BACHELOR THESIS & COLLOQUIUM – ME 141502

DESIGN OF AN ALTERNATIVE ELECTRICAL POWERPLANT USING COMBINATION SYSTEM BETWEEN GORLOV HELICAL TURBINE, SAVONIUS WIND TURBINE AND CONNECTED SURFACE BUOY SYSTEM AS A SOLUTION OF ELECTRICALLY ENERGY CRISIS IN EASTERN INDONESIA

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DOUBLE DEGREE PROGRAM
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APPROVAL FORM

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Faculty of Marine Technology
Institut Teknologi Sepuluh Nopember

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Name	: M. Rizqi Mubarok
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Abstract

Indonesia is in electrical energy crisis, especially in eastern Indonesia. To date, the average province in eastern Indonesia still has a low electrification ratio of between 20% - 40%, which means that many areas are not powered by electricity. In addition, until April 2016, there are still 12,659 disadvantaged villages in Indonesia that have not had full access to electricity for 24 hours, while 2,519 villages have not been fully electricity (Ministry of ESDM, 2016). As a result, economic activity, households are hampered, and regional development becomes very limited. With the potential as an archipelagic country, Indonesia can exploit new and renewable energy potential from ocean currents, sea winds and waves. Recorded, the strongest potential of ocean currents in Indonesia is in the Capalulu Strait, North Maluku Province, with a speed of 5.0 m / sec (PPGL, 2016). While the potential of Indonesia's sea wind in some areas has wind speeds above 5 m / s, in East Nusa Tenggara, West Nusa Tenggara, South Sulawesi and South Java Jawa (LIPI, 2007). So, it can be concluded that Indonesia has a lot of energy potential. We innovate to create an integrated power plant system that combines Helix Turbines, Savonius Turbine and Connected Surface Buoy System as the solution to this problem. The working system of this plant is to convert kinetic energy from the currents and waves of sea water and sea wind energy into electrical energy through generators to meet the electricity needs in Indonesia. The power generated by the powerplant reaches 5.8 mW and is capable of supplying more than 6400 homes in Indonesia (asumption every home requires 900 Watt). With this powerplant is expected to be a solution to overcome electrical energy crisis, especially in eastern Indonesia.

Keywords: energy crisis, ocean currents, sea waves, sea wind, coastal.

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FOREWORD

Praise be to Allah SWT who has given grace and hidayah to the author, so that the author can finish this thesis well. Shalawat and greetings are always poured into the Prophet the Great Prophet Muhammad who brought men from the dark ages to this bright era. The preparation of this thesis is intended to meet some of the requirements to achieve a Bachelor of Engineering degree at SepuluhNopember Institute of Technology.

The author realizes that this writing can not be solved without the support of various parties both morally and materially. Therefore, the authors would like to express their gratitude to all those who have helped in the preparation of this thesis especially to:

1. Both parents, honorable father Ahmad Rifai and beloved mother Salwiningsih, and dear sister Risalatur Rohmah and brother Anggit Rosadi who have provided both moral and material support and unceasing prayers to the author.
2. Mr. Eng Muhammad Badrus Zaman, ST., MT., As the head of Marine Engineering Department FTK - ITS Surabaya.
3. Mr. Ir. Agoes Achmad Masroeri, M.Eng., D.Eng, as a Supervisor I Ir. Hari Prastowo, M.Sc., as a Supervisor II who has the pleasure to provide additional knowledge and solution on every problem of difficulties in writing this thesis.
4. All Mr. / Ms lecturer Marine Engineering Department FTK - ITS which has provided knowledge that is very useful during the lecture.
5. All the classmates, especially the Double Degree Force 2014 who always fill the days become very fun.
6. Bagas Bimantoro and Muhammad Taufiq who have helped and give spirit every day in the completion of this thesis.

The author realizes that this thesis is far from perfect because of the limited experience and knowledge of the author. Therefore, the authors expect all forms of advice and input and even constructive criticism from various parties. Hopefully this thesis can be useful for readers and all parties, especially in the field of Marine Engineering.

Surabaya, 31th December 2017

Author,

(Muhammad Rizqi Mubarok)

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INTRODUCTION

1.1. Background

Electrical energy has been widely used to facilitate human life. Thus, in this modern era the need for electricity in Indonesia is enormous. In 2014, the average electricity consumption of 199 terawatt hour and that electricity consumption can be achieved with a total installed capacity of 53,585 megawatts (Ministry of Energy and Mineral Resources, 2014). However, behind the fact of the powerplant, in reality there are still many areas in Indonesia, especially in eastern Indonesia that has not been powered by electricity. That is can be shown in figure 1.1.From the map of electrification ratio of Indonesia in 2016 issued by the ministry of ESDM conclude that eastern Indonesia are in Electrical energy crisis.

Figure 1.1. Electrification ratio of Indonesia in 2016
(Source :*Ministry of Energy and Mineral Resources, 2016)*

From the picture can be seen that eastern Indonesia is still very low of electricity ratio or called the electricity energy crisis is limited by the red area. To date, there are fourteen provinces in western Indonesia with electrification ratios above 60%, the province is present in all of Java Island, Sumatra Island and Kalimantan Island. While other provinces in eastern Indonesia still have a low electrification ratio between 20% - 40%, there are West Nusa Tenggara (32.51%), East Nusa Tenggara (24.55%), Southeast Sulawesi (38.09%) And West Irian (32.35%). In addition, until april 2016, there are still 12,659 disadvantaged villages in Indonesia that have not had full electricity access for 24 hours, while 2,519 villages have not been fully electricity (Ministry of Energy and Mineral Resources, 2016). This is because electrical energy in eastern Indonesia is generated by PLTD (Powerplant Using Diesel Engine) whose capacity does not meet the maximum electrical load.

Another problem is the fossil resources are also beginning to thin out. Predicted if relying on wells that are currently installed can only survive until 2028 (Ministry of Energy and Mineral Resources, 2016). While for coal reserves can still survive until 2040 (BPPT, 2016). Meanwhile, according to BPPT, 75% of electricity supply in Indonesia comes from fossil energy. Indonesia should begin change to green energy or renewable energy considering the potential energy that exists in Indonesia is very potential.

In addition to the above facts, Indonesia is an archipelago country with abundant potential energy. Indonesia has a tidal current velocity in the coastal waters of less than 1.5 m / s, while in the straits between Bali, Lombok and East Nusa Tenggara, the speed can reach 2.5 to 3.4 m / s. The strongest tidal currents recorded in Indonesia are in the Capalulu Strait between Taliabu Island and Mangole Island in the Sula Islands, North Maluku Province, reaching a speed of 5 m / s (Subaktian, 2016).

In addition to tidal currents, Indonesia also has potential wind energy. The results of the mapping of the National Aeronautics and Space Agency (Lapan) at 120 locations show that some areas have wind speeds above 5 m / s. One of them is in West Nusa Tenggara, East Nusa Tenggara, South Sulawesi and South Java (LIPI, 2007)

Due to the abundance of Indonesia's potential, we have innovated to create an integrated electrical powerplant system, combining Helix and Savonius Turbine and Connected Surface Buoy System. The working system of this powerplant is to convert kinetic energy from sea currents, wind energy and wave energy into electrical energy through generators to meet electricity needs in eastern Indonesia. The main purpose of combining these three systems is that all potential energy sources can be utilized to the fullest.

This powerplant is a solution to overcome electrical energy crisis in eastern Indonesia. As we know that electricity is the most important aspect to encourage development in less developed areas. It hoped that by the end of the electricity crisis will encourage the development of various sectors of life in eastern Indonesia and encourage equitable infrastructure development in Indonesia. It is also expected that this powerplant is a solution that can be utilized to reduce emissions caused by the use of fossil resources.

1.2 Problem of Analysis

Based on the background that we described above, we raised the following problem, there are :

1. What most suitable energy converter to be applied in Indonesia to maximize the energy potential of ocean currents, sea waves and wind?
2. After selecting the appropriate energy converter applied in Indonesia, then what is the potential of electrical energy that can be generated from the selected energy converter?
3. How the optimum combination in each energy converter based on criteria of potential application?
4. How the economic analysis of this powerplant?

1.3. Scope of Problem

In this final project, where the alternative electric energy utilizes this potential energy from sea by utilizing the analysis from ***Gorlov Helical Turbine, Connected Surface Buoy System and Savonius Wind Turbine***, to avoid the problems that are too broad, it is necessary to hold the following restrictions, there are:

1The method used is the simulation method.
2. The model is used as an object of analysis.
3. Model testing is done using software.
4. The location observed is Sula Island, North Maluku.
5. Analysis is performed to obtain total potential power produced, excluding construction and resistance of platform.

1.4 Writing Purpose

The objectives to be achieved from this thesis are:
1. Obtain an alternative energy converter with energy source from sea with to be applied in Indonesia to maximize the energy potential of ocean currents, sea waves and wind
2. To know the potential energy can produce from this powerplant
3. Knowing the optimum configuration each energy converter to produce higher energy.
4. to know the economic analysis of this powerplant.

1.5 Benefit of Writing

• For academics (college)

1. Obtaining information about alternative powerplant to overcome the electricity crisis on the straits in Indonesia.
2. Examine further a means of ocean current, sea wave and sea wind.

• For coastal communities

1. Provide information to the public about energy crisis issues.
2. Providing solutions for handling environmentally friendly energy crisis through the application of design and prototype.

• For the government community

1. Provide alternative solutions to overcome the lack of electrical energy in the sea Indonesia.
2. As a reference to the implementation of the Green Energy program in Indonesia.

1.6 Writing Systematics

The writing systematics in this thesis are:

- CHAPTER 1 INTRODUCTION

In this section the authors explain the background of the problem of research to be done, the formulation of the problem, the objectives to be achieved in the experiment, the benefits of future research after the experiment was successfully performed, limiting the problem that limits in doing research, and systematical writing the final task.

- CHAPTER 2. LITERATURE REVIEWS AND BASIS THEORY

In this section the author explains some basic theories that support the alternative powerplant experiment using Gorlov Helical Turbine, Connected Surface Buoy System and Savonius Wind Turbine in this final project.

- CHAPTER 3. WRITING METHODOLOGY

In this section the authors describe and explain the flow chart steps in conducting this research task that is arranged systematically.

- CHAPTER 4. ANALYSIS OF RESULT AND DISCUSSION

In this section the authors describe the results powerplant model that has been done in the Laboratory of Energy and Marine Environment at the wave pool (flume tank) Department of Marine Engineering ITS.

- CHAPTER 5. CONCLUSION

In this section the authors draw conclusions based on the goals to be achieved in this bachelor thesis, as well as provide development advice for further research.

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CHAPTER II
LITERATURE REVIEWS AND BASIS THEORY

2.1Preliminary

Indonesia has a lot of energy resources. As for the potentials energy, the greatest potential is in the marine sector. It is also supported by data from the Indonesian Marine Energy Association *(ASELI)*. The data can be seen in table 2.1 below.

Table 2 .1 Data of Potential Electricity Energy in Sea
*(**Source:** ASELI, 2011)*

Jenis Sumber Energi	Potensi Teoritis (MW)	Potensi Teknis (MW)	Potensi Praktis (MW)
Panas Laut	57.000	52.000	43.000
Arus Laut	160.000	22.500	4.800
Gelombang Laut	510.000	2.000	1.200
Total	**727.000**	**76.500**	**49.000**

From the table can be concluded the theoretical potential of ocean energy is very large. But only a little for its technical potential, this is due to limited technology that is insufficient to develop this ocean energy. In addition to the technological limitations that are still less developed, there is no concrete solution from the government to maximize the potential of energy source from ocean sector.

From the table it can also be concluded that the marine sector is very potential if developed to meet the energy crisis in Indonesia in the future. This is also supported because according to the World Energy Council *(WEC)* trends in Europe are beginning to switch to alternative energy using wind turbines. And it will be predicted by 2050 that most of Europe has already turned to alternative energy using turbine.

The government has actually mapped potential areas for energy development in the marine sector. The map covers potential areas for the development of ocean currents, sea breezes and ocean waves. The area covers most of eastern Indonesia, which we know that eastern Indonesia still has a low electrification ratio of less than 40%.

Actually, the government has started to develop by creating a prototype renewable energy implemented by Research and Technology Centre *(BPPT)*. One of them is by installing the ocean currents energy under the suramadu bridge and on one of the beaches in Yogyakarta. Both prototypes are Oscillating Wave Column *(OWC)*. However, this solution is considered less because the powerplant system is only utilizing the tidal energy of ocean waves. Therefore we make a proposal by combining the helix turbine, the savonius wind turbine and the Connected Surface Buoy System. It is expected that with our new idea will be more effective in exploiting the energy potential from the marine sector. And hope is as a solution to handle the energy crisis in Indonesia and to state the development in Indonesia. This is because to grow up the regional economy must have infrastructure, including the most important is the availability of electricity.

2.2 Ocean Currents

Sea currents are the movement of the water mass vertically and horizontally so as to balance, or the vast movement of water that occurs throughout the world's oceans (Hutabarat and Evans, 1986). Sea currents is also a flowing motion of a mass of water due to wind blow or difference in density or long wave motion *(Nontji, 1987)*. Current movement is influenced by several things, such as :

1. Wind direction,
2. Water pressure difference,
3. Water density difference,
4. Coriolis force
5. Ekman current,
6. Topography of seabed,
7. Surface current,
8. Upwellng
9. Downwelling.

2.2.1. Causative Factor Ocean Currents

In addition to wind, currents are influenced by three factors, there are *(Sahala Hutabarat, 1986)*:

a. **Topographic shape of the ocean floor and surrounding islands:**

Some of the major ocean systems in the world are limited by land masses from three sides and are also limited by equatorial counter currents on the fourth side. These limits produce a nearly closed system of flow and tend to make the flow lead in a sphere shape.

b. **Coriollis Force and Ekman Currents :**

Corriolis forces affect the flow of water masses, where this force will bend their direction from the straight direction. Corriolis style also causes the changes - changes in the direction of the complex flow of the order that occurs in accordance with the depth of the depth of a waters.

c. **Different Density, upwelling dan sinking :**

Differences in density leads to a mass flow of water from deep seas in the polar regions of the south and north poles towards the tropics.

2.2.2. Currents Types

The types of currents are divided into two types, there are:

a. Based on cause of occurrence

- **Ekman Flow**: Flow that is affected by the wind.
- **Thermohaline currents**: Current influenced by density and gravity.
- **Tidalcurrents**: Flows that are affected by tides.
-**Geostropic currents**: Current influenced by horizontal pressure gradient and coriolis force.
- **Wind driven current**: The current is influenced by the pattern of wind movement and occurs in the surface layer.

b. Based on Depth

- **Surface current**: Occurred at several hundred meters from the surface, moving in a horizontal direction and influenced by the pattern of wind distribution.

- **Flow in**: Occurs deep at the bottom of the water column, the direction of movement is not affected by the pattern of wind distribution and bring the water mass from the polar regions to the equator.

2.2.3. Potential of Sea Currents Energy in Indonesia

Indonesia is very potential in the process of developing ocean currents energy. It has also received a positive response from the government through Ministry of Energy and Mineral Resources has started doing research in terms of energy by mapping potential areas for the development of ocean currents energy. The mapping of potential areas for the development of ocean currents energy can be seen in Figure 2.1 below.

Figure 2.1. Map of potential ocean currents in Indonesia
***(Source** Ministry of Energy and Mineral Resources, 2016)*

From Figure issued by the Ministry of Energy and Mineral Resources in 2016, it can be seen that many areas have potential as a place for regional development for ocean current energy applications. One of them is in capalulu strait area. Strait capalulu flank between mangole island and obi island. This strait has a current velocity of up to 5 m / s.

2.2.4. Sea Currents Energy Development

There has been developed many energy plants that utilize sea currents energy or can shown in figure 2.2. Powerplant that utilize energy from sea currents usually use turbines. And this type is also called tidal turbine.

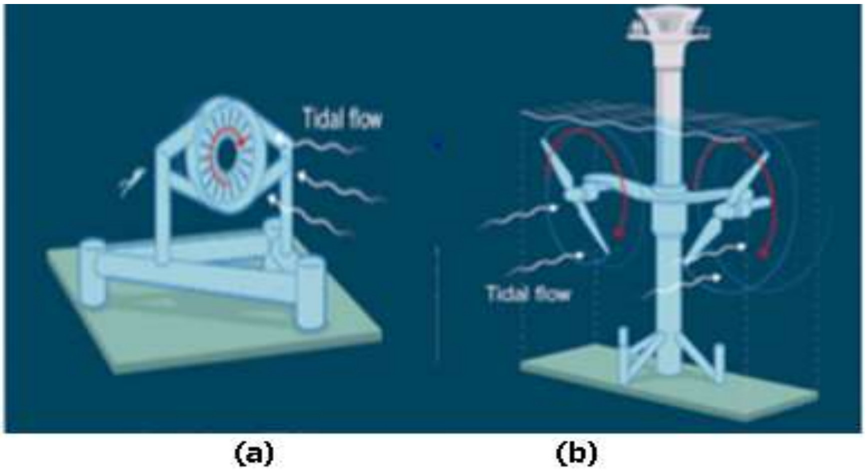

Figure 2.2. (a) Open Hidro turbine, (b) Marine Current Turbine
***(Source :** Zhong Lin Wanga et. all, 2017)*

Of the many types of turbines, the authors choose turbine helix or commonly called turbine gorlov. Turbine helix can shown in figure 2.3. This Turbine chosen because it has more high effectiveness compared to other types of turbines, up to 35% (Scott Anderson, 2009). This turbine has been patented in a series of patents from September 19, 1995 to July 3, 2001 and won the 2001 ASME Thomas A. Edison Patent Award.

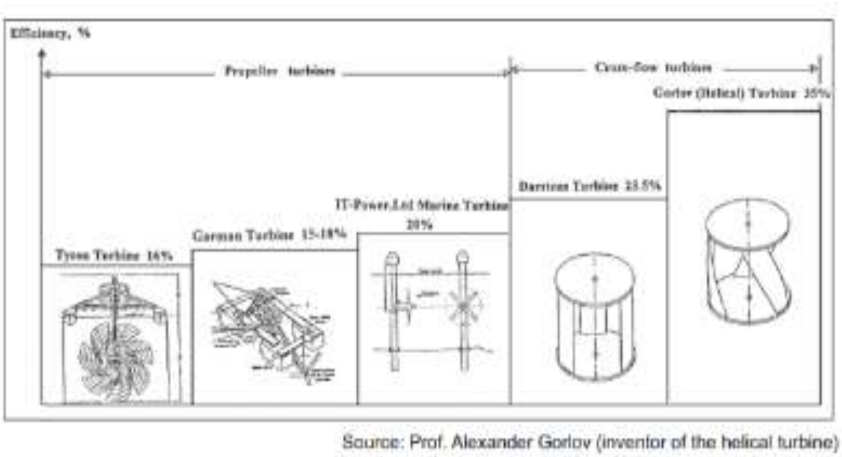

Figure 2.3. Efficiency of Gorlov Helical Turbine
***(Source :**Scott Anderson, 2009)*

2.2.5. Gorlov Helical Turbine

Helical turbine or Gorlov turbine is a marine current turbine created by Professor Alexander M. Gorlov.This turbine is can shown in figure 2.4.Gorlov helical turbine is a development of the Darrieus turbine, where it has a foil or a helical leaf. The working principle is the same as the Darrieus turbine, which utilizes ocean currents to drive turbines and generate electrical energy.

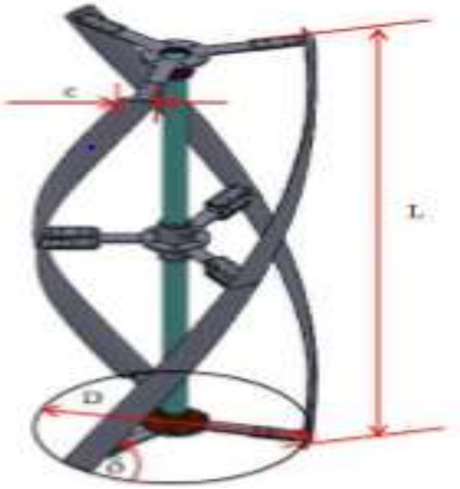

Figure 2.4. Helical Turbine
***(Source :** Sathit Pongduang et. all, 2015)*

2.2.6. Difference Between Gorlov Helical Turbine and Conventional Turbine

The main difference between conventional turbine and gorlov helical turbines is the orientation of the pivot in relation to the current. Helix turbine is a vertical axis turbine which means the shaft is positioned perpendicular to the current flow, while the traditional turbine is a horizontal axis turbine which means the shaft is positioned parallel to the current flow. Fluid flow, like wind, will naturally change direction, but will remain parallel to the ground. So on all vertical axis turbines, the flow remains perpendicular to the axis, regardless of the direction of the flow, and the turbine always rotates in the same direction. This is one of the main advantages of vertical axis turbines *(Gorlov, 1998).*

2.2.7. Fluid Perform in Gorlov helical Turbine

The term "foil" is used to shape the shape of the blade cross section at a particular point, regardless of the type of fluid (airfoil or hydrofoil). In the helical turbine design, the knife angle curve around the axis, which has the effect of evenly distributing the foil parts throughout the rotation cycle, so there is always a foil portion at each angle that is exposed to the fluid. In this way, the number of lifting forces and obstacles in each eye does not change suddenly with the rotation angle. Turbines produce a finer torque curve, so the vibration and noise is much less than the Darrieus design. It also minimizes peak pressure on structures and materials, and facilitates self-starting turbines. In the GHT testing environment it has been observed to have an efficiency of up to 35% (Scott Anderson, 2009)

2.2.8 Characteristic of Gorlov Helical Turbine

Gorlov Helical turbines have the following characteristics, there are :

1. The design is intended for running water.
2. Can move with a current speed of at least 0.5 m / s and able to work maximally at a current velocity of 1.5 m / s.
3. Does not require a platform that can damage the environment.
4. Current velocity is directly proportional to the electrical energy generated.
5. Easy to make use of local materials such as iron, aluminum, and others.
6. Can be applied with parallel system horizontally or vertically.

2.3. Wind

Wind is a large amount of airflow caused by the rotation of the earth and also because of the different air pressure around it. The wind moves from high-pressure air to low-pressure air.

2.3.1. Wind Causative Factors

a. Gradien Barometris

Numbers showing the air pressure difference of 2 isobars that are 111 km apart. The larger the barometric gradient, the quicker the wind blows

b. Place Location

Wind speeds near the equator are faster than those far from the equator.

c. Higher Place

The higher place, the faster the wind will blow, this is caused by the influence of friction force that inhibits the air rate. On the surface of the earth, mountains, trees, and other uneven topography provide a great frictional force. The higher a place, the frictional force is getting smaller.

d. Time

In the daytime the wind moves faster than at night

2.3.2. Wind Types

a. Sea Wind

Sea wind is a wind that blows from the sea towards the land that generally occurs during the day from 09.00 to 16.00 in the coastal area. This wind is commonly used by fishermen to come home from fishing in the sea. This sea wind occurs during the day. Because water has a greater heat capacity than land, sunlight heats the ocean more slowly than land. As terrestrial surface temperatures increase during the day, air above ground surface increases also due to conduction. The air pressure above the land becomes lower due to heat, whereas the air pressure in the oceans tends to be still higher as it is cooler. As a result there is a higher pressure gradient from the ocean to the lower ground, thus causing a sea wind, where its power is proportional to the temperature difference between land and sea. However, if there is a stronger offshore wind than 8 km / h, the sea wind does not occur.

b. Land Wind

Land wind is a wind that blows from the land toward the sea which generally occurs at night from 8 PM to 6 AM in the coastal area. This type of wind is useful for the fishermen to set out to fish in a simple wind-powered boat. At night the land becomes cooler faster than the oceans, because the soil heat capacity is lower than water. As a result, the temperature difference that causes the sea wind is slowly disappearing and vice versa the opposite pressure occurs because the air pressure over the warmer ocean becomes lower than the land, so the winds occur, especially if the coastal wind is not strong enough to fight it.

2.3.3. Potentional Wind Energy Development in Indonesia

Indonesia is very potential in wind energy development process. According to the National Aeronautics and Space Agency *(Lapan)*, the potential of winds that can be utilized to be Source of energy has a speed above 5 m/s and it is located in 120 locations and spread in East Nusa Tenggara, West Nusa Tenggara, South Sulawesi and South Java . The government has mapped potential areas for wind energy development. This can be seen in Figure 2.5 below

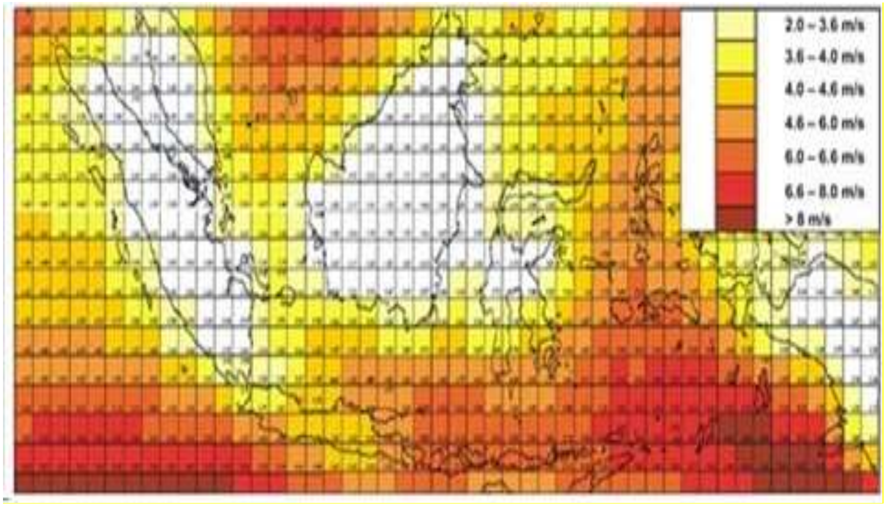

Figure 2.5. Map of wind potential in Indonesia
***(Source :** Ministry of Energy & Mineral resources , 2016)*

Based on Figure 2.5 the potential of wind energy capable of producing the greatest power comes from the southern region. This is because the average in southern Indonesia has wind speed 6 - 8 m / s. Even in some parts of southeast nusa have wind speed up to above 8 m / s. While in northern indonesia the average wind speed is 3.6 - 4 m / s. But different in some parts of maluku island, some of its area wind reach speed 6 m / s.

2.3.4. Wind Energy Development

One of the other energies that has been developed by the government is the energy from the wind. Recorded from 2007 until now has installed wind powerplants at five points with a capacity of 800 KW. With Indonesia potential in wind sector around 250 MW (*Ministry of Energy and Mineral Resources, 2016)*. This is considered the potential energy of the wind sector is very potential. But this is not matched by the government's readiness to further develop the generation of wind energy.

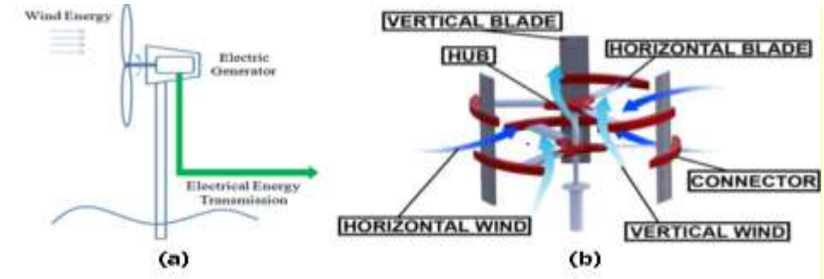

Figure 2.6. (a) Conventional wind energy converter,
(b) Novel Cross Axis Wind Turbine
(Source :*W.K.Muzammil, 2012)*

Actually, already many scientists who develop the converter energy from the wind to be converted to electrical energy. But the author chose savonius type. The reason for selecting the Savonius model compared to the conventional model because Savonius wind turbine is designed to work in areas with fluctuating wind nature both in the direction and speed. In the traditional wind turbine, although the wind direction problem can be overcome by steering, but the fact is not always running smoothly so that the efficiency of the wind turbine becomes low.The base material of the turbine does not always have to use metal, in simple circumstances the leaves can be replaced with fiber, even plywood

2.3.5. Savonius Wind Turbine

Savonius Wind turbines is one type of turbine with a vertical axis that is able to convert horizontal wind energy into kinetic rotational energy. The wheel was developed by Finnish engineer Sigurd Johannes Savonius in 1922, but long before that there had been a similar concept of the turbine made by Bishop of Czanad through his writing on the 1616 book of Machinae novae *(Scott Anderson, 2009).*This is can be seen at figure 2.7 below.

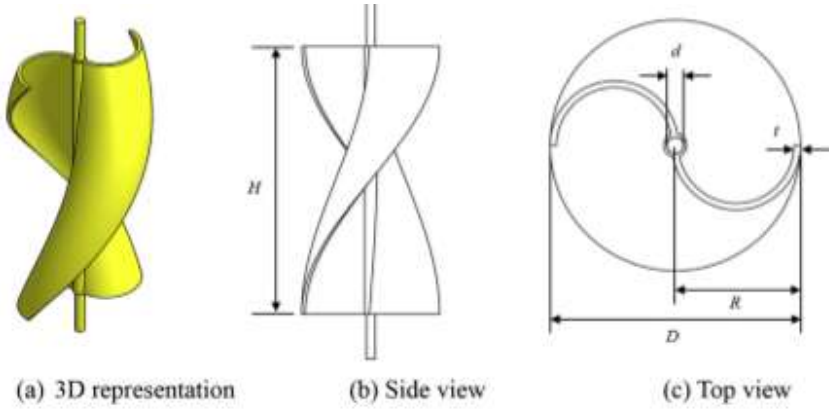

Figure 2.7. Savonius Wind Turbine
***(Source :** Keum Soo Jeon et. al, 2014)*

Savonius wind turbines are chosen because the cost of maintenance is more economical. Savonius turbines with larger blades are commonly used by wind power generation in the sea area. The design of this turbine is also easier and simpler when compared to horizontal axis wind turbines, there is no indicative mechanism required to allow for wind direction and turbine to start on their own. Savonius was chosen because it was not affected by angina when applied to areas with unidirectional wind.

2.4. Sea Waves

Sea waves are the shape of the sea surface in the form of the back or the peak of waves and troughs or valleys of waves by oscillatory movement due to the wind, volcanic eruptions, marine depletion, or ship traffic (Sunarto, 2003).

Holthuijsen (2007) explains that sea waves are the movement of rising and falling seawater with the direction of perpendicular sea level that form sinusoidal curves / graphs. (Nichols et al., 2009 in Bagus, 2014) explains that ocean waves arise because of the forces that work on the ocean. Waves that occur in the oceans can be classified into several kinds based on their generating forces, the generating force is primarily from the wind, from the Earth-Moon attraction - the Sun or so-called tidal waves and earthquakes. There are two types of waves, when viewed in terms of their properties. They are: Builder or Constructive Waves and Destructive Waves.

2.4.1. Waves Classification

Wave classification by size and cause *(Pond and Pickard, 1983)* there are :

1. **Ripples/ capillarywave**

With a max of wavelength of 1.7 meters and a period of less than 0.2 seconds due to the presence of surface tension and the wind that is not too strong at sea level.

2. **Seas/wind waves**

With a wavelength of up to approximately 130 meters and a period of 0.2 to 0.9 seconds generated by wind.

3. **Swell**

With wavelengths up to hundreds of meters and a period of 0.9-15 seconds generated by long-blowing winds.

4. **Tidal wave**

With a wavelength of several kilometers with a period of 5 hours, 12 hours, and 25 hours by the fluctuations of the gravitational force of the Sun and the Moon.

2.4.2 Potential of Sea Waves in Indonesia

Figure 2.8. Map of Potential of Sea Waves in Indonesia
***(Source :** Anggraini et, al, 2016)*

Based on Figure 2.8 the potential of ocean wave energy that is capable of producing the greatest power comes from the southern part of the coast. This is because the average height of waves on the south coast is higher than in the north coast. Based on the Meteorology, Climatology and Geophysics Agency (BMKG, 2016) states that the average height of the wave in the southern sea is about 2.5 - 4 meters, while on the north coast around 1.25 - 2.5 meters.

In addition to having the power potential generated larger theoretically in the long term, ocean wave energy is also easier to install, more efficient, environmentally friendly, easy maintenance and low operating costs. Thus, it is necessary to design the model of sea wave powerplant to fulfill the electricity needs in the long term in Indonesia.

2.4.3. Sea Wave Energy Development

Sea waves are one of the potential energy that can be utilized to meet the electrical energy crisis in Indonesia. Much research has been done to change the energy of ocean waves or sea tides. This is done because scientists have realized so much potential that can be utilized from the energy of sea waves. Actually already a lot of ocean currents energy developed. As for some types of them with OWC, Pressure differential, Floating Structure, Overtoping and oscilating wave surface. Of some tiper, at breakdown again with the distribution of location. Namely with the location in the middle of the ocean off / off shore, located in the waters close to the mainland / nearshore and also the last is in the mainland or onshore.

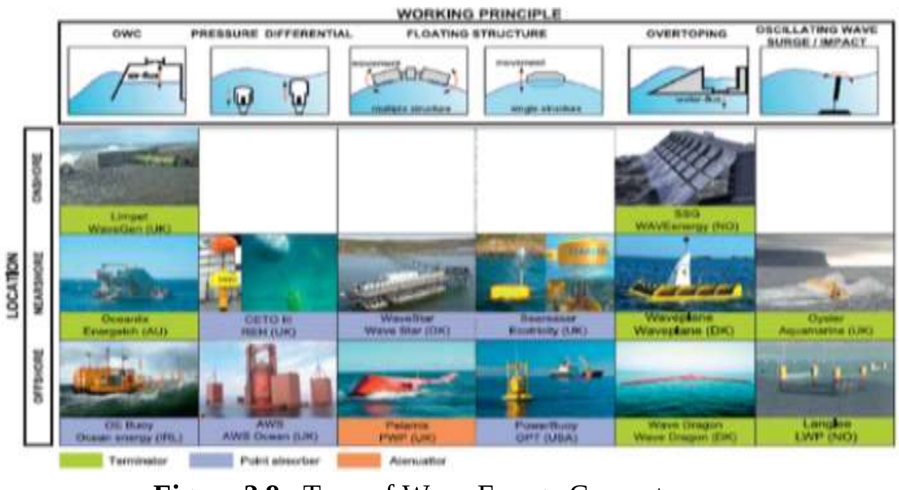

Figure 2.9. Type of Wave Energy Converter
(Source : *J Hardisty, 2012)*

Of the many prototypes developed for the energy converters of ocean waves, the authors chose the Connected Surface Bouy System. This system is an OWC (oscillating wave column) system with nearshore location application or waters close to the mainlandor can seen in figure 2.9. This system is chosen because in economical aspect cheaper because do not have to build off shore and in case of treatment also easier because it is near land or nearshore.

2.4.4. Connected Surface Buoy System

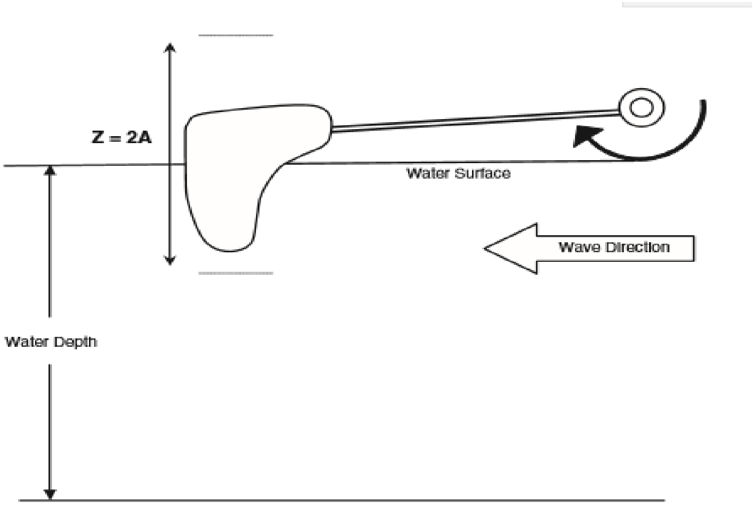

Figure 2.10. Surface Buoy connected with Rotary Potentiometer
***(Source :**J Hardisty, 2012)*

Connected Surface Buoy System or can seen at figure 2.10. is a type of Wave Energy Converter that converts ocean wave energy into electrical energy. The working principle of this tool is to utilize buoyancy or buoyant force on buoys and ocean waves. The synergy between the ocean waves and buoyant force will move the stalk up and down and experience the up and down translational forces. The resulting translational style will be transmitted through the gearbox to rotate the rotor on the generator to generate electrical energy.

The Buoy Connected Surface System was chosen because it is inexpensive in manufacture and has no operational costs (B.Drew, A.R. Plummer, and M.N. Sahinkaya, 2009). When applied to the straits in Indonesia, the efficiency of the Connected Surface Buoy System can reach 48% *(J Hardisty, 2012).*

2.5 Electrical Generator

An electrical generator is a device that produces electrical energy from mechanical energy resulting from electromagnetic induction. Generally, the generator is divided into AC and DC generators, based on the type of current generated, used in this generating system is an AC generator, as needed to meet the electricity needs of households and private industries Each generator has its own capacity which is adjusted to the number of devices to be Generated. To select the generator capacity in generating electrical energy adjusted to the power calculation from survey data, between 500 Megawatt -1000 Megawatts. The generator's ability to generate electricity is expressed in Volt Ampere (VA) *(DikySyahru, 2007).*This is can be seen at figure 2.11.

Figure 2.11. Electrical Generator in Powerplant
***(Source:** Championpowerequipment, 2004)*

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CHAPTER III
WRITING METHODOLOGY

3.1 Flow Chart

In this research, the authors take steps in the preparation of the Bachelor Thesis according to the flow chart in figure 3.1. below.

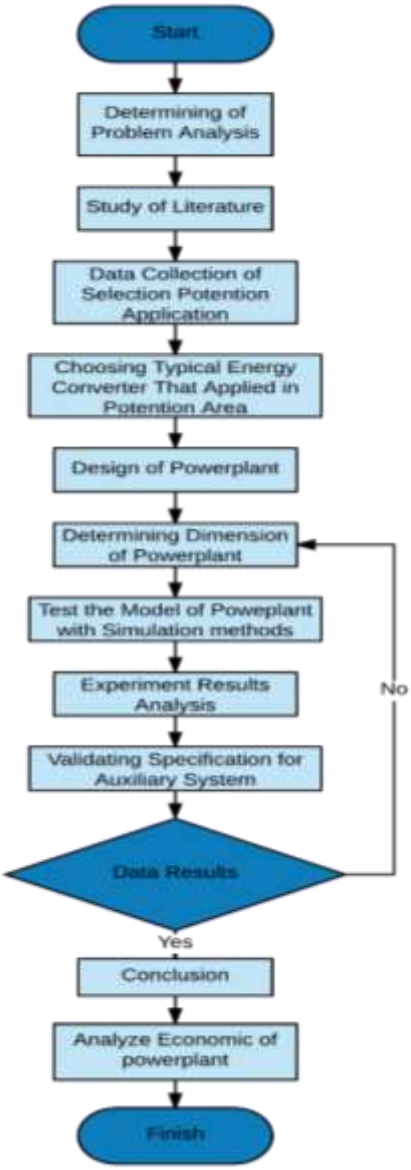

Figure 3.1. Flowchart of Writing Methodology

3.2 Explanation of Flow Chart

Based on the figure 3.1. above, there are described steps in research on the final task below :

1. **Determining of Problem Analysis**

   At this stage the author looks for the background of the problem. The background of the problem is that the electrification ratio is still low in eastern Indonesia, whereas Indonesia has a huge potential for renewable energy resources. Mini-powered resources include the potential of ocean currents, potential winds and potential waves up and down from the sea. This potential should be used as an alternative energy to overcome electrical energy crisis in eastern Indonesia.

2. **Study of Literature**

   At this stage the authors do a search for information resources and references. This literature study aims to find references of various kinds of wind turbine, current turbine and wave energy converter in accordance with the application in Indonesia. References taken from international journals.

3. **Data Collection of Selection Potention Application**

   At this stage the authors search for information resources, references and site surveys. This is done as a supporting material in this final project. The source of reference and information that the authors get from various national and international journals, books and various references from the internet.

4. **Choosing Typical Energy Converter that Applied in PotentionArea**

   After obtaining various kinds of energy generators that utilize renewable energy from ocean currents, from waves and from the wind then the next selected energy converter is appropriate applied in

Indonesia based on the criteria of the target area of application from this power plant.

5. Design of Powerplant

After obtaining the appropriate kinds of turbine when applied in the target area, then subsequently made the design of each turbine in detail and support system of this plant in the form of semi - submersible system or support system in the form of each deck compartment.

6. Determining Dimension of Powerplant

Once the design is obtained accordingly, then we determine the dimensions of the appropriate powerplant. The determination of this dimension is based on the criteria of the target area. These criteria include the maximum depth of the target area. The closest distance from the island, the furthest distance from the island, etc.

7. Test the Model of Powerplant with Simulation Methods

After the design and dimensions are obtained, then we will experiment with the simulation method. This simulation is done with solidworks flow simulation and ansys fluent. from this simulation method we got torque and velocity, where torque and velocity used for generator selection.

8. Validating the Specification for Auxiliary System

After performing simulation experiments from solidwork and ansys and obtained results in the form of torque and velocity. next is chose the specific generator that matches the torque results. The last step we determine the gearbox in accordance with the criteria of the selected generator. This is because the result of the simulation method produces a large torque but has a low speed or low RPM.

9. Data Results

After completion of simulation experiments and generator specs obtained, then is done data processing. Where when processing the data if the results were not in accordance with the specifications generator or gearbox, then conducted a retry by determining the dimensions of each turbine.

10. Conclusion

At this stage the analysis of data that has been processed in the form of tables. After that, draw conclusions based on the problems and objectives of this thesis research.

11. Analyze the Economic of Powerplant

The purpose of this economic analysis is to determine the feasibility of a project where this feasibility is determined by the size of the IRR (Internal Rate of Return). IRR is obtained by means of electricity sales every kwh worth IDR 1500 minus the costs of operational such as salary of staff, cost survey, investation, etc,.

12. Finish

This stage is the stage of preparation of the final project report from the research results of this generator model

CHAPTER IV
DISCUSSION

4.1. Potential Application of Selection Area

Indonesia's waters territory has strong ocean currents, thus saving potential that can be maximally utilized to generate electrical energy. One of the potential areas for applications of these powerplant is in the Capalulu Strait that shown in figure 4.1. Capalulu strait is located in the Sula islands, North Maluku. According to the Center for Marine Geology Research and Development, Ministry of Energy and Mineral Resources of Indonesia, the strait does have strong ocean currents. Current velocity in Capalulu strait reaches 5 m/s (18 Km/J or 9.72 Knot/Hour), in contrast to the straits in the islands of Southeast Nusa that reach 2.5 to 3 meters per second (9 Km/hours - 4.85 Knot up to 10.8 Km/Hours - 5.83 Knot/Hour). While based on research Nyuswantoro. et all (2012) mentions that of 19 tidal velocity velocity point that is issued by the oceanografi service of Capalulu Strait is the largest tidal energy that is equal to 429.7 kWh. In addition, Capalulu strait also has a relatively stable wave height, which ranges from 2.5 to 4 meters. As for the potential of winds energy, Capalulu strait has a relatively fast and stable wind, which is at a velocity of 4 m/s up to 6 m/s (Ministry of Energy and Mineral Resources, 2014).

Figure 4.1 CapaluluStrait
*(**Source:** PPHL, 2016)*

In addition,capalulu strait flank between two large islands of Mangole islands and Obi islands. Both islands are in a cluster of Sula islands. According to the Central Bureau of Statistics (BPS), the population in the District of Sula islands reach 93,435 inhabitantsthat are shown in figure 4.2. With electricity requirement reach 22 MW. But on the other hand the population in the island of sula still have electrification ratio that is still driven low, that is less than 40%. Whereas the island of sula has a huge potential that is precisely in the capalulu strait.

Figure 4.2. Demographics in the Sula Islands
*(**Source:** kepsulkab.bps.go.id,2014)*

And to create a powerplant in potential application, we have to consider the characteristics of Capalulu strait. The characteristics of the Sula islands that shown in Table 4.1 such as distance the fartest & nearest between 2 island, depth of this strait, etc.

Table 4.1. Characteristics of Capalulu Strait
*(**Source** :kepsulkab.bps.go.id,2014, 2014)*

No	Potential	Note
1	Total Population	93.435
2	Currents Velocity	5 m/s
3	Winds velocity	6 m/s – 8 m/s
4	High Wave	2 m – 4 m
5	Distance the fartest between 2 island	3,07 km
6	Distance the nearest between 2 island	1,04 km
7	Depth of Capalulu Strait	40 m
8	Electricity Needed	20 mw
8	Electrification Ratio	<40%

4.2. Design Powerplant Analysis

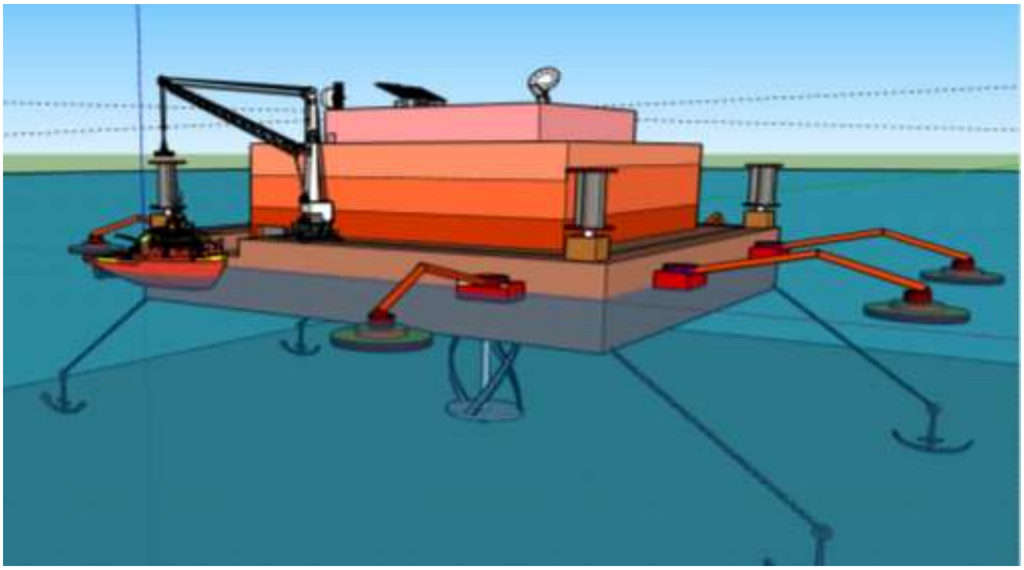

Figure 4.3. Design of Powerplant

This is the three dimensional design of powerplant, this can be seen in figure 4.3. This powerplant will be applied in Capalulu Strait. In This Design we use one Gorlov Helical turbine with dimension 3m (diameter) and 5m (height). The function of gorlov helical turbine is to converts of potential of current, or we can named current energy converter. To convert the potential of energy from wind, we use four savonius wind turbine. This powerplant consist of four savonius wind turbine. This savonius wind turbine have a dimension is 3m (diameter) & 5m (height). For wave energy converter, we use seven connected surface buoy system. The specification dimension of connected surface buoy system is 5m (diameter), 3m (height) and 10m (arm). The support platform we can use barge or we call semi – submersible system. This platform will anchoring in four side of this semi submersible.

4.2.1. Design Analysis of Gorlov Helical Turbine

Gorlov Helical Turbines are highly applicable to the straits in Indonesia. This is because Gorlov Helical Turbines characteristic is capable of operating with low ocean velocity that is below 2.5 m / s. Gorlov Helical Turbines also investigated the foil characteristics. The study was conducted using various models of turbines with different foil angles. The results show that the foil angle has an effect on turbine efficiency. At the corner angle $\delta = 135^{o}$ the turbine shows the best efficiency that this turbine can be seen on figure 4.4. With an angle of 135^{o}, so the efficiency increases to 54% (Hiromichi Akimoto, 2013). Thus, the best turbine design is Gorlov Helical Turbines with 135^{o} foil angle (Sathit Pongduang et al, 1978).

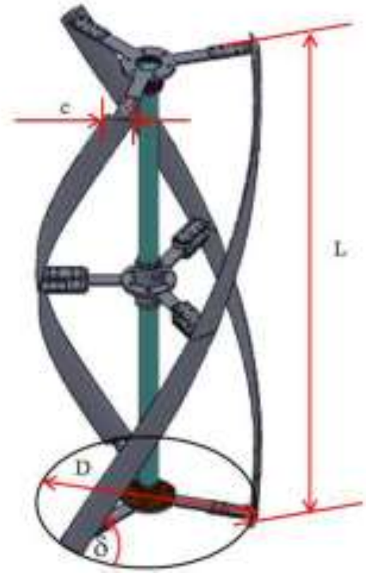

Figure 4.4. Design of Gorlov Helical Turbine with Angle 135^{o}
(Source : *Sathit Pongduang et al, 1978)*

4.2.2. Design Analysis of Connected Surface Buoy System

Furthermore, the powerplant can utilize the energy generated from the ocean waves by using a connected surface buoy system. The working principle of this tool is by converting kinetic energy into electricity (J. Hardisty, 2012). Currently, the tool is being developed by Tracetebel Energy and supported by the Ceara government in Brazil. Th prototype of this tool is installed at Pecem harbor on the coast of Ceara, - 60 km from the capital of the state of Fortaleza, Brazil. This can be seen at figure 4.5.

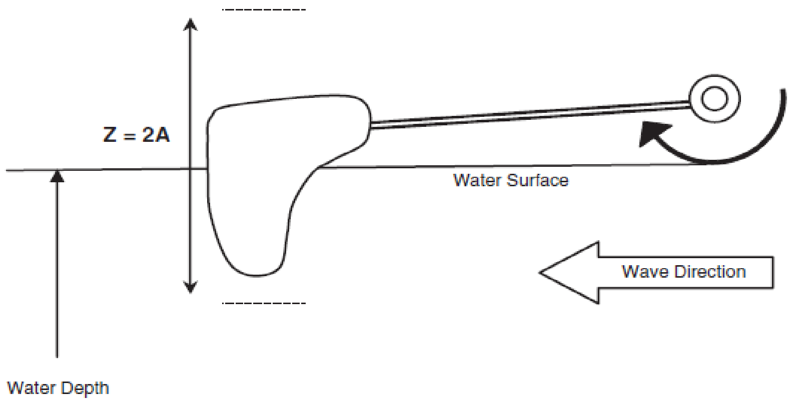

Figure 4.5. Design of Connected Surface Buoy System
(Source :*J Hardisty, 2012)*

This tool consists of a 5 meter diameter disc buoy module attached to a 10 meter long mechanical arm. This arm is attached to the pedestal on the platform, where the arm is also connected with a pump.

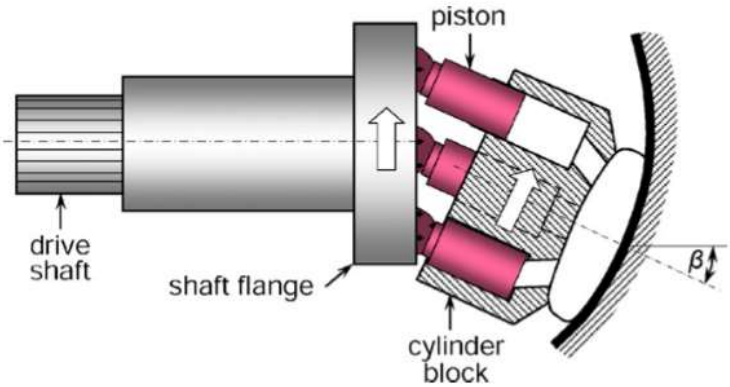

Figure 4.6. Design of Pump in Connected Surface Buoy System
(Source : *Antonio de Falcao, 2017)*

As the buoy disc moves up and down due to wave energy, the mechanical arm activates the pump that transfers energy to drive the electric generator. This can be seen at figure 4.6.

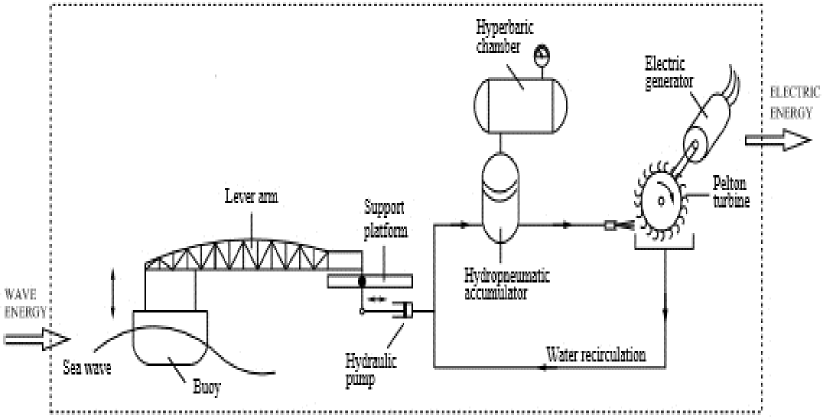

Figure 4.7. System in Connected Surface Buoy System

This is the system of connected surface buoy system. From figure 4.7,we can seen if this system begin with kinetic energy from moving up or down of buoy, kinetic energy connect with hydraulic pump. After that, hydraulic pump will pump the fluids in system. This fluids will collect in hydropneumatic accumulator. The function of hydropneumatic accumulator to make capacity fluids in system stable. After from hydropneumatics accumulator, the fluids will transfer to pelton turbine. We want to know the head and capacity because the requirement of pelton turbine is head and capacity.

4.2.3. Design Analysis of Savonius Wind Turbine

And finally, in order to exploit the energy potential of the wind, the savonius wind turbine was chosen. We use two blades of savonius wind turbine based on research, two blades is more effective than three blades. This type of wind energy converter is chosen because it can operate on a diffuse wind. As for other advantages is that this turbine can operate well at a relatively low wind velocity. This can be seen at figure 4.8.

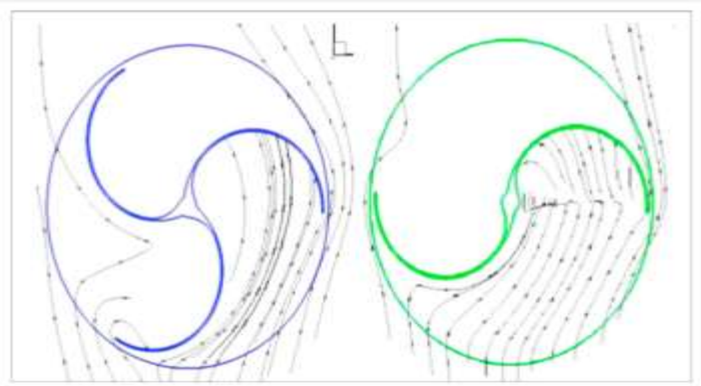

Figure 4.8. Savonius Wind Turbine With 2 Blades Design in Flow Simulation
*(**Source:** A. Kumar, R.P. Saini, 2016)*

Savonius wind turbine used 2 blades, for the purpose of simulation nresults conducted by Anuj Kumar, et al. More effective using 2 blades. Savonius wind turbine is also more effective because it is effective in working at low velocity winds.

4.2.4. Design of Support Sytem in Powerplant

As for applications in the sea, this power plant uses semi-submersible building construction like a concept of barge that are shown in figure 4.9. The concept of this building is appropriately applied in the waters of Indonesia because it can move places when one day found more potential areas and more needed. In this concept, the slope of the turbine axis is passively determined in the balance of hydrodynamic load, buoyancy and weight.

Figure 4.9. Semi-Submersible by utilizing the working principle of barge
*(**Source:** Wikimedia, 2009)*

4.3. Flow Simulation Simulation Result Analysis

To get the required torque as the requirement of the generator then it is necessary to simulate flow simulation. The dimensional determination of Gorlov Helical Turbine, Savonius Wind Turbine and Connected Surface Buoy System are based on the criteria of the capalulu strait that are shown in table 4.2. as for the following criteria:

Table 4.2. Potential in Capalulu Strait
*(**Source** :kepsulkab.bps.go.id,2014, 2014)*

No	Potential	Note
1	Total Population	93.435
2	Currents Velocity	5 m/s
3	Winds velocity	6 m/s – 8 m/s
4	High Wave	2 m – 4 m
5	Distance the fartest between 2 island	3,07 km
6	Distance the nearest between 2 island	1,04 km
7	Depth of Capalulu Strait	40 m
8	Electricity Needed	22 mw
9	Electrification Ratio	<40%

After obtaining the required criteria from the target area that is Capalulu strait, then determined the dimensions of each energy converter both wind, wave and current.

4.3.1. Simulation of Gorlov Helical Turbine

Before simulation of gorlov helical turbine, we determine the the dimension of gorlov helical turbine, that are shown in table 4.3. The determination of dimension turbine is based on criteria that shown in table 4.2. Here the dimension of gorlov helical turbine :

Table 4.3. Dimension of Gorlov Helical Turbine

No	Diameter (m)	Length / High of Turbine (m)
1	3	5
2	5	20
3	5	10
4	10	15
5	5	25
6	7	25

Furthermore, after determining the dimensions is done simulating all the turbine with different dimensions. We will analyze the results of the simulation, that are shown in figure 4.10. From So the data obtained as follows :

1. Static force
2. Velocity
3. Average velocity
4. Force
5. Torque, etc

But, from all the results from flow simulation, we just need the results of two criteria, there are torque and velocity. We just need two criteria because the generator needed is the data about torque produce from gorlov helical turbine and the velocity of turbine to determine the right gearbox for generator.

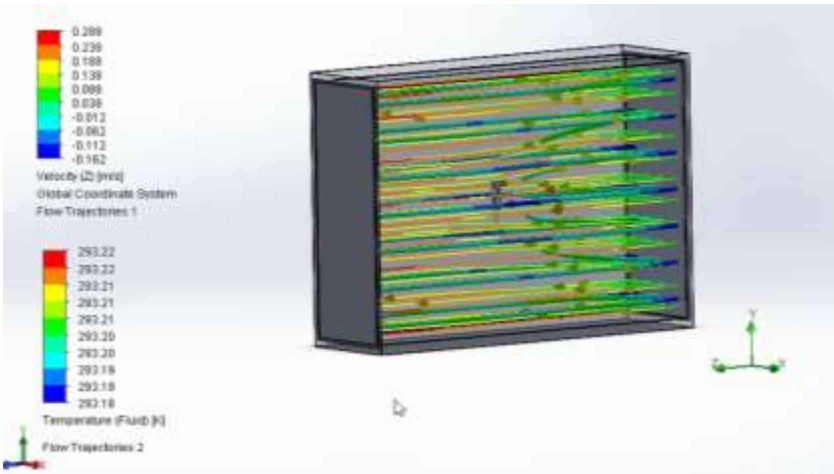

Figure 4.10. Flow Simulation Gorlov Helical Turbine

The simulation is done by creating of Gorlov Helical Turbine model with its original dimension to be passed by water fluid in the idealized room. The velocity is adjusted to the condition of sea currents on the Capalulu Strait, in velocity 2 m / s. We choose 2 m/s in simulation because the potential specific place have a minimum current condition in 2 m/s. From the simulation we get the average torque generated by the Gorlov Helical Turbine.

a. Simulation Results of Gorlov Helical Turbine 3m x 5m

Name	Current Value	Progress	Criterion	Comment
GG Av Static Pressure 1	101325 Pa	Achieved (IT = 1000)	191.684 Pa	Checking criteria
GG Av Velocity (Z) 1	-0.000307648 m/s	Achieved (IT = 1000)	0.381803 m/s	Checking criteria
GG Force (Z) 1	-0.0027002 N	Achieved (IT = 1000)	7578.47 N	Checking criteria
GG Friction Force (Z) 1	-0.00269952 N	Achieved (IT = 1000)	7576.69 N	Checking criteria
GG Max Static Pressure 1	101325 Pa	Achieved (IT = 1000)	0.00101325 Pa	Checking criteria
GG Max Velocity (Z) 1	0 m/s	Achieved (IT = 1000)	0.365134 m/s	Checking criteria
GG Normal Force (Z) 1	-6.79979e-007 N	Achieved (IT = 1000)	1.80817 N	Checking criteria
GG Torque (Z) 1	0.053383 N*m	Achieved (IT = 1000)	85061.9 N*m	Checking criteria

Figure 4.11. Result Simulation Gorlov Helical Turbine 3m x 5m

After determined the appropriate dimension, then simulation method using solidworks flow simulation. In this simulation obtained results of Static Pressure, Velocity, Normal force, torque, friction force and max static pressure. However, in this simulation only torque and velocity data is taken, this is because the requirement of the generator is velocity and torque. From flow simulation of gorlov helical turbine with dimension 3m x 5m that are shown in figure 4.11, we can get the results if the torque in gorlov helical turbine reached 85061 Nm. With the velocity of turbine in stable condition is 0,38 m/s.

b. Simulation Results of Gorlov Helical Turbine 5m x 10m

Name	Current Value	Progress	Criterion	Comment
GG Av Total Pressure 1	101325 Pa	Achieved (IT = 1000)	233.718 Pa	Checking criteria
GG Av Velocity (Z) 1	-0.000206962 m/s	Achieved (IT = 1000)	0.368727 m/s	Checking criteria
GG Force (Z) 1	-0.00164821 N	Achieved (IT = 1000)	7716.33 N	Checking criteria
GG Friction Force (Z) 1	-0.00160834 N	Achieved (IT = 1000)	7329.51 N	Checking criteria
GG Max Total Pressure 1	101325 Pa	Achieved (IT = 1000)	427.051 Pa	Checking criteria
GG Max Velocity (Z) 1	2.40065e-005 m/s	Achieved (IT = 1000)	0.371167 m/s	Checking criteria
GG Torque (Z) 1	-0.447709 N*m	Achieved (IT = 1000)	105530 N*m	Checking criteria

Figure 4.12. Result Simulation Gorlov Helical Turbine 5m x 10m

After determined the appropriate dimension, then simulation method using solidworks flow simulation. In this simulation obtained results of Static Pressure, Velocity, Normal force, torque, friction force and max static pressure. However, in this simulation only torque and velocity data is taken, this is because the requirement of the generator is velocity and torque. From flow simulation of gorlov helical turbine with dimension 5m x 10m that are shown in figure 4.12, we can get the results if the torque in gorlov helical turbine reached 105530 Nm. With the velocity of turbine in stable condition is 0,368 m/s.

c. Gorlov Helical Turbine 5m x 15m

Name	Current Value	Progress	Criterion	Comment
GG Av Static Pressure 1	101325 Pa	Achieved (IT = 1000)	198.263 Pa	Checking criteria
GG Av Velocity (Z) 1	-0.000345734 m/s	Achieved (IT = 1000)	0.368158 m/s	Checking criteria
GG Av Velocity 1	0.000346391 m/s	Achieved (IT = 1000)	0.35645 m/s	Checking criteria
GG Force (Z) 1	-0.00344582 N	Achieved (IT = 1000)	8995.84 N	Checking criteria
GG Friction Force (Z) 1	-0.00338705 N	Achieved (IT = 1000)	7234.85 N	Checking criteria
GG Max Static Pressure 1	101325 Pa	Achieved (IT = 1000)	110.063 Pa	Checking criteria
GG Max Velocity (Z) 1	0 m/s	Achieved (IT = 1000)	0.384358 m/s	Checking criteria
GG Max Velocity 1	0.00046177 m/s	Achieved (IT = 1000)	0.384419 m/s	Checking criteria
GG Torque (Z) 1	0.0306215 N*m	Achieved (IT = 1000)	48378.7 N*m	Checking criteria

Figure 4.13. Result Simulation Gorlov Helical Turbine 5m x 15m

After determined the appropriate dimension, then simulation method using solidworks flow simulation. In this simulation obtained results of Static Pressure, Velocity, Normal force, torque, friction force and max static pressure. However, in this simulation only torque and velocity data is taken, this is because the requirement of the generator is velocity and torque. From flow simulation of gorlov helical turbine with dimension 5m x 15mthat are shown in figure 4.13, we can get the results if the torque in gorlov helical turbine reached 48378.7 Nm. With the velocity of turbine in stable condition is 0,368 m/s. It means more bigger dimension not always more bigger torque. Its depends of efficiency of turbine.

d. Gorlov Helical Turbine 5m x 25m

GG Av Velocity (Z) 1	-0.000951974 m/s	Achieved (IT = 1000)	0.49477 m/s	Checking criteria
GG Av Velocity 1	0.000951995 m/s	Achieved (IT = 1000)	0.736261 m/s	Checking criteria
GG Force (Z) 1	-0.303793 N	Achieved (IT = 1000)	463264 N	Checking criteria
GG Friction Force (Z) 1	-0.303792 N	Achieved (IT = 1000)	463175 N	Checking criteria
GG Max Dynamic Pressure 1	0.000487446 Pa	Achieved (IT = 1000)	1837.46 Pa	Checking criteria
GG Max Heat Flux 1	0 W/m^2	Achieved (IT = 1000)	0 W/m^2	Checking criteria
GG Max Static Pressure 1	101325 Pa	Achieved (IT = 1000)	1.91721 Pa	Checking criteria
GG Max Total Pressure 1	101325 Pa	Achieved (IT = 1000)	1809.51 Pa	Checking criteria
GG Max Turbulent Energy 1	9.24127e-010 J/kg	Achieved (IT = 1000)	0.0143971 J/kg	Checking criteria
GG Max Velocity (Z) 1	0 m/s	Achieved (IT = 1000)	0.743028 m/s	Checking criteria
GG Max Velocity 1	0.000988147 m/s	Achieved (IT = 1000)	0.742895 m/s	Checking criteria
GG Normal Force (Z) 1	-1.25293e-006 N	Achieved (IT = 1000)	111.07 N	Checking criteria
GG Torque (Z) 1	1.3416 N*m	Achieved (IT = 1000)	9.28915e+006	Checking criteria

Figure 4.14. Result Simulation Gorlov Helical Turbine 5m x 25m

After determined the appropriate dimension, then simulation method using solidworks flow simulation. In this simulation obtained results of Static Pressure, Velocity, Normal force, torque, friction force and max static pressure. However, in this simulation only torque and velocity data is taken, this is because the requirement of the generator is velocity and torque. From flow simulation of gorlov helical turbine with dimension 5m x 25m that are shown in figure 4.14., we can get the results if the torque in gorlov helical turbine reached 9.289.150 Nm. With the velocity of turbine in stable condition is 0,73 m/s.

e. Simulation Result of Gorlov Helical Turbine 7m x 25m

GG Av Velocity (Z) 1	-0.000951974 m/s	Achieved (IT = 1000)	0.83099 m/s	Checking criteria
GG Av Velocity 1	0.000951995 m/s	Achieved (IT = 1000)	0.736261 m/s	Checking criteria
GG Force (Z) 1	-0.303793 N	Achieved (IT = 1000)	463264 N	Checking criteria
GG Friction Force (Z) 1	-0.303792 N	Achieved (IT = 1000)	463175 N	Checking criteria
GG Max Dynamic Pressure 1	0.000487446 Pa	Achieved (IT = 1000)	1837.46 Pa	Checking criteria
GG Max Heat Flux 1	0 W/m^2	Achieved (IT = 1000)	0 W/m^2	Checking criteria
GG Max Static Pressure 1	101325 Pa	Achieved (IT = 1000)	1.91721 Pa	Checking criteria
GG Max Total Pressure 1	101325 Pa	Achieved (IT = 1000)	1809.51 Pa	Checking criteria
GG Max Turbulent Energy 1	9.24127e-010 J/kg	Achieved (IT = 1000)	0.0143971 J/kg	Checking criteria
GG Max Velocity (Z) 1	0 m/s	Achieved (IT = 1000)	0.743028 m/s	Checking criteria
GG Max Velocity 1	0.000988147 m/s	Achieved (IT = 1000)	0.742895 m/s	Checking criteria
GG Normal Force (Z) 1	-1.25293e-006 N	Achieved (IT = 1000)	111.07 N	Checking criteria
GG Torque (Z) 1	1.3416 N*m	Achieved (IT = 1000)	1.38229e+007 N*m	Checking criteria

Figure 4.15. Simulation Results of Gorlov Helical Turbine 7m x 25m

After determined the appropriate dimension, then simulation method using solidworks flow simulation. In this simulation obtained results of Static Pressure, Velocity, Normal force, torque, friction force and max static pressure. However, in this simulation only torque and velocity data is taken, this is because the requirement of the generator is velocity and torque. From flow simulation of gorlov helical turbine with dimension 7m x 25m that are shown in figure 4.15, we can get the results if the torque in gorlov helical turbine reached 13.822.900 Nm. With the velocity of turbine in stable condition is 0,73 m/s.

f. Simulation Results of Gorlov Helical Turbine 10m x 15m

GG Av Velocity (Z) 1	-0.000951974 m/s	Achieved (IT = 1000)	0.38507 m/s	Checking criteria
GG Av Velocity 1	0.000951995 m/s	Achieved (IT = 1000)	0.736261 m/s	Checking criteria
GG Force (Z) 1	-0.303793 N	Achieved (IT = 1000)	463264 N	Checking criteria
GG Friction Force (Z) 1	-0.303792 N	Achieved (IT = 1000)	463175 N	Checking criteria
GG Max Dynamic Pressure 1	0.000487446 Pa	Achieved (IT = 1000)	1837.46 Pa	Checking criteria
GG Max Heat Flux 1	0 W/m^2	Achieved (IT = 1000)	0 W/m^2	Checking criteria
GG Max Static Pressure 1	101325 Pa	Achieved (IT = 1000)	1.91721 Pa	Checking criteria
GG Max Total Pressure 1	101325 Pa	Achieved (IT = 1000)	1809.51 Pa	Checking criteria
GG Max Turbulent Energy 1	9.24127e-010 J/kg	Achieved (IT = 1000)	0.0143971 J/kg	Checking criteria
GG Max Velocity (Z) 1	0 m/s	Achieved (IT = 1000)	0.743028 m/s	Checking criteria
GG Max Velocity 1	0.000988147 m/s	Achieved (IT = 1000)	0.742895 m/s	Checking criteria
GG Normal Force (Z) 1	-1.25293e-006 N	Achieved (IT = 1000)	111.07 N	Checking criteria
GG Torque (Z) 1	1.3416 N*m	Achieved (IT = 1000)	7.2295e+006	Checking criteria

Figure 4.16. Simulation Results of Gorlov Helical Turbine 10m x 15m

After determined the appropriate dimension, then simulation method using solidworks flow simulation. In this simulation obtained results of Static Pressure, Velocity, Normal force, torque, friction force and max static pressure. However, in this simulation only torque and velocity data is taken, this is because the requirement of the generator is velocity and torque. From flow simulation of gorlov helical turbine with dimension 10m x 15m that are shown in figure 4.16, we can get the results if the torque in gorlov helical turbine reached 7.229.500 Nm. With the velocity of turbine in stable condition is 0,73 m/s. From the results of simulation conducted optimization, like as shown in table 4.4. The optimization value is obtained:

Table 4.4. Result Simulation Gorlov Helical Turbine

GORLOV HELICAL TURBINE						
Type	DIMENSION (m)		RESULTS			
No.	DIAMETER	LENGTH	TORQUE		Velocity	
1	3	5	85061.9	Nm	0.382	m/s
2	5	10	105530	Nm	0.368	m/s
3	5	15	48378.7	Nm	0.3681	m/s
4	10	15	7.229.500	Nm	0.385	m/s
5	5	25	9.289.150	Nm	0.494	m/s
6	7	25	13.822.900	Nm	0.831	m/s

4.3.2. Simulation of Savonius Wind turbine

Before simulation of savonius wind turbine, we determine the the dimension of savonius wind turbine that are shown in table 4.5. The determination of dimension turbine is based on criteria that shown in table 4.3. Here the dimension of savonius wind turbine :

Table 4.5. Dimension of Savonius Wind Turbine

No	Diameter (m)	Length / High of Turbine (m)
1	3	5
2	5	10
3	5	15

Furthermore, after determining the dimensions is done simulating all the turbine with different dimensions. We will analyze the results of the simulation that are shown in figure 4.6. From So the data obtained as follows :

1. Static force
2. Velocity
3. Average velocity
4. Force
5. Torque, etc

But, from all the results from flow simulation, we just need the results of two criteria, there are torque and velocity. We just need two criteria because the generator needed is the data about torque produce from savonius wind turbine and the velocity of turbine to determine the right gearbox for generator.

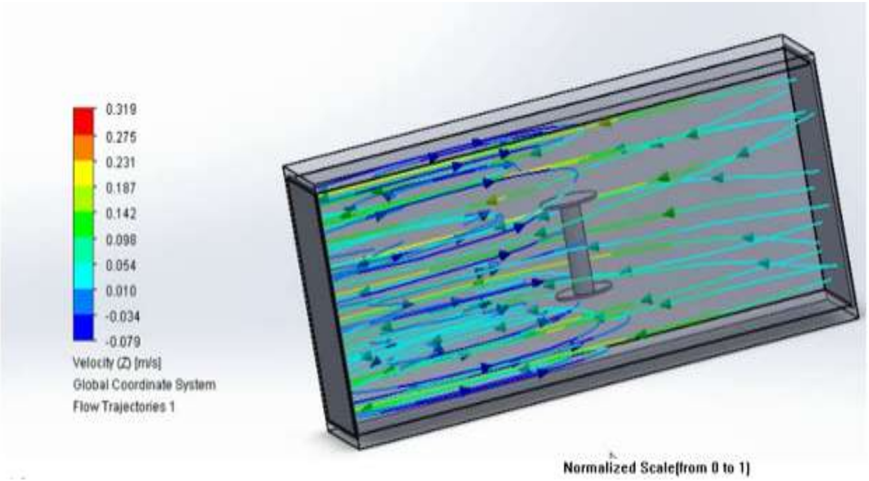

Figure 4.17. Flow Simulation Savonius Wind Turbine

The simulation is done by creating the model of Savonius Wind Turbine with its original dimension to be passed by the wind fluid in the idealized room that are shown in figure 4.17. The velocity is adjusted to wind conditions on the Capalulu Strait, which is 4-6 m / s. From the simulation is obtained the average torque generated by savonius wind turbine with flow 2 m/s. we choose 2 m/s because this is the minimum wind in Capalulu strait.

a. Savonius Wind Turbine 3m x 5m

GG Av Velocity (Z) 1	0.0225946 m/s	Achieved (IT = 955)	0.857927 m/s	Checking criteria
GG Av Velocity 1	0.0461138 m/s	Achieved (IT = 950)	0.857927 m/s	Checking criteria
GG Force (Z) 1	14.5069 N	13%	0.435206 N	Checking criteria
GG Friction Force (Z) 1	0.172358 N	15%	0.00517073 N	Checking criteria
GG Max Dynamic Pressure 1	0.0916437 Pa	25%	0.00458218 Pa	Checking criteria
GG Max Heat Flux 1	0 W/m^2	Achieved (IT = 880)	1e-008 W/m^2	Checking criteria
GG Max Static Pressure 1	101329 Pa	84%	0.513606 Pa	Checking criteria
GG Max Temperature (Fluid) 1	293.31 K	Achieved (IT = 2590)	0.003377 K	Checking criteria
GG Max Total Pressure 1	101329 Pa	84%	0.513608 Pa	Checking criteria
GG Max Turbulent Energy 1	0.0470504 J/kg	Achieved (IT = 5150)	0.00235251 J/kg	Checking criteria
GG Max Velocity (Z) 1	0.390215 m/s	Achieved (IT = 1130)	0.857927 m/s	Checking criteria
GG Max Velocity 1	0.390216 m/s	Achieved (IT = 1130)	0.857927 m/s	Checking criteria
GG Normal Force (Z) 1	14.3345 N	13%	0.430035 N	Checking criteria
GG Torque (Z) 1	11443 N*m	06%	1073 N*m	Checking criteria

Figure 4.18. Result Simulation Savonius Wind Turbine 3m x 5m

After determined the appropriate dimension, then simulation method using solidworks flow simulation. In this simulation obtained results of Static Pressure, Velocity, Normal force, torque, friction force and max static pressure. However, in this simulation only torque and velocity data is taken, this is because the requirement of the generator is velocity and torque. From flow simulation of savonius wind turbine with dimension 3m x 5m we can get the results if the torque in savonius wind turbine reached 1043 Nm that are shown in figure 4.18. With the velocity of turbine in stable condition is 0,857 m/s.

b. Savonius Wind Turbine 5m x 10m

GG Av Velocity (Z) 1	0.0443102 m/s	Achieved (IT = 1095)	0.857923 m/s	Checking criteria
GG Av Velocity 1	0.0726986 m/s	Achieved (IT = 1095)	0.857923 m/s	Checking criteria
GG Force (Z) 1	335.291 N	08%	10.0587 N	Checking criteria
GG Friction Force (Z) 1	0.314488 N	12%	0.00943465 N	Checking criteria
GG Max Dynamic Pressure 1	0.0591689 Pa	20%	0.00295844 Pa	Checking criteria
GG Max Heat Flux 1	0 W/m^2	Achieved (IT = 880)	1e-008 W/m^2	Checking criteria
GG Max Static Pressure 1	101337 Pa	58%	1.36945 Pa	Checking criteria
GG Max Temperature (Fluid) 1	293.37 K	Achieved (IT = 5845)	0.00537689 K	Checking criteria
GG Max Total Pressure 1	101337 Pa	58%	1.37 Pa	Checking criteria
GG Max Turbulent Energy 1	0.101185 J/kg	Achieved (IT = 1110)	0.00505924 J/kg	Checking criteria
GG Max Velocity (Z) 1	0.313549 m/s	Achieved (IT = 1350)	0.857923 m/s	Checking criteria
GG Max Velocity 1	0.31355 m/s	Achieved (IT = 1350)	0.857923 m/s	Checking criteria
GG Normal Force (Z) 1	334.976 N	08%	10.0493 N	Checking criteria
GG Torque (Z) 1	-107186 N*m	13%	3215.58 N*m	Checking criteria

Figure 4.19. Result Simulation Savonius Wind Turbine 5m x 10m

After determined the appropriate dimension, then simulation method using solidworks flow simulation. In this simulation obtained results of Static Pressure, Velocity, Normal force, torque, friction force and max static pressure. However, in this simulation only torque and velocity data is taken, this is because the requirement of the generator is velocity and torque. From flow simulation of savonius wind turbine with dimension 5m x 10m we can get the results if the torque in savonius wind turbine reached 3215,6 Nm that are shown in figure 4.19. With the velocity of turbine in stable condition is 0,857 m/s

c. Savonius Wind Turbine 5m x 15m

GG Av Velocity (Z) 1	0.0420001 m/s	Achieved (IT = 1095)	0.857924 m/s	Checking criteria
GG Av Velocity 1	0.0711175 m/s	Achieved (IT = 1095)	0.857924 m/s	Checking criteria
GG Force (Z) 1	299.442 N	07%	8.98325 N	Checking criteria
GG Friction Force (Z) 1	0.288821 N	11%	0.00866464 N	Checking criteria
GG Max Dynamic Pressure 1	0.0612814 Pa	20%	0.00306407 Pa	Checking criteria
GG Max Heat Flux 1	0 W/m^2	Achieved (IT = 880)	1e-008 W/m^2	Checking criteria
GG Max Static Pressure 1	101337 Pa	45%	1.24358 Pa	Checking criteria
GG Max Temperature (Fluid) 1	293.372 K	Achieved (IT = 1570)	0.00540397 K	Checking criteria
GG Max Total Pressure 1	101337 Pa	45%	1.24359 Pa	Checking criteria
GG Max Turbulent Energy 1	0.101452 J/kg	Achieved (IT = 1130)	0.00482571 J/kg	Checking criteria
GG Max Velocity (Z) 1	0.319096 m/s	Achieved (IT = 1355)	0.857924 m/s	Checking criteria
GG Max Velocity 1	0.319103 m/s	Achieved (IT = 1355)	0.857924 m/s	Checking criteria
GG Normal Force (Z) 1	299.153 N	07%	8.97459 N	Checking criteria
GG Torque (Z) 1	-97979.7 N*m	12%	2939.39 N*m	Checking criteria

Figure 4.20. Result Simulation Savonius Wind Turbine 5m x 15m

After determined the appropriate dimension, then simulation method using solidworks flow simulation. In this simulation obtained results of Static Pressure, Velocity, Normal force, torque, friction force and max static pressure. However, in this simulation only torque and velocity data is taken, this is because the requirement of the generator is velocity and torque. From flow simulation of savonius wind turbine with dimension 5m x 15mthat are shown in figure 4.20., we can get the results if the torque in savonius wind turbine reached 2939,4 Nm. With the velocity of turbine in stable condition is 0,857 m/s. From the results of simulation conducted optimization. The optimization value is obtained:

Table 4.6. Result Simulation Savonius Wind Turbine

SAVONIUS WIND TURBINE					
DIMENSION (m)		RESULTS			
DIAMETER	LENGTH	TORQUE		Velocity	
3	5	1043,3	Nm	0.857	m/s
5	10	3215.6	Nm	0.857	m/s
5	15	2939,39	Nm	0.857	m/s

4.3.3. Simulation of Connected Surface Buoy System

Before simulation of connected surface buoy system, we determine the the dimension of connected surface buoy systemthat are shown in table 4.7. The determination of dimension turbine is based on criteria that shown in table 4.2. Here the dimension of connected surface buoy system :

Table 4.7. Connected Surface Buoy System

No	Diameter (m)	High (m)
1	5	3
2	7	5
3	10	5

Furthermore, after determining the dimensions is done simulating all the buoy with different dimensions. We will analyze the results of the simulation that are shown in figure 4.21. From So the data obtained as follows :

1. Static force
2. Velocity
3. Average velocity
4. Force
5. Torque, etc

But, from all the results from flow simulation, we just need the results of one criteria, there are torque. We just need this criteria criteria because the pelton turbine generator needed is the data about torque produce from connected surface buoy system, from the torque we want to search head and capacity to choose the pelton turbine generator.

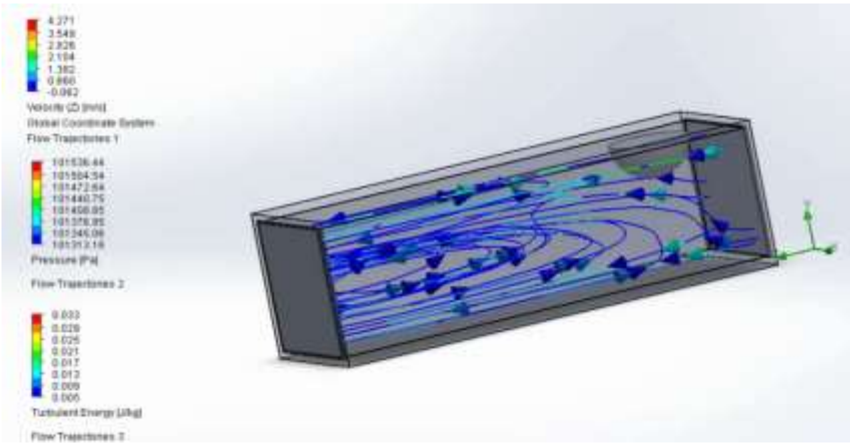

Figure 4.21. Flow Simulation Connected Surface Buoy System

The simulation is done by creating the model of connected surface buoy system with its original dimension to be passed by fluid in the form of water in an idealized room that are shown in figure 4.21. The velocity is adjusted to the sea wave conditions on the Capalulu Strait, which is 2 m. From the simulation we get the average torque generated by connected surface buoy system.

a. Connected Surface Buoy System Dimension 5m x 3m

GG Av Velocity (X) 1	-4.74921e-006 m/s	Achieved (IT = 1000)	0.00106115 m/s	Checking criteria
GG Av Velocity (Y) 1	-6.4377e-007 m/s	Achieved (IT = 1000)	0.00617112 m/s	Checking criteria
GG Av Velocity (Z) 1	0.000464598 m/s	Achieved (IT = 1000)	0.788324 m/s	Checking criteria
GG Av Velocity 1	0.000465987 m/s	Achieved (IT = 1000)	0.721794 m/s	Checking criteria
GG Force (Z) 1	0.00530717 N	Achieved (IT = 1000)	44353.5 N	Checking criteria
GG Friction Force (Z) 1	0.00291923 N	Achieved (IT = 1000)	12060.7 N	Checking criteria
GG Max Dynamic Pressure 1	0.000602357 Pa	Achieved (IT = 1000)	3353.59 Pa	Checking criteria
GG Max Heat Flux 1	0 W/m^2	Achieved (IT = 1000)	0 W/m^2	Checking criteria
GG Max Static Pressure 1	101325 Pa	Achieved (IT = 1000)	919.277 Pa	Checking criteria
GG Max Temperature (Fluid) 1	293.2 K	Achieved (IT = 1000)	0.00182523 K	Checking criteria
GG Max Total Pressure 1	101325 Pa	Achieved (IT = 1000)	2913.8 Pa	Checking criteria
GG Max Turbulent Energy 1	2.92644e-008 J/kg	Achieved (IT = 1000)	0.0325419 J/kg	Checking criteria
GG Max Velocity (X) 1	0.000242173 m/s	Achieved (IT = 1000)	0.409314 m/s	Checking criteria
GG Max Velocity (Y) 1	0.000152298 m/s	Achieved (IT = 1000)	0.452054 m/s	Checking criteria
GG Max Velocity (Z) 1	0.00109675 m/s	Achieved (IT = 1000)	1.00296 m/s	Checking criteria
GG Max Velocity 1	0.00109846 m/s	Achieved (IT = 1000)	1.00367 m/s	Checking criteria
GG Normal Force (Z) 1	0.00238793 N	Achieved (IT = 1000)	32817.7 N	Checking criteria
GG Torque (Z) 1	-0.00197829 N*m	Achieved (IT = 1000)	366986 N*m	Checking criteria

Figure 4.22. Result Simulation Connected Surface Buoy System

After determined the appropriate dimension, then simulation method using solidworks flow simulation. In this simulationobtained results of Static Pressure, Velocity, Normal force, torque, friction force and max static pressure. However, in this simulation only torque and velocity data is taken, this is because the requirement of the generator is velocity and torque. From flow simulation of connected surface buoy system with dimension 5m x 3m we can get the results if the torque in connected surface buoy system reached 366.986 Nm that are shown in figure 4.22.

b. Connected Surface Buoy System Dimension 7m x 5m

GG Av Velocity (X) 1	5.22027e-008 m/s	Achieved (IT = 1000)	0.00133978 m/s	Checking criteria
GG Av Velocity (Y) 1	-4.00645e-006 m/s	Achieved (IT = 1000)	0.0134006 m/s	Checking criteria
GG Av Velocity (Z) 1	-0.000101285 m/s	Achieved (IT = 1000)	0.769066 m/s	Checking criteria
GG Av Velocity 1	0.000146152 m/s	Achieved (IT = 1000)	0.714068 m/s	Checking criteria
GG Force (Z) 1	-0.00156043 N	Achieved (IT = 1000)	54149.4 N	Checking criteria
GG Friction Force (Z) 1	-0.000855536 N	Achieved (IT = 1000)	11662.5 N	Checking criteria
GG Max Dynamic Pressure 1	0.000142073 Pa	Achieved (IT = 1000)	3880 Pa	Checking criteria
GG Max Heat Flux 1	0 W/m^2	Achieved (IT = 1000)	0 W/m^2	Checking criteria
GG Max Static Pressure 1	101325 Pa	Achieved (IT = 1000)	4009.68 Pa	Checking criteria
GG Max Temperature (Fluid) 1	293.2 K	Achieved (IT = 1000)	0.00757457 K	Checking criteria
GG Max Total Pressure 1	101325 Pa	Achieved (IT = 1000)	6004.22 Pa	Checking criteria
GG Max Turbulent Energy 1	4.21931e-005 J/kg	Achieved (IT = 1000)	0.199111 J/kg	Checking criteria
GG Max Velocity (X) 1	0.000129614 m/s	Achieved (IT = 1000)	0.36301 m/s	Checking criteria
GG Max Velocity (Y) 1	0.000123249 m/s	Achieved (IT = 1000)	0.336075 m/s	Checking criteria
GG Max Velocity (Z) 1	0.00017766 m/s	Achieved (IT = 1000)	1.07832 m/s	Checking criteria
GG Max Velocity 1	0.000533476 m/s	Achieved (IT = 1000)	1.08092 m/s	Checking criteria
GG Normal Force (Z) 1	-0.000704891 N	Achieved (IT = 1000)	43281.4 N	Checking criteria
GG Torque (Z) 1	0.00552073 N*m	Achieved (IT = 1000)	424199 N*m	Checking criteria

Figure 4.23. Result Simulation Connected Surface Buoy System

After determined the appropriate dimension, then simulation method using solidworks flow simulation. In this simulation obtained results of Static Pressure, Velocity, Normal force, torque, friction force and max static pressure.

However, in this simulation only torque and velocity data is taken, this is because the requirement of the generator is velocity and torque. From flow simulation of connected surface buoy system with dimension 7m x 5m we can get the results if the torque in connected surface buoy system 424.199 Nm that are shown in figure 4.23.

c. Connected Surface Buoy System Dimension 10m x 5m

GG Av Velocity (X) 1	5.22027e-008 m/s	Achieved (IT = 1000)	0.00133978 m,	Checking criteria
GG Av Velocity (Y) 1	-4.00645e-006 m/s	Achieved (IT = 1000)	0.0134006 m/:	Checking criteria
GG Av Velocity (Z) 1	-0.000101285 m/s	Achieved (IT = 1000)	0.769066 m/s	Checking criteria
GG Av Velocity 1	0.000146152 m/s	Achieved (IT = 1000)	0.714068 m/s	Checking criteria
GG Force (Z) 1	-0.00156043 N	Achieved (IT = 1000)	54149.4 N	Checking criteria
GG Friction Force (Z) 1	-0.000855536 N	Achieved (IT = 1000)	11662.5 N	Checking criteria
GG Max Dynamic Pressure 1	0.000142073 Pa	Achieved (IT = 1000)	3889 Pa	Checking criteria
GG Max Heat Flux 1	0 W/m^2	Achieved (IT = 1000)	0 W/m^2	Checking criteria
GG Max Static Pressure 1	101325 Pa	Achieved (IT = 1000)	4009.68 Pa	Checking criteria
GG Max Temperature (Fluid) 1	293.2 K	Achieved (IT = 1000)	0.00757457 K	Checking criteria
GG Max Total Pressure 1	101325 Pa	Achieved (IT = 1000)	6004.22 Pa	Checking criteria
GG Max Turbulent Energy 1	4.21931e-005 J/kg	Achieved (IT = 1000)	0.199111 J/kg	Checking criteria
GG Max Velocity (X) 1	0.000129614 m/s	Achieved (IT = 1000)	0.36301 m/s	Checking criteria
GG Max Velocity (Y) 1	0.000123249 m/s	Achieved (IT = 1000)	0.336075 m/s	Checking criteria
GG Max Velocity (Z) 1	0.00017766 m/s	Achieved (IT = 1000)	1.07852 m/s	Checking criteria
GG Max Velocity 1	0.000533476 m/s	Achieved (IT = 1000)	1.08092 m/s	Checking criteria
GG Normal Force (Z) 1	-0.000704891 N	Achieved (IT = 1000)	43281.4 N	Checking criteria
GG Torque (Z) 1	0.00552073 N*m	Achieved (IT = 1000)	424199 N*m	Checking criteria

Figure 4.24. Result Simulation Connected Surface Buoy System

After determined the appropriate dimension, then simulation method using solidworks flow simulation. In this simulation obtained results of Static Pressure, Velocity, Normal force, torque, friction force and max static pressure. However, in this simulation only torque and velocity data is taken, this is because the requirement of the generator is velocity and torque.From flow simulation of connected surface buoy system with dimension 10m x 5m we can get the results if the torque in connected surface buoy system reached 424.199 Nm that are shown in figure 4.24. From the results of simulation conducted optimization shown in table 4.8. The optimization value is obtained:

Table 4.8. Result Simulation Connected Surface Buoy System

CONNECTED SURFACE BUOY SYSTEM					
DIMENSION (m)		RESULTS			
DIAMETER	LENGTH	TORQUE		Velocity	
5	3	366.986	Nm	0.788	m/s
7	5	424.199	Nm	0.769	m/s
10	5	424.199	Nm	0.769	m/s

4.4. Analysis of Calculation Result

4.4.1. Calculation results of Gorlov Helical Turbine

Table 4.9. Relationship Between Straight Motion & Circular Motion

Straight Motion	Unit	Circular Motion	Unit
X	**M**	**ϴ**	**Rad**
V	**m/s**	**ω**	**Rad/s**
A	**m/s²**	**α**	**Rad/s²**

Then change from the velocity obtained from the motion straight into a circular motion :

$$v = r \times \omega$$

$$RPS = \omega \; . \; 9{,}55$$

$$RPM = \omega \; . \; 9{,}55 \; . \; 60$$

v: Linear velocity, in m/s
r: Radius, in meter
ω: Angular velocity, in rad/s
1 rad/s = 9,55 rpm

Figure 4.25. Relationship Between Angular Velocity & RPM

From the table 4.9, it can be seen that the velocity obtained associated with the rotation. this is the requirement of the generator needed to generate electricity. Because the required to generator is RPM and torque. The torque is generated from the flow simulation of solidworks. The torque determination was obtained from the simulation of solidworks that are shown in table 4.10.

Table 4.10. Calculation Results Gorlov Helical Turbine

GORLOV HELICAL TURBINE										
Type	DIMENSION (m)		RESULTS							
No.	DIAMETER	LENGTH	TORQUE		Velocity		ω (Angular Velocity)		RPS	RPM
1	3	5	85061.9	Nm	0.382	m/s	0.254667	Rad/s	0.243207	14.5924
2	5	10	105530	Nm	0.368	m/s	0.1472	Rad/s	0.140576	8.43456
3	5	15	48378.7	Nm	0.3681	m/s	0.14724	Rad/s	0.140614	8.436852
4	10	15	7.229.500	Nm	0.385	m/s	0.077	Rad/s	0.073535	4.4121
5	5	25	9.289.150	Nm	0.494	m/s	0.1976	Rad/s	0.188708	11.32248
6	7	25	13.822.900	Nm	0.831	m/s	0.237429	Rad/s	0.226744	13.60466

After obtained RPM, then we find the specification generator shown in figure 4.26 that matches the rpm and torque generated from the simulation results. From the simulation gorlov helical turbine then got the generator specification is very suitable is as follows:

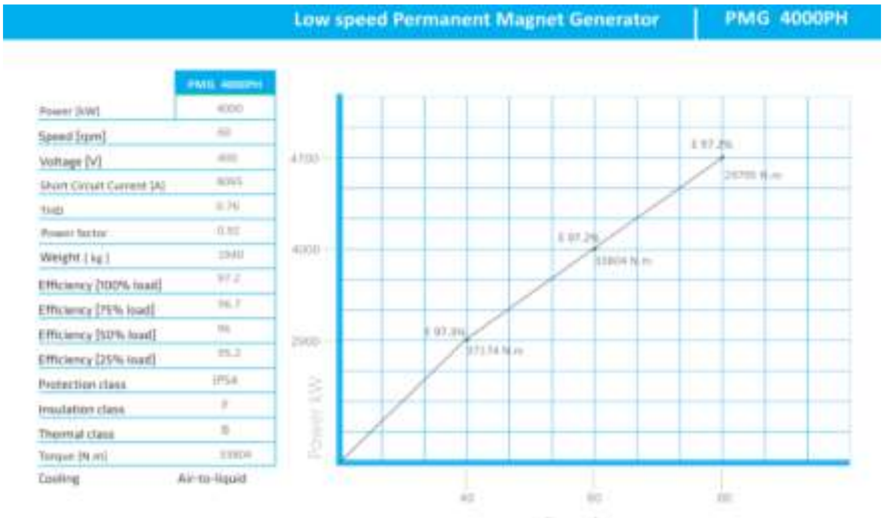

Figure 4.26. Spesification Generator for Gorlov Helical Turbine
*(**Source:** Enerset, 2017)*

From these results obtained minimum torque and RPM for the generator to work properly. The minimum torque is 33.000 Nm, so we choose the output of generator which more than 33.000 Nm. After that we know the minimum RPM for generator, we choose right gearbox. The minimum RPM for Generator working properly is 60 RPM, but the RPM from gorlov helical turbine is 14 RPM. After that we choose JBJ gearbox with ratio input 12 RPM and output 73 RPM, with the output of torque can reach 50.000 Nm with the specification shown in figure 4.27. This is the right gearbox for gorlov helical turbine.

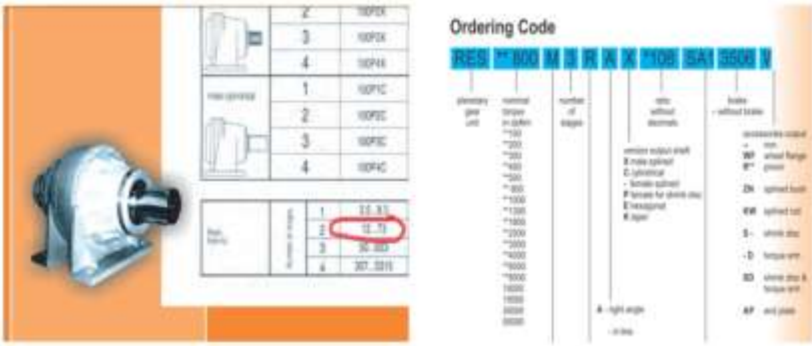

Figure 4.27. Gearbox Spesification for Gorlov Helical Turbine
*(**Source:** JBJ, 2017)*

After know the output of RPM, we calculate the output of the generator. So, the results can seen in table 4.11.

Table 4.11. Calculation Results Gorlov Helical Turbine

GORLOV HELICAL TURBINE			
GENERATOR	=	ENERSET PMG 4000 PH	
POWER	=	4000	KW
SPEED	=	60	RPM
WEIGHT	=	1940	KG
TORQUE	=	33804	Nm
TORQUE FROM GORLOV HELICAL TURBINE	=	85061.9	Nm
RPM FROM GORLOV HELICAL TURBINE	=	14.5924	RPM
GEARBOX	=	JBJ	
GEARBOX INPUT	=	12	RPM
GEARBOX OUTPUT	=	73	RPM
TORQUE MAX OUTPUT FROM GEARBOX	=	50,000	NM
ELECTRICITY	=	4866.666667	KW

Thus, from a total of one gorlov helical turbine with a diameter of 3m and a height of 5 m can produce a total power of 4866.7 Kw.

4.4.2. Calculation results of Savonius Wind Turbine

Table 4.12. Relationship Between Straight Motion & Circular Motion

Straight Motion	Unit	Circular Motion	Unit
X	M	Θ	Rad
V	m/s	ω	Rad/s
A	m/s^2	α	Rad/s^2

Then change from the velocity obtained from the motion straight into a circular motion :

$$\mathbf{v = r \times \omega}$$

$$\mathbf{RPS = \omega\ .\ 9{,}55}$$

$$\mathbf{RPM = \omega\ .\ 9{,}55\ .\ 60}$$

v: Linear velocity, in m/s
r: Radius, in meter
ω: Angular velocity, in rad/s
1 rad/s = 9,55 rpm

Figure 4.28. Relationship Between Angular Velocity & RPM

From the table 4.12., it can be seen that the velocity obtained associated with the rotation. this is the requirement of the generator needed to generate electricity. Because the required to generator is RPM and torque. The torque is generated from the flow simulation of solidworks. The torque determination was obtained from the solidworks flow simulation.

Table 4.13. Calculation Savonius Wind Turbine

SAVONIUS WIND TURBINE									
DIMENSION (m)		RESULTS							
DIAMETER	LENGTH	TORQUE		Velocity		ω (Angular Velocity)		RPS	RPM
3	5	1043,3	Nm	0.857	m/s	0.571333333	Rad/s	0.545623	32.7374
5	10	3215.6	Nm	0.857	m/s	0.3428	Rad/s	0.327374	19.64244
5	15	2939,39	Nm	0.857	m/s	0.3428	Rad/s	0.327374	19.64244

After obtained RPM, then we find the specification generator shown in figure 4.29 that matches the rpm and torque generated from the simulation results. From the simulation savonius wind turbine then got the generator specification is very suitable is as follows :

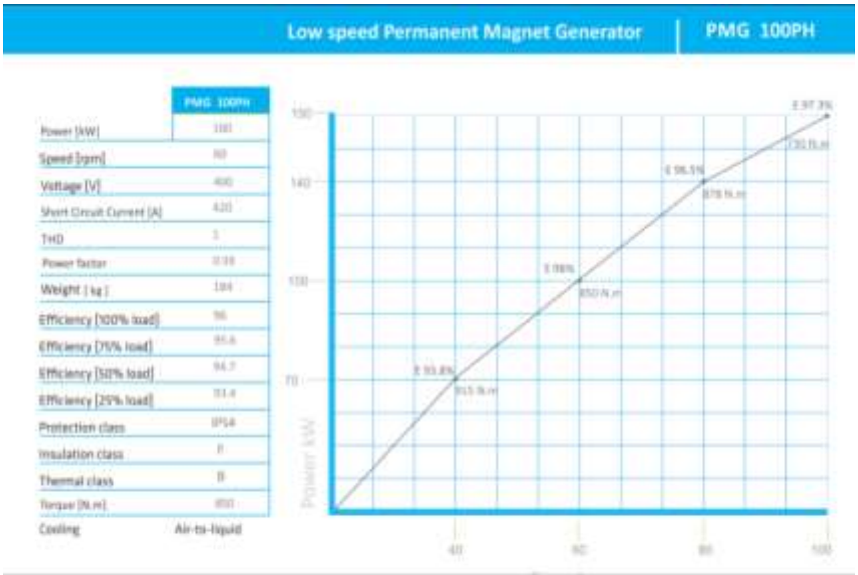

Figure 4.29. Specification Generator for Savonius Wind Turbine
*(**Source:** Enerset, 2017)*

From these results obtained minimum torque and RPM for the generator to work properly. The minimum torque is 850 Nm, so we choose the output of generator which more than 850 Nm. After that we know the minimum RPM for generator, we choose right gearbox. The minimum RPM for Generator working properly is 60 RPM, but the RPM from gorlov helical turbine is 19 RPM. After that we choose JBJ gearbox with ratio input 12 RPM and output 73 RPM, with the output of torque can reach 1000 Nm shown in figure 4.30. This is the right gearbox for savonius wind turbine.

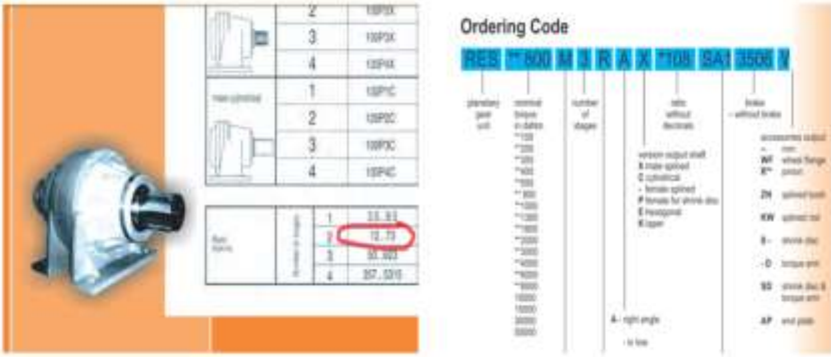

Figure 4.30. Specification Gearbox for Savonoius Wind Turbine
*(**Source:** JBJ, 2017)*

After know the output of RPM, we calculate the output of the generator. So, the results can seen in table 4.14.

Table 4.14. Calculation Results for Savonoius Wind Turbine

SAVONIUS WIND TURBINE			
GENERATOR	=	ENERSET PMG 100 PH	
POWER	=	100	KW
SPEED	=	60	RPM
WEIGHT	=	468	KG
TORQUE	=	850	Nm
TORQUE FROM SAVONIUS WIND TURBINE	=	3215.6	Nm
RPM FROM SAVINIUS WIND TURBINE	=	19.64244	RPM
GEARBOX MANUFACTORIES	=	JBJ	
GEARBOX INPUT	=	19.64244	RPM
GEARBOX OUTPUT	=	73	RPM
TORQUE MAX OUTPUT FROM GEARBOX	=	1,000	NM
ELECTRICITY	=	121.7	KW

Thus, from a total of one savonius wind turbine with a diameter of 3 m and a height of 5 m can produce a total power of 121.7 Kw.

4.4.3. Calculation results of Connected Surface Buoy System

$$P = \rho \cdot \mathrm{g} \cdot h$$

$$h = \frac{P}{\rho . g}, P = \frac{F}{A}$$

$$h = \frac{\frac{F}{A}}{\rho . g}, F = \frac{\tau . \eta}{l}$$

$$h = \frac{\frac{\tau . \eta}{l . A}}{\rho . \mathrm{g}}$$

$$h = \frac{\tau . \eta}{l . A . \rho . g}$$

After know head of hydraulic pump in system, we want to know capacity in system.

$$Q = V . A$$

$$Q = (\sqrt{2 . g . h}) . (\pi . r^2)$$

P = Hidrostatic Pressure (N/m^2)
ρ = Density (kg/m^3)
h = Head (m)
g = Gravity (m/s^2)
F = Force (N)
A = Area of Piston in Hidraulic Pump (m^2)
η = Efficiency of Hidraulic Pump
l =Length of Arm in CSBS (m)
τ = Torque in CSBS (Nm)
Q = Capacity in pipe (m^3/s)
V = Velocity of flow (m^2/s)
A = Area of pipe (m^2)
h = Head (m)
g = Gravity (m/s^2)
r = radius of pipe (m)

After obtaining the appropriate head and capacity, then the appropriate pelton turbine is selected that are shown in table 4.15. The appropriate pelton turbines are:

Table 4.15. Specification of Pelton Turbine
*(**Source :** HS Dynamic Energy, 2017)*

Pelton type generating set Specification and Applicable Scope of Unit

Turbine				Generator			Governor	Inlet Valve
Head M	Flow M^3/s	Output KW	Dia. Of tube (mm)	Type	Output KW	Power Output	Type	Type
60	0.06	20	200	HS-20	20	Option	Auto Load	Option
70	0.065	30	200	HS-30	30	Option	Auto Load	Option
80	0.07	40	200	HS-40	40	Option	Auto Load	Option
100	0.062	50	200	HS-50	50	Option	Auto Load	Option
110	0.071	60	200	HS-60	60	Option	Auto Load	Option
120	0.074	70	200	HS-70	70	Option	Auto Load	Option
140	0.083	90	200	HS-90	90	Option	Auto Load	Option
160	0.087	100	200	HS-100	100	Option	Auto Load	Option

Table 4.16. Calculation Results Connected Surface Buoy System

RESULTS OF CONNECTED SURFACE BUOY SYSTEM			
TORQUE FROM TURBINE	=	366.986	*Nm*
EFFICIENCY OF HYDRAULIC PUMP	=	0.9	
LENGTH OF CSBS ARM	=	10	*m*
DIAMETER OF CSBS	=	5	*m*
DIAMETER OF PIPE IN SYSTEM	=	0.2	*m*
DENSITY OF WATER IN SYSTEM	=	1	kg/m^3
GRAVITY	=	9.8	m/s^2
HEAD	=	107.3337	*m*
CAPACITY	=	1.44021	m^3/s
PELTON TURBINE	=	HS-50	
HEAD REQUIRED	=	100	*m*
CAPACITY REQUIRED	=	0.062	m^3/s
POWER PRODUCED	=	50	*Kw*
ITEM	=	7	
TOTAL POWER PRODUCED	=	350	*Kw*

Thus, from a total of one Connected Surface Buoy System with a diameter of 5m and a height of 3m can produce a total power of 50 Kw that are shown in table 4.16. So with the seven item of connected surface buoy buoy system in powerplant, it will produce reach 350 kw.

d. Total Results

Table 4.17. Total Results of Powerplant

TOTAL POWER PRODUCED IN POWERPLANT							
No	Device	Power (kw)		Devices	Total Power (kw)	
1	Gorlov Helical Turbine	4866.67	kw	1	4866.667	kw
2	Savonius Wind Turbine	121.70	kw	4	486.8	kw
3	Connected Surface Buoy System	50.00	kw	7	350	kw
	TOTAL POWER PRODUCED				5703.467	kw

From one gorlov helical turbine with dimention 3m x 5m, we can obtained power reached 4866,7 kw. From four savonius wind turbine with dimention 5m x 10m, we can obtained power reached 486,8 kw. And from seven connected surface buoy system, we can obtained power reached 350 kw. So, total power produced from this powerplant can reached 5,7 Mw (shown in table 4.17), with assumption every house needed about 900 w, this powerplant can give the electricity about more than 6300 house in land near capalulu strait.

4.5 Economic Analysis of Powerplant

Next we will analyze the economic of this powerplant. Economic analysis includes:

1. Cost production
2. Investation
3. Risk calculation
4. Cost survey
5. Salary of staff
6. Expenditure
7. Revenue plan
8. Total revenue
9. NPV (Net Present Value)
10. Cash flow

The purpose of this economic analysis is to determine the feasibility of a project where this feasibility is determined by the size of the IRR (Internal Rate of

Return). IRR is obtained by means of electricity sales every kwh worth IDR 1500 minus the costs of operational such as salary of staff, cost survey, investation, etc,.

4.5.1. Cost Production

For the manufacture of one generating powerplant, a manufacturing cost is required consisting of every area in the construction and on each turbine area. The material price is obtained from standard marine provider. The price of these material can be seen in the following table 4.18.

Table 4.18. Price Material Marine Standard
*(**Source** : Sinarindo, 2017)*

Price of Plat Marine Standard						
No	Thickness (mm)	Dimension (ft)	Dimension (m2)	Weight (kg)	Price per Pieces	Price / m2
1	4,7	5 ft x 20 ft	9.3025	328	IDR 2,461,000.00	IDR 264,552.54
2	5	5 ft x 20 ft	9.3025	365	IDR 2,731,500.00	IDR 293,630.74
3	6	5 ft x 20 ft	9.3025	438	IDR 3,283,000.00	IDR 352,915.88
4	7	5 ft x 20 ft	9.3025	510	IDR 3,823,000.00	IDR 410,964.79
5	8	5 ft x 20 ft	9.3025	583	IDR 4,735,000.00	IDR 509,002.96
6	9	5 ft x 20 ft	9.3025	656	IDR 4,921,000.00	IDR 528,997.58
7	10	5 ft x 20 ft	9.3025	729	IDR 5,461,500.00	IDR 587,100.24
8	12	5 ft x 20 ft	9.3025	875	IDR 6,563,500.00	IDR 705,563.02

After obtaining the price of each material thickness, then subsequently calculate the area of each surface in the construction of the powerplant. The dimensions and general arrangement of the plant can be seen as follows:

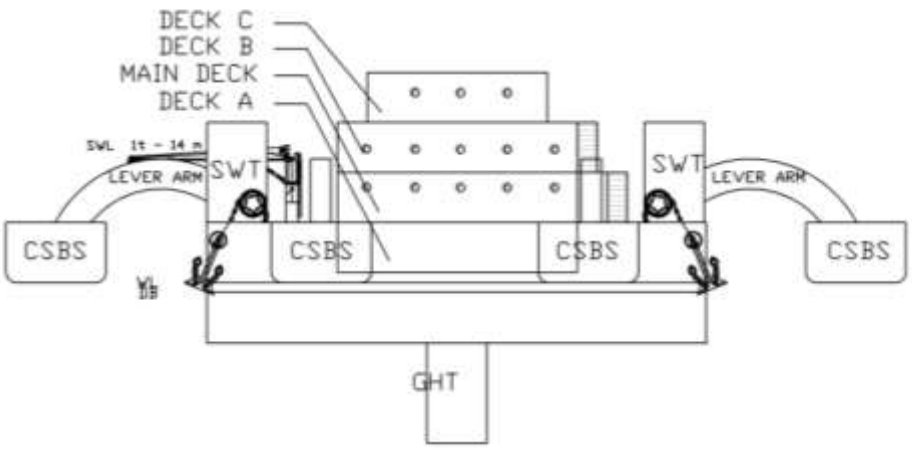

Figure 4.31. Side View Powerplant

In Figure 4.31. is the side view of the powerplant. On this side view can be seen that this powerplant has 4 decks of Deck A, Main Deck, Deck B, and Deck C. Deck A is inside the platform so it does not appear from the outside. The dimensions of this platform are 20 m x 20 m with height measured from the water requirement of 10.5 m with the details of the platform height of 3m and water laden each deck 2.5 m.

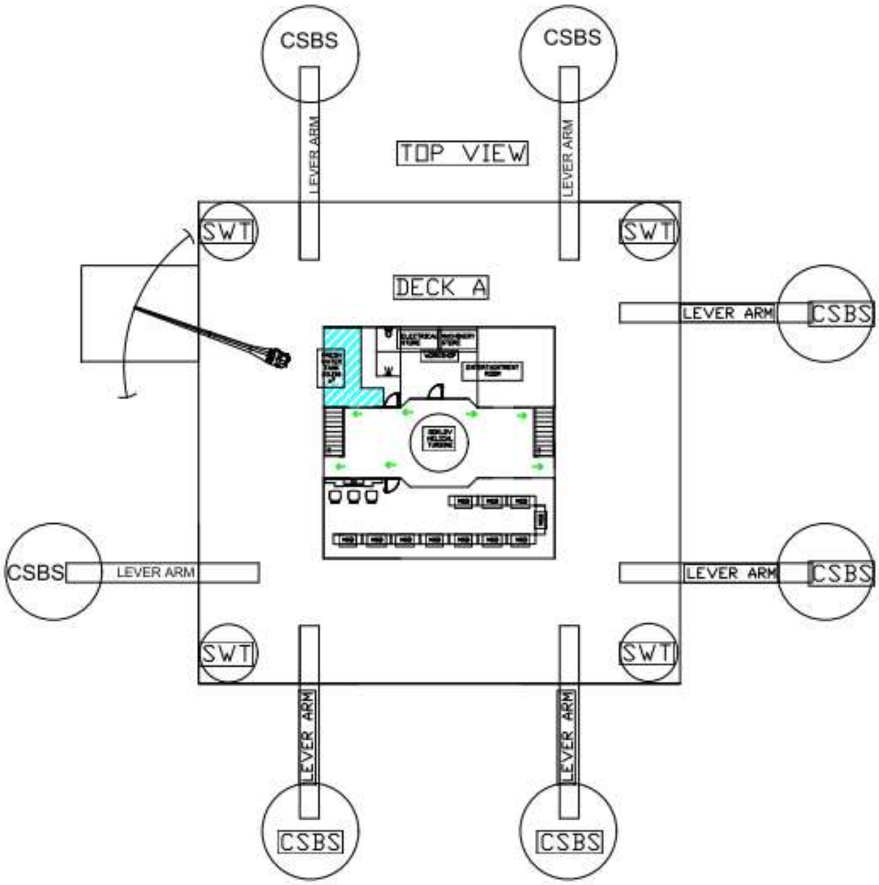

Figure 4.32. Top View Powerplant

In Figure 4.32. is the top view of the powerplant. In this top view it can be seen that this powerplant has 4 savonius wind turbine 7 connected surface buoy system and 1 provision crane and mini port to lean the ship along with unloading requirement from crew from this powerplant.

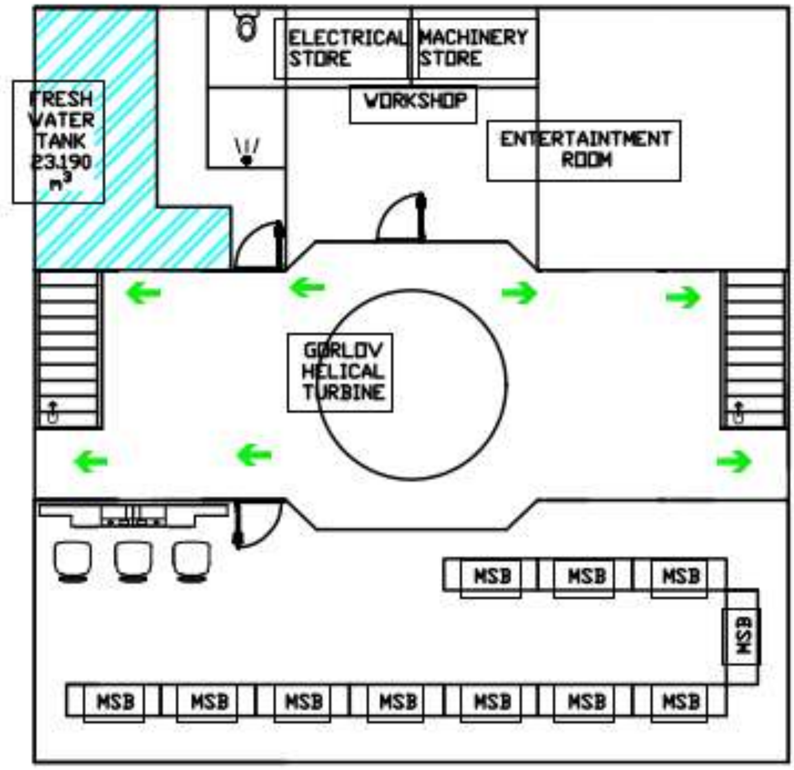

Figure 4.33. Deck A View of Powerplant

In Figure 4.33. is a Deck A view of powerplant. This deck has an area of 12 m x 12 m. In Deck A it can be seen that this powerplant has 4 main rooms, namely Engine Control Room which contains 11 MSB (main switch board) representing every generator of every energy converter, which is 4 MSB for Savonius Wind turbine, 1 MSB for Gorlov Helical Turbine and 7 MSB for connected surface buoy system. The next room is a lavatory that contains 1 closet and 1 shower. The room next workshop room and which contains electrical store and machinery store. And the last is the entertainment room.

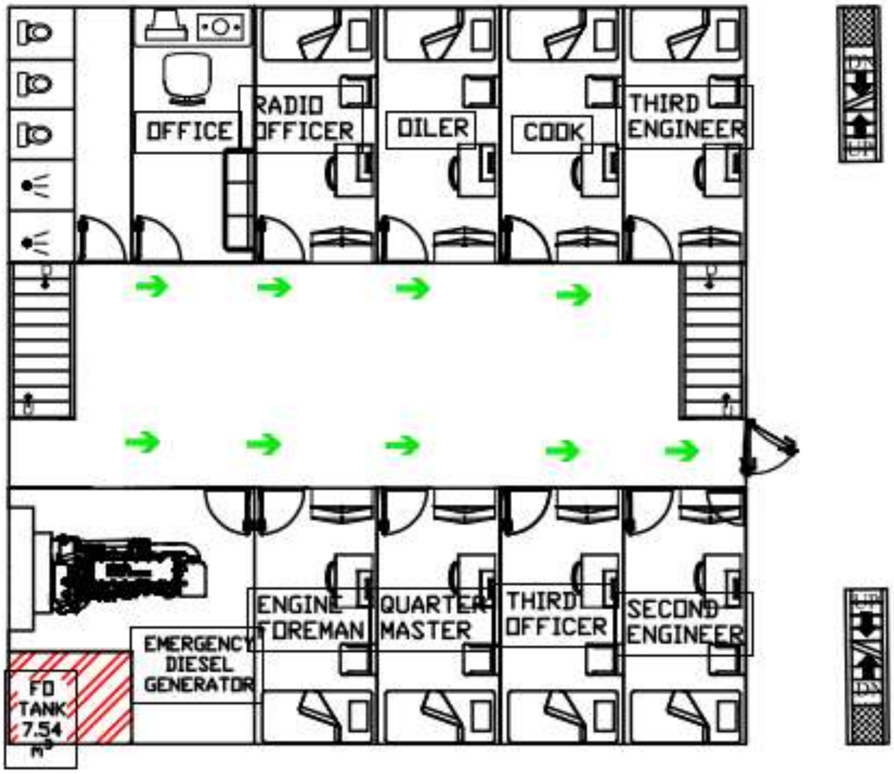

Figure 4.34. Main Deck View of Powerplant

In Figure 4.34. is the Main Deck view of the powerplant. This deck has an area of 12 m x 12 m. On this Main Deck can be seen that this powerplant has 11 main room, namely Emergency Diesel Generator Room, Chief Engineer Room, Second Room Officer, Second Engineer Room, Cooker Room, Oiler Room, Third Engineer Room, Engine Foreman Room, Radio Officer Room, Office Room and Lavatory. And the main deck has two ladder of ketas and down to connect between deck a and deck b. and in front of the main deck has 2 emergency stairs that serve as an mergency stair that connects to the muster station in deck B.

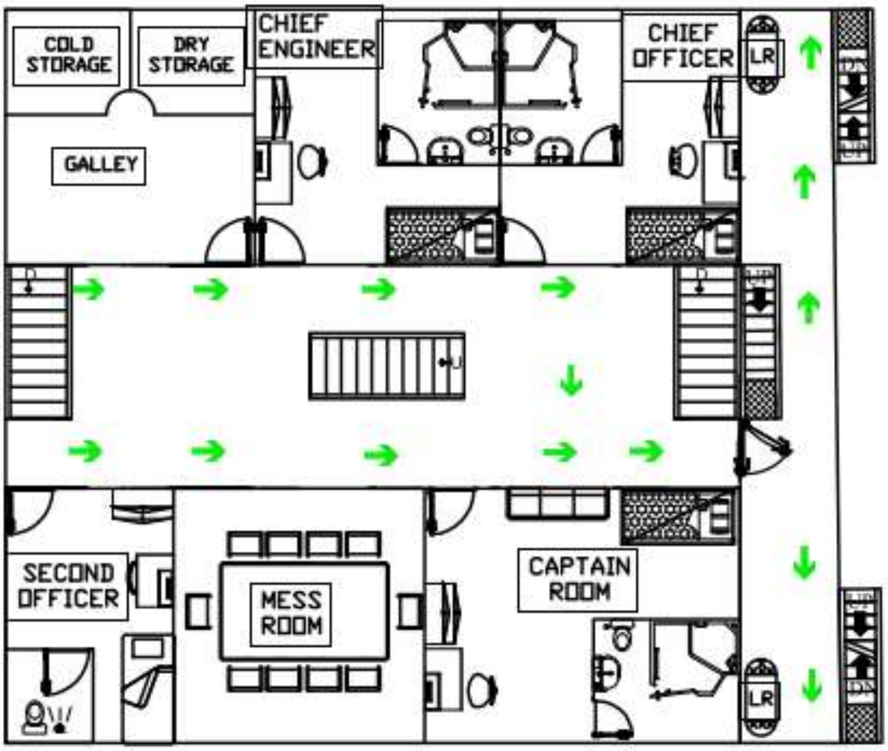

Figure 4.35. Deck B View of Powerplant

In Figure 4.35. is Deck B view from powerplant. This deck has an area of 13.5 m x 12 m. In Deck B it can be seen that this powerplant has 6 main rooms, namely Captain Room, Mess Room which serves as a place to eat, Chief Officer Room, Chief Engineer Room, and Galley containing cold storage and dry storage. Deck B is also equipped with a muster station measuring 1.5 m x 12 m. muster station there are also 2 life raft with each 8 person capacity and 3 pieces of emergency ladder connecting with main deck and deck c.

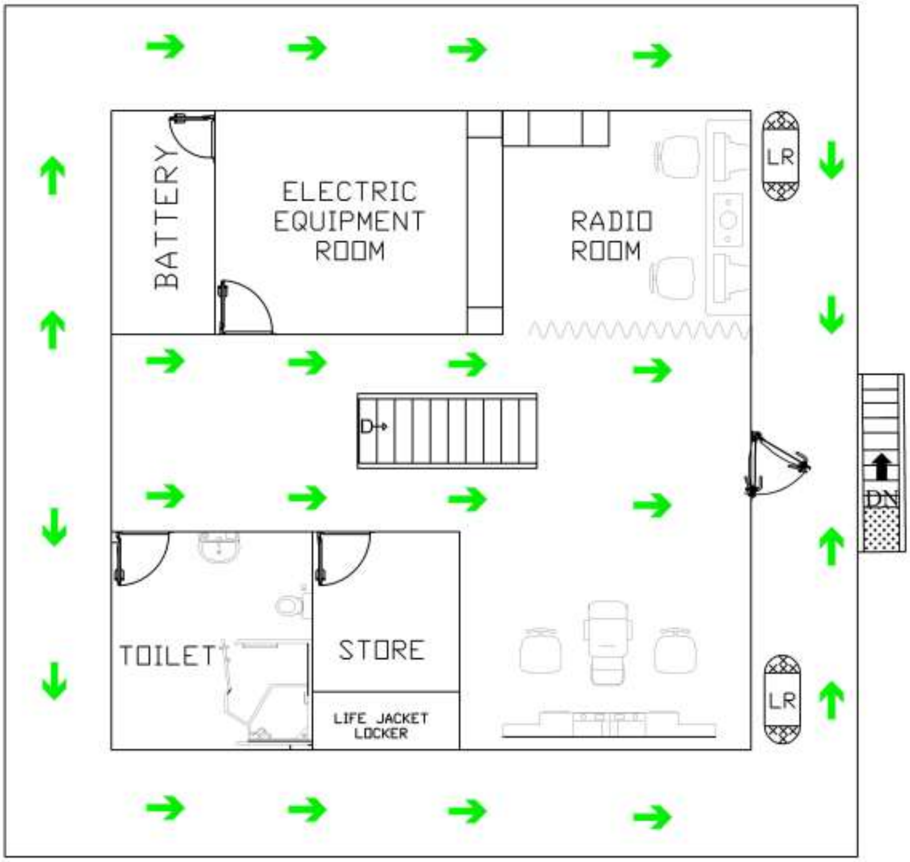

Figure 4.36. Deck C View of Powerplant

In Figure 4.36. is Deck C view from powerplant. This deck has an area of 9 m x 9 m. This Deck C has 6 main rooms with 4 sealed rooms. The room is Store, Toilet, Battery room, Electruc equipment room and 2 room that is not insulated is radio room and electrical and navigation panel.

After the general arrangement was obtained. Next calculate the area of each area (shown in table 4.19, 4.20, 4.21, 4.22, 4.23.). Determination of each area also to know the displacement of the powerplant. This displacement aims to determine the weight of the plant. Calculation of this weight to know the double bottom height for the ballast used as a stabilizer. The calculation is as follows:

Table 4.19. Material Calculation of Savonius Wind Turbine

Savonius Wind Turbine (4.7mm)									
1	Circle Cover (m)		Thickness (mm)	Wide (m2)	Wide tota	Weight/m2 (kg)	Total Weight kg	Price / m2	Total Price
	Up	7.07	4,7	14.14	35.98	35.26	1,268.63	IDR 264,552.54	IDR 9,518,600.38
	Down	7.07	4,7						
2	Blade (m)		Thickness (mm)	Wide (m2)					
	Right	10.92	4,7	21.84					
	Left	10.92	4,7						

Table 4.20. Material Calculation of Gorlov Helical Turbine

Gorlov Helical Turbine (8mm)									
1	Circle Cover (m)		Thickness (mm)	Wide (m2)	Wide total (m2)	Weight/m2 (kg)	Total Weight kg	Price / m2	Total Price
	Up	6.64	8	13.28	26.15	62.67	1,638.86	IDR 470,088.69	IDR 12,292,819.13
	Down	6.64	8						
2	Blade (m)		Thickness	Wide (m2)					
	1	4.29	8	12.87					
	2	4.29	8						
	3	4.29	8						

Table 4.21. Material Calculation of Connected Surface Buoy System

Weight Connected Surface Buoy System 8 mm									
H of CSBS	D of CSBS	L Area of each CSBS	L area Lever Arm	Thicknes s (mm)	Wide total (m2)	Weight/m2 (kg)	Total Weight kg	Price / m2	Total Price
3	5	86.35	40	8	884.45	62.67	55,429.65	IDR 470,088.69	IDR 415,769,938.19

Table 4.22. Material Calculation of Deck

Weight of Main Deck (8mm)									
1	Wall of Main deck (m)		Thickness (mm)	Wide (m2)	Wide total (m2)	Weight/m2 (kg)	Total Weight (kg)	Price / m2	Total Price
	2.5	12	10	120	350	62.67	21,934.96	IDR 470,088.69	IDR 164,531,040.04
	2.5	12	10	120					
	2.5	10	10	100					
	2.5	12	10	120					
2	Floor (m)		Thickness (mm)	Wide (m2)	Wide total (m2)	Weight/m2 (kg	Total Weight kg	Price / m2	Total Price
	12	12	10	144	388	62.67	24,316.47	IDR 470,088.69	IDR 182,394,410.10
	12	12	10	144					
	10	10	10	100					

Table 4.23. Material Calculation of Construction

Weight Construction (minus inner construction) 12 mm									
H of Barge (m)	L of Barge (m)	L of Barge (m)	Thickness (mm)	Wide m2	Wide total (m2)	Weight/m2 (kg)	Total Weight kg	Price / m2	Total Price
6	25	25	12	1850	1850	88.69	164,068.80	IDR 705,563.02	IDR 1,305,291,588.28

Table 4.24. Total Material Calculation of Construction

Total Weight of Plat (kg)		Total Cost of Plat	
weight	268,657.38	COST (IDR)	IDR 2,089,798,396.13

From the calculation it is found that construction cost for this powerplant reach IDR 2,089,798,396,13 where this result only for construction only and with construction weight reach 268,7 ton.

After obtaining the total weight of this construction, then determine the height of the double bottom. This double bottom serves as a ballast to hold this platform in laden 3m. as for the calculation can be seen in table 4.25.

Table 4.25. Calculation of Ballast in Double Bottom

DOUBLE BOTTOM CONSTRUCTION		
Total Weight (kg)	268000	kg
Total Weight (ton)	268	ton
Height	6	
Length	20	
Breadth	20	
Draft	3	
Volume of Displacement	1200	
Weight of Displacement	1230000	
Displacement Weight	962000	kg
Water Ballast	938.5366	m3
Height of Double Bottom	2.346341	m

From the calculation found that with a platform measuring 20 m x 20 m to hold water-laden as high as 3 m then required sea water with a volume of 956.1 m3 and requires a double double bottom as high as 2.39 m.

After obtaining all costs for the construction needs, next is set the cost for the support system of this powerplant. The cost of this support system includes the cost of a generator or a pelton turbine for each energy converter. This can be seen in Table 4.26.

Table 4.26. Cost Calculation of Support System in Powerplant

Support System					
No	Item	Type	Amount	Price	Total Price
1	Generator	Enerset PMG 4000	1	IDR 200,000,000.00	IDR 200,000,000.00
2	Generator	Enerset PMG 100	4	IDR 30,000,000.00	IDR 120,000,000.00
3	Pelton Turbine	HS 50	7	IDR 35,000,000.00	IDR 245,000,000.00
4	Gearbox	JBJ	8	IDR 65,000,000.00	IDR 520,000,000.00
5	Sistem in CSBS		7	IDR 75,000,000.00	IDR 525,000,000.00
TOTAL					IDR 1,610,000,000.00

Table 4.27. Total Cost Calculation

COST	
MATERIAL	IDR 2,089,798,396.13
ASSEMBLING (350% * MATERIAL)	IDR 5,859,099,602.79
DESIGN & APPROVAL (5% From Cost Powerplant)	IDR 542,360,062.10
ELECTRICAL EQUIPMENT	IDR 1,610,000,000.00
ALLOWANCE	IDR 1,288,303,243.00
OVERHEAD (OFFICE & INVENTORY)	IDR 317,910,000.00
TOTAL COST INVESTATION	IDR 11,707,471,304.02

From table 4.27. it was found that the total cost calculation for the manufacture of this tool is IDR 7,499,144,326.04. this cost includes construction cost of IDR 2,089,798,396., support system cost reach IDR 1,610,000,000,00 assembling fee reach IDR 2,511,042,686.9, other cost reach IDR 544,151,621.50 and withdrawal fee platform from makassar to target area is IDR 744,151,621.50.

Furthermore, after calculating the cost of manufacture, then calculate the IRR (Internal Rate of Return). Calculating IRR serves to determine if the plant is sustainable when applied. The IRR calculation includes:

4.5.2. Investation

Investment of investing money or capital in a company or project for the purpose of obtaining profit. The investment for the manufacture of this powerplant such as Office & Workshop, Office inventory, and Powerplant detail calculationn. This is can be seen from table 4.28 until 4.30.

1. Office & Workshop

Table 4.28. Cost Calculation of Office and Workshop

No	Describtion	Unit	Rent Cost (Per Year)		Total Cost	
1	Office in Land	1	Rp	50,000,000	Rp	50,000,000
2	Workshop in Land	1	Rp	50,000,000	Rp	50,000,000

2. Office inventory

Table 4.29. Cost Calculation of Office Inventory

No	Describtion	Unit	Cost		Total Cost	
1	Computer	12	Rp	6,899,000	Rp	82,788,000
2	Printer	8	Rp	419,000	Rp	3,352,000
3	Air Condition	10	Rp	2,635,000	Rp	26,350,000
4	Desk	20	Rp	548,000	Rp	10,960,000
5	Chair	30	Rp	2,200,000	Rp	66,000,000
6	Telephone, Faximile	4	Rp	1,350,000	Rp	5,400,000
7	Refrigerator	2	Rp	1,550,000	Rp	3,100,000
8	Craft/Support Vessel	2	Rp	9,980,000	Rp	19,960,000
Total					Rp	217,910,000

3. Powerplant Cost Detail Calculation

Table 4.30. Cost Calculation of Powerplant

No	Describtion	Unit	Cost		Total Cost	
1	Powerplant	1	Rp	10,847,201,242	Rp	10,847,201,242
3	Approval (5% From investation)	1		542,360,062.10	Rp	542,360,062
Total					Rp	11,389,561,304

Table 4.31. Cost Calculation of Powerplant

TOTAL INVESTATION	Rp	11,707,471,304

Then obtained the calculation that the total investment costs that need to be issued amounted to IDR 11,707,471,326,00.

4.5.3. Risk Calculation

In creating this powerplant, of course there is a risk. These risks include the risk of occupational accidents as well as the risk of accidents due to natural factors that are shown in table 4.32. until table 4.37. The costs of such risks include:

1. **Crew**

Table 4.32. Cost Compensation of Crew

Description	Cost		Casualties	Total Compensation	
Death	Rp	150,000,000	2	Rp	300,000,000
Missing One Arm	Rp	50,000,000	1	Rp	50,000,000
Mising Both Arm	Rp	120,000,000	0	Rp	-
Missing One Hand Palm	Rp	50,000,000	0	Rp	-
Missing Both Palm	Rp	120,000,000	0	Rp	-
Missing One Leg	Rp	60,000,000	0	Rp	-
Missing Both Leg	Rp	140,000,000	0	Rp	-
Missing One Feet Sole	Rp	45,000,000	0	Rp	-
Missing Both Feet Sole	Rp	110,000,000	0	Rp	-
Missing One Eye	Rp	45,000,000	2	Rp	90,000,000
Missing Both Eye	Rp	110,000,000	1	Rp	110,000,000
Deaf in One Ear	Rp	20,000,000	0	Rp	-
Totally Deaf	Rp	50,000,000	0	Rp	-
Missing One Hand Finger	Rp	10,000,000	3	Rp	30,000,000
Missing More 1 Hand Fing	Rp	30,000,000	2	Rp	60,000,000
Missing One Foot Finger	Rp	10,000,000	3	Rp	30,000,000
Missing More 1 Foot Finge	Rp	30,000,000	2	Rp	60,000,000
Total Compensation (All Cost Covered by Insurance)				Rp	730,000,000

2. **Disaster Countermeasure**

Table 4.33. Cost Disaster Countermeasure

Description	Cost	
Environment Comp.	Rp	150,000,000
SAR team	Rp	50,000,000
Total Compesation	Rp	200,000,000

3. Collision Compensation

Table 4.34. Cost Collision Compensation

Total	Rp	250,000,000

4. Build Powerplant Again

Table 4.35. Cost Build Powerplant Again

No	Describtion	Unit	Cost		Total Cost	
1	Powerplant	1	Rp	10,847,201,242	Rp	10,847,201,242
3	Approval (5% From investation)	1		542,360,062.10	Rp	542,360,062
Total					Rp	11,389,561,304

5. All Compensation Cost

Table 4.36. Cost All Compensation

ALL COMPENSATION COST	Rp	12,027,201,242

From calculation of risk calculation got result that total cost incurred for risk is equal to IDR 12,027,201,242.. The calculation includes compensation crew, cost disaster countermeasure, collision compensation and built powerplant again.

4.5.3. Cost Survey

For the manufacture of this powerplant, of course required maintenance and survey. This cost is likened to cost on barge that shown in table 4.37..

Table 4.37. Cost Survey and Maintenance

POWERPLANT MAINTENANCE			
POWERPLANT WITH CAP. 5,7 MW			
No	Maintenance	Cost	
1	Annual (3% Price)	Rp	325,416,037
2	Special (5% Price)	Rp	542,360,062

4.5.4. Salary Of Staff

Due to the need of workers who are in powerplant in the middle of the strait and management are on land, the projected salary of employees divided into 2 kinds. This is can be seen in table 4.38 & 4.39. The projection is:

Table 4.38. Salary Staff Management in Land

No	Description	Salary		Total		Year
		Per-Month	Per-Year	Quantity	Salary	2019
1	Branch Head	5,000,000	60,000,000	1	60,000,000	60,000,000
2	Kadin Personalia dan	4,000,000	48,000,000	1	48,000,000	48,000,000
3	Head of Teknik	4,000,000	48,000,000	1	48,000,000	48,000,000
4	Head of Tourism Departement	4,000,000	48,000,000	1	48,000,000	48,000,000
5	Staf Personalia dan Keuangan	3,000,000	36,000,000	4	144,000,000	144,000,000
6	Staf Teknik	3,000,000	36,000,000	4	144,000,000	144,000,000
7	Security	3,000,000	36,000,000	4	144,000,000	144,000,000
8	Driver	2,500,000	30,000,000	2	60,000,000	60,000,000
9	Field Worker	1,500,000	18,000,000	5	90,000,000	90,000,000
	Total Salary	30,000,000	360,000,000	23	786,000,000	786,000,000

No	Description	Year				
		2020	2021	2022	2023	2024
1	Branch Head	60,000,000	63,000,000	63,000,000	66,150,000	66,150,000
2	Kadin Personalia dan Keuangan	48,000,000	50,400,000	50,400,000	52,920,000	52,920,000
3	Head of Teknik	48,000,000	50,400,000	50,400,000	52,920,000	52,920,000
4	Head of Tourism Departement	48,000,000	50,400,000	50,400,000	52,920,000	52,920,000
5	Staf Personalia dan Keuangan	144,000,000	151,200,000	151,200,000	158,760,000	158,760,000
6	Staf Teknk	144,000,000	151,200,000	151,200,000	158,760,000	158,760,000
7	Security	144,000,000	151,200,000	151,200,000	158,760,000	158,760,000
8	Driver	60,000,000	63,000,000	63,000,000	66,150,000	66,150,000
9	Field Worker	90,000,000	94,500,000	94,500,000	99,225,000	99,225,000
	Total Salary	786,000,000	825,300,000	825,300,000	866,565,000	866,565,000

No	Description	Year				
		2025	2026	2027	2028	2029
1	Branch Head	69,457,500	69,457,500	72,930,375	72,930,375	76,576,894
2	Kadin Personalia dan Keuangan	55,566,000	55,566,000	58,344,300	58,344,300	61,261,515
3	Head of Teknik	55,566,000	55,566,000	58,344,300	58,344,300	61,261,515
4	Head of Tourism Departement	55,566,000	55,566,000	58,344,300	58,344,300	61,261,515
5	Staf Personalia dan Keuangan	166,698,000	166,698,000	175,032,900	175,032,900	183,784,545
6	Staf Teknk	166,698,000	166,698,000	175,032,900	175,032,900	183,784,545
7	Security	166,698,000	166,698,000	175,032,900	175,032,900	183,784,545
8	Driver	69,457,500	69,457,500	72,930,375	72,930,375	76,576,894
9	Field Worker	104,186,250	104,186,250	109,395,563	109,395,563	114,865,341
	Total Salary	909,893,250	909,893,250	955,387,913	955,387,913	1,003,157,308

No	Description	Year				
		2030	2031	2032	2033	2034
1	Branch Head	76,576,894	80,405,738	80,405,738	84,426,025	84,426,025
2	Kadin Personalia dan Keuangan	61,261,515	64,324,591	64,324,591	67,540,820	67,540,820
3	Head of Teknik	61,261,515	64,324,591	64,324,591	67,540,820	67,540,820
4	Head of Tourism Departement	61,261,515	64,324,591	64,324,591	67,540,820	67,540,820
5	Staf Personalia dan Keuangan	183,784,545	192,973,772	192,973,772	202,622,461	202,622,461
6	Staf Teknk	183,784,545	192,973,772	192,973,772	202,622,461	202,622,461
7	Security	183,784,545	192,973,772	192,973,772	202,622,461	202,622,461
8	Driver	76,576,894	80,405,738	80,405,738	84,426,025	84,426,025
9	Field Worker	114,865,341	120,608,608	120,608,608	126,639,038	126,639,038
	Total Salary	1,003,157,308	1,053,315,174	1,053,315,174	1,105,980,932	1,105,980,932

Table 4.39. Salary Staff Field Worker in Middle Strait

No	Description	Salary		Total		Year
		Per-Month	Per-Year	Quantity	Salary	2019
1	Captain	8,000,000	96,000,000	3	288,000,000	288,000,000
2	Chief Officer	7,000,000	84,000,000	2	168,000,000	168,000,000
3	Chief Engineer	7,000,000	84,000,000	2	168,000,000	168,000,000
4	Second Officer	6,000,000	72,000,000	2	144,000,000	144,000,000
5	Second Engineer	6,000,000	72,000,000	3	216,000,000	216,000,000
6	Third Officer	5,500,000	66,000,000	2	132,000,000	132,000,000
7	Third Engineer	5,500,000	66,000,000	2	132,000,000	132,000,000
8	Quarter Master	4,500,000	54,000,000	3	162,000,000	162,000,000
9	Cook	4,000,000	48,000,000	2	96,000,000	96,000,000
10	Oiler	3,500,000	42,000,000	2	84,000,000	84,000,000
11	Engine Foreman	4,000,000	48,000,000	2	96,000,000	96,000,000
12	Radio Officer	6,000,000	72,000,000	4	288,000,000	288,000,000
	Total Salary	67,000,000	804,000,000	29	1,974,000,000	1,974,000,000

No	Description	Year				
		2020	2021	2022	2023	2024
1	Captain	288,000,000	302,400,000	302,400,000	317,520,000	317,520,000
2	Chief Officer	168,000,000	176,400,000	176,400,000	185,220,000	185,220,000
3	Chief Engineer	168,000,000	176,400,000	176,400,000	185,220,000	185,220,000
4	Second Officer	144,000,000	151,200,000	151,200,000	158,760,000	158,760,000
5	Second Engineer	216,000,000	226,800,000	226,800,000	238,140,000	238,140,000
6	Third Officer	132,000,000	138,600,000	138,600,000	145,530,000	145,530,000
7	Third Engineer	132,000,000	138,600,000	138,600,000	145,530,000	145,530,000
8	Quarter Master	162,000,000	170,100,000	170,100,000	178,605,000	178,605,000
9	Cook	96,000,000	100,800,000	100,800,000	105,840,000	105,840,000
10	Oiler	84,000,000	88,200,000	88,200,000	92,610,000	92,610,000
11	Engine Foreman	96,000,000	100,800,000	100,800,000	105,840,000	105,840,000
12	Radio Officer	288,000,000	302,400,000	302,400,000	317,520,000	317,520,000
	Total Salary	1,974,000,000	2,072,700,000	2,072,700,000	2,176,335,000	2,176,335,000

No	Description	Year				
		2025	2026	2027	2028	2029
1	Captain	333,396,000	333,396,000	350,065,800	350,065,800	367,569,090
2	Chief Officer	194,481,000	194,481,000	204,205,050	204,205,050	214,415,303
3	Chief Engineer	194,481,000	194,481,000	204,205,050	204,205,050	214,415,303
4	Second Officer	166,698,000	166,698,000	175,032,900	175,032,900	183,784,545
5	Second Engineer	250,047,000	250,047,000	262,549,350	262,549,350	275,676,818
6	Third Officer	152,806,500	152,806,500	160,446,825	160,446,825	168,469,166
7	Third Engineer	152,806,500	152,806,500	160,446,825	160,446,825	168,469,166
8	Quarter Master	187,535,250	187,535,250	196,912,013	196,912,013	206,757,613
9	Cook	111,132,000	111,132,000	116,688,600	116,688,600	122,523,030
10	Oiler	97,240,500	97,240,500	102,102,525	102,102,525	107,207,651
11	Engine Foreman	111,132,000	111,132,000	116,688,600	116,688,600	122,523,030
12	Radio Officer	333,396,000	333,396,000	350,065,800	350,065,800	367,569,090
	Total Salary	2,285,151,750	2,285,151,750	2,399,409,338	2,399,409,338	2,519,379,804

No	Description	Year				
		2030	2031	2032	2033	2034
1	Captain	367,569,090	385,947,545	385,947,545	405,244,922	405,244,922
2	Chief Officer	214,415,303	225,136,068	225,136,068	236,392,871	236,392,871
3	Chief Engineer	214,415,303	225,136,068	225,136,068	236,392,871	236,392,871
4	Second Officer	183,784,545	192,973,772	192,973,772	202,622,461	202,622,461
5	Second Engineer	275,676,818	289,460,658	289,460,658	303,933,691	303,933,691
6	Third Officer	168,469,166	176,892,625	176,892,625	185,737,256	185,737,256
7	Third Engineer	168,469,166	176,892,625	176,892,625	185,737,256	185,737,256
8	Quarter Master	206,757,613	217,095,494	217,095,494	227,950,268	227,950,268
9	Cook	122,523,030	128,649,182	128,649,182	135,081,641	135,081,641
10	Oiler	107,207,651	112,568,034	112,568,034	118,196,436	118,196,436
11	Engine Foreman	122,523,030	128,649,182	128,649,182	135,081,641	135,081,641
12	Radio Officer	367,569,090	385,947,545	385,947,545	405,244,922	405,244,922
	Total Salary	2,519,379,804	2,645,348,795	2,645,348,795	2,777,616,234	2,777,616,234

Table 4.40. Total Salary Staff

*TOTAL SALARY OF OFFICERS and CREWS		
NO	Year	Total Salary
1	2019	Rp 2,760,000,000
2	2020	Rp 2,760,000,000
3	2021	Rp 2,898,000,000
4	2022	Rp 2,898,000,000
5	2023	Rp 3,042,900,000
6	2024	Rp 3,042,900,000
7	2025	Rp 3,195,045,000
8	2026	Rp 3,195,045,000
9	2027	Rp 3,354,797,250
10	2028	Rp 3,354,797,250
11	2029	Rp 3,522,537,113
12	2030	Rp 3,522,537,113
13	2031	Rp 3,698,663,968
14	2032	Rp 3,698,663,968
15	2033	Rp 3,883,597,167
16	2034	Rp 3,883,597,167

From the calculation of the total salary of staff that shown in table 4.40., it is found that in 2019 where the powerplant starts to operate the salary required for the staff is IDR 2,760,000,000.00 and the salary will increase by 1% every two years so that in 2034 the salary required for staff is equal to IDR 3,883,597,167.00.

4.5.5. Expenditure

Capital expenditure is the costs incurred in order to acquire fixed assets, improve operational efficiency and productive capacity of fixed assets, and extend the useful life of fixed assets. These costs are usually issued in large quantities that shown in table 4.41.

Table 4.41. Expenditure

No.	Information	2017	2019	2020
1.	Office Rents	Rp 100,000,000	Rp 100,000,000	Rp 101,000,000
2.	Office Inventories	Rp 217,910,000	Rp -	Rp -
3.	Ships Cost	Rp 11,389,561,304	Rp -	Rp -
4.	Accident Cost	Rp -	Rp -	Rp -
5.	Innovation Cost	Rp -	Rp -	Rp -
6.	Operational Cost	Rp -	Rp -	Rp -
7.	Port Expenses	Rp -	Rp 23,624,640	Rp 23,624,640
8.	Bank Installment (11%)	Rp -	Rp 649,764,657	Rp 649,764,657
9.	Tax (1,2% Bruto)	Rp -	Rp 37,468,710	Rp 37,843,397
10.	Innovation	Rp -	Rp -	Rp -
11.	Annual Survey	Rp -	Rp 325,416,037	Rp 325,416,037
12.	Spesial Survey	Rp -		
Total		Rp 11,707,471,304	Rp 1,136,274,045	Rp 1,137,648,732

2021	2022	2023	2024	2025
Rp 101,000,000	Rp 102,010,000	Rp 102,010,000	Rp 103,030,100	Rp 103,030,100
Rp -	Rp -	Rp -	Rp -	Rp -
Rp -	Rp -	Rp -	Rp -	Rp -
Rp -	Rp -	Rp -	Rp -	Rp -
Rp -	Rp -	Rp -	Rp -	Rp -
Rp -	Rp -	Rp -	Rp -	Rp -
Rp 23,624,640	Rp 23,624,640	Rp 23,624,640	Rp 23,624,640	Rp 23,624,640
Rp 649,764,657	Rp 649,764,657	Rp 649,764,657	Rp 649,764,657	Rp -
Rp 38,221,831	Rp 38,604,049	Rp 38,990,090	Rp 39,379,991	Rp 39,773,791
Rp -	Rp -	Rp -	Rp -	Rp -
Rp 357,957,641	Rp 357,957,641	Rp -	Rp 393,753,405	Rp 433,128,746
		Rp 542,360,062		
Rp 1,170,568,769	Rp 1,171,960,988	Rp 1,356,749,449	Rp 1,209,552,793	Rp 599,557,276

2026	2027	2028	2029	2030
Rp 104,060,401	Rp 104,060,401	Rp 105,101,005	Rp 105,101,005	Rp 106,152,015
Rp 220,089,100	Rp -	Rp -	Rp -	Rp -
Rp -	Rp -	Rp -	Rp -	Rp -
Rp -	Rp -	Rp -	Rp -	Rp -
Rp -	Rp -	Rp -	Rp -	Rp -
Rp -	Rp -	Rp -	Rp -	Rp -
Rp 23,624,640	Rp 23,624,640	Rp 23,624,640	Rp 23,624,640	Rp 23,624,640
Rp -	Rp -	Rp -	Rp -	Rp -
Rp 40,171,529	Rp 40,573,244	Rp 40,978,976	Rp 41,388,766	Rp 41,802,654
Rp -	Rp -	Rp -	Rp -	Rp -
Rp 433,128,746	Rp 476,441,620	Rp -	Rp 524,085,782	Rp 524,085,782
Rp 821,074,415	Rp 644,699,905	Rp 169,704,621	Rp 694,200,193	Rp 695,665,091

2031		2032		2033		2034	
Rp	106,152,015	Rp	107,213,535	Rp	107,213,535	Rp	108,285,671
Rp	-	Rp	-	Rp	-	Rp	222,289,991
Rp	-	Rp	-	Rp	-	Rp	-
Rp	-	Rp	12,027,201,242	Rp	-	Rp	-
Rp	-	Rp	-	Rp	-	Rp	-
Rp	-	Rp	-	Rp	-	Rp	-
Rp	23,624,640	Rp	23,624,640	Rp	23,624,640	Rp	23,624,640
Rp	-	Rp	-	Rp	-	Rp	-
Rp	42,220,680	Rp	42,642,887	Rp	43,069,316	Rp	43,500,009
Rp	-	Rp	-	Rp	-	Rp	-
Rp	576,494,360	Rp	576,494,360	Rp	-	Rp	634,143,796
Rp	748,491,696	Rp	12,777,176,665	Rp	173,907,491	Rp	1,031,844,107

Modal			
a.	Personal Capital		
Presentase		70%	
Absolut		Rp	8,195,229,913
b.	Loan Capital		
Presentase		30%	
Absolut		Rp	3,512,241,391
Installment (6 tahun)		Rp	585,373,565

Note :	
(red)	Accident Assumption
(grey)	5 years special survey

4.5.6. Revenue Plan

Revenue Plan is a statement related to the results of the principal business of products or services performed by the company in a period. Simply revenue is the amount of money received by the company from the sale of products (goods or services) from customers and not derived from investment that shown in table 4.42. This powerplant has income from electricity amount IDR 3,122,392,500.00. this amount from selling each kwh about IDR 1500 in a year and the capacity of powerplant about 5703 kw.

Table 4.42. Revenue Plan

INCOME FOR POWERPLANT					
Decription	Capacity (kw)	Cost/kwh	Time	Units	One Year
Income From Electricity	5703	1500	365	1	
TOTAL INCOME					IDR 3,122,392,500.00

4.5.7. Total Revenue

Table 4.43. Total Revenue

2019		2020		2021	
Rp	3,122,392,500	Rp	3,153,616,425	Rp	3,185,152,589
Rp	3,122,392,500	Rp	3,153,616,425	Rp	3,185,152,589

2022		2023		2024	
Rp	3,217,004,115	Rp	3,249,174,156	Rp	3,281,665,898
Rp	3,217,004,115	Rp	3,249,174,156	Rp	3,281,665,898

2024		2025		2026	
Rp	3,281,665,898	Rp	3,314,482,557	Rp	3,347,627,382
Rp	3,281,665,898	Rp	3,314,482,557	Rp	3,347,627,382

2027		2028		2029		2030	
Rp	3,381,103,656	Rp	3,414,914,693	Rp	3,449,063,840	Rp	3,483,554,478
Rp	3,381,103,656	Rp	3,414,914,693	Rp	3,449,063,840	Rp	3,483,554,478

2029		2030		2031	
Rp	3,449,063,840	Rp	3,483,554,478	Rp	3,518,390,023
Rp	3,449,063,840	Rp	3,483,554,478	Rp	3,518,390,023

2032		2033		2034	
Rp	3,553,573,923	Rp	3,589,109,662	Rp	3,625,000,759
Rp	3,553,573,923	Rp	3,589,109,662	Rp	3,625,000,759

NOTE	
	Revenue
	POWERPLANT
	TOTAL INCOME

4.5.8. NPV (Net Present Value)

NPV (Net Present Value) is the difference between disbursement and discounted income by using social opportunity cost of capital as a discount factor, or in other words, an estimated future cash flow that is currently discounted. To calculate NPV data is needed on the estimated investment cost, operating cost, and maintenance as well as the estimated benefits of the planned project that shown in table 4.44..

Table 4.44. Total Revenue

2017	2018	2019	2020
Rp (11,707,471,304)	Rp -	Rp (1,136,274,045)	Rp (1,137,648,732)
Rp -	Rp -	Rp 3,122,392,500	Rp 3,153,616,425
Rp (11,707,471,304)	Rp -	Rp 1,986,118,455	Rp 2,015,967,693

2026	2027	2028	2029
Rp (821,074,415)	Rp (644,699,905)	Rp (169,704,621)	Rp (694,200,193)
Rp 3,347,627,382	Rp 3,381,103,656	Rp 3,414,914,693	Rp 3,449,063,840
Rp 2,526,552,967	Rp 2,736,403,751	Rp 3,245,210,071	Rp 2,754,863,646

2030	2031	2032	2033	2034
Rp (695,665,091)	Rp (748,491,696)	Rp (12,777,176,665)	Rp (173,907,491)	Rp (1,031,844,107)
Rp 3,483,554,478	Rp 3,518,390,023	Rp 3,553,573,923	Rp 3,589,109,662	Rp 3,625,000,759
Rp 2,787,889,387	Rp 2,769,898,327	Rp (9,223,602,741)	Rp 3,415,202,171	Rp 2,593,156,652

Note	
	Description Year
	Total Cash Outflows
	Total Cash Inflows
	Total Net Cash flows

4.5.9. Cash Flow

Cash flow is the net amount of cash and cash-equivalents moving into and out of a business. Positive cash flow indicates that a company's liquid assets are increasing, enabling it to settle debts, reinvest in its business, return money to shareholders, pay expenses and provide a buffer against future financial challenges. Negative cash flow indicates that a company's liquid assets are decreasing. Net cash flow is distinguished from net income, which includes accounts receivable and other items for which payment has not actually been received.

Table 4.45. Total Revenue

No .	Description	2017	2018	2019	2020
1.	Gross Revenue	Rp -	Rp -	Rp 3,122,392,500	Rp 3,153,616,425
2.	Expenses	Rp 7,967,054,326	Rp -	Rp 678,264,865	Rp 679,639,552
3.	Net Income	Rp (7,967,054,326)	Rp -	Rp 2,444,127,635	Rp 2,473,976,873
4.	Cash	Rp -	Rp -	Rp 2,444,127,635	Rp 4,918,104,508
5.	Reserve Cash		Rp -	Rp 1,764,488,083	Rp 5,995,074,604

2021	2022	2023	2024	2025
Rp 3,185,152,589	Rp 3,217,004,115	Rp 3,249,174,156	Rp 3,281,665,898	Rp 3,314,482,557
Rp 687,517,986	Rp 688,910,204	Rp 756,796,245	Rp 698,956,246	Rp 266,253,531
Rp 2,497,634,603	Rp 2,528,093,911	Rp 2,492,377,911	Rp 2,582,709,652	Rp 3,048,229,026
Rp 7,415,739,111	Rp 9,943,833,021	Rp 12,436,210,933	Rp 15,018,920,585	Rp 18,067,149,611
Rp 12,721,903,511	Rp 21,908,940,287	Rp 33,646,194,974	Rp 48,398,862,028	Rp 65,978,240,969

2026	2027	2028	2029	2030
Rp 3,347,627,382	Rp 3,381,103,656	Rp 3,414,914,693	Rp 3,449,063,840	Rp 3,483,554,478
Rp 487,770,670	Rp 278,065,785	Rp 169,704,621	Rp 290,902,661	Rp 292,367,559
Rp 2,859,856,713	Rp 3,103,037,871	Rp 3,245,210,071	Rp 3,158,161,179	Rp 3,191,186,919
Rp 20,927,006,324	Rp 24,030,044,195	Rp 27,275,254,267	Rp 30,433,415,445	Rp 33,624,602,365
Rp 86,627,181,508	Rp 110,487,521,082	Rp 137,471,872,687	Rp 167,612,920,574	Rp 200,932,658,528

2031	2032	2033	2034
Rp 3,518,390,023	Rp 3,553,573,923	Rp 3,589,109,662	Rp 3,625,000,759
Rp 304,864,410	Rp 8,985,492,463	Rp 173,907,491	Rp 543,854,093
Rp 3,213,525,613	Rp (5,431,918,540)	Rp 3,415,202,171	Rp 3,081,146,666
Rp 36,838,127,977	Rp 31,406,209,437	Rp 34,821,411,608	Rp 37,902,558,274
Rp 228,785,294,042	Rp 260,017,595,987	Rp 294,295,153,502	Rp 332,197,711,776

Capital Investment

Discription :

For the operation from new year until close book we used net income from last year but we also keep Reserve cash every year.

4.5.10. Expenses & Revenue

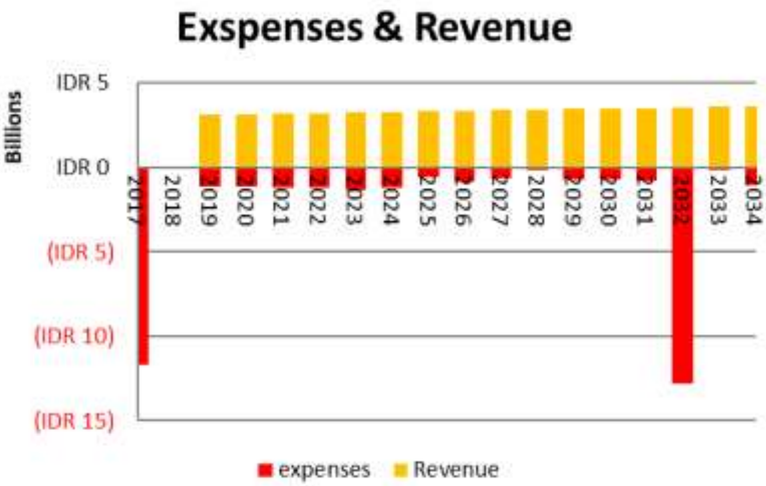

Figure 4.37. Expenses & Revenue

4.5.11. Total Net Cash Flow

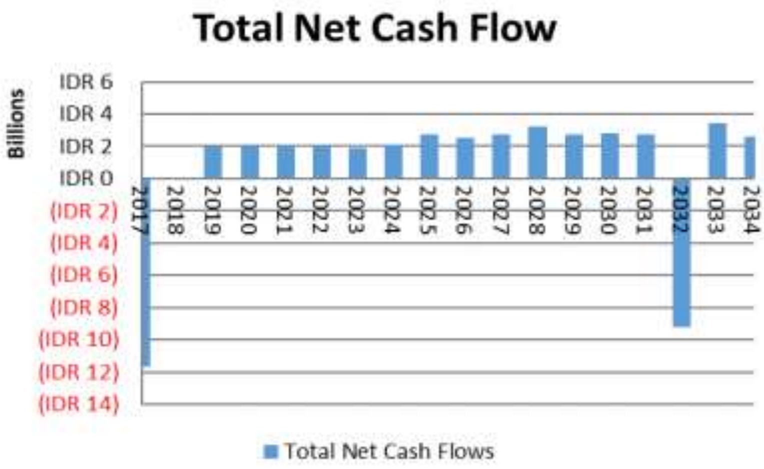

Figure 4.38. Total net Cash Flow

4.5.12. Net Present Value

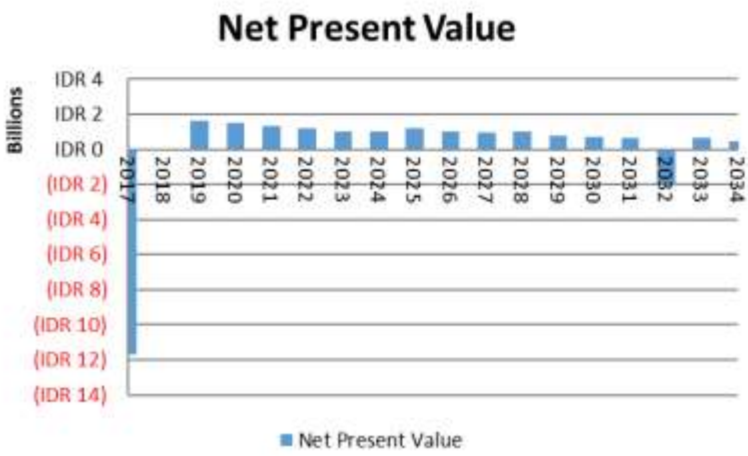

Figure 4.39. Net Present Value

Table 4.46. Total Cash Flow, NPV & IRR

Secure Years	Year	Total Net Cash Flows		Present Value	
0	2017	Rp	(11,707,471,304)	Rp	(11,707,471,304)
1	2018	Rp	-	Rp	-
2	2019	Rp	1,986,118,455	Rp	1,611,978,293
3	2020	Rp	2,015,967,693	Rp	1,474,058,202
4	2021	Rp	2,014,583,820	Rp	1,327,068,762
5	2022	Rp	2,045,043,127	Rp	1,213,633,560
6	2023	Rp	1,892,424,707	Rp	1,011,767,528
7	2024	Rp	2,072,113,105	Rp	998,050,705
8	2025	Rp	2,714,925,281	Rp	1,178,078,015
9	2026	Rp	2,526,552,967	Rp	987,692,141
10	2027	Rp	2,736,403,751	Rp	963,718,929
11	2028	Rp	3,245,210,071	Rp	1,029,651,007
12	2029	Rp	2,754,863,646	Rp	787,452,494
13	2030	Rp	2,787,889,387	Rp	717,921,260
14	2031	Rp	2,769,898,327	Rp	642,602,077
15	2032	Rp	(9,223,602,741)	Rp	(1,927,773,065)
16	2033	Rp	3,415,202,171	Rp	643,055,945
17	2034	Rp	2,593,156,652	Rp	439,883,948

Net Present Value	**Rp**	**1,625,677,227**
IRR		**13%**

From the calculation analysis of Internal Rate of Return and Net Present Value shows that the initial capital investment required for workers' salary and power plant construction is about IDR 11.707.471.304,00. While income is derived from electricity sales per kwh. With a generated capacity of 5700 kw or 5.7 MW and calculating the worst risk in 2032 is an accident that causes all workers to die and equipment destroyed by IDR 12.027.201.242,00 the application of the powerplant until 2034 generates a total revenue of IDR 1.625.677.227,00. And the average of revenue is 13%. Thus, this power plant is very potential when applied.

4.5. Parties Who Can Implement Ideas

Parties that can implement this powerplant are:

a. PLN: Need for in-depth research, therefore PLN needs to hold the academics or researchers to examine the potency of ocean currents in the Capalulu Strait.

b. Government: Government functions as a policy controller.

c. Consultant: Serves to analyze the feasibility of this power plant system.

d. Society: It is the party that influence, because without the support and the role of the community to maintain or maintain this generating system will be quickly damaged.

CHAPTER 5
CLOSING

5.1 Conclusion

Based on the problems and objectives of this study, obtained some conclusions to answer the formulation of the problem on this Bachelor Thesis, as follows:

1. There are several energy converter that is most suitable to be applied in Indonesia. Based on analysis, to maximize the potential of current energy is using gorlov helical turbine, to maximize the potential of the wind we use savonius wind turbine and to maximize the potential of ocean waves using a connected surface buoy system.

2. This Powerplant can be used as a new and renewable energy source as an alternative energy to cover the electricity needs of the straits in Indonesia. With total power generated based on simulation analysis that is equal to 5703,4 kW. Assuming a house uses 900 watts of electricity (0.9 kW), then this powerplant can electricity 6336 houses.

3. The optimum design based on criteria of capalulu strait, the dimension of gorlov helical turbine is 3m (diameter) x 5m (height), the dimension of savonius wind turbine is 3m (diameter) x 5m (height). And the dimension of connected surface buy system is 5m (diameter) x 3m (height).

4. From the calculation analysis of Internal Rate of Return and Net Present Value shows that the initial capital investment required for workers' salary and power plant construction is about IDR 11.707.471.304,00. While income is derived from electricity sales per kwh. With a generated capacity of 5700 kw or 5.7 MW and calculating the worst risk in 2032 is an accident that causes all workers to die and equipment destroyed by IDR 12.027.201.242,00 the application of the powerplant until 2034 generates a total revenue of IDR 1.625.677.227,00. And the average of revenue is 13%. Thus, this power plant is very potential when applied.

5.2 Suggestion

The potential of renewable energy in Indonesia is very large, spread in various forms of energy, including ocean currents energy, wind energy and waves environment. In addition, the eastern part of Indonesia is still experiencing a crisis of electrical energy. Thus, it is fitting that we are able to cultivate the use of these energy sources to overcome the energy crisis in Indonesia. With the fulfillment of electricity demand in Indonesia, the regional development towards the advanced Indonesia can be achieved more quickly.

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ATTACHMENT

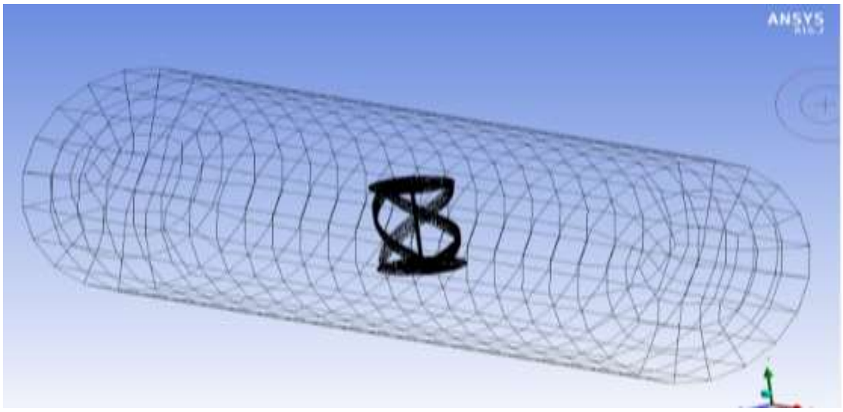


Figure 1. Simulation Results of Gorlov Helical Turbine 3m x 5m

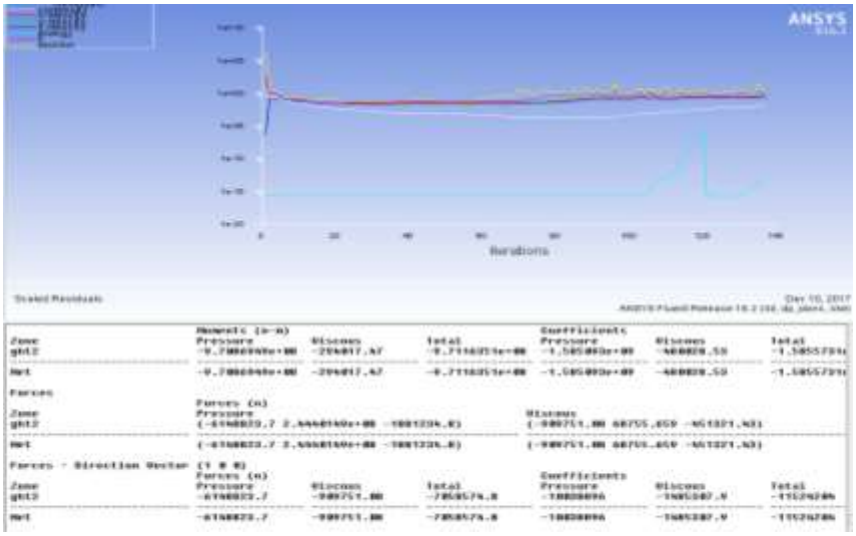


Figure 2. Simulation Results of Gorlov Helical Turbine 3m x 5m

From ansys fluent simulation, the result is that the force generated from the turbine is 70000 Nm that are shown in figure 2, which is this results not too far from the soliworks flow simulation obtained by 85061 Nm. It can be said that this result is valid.

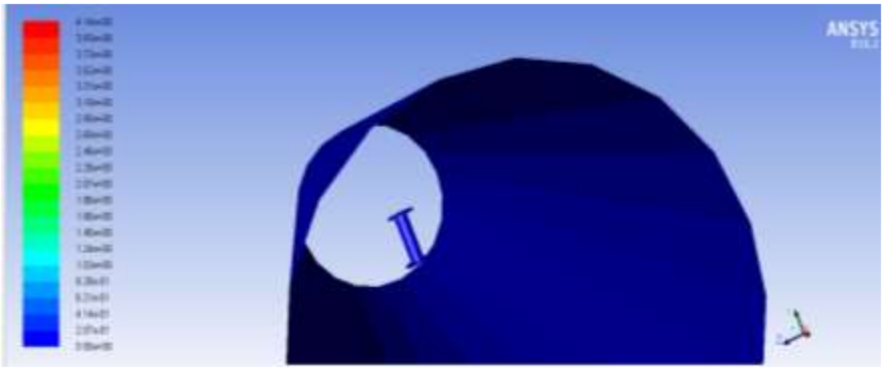


Figure 3. Result Simulation Savonius Wind Turbine 3m x 5m

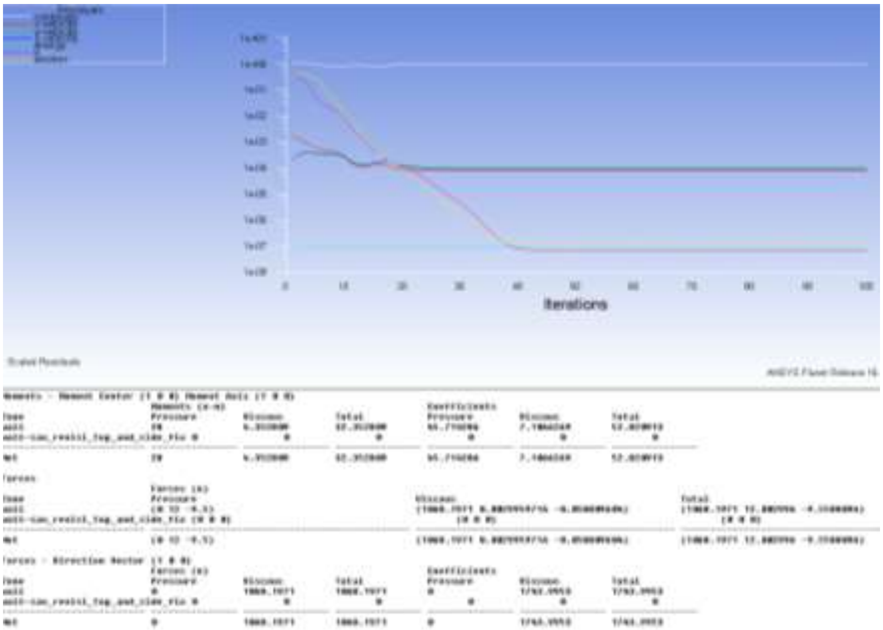
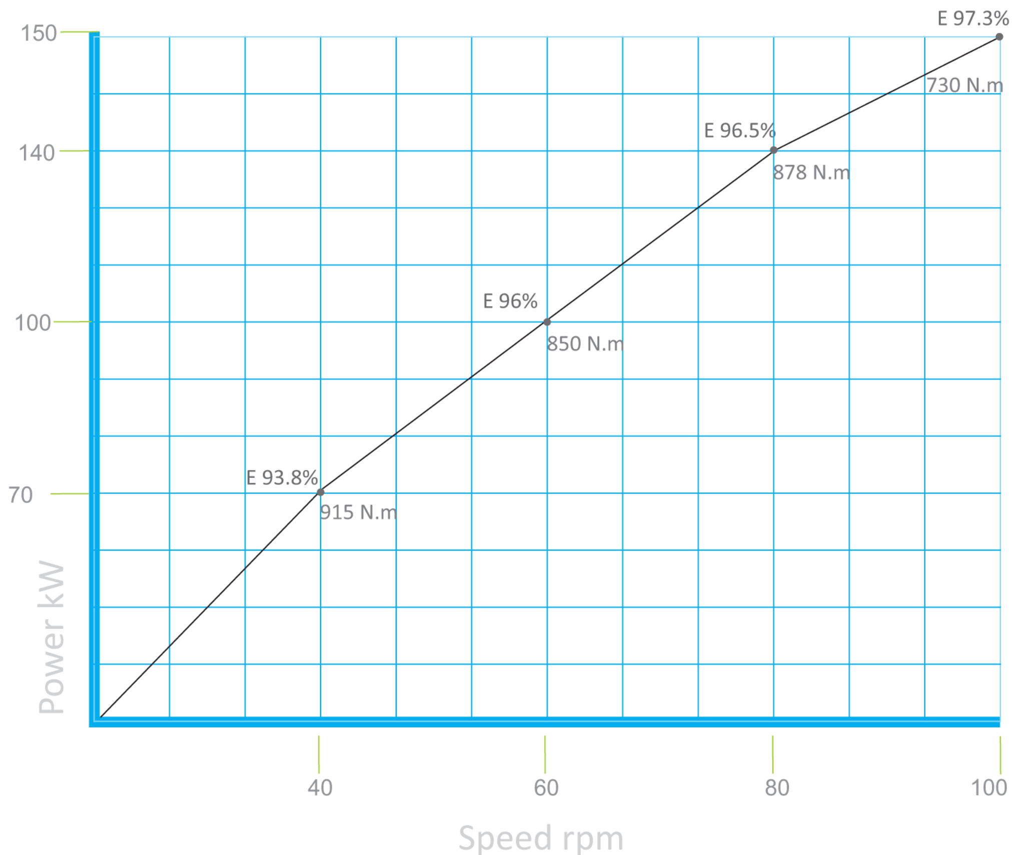
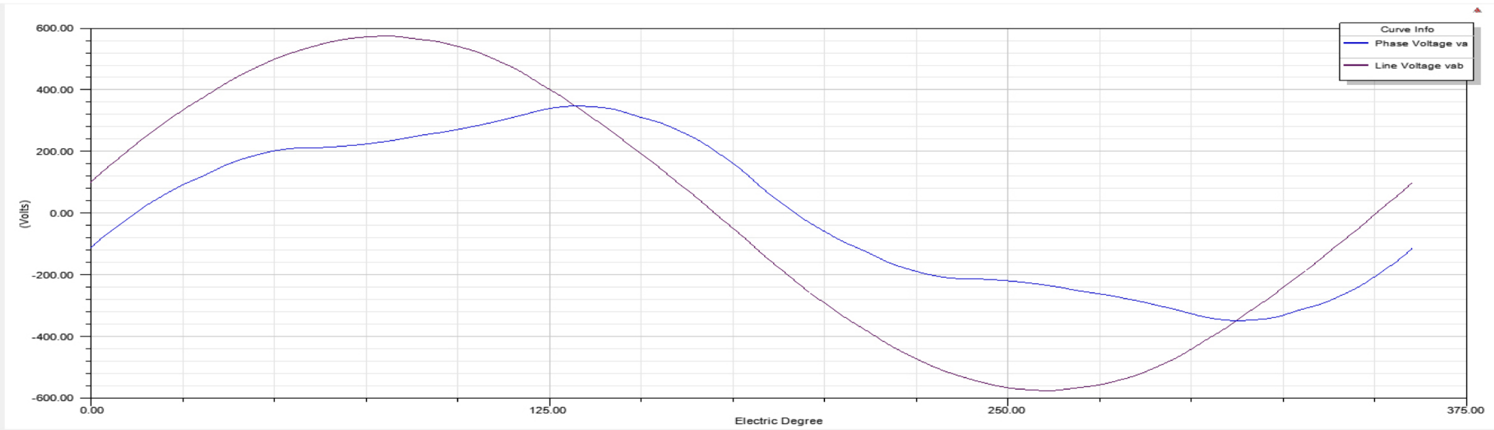


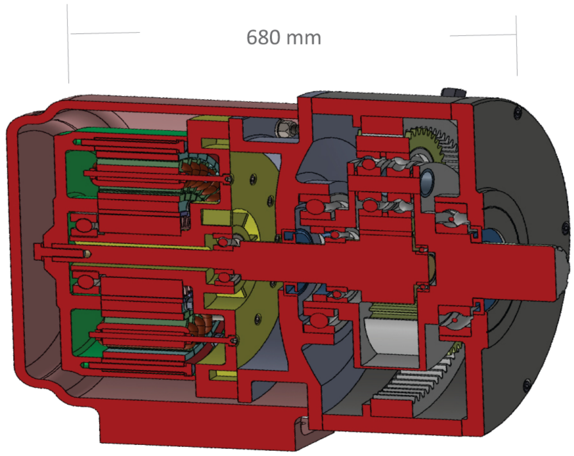
Figure 4. Result Simulation Savonius Wind Turbine 3m x 5m

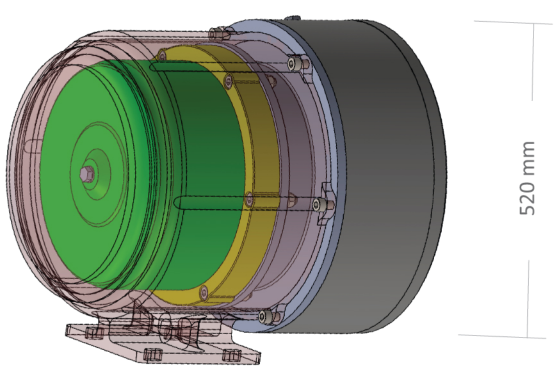
From ansys fluent simulation, the result is that the force generatedfrom the turbine is 1068 Nm that are shown in figure 4, which is this results not too far from the soliworks flow simulation obtained by 1043 Nm. It can be said that this result is valid.

	PMG 100PH
Power [kW]	100
Speed [rpm]	60
Voltage [V]	400
Short Circuit Current [A]	420
THD	1
Power factor	0.93
Weight [kg]	184
Efficiency [100% load]	96
Efficiency [75% load]	95.6
Efficiency [50% load]	94.7
Efficiency [25% load]	93.4
Protection class	IP54
Insulation class	F
Thermal class	B
Torque [N.m]	850
Cooling	Air-to-liquid



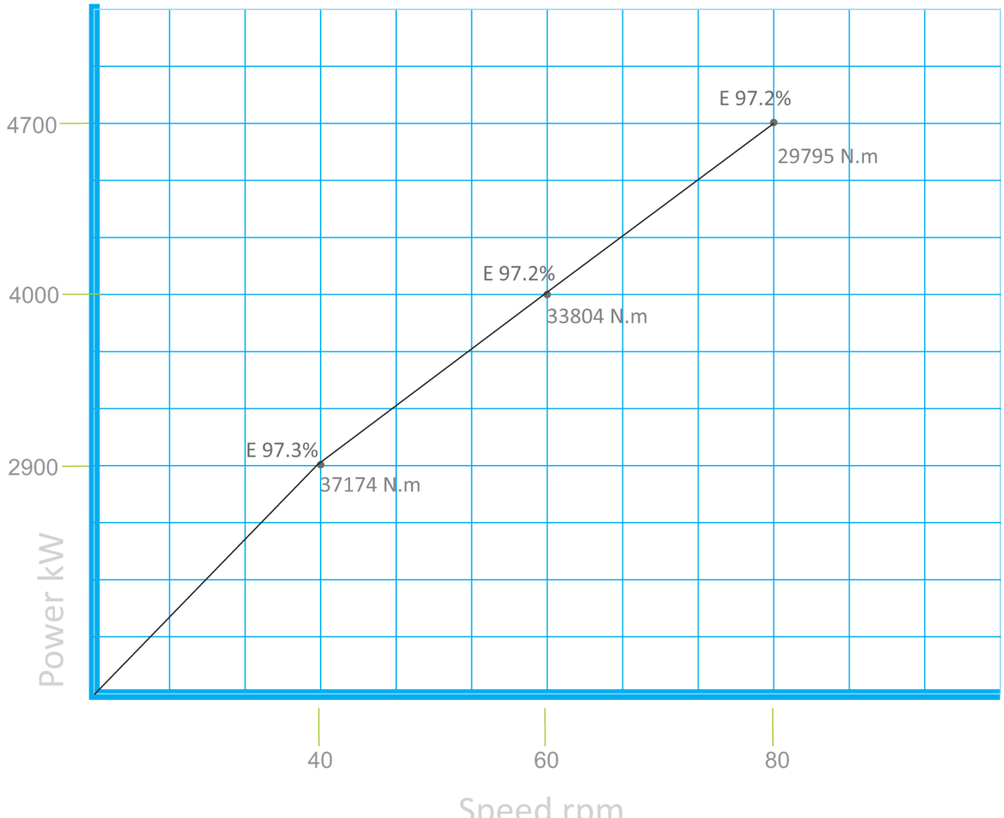


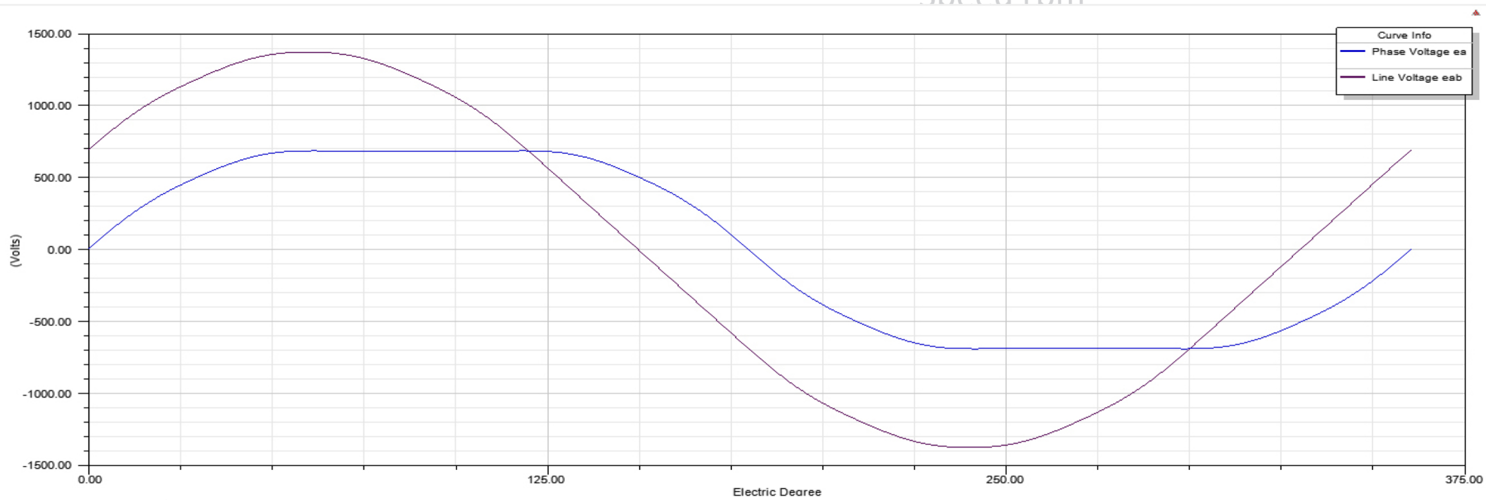


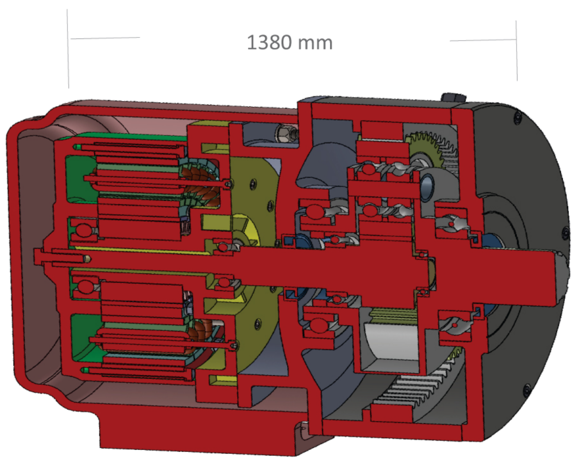


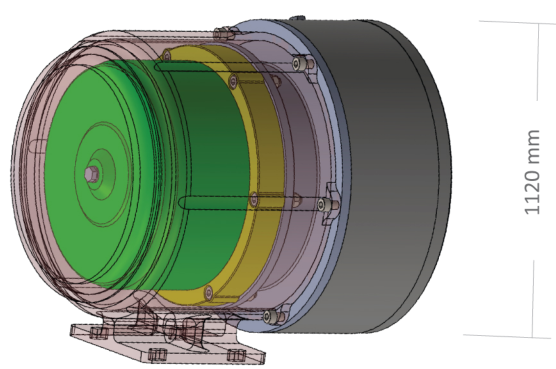
PMG 100PH

	PMG 4000PH
Power [kW]	4000
Speed [rpm]	60
Voltage [V]	400
Short Circuit Current [A]	8065
THD	0.76
Power factor	0.92
Weight [kg]	1940
Efficiency [100% load]	97.2
Efficiency [75% load]	96.7
Efficiency [50% load]	96
Efficiency [25% load]	95.2
Protection class	IP54
Insulation class	F
Thermal class	B
Torque [N.m]	33804
Cooling	Air-to-liquid









PMG 4000PH

This kind of system is very suitable for the Mountain area without electricity Grid, Mining areas, Vacation Villa, Temples, Farm, Community and all far away Location with water resources without electricity Grid, with competitive price and easy installation, we offer you with hydropower system from 300w to 100kw.

Customer made micro hydro turbine from 5kw to 100kw with carbon brush excitation generator, Table data just for reference, all the products are designed based on client's local site real condition.

Pelton type generating set Specification and Applicable Scope of Unit

Turbine				Generator			Governor	Inlet Valve
Head M	Flow M^3/s	Output KW	Dia. Of tube (mm)	Type	Output KW	Power Output	Type	Type
60	0.06	20	200	HS-20	20	Option	Auto Load	Option
70	0.065	30	200	HS-30	30	Option	Auto Load	Option
80	0.07	40	200	HS-40	40	Option	Auto Load	Option
100	0.062	50	200	HS-50	50	Option	Auto Load	Option
110	0.071	60	200	HS-60	60	Option	Auto Load	Option
120	0.074	70	200	HS-70	70	Option	Auto Load	Option
140	0.083	90	200	HS-90	90	Option	Auto Load	Option
160	0.087	100	200	HS-100	100	Option	Auto Load	Option

We customize micro hydro turbine generating system based on customer's local situation (water head and flow rate), product ranging from 300w to 100kw, and can also adjust the product's voltage and frequency based on customer’s local facility needed as well.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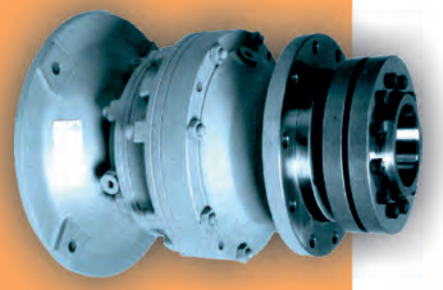

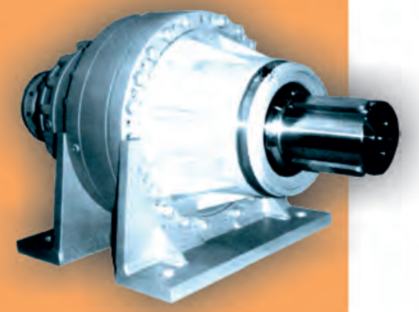

Output shaft	Nominal torque [daNm] / Stages	100	200	300	400	500	800	1000	1300
male splined	1	100M1X 100M1RX	200M1X 200M1RX	300M1X 300M1RX		500M1X 500M1RX	800M1RX		1300M1X 1300M1RX
	2	100M2X 100M2RX	200M2X 200M2RX	300M2X 300M2RX	400M2X 400M2RX	500M2X 500M2RX	800M2RX	1000M2X	1300M2X 1300M2RX
	3	100M3X 100M3RX	200M3X 200M3RX	300M3X 300M3RX	400M3X 400M3RX	500M3X 500M3RX	800M3RX	1000M3X	1300M3X 1300M3RX
	4	100M4X 100M4RX	200M4X 200M4RX	300M4X 300M4RX	400M4X 400M4RX	500M4X 500M4RX	800M4RX	1000M4X	1300M4X 1300M4RX
male cylindrical	1	100M1C 100M1RC	200M1C 200M1RC	300M1C 300M1RC		500M1C 500M1RC	800M1RC		1300M1C 1300M1RC
	2	100M2C 100M2RC	200M2C 200M2RC	300M2C 300M2RC	400M2C 400M2RC	500M2C 500M2RC	800M2RC	1000M2C	1300M2C 1300M2RC
	3	100M3C 100M3RC	200M3C 200M3RC	300M3C 300M3RC	400M3C 400M3RC	500M3C 500M3RC	800M3RC	1000M3C	1300M3C 1300M3RC
	4	100M4C 100M4RC	200M4C 200M4RC	300M4C 300M4RC	400M4C 400M4RC	500M4C 500M4RC	800M4RC	1000M4C	1300M4C 1300M4RC
female splined	1	100F1	200F1	300F1		500F1	800F1		1300F1
	2	100F2	200F2	300F2	400F2	500F2	800F2	1000F2	1300F2
	3	100F3	200F3	300F3	400F3	500F3	800F3	1000F3	1300F3
	4	100F4	200F4	300F4	400F4	500F4	800F4	1000F4	1300F4
shrink coupling	1	100F1P	200F1P	300F1P		500F1P	800F1P		1300F1P
	2	100F2P	200F2P	300F2P	400F2P	500F2P	800F2P	1000F2P	1300F2P
	3	100F3P	200F3P	300F3P	400F3P	500F3P	800F3P	1000F3P	1300F3P
	4	100F4P	200F4P	300F4P	400F4P	500F4P	800F4P	1000F4P	1300F4P
male splined	1	100P1X	200P1X	300P1X		500P1X	800P1X		1300P1X
	2	100P2X	200P2X	300P2X	400P2X	500P2X	800P2X	1000P2X	1300P2X
	3	100P3X	200P3X	300P3X	400P3X	500P3X	800P3X	1000P3X	1300P3X
	4	100P4X	200P4X	300P4X	400P4X	500P4X	800P4X	1000P4X	1300P4X
male cylindrical	1	100P1C	200P1C	300P1C		500P1C	800P1C		1300P1C
	2	100P2C	200P2C	300P2C	400P2C	500P2C	800P2C	1000P2C	1300P2C
	3	100P3C	200P3C	300P3C	400P3C	500P3C	800P3C	1000P3C	1300P3C
	4	100P4C	200P4C	300P4C	400P4C	500P4C	800P4C	1000P4C	1300P4C

	Number of stages	100	200	300	400	500	800	1000	1300
Ratio from-to	1	3,5...8,5	3,5...8,5	3,5...7,3		3,5...7,3	3,8...6		3,4...6,2
	2	12...73	12...73	12...62	12...62	12...62	13...44	12...45	12...45
	3	50...623	50...623	50...529	50...529	50...529	47...371	50...386	42...386
	4	357...5315	357...5315	290...4513	290...4513	290...4513	258...3171	225...3293	259...3293

Output shaft	Nominal torque [daNm] / Stages	1800	2000	3000
male splined	1		2000M1X 2000M1RX	3000M1X
	2	1800M2X 1800M2RX	2000M2X 2000M2RX	3000M2X
	3	1800M3X 1800M3RX	2000M3X 2000M3RX	3000M3X
	4	1800M4X 1800M4RX	2000M4X 2000M4RX	3000M4X
male cylindrical	1		2000M1C 2000M1RC	3000M1C
	2	1800M2C 1800M2RC	2000M2C 2000M2RC	3000M2C
	3	1800M3C 1800M3RC	2000M3C 2000M3RC	3000M3C
	4	1800M4C 1800M4RC	2000M4C 2000M4RC	3000M4C
female splined	1		2000F1	3000F1
	2	1800F2	2000F2	3000F2
	3	1800F3	2000F3	3000F3
	4	1800F4	2000F4	3000F4
shrink coupling	1		2000F1P	3000F1P
	2	1800F2P	2000F2P	3000F2P
	3	1800F3P	2000F3P	3000F3P
	4	1800F4P	2000F4P	3000F4P
male splined	1		2000P1X	3000P1X
	2		2000P2X	3000P2X
	3		2000P3X	3000P3X
	4		2000P4X	3000P4X
male cylindrical	1		2000P1C	3000P1C
	2		2000P2C	3000P2C
	3		2000P3C	3000P3C
	4		2000P4C	3000P4C

	Number of stages	1800	2000	3000
Ratio from-to	1		3,4...6,2	3,4...6,2
	2	12...45	13...37	13...37
	3	50...386	46...271	46...271
	4	265...3293	193...2314	193...2314

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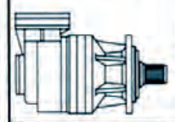
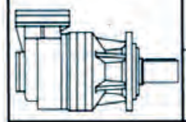
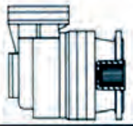
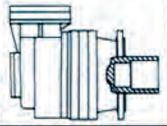
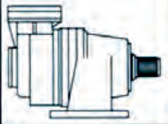
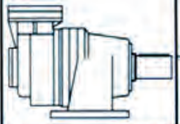
4000	6000	8000	10000	15000
4000M1X	6000M1X	8000M1X	10000M1X	15000M1X
4000M2X	6000M2X	8000M2X	10000M2X	15000M2X
4000M3X	6000M3X	8000M3X	10000M3X	15000M3X
4000M4X	6000M4X	8000M4X	10000M4X	15000M4X
4000M1C	6000M1C	8000M1C	10000M1C	15000M1C
4000M2C	6000M2C	8000M2C	10000M2C	15000M2C
4000M3C	6000M3C	8000M3C	10000M3C	15000M3C
4000M4C	6000M4C	8000M4C	10000M4C	15000M4C
4000F1	6000F1	8000F1	10000F1	15000F1
4000F2	6000F2	8000F2	10000F2	15000F2
4000F3	6000F3	8000F3	10000F3	15000F3
4000F4	6000F4	8000F4	10000F4	15000F4
4000F1P	6000F1P	8000F1P	10000F1P	15000F1P
4000F2P	6000F2P	8000F2P	10000F2P	15000F2P
4000F3P	6000F3P	8000F3P	10000F3P	15000F3P
4000F4P	6000F4P	8000F4P	10000F4P	15000F4P
4000P1X	6000P1X	8000P1X	10000P1X	15000P1X
4000P2X	6000P2X	8000P2X	10000P2X	15000P2X
4000P3X	6000P3X	8000P3X	10000P3X	15000P3X
4000P4X	6000P4X	8000P4X	10000P4X	15000P4X
4000P1C	6000P1C	8000P1C	10000P1C	15000P1C
4000P2C	6000P2C	8000P2C	10000P2C	15000P2C
4000P3C	6000P3C	8000P3C	10000P3C	15000P3C
4000P4C	6000P4C	8000P4C	10000P4C	15000P4C

3,4...6,2	3,2...6,2	3,4...6,2	4,1...5,3	4,1...6,2
12...39	11...39	12...39	14...33	13...39
41...282	43...232	40...242	48...204	46...241
205...2403	193...1684	201...1754	201...1478	178...1448

Output shaft	Nominal torque [daNm] / Stages	300	500	800	1300	1800	2000	3000	4000	6000	8000	10000
male splined 	2	300M2AX 300M2RAX	500M2AX 500M2RAX	800M2RAX	1300M2AX 1300M2RAX							
	3	300M3AX 300M3RAX	500M3AX 500M3RAX	800M3RAX	1300M3AX 1300M3RAX	1800M3AX 1800M3RAX	2000M3AX 2000M3RAX	3000M3AX	4000M3AX			
	4	300M4AX 300M4RAX	500M4AX 500M4RAX	800M4RAX	1300M4AX 1300M4RAX	1800M4AX 1800M4RAX	2000M4AX 2000M4RAX	3000M4AX	4000M4AX	6000M4AX	8000M4AX	10000M4AX
male cylindrical 	2	300M2AC 300M2RAC	500M2AC 500M2RAC	800M2RAC	1300M2AC 1300M2RAC							
	3	300M3AC 300M3RAC	500M3AC 500M3RAC	800M3RAC	1300M3AC 1300M3RAC	1800M3AC 1800M3RAC	2000M3AC 2000M3RAC	3000M3AC	4000M3AC			
	4	300M4AC 300M4RAC	500M4AC 500M4RAC	800M4RAC	1300M4AC 1300M4RAC	1800M4AC 1800M4RAC	2000M4AC 2000M4RAC	3000M4AC	4000M4AC	6000M4AC	8000M4AC	10000M4AC
female splined 	2	300F2A	500F2A	800F2A	1300F2A							
	3	300F3A	500F3A	800F3A	1300F3A	1800F3A	2000F3A	3000F3A	4000F3A			
	4	300F4A	500F4A	800F4A	1300F4A	1800F4A	2000F4A	3000F4A	4000F4A	6000F4A	8000F4A	10000F4A
shrink coupling 	2	300F2AP	500F2AP	800F2AP	1300F2AP							
	3	300F3AP	500F3AP	800F3AP	1300F3AP	1800F3AP	2000F3AP	3000F3AP	4000F3AP			
	4	300F4AP	500F4AP	800F4AP	1300F4AP	1800F4AP	2000F4AP	3000F4AP	4000F4AP	6000F4AP	8000F4AP	10000F4AP
male splined 	2	300P2AX	500P2AX									
	3	300P3AX	500P3AX	800P3AX	1300P3AX		2000P3AX	3000P3AX	4000P3AX			
	4	300P4AX	500P4AX	800P4AX	1300P4AX		2000P4AX	3000P4AX	4000P4AX	6000P4AX	8000P4AX	10000P4AX
male cylindrical 	2	300P2AC	500P2AC									
	3	300P3AC	500P3AC	800P3AC	1300P3AC		2000P3AC	3000P3AC	4000P3AC			
	4	300P4AC	500P4AC	800P4AC	1300P4AC		2000P4AC	3000P4AC	4000P4AC	6000P4AC	8000P4AC	10000P4AC

Ratio from-to	Number of stages	300	500	800	1300	1800	2000	3000	4000	6000	8000	10000
	2	17...36	17...36	18...30	16...30							
	3	59...301	59...301	65...211	58...219	58...219	64...182	64...182	57...189			
	4	245...2567	245...2567	229...1804	204...1873	204...1873	224...1550	224...1550	199...1367	210...1128	195...1175	233...990

Modular System

Input Side

1 » electric motor
2 » vee-belt or chain drive
3 » customer provided flange/adaptor
4 » hydraulic motor
5 » flange for electric motor
6 » cylindrical keyed input shaft
7 » male splined input shaft
8 » universal input flange
9 » adaptor for hydraulic motor

Brake

10 » hydraulic multi-disc brake

Reduction Stages

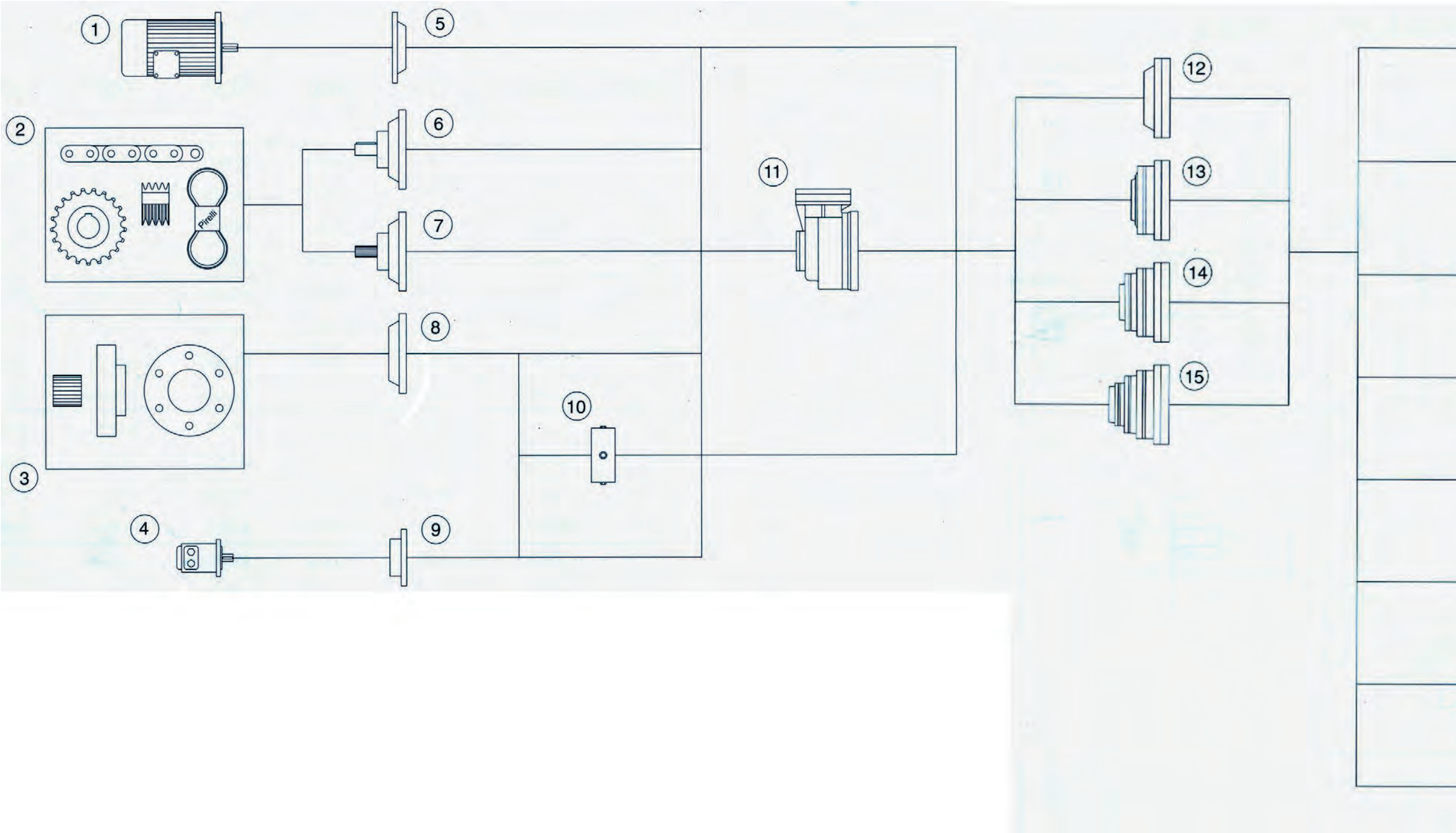
11 » right angle with bevel gears
12 » one planetary stage
13 » two planetary stages
14 » three planetary stages
15 » four planetary stages

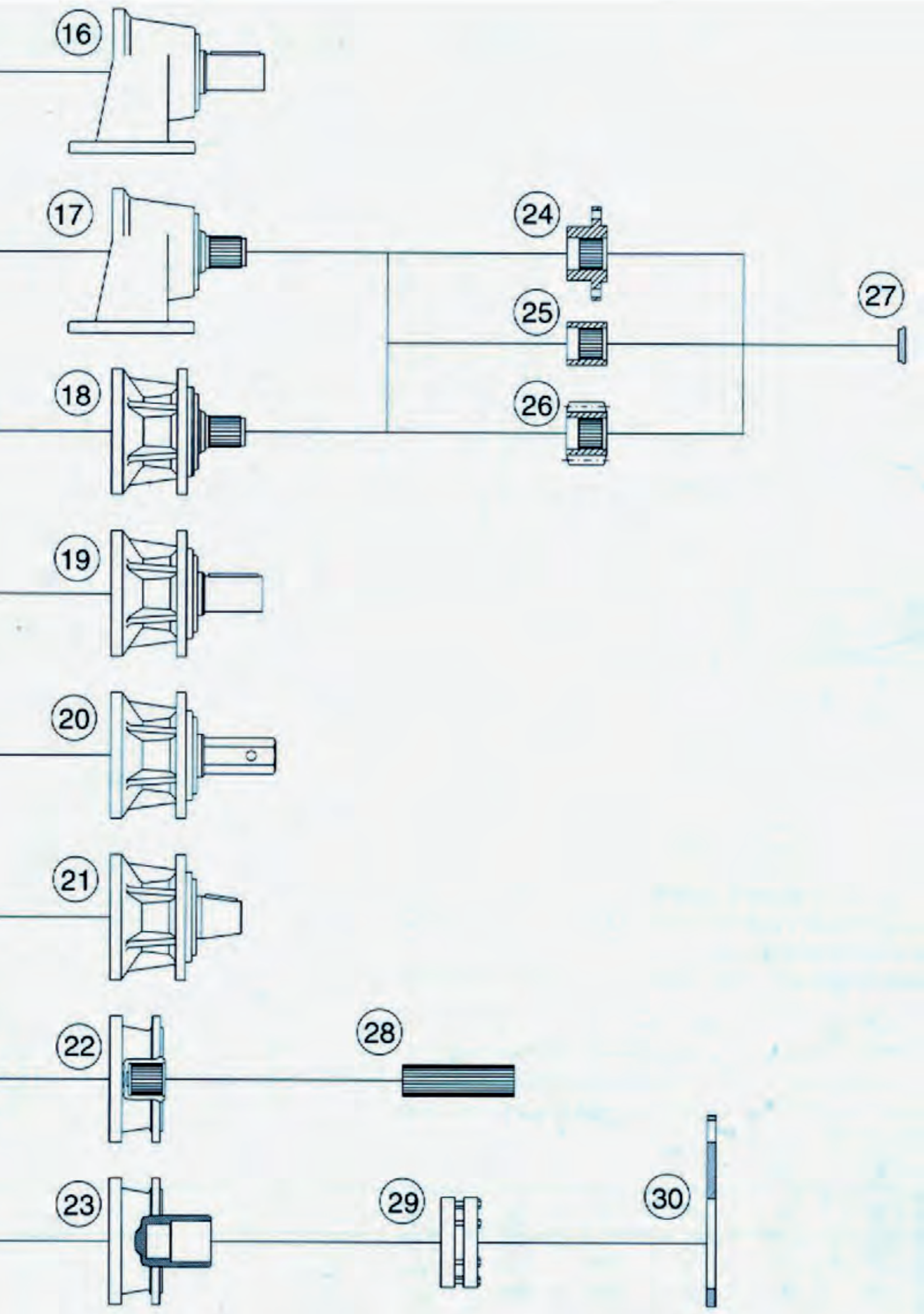
Output Side

16 » foot mounted & cylindrical shaft
17 » foot mounted & splined shaft
18 » flange & male splined shaft
19 » flange & cylindrical shaft
20 » flange & hexagonal shaft
21 » flange & tapered shaft
22 » female splined shaft
23 » female shaft for shrink disc

Accessories Output Side

24 » wheel flange WF
25 » splined bush ZN
26 » slewing pinion R
27 » end plate AP
28 » splined rod KW
29 » shrink disc S
30 » torque arm D





Ordering Code

RES	** 800	M	3	R	A	X	*108	SA1	3506	W

planetary gear unit

nominal torque in daNm
**100
**200
**300
**400
**500
** 800
**1000
**1300
**1800
**2000
**3000
**4000
**6000
**8000
10000
15000
30000
50000

number of stages

ratio without decimals

brake
– without brake

accessories output
-- non
WF wheel flange
R** pinion

ZN splined bush

KW splined rod

S - shrink disc

- D torque arm

SD shrink disc & torque arm

AP end plate

version output shaft
X male splined
C cylindrical
- female splined
P female for shrink disc
E hexagonal
K taper

A - right angle

- in line

accessories input
WEC cylindrical
WUC input
WHC shaft

WRC cylindrical reinforced input shaft

WRX reinforced male splined input shaft

E** flange for electric motor

***** flange for hydraulic motor

R - reinforced housing

- standard version

version housing/shaft
M - flange/male shaft
F - flange/female/shaft
P - foot/male shaft

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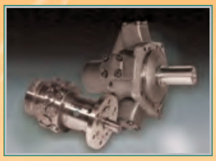
Mini Power Packs


Screw Pumps


Vane Pumps

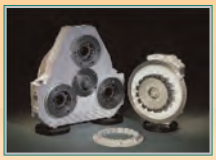

Axial & Radial Piston Motors


Coolers


BD Clutches & Gearboxes


BDS Clutches


Planetary Gearboxes


Splitter Gearboxes


Marine Gearboxes

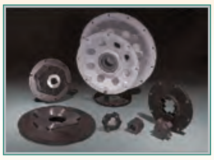

LSHT Motors/Geared Motors


Bellhousings


Torsional Couplings


Torsionally Flexible Couplings


Torsionally Rigid Couplings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Engine Adaptor Kits


Pressure Intensifiers


Dampers


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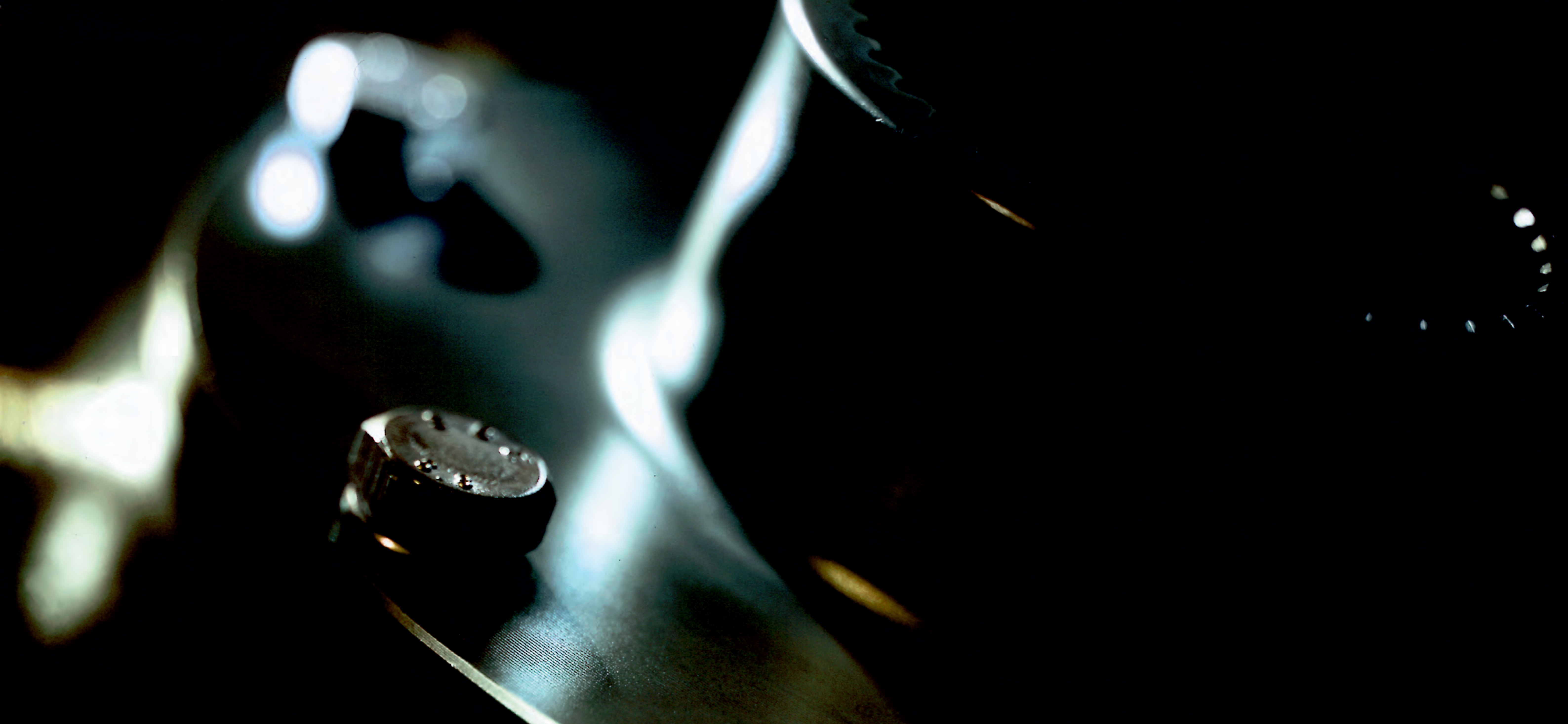

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A. Perencanaan Jangkar, Rantai Jangkar dan Tali Tambat

1. Perhitungan Equipment Number

Equipment Number

Z = D^2/3 + 2 h B + A/10

Dimana

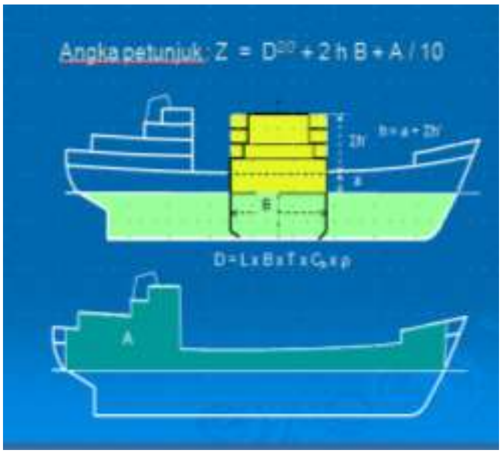
D = Displasment [ton] pada sarat muat musim panas

H = a + ∑h' ,Tinggi efektif dari garis air muat musim panas hingga bagian atas rumah geladak [m]

a = jarak garis air muat musim panas [m] sampai geladak teratas di sisi kapal

∑h' =Jumlah tinggi dari bangunan atas dan rumah geladak yang mempunyai lebar lebih besar dari B/4 [m]

A = Luas penampang badan kapal, bangunan atas dan rumah geladak yang mempunyai lebar lebih besar dari B/4. Diatas garis air muat musim panas pada panjang L sampai ketinggian h.



Data,

D = Displasment, Lwl x B x T x Cb x ρ

= 1230 ton

h= a + ∑h' a= 3 meter

10,5 meter ∑h' = 7.5 meter

Sehingga, Equipment Number

D^2/3 = 114.8

Z = D^2/3 + 2 h B + A/10

= 456,8

A/10 = 6

2hB = 336

Equipment numeral Z_1 or Z_2	Stockless anchor			Stud link chain cables						Recommended ropes				
	Bower anchor		Stream anchor	Bower anchors				Stream wire or chain for stream anchor		Towline		Mooring ropes		
	Number [1]	Mass per anchor		Total length	Diameter d_1	d_2	d_3	Length	Br. load [2]	Length	Br. load [2]	Number	Length	Br. load [2]
		[kg]		[m]	[mm]	[mm]	[mm]	[m]	[kN]	[m]	[kN]		[m]	[kN]
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
up to 50	2	120	40	165	12,5	12,5	12,5	80	65	180	100	3	80	35
50 - 70	2	180	60	220	14	12,5	12,5	80	65	180	100	3	80	35
70 - 90	2	240	80	220	16	14	14	85	75	180	100	3	100	40
90 - 110	2	300	100	247,5	17,5	16	16	85	80	180	100	3	110	40
110 - 130	2	360	120	247,5	19	17,5	17,5	90	90	180	100	3	110	45
130 - 150	2	420	140	275	20,5	17,5	17,5	90	100	180	100	3	120	50
150 - 175	2	480	165	275	22	19	19	90	110	180	100	3	120	55
175 - 205	2	570	190	302,5	24	20,5	20,5	90	120	180	110	3	120	60
205 - 240	2	660		302,5	26	22	20,5			180	130	4	120	65
240 - 280	2	780		330	28	24	22			180	150	4	120	70
280 - 320	2	900		357,5	30	26	24			180	175	4	140	80
320 - 360	2	1020		357,5	32	28	24			180	200	4	140	85
360 - 400	2	1140		385	34	30	26			180	225	4	140	95
400 - 450	2	1290		385	36	32	28			180	250	4	140	100
450 - 500	2	1440		412,5	38	34	30			180	275	4	140	110
500 - 550	2	1590		412,5	40	34	30			190	305	4	160	120
550 - 600	2	1740		440	42	36	32			190	340	4	160	130
600 - 660	2	1920		440	44	38	34			190	370	4	160	145
660 - 720	2	2100		440	46	40	36			190	405	4	160	160
720 - 780	2	2280		467,5	48	42	36			190	440	4	170	170

Berdasarkan tabel diatas, maka didapatkan spesifikasi:

a. Jangkar

Jumlah 4 pieces

berat 1440 kg

Type Stocklees anchor

b. Rantai Jangkar

Panjang 412,5 m

Diameter 38 mm

Type Stud link chain cables

B. Perhitungan daya mesin jangkar

Perhitungan daya mesin jangkar menurut buku "Practical Ship Building oleh M. Khetagurof"

a. Gaya Tarik Pengangkat Jangkar (Tcl)

Tcl = 2fh x (Ga + (Pa x La)) x (1 - (γ w/γ a)

Dimana : Ga = Berat jangkar = 1440 kg

Pa = Berat rantai jangkar

Untuk Stud - link, Pa = 0,0218 x (d)2 = 31.479 kg

d = diameter rantai = 38 mm

La = panjang rantai yg menggantung = 100 m

γa = density material = 7750 kg/m3

γw = density sea water = 1025 kg/m3

fh = factor gesekan pada hawse pipe dan stoper,

nilainya antara 1,28 - 1,35 diambil = 1.34

Sehingga,

Tcl = 2 x 1,34 x (2460+ (54,5x 100) x (1 - (1025/7750)

= 10669 kg

b. Torsi pada Cable Lifter (Mcl)

Mcl = (Tcl x Dcl)/(2 x ηcl)

Dimana :

Dcl = Diameter efektif kabel lifter

Dcl = 13,6 x d

=516.8 mm = 0.5168 m

ηcl = effisiensi kabel lifter,nilainya berkiar antara 0,9 - 0,92, diambil = 0.91

Mcl = (18395 x 0,68)/(2 x 0,91)

= 3029.649 kg.m

c. Torsi pada Poros Motor (Mm)

Mm = Mcl/(ia x ηa) ; (kg.m)

Dimana : ncl = putaran kabel lifter = 300/d = 7.89 Rpm

nm = putaran motor penggerak, nilainya

antara 750 - 1550 Rpm, diambil = 1200 Rpm

ia = perbandingan gigi mekanis

ia = nm/ncl = 152

ηa = effisiensi peralatan, untuk worm

gearing = 0,7 ~ 0,85, diambil = 0.8

Mm = 6872,890 /(200 x 0,8)

Mm = 24.915 kg.m

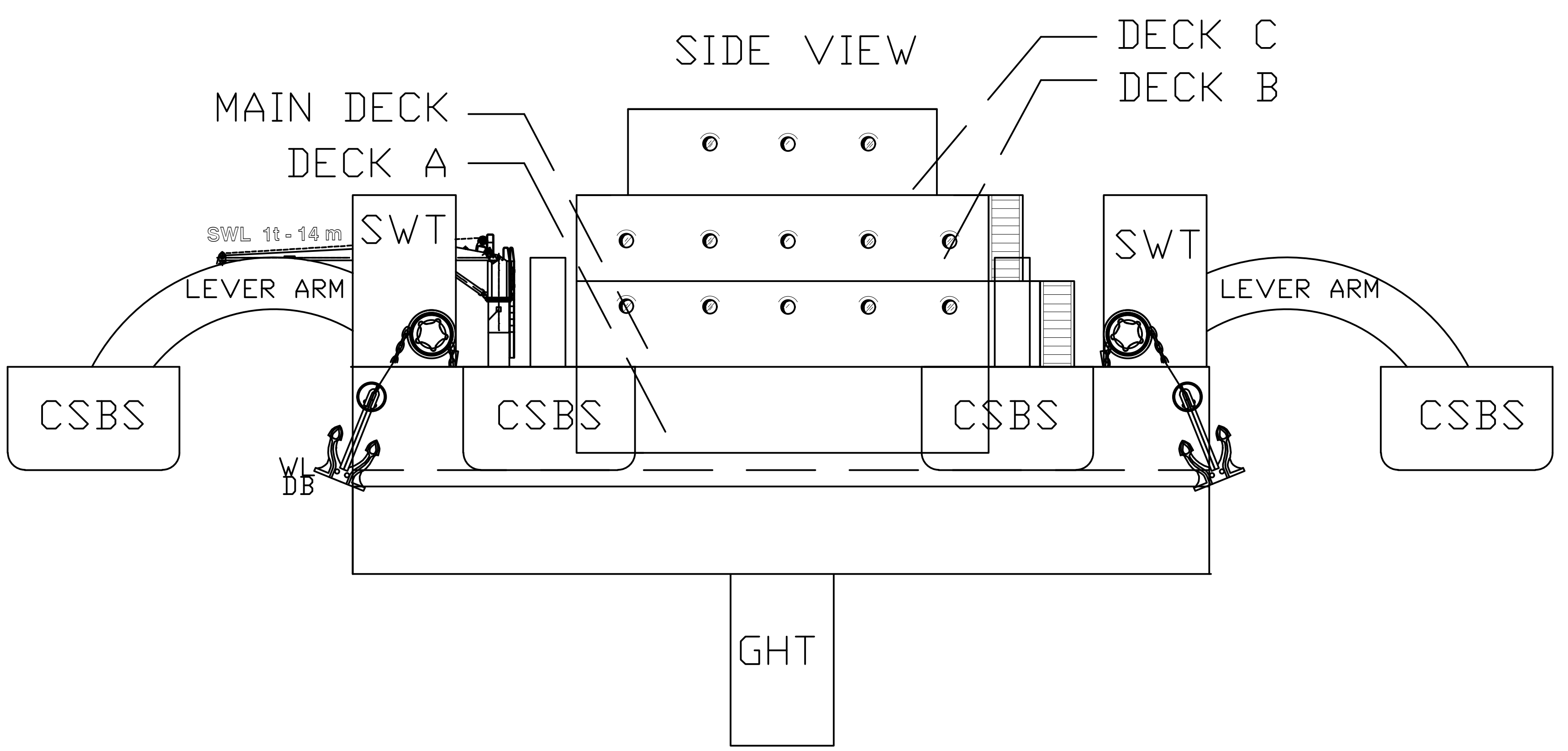
d. Daya Motor Penggerak Windlass (Ne)

Ne = (Mm x nm) / 716,2

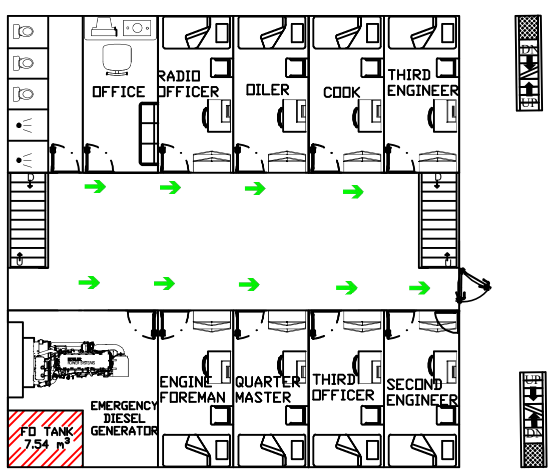
= (42,956 x 1200) / 716,2 HP

= 41.74511753 HP

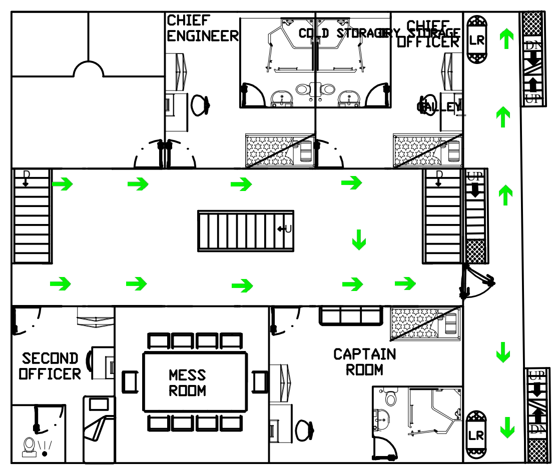
SIDE VIEW



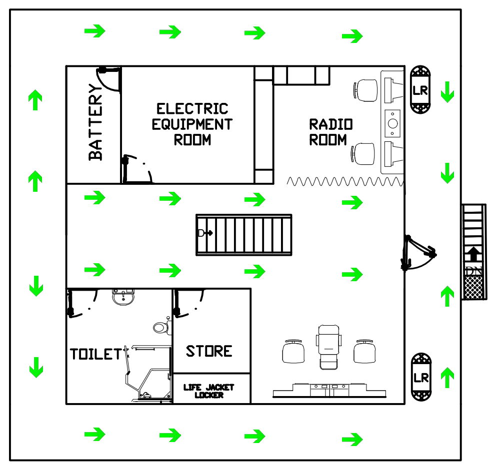
MAIN DECK



DECK B



DECK C



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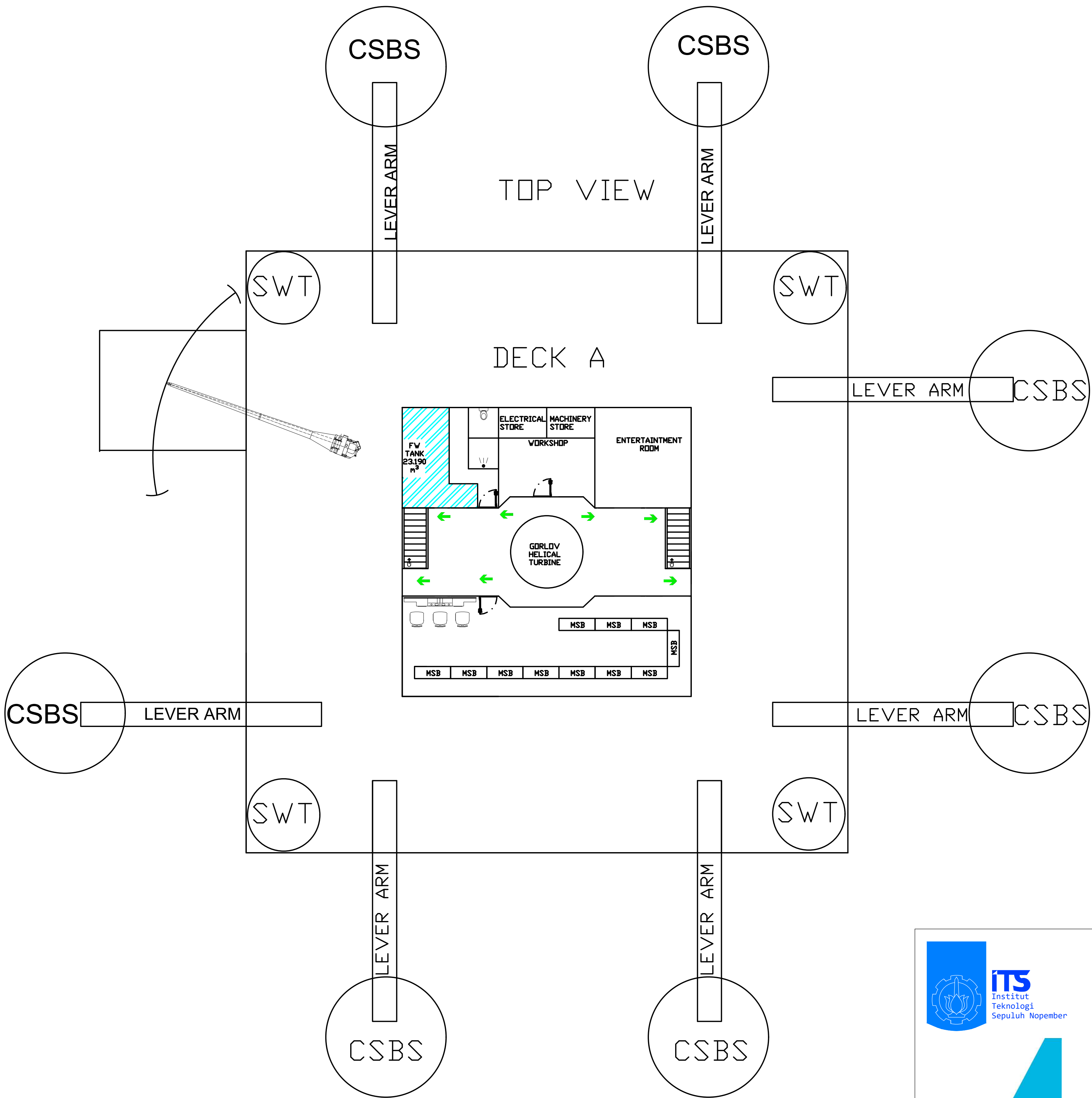

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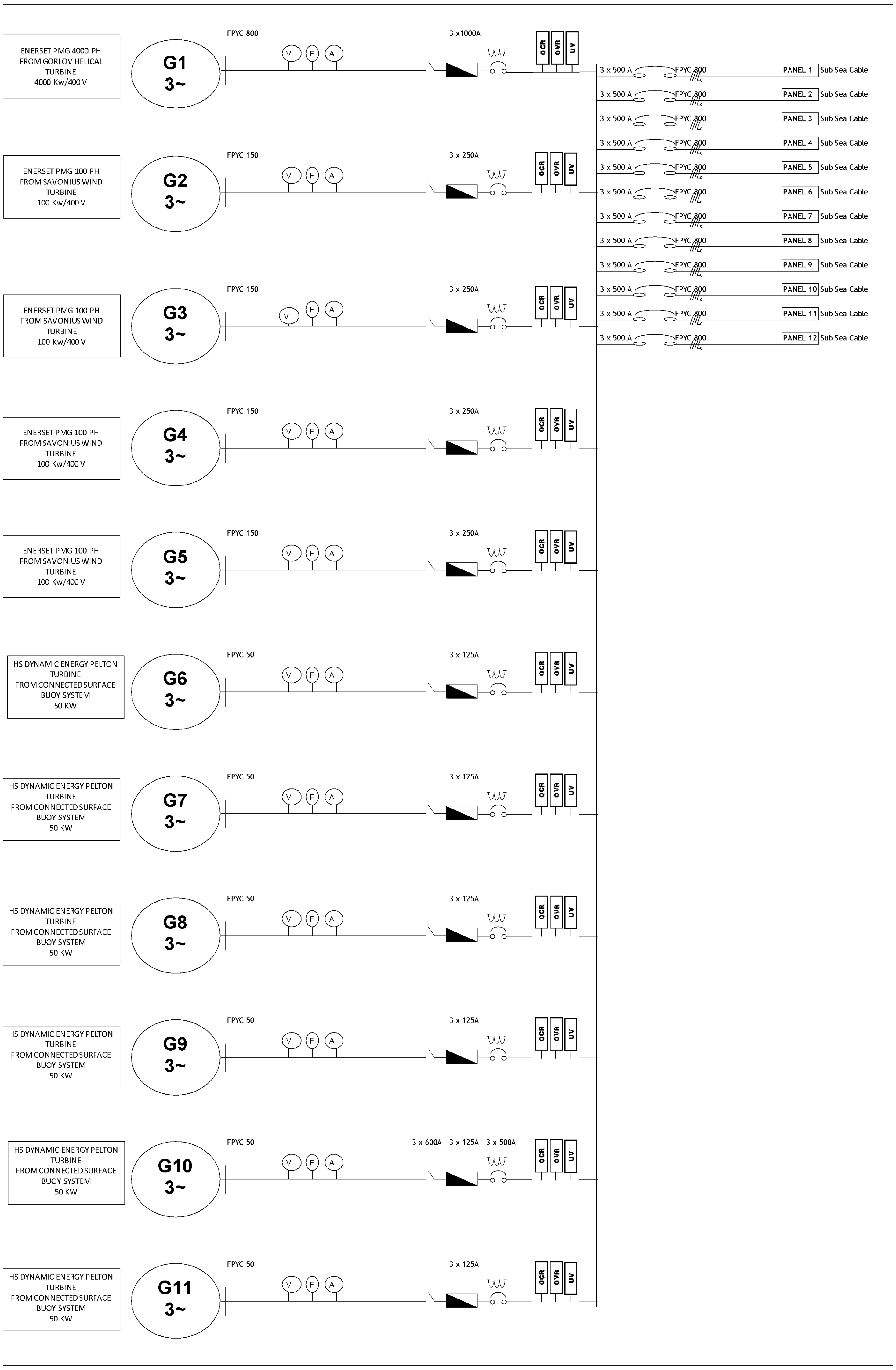

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POWERPLANT ONE LINE DIAGRAM

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M. RIZQI MUBAROK, born on 13 July 1995 in Gandusari, Blitar regency, East Java. Derived from a simple family that mixed cultures between farmers and santri with a Father named Ahmad Rifai and Mother named Salwiningsih. However, fortunate to have a formal education at SDN Sukosewu 01, he continued his study at SMP Negeri 2 Gandusari, his luck overshadowed him, because after high school in SMAN 1 Talun was accepted at the Department of Marine Engineering, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember PMDK line. During his tenure at the Institute Technologi Sepuluh Nopember the writer gained some achievements, namely: 1st Winner of National Scientific Writing Competition GSC 2017, Unnes - Semarang. Winner of National Scientific Writing Competition YS 2017, UTM - Madura. Winner of UCC National Scientific Writing Competition 2017, Unej - Jember. 1st Winner of National Scientific Writing Competition AIC 2017, Unair - Surabaya. He was also a speaker at the International Conference on Marine Technology, Nasdec - Surabaya. The author also actively organizes the chairman of the department of Innovation and Works HIMASISKAL FTK - ITS 16/17 and ITS 17/18 INTEGRATOR SCIENTIFIC SALINARY TRAINER. The author takes the Marine Electrical and Automation System (MEAS) as an interest.

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