Malaysia East Coast Energy Harvesting Invention

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***Abstract*—Tourism had been one of economic contribution and increasing countries as renewable income. Sea view and river front and coastal development concept as resorts, hotels and infrastructure had been developed rapidly and consumed water and energy resources tremendiously. Coastal infrastructure development near to the coastline and facing coastal erosion every second around the globe. Coastal erosion had potential damaging coastal infrasturcture, thus requiring annual cost for rectification. Many coastal breakwater and ocean wave breaker had been in many designs and deployed around the world in order to reduce coastal erosion. Today, the concept of coastal wave breaker had been incoorperated with energy harvesting invention. This study carried out a prototype that reducing coastal erosion by dissipating nature energy force from ocean wave. Since 2015, prototype named NAHRIM's Coastal Defense and Energy Generator (N-CODE) had been started invented, tested at laboratory and sites in order to solve coastal erosion at Malaysian East Coast, by dissipating South China Sea wave converted into electricity. Many designs had been tested at Hydraulic and Instrumentation Laboratory (ISO9001:2008), National Hydraulic Research Institute of Malaysia (NAHRIM). The design of N-CODE had been go through laboratory testing scenario and on site testing scenario. In this study, N-CODE could able to harvest ocean's energy between 2-4 Amphere per second in Direct Current (DC), able to charging powerbanks and lighted up LED.**

***Index Terms*—Energy harvesting, coastal erosion, hydraulic, ocean energy, ocean wave, direct current.**

I. Introduction

The energy created from natural resources such as from oceans, rivers and lakes had the potential to provide environmental friendly and reliable in generating electricity as renewable energy source that economically feasible [1]. Nowadays, energy harvesting invention from ocean current and ocean wave had been taken place worldwide in comercial scale. Its had been believe that the ocean energy harvesting had displaced fossil fuel-based energy resources and prooven reducing carbon foot print which contributing in ocean acidification reduction and climate change improvement [2]-[11].

Many design of energy harvesting invention had been made to generate electricity from ocean wave. Some had been deployed along coastline, remote island, shallow or deep bed ocean. Some studies had found ocean current and ocean wave could be converted into electric generation. Tides occur twice in 24 hours and are caused by the gravitational effect of the Moon. Tide potential creating energy by having engineering structural design [12]-[20]. Many design has been deployed, currently at United Kingdom and France since the 11th Century. Currently, there are commercial scale for the ocean's energy harvesting in the world. In 1966, the mouth of the La Rance estuary in Brittany France with the average tidal range of 8 meters, producing 240MW [21]-[25]. A 16MW plant at Bay of Fundy coastline of Canada generated 30 million kWh of electricity per year from a tidal change in the range of 10.8meter [26].

In Malaysia, there are potential of ocean energy harvesting by South China Sea at Malaysia East Coast, Malacca Straits at Malaysia West Coast and Tebrau Straits at Malaysia South Coast. Therefore, in this study, in order to harvest energy from ocean, the on site testing will be carried out after laboratory testing. Two location under Malaysia East Coast are: Pantai Sepat of Pahang State and Pulau Tinggi of Johore State. The site of Pantai Sepat will be used for preliminary testing before the N-CODE tested at Pulau Tinggi. Pulau Tinggi will be the actual testing for N-CODE in short, medium and along term study observation. Medium and long terms observation still on going for data collection and will be not included in this article. This article will go through all findings at Pulau Tinggi in order to meet objectives.

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II. Objectives and Scope of Study

The objectives of this research is to study the possiblity of natural ocean wave resources from Malaysian East Coast (MEC) as an alternative electricity generator for N-CODE.

The scope of study covered the transformation of conceptual design into final design of N-CODE, installation of the design at selected site, data collection for structural stability, energy harvested and others factor influenced. Others hydraulic factors will be considered are such as wind effect, currents effect and tide effect.

III. Methodology

The conceptual design found in 2015 as Fig. 1. The design of N-CODE had been transformed in middle of 2016 after certain modification. Each modification were tested inside the water basin facilities at NAHRIM's Hydraulic Laboratory. Physical observation had been recorded for final design improvement.

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Fig. 1. Conceptual design tested early 2016 at Pantai Sepat, State of Pahang, Malaysia east coast.

After the stability test, conceptual design prototype will be improving its design to be final design prototype named NAHRIM's Coastal Defense and Energy Generator (N-CODE). Further testing proceedures illustrated in Fig. 1, are testing at area of MEC.

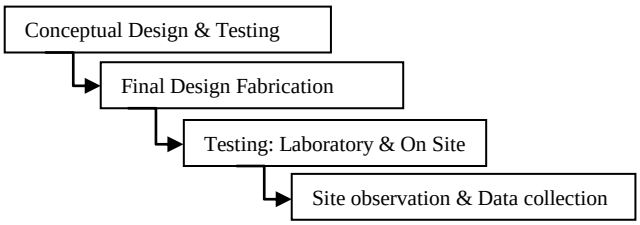


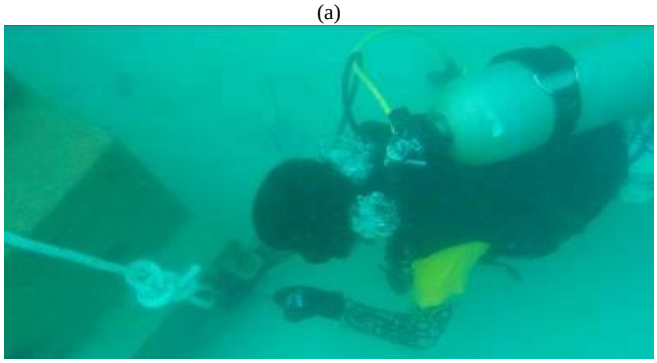
Fig. 2. Block Diagram of the N-CODE prototype research since 2015.

Material selection had been revised during the modification. Most of the material selected are based on law of electromagnetism such as copper coils, magnet bars and a hollow pipe of PVC. While others are a set of circuit box consist of rechargable batteries, a set of electrical converter from DC to AC and led light with sensor. All material, component had been assembled, fabricated and tested at Penang.

Fig. 3. Final design tested in middle 2016, State of Penang.

The overall structure of N-CODE, was customized manufactured by fiberglass material in order to let the N-CODE floating and strong enough to absorbed the wave forces, as Fig. 3. A simple PVC rope will be use in order to make sure the design does not move from the deployment point and act as anchoring assist mechanism. PVC rope will be using to anchoring the design to the ground of ocean. In this case, the rope will be tight to 4,000 kilogram of artificial reef named WABCORE, a product of invented by NAHRIM. After the prototype had been tighted up between WABCORE and N-CODE, the prototype is ready to be tested for its operational, performance, behavior and physical stability.

(a)



(b)

Fig. 4. Anchoring N-CODE. (a) artificial reef named WABCORE, a product of invented by NAHRIM. (b) PVC Rope Tigthed manually during diving at almost 10 meters depth.

In this study, Pulau Tinggi had been selected for the testing location. The wave height at the Pulau Tinggi island measured higher than the wave of Straits of Malacca. Tide scheduled shows that the on site testing will be most of in a daylight. The others factors such as wind, will be observed its influence to the performance efficiency. Wind measurement will be taken in order to verify the influences. The last part of the site testing will be not shared in this article are the result of long terms deployment impact to oversee the structural stability of the design.

Exact location had been study by having data collection of wave height and wave frequency by using wave measurement instrument to produce the wave spectrum of Pulau Tinggi. Previous wave spectrum had been reffered during the WABCORE deployment in 2016. Fig. 5 below is the wave spectrum model of Pulau Tinggi had been as criteria for N-CODE deployment at exact location. The exact location for the N-CODE deployment remarked as 'X', was at 300 meters off from the Pulau Tinggi, located at At 2.278436 East, 104.12899 North of Pulau Tinggi.

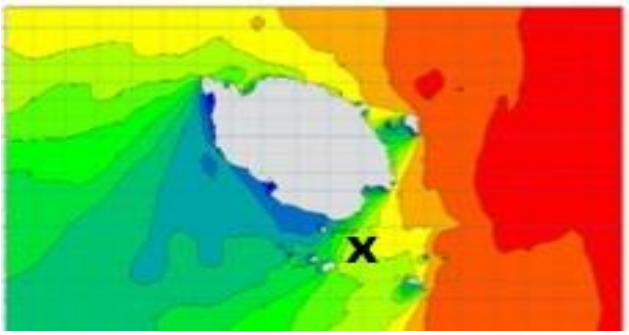


Fig. 5. Wave spectrum model at pulau tinggi in 2016 for deploying pre real design exact location.

Wave Spectrum as in Fig. 5 had been find the best method

for determination of N-CODE deployment. From the Wave Spectrum, others potential location is in 'red' color code, compared to 'blue' color code.

Fig. 6 shows two unit of N-CODE deployed on October 2016 and being leave for few months to observed long terms structural stability. As a safety features, sensored had been installed to protect circuit from electrical surge in a long period of time.

Fig. 6. Final design testing at 2.278436 east, 104.12899 north of Pulau Tinggi, State of Johore, Malaysia east coast, end of 2016.

IV. Results and Discussion

TABLE I: The Second Day Performance of N-CODE Power Generating Vs. Estimated Wave Height and Tide Time

Time	Estimated Wave Height (Meter)	N-CODE Power Generated (Volt)
1130	0	3.00
1145	0	2.90
1200	0	3.00
1215	0	3.00
1230	0	2.80**
1245	0	3.03
1300	0.1	3.05
1315	0.1	3.20
1330	0.2	3.30
1345	0.2	3.60
1400	0.3	5.00
1415	0.3	4.70
1430	0.2	4.00
1445	0.3	6.60
1500	0.2	5.58
1515	0.3	6.70
1530	0.2	5.70
1545	0.2	5.00
1600	0.3	5.90
1615	0.3	5.30
1630	0.3	7.30*
1645	0.2	5.40
1700	0.3	5.00

*maximum ** minimum

Two day of data collection had been recorded in October 2016 due to the monsoon season limiting days of site testing. The most achievable performance of N-CODE was on the second day as Table I. From the Table I, the N-CODE had succeed generating power in a small amount of quantity, at minimum of 2.6Volt at the beginning of high tide (or at the end of low tide). After few hours of high tide, the N-CODE could performed in sustained power generating at average of 4.25Volt. Surprisingly, N-CODE could possible reached maximum power of 7.3 Volt as recorded. These shows that N-CODE could be possible generating direct current.

During on this study, wind had been observed as a factor that influenced the N-CODE operational. However the wind study had not been included in this study. Further study is possible as to determine the wind contirbution to the power generating from the wind.

From the data collection, found that, the performance of N-CODE power generation will be increase according to the increment time of high tide development. Thus, also mean that the N-CODE power decreased it generation according to the deteroriation of hig tide or under low tide development.

Significant recorded data for the first day had been tabulated as Table II. Although study had found that, the first day performance is slightly lower reading of minimum value and maximum value, respectively, surprisingly, it shows that N-CODE could performance for at least 2.74 Volt within an hour consistently.

TABLE II: The Second Day Performance of N-CODE Power Generating Vs. Estimated Wave Height and Tide Time

Time	Estimated Wave Height (Meter)	N-CODE Power Generated (Volt)
1130	0	3.00
1145	0	2.68**
1200	0	3.08
1215	0	3.00
1230	0	3.80
1245	0	3.01
1300	0	3.00
1315	0	2.80
1330	0	3.11
1400	0	3.20
1415	0	3.20
1430	0	3.22
1445	0	3.24
1500	0.1	3.26
1515	0.2	3.90*
1530	0.1	3.70
1545	0.1	3.29
1600	0	3.00
1615	0	3.10
1630	0	3.00
1645	0.1	3.80
1700	0	3.70

*maximum ** minimum

Thus, leads to new significant findings prooven that N-CODE could performed within a short period of time. As this could remarked electrical surged possiblity could happen, at more than a unit of N-CODE installed at the same time. However, both finding on the first and second day had meet the study objectives whereas, wave resources from Malaysian East Coast could possible operating energy harvesting invention, N-CODE, as renewable energy, generate electricity. Fig. 7 shows that tremendously ocean energy harvesting at constant high tide by N-CODE. It also show that low tide does not contributing energy. Thus could lead to further study to improved minimum generating design of N-CODE in order to increase efficiency of N-CODE.

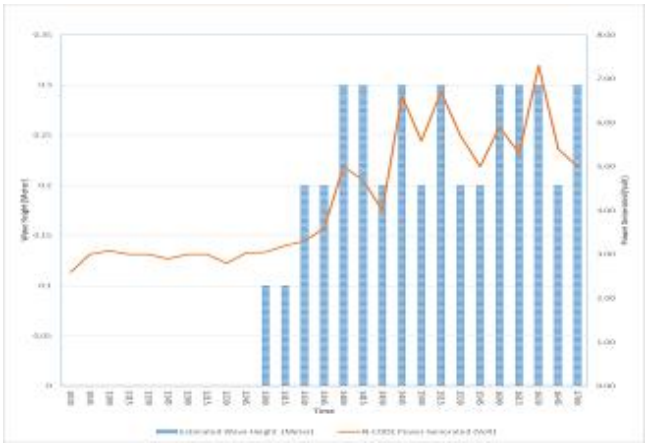


Fig. 7. The performance of N-CODE power generating Vs. estimated wave height.

As in Fig. 8, study had found that, wind speed does not inffluencing the electricity generation by N-CODE. However, from the data collection, surprisingly significant that, the design of N-CODE could be possible review incooperted with additional physical design to increase the movement of N-CODE during all time include during low tide.

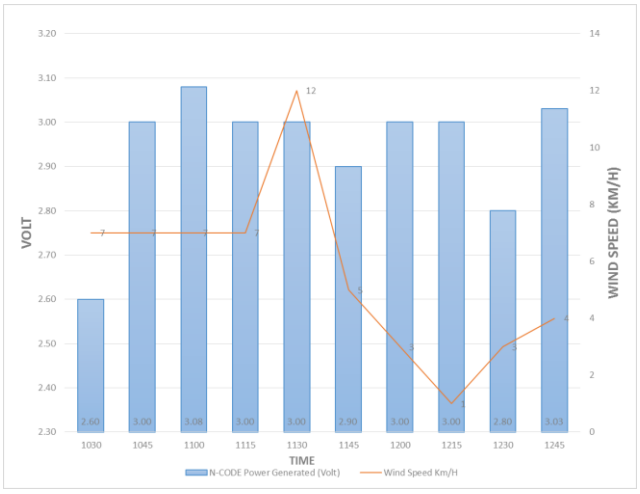


Fig. 8. The performance of N-CODE power generating Vs. wind speed.

V. Conclusion

In this study, N-CODE prototye had achived the objectives of the study, that is power is possible could be generating from Malaysia East Coast include all area of its coastline and Malaysia's Island under the coast facing South China Seas.

The real design had its own stablity of performance due to the proper anchoring. In this case, product of WABCORE had been used for the anchoring. Anchoring is the factors as to frequent operating N-CODE. Further study could be conducted in order to replacing WABCORE function on to look forward method of anchoring approach installation nearby to the coastaline.

Wave Spectrum Study (WSS) is recommended for deciding the exact location of N-CODE deployment. This require on site hydraulic study, spesific software resulting a new map indicating potential location of high efficient performance of N-CODE.

Further study shall be done in order to increase the prototype efficiency especially during low tide. Observation found that tidal schedule influenced the N-CODE performance. Monsoon season could be the best time for ocean energy harvesting, however, method of data collection shall be revised accordingly.

Type of wave's frequency also could influenced the performance. More frequent range of wave's frequency will increase the N-CODE performance while less frequent of wave's frequency will decrease N-CODE performance. From the study, power management is the final main concerned for N-CODE to determined type of power load such as power bank, led lights and others electrcal/electronic devices. Further study shall be recommended to reduce electrical leakings and efficient power management.

Wind Speed is an advantage to N-CODE. Further study involving wind speed could possible assist to be operate almost at 24 hours a day at any low and high tide scheduled.

Finally, further studies could be done for developing N-CODE Installation Calculator (NIC) to calculate N-CODE at optimum cost for a spesific deployment or calculating numbers of N-CODE at certain size of N-CODE. By this, N-CODE could possible be commercialized and preliminary for lifetime operational and calculated maintenance cost within the commercialization deployment.

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