

GREEN WAVE: A RESERVED ENERGY SOURCE

ENRICO M. DALANGIN, LORISSA JOANA E. BUENAS, AND
MARK ANGELO C. DRIO

*Batangas State University, Apolonio R. Apacible School of Fisheries
(ARASOF) Nasugbu Campus*

Abstract: Excessive and wasteful use of power in addition to the continuous growth in population has stressed the supply of primary available energy resources. These resources, while damaging the earth's environment, may not be able to meet the future needs for energy. A great shortage of energy is being experienced nowadays. It is necessary that it should be acquired or captured, saved, conditioned and be used through different techniques. One of these promising energy sources is ocean energy.

In this project, the waves typically have low power so that storage became an important consideration to maintain a consistent power output. By submerging a floater, it forms fluctuations. The force of the floater above the water is fluctuating as the water rises and falls, driving a floater by using a pedal which passes the energy through a rotating wheel to the dynamo to generate electricity.

This project provides a brief review of ocean waves and their potential as green energy surrogate to conventional energy sources. The basic wave energy conversion is discussed to provide an overview of the fundamentals related to the field. Nevertheless, the existing crisis of the country requires appropriate selection of renewable energy solutions. Ocean wave energy has the potential and is expected to contribute in the future needs for energy.

Keywords: *floater, pedal rotating wheel, alternator, green energy*

1. INTRODUCTION

Conversion of energy by the ocean surface waves, and the capture of heat energy to do useful work such as pumping of water into reservoirs, water desalination and the generation of electricity, is known as wave power. A wave energy converter is generally known as the machinery able to utilize wave power.

Excessive and wasteful use of power in addition to the continuous growth in population has stressed the supply of primary available energy resources. These resources, while damaging the earth's environment, may not be able to meet the future needs for energy. Nevertheless, with the evident data of diminishing resources and in the process of continuous improvement, many alternative modes for sourcing energy have been explored by humans. We are so fortunate that wind, solar and ocean energy are natural sources which can solve many concerning issues, mainly about energy availability and environmental impact. These are now established as potential energy sources, which are, of course, renewable, and a lot less damaging to the earth's atmosphere. A great shortage of energy is being experienced nowadays. It is necessary that it should be acquired or captured, saved, conditioned and be used through different techniques. One of these promising energy sources is ocean energy. It is traditionally recognized as massively powerful and resource-rich, as three-fourths of earth's surface is enveloped by ocean.

One of the main concerns of nations should be the need to apply green energy technologies in general, and wave energy in particular, due to some important reasons. First, there is severe shortage of electricity around the world. The second reason for implementing green energy technologies is economic. This is especially pressing for oil-importing countries. Their import bill for energy commodities can drop significantly. The third reason is environmental. The challenges posed by energy-related environmental issues are considerable. Air pollution is produced by traditional power plants used in many countries. Emissions coming from energy-related power plants are a major contributor to the levels of ambient air pollution, specifically in cities. On the other hand, the extraction of commercial fuels like oil and coal, which are often highly damaging to local ecosystems, is an immediate cause of land and water pollution (Ahuja, 2005).

Other renewable energy sources, such as ocean wave energy, are expected to provide a major proportion of future energy needs without contributing to global warming and pollution. Considerable research progress has already been made in this field, and several methods of harvesting ocean waves have materialized. However, utilization of this boundless source is still in its early development, and energy costs compared to traditional methods is still high. But history tells us that all technologies take some time to become cost effective, and the capital cost of wave energy conversion methods will also fall. Hence, wave energy is expected to eventually replace a significant percentage of conventional energy sources, while at the same time also addressing pollution and other associated issues. Helping its transformation into a useful form at the right time and place, with reasonable and non-prohibitive attendant costs, is the real endeavor of this study.

With the mentioned difficulties, the researchers believe that the fastest and most reliable solution is to use wave energy. This renewable energy will certainly help the world's economic and green development.

The purpose of the research is to provide enough energy to sustain the needs of communities for energy supply. The researchers aim to develop a Reserved Energy Source to save energy and to improve the supply of electricity by means of the ocean's waves. Specifically, it seeks to determine the suitable materials for the project, identify and compute the economic viability of the project, and determine the opinion of experts on its acceptability in terms of efficiency, accuracy, cost-effectiveness, user-friendliness and maintenance.

2. METHODOLOGY

The researchers followed the Engineering Design Cycle (Figure 1) formulated and used in the Imperial College of London. The said cycle approach believes that requirements are established and stationary across the project plan.

In building the project, it is important to determine and understand the design, as well as the process it would go through. The engineering design cycle helps to emphasize clearly the mechanics and process of the project to both the user and the reader. This engineering design cycle project shows the step-by-step process in creating the actual project.

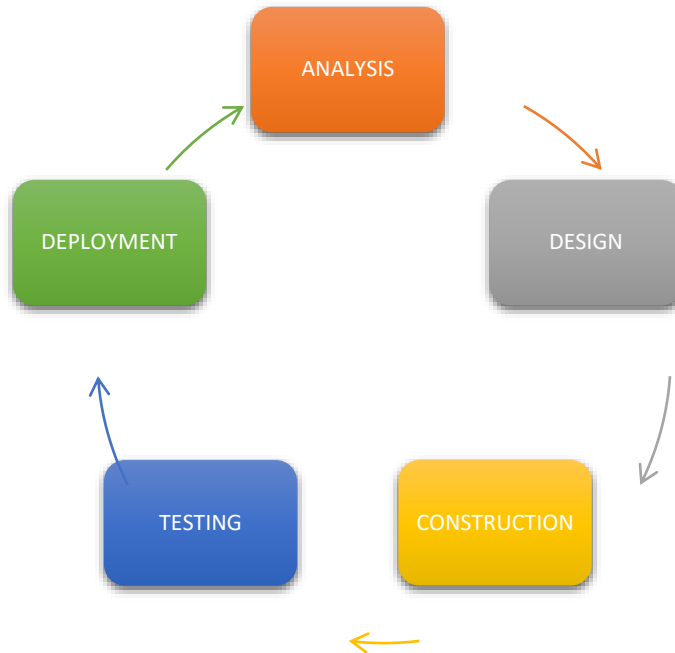


Figure 1. Engineering design cycle (Imperial College of London)

During the analysis stage, the researchers gathered and analyzed information that will be required in creating a project. It also involved carrying out a detailed study and arriving at the exact requirements for the proposed system.

In design stage, the researchers obtained the final design by converting the defined requirements into a logical structure that can be executed in the process and mechanism used in the project.

The researchers tested all the modules created in the prior stage as a complete system during the construction and testing phases. The researchers placed the device where the wave is neutral. They observed the output voltage of the said project, the common problems encountered and the effects of the wave on the clapper.

During the last stage, which is the deployment stage, the researchers put the new system design into operation. This involved implementing the identified requirements into the project, and training the intended users.

Previous Works

A project named Vertical Axis Pendulum Wave Energy Converter (VAPWEC) used the motion of a pendulum. The developers used a hull that floats atop the ocean's

surface. The rolling and pitching of the hull, in turn, causes the VAPWEC's pendulum to swing (Boren *et al.*, 2017).

Another project similar to this study is A New Wave Energy Converter using Flap-type Blade and its Power Generation Test. The said harvesting system consists of a floating body and a submerged body, and the two bodies are connected by elastic wire. The floating body functions as a conventional buoy, which contains electrical devices, batteries, navigation sensors, and observation instruments. The submerged body is a power take-off similar to a turbine, which is called wave turbine. The wave turbine is a self-rectifying wave induced turbine. The wave turbine has two rotors to countervail rotating movement. Each rotor has flap-type blades hinged on its frame. The angle of attack of the blades change in response to the motion of wave. Thus, the flap-type blades generate the lift force in both upward and downward motion of waves, and the rotor with the flap-type blades is able to rotate continuously (Joe *et al.*, 2016).

The project, Effective Energy-Saving Device of Eco-Ship by Using Wave Propulsion, demonstrated that the proposed device is effective in augmenting ship speed and saving energy by harnessing wave energy. At the same ship speed, the power needed for driving the pitch-oscillating bow fin is relatively small (Huang, 2016).

Analytical Design of Sea Wave Energy Power Plant Using Tubular Linear PM Generator in Southern Coast of Yogyakarta, Indonesia used components such as a floating buoy and a tubular linear permanent magnet generator. The design and dimension of the components considered the characteristics of the sea wave at the placement site, as well as the expected power. The output power of the generator reaches its peak value when the load resistance equals 3.3Ω , despite the capability of the coil. Furthermore, the generator only generated power at certain times. This is due to the difference in length between the wave magnitude and the translation path of the translator (Azhari, 2016).

Final design, description, features and limitations

The final design shown in Figure 2 illustrates the complete look of the project. The required hardware components that were used in the execution of processes of the design project are also presented.

The final design of the "Green Wave: A Reserved Energy Source" shows the different parts of the prototype model, as well as the function of each, in the design project.

The load represents electronic devices or common household appliances that have a power consumption not exceeding 1000 watts, such as LED bulb lights, electric fan, LCD/LED television, etc

Figure 3 illustrates the front view of the design project. The floater connects to the belt wheel through the pedal bar.

Figure 4 illustrates the side view of the design project. It shows the different interconnected devices like the floater, belt wheel, dynamo, battery, etc.

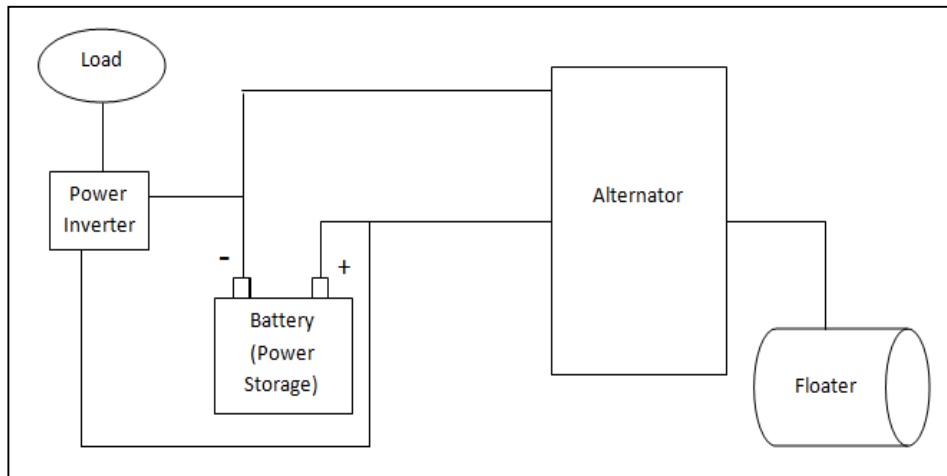


Figure 2. Schematic diagram of the design project.

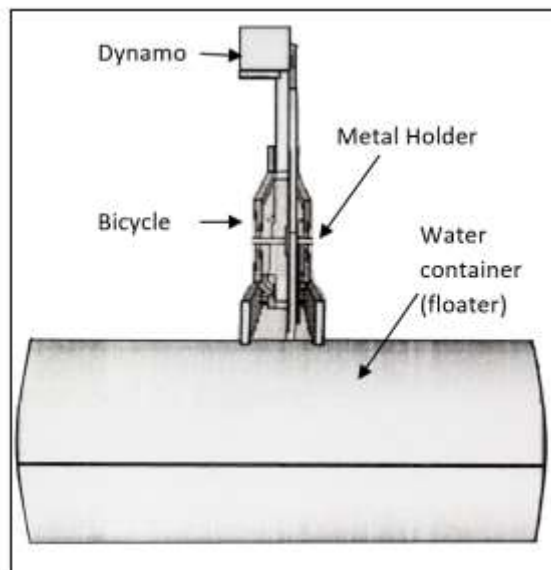


Figure 3. Front view of the design project.

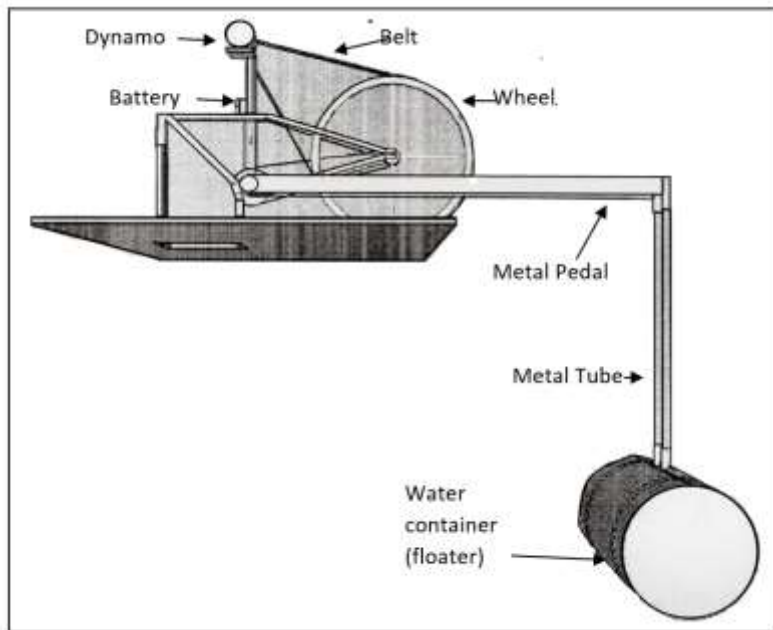


Figure 4 Side view of the design project



Figure 5. Actual testing of the device.

Hardware requirements and specifications

Hardware requirements are the physical features needed for the development and completion of the design project. It includes components and gears that were used to make the design project dependable, more useful, durable, and easier to assemble.

A hardware requirement supports the performance, process, and guidelines of the design project. It also indicates requirements and specifications needed to complete the flow of the design project.

Table 1 shows the parts and materials used, and their respective function, in the development of the project.

On the other hand, Table 2 lists the hardware requirements and specifications. It also shows the cost breakdown of the materials needed to complete the device.

Table 1. List of materials used in the development of the project.

Materials	Description
Dynamo	This is a type of alternator commonly associated with bicycles for generating electricity that is used for lighting a small head lamp. The unit eliminates the need for a battery and provides an easy alternative for illuminating a lamp whenever the bicycle is in motion.
Battery	This is the storage of electrical charge. It can store a charge and then release that charge. It resists any change of voltage across it.
Water Container	This is a raw material and the main part of this project that catches the movement of waves. This material helps trigger the other components and creates motions to move the sliding gear and move the dynamo forward and backward.
Belt	This is a loop of flexible material used to mechanically link two or more rotating shafts, most often parallel. Belts are used as a source of motion, to transmit power efficiently, or to track relative movement.
Bike	This is a vehicle composed of two wheels held in a frame one behind the other, propelled by pedals and steered with handlebars attached to the front wheel.
Belt wheel	This is a wheel on an axle that is designed to support movement of a cable or belt along its circumference. Belt wheels are used in a variety of ways to apply forces, and to transmit power.

Table 2. List of hardware requirements and specifications.

Hardware Requirement	Quantity	Specifications	Cost
Dynamo	1	12 volts DC output	Php 1,500.00
Battery	1	12 volts storage	Php 500.00
Water Container	1	4 ft. high, 2 ft. diameter	Php 1,500.00
Bike	1	3 ft. high, metal body	Php 2,200.00
Belt	1	2 ft. diameter rubber material	Php 500.00
Belt Wheel	1	1 ft. diameter metal	Php 1,200.00
Wire	4	2 yards, 220 voltage capacitor	Php 300.00
Inverter	1	1200 watts, 220 AC power voltage output	Php 1,800.00
Metal Frame	1	Angle bar: 3 ft.x1 ft.	Php 800.00
TOTAL	12		Php 10,300.00

Stored Energy

Table 3 shows the number of hours it took to fully charge the battery each day.

A battery with 100 Ampere-Hour (Ah) capacity was used as a power bank. The regulator/rectifier of the alternator cuts-off at 12.7 Volts. In this case, it signifies that the battery is already fully-charged. The fluctuations of the waves affect the charging time of the battery. It took longer hours to fully-charge the battery when there was less wave movement.

Economic viability of the project

To evaluate the efficiency of the investment, the financial assessment of the device was projected through economic viability computation. The project of course needs capital to make the device. It needs a certain amount of money to build, but the upside is that it helps change the world from being dependent on fossil fuels and other hazardous sources of energy which pollute our environment into a new green world with a healthy environment. Wave energy is the best alternative power supply; it works 24/7 continuously to produce electricity.

Table 3. Power harvested.

DAY	No. of hours to fully charge the battery	Alternator Charging Voltage
1	5 hours	13V(min) – 14V(max)
2	7 hours	13V(min) – 14V(max)
3	6 hours	13V(min) – 14V(max)
4	4 hours	13V(min) – 14V(max)
5	7 hours	13V(min) – 14V(max)
6	6 hours	13V(min) – 14V(max)
7	5 hours	13V(min) – 14V(max)

Table 4. Economic viability of the project.

COST		Current Year	CY +1	CY +2	CY +3	CY +4	CY +5 (ROI)
Dynamo	Php 1,500.00						
Battery	Php 500.00						
Water Container	Php 1,500.00						
Bike	Php 2,200.00						
Belt	Php 500.00						
Belt Wheel	Php 1,200.00						
Wire	Php 300.00						
Inverter	Php 1,800.00						
Metal Frame	Php 800.00						
TOTAL	Php 10,300.00	10,300	2,000	2,000	2,000	2,000	18,300
BENEFITS		Current Year	CY +1	CY +2	CY +3	CY +4	
Electric Bill wit "Green Wave: A Reserved Energy Source"		4,942.08	2,471.04	4,118.40	4,530.24	4,942.08	21,003.84

Demonstration

The researchers presented the design project to its intended users with the primary purpose of showcasing its idea, performance, method and features. They introduced the actual performance of the device and how it works.

Table 4 shows the estimated cost-benefit viability of the project:

- 40 Watts x 24 hours = 960 Watts
- 960 Watts x 30 days = 28,800 watts
- 28,800 watts x (1 KW/ 1000 Watts) = 28.8 KW
- 28.8 KW x Php 14.30 = Php 411.84 per month
- Php 411.84 x 12 = 4,942.08 per year

Testing and evaluation

During the first testing of the project, the researchers encountered errors, and at that point, they immediately provided solutions to those problems. The device was repeatedly checked to confirm that it attained its objectives.

In the evaluation process, the researchers invited three (3) engineers from Emperador Distillers, Inc., Lumbangan, Nasugbu Batangas to evaluate the quality and functionality of the proposed project. One is a registered Mechanical Engineer, and two are registered Electrical Engineers. They evaluated the project in terms of its ability to store energy at a given time.

3. RESULTS AND DISCUSSION

The researchers used a water container instead of a wave clapper for the floater because the waves in the port area are not suitable for moving a wave clapper. The device is covered by a plastic box for its protection. Instead of using a capacitor for storing energy, the proponents used a 12 volts battery.

The researchers tested the prototype at the port area to support the performance. They also used an energy converter because it is inexpensive, simple, and can gather wave energy from the desired measure of waves.

Through the advantage of mass production, technological change, and market competition, renewable energy technologies are getting cheaper. Like the proposed project, “Green Wave: A Reserved Energy Source”, the total cost in building the project is much cheaper than other sources of renewable energy. The fact that wave energy will never run out is the best thing about it. Waves will always be crashing upon the shores of lands, near populated coastal regions.

After the evaluation process, the researchers assessed the findings regarding the efficiency, accuracy and effectiveness of the “Green Wave: A Reserved Energy Source”.

Non-probability sampling is the tool used by the researchers. The individuals in the population were not given equal chances of being selected.

Table 5. Guidelines interval for evaluation and interpretation.

Scale	Mean Range	Verbal Interpretation
5	4.21 – 5.00	Excellent
4	3.41 – 4.20	Very Good
3	2.61 – 3.40	Good
2	1.81 – 2.60	Fair
1	1.00 – 1.80	Poor

Table 6. Frequency distribution of “Green Wave: A Reserved Energy Source.”

Criteria	Rating					Weighted Mean
	5	4	3	2	1	
Efficiency	0	0	2	1	0	2.6667
Accuracy	0	1	1	1	0	3.0000
Effectiveness	0	2	1	0	0	3.6667
User-Friendliness	2	0	1	0	0	4.3333
Maintenance	2	0	0	0	1	3.6667

Table 5 represents the guidelines interval in determining the level of acceptability of the design project. It also includes the verbal interpretation for every scale and mean range.

In computing the weighted mean, the proponent used the formula:

$$\sum f(v)WM = \frac{f_1v_1 + f_2v_2 \dots + f_nv_n}{S_s}$$

where:

WM = the weighted mean

f = the frequency

v = the value of the scale

S = the sample size,

n = the number of frequency/scale.

Table 6 shows the frequency distribution of respondent scores for “Green Wave: A Reserved Energy Source”. It depicts the weighted mean of the respondents’ ratings for each relevant criterion.

4. CONCLUSIONS

In developing and completing this project, “Green Wave: A Reserved Energy Source”, the researchers used water container, 12 volts battery and the device is covered by a plastic box for its protection.

In five (5) years, the money that the researchers invested to build the project will return.

The acceptability level of the proposed project was rated as Very Good in terms of effectiveness, efficiency, accuracy, user-friendliness and Maintainability.

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