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DESIGN OF AN OPTIMUM BATTERY ELECTRIC FISHING VESSEL FOR NATUNA SEA

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DEPARTEMENT OF MARINE ENGINERING
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APPROVAL FORM

DESIGN OF AN OPTIMUM BATTERY ELECTRIC FISHING VESSEL FOR NATUNA SEA

BACHELOR THESIS

Submitted to Comply One of the Requirements to Obtain a Bachelor
Engineering Degree
on
Laboratory of Marine Electrical and Automation System (MEAS)
Bachelor Program Department of Marine Engineering
Faculty of Marine Technology
Sepuluh Nopember Institute of Technology

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ABSTRACT

Natuna Sea is one of the places in Indonesia, which has a high potency of fish up to one million ton per year. Fisherman in Indonesia relies too much on the fossil fuel, which has limited resources. The author wants to redesign the fishing vessel into the battery electric fishing vessel that can be recharge to reduce the use of fossil fuel and also to increasing the revenue of the fisherman. To minimize the capacity of the battery, the fishing activities concept is also change into centralized fishing activities which the activities is centralized in an open sea and has the offshore building as the fishing base that has power station to recharge the batteries and cold storage to collect all the fishes. As the object to redesign, it is used 10 GT purse seine fishing vessel. As the results of the calculation, it gets the total battery capacity 6000 Ah for operation 11 hours (4 hours travel time, 6.5 hours fishing activities, and 0.5 hours break). Based on the technical and economic analysis, it can be concluded that the battery electric fishing vessel has a better revenue and fewer expenses than the diesel-powered fishing vessel.

Keywords: Fishing Vessels, Batteries, Electric Propulsion Systems, Natuna Sea

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PREFACE

Grateful to the God because of His grace, the author can finish this bachelor thesis with title "DESIGN OF AN OPTIMUM BATTERY ELECTRIC FISHING VESSEL FOR NATUNA SEA" in order to fulfill the requirement of obtaining a Bachelor Engineering Degree on Department of Marine Engineering, Faculty of Marine Technology, Sepuluh Nopember Institute of Technology.

Along the process of writing this bachelor thesis, author want to give thank you to the all people who helped and support, among others:

1. Father, Mother, Brother, Sister, and all the family whose always giving pray, support, and love.
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6. All of friends in Double Degree Marine Engineering ITS-Hochscule Wismar batch 2014 for all the memories and knowledges.
7. Alvis M. R., Aditya Prabowo, Himawan A., Bilton S., Richart T. P., and Dion A. L. for the support and accompany along the process of writing this bachelor thesis.
8. All technicians, member and grader of Marine Electrical and Automation System Laboratory (MEAS) for the great time and support.

Author hoping this bachelor thesis can help all of the fisherman in Indonesia for the better living and if there any comments from the reader, author is open for it.

Surabaya, January 2018

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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Natuna Sea is one of the places in Indonesia, which has a high potency of catching fish. The potency of catching fish in the Natuna Sea nearly reached one million tons per year. There are three fishes with the high potency in Natuna which are, Small Pelagic fish with a potency of 621.500 tons per year, Demersal fish with a potency of 334.800 tons per year, and Big Pelagic fish with a potency of 66.100 tons per year.

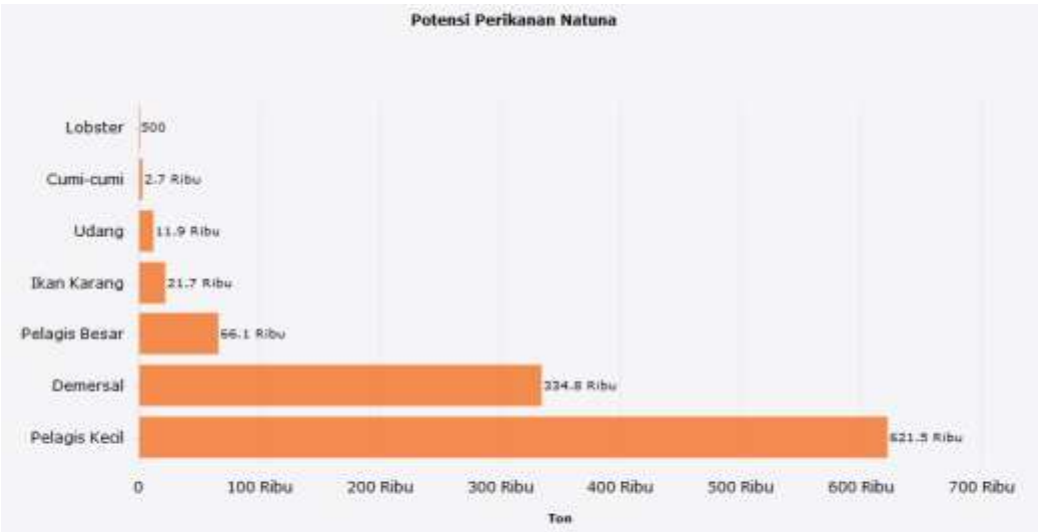


Figure 1.1-1. Fish potency in Natuna Sea (2016)
Source: Databoks, Katadata Indonesia, 2016

The weather condition of the Natuna Sea has been categorized as "Slight Sea" by BMKG, where the wave height of Natuna Sea never gets higher than 1,25 meters. The average of the wave height of Natuna Sea is about 0,5 meters with the range of the wind speed is from 6 knots up to 20 knots. It makes sea around Natuna Island is a safe place for the fisherman to catch fish on there.

Natuna Sea does surround by islands which have the majority of the people works as a fisherman. Natuna Island is one of the islands that located in the north of Natuna Sea. In 2015, there are 7.066 families of fisherman from around 20.401 total families in Natuna Island. It means almost 35% of the people in Natuna Island does depend on the outcome of the fisherman.

Figure 1.1-2. Map of Natuna Sea
Source: BMKG, 2017

The life of the Fisherman is relying on the price and the availability of fuel oil as the main energy of their boat, either for a main engine or generator to produce electricity. As today, the price of fuel is not being subsided again by the government and the availability also getting rare in the future, the fisherman activities got involved and their revenue is getting lower each day. Therefore, a fishing boat without using any fuel is needed to help the life of the fisherman in Indonesia, especially in Natuna Island.

A Fishing boat or Fishing vessel that using rechargeable batteries as the source of power onboard is one of the answers to deny the using of fuel oil on the fishing vessel. So the idea is, the batteries can be recharged or switch when the fisherman is on the power station. The location of power station can be located either on the sea or land or both.

Considering the weight and the price of the batteries used on the ship is getting heavy and expensive if the size of the batteries is getting larger, then the idea is to make a fishing activity which centralized in an area. Those areas will have like offshore building which consists of the energy station (produce energy), fish tanks (stored catching fish), guard tower (observe the area), and living or accommodation room for the crews. This offshore building or aquaculture or energy station on the sea is becoming a place for the fisherman to depart and arrive for fishing activities. Later, for once in 3 days or a week, a large fishing vessel which also as a supply vessel will come to collect all the fish to bring it to the shore. So, by that, the small battery electric fishing vessel won't have a long operation time.

The location and the design of the offshore building or aquaculture won't be discussed in this thesis. This thesis will focus on designing and calculating the battery capacity of the small battery electric fishing vessel. The fishing vessel used in this thesis is the existed fishing vessel design and will be redesigning the propulsion system into electrical propulsion.

1.2 STATEMENTS OF PROBLEMS

Based on the description above, the statement of the problems of this thesis are:

1. How to design an optimum battery electric fishing vessel for Natuna Sea?
2. How is the wiring diagram of the electrical power of the fishing vessel?
3. How is the battery room layout of the fishing vessel?

1.3 RESEARCH LIMITATIONS

The limitations of this thesis are:

1. This thesis focuses on determining the optimum battery capacity of a fishing vessel in the area of Natuna Sea that will have a size 10 GT.
2. The system and the capacity of the aquaculture is not discussed in this thesis and will assume that enough to cover the electricity needed to charge the fishing vessel.

1.4 RESEARCH OBJECTIVES

The objectives of this thesis are:

1. To design an optimum battery electrical fishing vessel for Natuna Sea.
2. To design the wiring diagram of the electrical power of the fishing vessel.
3. To design the battery room layout of the fishing vessel.

1.5 RESEARCH BENEFITS

The benefits of this thesis are:

1. Make a suggestion to Ministry of Marine Affairs and Fisheries to develop an electrical fishing vessel in Natuna area.
2. Reduce the illegal fishing in Natuna area.
3. Improve the prosperity of fisherman on Natuna.
4. Improve the export of Indonesia fish product.

CHAPTER 2
LITERATURE REVIEW

2.1 FISHING VESSEL

A fishing vessel is a mobile floating objects of any kind and size, operating in freshwater, brackish water, and marine waters which are used for catching, harvesting, searching, transporting, landing, preserving and/or processing fish, shellfish and other aquatic organisms, residues and plants (FAO, 2017).

In a fishing vessel, there is equipment that must installed like cranes, seine boom, picking boom, pot launchers, anchor, winch, etc. Besides, in cargo space also must installed a refrigerant system to chill or to keep the freshness of the fish, but mostly for a small fishing vessel (less than 25 m) it replaced by ice. The amount of ice will affect the endurance of the fish to keep the freshness.

2.1.1 Endurance of Fish

Most fish caught in the open sea by the fisherman, but all selling activities happened in the land. So, the fisherman should keep the freshness of the fish until it arrives in the land. All species of fish can stay fresh for longer periods when it chilled properly.

Chilling means to keep the temperature of the fishes below the temperature of melted ice, $0^{o}C$. To provide chilling, the commoner it will use ice, but it can also use chilled water, ice slurries, and refrigerated seawater (RSW). The use of ice for chilled the fish is the effective handling method on board fishing vessel because ice is available in many fishing areas or ports, harmless, and transportable, also it has a very high cooling capacity.

There are three main factors that affect the rate of endurance of the chilled fish:

- Temperature
  The lower the temperature the longer the endurance of fish.
- Physical Damage
  The soft and careful handling can keep the endurance of the fish longer
- Intrinsic Factors

These factors depend on the fish. The fish which has a flat shape, large size, small fat content, and thick skin will have the longer endurance.

2.1.2 Ice Requirement

Chilling the fish needs some amount of ice. In figure 2.1 below shows the weight of ice necessary to cool 10 kg of fish to 0°C from various ambient temperatures.

Temperature of fish (°C)	Weight of ice needed (kg)
30	3.4
25	2.8
20	2.3
15	1.7
10	1.2
5	0.6

Figure 2.1-1. Theoretical weight of ice needed to chill 10 kg of fish to 0°C from various ambient temperature
Source: FAO, 1984

Besides that, we can also use the graph provided by FAO that can be seen in figure 2.2.

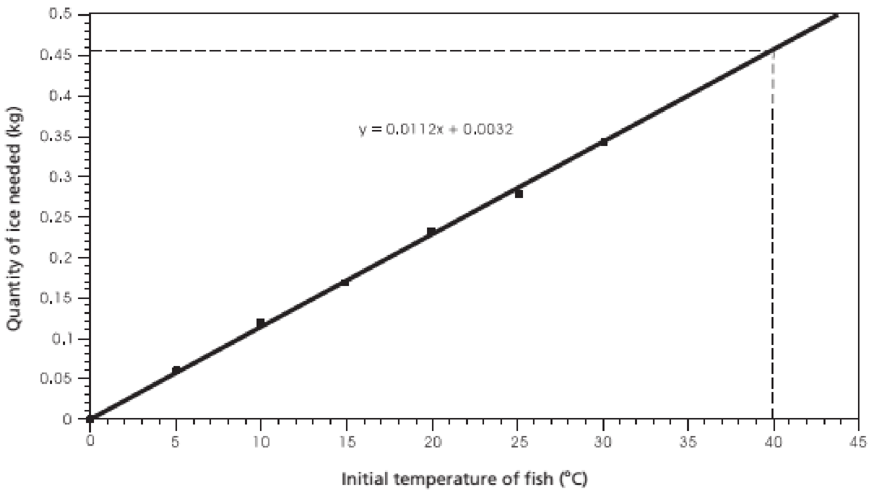


Figure 2.1-2. Graph for quick calculation of the theoretical weight of ice needed to chill 1 kg of fresh fish to 0°C from various initial temperatures
Source: FAO, 1981

Those are only the amount of ice need to chill down the temperature into 0^oC, so it needs more ice to ensure that the fish remains chilled once its temperature has been reduced to 0^oC. The “rule of thumb minimum” to use an ice to a fish is in a ratio of 1:1 for the tropics, but it also depends on the length of the fishing trip.

To calculate the ice required to chill the fish and maintain the temperature in a certain time, it is needed to consider some loss factor such as heat losses, bad handling, and water in equilibrium in ice. Those loss factors can be estimated depending on the insulated container used. In Table 2.2 describe the ice requirements in total for chilling 40 kg fresh fish in a 90 liters insulated container.

Consumption/loss factor	Ice requirements *(kg)*
To compensate for heat losses in the insulated container	24.7 (4.932 kg/day × 5 days)
To cool down 40 kg of fish from 40 °C to 0 °C	16
To compensate for bad ice-handling practices	2.5 (estimated as 5% of total ice used)
To compensate for water in equilibrium in ice	7 (estimated as 14% of total ice used)
Total consumption	50.2

Figure 2.1-3. Summary of ice requirements for chilling fresh fish in a 90 liters insulated container
Source: FAO, 2003

2.2 PURSE SEINE AND FISHING ACTIVITIES

Purse Seine is a fishing catch tool which made from a rectangular net with buoys on the top and on the bottom installed ballast and purse line to merge the bottom of the net so the fish cannot escape from below and aside. It is called purse seine because it has a ring as a place to install the purse line on the bottom. There are a lot of purse seine types, but in general and the parts it can be drawn as shown in the figure 2.2-1.

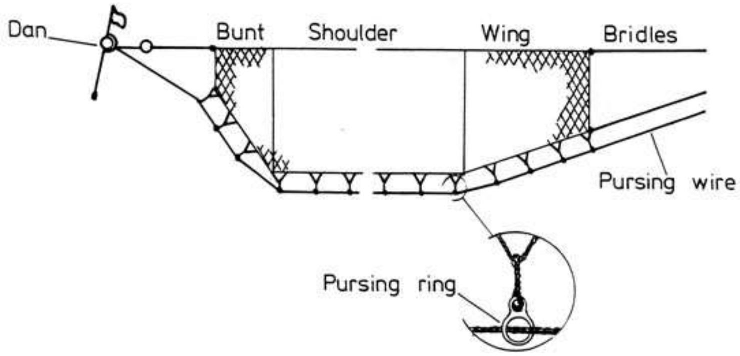


Figure 2.2-1 Part of purse seine in general
Source: FAO, 2001

Purse Seine is using different lengths of the net on every condition of the sea. Usually, for coastal lines, length of the net will be around 300-400 meter and width of 40-50 meter; a little bit into the open sea, the length of the net will be around 600-700 meter with a width of 100 meters; for open sea, mostly in Indonesia to catch a school of Skipjacks (*Katsuwonus pelamis*), it will be used net with length reaches about 1500-2500 meters or more.

In finding a fish school, there are two ways, first is by using the technology such as a fish finder, or secondly it can use a binocular to looking for a sign if there is a fish school around. The sign of there is a fish school can be seen as:

1. There are fishes who are jumping out of the water.
2. There is a seabird who's flying near the water. If the bird is flying fast, then it means the fish is swimming fast, and the direction of the fish swim can be seen in the direction of the birds fly. If the bird is flying slowly and high, then it means the fish is also swimming slowly.
3. There is a change of color in the water. If there is a big fish school, so the watercolor on the surface will be darker than usual, it can be a little bit browner. If there is a small fish school, then the color of the water will be a little bit become purple.
4. There is foam on the surface.
5. There is the water splash on the surface.
6. There is some kind of flash from the fish color in the water.
7. Oceanographic and Meteorology data, such as water temperature, salinity, air pressure, etc.
8. Another sign, such as:

a. There is a floating trunk.
b. There is small swordfish swimming near the surface.
c. There are dolphins whose playing around.
d. There is whale who can be an indicator if there are skipjacks around.

After searching activity and decision making to catch the fish, so the next activity is called setting or put down the net (purse seine), where the activity is like setting the position of the boat, then setting down the purse seine, and the boat shall move slowly to rounding up the school fish. After rounding up, turn on the purse seine winch to pull up the purse line until the bottom side is merged and closing the escape way.

After setting, the next activity is hauling, where the purse seine will be pulled out until all the fish is collected on the bunt side. When the fish are collected in bunt side, it can use the electric motor or by manually pick up the fish and collect them into the cargo space with low temperature. After that, the purse seine can be used again for catching the next school fish.

2.3 ELECTRICAL PROPULSION SYSTEM

A propulsion system is a machine that produces thrust to push an object forward, while electrical propulsion system means the machine used to produce thrust is consuming the electrical power. As an example, an electric motor which consumes electrical power coupled with a propeller that produces thrust. The electrical power on the ship can come from generators or batteries. Most of the cases, generators are used to produce the electrical power on the ship. In some cases, generators and batteries are used to provide the electrical power on the ship. But, it can also only use batteries to store electrical power on the ship. It all depends on the requirements.

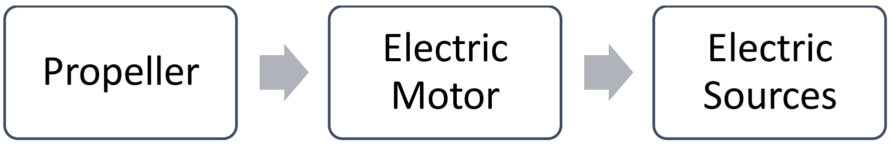


Figure 2.3-1. Electrical Propulsion schematic in general

2.3.1 Generator

A generator is a kind of device which is used to convert mechanical energy (rotation) into electrical energy. Mechanical energy can come from a lot of sources, but mostly in the ship, it will come from the diesel engine. The generator can produce electrical power with variate value depend on the needs.

Figure 2.3-2. Diesel Generator use on the ship
Source: https://dir.indiamart.com/mumbai/diesel-generator.html

Other than the diesel generator, there are still many types of generator available right now. As an example, the gas generator which using gas fuel to produce the mechanical energy, the steam generator which using steam to produce the mechanical energy, and nature generator which using mechanical energy from the nature such as wind, water flow, wave, etc.

The using of the generator is common in electric propulsion because the generator can produce the electrical power for a longer time than a battery can store. The generator also has a longer lifetime than the battery. However, a generator has a more complex system than a battery, it needs a lot of maintenance, and it cost higher than the battery in operation and maintenance terms.

2.3.2 Battery

A battery is a kind of device used to store electrical energy where the energy can be distributed to power up the electrical load or sometimes being known as electrochemical generators used as main or secondary energy sources.

There are two kinds of batteries in general, Primary Battery and Secondary Battery. A Primary Battery is a battery that can't be recharge because the chemical reaction can't be restored. Otherwise, a Secondary Battery is a rechargeable battery that can be used multiple times, because the chemical reaction of the battery is like the cycle. When the battery is full, the electrode is in full condition and ready to supply the electricity. When the battery is empty, the electrode can be recharge or regenerate by transfer the electricity in opposite direction of the polarity inside the cell.

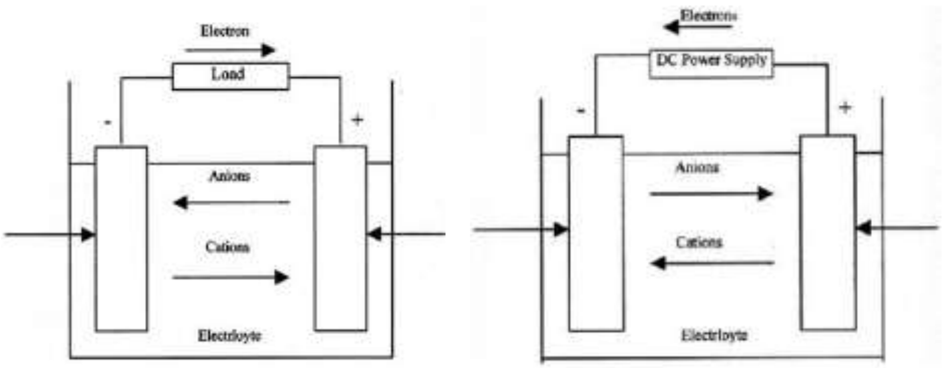


Figure 2.3-3 Electrochemical operation of cell (discharge & charge)
Source: EOLSS, 2009

The requirement of the battery capacity on the ship come from the electrical power needed to store and the time of electrical power needs. In this thesis, the calculation of battery capacity comes from the electrical power needed on the ship such as propulsion system, the navigation system, deck equipment, and lightning. The electrical power needed for the navigation system, deck equipment, and lightning can be seen in the design of the vessel before, but for the propulsion system, it needs to recalculate because the losses are different between mechanical propulsion system and electrical propulsion system.

2.4 COMPONENTS OF ELECTRICAL PROPULSION

2.4.1 Rechargeable Battery

A rechargeable battery is a kind of device which is used to store electrical energy where the energy is rechargeable. This kind of battery usually called a secondary battery.

More energy stored in a battery, it means more battery material needed. Every technology of the battery has their own comparison between the mass of battery and energy that can be stored. This parameter called energy density.

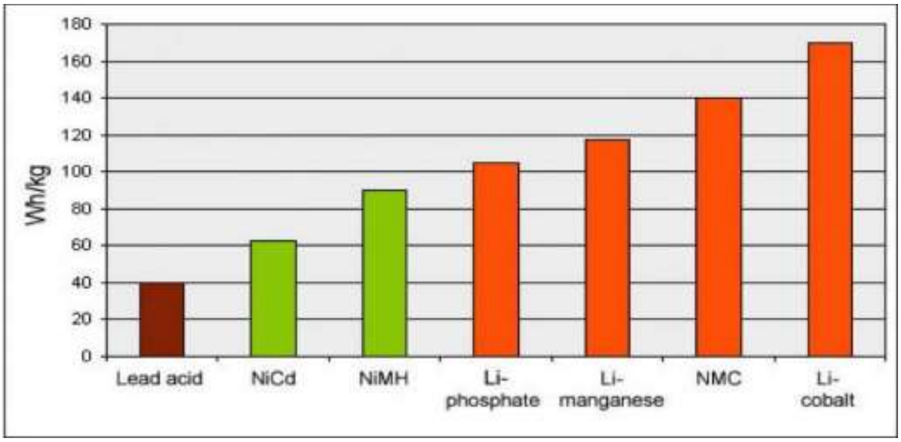


Figure 2.4-1. Battery energy densities
Source: rebresearch.com

2.4.2 Battery Management System (Battery Monitoring System)

A battery management system (BMS) is an electronic system that manages a rechargeable battery (cell or battery pack), such as by protecting the battery from operating outside its Safe Operating Area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it.

2.4.3 Three Phase DC-AC Inverter

Three-phase inverter is a kind of power electronics which transform a DC voltage into three-phase AC voltage. Commonly, the three-phase inverter is used for high power applications. Based on Power Electronic Handbook by Rashid, M. H. there are some advantages using a three-phase inverter, such as:

- The frequency can be varied over a wide range.
- The direction of rotation of the motor can be reversed.
- The output AC voltage can be controlled by varying the DC link voltage.

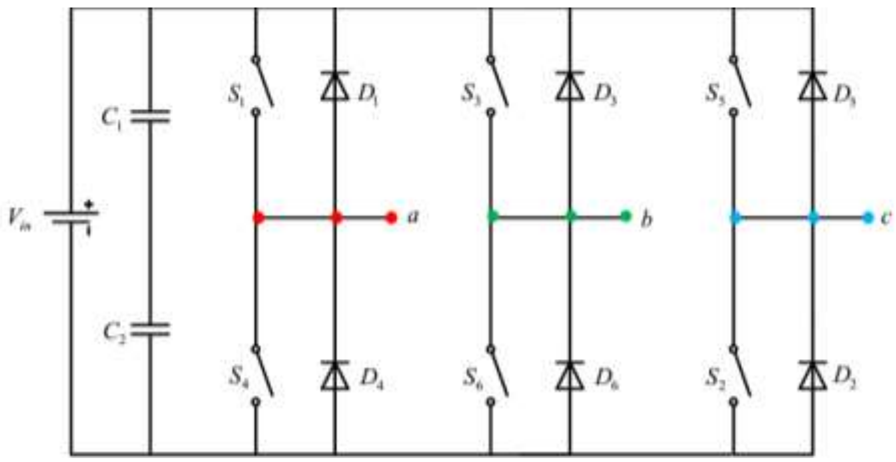


Figure 2.4-2 General configuration of a Three-Phase DC-AC Inverter
Source: (Power electronic Handbook)

Three phase inverter can transform a DC voltage to three-phase AC voltage where the amplitude, phase, and frequency of the voltage can always be controlled. It can be controlled by varying the switching rate of the switches. The standard of the valid switch stage is given in table 2.4-1.

Table 2.4-1 Valid switch states for a three phase inverter
Source: (Power electronic Handbook)

State	State #	v_{ab}	v_{bc}	v_{ca}	Space vector
S_1, S_2, and S_6 are on and S_4, S_5, and S_3 are off	1	v_i	0	$-v_i$	$\vec{v}_1 = 1 + j0.577$
S_2, S_3, and S_1 are on and S_5, S_6, and S_4 are off	2	0	v_i	$-v_i$	$\vec{v}_2 = j1.155$
S_3, S_4, and S_2 are on and S_6, S_1, and S_5 are off	3	$-v_i$	v_i	0	$\vec{v}_3 = -1 + j0.577$
S_4, S_5, and S_3 are on and S_1, S_2, and S_6 are off	4	$-v_i$	0	v_i	$\vec{v}_4 = -1 - j0.577$
S_5, S_6, and S_4 are on and S_2, S_3, and S_1 are off	5	0	$-v_i$	v_i	$\vec{v}_5 = -j1.155$
S_6, S_1, and S_5 are on and S_3, S_4, and S_2 are off	6	v_i	$-v_i$	0	$\vec{v}_6 = 1 - j0.577$
S_1, S_3, and S_5 are on and S_4, S_6, and S_2 are off	7	0	0	0	$\vec{v}_7 = 0$
S_4, S_6, and S_2 are on and S_1, S_3, and S_5 are off	8	0	0	0	$\vec{v}_8 = 0$

As shown in the table 2.4-1, the state 7 and 8 are producing zero AC current, which the AC line currents freewheel through either lower or upper component. The inverter is moving from one state to another state in order to produce the given voltage waveform, where the resulting voltage consists of discrete values of voltages (v_i, o, $-v_i$).

2.4.4 Three Phase Induction AC Motor

AC motor is a kind of electric motor which transforms the electrical power into mechanical power, where the electrical power type of current is alternating current (AC). Basically, there are two types of AC motor, three phase induction motor, and single phase induction motor. The difference is in the phase of the alternating current, where three-phase induction motors are using three-phase AC and single-phase induction motor is using one phase AC.

Three phase induction motors as mentioned before, it is using three-phase AC which supplies the three windings on the motor, with each phase connected to different windings. The current of each phase has a different 120 electrical degrees to others. Those differences lead to creating the moving North Pole and South Pole on the stator which made the rotor also move follows the moving North Pole and South Pole on the stator.

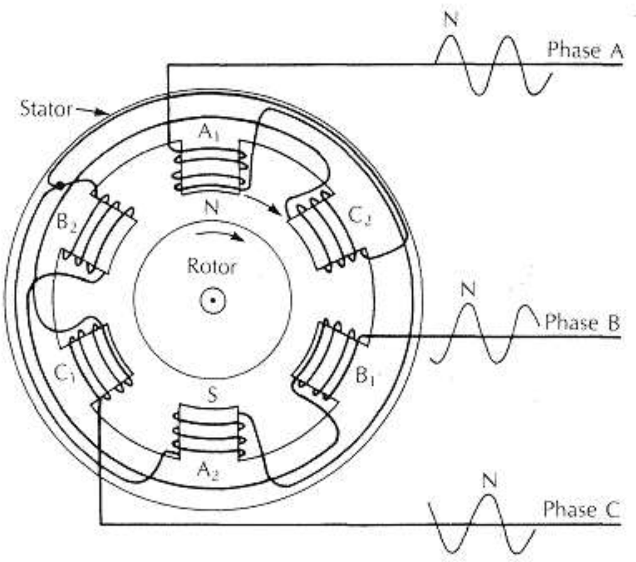


Figure 2.4-3 Three phase induction motor windings

As shown on figure 2.4-3, the movement of the North Pole is starting from A1 – B1 – C1. So in those kind of configuration the rotor will also turnaround from A1 – B1 – C1 (clockwise). In reversing the rotation of three phase induction motors, it just needs to switch out two phases. In an example phase B switch with the phase C (figure 2.4-4), so the North Pole movement will be A1 – C1 – B1 (counter clockwise).

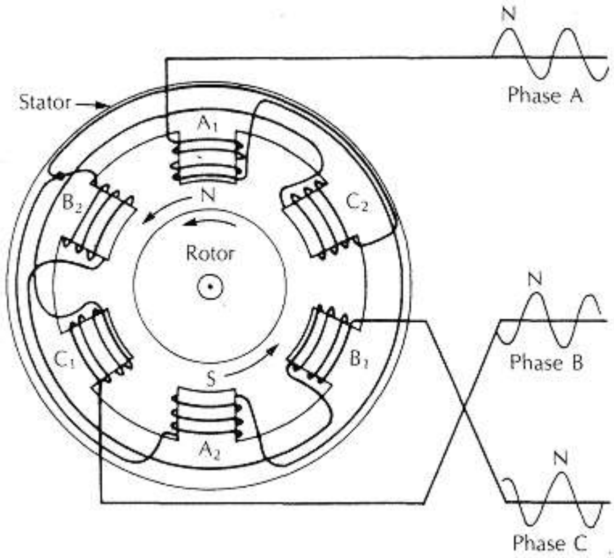


Figure 2.4-4 Reversed phase of three phase induction motor

As mentioned before that the rotor movement is following the stator electromagnetic movement, in that kind of situation, it has a difference between the rotations of electromagnets in a stator and mechanical rotation on the rotor. The rotation difference between stator and rotor is called slip. This slip is getting higher following the higher loads. Slip is can be formulated as:

$$S = \frac{(Ns - N)}{Ns} x\ 100\%$$

Where, S = Slip (%)

NS = Stator speed (RPM)

N = Rotor speed (RPM)

The stator speed can be calculated by using this formula:

$$Ns = \frac{f}{p} x120$$

Where, f = frequency (Hz)

P = number of poles

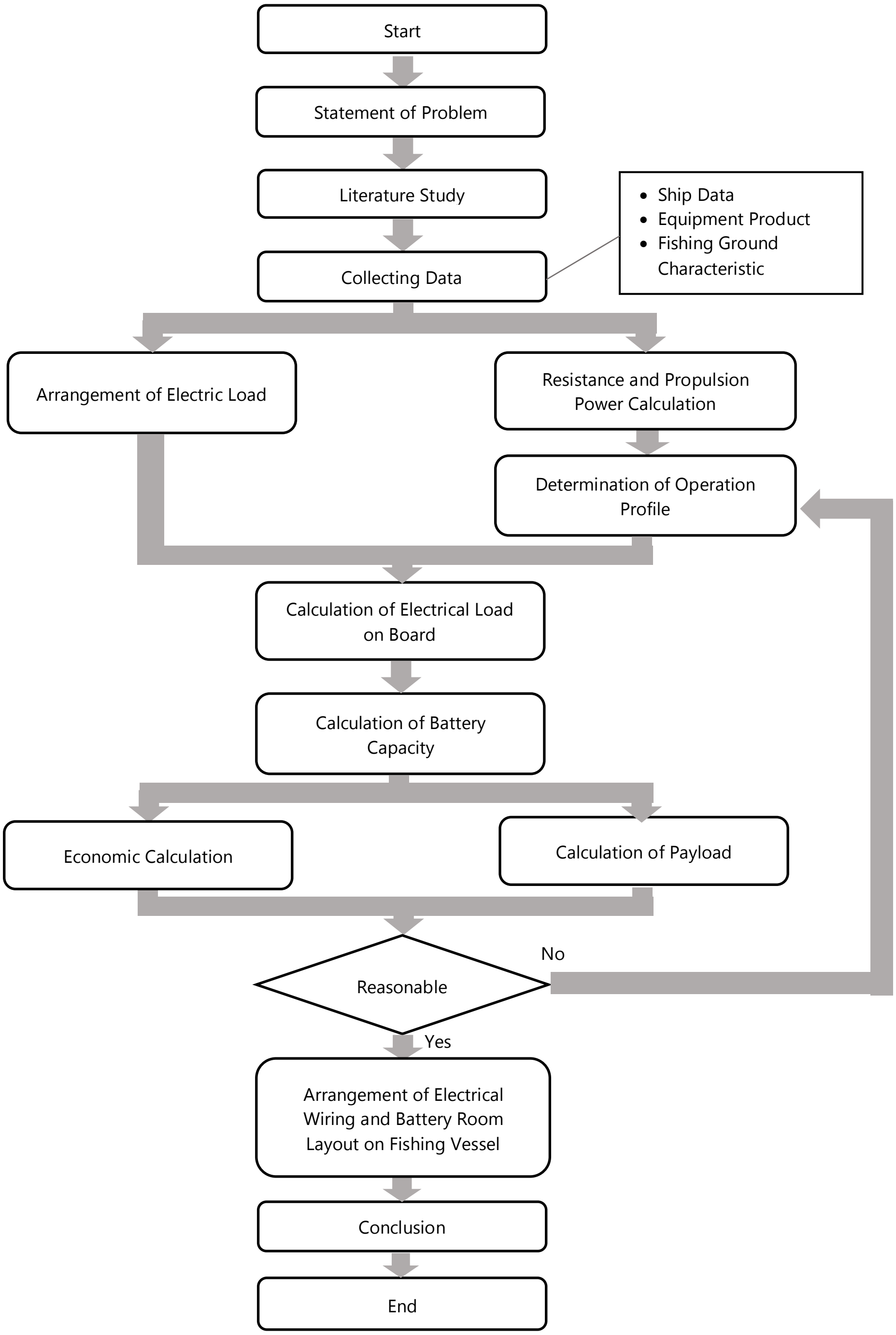
By looking into the formula on top, we can say that in order to change the stator speed, it should use the difference frequency, because the number of poles is permanent and couldn't be changed.

2.4.5 Propulsor

Propulsor or propeller has a function to convert the rotary mechanic energy from the electric motor or diesel motor into the translation mechanic energy or thrust which will drive the vessel forward or backward. There are many types of the propeller, and each propeller has their own characteristic for each vessel, so every vessel has their own customize propeller.

CHAPTER 3
METHODOLOGY

3.1 METHODOLOGY FLOW CHART



3.2 DEFINITION OF METHODOLOGY FLOW CHART

1. Statement of Problem
   This stage is an early stage to construct the thesis. In this stage, questions and problems are being prepared specifically in order to determine the specific objectives of this thesis. The content of the thesis is to overcome the statement of the problems mentioned earlier and it will be done by collecting some information about the problems. Therefore, the purpose of this thesis can be understood at this stage.
2. Literature Study
   Right after the problems is raised, a literature study is performed. In this stage, literature will be used to connect the problems with existing theories and facts from various sources. Since this thesis is an implementation of many aspects discipline, various literature topics are required to be constructed into one project. The study of literature is done by reading papers, journals, thesis, media and literature books that relate and able to support this thesis.
3. Collecting Data
   After literature study, the next stage is collecting data. Data collection is done by gathering information about the existed design of fishing vessel equal to 10 GT, electrical equipment specifications and requirements such as Induction motor, purse seine winch, windlass, radio navigation, etc. and also the fishing activities profiles to know the operation time.
4. Resistance and Power Calculation
   In calculating the resistance and power needed for the electric motor, Maxsurf software will be used with the efficiency of propeller between 40-55%. So after the data from the Maxsurf is out, it will be easier to select the Electric motor for the propulsion engine.
5. Determination of Operation Profile
   In determining the operation profile, there will be some factors should be considered such as the radius of the fishing vessel will operate, time for setting and hauling the purse seine, time for searching the fish, and how many settings and hauling will be doing. Those factors will be considered

to choose the best operation profile, which has the long radius with many fishing activities and also operate in one day.

6. Arrangement of Electrical Load
   Planning and arranging the electrical equipment will be doing at this stage. Besides planning the electrical equipment, there will be also the selection of the best electrical equipment which has the lowest electric consumption. And if the equipment can be operated manually, then it will be selected, in order to minimize the electrical consumption on the fishing vessel, so that the battery capacity needed can be minimized.
7. Calculation of Electrical Load on Board
   At this stage, all the equipment which consume electricity will be calculated to know how much electricity needed on board, so that the battery can be calculated. This calculation stage collects all equipment on board and lists them on voltage, power, current, operation time, and the last is the ampere-hour to know the battery capacity needed on the board.
8. Calculation of Battery Capacity
   On this stage, the calculation of battery capacity need to install is performed. The steps are collecting all the electrical loads on the fishing vessel and the time estimated of all the electrical load will be consumed, then find out the ampere consumption for all electrical load and multiply them with the time consumed to get the battery capacity in ampere-hour. Last, adding some reserve capacity around 10% to 15% for the uncommon situation and for an emergency.
9. Calculation of Payload
   This stage is performing a calculation of payload to see if the battery is changing the payload or not. Calculating the payload will need some data such as weight displacement, construction weight, machinery weight except battery and DC motor, and moveable weight. These data will help to find the payload for each type of battery will select.
10. Economic Calculation
    After knowing the battery capacity and types of battery that will be chosen, there will be an economic calculation to calculate the price to

invest on the electrical propulsion and the operation cost of the electrical propulsion and diesel propulsion where later on will compare each other and showing which type of propulsion has the economic advantage. Besides that, there will be also a break-even calculation of the electrical propulsion to show in which year the money to invest in the battery electric fishing vessel will be paid off.

11. Arrangement of Electrical Wiring and Battery Room Layout on Fishing Vessel
    In this stage, designing the wiring diagram of the electrical load is performed. Not only that, it is also doing an arrangement of battery room. In designing and planning the wiring there are several factors which should be considered such as voltage needed, current flow, type of the current, and etc. Planning battery room also cannot just put them in the room, but should also consider the space available to do the replacement or maintenance of the equipment there.

CHAPTER 4
DATA ANALYSIS

4.1 FISHING VESSEL PRINCIPAL DIMENSION

The fishing vessel used to redesign the propulsion system is a 10 GT fishing vessel with fishing equipment used is purse seine. The principal dimension of the fishing vessel can be seen on the table 4.1-1.

Table 4.1-1. Principle dimension of the 10 GT fishing vessel

Type of Ship	Fishing Vessel Purse Seine	
Length (Lwl)	11.83	m
Length (Lpp)	10	m
Max. Breadth (B)	3	m
Height (H)	1.3	m
Draught (T)	0,9	m
Service Speed	7	knots
Block Coefficient	0,435	
Prismatic Coefficient	0,519	
Mid-ship Area Coefficient	0,838	

4.2 RESISTANCE AND PROPULSION POWER CALCULATION

In calculating the resistance by Maxsurf software, the power propulsion is calculated based on overall efficiency set at 50%. It consists of propeller efficiency, transmission efficiency, and electrical efficiency. So the power describes on the table 4.2-1 is the power of the electrical motor needed to produce thrust and accelerate the ship up to 7 knots.

Table 4.2-1. Ship resistance and power based on Maxsurf software

Speed (knots)	Holtrop Resistance (kN)	Electrical Motor Power (kW)
0	--	--
0,5	0,01	0
1	0,03	0,03
1,5	0,06	0,09
2	0,09	0,19
2,5	0,14	0,36
3	0,2	0,61
3,5	0,26	0,94
4	0,34	1,39
4,5	0,43	1,98
5	0,55	2,82
5,5	0,71	4,04
6	0,92	5,65

Speed (knots)	Holtrop Resistance (kN)	Electrical Motor Power (kW)
6,5	1,17	7,85
7	1,58	11,36

4.3 DETERMINATION OF OPERATION TIME

4.3.1 Operational Time to Catch the Fish Using 10 GT Fishing Vessel and Time to Use Induction Motor in One Trip.

The fishing vessel is planned to have an operation in one day trip. Depart in the morning at 7 o'clock and goes from Aquaculture (fishing base) to the Fishing Ground which has distance about 14 NM from aquaculture. With the speed vessel about 7 knots, the time needed to be arriving at the fishing ground is about 2 hours.

Based on Fisherman's Workbook by J. Prado and P.Y. Dremiere, so the plan of the operational time of the fishing vessel will be like:

1. Searching = 30 minutes
2. Setting-Hauling for fishing activities.
   a. Setting the purse seine = 10 minutes.
   b. Pull in (Hauling) the purse seine = 25 minutes (Induction motor off)
3. Fishing activities (setting-hauling) is done about 6 times, So the total use of Induction Motor = 8 hours (4 hours fishing activities + 4 hours voyage)
4. Use of Purse Seine machine 25 minutes x 6 times = 2.5 hours

4.3.2 Lunch break

Time for lunch break is about half an hour (0.5 hour)

From those times above, it can determine the total operation time, which can be calculated like:

Operation time = Departure time + fishing activities + lunch break + arriving time
Operation time = 2 hours + 6.5 hours + 0.5 hours + 2 hours
Operation time = 11 hours

So the total operation time of the fishing vessel is 11 hours, and because the departure time is 7 AM then the time the fishing vessel finish or arrive again in aquaculture is at 6 PM.

4.4 CALCULATION OF ELECTRICAL LOAD ON THE BOARD

4.4.1 Selection of Electric Motor

From the table 4.1-1, it can be concluded that the power needed to speed up the fishing vessel up to 7 knots is 11,36 kW. Then, to select the electrical motor power, it just picks the motor which produces the power minimum 11,36 kW and the selected electric motor is AC motor VM 160L which produce power up to 12,5 kW.

AC Motor specification:

Type	: VM 160L	Voltage	: 220 V
RPM	: 2930 RPM	Weight	: 111,5 kg
Power	: 12,5 kW		

4.4.2 Electrical Load on the Board

The electrical load on board is a load of electricity needed to power up all devices and equipment which need electrical power to operate. The devices and equipment which need electrical power to supply can be seen in the table 4.4-1.

Table 4.4-1. Electrical load on board

Equipment	unit(s)	Power (kW)	Voltage (volt)	Current (Ampere)	Operation time (hours)	kWh
Propulsion AC Motor*	1	12,50	380	32,89	8,00	117,65
Purse Seine motor (AC)*	1	5,00	380	13,16	2,50	14,71
Navigation Lamp	5	0,24	24	10,00	1,00	1,26
Emergency Lamp	1	0,06	24	2,50	0,50	0,03
Radio Navigation	1	0,025	24	1,04	11,00	0,29
Fish finder	1	0,006	24	0,25	9,00	0,06
Power Total (kWh)						133,99
Total Ampere Hour (Ah)						5583,08
Battery Capacity Needed (Ah)						5973,90

*Using a power inverter (loses 10%) to produce AC current

4.4.3 Selection of Battery Capacity

According to the table 4.4-1, the total power needed is 133,99 kWh to cover all the electrical load on board. So the battery will be selected with minimum capacity about 5973,90 Ah, which get from dividing the kWh with the battery voltage. Besides the capacity, in selecting the battery there will be other factors need to look up such as weight, dimensions, and price. Table 4.4-2 will show the batteries can be selected as the energy source on the fishing vessel.

Table 4.4-2. Battery needed on electrical load

No	Name	Capacity (AH)	Voltage (Volt)	Weight (kg)	Amount of Batteries			
					Series	Parallel	Total	Weight total (kg)
1	Fortune 100Ah 3,2V 3C Type: Li-Ion	100	3	3	8	60	480	1440
2	RB24V100 Type: Li-Ion	100	24	27,7	1	60	60	1662
3	Bright Star 120Ah 3,2V 3C Type: Li-Ion	120	3	2,8	8	50	400	1120
4	Deep Blue Sealed Type: Lead Acid	220	24	77,1	1	28	28	2159
5	Bright Star 220Ah 3,2V 3C Type: Li-Ion	220	3	6	8	28	224	1344
6	EV LiFePO4 Battery Pack Type: Li-Ion	10	24	2,4	1	600	600	1440

4.5 CALCULATION OF PAYLOAD

A payload can determine by subtracting the new DWT (Dead Weight Tonnage) with the weight of the moveable items. The DWT can get by subtracting the displacement with the LWT (Light Weight Tonnage), where the LWT can be got from adding the construction weight with the machinery weight.

4.5.1 Determining the Construction Weight by using the LWT of Mechanical Propulsion

- Calculation of Weight Displacement

  The Weight displacement of the fishing vessel is can be get from multiplying the Lwl, T, B, Cb, and $\rho_{seawater}$. The result is 14,05 ton.

- Calculation of DWT

  Based on the early planning for the fishing vessel, it can be known that the DWT of the fishing vessel is 5,4 ton. The DWT is consist of Payload and Weight of the moveable items, where the payload itself is 3,9 ton and the rest is the weight of the moveable items.

  The weight of the moveable items is consists of fresh waters, foods, crews and provisions, fuel oils, and the reserves.

  - Weight of fresh waters

The need of fresh water on board is between 5-25 liters/person/day. It is picked 12 liters/person/day.

Cfwd = 12 liters/person/day

Operation time (t) = 5 days

Total crew (n) = 5 persons

Weight of fresh water = n x t x Cfwd

= 5 x 5 x 12 / 1000

= 0,3 ton

So the weight of fresh water needed on board is 0,3 ton

- Weight of foods

  The need of foods on board is between 4-6 kg/person/day. It is picked 5 kg/person/day.

  Weight of foods = 5 kg/person/day x 5 persons x 5 days / 1000

  = 0,125 ton

  So the weight of foods needed on board is 0,125 tons.

- Weight of crews and provisions

  The weight of crews can be estimated between 60-70 kg/person and the provision is about 1kg/person/day. It is picked 75 kg/person in 5 days operation.

  Weight of crews & prov. = 75 kg/person x 5 persons / 1000

  = 0,375 ton.

- Reserve Weight

  Reserve weight is for unintentional things and things in store. It can be estimated about 0,45% from weight displacement.

  Reserve weight = 0,45% x Δ

  = 0,0625 ton

- Fuel oil weight = 0,6375 ton

So the total weight of moveable items are 1,5 ton.

- Calculation of Construction Weight

  In determining the LWT, it can get by subtracting weight displacement with DWT.

  LWT = Δ – DWT

= 14,05 – 5,4 = 8,65 ton

By knowing the value of LWT, the weight of construction can be calculated by subtracting LWT with the weight of machineries.

Machineries weight = 0,5 tons (main engine + others)

Construction weight = LWT – machineries weight

= 8,65 – 0,5

= 8,15 ton

4.5.2 Calculation of Payload using Battery Electric Propulsion

- Calculation of LWT

  LWT in battery electric propulsion is different with the mechanical propulsion. The difference is located in the machineries weight. The machineries weight on battery electric propulsion are consist of AC motor, batteries, and other machineries.

  LWT = construction weight + machineries weight

  Construction weight = 8,15 ton

  AC motor weight = 0,112 ton

  Other machineries = 0,2 ton

  Batteries weight can be seen in table 4.4-2 on page 24.

  So for the LWT variation result can be seen in figure 4.5-1.

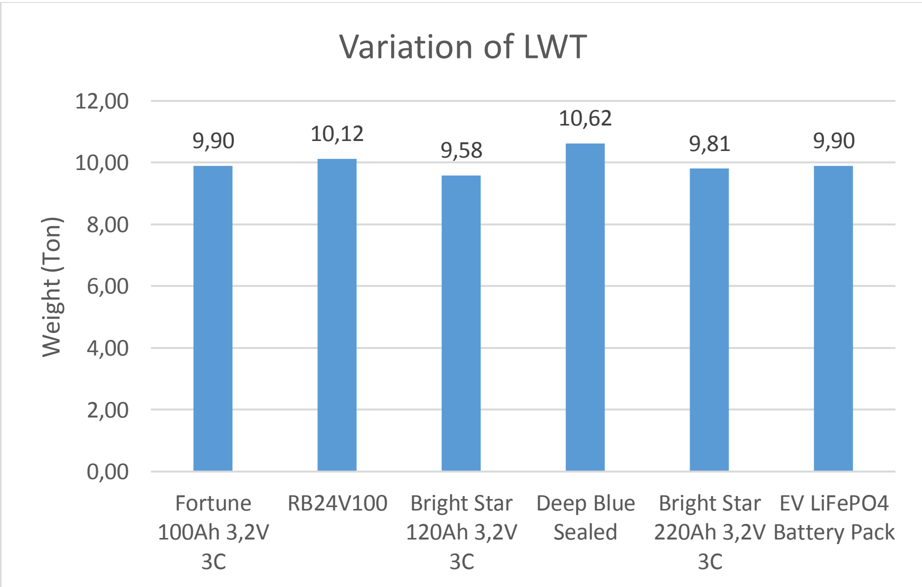


Figure 4.5-1. Variation of LWT on each kind of batteries

- Calculation of Payload

  Payload can achieve from the DWT subtract weight of moveable items. DWT itself can be get by subtracting weight displacement with LWT.

  - Weight of moveable items

    It consists of fresh water weight, food weight, crew and provision weight and reserve weight.

    Fresh water weight = 15 liters/person/day x 5 persons x 1 day / 1000
    = 0,075 ton

    Food weight = 5 kg/person/day x 5 persons x 1 day / 1000
    = 0,025 ton

    Crew & prov. = 71 kg/person x 5 persons / 1000
    = 0,355 ton

    Reserve weight = 0,06 ton

    W moveable = 0,075 + 0,025 + 0,355 + 0,06
    = 0,52 ton

So for the Payload variation result can be seen on figure 4.5-2.

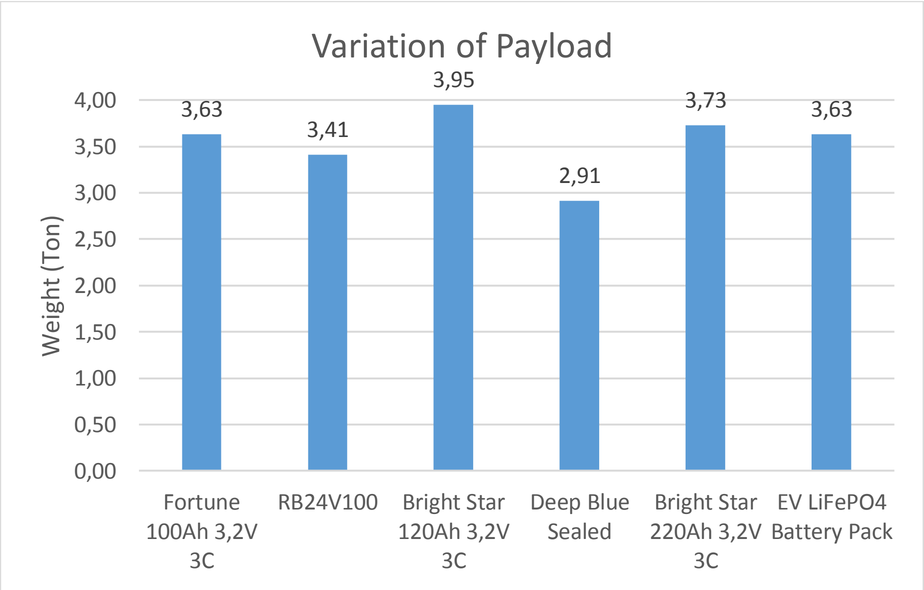


Figure 4.5-2. Variation of payload on each type of batteries

4.6 ECONOMIC CALCULATION

In calculation of economic, it will include some expenses such as, new build fishing vessel cost both use mechanical propulsion and electrical propulsion, operation cost both mechanical propulsion and electrical propulsion, and a comparison of both mechanical propulsion and electrical propulsion in the term of expenses each year up to 29 years to see which one is better or cheaper in expenses.

4.6.1 New Shipbuilding Cost

In calculating the shipbuilding cost, it uses an estimation written by Saut Gurning, ST., M.Sc in a paper called "Aplikasi Pendanaan Kapal". Where the estimation of new shipbuilding using mechanical propulsion can be seen on the table 4.6-1.

Table 4.6-1 New shipbuilding cost using mechanical propulsion

Item	Unit		Unit Price	Total Price
Construction cost	10	GT	Rp 12.500.000,00	Rp 125.000.000,00
Ship equipment	10	GT	Rp 1.500.000,00	Rp 15.000.000,00
Deck equipment	10	GT	Rp 3.000.000,00	Rp 30.000.000,00
Main engine	55	HP	Rp 4.500.000,00	Rp 247.500.000,00
Propulsion w/o M/E	55	HP	Rp 2.250.000,00	Rp 123.750.000,00
Sub TOTAL				Rp 541.250.000,00
Item	**Percentage**			**Total Price**
Inflation	10%			Rp 54.125.000,00
Currensies	15%			Rp 81.187.500,00
Taxes	10%			Rp 54.125.000,00
Administration	1%			Rp 5.412.500,00
TOTAL				**Rp 736.100.000,00**

For the new shipbuilding cost without mechanical propulsion, it can be determined by the same method of estimation but without using the mechanical propulsion. The calculation is described in the table 4.6-2.

Table 4.6-2 New shipbuilding cost without propulsion

Item	Unit		Unit Price	Total Price
Construction cost	10	GT	Rp 12.500.000,00	Rp 125.000.000,00
Ship equipment	10	GT	Rp 1.500.000,00	Rp 15.000.000,00
Deck equipment	10	GT	Rp 3.000.000,00	Rp 30.000.000,00
Propulsion w/o M/E	55	HP	Rp 2.250.000,00	Rp 123.750.000,00
Sub TOTAL				Rp 293.750.000,00
Inflation	10%			Rp 29.375.000,00
Currensies	15%			Rp 44.062.500,00
Taxes	10%			Rp 29.375.000,00
Administration	1%			Rp 2.937.500,00
TOTAL				**Rp 399.500.000,00**

4.6.2 Electrical Propulsion Cost

In calculating electrical propulsion cost, at first, it must be chosen which battery will be used as the electric source on the board. In choosing or selecting the battery, it comes to two factors which are the payload of the fishing vessel and the cost of the batteries. In the table 4.6-3, it will display the battery total cost.

Table 4.6-3 Batteries cost

No	Name	Total of Batteries	Unit Price	Total Price
1	Fortune 100Ah 3,2V 3C	480	$ 108,00	Rp 700.047.878,40
2	RB24V100	60	Rp 34.375.000,00	Rp 2.062.500.000,00
3	Bright Star 120Ah 3,2V 3C	400	$ 129,00	Rp 696.806.916,00
4	Deep Blue Sealed	28	Rp 8.021.400,00	Rp 224.599.200,00
5	Bright Star 220Ah 3,2V 3C	224	$ 237,00	Rp 716.900.882,88
6	EV LiFePO4 Battery Pack	600	$ 191,00	Rp 1.547.559.546,00

Currency Converter	
$ 1,00	Rp 13.504,01

So by comparing and analyzing the payload on the figure 4.5-2 and the battery cost of the table 4.6-3 for the six batteries, it will select the battery which has nearly the same or more payload with the previous design and has a lower cost among others. The selected battery is:

Name : Bright Star 120Ah 3,2V 3C
Type : Lithium Ion
Capacity : 120Ah
Voltage : 3,2V
Max discharge current: 200 A
Total Batteries : 400 pieces
Total Weights : 1120 kg
Total Price : Rp. 696.806.916

Besides the battery, for electrical propulsion, there are other items that should be bought and installed on the board. Table 4.6-4 showing the total investment should be paid for building a new ship using electrical propulsion.

Table 4.6-4 New shipbuilding cost using electric propulsion

No	Item	Unit	Unit Price	Total Price
1	Batteries	400	$ 129,00	Rp 696.806.916,00
2	AC Motor	1	Rp 15.403.000,00	Rp 15.403.000,00
3	DC-AC Inverter	1	£ 622,80	Rp 11.262.590,64
4	Battery Charger	25	$ 156,00	Rp 52.665.639,00
5	BMS	25	$ 9,60	Rp 3.240.962,40
6	Shipbuilding cost without propulsion	1	Rp 399.500.000,00	Rp 399.500.000,00
INVESTMENT TOTAL				**Rp1.178.879.108,04**

Currency Converter	
$ 1,00	Rp 13.504,01
£ 1,00	Rp 18.083,80

4.6.3 Operation Costs

In calculating the operation cost of the fishing vessel either use diesel or electric propulsion, it should have the same operational profile, so that the comparison is valid. As mentioned on subchapter 4.3 about the operation time or profile, here the calculation of operation cost.

- Diesel Propulsion

The operation cost of diesel propulsion is about the consumption of the fuel. The fuel consumption cost can be calculated by multiplying the fuel consumption in a year with the price of the Diesel fuel that the Indonesian fisherman bought. To know the fuel consumption in a year, here is the calculation.

Fuel consumption in a year = fuel consumption rate x operation time x day of operation in a year

Fuel consumption in a year = 12,2 $\frac{liter}{hour}$ x 8 hrs x 28 $days/month$ x 12 $months$

Fuel consumption in a year = 32.793,6 liters

So, the operation cost in a year for the diesel propulsion is:

Operation cost = Fuel consumption in a year x price of fuel

Operation cost = 32.793,6 $liters$ x 7.600 $\frac{IDR}{liter}$

Operation cost = Rp 249.231.360,00 /year

- Electric Propulsion

The operation cost of electric propulsion is about the amount of electric power used to recharge the batteries. At first, it must know which category in PLN is the cost of consumption by calculating the electric power needed. Here it is the calculation of the electric power needed from PLN:

Voltage = 24 V
Load total = 6000 Ah
Charging time = 12 $hour$s
Current = Load total / charging time
= 6000 Ah / 12 h
= 500 A
Electric Power = Voltage x Current
= 24 V x 500 A
= 12.000 VA = 12 kVA

So from the electric power needed from PLN, it can determine the cost of the electric power consumed.

From the table 4.6-5, it can know that the cost category is R-3/TR with power limitation from 6,6 kVA – 200 kVA and the cost is Rp. 1.467,28/kWh.

Table 4.6-5 Indonesian electric power tariff adjustment
Source: PLN, 2017

PENETAPAN
PENYESUAIAN TARIF TENAGA LISTRIK *(TARIFF ADJUSTMENT)*
BULAN JULI - SEPTEMBER 2017

NO.	GOL. TARIF	BATAS DAYA	REGULER		PRA BAYAR (Rp/kWh)
			BIAYA BEBAN (Rp/kVA/bulan)	BIAYA PEMAKAIAN (Rp/kWh) DAN BIAYA kVArh (Rp/kVArh)	
1.	R-1/TR	900 VA-RTM	*)	1.352,00	1.352,00
2.	R-1/TR	1.300 VA	*)	1.467,28	1.467,28
3.	R-1/TR	2.200 VA	*)	1.467,28	1.467,28
4.	R-2/TR	3.500 VA s.d. 5.500 VA	*)	1.467,28	1.467,28
5.	R-3/TR	6.600 VA ke atas	*)	1.467,28	1.467,28
6.	B-2/TR	6.600 VA s.d. 200 kVA	*)	1.467,28	1.467,28
7.	B-3/TM	di atas 200 kVA	**)	Blok WBP = K x 1.035,78 Blok LWBP = 1.035,78 kVArh = 1.114,74 ****)	-
8.	I-3/TM	di atas 200 kVA	**)	Blok WBP = K x 1.035,78 Blok LWBP = 1.035,78 kVArh = 1.114,74 ****)	-
9.	I-4/TT	30.000 kVA ke atas	***)	Blok WBP dan Blok LWBP = 996,74 kVArh = 996,74 ****)	-
10.	P-1/TR	6.600 VA s.d. 200 kVA	*)	1.467,28	1.467,28
11.	P-2/TM	di atas 200 kVA	**)	Blok WBP = K x 1.035,78 Blok LWBP = 1.035,78 kVArh = 1.114,74 ****)	-
12.	P-3/TR		*)	1.467,28	1.467,28
13.	L/TR, TM, TT		-	1.644,52	-

Catatan :
*) Diterapkan Rekening Minimum (RM):
RM1 = 40 (Jam Nyala) x Daya tersambung (kVA) x Biaya Pemakaian.
**) Diterapkan Rekening Minimum (RM):
RM2 = 40 (Jam Nyala) x Daya tersambung (kVA) x Biaya Pemakaian LWBP.
Jam nyala : kWh per bulan dibagi dengan kVA tersambung.
***) Diterapkan Rekening Minimum (RM):
RM3 = 40 (Jam Nyala) x Daya tersambung (kVA) x Biaya Pemakaian WBP dan LWBP.
Jam nyala : kWh per bulan dibagi dengan kVA tersambung.
****) Biaya kelebihan pemakaian daya reaktif (kVArh) dikenakan dalam hal faktor daya rata-rata setiap bulan kurang dari 0,85 (delapan puluh lima per seratus).
K : Faktor perbandingan antara harga WBP dan LWBP sesuai dengan karakteristik beban sistem kelistrikan setempat (1,4 ≤ K ≤ 2), ditetapkan oleh Direksi Perusahaan Perseroan (Persero) PT Perusahaan Listrik Negara.

WBP : Waktu Beban Puncak.
LWBP : Luar Waktu Beban Puncak.

By knowing the cost of the electric power, it can calculate the operation cost of the electric propulsion, here is the calculation.

Total power = Voltage x Current x Power factor
= 24 V x 500 A x 0,8
= 9600 W = 9,6 kW
Power needed = Total Power x Charging time
= 9,6 kW x 12 $hour$
= 115,2 kWh
Operation cost= Power needed x electric cost x total charge in a year
= 115,2 kWh x 1.467,28 $\frac{IDR}{kWh}$ x 28 $days/month$ x 12 $months$
= Rp 56.794.300,42 /year
= Rp 57.000.000,00 /year (round up)

So the operation cost for diesel propulsion in a year is Rp 249.231.360,00, and electric propulsion in a year is Rp. 57.000.000,00.

Besides, the cost of propulsion, there are also others operation cost, such as food, ice, crew salary, and maintenance cost. Table shows the total expenses for operation of diesel-powered fishing vessel and battery electric fishing vessel.

Table 4.6-6 Expenses for operation the fishing vessel

DIESEL-POWERED FISHING VESSEL			**BATTERY ELECTRIC FISHING VESSEL**		
ICE			ICE		
Ice needed in a day	1,11	Ton	Ice needed in a day	1,11	Ton
Ice price /kg	Rp	1.400,00	Ice price /kg	Rp	1.400,00
Ice cost for one year	Rp	522.144.000,00	Ice cost for one year	Rp	522.144.000,00
FOOD			FOOD		
Food needed in a day	15	Portion	Food needed in a day	15	Portion
Food price /portion	Rp	12.500,00	Food price /portion	Rp	12.500,00
Food cost in a year	Rp	63.000.000,00	Food cost in a year	Rp	63.000.000,00
CREW SALARY			CREW SALARY		
Total crew	10	Person	Total crew	10	Person
Crew salary	Rp	2.500.000,00	Crew salary	Rp	2.500.000,00
Crew salary in a year	Rp	300.000.000,00	Crew salary in a year	Rp	300.000.000,00
MAINTENANCE			MAINTENANCE		
Maintenance cost	Rp	58.943.955,40	Maintenance cost	Rp	58.943.955,40
FUEL			ELECTRICAL		
Fuel needed /day	97,6	liters	Electric needed /day	115,2	KWh
Fuel price /litre	Rp	7.600,00	Electric price /kWh	Rp	1.467,28
Fuel cost in a year	Rp	249.231.360,00	Electric cost in a year	Rp	56.794.300,42
TOTAL EXPENSES a year	**Rp1.193.319.315,40**		**TOTAL EXPENSES a year**	**Rp1.000.882.255,82**	

4.6.4 Loan Repayment

Beside all the expenses from the table 4.6-6, actually there is additional cost need to pay which called loan repayments. Loan repayments is a cost need to pay through the loan activities which happened before, in this case is the loan to build the fishing vessel. Loan repayments value is depend on the amount of money borrowed, time to repay, and the interest. Table 4.6-7 will show the total loan repayment per year for the diesel-powered fishing vessel and the battery electric fishing vessel.

Table 4.6-7 Total loan repayment per year

Loan Repayment (Battery Electric Fishing Vessel)	
Total Loan	Rp 1.178.761.220,13
Total Loan Interest (10%/year)	Rp 117.876.122,01
Total Inflation (0,19%/year)	Rp 2.239.646,32
Total Interest + Inflation (/year)	Rp 120.115.768,33
Target repayment (years)	10
Total Repayment w/o interest (/year)	Rp 117.876.122,01
Total Loan Repayment (/year)	**Rp 237.991.890,34**
Loan Repayment (Diesel-Powered Fishing Vessel)	
Total Loan	Rp 736.026.390,00
Total Loan Interest (10%/year)	Rp 73.602.639,00
Total Inflation (0,19%/year)	Rp 1.398.450,14
Total Interest + Inflation (/year)	Rp 75.001.089,14
Target repayment (years)	10
Total Repayment w/o interest (/year)	Rp 73.602.639,00
Total Loan Repayment (/year)	**Rp 148.603.728,14**

4.6.5 Expenses Comparison of Diesel-Powered and Battery Electric Fishing Vessel

Based on all result calculation in table 4.6-1, 4.6-4, 4.6-6, and 4.6-7, it can be presented in a graph which shows the expenditure comparison between diesel-powered fishing vessel and battery electric fishing vessel each year for 29 years. The Figure 4.6-1 shows the expenditure comparison between diesel-powered fishing vessel and battery electric fishing vessel.

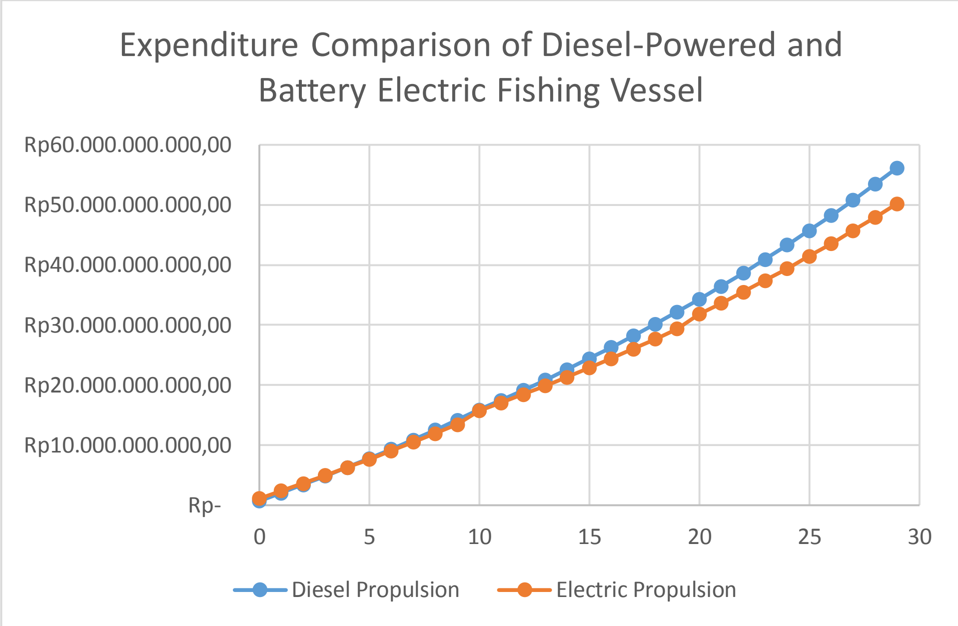


Figure 4.6-1 Expenditure comparison of Diesel-Powered and Battery Electric Fishing Vessel

In figure 4.6-1 for electric propulsion, it is shown that in the 10th and 20th year of operation there is some unusual rise of the graph. Because in that year, there is an expense of buying new batteries in order to change the old batteries that happened to be at the end of the lifetime.

Based on figure 4.6-1 also can be concluded that using an electric propulsion has a bigger investment than diesel propulsion, but in the end of fishing vessel lifetime, in this case, 29 years, the electric propulsion has a lower expense than diesel propulsion up to 6 billion Indonesian Rupiah (IDR). So, it can say that the electric propulsion use in this fishing vessel is better than diesel propulsion in the term of expenses.

4.6.6 BEP (Break Even Point) Analysis

Break Even Point is a point which has a condition of the total income and total expenses is the same or equal. This point has an important role in determining if the investment is a good investment or not, because this point tells about where the time when all the investment is getting paid off.

In analyzing the Break Even Point, it is need to know the price to invest, cost for operating the fishing vessel and also needs to know the income from doing fishing. The table 4.6-8 show the total income from operating the diesel-powered fishing vessel and the battery electric fishing vessel.

Table 4.6-8 Total income a year

Cargo space	6	m^3
Stowage rate	2,7	m^3/tonne of fish
ton of fish	2,22	Ton
ton of ice	1,11	Ton
Payload	3,33	Ton
Price of fish	Rp	2.000,00
Income in one day	Rp	4.400.000,00
Income in a month	Rp	123.200.000,00
Income in a year	**Rp**	**1.478.400.000,00**

From the table 4.6-1, 4.6-4, 4.6-6, 4.6-7 and 4.6-8, it can derive and make an accumulation of the income and expenses each year for 10 years as shown in the table 4.6-9, figure 4.6-2 and figure 4.6-3.

Table 4.6-9 Accumulation of income and expenses each year

Diesel-powered Fishing Vessel		
Year	Income	Expenses
0	Rp -	Rp 1.178.879.108,04
1	Rp 1.478.400.000,00	Rp 2.417.753.254,20
2	Rp 3.001.152.000,00	Rp 3.686.653.868,04
3	Rp 4.569.586.560,00	Rp 4.986.481.743,58
4	Rp 6.185.074.156,80	Rp 6.318.164.698,68
5	Rp 7.849.026.381,50	Rp 7.682.658.385,72
6	Rp 9.562.897.172,95	Rp 9.080.947.126,66
7	Rp11.328.184.088,14	Rp10.514.044.773,12
8	Rp13.146.429.610,78	Rp11.982.995.592,26
9	Rp15.019.222.499,11	Rp13.488.875.179,27
10	Rp16.948.199.174,08	Rp15.729.598.313,17
Battery Electric Fishing Vessel		
Year	Income	Expenses
0	Rp -	Rp 736.100.000,00
1	Rp 1.478.400.000,00	Rp 2.078.023.043,54
2	Rp 3.001.152.000,00	Rp 3.455.745.666,55
3	Rp 4.569.586.560,00	Rp 4.870.341.856,40
4	Rp 6.185.074.156,80	Rp 6.322.917.820,10
5	Rp 7.849.026.381,50	Rp 7.814.612.950,87
6	Rp 9.562.897.172,95	Rp 9.346.600.823,72
7	Rp11.328.184.088,14	Rp10.920.090.220,91
8	Rp13.146.429.610,78	Rp12.536.326.188,17
9	Rp15.019.222.499,11	Rp14.196.591.122,60
10	Rp16.948.199.174,08	Rp15.902.205.893,23

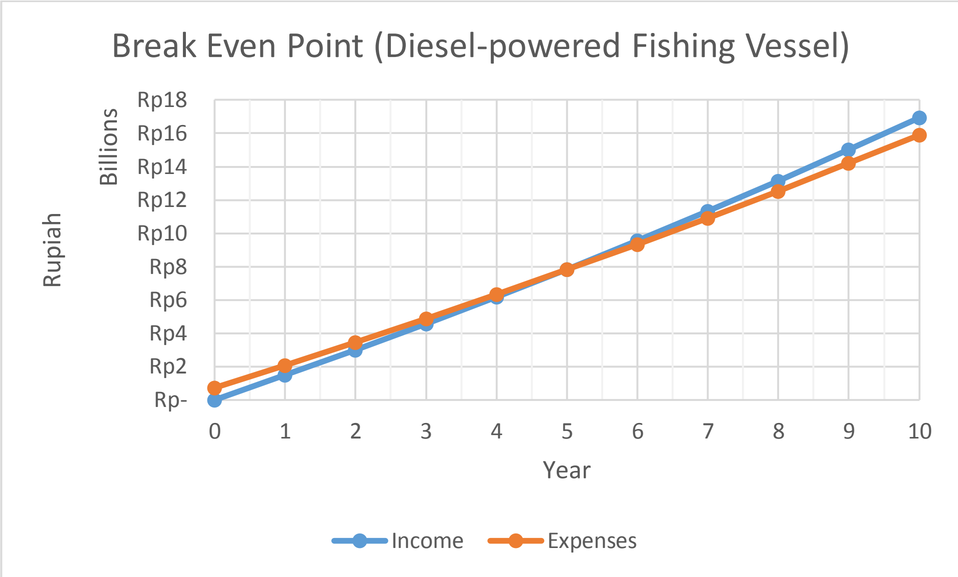


Figure 4.6-2 Break Even Point graph (Diesel-powered Fishing Vessel)

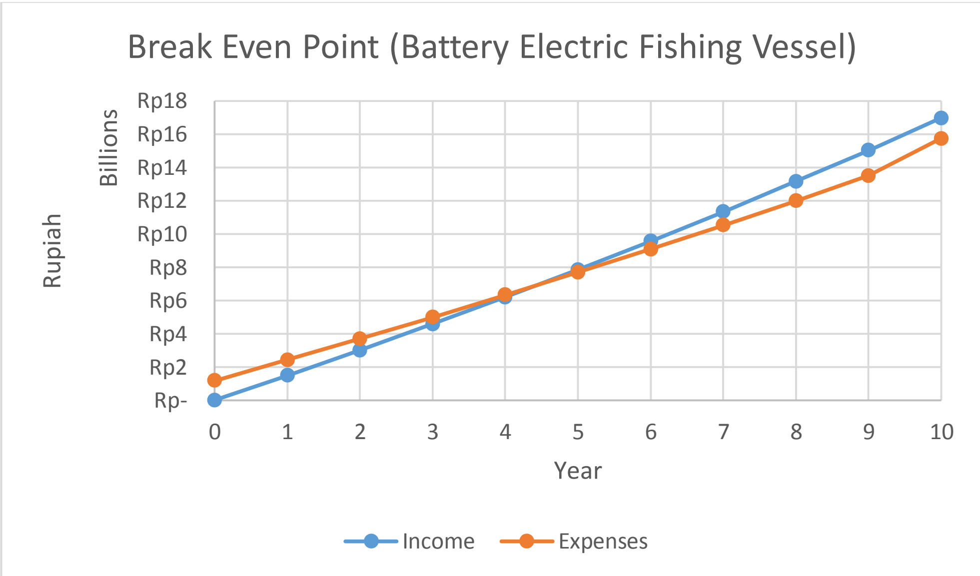


Figure 4.6-3 Break Even Point graph (Battery Electric Fishing Vessel)

As shown in the figure 4.6-2 and 4.6-3, between income and expenses has an intersection on 4th year of operation. So, it means that the investment of diesel-powered fishing vessel and battery electric fishing vessel will pay off in the 4th year of operation. In figure 4.6-3, in the 10th year, there is a sudden rise of expenses happened because of buying new batteries to replace the old one.

4.6.7 Internal Rate of Return (IRR) Analysis

Internal Rate of Return is the value that show the investor the annual growth rate of an investment. The value of IRR is related with the present value, because the goal of IRR is to find the rate that makes the present value of the sum of annual cash inflows equal to initial net cash outflow for the investment.

By knowing the net cash flow which is calculated by subtracting the cash inflows and outflows each year, the value of Present value can be calculated by dividing the net cash flow with the sum of one and discount rate rise to the power of time period. The present value later on, will be used to calculate the IRR by using IRR formula in Microsoft excel.

The resulting IRR for diesel-powered fishing vessel is 13,9% and for battery electric fishing vessel is 14,1%. It means, in the side of investor also, the battery electric fishing vessel is better to invest than diesel-powered fishing vessel. In the case of comparing it with the loan interest which is about 10%, this battery electric fishing vessel is a good investment project, because has higher value.

4.7 ARRANGEMENT OF ELECTRICAL WIRING AND BATTERY ROOM LAYOUT ON FISHING VESSEL

Electrical wiring on this fishing vessel is consist of two junctions which are AC junction and DC junction. AC junction consists of all equipment on the fishing vessel that required AC voltage to run such as propulsion motor and purse seine motor. DC junction consists of all equipment on the fishing vessel that required DC voltage to run such as radio navigation, navigation lamp, fish finder, and emergency lamp.

Each junction and the battery panel should be installed a good wiring that has the capability to deliver the electricity and also safe during the operation. In calculating the right wiring for each installation, it needs to calculate the nominal current. Nominal current can be calculated using these formulas:

- For three phase AC current:

$$I_{nominal} = \frac{P}{380\ x\ \sqrt{3}\ x\ \cos\theta}$$

Where, $\cos\theta = 0{,}8$

- For DC current:

$$I_{nominal} = \frac{P}{V}$$

After knowing the nominal current, the wiring can be selected by picking the value of nominal current as the minimum value of current the wiring should deliver.

Besides selecting the right wiring, it also needs to select the right busbar that can deliver the electricity safely. In order to select the right busbar, it needs to calculate the busbar current by using the formula below:

$$I_{busbar} = 4\ x\ I_{nominal}$$

After knowing the busbar current, the busbar can be selected by picking the value of busbar current as the minimum value of current the busbar should deliver.

As for the complete wiring diagram and battery room layout can be seen in the Appendix 1 and Appendix 2.

CHAPTER 5
CONCLUSION

5.1 CONCLUSION

The optimum battery for Natuna Sea electric fishing vessels 10 GT is 6000 Ah with range of distance about 14 NM, speed service about 7 knots, and fishing activities about 6,5 hours.

The electrical wiring of Battery Electric Fishing Vessel for Natuna Sea divided into DC system and AC system. The detail electrical wiring diagram can be seen on the Appendix 1.

The battery room is located on the engine room and the detail layout can be seen on the Appendix 2.

5.2 SUGGESTION

The design of the optimum aquaculture for Natuna Sea shall consider the amount of the fishing vessel can operate by the capability of electricity production and the capability of the fishing vessel in that area.

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BIBLIOGRAPHY

Crompton, T. R. (2000). *Battery Reference Book Third Edition*. Oxford: Newnes.

Cultu, M. (2009). Batteries and Their Chemistry. In Y. Gogus, *Energy Storage Systems*. Paris: Eolss Publishers.

Food and Agriculture Organization (FAO). (1990). *Fisherman's Workbook*. Oxford: Fishing News Books.

Gurning, S. (n.d.). *Aplikasi Pendanaan Kapal*. Surabaya.

Kementrian Kelautan dan Perikanan RI. (2017). *Laporan Tahunan Kementrian Kelautan dan Perikanan Tahun 2016*. Jakarta: Kementrian Kelautan dan Perikanan.

Pusat Data, Statistik, dan Infromasi. (2016). *Potensi Kelautan dan Perikanan Kabupaten Natuna*. Jakarta: Kementrian Kelautan dan Perikanan.

Pusat Pendidikan Kelautan dan Perikanan. (2012). *Penangkapan Ikan dengan Purse Seine*. Jakarta: Kementrian Kelautan dan Perikanan.

Rashid, M. H. (2011). *Power Electronic Handbook Third Edition*. Pensacola: Elsevier.

Shawyer, M., & Pizzali, A. F. (2003). *The Use of Ice on Small Fishing Vessel*. Rome: FAO.

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APPENDIX 1

WIRING DIAGRAM

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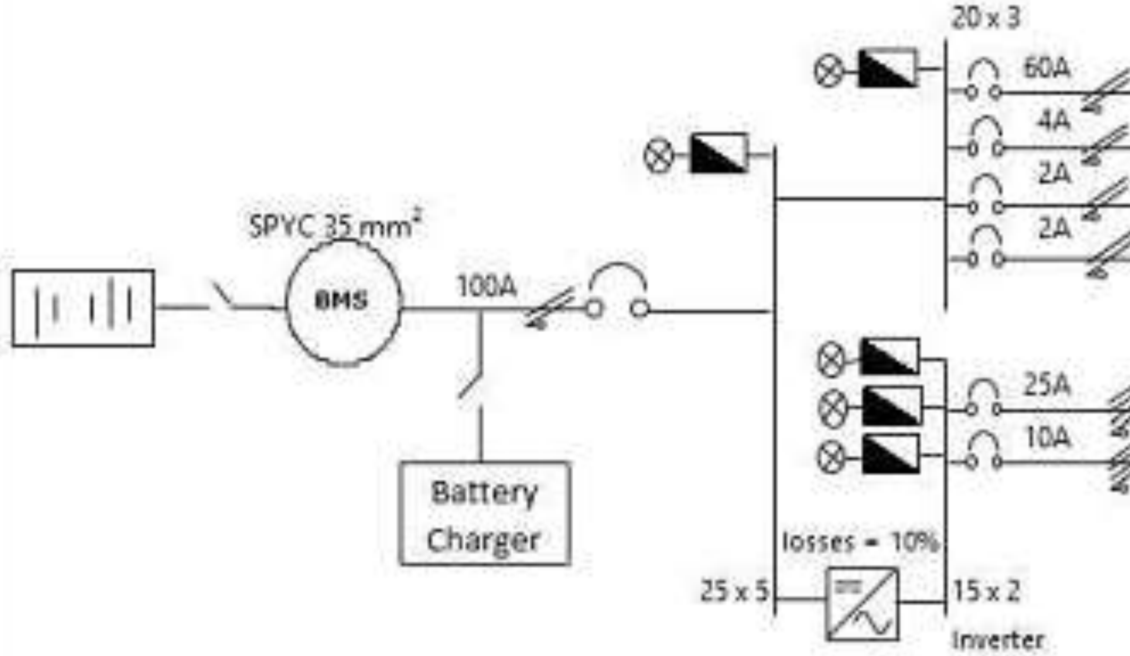

No	Current (amp)	Equipment	Qty	Power Watt	Total Power Watt
1	50	Navigation Lamp	5	240	1200
2	2,5	Emergency Lamp	1	60	60
3	1,04	Radio Navigation	1	25	25
4	0,25	Fish Finder (CP200 CHIRP)	1	6	6
	53,79				1291
5	23,74	Induction motor	1	12,5	12,5
6	9,5	Purse Seine Motor	1	5	5
	33,24				17,5

Battery Panel		
I nominal	87,03	A
Kabel pengaman	35	mm
I busbar	348,13	A
Busbar Dimension	25 x 5	

Junction AC		
I nominal	33,2	A
Kabel Pengaman	10	mm
I busbar	133	A
Busbar Dimension	15 x 2	

Junction DC		
I nominal	53,8	A
Kabel Pengaman	16	mm
I busbar	215,167	A
Busbar Dimension	20 x 3	

PRINCIPAL DIMENSION	
TYPE	Fishing Vessel
Lwl	11,83 m
Lpp	10,00 m
B	2,70 m
H	1,30 m
T	0,80 m
Cb	0.63
Vs	7 knot

DEPARTMENT OF MARINE ENGINEERING
DOUBLE DEGREE PROGRAM
INSTITUT TEKNOLOGI SEPULUH NOPEMBER - HOCHSCHULE WISMAR

FISHING VESSEL 10GT

WIRING DIAGRAM

04211441000010	SCALE N/A	SIGNATURE	DATE
Rivaldi Clarence Tjoa			
Dr. Eddy Setyo K ST., M.Sc.			
Juniarko Prananda ST., MT.			
Dwg. No. 01-14-010-WD	1 OF 1		

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APPENDIX 2

BATTERY ROOM LAYOUT

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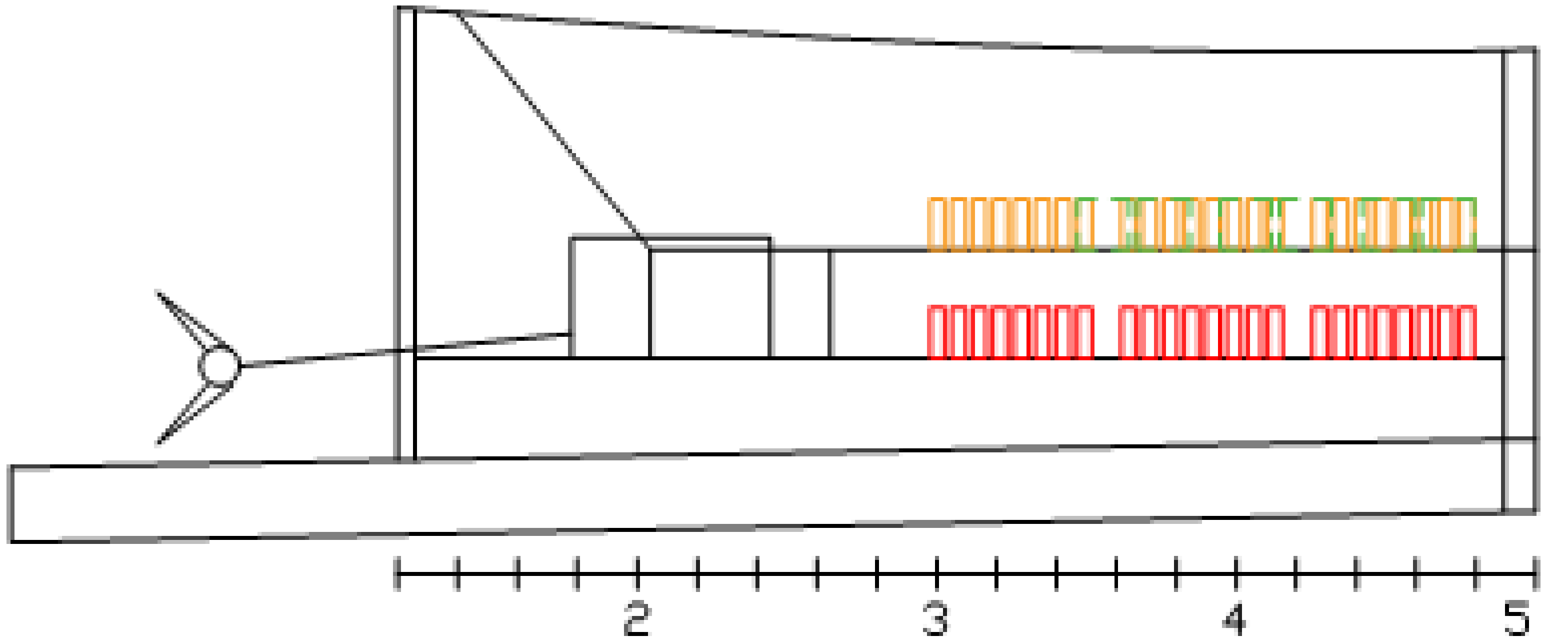

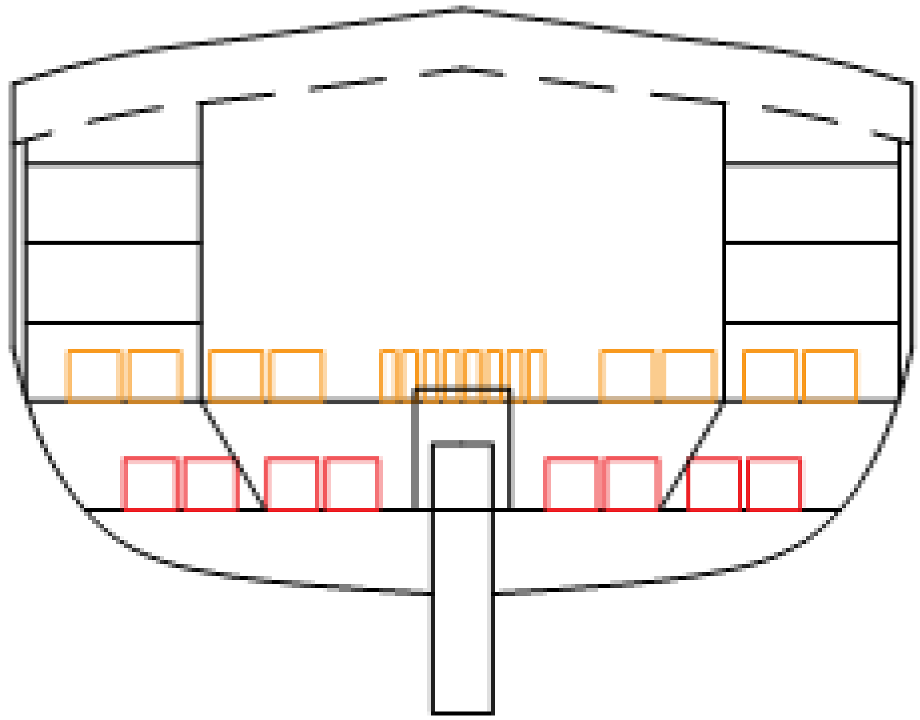

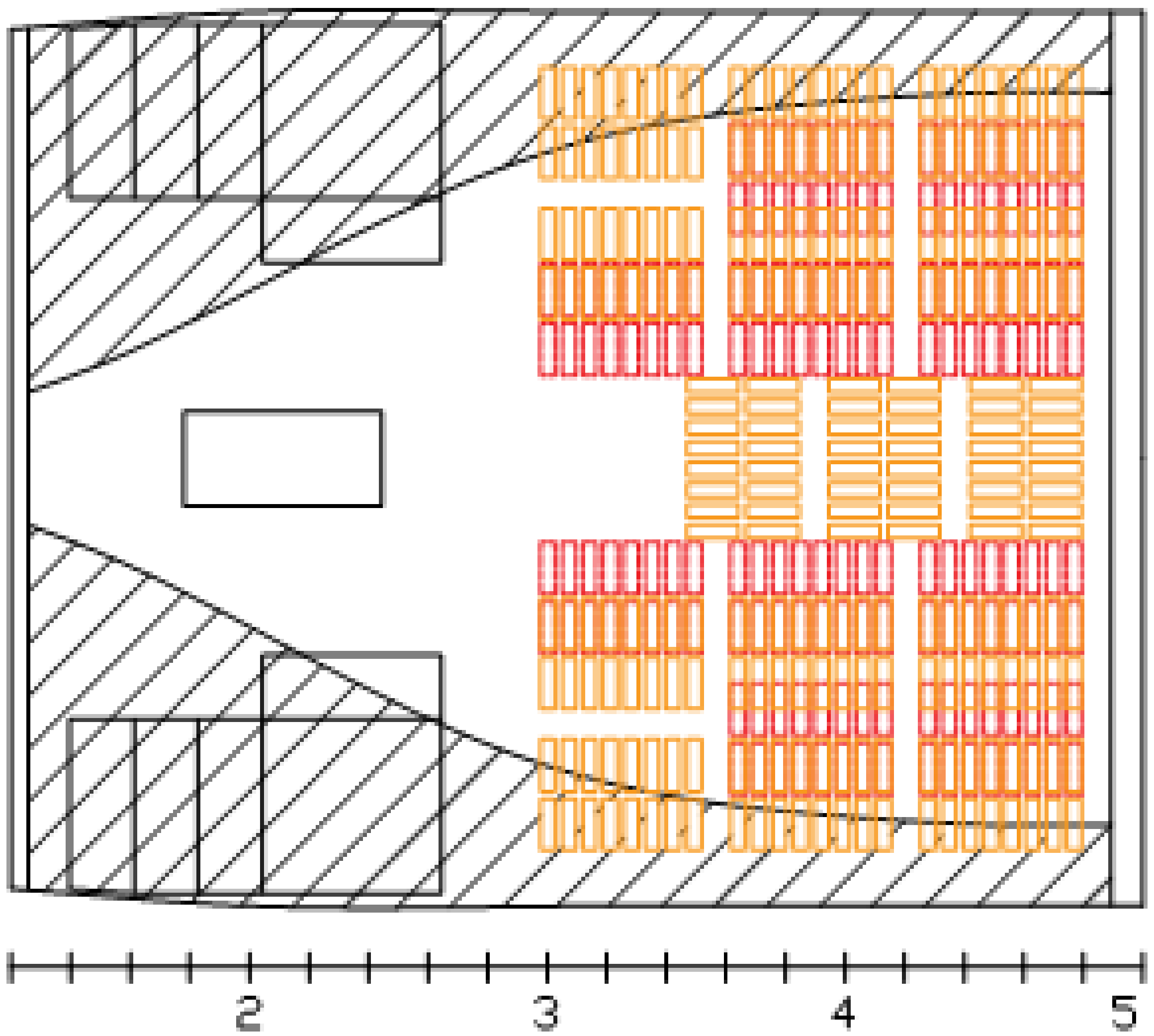

PRINCIPAL DIMENSION	
TYPE	Fishing Vessel
Lwl	11,83 m
Lpp	10,00 m
B	2,70 m
H	1,20 m
T	0,80 m
Cb	0,63
Vs	7 knot

DEPARTMENT OF MARINE ENGINEERING
DOUBLE DEGREE PROGRAM
INSTITUT TEKNOLOGI SEPULUH NOPEMBER - HOCHSCHULE WISMAR

FISHING VESSEL 10GT

BATTERY ROOM LAYOUT

04211441000010	SCALE 1 : 25	SIGNATURE	DATE
: Rivaldi Clarence Tjoa			
Dr. Eddy Setyo K ST., M.Sc.			
Juniarko Prananda ST., MT.			
Dwg. No. 01-14-010-BRL	1 OF 1		

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APPENDIX 3

INDUCTION MOTOR

ASYNCHRONOUS THREE-PHASE TWO-SPEED (Dahlander CIRCUIT) MOTORS, 4/2 POLES

VOLT MOTOR CODE	Type	Rated Values					Efficiency	Starting Data		Breakdown Torque	Weight B3
		Power	Speed	Current I_N	Torque T_N	Power Factor		Locked Rotor Current	Locked Rotor Torque		
		kW	rpm	A	Nm	Cos φ	η %	I_A/I_N	T_{LR}/T_N	T_B/T_N	kg
4/2 Poles										Synchronous Speed 1500/3000 rpm	
V1T-A-71-M-1-A	VM 71	0,22	1340	0,8	1,5	0,73	58	2,9	1,7	2	5
		0,3	2780	0,8	1,0	0,78	68	3,6	2	1,8	
V1T-A-71-M-1-B	VM 71	0,3	1370	1,0	2,2	0,66	66	3,4	2	2,1	6
		0,44	2800	1,2	1,5	0,78	71	4,2	2,1	2	
V1T-A-80-M-1-A	VM 80	0,6	1370	1,5	3,5	0,8	65	3,5	1,3	1,7	7,5
		0,8	2780	1,7	2,1	0,87	67	3,9	1,9	2	
V1T-A-80-M-1-B	VM 80	0,7	1370	2,1	4,9	0,76	67	3,1	1,5	1,7	8,6
		0,85	2800	2,4	2,9	0,79	72	3,8	2,3	2	
V1T-A-90-S-1-A	VM 90S	1	1360	2,9	7,2	0,75	71	3,4	2	1,9	11,3
		1,3	2770	3,5	4,6	0,78	71	3,8	2,1	2	
V1T-A-90-L-1-B	VM 90L	1,3	1390	3,4	8,9	0,79	74	4,5	2,2	2,5	13,3
		1,8	2780	4,5	6,1	0,84	73	4,8	2	2,1	
V1T-A-100-M-1-A	VM 100	1,8	1420	4	12,1	0,85	77	5,8	2,4	2,8	17,5
		2,2	2850	5,8	7,4	0,8	71	5,5	2,5	2,8	
V1T-A-100-M-1-B	VM 100	2,4	1400	5,5	16,5	0,82	79	5,8	2,4	2,4	21,1
		3	2850	7,2	10,2	0,84	74	6	2,5	2,9	
V1T-A-112-M-1-A	VM 112	3,7	1417	8	25	0,83	80,5	4,8	1,8	2,2	28
		4,5	2872	10	15	0,86	78	5,4	2	2,4	
V1T-A-132-S-1-A	VM 132S	4,7	1430	10	31	0,86	84,7	5,4	2	2,2	40
		6	2850	14	20	0,85	79,9	5,1	1,9	2,2	
V1T-A-132-M-1-B	VM 132M	6,3	1440	13,2	42	0,88	87	5,8	2,3	2,4	48
		7,8	2880	17,5	26	0,85	83,5	6	2,4	2,7	
V1T-A-160-M-1-A	VM 160M	9	1450	19,5	59	0,79	88,5	6,1	2,4	2,8	81,3
		11	2910	24	36	0,82	84	5,4	2,7	3,2	
V1T-A-160-M-1-B	VM 160L	12,5	1460	24,8	82	0,86	87	5,6	2,2	2,2	111,5
		15	2930	29,7	49	0,89	84	6,9	2,4	2,5	

TABLE 41: Asynchronous three-phase two-speed (Dahlander circuit) motors, 4/2 poles

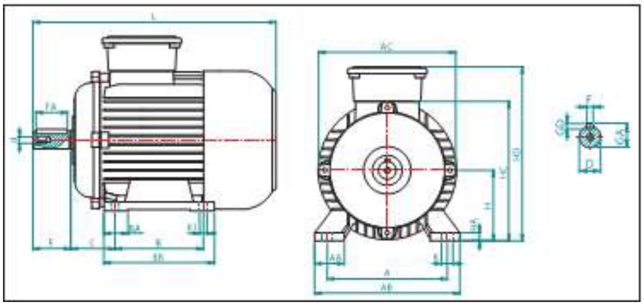
Volt Electric Has Right To Change All The Data Without Prior Notice.

Voltage	:380V
Frequency	:50 Hz
I. Protection	:IP 55
Insulation Class	:F
Duty Type	:S1
IEC 60034	

Type	A	AA	AB	AC	B	BB	BA	C	D	d	E	FA	F	GD	GA	H	HA	HC	HD	K	K1	L
132S	216	58,5	260	255	140	180	37	89	38	M12	80	70	10	8	41	132	17,5	263	317	28	12	482
132M	216	58,5	260	255	178	218	37	89	38	M12	80	70	10	8	41	132	17,5	263	316	28	12	520
160M	254	72	316	305	210	264	52	108	42	M16	110	90	12	8	45	160	23	319,5	400	29,5	15	621
160L	254	72	316	305	254	308	52	108	42	M16	110	90	12	8	45	160	23	319,5	400	29,5	15	664
180M	279	73,5	344	341	241	291	42	121	48	M16	110	100	14	9	51,5	180	25	356	436	41	14,5	708
180L	279	73,5	344	341	279	329	42	121	48	M16	110	100	14	9	51,5	180	25	356	436	41	14,5	708

All dimensions in mm

TABLE 59: Asynchronous IE3 three-phase motors, aluminum housing, foot mounted, B3



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APPENDIX 4

BATTERY

I. Fortune 100Ah 3,2V 3C

100Ah, 3V-3.2V-3.65V, 3C
Aluminum Shell Batteries
EV Lithium LiFePO4
5.1L * 1.4W * 11.4H in
130 * 36 * 290 mm
6.6 Lbs. / 3 Kg

NOMINAL/MINIMUM CAPACITY	100Ah @ 1/3C Discharge
MAX DISCHARGE CURRENT (continuous)	200A (2C)
STANDARD CHARGE CURRENT	50A (0.5C)
MAX PULSE CHARGE CURRENT (<10 sec)	100A (2C)
MAX PULSE DISCHARGE CURRENT (<5 sec)	500A
NOMINAL VOLTAGE	3.2
SUGGESTED MAX CHARGE VOLTAGE	3.65
END OF DISCHARGE VOLTAGE	2.2
CYCLE LIFE AT STANDARD (80%)	>3000
INTERNAL RESISTANCE/IMPEDANCE (milliohms)	1
SUGGESTED CHARGING CURVE	Constant Amperage to 3.65V, Constant Voltage, Decrease Amperage, Stop at 1A Charge
CHARGE WORKING TEMP F (C)	32 to 122 (0 to 50)
DISCHARGE WORKING TEMP F (C)	-4 to 122 (-20 to 50)

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II. RELi³ON RB24V100

Part Number	BCI Group Size	Capacity^ @ 25°C (77°F) Ah	Capacity^ @ 25°C (77°F) Min @ 25A	Dimensions inches (mm) Length	Dimensions inches (mm) Width	Dimensions inches (mm) Height	Weight lbs (kg)	Terminal Type	Cell Structure
12V									
RB50	NA	50	120	7.8 (199)	6.5 (166)	6.7 (171)	15 (6.8)	M8	Cylindrical
RB60	24	60	144	10.2 (260)	6.7 (170)	8.6 (219)	20 (8.9)	M8	Cylindrical
RB75	24	75	180	10.2 (260)	6.7 (170)	8.6 (219)	26 (11.8)	M8	Cylindrical
RB80	27	80	192	12.1 (308)	6.8 (172)	8.7 (221)	28 (12.7)	M8	Cylindrical
RB100	31	100	240	13.0 (329)	6.8 (172)	8.9 (226)	32 (14.5)	M8	Cylindrical
RB150	8D	150	360	19.3 (490)	10.5 (267)	9.0 (229)	60 (27.2)	M8	Cylindrical
RB200	8D	200	480	19.3 (490)	10.5 (267)	9.0 (229)	72 (32.6)	M8	Cylindrical
RB260	8D	260	624	19.3 (490)	10.5 (267)	9.0 (229)	88 (39.9)	M8	Cylindrical
RB300	8D	300	720	20.5 (520)	10.6 (269)	8.7 (221)	84 (38.1)	M8	Prismatic
12V DIN									
RB80-DIN	DIN	80	192	13.2 (335)	6.9 (175)	7.5 (191)	26 (11.6)	M8	Cylindrical
RB100-DIN	DIN	100	240	13.2 (335)	6.9 (175)	7.5 (191)	29 (13.3)	M8	Cylindrical
24V									
RB24V50	31	50	120	13.0 (329)	6.8 (172)	8.9 (226)	32 (14.5)	M8	Cylindrical
RB24V100	NA	100	240	19.3 (490)	6.7 (170)	10.6 (270)	53 (24.2)	M8	Prismatic
48V STEEL CASE									
RB48V100	NA	100	240	22.8 (578)	16.1 (410)	7.8 (198)	145 (66)	Amphenol	Cylindrical
RB48V300	NA	300	720	29.1 (740)	16.1 (410)	17.6 (447)	375 (170)	Amphenol	Cylindrical
RB48V100H	NA	100	240	24.6 (625)	6.1 (155)	20.5 (520)	143 (65)	Amphenol	Prismatic
RB48V150H	NA	150	360	28.3 (720)	5.7 (145)	20.5 (520)	209 (95)	Amphenol	Prismatic

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III. Bright Star 120Ah 3,2V 3C

120Ah, 3V-3.2V-3.65V, 3C
Aluminum Shell Batteries
EV Lithium LiFePO4
6.8L * 1.9W * 6.7H in
174 * 48 * 170 mm
6.2 Lbs. / 2.8 Kg

NOMINAL CAPACITY	120Ah
MINIMUM CAPACITY	115Ah
MAX CHARGE CURRENT (continuous)	1C
MAX DISCHARGE CURRENT (continuous)	2C
PULSE DISCHARGE CURRENT (<10 sec)	3C
NOMINAL VOLTAGE	3.2
MAX CHARGE VOLTAGE	3.65
DISCHARGE CUT-OFF VOLTAGE	2.5
CYCLE LIFE AT STANDARD (80%)	>2500
INTERNAL RESISTANCE/IMPEDANCE (milliohms)	0.5
SUGGESTED CHARGING CURVE	Constant Amperage to 3.65V, Constant Voltage, Decrease Amperage, Stop at 2.4A Charge
CHARGE WORKING TEMP F (C)	32 to 113 (0 to 45)
DISCHARGE WORKING TEMP F (C)	-4 to 140 (-20 to 60)
STORAGE TEMP F (C)	23 to 113 (-5 to 45)

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IV. Deep Blue Sealed

DEEP BLUE SEALED BATTERY

POWER — Power for a World of Applications

STARTING & DEEP CYCLE MARINE BATTERY SYSTEM DB12-2-3ETX

Power Battery Company, the leader in high peformance sealed batteries for industrial and commercial uses, brings you the **DEEP BLUE DOUBLE DUTY BATTERY** specifically designed for marine application.

The **DEEP BLUE DOUBLE DUTY BATTERY** uses a proprietary **Advanced Gel Technology** design which combines the very high-rate discharge capabilities of AGM technology together with the cycling advantages of a GEL battery.

SPECIFICATIONS

Rating	220 AH (2x110)
Res. Cap.	400 minutes
MCA	1098 amps
CCA	900 amps
Overall dimensions	22.083" L x 10.430" W x 11.250" H 561 mm L x 265 mm W x 286 mm H
Weight	170 lbs / 77.1 kg

CONFIGURED FOR 12 VOLTS

CONFIGURED FOR 24 VOLTS

6" LOAD CABLES COMPLETE WITH LUGS AND CENTER DISCONNECT

ISO CERTIFIED SYSTEM

MADE IN CANADA

FEATURES & BENEFITS

- Shock absorbent polypropylene plastic. Both the batterycases and the system container are resistant to extreme temperature and vibration.
- Maintenance free construction. Sealed technology does not requiretopping up with water.
- Oversized internal battery components. Insures minimal voltage drop and more power availability.
- Industrial grade battery plates: Provides long life and durability.

DOUBLE DUTY ADVANTAGE

The DEEP BLUE DOUBLE DUTY BATTERY has the double advantage of combining two independent 12 volt batteries in a parallel redundant configuration. In the event that one battery should fail, the other will continue to supply power to your critical loads. No more downtime waiting for a replacement battery or cell to arive.

OPTIONS

- 6" cables complete with a 175 amp plug in type disconnect and lugged wires at both ends for easy connection to the battery and your load. Specify option part number: CBL-CAN-056(2).
- This system can be configured for 24 volt operation. Specify system part number: DB24-2-3ETX.
- Custom systems for all voltages and run times, taylored to meet your specific requirements.

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Fax: (973) 523-3023
E-mail: sales@powbat.com
Website: www.powerbattery.com

CANADA
Power Battery (Iberville) Ltd.
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Fax: (450) 346-8003
E-mail: sales@powbat.com
Website: www.powerbattery.com

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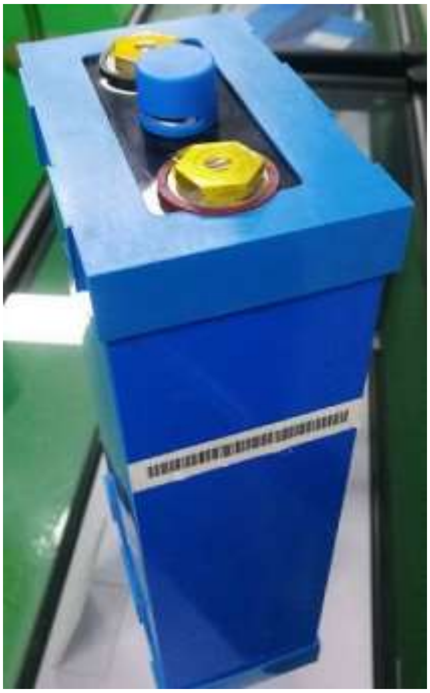
V. Bright Star 220Ah 3,2V 3C



220Ah, 3V-3.2V-3.65V, 3C
Aluminum Shell Batteries
EV Lithium LiFePO4
5.1L * 3.1W * 11.9H in
130 * 79 * 304 mm
13.2 Lbs. / 6 Kg

NOMINAL/MINIMUM CAPACITY	220Ah
MAX CHARGE CURRENT (continuous)	1C
MAX DISCHARGE CURRENT (continuous)	1C
PULSE DISCHARGE CURRENT (<10 sec)	3C
NOMINAL VOLTAGE	3.2
MAX CHARGE VOLTAGE	3.65
DISCHARGE CUT-OFF VOLTAGE	2.5
CYCLE LIFE AT STANDARD (80%)	>2000
INTERNAL RESISTANCE/IMPEDANCE (milliohms)	0.35
SUGGESTED CHARGING CURVE	Constant Amperage to 3.65V, Constant Voltage, Decrease Amperage, Stop at 2.4A Charge
CHARGE WORKING TEMP F (C)	32 to 113 (0 to 45)

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VI. EV LiFePO4 Battery Pack

24V 10Ah

EV LiFePO4 Lithium Battery Pack

7.1 * 2.9 * 6.5 in.

180 * 75 * 165 mm

5.3 Lbs. / 2.4 Kg

NOMINAL VOLTAGE	24V
TYPICAL CAPACITY	10Ah
MAX CHARGE VOLTAGE	29.2V
CUT-OFF DISCHARGE VOLTAGE	<20V
MAX CHARGE CURRENT	10A
CONTINUOUS DISCHARGE CURRENT	15A
MAX DISCHARGING CURRENT	30A (3 sec)
INNER RESISTANCE	<60 milliohm
WORKING TEMPERATURE	-4F~+113F (-20C~+45C)

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BATTERY CHARGER

QET600w-ECPC-D-1-24-20

Model D-1

Lithium or Lead-Acid

Intelligent Battery Charger

*7.2-L * 5.6-W * 2.8-H in*

*184 * 143 * 71 mm*

4.0 Lbs. / 1.8 Kg

AC Input Voltage: 100-240V

AC Input Frequency: 50-60Hz

Power Factor Correction: >0.98

Full Load Efficiency: > 85%

Operating Temperature: +14F - 104F (-10C - +40C)

Storage Temperature: -4F - 158F (-20C - +70C)

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AUTHOR BIOGRAPHY

Author's name is Rivaldi Clarence Tjoa, born in Surabaya on December 16th 1996. The second of the three siblings from a couple Mr. Loeky Tjoa and Mrs. Selvyna Thia. Author has finished several formal education, started from Santa Theresia 2 Elementary School Surabaya (2002-2008), Santo Stanislaus 2 Junior High School Surabaya (2008-2011), and Santo Hendrikus Senior High School Surabaya (2011-2014). After graduated from senior high school, author continue his education to the university that take place in Double Degree Program, Department of Marine Engineering, Faculty of Marine Technology, Institute Teknologi Sepuluh Nopember (ITS) with Hochscule Wismar Germany. During the university study, the author active in managing events, such as SENTA 2015 as a proceeding team, and Marine Icon 2017 in the subevent called Roboboat. Besides, the author also had some practical experience in PT. Dumas Tanjung Perak Shipyard (2016) and PT. Biro Klasifikasi Indonesia branch Surabaya (2017). In the fourth year of university education, the author takes the research group of Marine Electrical and Automation Systen (MEAS) as the study of interest.

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