Analysis of ocean wave power plant buoy system at Kelong

T Suhendra¹, R A Putra¹, S Nugraha¹, H A Kusuma¹, A H Yunianto², E Prayetto² and D Nusyirwan³

¹Departemen of Electrical Engineering, Faculty of Engineering, Universitas Maritim Raja Ali Haji, Tanjungpinang, Indonesia
²Departemen of Naval Engineering, Faculty of Engineering, Universitas Maritim Raja Ali Haji, Tanjungpinang, Indonesia

*E-mail: tonny@umrah.ac.id

Abstract. The potential of sea waves, located precisely in the Berakit area, can be used as electrical energy on a small scale. Kelong is a floating house situated on the coast, which anglers (fishermen) use to catch fish. In the Bintan area, there are two types of kelong, namely floating kelong and cacak (permanent) kelong. Floating kelong, as the name implies, is a kelong that can be moved anywhere. During the fish season, the kelong are offered to the middle of the sea, but if the west wind season or not during the fish season, the kelong will be brought ashore. On the other hand, kelong cacak are usually not far from the beach or coast and cannot be moved and operated at night by using a lamp to catch cuttlefish or anchovies. This research was conducted on Kelong Cacak and Floating Kelong (pontoon) located in Berakit, Disab Telok Sebong, Kabupaten Bintan. The power generation system was built using the buoy method. Based on the research results, the wave power plant can be driven by sea waves with an average height of 6 cm and produces a voltage and continuously the voltage is not always stable. The maximum peak output voltage is up to 15 Volt DC; after knowing the test results, the power plant can supply as a charger for the battery in the kelong cacak of 0.8839 Volt DC with an average battery voltage 11.4902 Volt DC on Floating Kelong (Pontoon).

1. Introduction

Fossil fuels are often the main ingredients of power plants whose availability will certainly run low and even run out. It is necessary to overcome such as diverting to the use of electrical energy instead of using fossil fuels, especially for islands where the majority of fishing communities are because their daily activities at sea using kelong or sampan using fuel.

Natural energy can be alternative energy to be converted into electrical energy, or now more commonly known as renewable energy (renewable). Ocean Wave Power Plant The Buoy System is one of the alternative equipment units to convert artificial ocean wave energy into electrical energy. Ocean wave energy is a renewable energy that is sustainable and very environmentally friendly [1]. In utilizing this alternative energy, a tool is needed that can convert ocean wave energy into electrical energy, namely the ocean wave power plant. The buoy system is used to convert the power of ocean waves to turn a generator to produce an electric voltage, especially placed on harbor platforms or kelongs. The results from the rotation of the generator will be saved to the battery storage device. The diode bridge circuit is needed for charging the electric voltage to the battery. This study was conducted to see how much voltage is generated when tested with two different concepts. First, the ocean power plant is placed...
floating on the water (pontoon system) where the power plant follows the rise and fall of ocean waves, and the second is where the ocean power plant is placed in a kelong cacak, where conditions are more stable.

2. Literature Review

2.1. Ocean wave

Ocean waves can be divided into several types depending on the forces that cause them to move, namely due to wind, pulling forces caused by the interaction of the earth, moon and sun (tidal waves), earthquakes which can be tectonic and volcanic that occur on the seabed (tsunami waves), and also caused by the movement of the ship [2].

2.2. Methods of Utilizing Ocean Waves to Generate Electrical Energy

The buoy system has almost the same working principle as using a float system that utilizes the vertical movement of the float to drive hydraulic and mechanical pumps. This system is attached to a raft that is floated and moored to the seabed [2].

2.3. Generator

A generator is a source of electrical voltage obtained through the conversion of mechanical energy into electrical energy. The generator works based on the principle of electromagnetic induction, namely by rotating a coil in a magnetic field to induce Electromotive Force (EMF) [3].

2.4. Generator AC

An AC generator is a generator that produces alternating current electricity. Alternating current generators are often called synchronous generators or alternators. In an AC generator, the armature coil is also called the stator coil because it is different in a fixed place. In contrast, the rotor coil, together with the magnetic poles, is rotated by mechanical power [4]. The frequency of the emf (electromotive force) generated by the AC generator depends on the rotor speed and the number of poles. The relationship can be determined by the following equation:

\[ n_s = \frac{120 \cdot f}{p} \]

with:
- \( n_s \) = stator field speed (RPM)
- \( f \) = voltage frequency (Hertz)
- \( p \) = number of poles on the rotor [4]

2.5. Freewheel

Freewheel is a rear gear on bicycle system that makes the rear wheels free to rotate (figure 1), when the pedal is rotated, the chain and rear wheel rotate, while if the pedal stops rotating, the chain will stop, but the rear wheel will continue to rotate according to the momentum. The working core of the freewheel only rotates in the same direction [5].

Figure 1. Freewheel [5]
2.6. Pulley
Pulleys can transmit power from one shaft to another through a drive transmission system in the form of a flat belt, V-belt, or circular belt. The way the pulley works is often used to change the direction of the applied force, send motion, and change the direction of rotation [6].

![Figure 2. Pulley](image)

We can use equation 2 to describe what is seen on figure 2.

\[
\frac{n_1}{n_2} = \frac{d_1}{d_2}
\]  

(2)

with [7]:
- \( d_1 \) = pulley diameter on drive (mm)
- \( d_2 \) = diameter of the pulley on the drive (mm)
- \( n_1 \) = driving speed (RPM)
- \( n_2 \) = driven pulley rotation (RPM)

2.7. Buoy
The shape of the buoy affects the generation energy produced by the ocean wave power plant with the float method, the form of the spherical float has the most significant generation energy value. It is suitable for wave types with minor frequencies and small amplitudes to critical frequencies and large amplitudes. The greater the inverter frequency, will cause the frequency of the wave to increase so that the generated energy generation will be even greater. The greater the amplitude of the stroke, the higher the resulting wave height and the greater the generation energy [8].

2.8. Battery
The battery is an electrical chemical process, where charging the electrical energy is converted into chemical energy and when the discharge or discharge the chemical energy is converted into electrical energy. Batteries generate electricity through a chemical process. A battery or accumulator is an electric cell in which a reversible electrochemical process occurs [9]. The battery capacity can be expressed by equation 3 [9].

\[
N (Ah) = I \text{(ampere)} \times t \text{(hours)} 
\]  

(3)

Where:
- \( N \) = battery capacity of the battery
- \( I \) = current (amperes)
- \( t \) = time (hour/second) [9]

2.9. Rectifier
A rectifier is a part of a power supply that converts an AC voltage signal into a DC voltage. There are several types of wave rectifiers, but a full-wave rectifier with a bridge configuration is used [10].
3. Research Methods

Berakit is one of the villages in Teluk Sebong sub-district, Bintan Regency, Riau Islands province, Indonesia (Figure 3). At this location the data collection process, where in this location there are many kelong which is the location of fishermen to look for cuttlefish and anchovies.

![Specific Area of Berakit](image)

**Figure 3.** Specific Area of Berakit

3.1. Power Plant Buoy System Design

The design of the ocean wave power plant buoy system includes the Transmission Framework Design. This design has dimensions of 49 cm long, 40 cm wide, and 55 cm high, using mild hollow steel. In creating the Leverage and Floating Arm Framework, the arm works like a lever with a fulcrum in the middle. The fulcrum uses bearings so that the up and down movement to drive the transmission system will work well. The lever arm design is 162 cm long. The buoys used in the study used jerry cans with a volume of 25 liters, two pieces. The Transmission Shaft and Transmission Drive Rail method are designed as a rotary motion sender obtained from the axle shaft through the freewheel gear to be forwarded to the pulley on the generator.

The design of the Rectifier Circuit design that will be designed uses two bridge diodes, 1 and 1 25 VDC 100 F capacitor. 2 pieces of output cable output from the generator will be inserted into the rectifier circuit. The cable from the result in the course is paralleled at the voltage output terminal to the battery and the digital voltmeter.

3.2. Device Works

Ocean waves are a force that is needed as a prime mover in conducting tests at the test location to drive a mechanical system. The transmission system is an automatic energy converter provided by ocean waves to get the pulleys and generators to rotate. The rectifier circuit is the main component needed in storing power to the battery generated from the wave power plant. The work system block diagram can be seen in Figure 4.

![Diagram Block System](image)

**Figure 4.** Diagram Block System
4. System Testing and Analysis

4.1. Lever Arm Design
The results of the design are made using mild steel. The physical form of the frame and arms and the lever transmission system can be seen in Figure 5.

![Figure 5. Ocean Power Plant Buoy Floating System (pontoons)](image)

4.2. Testing of Ocean Wave Power Plant Buoy System at Pontoons
Testing the ocean power plant buoy system was generated by the researcher's design, immediately carried out the test at the kelong location. What was done was taking the form of output voltage from the generator using a Multimeter measuring instrument, with a benchmark for comparison of wave height, data retrieval was carried out in 3 hours. Testing power plants on pontoons can be seen in Figure 6, and the results of testing power plants using pontoons can be seen in Table 1.

![Figure 6. Testing of Power Plant at Pontoons](image)

| No | Charging duration (minute) | Battery voltage (VDC) | Voltage sign in (VDC) |
|----|---------------------------|-----------------------|----------------------|
| 1  | 1                         | 10.40                 | -                    |
| 2  | 15                        | 10.40                 | 0.085                |
| 3  | 30                        | 10.40                 | 0.109                |
| 4  | 45                        | 10.40                 | 0.07                 |
| 5  | 60                        | 10.76                 | 0.099                |
| 6  | 75                        | 10.86                 | 0.1                  |
| 7  | 90                        | 10.96                 | 0.1                  |
| 8  | 105                       | 11.02                 | 0.06                 |
| 9  | 120                       | 11.14                 | 0.12                 |
| 10 | 135                       | 11.26                 | 0.05                 |
| 11 | 150                       | 11.31                 | 0.07                 |
| 12 | 165                       | 11.38                 | 0.02                 |
| 13 | 180                       | 11.36                 | 0.02                 |
|    | Total                     | 130.68                | 0.9030               |
|    | Average                   | 10.05215              | 0.0753               |
The results of the maximum wave height measurement do not occur often but can still be seen from the measuring instrument, with a voltage of 15 VDC. The charging obtained in the battery after the test was measured with a multimeter and the voltage on the battery was 11.36 VDC, with total \( V_{in} \) (input Voltage) is 0.903 Volt DC and average battery voltage is 10.052 Volt DC.

![Figure 7. Testing of Ocean Power Plant at Kelong](image)

4.3. Testing of Ocean Wave Power Plant Buoy System at Kelong

Testing of the ocean wave power plant carried out in Kelong without using a pontoon. Data was taken for 3 hours, testing the power plant in Kelong can be seen in Figure 7.

![Figure 8. Test data were taken with Multimeter](image)

The results of testing the power plant on the kelong can be seen in Table 2, and the test data taken using a multimeter can be seen in Figure 8. The results obtained in this kelong test are less than optimal because the total voltage increase \( (V_{in}) \) is only 0.368 Volt DC and average voltage in battery in 11.4902 Volt DC.

| No | Charging duration (minute) | Battery voltage (VDC) | Voltage sign in (VDC) |
|----|----------------------------|-----------------------|-----------------------|
| 1  | 1                          | 11.292                | 0.063                 |
| 2  | 15                         | 11.355                | 0.027                 |
| 3  | 30                         | 11.382                | 0.017                 |
| 4  | 45                         | 11.399                | 0.015                 |
| 5  | 60                         | 11.414                | 0.036                 |
| 6  | 75                         | 11.45                 | 0.04                  |
| 7  | 90                         | 11.49                 | 0.035                 |
| 8  | 105                        | 11.525                | 0.026                 |
| 9  | 120                        | 11.551                | 0.047                 |
| 10 | 135                        | 11.598                | 0.02                  |
| 11 | 150                        | 11.618                | 0.02                  |
| 12 | 165                        | 11.638                | 0.02                  |
| 13 | 180                        | 11.66                 | 0.022                 |
|    | Total                      | 149.372               | 0.368                 |
|    | Average                    | 11.4902               | 0.03067               |
5. Conclusion
The ocean power plant buoy system has been successfully designed and implemented on a kelong using two buoy and a pontoon (floating systems). The magnitude of the output voltage depends on the height and frequency of the wave. The maximum size of the output voltage obtained from the test is 15 V. The tests carried out in the kelong can supply the battery voltage of the battery, which has a voltage of 12 V, but not in a short time. This is due to the wave height factor, which is not always constant. Storage of electrical voltage generated by the power plant in the battery through the rectifier circuit gets a voltage of 0.903 VDC during the 3-hour test until the battery voltage becomes 11.36 VDC on floating system (pontoons) and average battery voltage on kelong caacak is 11.4902 Volt DC, and get a total voltage is 0.368 Volt DC.

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