator Output |
| 1  | 1 6 6 100 1 6                       |     |       |     |       | 80,4047 |

The power requirement of the ship during the day with a total intermittent load of 110.6 KW and a total continuous load of 130.6 KW, as well as the power requirement in an emergency...
At this stage, calculations will be made during day and night conditions, as follows:

### Table 22. Harbour condition in day night

| No. | Item                                | Set | Power            | Night Harbour            |
|-----|-------------------------------------|-----|------------------|--------------------------|
|     |                                     |     | KW Total | % | Set | Cont | Int |
| A.  | Pumps                               |     |           |                           |
| 1   | Bilge Pump / Fire Pump              | 1   | 7,5      | 7,5                      |
| 2   | General Service & Ballast Pump      | 2   | 7,5      | 15                       |
| 3   | Sea Water Hydrophore Pump           | 1   | 2,2      | 2,2                      |
| 4   | Fresh Water Hydrophore Pump         | 1   | 2,2      | 2,2                      |
| 5   | Fuel Oil Transfer Pump              | 1   | 1,5      | 1,5                      |
| 6   | Working Air Compressor              | 1   | 1,5      | 43                       |
| 7   | Lub Oil Transfer Pump               | 1   | 1,5      | 15                       |
| 8   | Fuel Purifier                       | 1   | 2,2      | 2,2                      |
| 9   | Sludge Transfer Pump                | 1   | 1,5      | 1,5                      |
| 10  | Sewage Treatment Plant              | 1   | 2,5      | 2,5                      |
| 11  | Oil Water Separator                 | 1   | 0,4      | 0,4                      |
| 12  | Navigation Lighting                 | 1   | 2,5      | 2,5                      |
| 13  | Navigation and Communication        | 1   | 6        | 6                        |
| 14  | Other Equipment                     | 1   | 15,7     | 15,7                     |
| B.  | Operations                          |     |           |                           |
| 1   | Anchor windlass 1                   | 1   | 22       | 22                       |
| 2   | Anchor windlass 2                   | 1   | 15       | 15                       |
| 3   | Anchor windlass 3                   | 1   | 15       | 15                       |
| 4   | Windlass Sekoci                     | 1   | 0,52     | 0,52                     |
| 5   | Windlass Rampdoor                   | 2   | 7        | 14                       |
| 6   | Air Condition                       | 1   | 49,3     | 49,3                     |
| 7   | Lights Inside the Ship              | 1   | 2,2      | 2,2                      |
| 8   | Lights Outside the Ship             | 1   | 2,2      | 2,2                      |
| 9   | Navigation Lighting                 | 1   | 2,5      | 2,5                      |
| 10  | Kitchen equipment                   | 1   | 77,5     | 77,5                     |
| 11  | Washing Equipment                   | 1   | 2,1      | 2,1                      |
| 12  | Other Equipment                     | 1   | 100      | 100                      |
| 13  | Navigation and Communication        | 1   | 6        | 6                        |
| 14  | Other Equipment                     | 1   | 15,7     | 15,7                     |

### Intermitten Load

| Load Percentage (%) |
|---------------------|
| 65                  |

### Table 23. Sailing condition in day night

| No. | Item                                | Set | Power | Night Sailing |
|-----|-------------------------------------|-----|-------|---------------|
|     |                                     |     | KW Total | % | Set | Cont | Int |
| A.  | Pumps                               |     |           |                           |
| 1   | Bilge Pump / Fire Pump              | 1   | 7,5      | 7,5                      |
| 2   | General Service & Ballast Pump      | 2   | 7,5      | 15                       |
| 3   | Sea Water Hydrophore Pump           | 1   | 2,2      | 2,2                      |
| 4   | Fresh Water Hydrophore Pump         | 1   | 2,2      | 2,2                      |
| 5   | Fuel Oil Transfer Pump              | 1   | 1,5      | 1,5                      |
| 6   | Working Air Compressor              | 1   | 1,5      | 43                       |
| 7   | Lub Oil Transfer Pump               | 1   | 1,5      | 15                       |
| 8   | Fuel Purifier                       | 1   | 2,2      | 2,2                      |
| 9   | Sludge Transfer Pump                | 1   | 1,5      | 1,5                      |
| 10  | Sewage Treatment Plant              | 1   | 2,5      | 2,5                      |
| 11  | Oil Water Separator                 | 1   | 0,4      | 0,4                      |
| 12  | Navigation Lighting                 | 1   | 2,5      | 2,5                      |
| 13  | Navigation and Communication        | 1   | 6        | 6                        |
| 14  | Other Equipment                     | 1   | 15,7     | 15,7                     |

### Table 24. Loading and unloading condition in day night

| No. | Item                                | Set | Power | Night Loading/Unloading |
|-----|-------------------------------------|-----|-------|-------------------------|
|     |                                     |     | KW Total | % | Set | Cont | Int |
| A.  | Pumps                               |     |           |                           |
| 1   | Bilge Pump / Fire Pump              | 1   | 7,5      | 7,5                      |
| 2   | General Service & Ballast Pump      | 2   | 7,5      | 15                       |
| 3   | Sea Water Hydrophore Pump           | 1   | 2,2      | 2,2                      |
| 4   | Fresh Water Hydrophore Pump         | 1   | 2,2      | 2,2                      |
| 5   | Fuel Oil Transfer Pump              | 1   | 1,5      | 1,5                      |
| 6   | Working Air Compressor              | 1   | 1,5      | 43                       |
| 7   | Lub Oil Transfer Pump               | 1   | 1,5      | 15                       |
| 8   | Fuel Purifier                       | 1   | 2,2      | 2,2                      |
| 9   | Sludge Transfer Pump                | 1   | 1,5      | 1,5                      |
| 10  | Sewage Treatment Plant              | 1   | 2,5      | 2,5                      |
| 11  | Oil Water Separator                 | 1   | 0,4      | 0,4                      |
| 12  | Navigation Lighting                 | 1   | 2,5      | 2,5                      |
| 13  | Navigation and Communication        | 1   | 6        | 6                        |
| 14  | Other Equipment                     | 1   | 15,7     | 15,7                     |

### Table 25. Emergency condition in day night

| No. | Item                                | Set | Power | Night Emergency |
|-----|-------------------------------------|-----|-------|-----------------|
|     |                                     |     | KW Total | % | Set | Cont | Int |
| A.  | Pumps                               |     |           |                           |
| 1   | Bilge Pump / Fire Pump              | 1   | 7,5      | 7,5                      |
| 2   | General Service & Ballast Pump      | 2   | 7,5      | 15                       |
| 3   | Sea Water Hydrophore Pump           | 1   | 2,2      | 2,2                      |
| 4   | Fresh Water Hydrophore Pump         | 1   | 2,2      | 2,2                      |
| 5   | Fuel Oil Transfer Pump              | 1   | 1,5      | 1,5                      |
| 6   | Working Air Compressor              | 1   | 1,5      | 43                       |
| 7   | Lub Oil Transfer Pump               | 1   | 1,5      | 15                       |
| 8   | Fuel Purifier                       | 1   | 2,2      | 2,2                      |
| 9   | Sludge Transfer Pump                | 1   | 1,5      | 1,5                      |
| 10  | Sewage Treatment Plant              | 1   | 2,5      | 2,5                      |
| 11  | Oil Water Separator                 | 1   | 0,4      | 0,4                      |
| 12  | Navigation Lighting                 | 1   | 2,5      | 2,5                      |
| 13  | Navigation and Communication        | 1   | 6        | 6                        |
| 14  | Other Equipment                     | 1   | 15,7     | 15,7                     |
it can be seen that the operational power requirement of the ship at night with a total intermittent load of 98.2 kW and a total continuous load of 181.5 kW and power requirements in an emergency vessel condition of 38.5 kW and the largest power is in the condition of the sailing vessel of 102.5 kW.

4.11 Generator Selection

The generator selection is based on the calculation of the largest operational power capacity which is located on the condition of the ship sailing at night as much as 2 sets. Then we get a generator with the following capacity:

- **Brand**: Caterpillar
- **Type**: EM 5153
- **Number of Cylinders**: 4
- **Rpm/Frequency**: 1800/60 Hz
- **BHP**: 60 kW
- **Bore**: 105 mm
- **Stroke**: 127 mm
- **Weight**: 1142 kg
- **Length**: 1699 mm
- **Width**: 956 mm
- **Height**: 1245 mm

Then the generator selection based on ship operations in an emergency is 1 set as follows:

- **Brand**: John Deere
- **Type**: 4045DFM70
- **Number of Cylinders**: 4
- **Rpm/Frequency**: 1800/60 Hz
- **BHP**: 45 kW
- **Bore**: 106.5 mm
- **Stroke**: 127 mm
- **Weight**: 462 kg
- **Length**: 885 mm
- **Width**: 712 mm
- **Height**: 902 mm

5 Conclusion

In accordance with the calculation results obtained with various ship operating conditions. The condition of the ship anchored during the day is 49.8 KW. The condition of the ship anchored at night is 64 KW, The condition of the ship sailing during the day is 100.3 KW, The condition of the ship sailing at night is 102.5 KW. The condition of loading and unloading ships during the day is 58.2 KW. The condition of loading and unloading ships at night is 74.6 KW. The condition of the emergency ship during the day is 32.9 KW. The condition of the emergency ship at night is 38.5 KW. Determination of generator power capacity based on the operational electricity needs of the largest ship when the ship is sailing as many as 2 sets with power 60 kW x 2. Then determine the generator power capacity based on the condition of the ship when in an emergency as much as 1 set with power 45 kW x 1.

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