iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 Issue: III Month of publication: March 2022

DOI: https://doi.org/10.22214/ijraset.2022.41141

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

# Power Generation Using Sea Tidal Waves

Nikhil Mangale[1], Rushikesh Jadhav[2], Meetkumar Kuvekar[3], Vikas Gupta[4], Abdul Bari[5]
*[1, 2, 3, 4]Student, [5]Assistant Professor, Department of Mechanical Engineering, Theem College of Engineering, Boisar 401501*

***Abstract: This project reports on how to generate electricity from ocean wave by using RACK AND PINION arrangement and generators. The objectives of this project are to design and build a small scale power generator powered by ocean wave energy that able to generate electricity in other words a WAVE ENERGY CONVERTOR. It is not easy to harness wave energy and convert it into electricity in large amounts. So, the studies for this project include finding information and knowledge related to the topic besides developing skill through enquiry and literature review. In this mechanism ELECTRICAL POWER is generated simply by forced linear movement of rack and pinion by the waves. The rack will oscillates with the wave up and down which is in mesh pinion hence it will turn the pinion mounted on pinion shaft. The rotational movement of the pinion is transferred to the generator which results as electricity. To become a successful project, several things need to be reviewed like literature review on linear generator, design and development of the generator, experiment of before gaining result and correct data.***
***Keywords: Rack and pinion, wave energy convertor, electrical power***

## I. INTRODUCTION

Wave energy can be considered as concentrated form of solar energy. Winds are generated by the differential heating of the earth and, as they pass over open bodies of water, they transfer some of their energy to form waves. Energy is stored in waves as both potential energy (in the mass of water displaced from the mean sea level) and kinetic energy (in the motion of the water particles). The amount of energy transferred, and hence the size of the resulting waves, depends on the wind speed, the length of time for which the wind blows and the direction over which it blows (the "fetch"). Power is concentrated at each stage in the transformation process, so that the original average solar power levels of typically ~ 100 W/m² can be transformed into waves with power levels of typically 10 to 50 kW per meter of wave crest length. Waves lying within or close to the areas where they are generated appear as a complex, irregular "wind sea". These waves will continue to travel in the direction of their formation even after the wind is no longer acting on them. In deep water, waves lose energy only slowly, so they can travel out of the storm areas with minimal loss of energy, becoming progressively regular, smooth waves or "swell". These can persist at great distances (up to ten thousand kilometers or more) from the point of origin. Therefore, coast with exposure to the prevailing wind direction and long fetches tend to have the most energetic wave climates, for instance the west coast of the Americas, Europe and Australia/New Zealand. The global wave power resource in deep water (i.e. ≥ 100 m water depths) is estimated to be ~ 1012 – 1013 W.

## II. LITERATURE REVIEW

### A. A Review of Wave Energy Convertor

*B drew, A.R.Plummer, M.N.Sahinkaya,* The study shows that the Ocean waves are a huge, largely untapped energy resource, and the potential for extracting energy from waves is considerable. Research in this area is driven by the need to meet renewable energy targets, but is relatively immature compared to other renewable energy technologies. This review introduces the general status of wave energy and evaluates the device types that represent current wave energy converter (WEC) technology, particularly focusing on work being undertaken within the United Kingdom. The possible power take-off systems are identified, followed by a consideration of some of the control strategies to enhance the efficiency of point absorber-type WECs. There is a lack of convergence on the best method of extracting energy from the waves and, although previous innovation has generally focused on the concept and design of the primary interface, questions arise concerning how best to optimize the powertrain. This article concludes with some suggestions of future developments.

### B. Characterizing the Wave Energy Resource

*Pavol Bauer, Lenee-Bluhm, P.; Paasch, R.; Özkan-Haller,* The study shows that the utilization of renewable energy sources is a vital aspect for development of sustainability. Currently, an unexploited energy source is ocean waves. Various types of wave energy converters (WECs) are able to transform the motion of the waves into electricity. During the last 30 years, a wide range of prototypes was presented with different rates of success. The aim of this survey is to give an overview of how WECs are categorized [operation principle and power takeoff (PTO) system] and show what are the most important criteria that have to be kept in mind when designing a WEC. A few important WECs are described and evaluated.

### C. Estimating the Potential of Ocean Wave Power Resources.

*Izadparast, A.H.; Niedzwecki, J.M,* The study shows that the current state of the wave energy converters worldwide, introducing the most promising devices to date and the governing processes behind their operation. This also includes an overview of existing and potential power take-off (PTO) systems for wave energy converters.

### D. Trial Test on Offshore Wave Energy Device

*XiongboZheng, MingzeJi, Fengmei jing, Ye Lu, Wenhui Zheng, Shuanghong Zhou, Xialoe Li, Han Yan,* The study shows that the wave energy has not yet been commercialized due to its high cost and low efficiency. The combination of wave energy devices and breakwaters can greatly improve the utilization of breakwaters and also reduce the cost of wave power generation devices. In this paper, four oscillating buoy wave energy devices with different geometries are proposed, where a kind of dolphin buoy design method with excellent energy harvesting mechanism is formed. And the integrated method of wave energy device and floating breakwater is proposed and the integrated model is tested in the tank, and on the basis of that a one-year sea trial test of the prototype was carried out in the real sea area, and the power generation performances of the wave energy device under different sea conditions are analyzed. The sea trial results show that the average energy conversion efficiency of wave energy device can reach more than 18% when the significant wave height is from 0.5 m to 2 m and an average period is from 2 s to 6 s, and that can even reach 27.2% under the optimal sea state. The research and manufacturing process of sea trial prototype and the sea trial operation of the prototype show that the combination of oscillating buoy wave energy device and floating breakwater can reduce the construction cost of wave energy device and also improve reliability and energy conversion efficiency of that. The research results of this paper are of great significance for the further commercialization of wave energy devices.

## III. PROBLEM DEFINITION

Ocean wave energy is captured directly from surface waves or from pressure fluctuations below the surface. Waves are caused by the wind blowing over the surface of the ocean. In many areas of the world, the wind blows with enough consistency and force to provide continuous waves. There is tremendous energy in the ocean waves. Wave power devices extract energy directly from the surface motion of ocean waves or from pressure fluctuations below the surface. The problem is that it's not easy to harness this energy and convert it into electricity in large amounts. Thus, wave power stations are rare. This project attempts to capture the energy from wave and convert it into electricity.

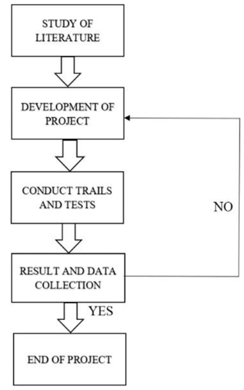
1) Problems occurred before related to these technologies are:
2) Mostly the current technology are consist submerged or floating type structures. So they affected to limitations (like corrosion, fouling) hence the special type of material required, Also design, operation quite complex; so they're not economic feasible.
3) Affecting the marine ecosystems.
4) Generally located to deep sea, so the power distribution not reliable. In some of the cases chances of international conflict.
5) The limitations of working principle, the continuous power output not achieve. (Depending on Flood tide and ebb tide, Air pressure difference.)
6) These unavoidable variations in wave parameters also impose changes in WEC outputs. When the WEC runs at wave conditions below what it is designed for, it is called part-load operation. Similarly, wave conditions exceeding design conditions impose overload operation. At these two operating conditions, WEC output is reduced (i.e., the energy conversion efficiency drops). The overload could also lead to significant structural damage.
7) Current technologies does not make it available to coastal rural areas

## IV. RESEARCH METHODOLOGY

### A. Working Principle

This project works on the principle operation of aqua Wave energy convertor with certain modification The device consists of a floater connected to rack and pinion arrangement with sprocket and freewheel to avoid the backward rotation. The sprocket teeth's are removed through machining such that it could be press fitted into the enlarged inner diameter of the pinion. A dc motor and a flywheel is used. The pinion with sprocket is mounted on the flywheel which is connected to the dc motor with the help of open belt. This way only either clockwise or anticlockwise rotational motion of pinion would be transfer to the dc motor. As wells as flywheel helps to attain continuous power generation. A steel framework is use to support this mechanism. The floater functions as a base to capture the movement of wave. As the float oscillates up and down, the rack oscillates too resulting in rotating the pinion and the flywheel further the rotational power is transmited to the dc motor through the open belt drive.

*B. Flow chart*




*C. Components of Power Generation using Sea Tidal Waves*

1) *Rigid Frame:* The rigid frame function as a strong hold to all the components the material which is used in making the frame is mild steel. The MS is easily weldable and cost effective which gives a advantage in fabrication, The has appropriate dimensions such that the float can easily reciprocate without any abstraction The frame is 90 degree angle frame which reduces the overall weight of the project the dimensions of angle frame are 40 x 40 x 3 mm dimensions The overall dimension of frame is 1000 x 650 x 400 mm.
2) *Rack and pinion:* The rack and pinion are the principal components of this project. The linear harmonic motion of the rack is converted into the electrical power with the help of pinion and a Dc motor. The force of the ocean waves lift the float and the rack. Therefore the rack has to be rigid and should able withstand the sudden impact forces, as well as it has to be lighter in weight so that it could lift. The rack dimensions are 30 x 30 x 800 mm and the pinion dimensions are 12dp 47 teeths
3) *Dc motor:* The rotating energy of the flywheel is converted into the electrical energy. The Dc motor is of 24 v, 150W dc dynamo max rpm is between 2600-3000 rpm and the rated current is 14.3A . The belt drive is fitted to an 8mm d-cut shaft with a circlip. It is also removable
4) *Flywheel And Freewheel Sprocket:* The function of the flywheel is to store the energy and provide when required. When the freewheel sprocket is in free rotation The flywheel will keep rotating in one direction due to inertia from the previous stroke thus providing the stored energy. The flywheel could be the medium of the continuous energy supply.The sprocket is mounted inside the pinion by enlarging the inner diameter of the pinion and freewheel is press fitted in to the pinion. Freewheel helps to restrict the oscillatory rotating movement of the Dc motor shaft and only allowing power transfer in one direction.
5) *Float:* Float selected here is on basis of weight, ability to float and should have a symmetrical shape the function of the float is to capture the wave motion and transfer it to the rack and other elements.
6) *Castor wheels:* As one of our aim is to make the project easily portable to accomplish that four castor wheels are joint at the bottom corners of the rigid frame. Hence giving access to all freedom of axis.
7) *Belt:* The function of the belt is .to drive the Dc motor. The belt is attached to the flywheel and the motor shaft with help of small pulley mounted on the motor shaft

## V. DESIGN AND CALCULATIONS

*A. Solid Works Model*

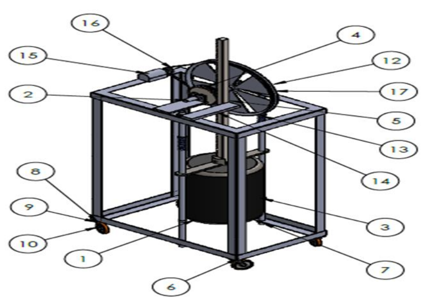
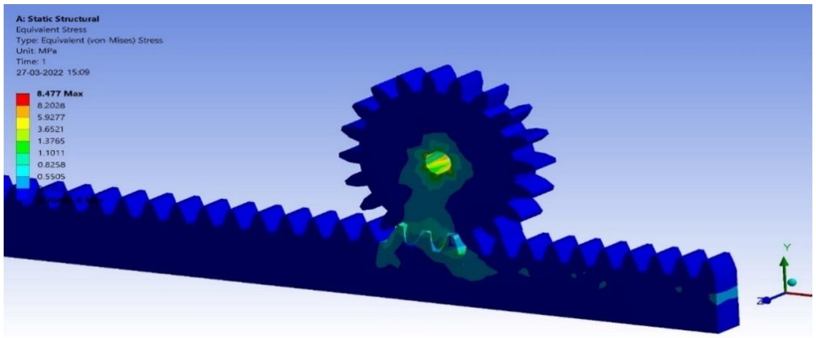



Figure 1: Assembly of Project using solid work

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 10 Issue III Mar 2022- Available at www.ijraset.com*

*B. Analytical Part of Rack and pinion using Ansys*



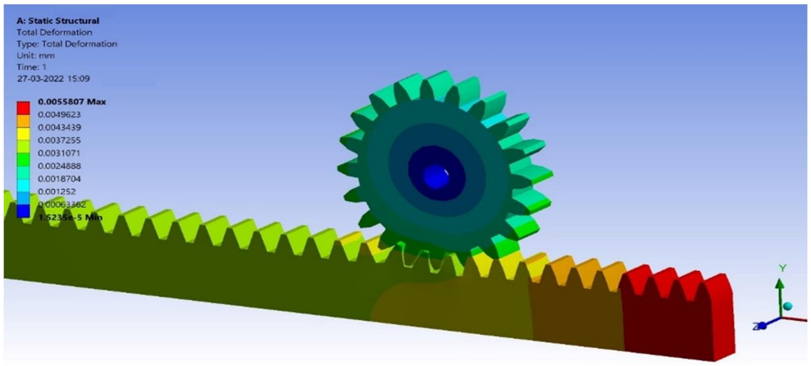




Figure 3: Analytical Part of Rack and pinion using Ansys

*D. Estimated Power Generation*

N -no of revolutions

P- power in watts

$$P = \frac{2\pi N}{60} * torque$$

$$N = 120 * \frac{electrical\ frequency}{no\ of\ poles}$$

The nominal frequency grid in india is of 50Hz

If we select a 2 pole generator motor

$$N = 120 * \frac{50}{2}$$

$$N = 3000\ rpm$$

Substituting this value in the power equation

The torque on the motor shaft

$$1000 = \frac{2\pi * 3000}{60} * torque$$

$$T = 3.183\ Nm$$

velocity of wave near shore = 1-3 m/s

near the shore power density is:

$$= \frac{Power}{Area} = \frac{P}{A}$$

$$=558\ W/m^2$$

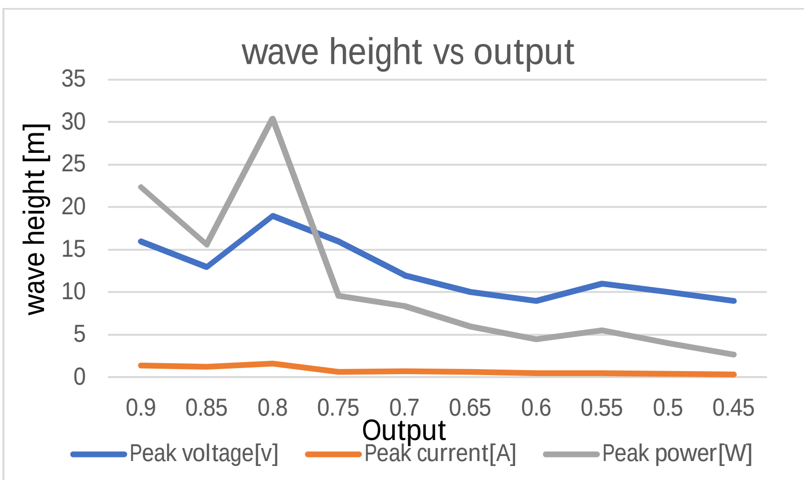
International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 10 Issue III Mar 2022- Available at www.ijraset.com*

## VI. RESULTS

During the practical performance of the project, we observed that the project is capable of generating power. we tested the project at its fullest potential The time of testing was around 16.00, the total period of testing was 90 minutes. Wind speed was around 14km/h the water level was 0.5 m and the average wave heigh was around 0.9 m the average wave period observed was approximately 4.5 seconds. And the wave frequency was approximately in between 0.2 to 0.4 waves per second. It was observed that the range of voltage generated is about 8 to 19 volts, The maximum voltage generated was 19 volts. It was also observed that the wave height plays a prominent role the more the wave height the more the deflection of the float from its mean position. The vertical velocity of the float also a key to generate the higher voltages. The more the vertical velocity the more the flywheel will rotate and the dc motor will produce higher voltages.

| Sr. No. | Wave height (m) | Wave period (s) | Peak voltage (V) | Peak current (A) | Peak power (W) |
|---|---|---|---|---|---|
| 1 | 0.9 | 3 | 16 | 1.4 | 22.4 |
| 2 | 0.85 | 3 | 13 | 1.2 | 15.6 |
| 2 | 0.8 | 3 | 19 | 1.6 | 30.4 |
| 3 | 0.75 | 4 | 16 | 0.6 | 9.6 |
| 4 | 0.7 | 3 | 12 | 0.7 | 8.4 |
| 5 | 0.65 | 4 | 10 | 0.6 | 6 |
| 6 | 0.6 | 5 | 9 | 0.5 | 4.5 |
| 7 | 0.55 | 4 | 11 | 0.5 | 5.5 |
| 8 | 0.5 | 5 | 10 | 0.4 | 4 |
| 9 | 0.45 | 5 | 9 | 0.3 | 2.7 |
| 10 | 0.4 | 6 | 8 | 0.3 | 2.4 |

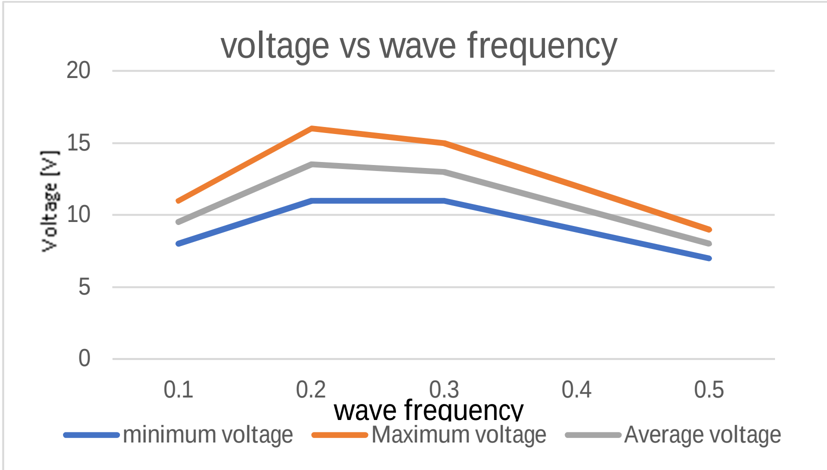
Table 1: Output for different wave height




Graph 1: Wave height vs output

| Wave Frequency [hz] | Voltage [V] | | |
|---|---|---|---|
| | Minimum | Maximum | Average |
| 0.1 | 8 | 11 | 9.5 |
| 0.2 | 11 | 16 | 13.5 |
| 0.3 | 11 | 15 | 13 |
| 0.4 | 9 | 12 | 10.5 |
| 0.5 | 7 | 9 | 8 |

Table 2: Voltage output for different frequencies




Graph 2: Voltage vs Wave Frequency

## VII. SUMMARY

Electricity generation is the leading cause of industrial air pollution. Most of our electricity comes from coal, nuclear, and other non-renewable power plants. Producing energy from these resources takes a severe toll on our environment, polluting our air, land, and water. Renewable energy sources can be used to produce electricity with fewer environmental impacts. It is possible to make electricity from renewable energy sources without producing CO2, the leading cause of global climate change. One of the many renewable resources is wave energy, this project proposed a devices that convert the kinetic and potential energy associated with a moving ocean wave into useful electrical energy. The mechanism used falls under the category of point absorbers it uses a rack and pinion arrangement, floater, flywheel and a dc motor. The device model is tested in real sea area and the results shows that the device could generate power and the performance could increase under optimal sea conditions. The projects is environmental friendly, compact in size, portable and cost effective.

## VIII. CONCLUSION

As the conclusion, we can generate electricity from renewable sources of energy like ocean wave. Ocean wave energy is captured directly from surface waves or from pressure fluctuations below the surface. One of the ways to generate electricity from it is by using rack and pinion arrangement. It uses upward and downward motion of the float which drives the flywheel and the dc motor and results in generating electricity. So, the model very suitable since it follows the vertical motion of the wave. This application can only be done for offshore projects. Apart from that, we should also consider types of waves available because wave power is determined by wave height, wave speed, wavelength, and water density. Wave power is important for floater movement which will relate to rack movement. Some works had been done to calculate correct data to be used for this project. The experiment had been done in the real sea area. The power output can be scaled up by either increasing the number of modules built or with certain modifications.

## IX. FUTURE SCOPE

The power generation depends on different factors such as wave height, speed and frequency More the height of the wave more the displacement of the floater from its mean position results in more power output therefore the model's height could be extended to twice the current height. The weight of the rack also alter the result therefore more lighter material can be used to fabricate the rack like nylon cast The model which we developed extract the energy only from the downward stroke of the rack due to the limitation of single dc motor. The power generation could be doubled if instead of single dc motor two dc motors are used and the terminals are connected in series. The flywheel used is of 0.4m in diameter, the flywheel can be used of bigger diameter and of more weight because it will store more energy in one stroke which can be used later to produce continuous power output. The material and dimensions of the float could also be modified, the height of the floater could be halved and the material could be of hard and light in weight. The dc motor is used as dynamo which is useful at when the torque is low but for higher torques an alternator is an option which can give considerable amount of power outputs.

## X. ACKNOWLEDGMENT

We would like to express our deep sense of respect and gratitude toward our guide, Prof. Abdul Bari, who didn't only guide the academic project work but also stood as a teacher and philosopher in realizing the imagination in pragmatic way, we want to thank him for introducing us to the field of Optimization and giving the opportunity to work under him. His optimism has provided an invaluable influence on my career and outlook for the future. We consider it our good fortune to have got an opportunity to work with such a wonderful person. He has been great source of inspiration to us and we thank him from bottom of our heart. We like to express our gratitude to our workshop staff, our Head of the Department, Prof. M.A. Gulbarga and our Principal Dr. Aqueel Ahmed Shah for their valuable advice and permission for carrying out project work inside the college premises. We are especially indebted to our parents for their love, sacrifices and Support. They are our teachers after we came to this world and have set great example for us about how to live, study and work.

## REFERENCES

[1] B drew, A.R.Plummer, M.N.Sahinkaya, A review of wave energy convertor, Received: 26 March 2016 / Accepted: 16 june 2016 / Published online: 16 june 2016.
[2] Pavol Bauer, Lenee-Bluhm, P.; Paasch, R.; Özkan-Haller, H.T. Characterizing the wave energy resource of the US Pacific Northwest. Renew. Energy,36, 2106–2119, 2015
[3] Izadparast, A.H.; Niedzwecki, J.M. Estimating the potential of ocean wave power resources. Ocean Eng,38, 177–185, 2011.
[4] XiongboZheng, MingzeJi, Fengmei jing, Ye Lu, Wenhui Zheng, Shuanghong Zhou, Xialoe Li, Han YanSea trial test on offshore integration of an oscillating buoy wave energy device and floating breakwater, Energy Conversion and Management, Volume 256, 15 March, 115375, 2022
[5] A.Ramadan, M.H.Mohamed, Hossam A Gabbar, Experimental analysis of an enhanced design of float with inverted cup for wave energy conversion, Ocean Engineering, Volume 249, 1 April 110910, 2022
[6] Domenico Curto, Lehmann, M.; Karimpour, F.; Goudey, C.A.; Jacobson, P.T.; Alam, M.R. Ocean wave energy in the United States: Current status and future perspectives. Renew. Sustain. Energy Rev,74, 1300–1313, 2021.
[7] H.P.Nguyen, Folley, M.; Whittaker, T.J.T.; Henry, A. The effect of water depth on the performance of a small surging wave energy converter. Ocean Eng,34, 1265–1274, 2020.
[8] Lucia margheritini, jens peter Kofoed, weptos wavesenergy convertors to cover the energy needs of the island Civil Engineering Department, Aalborg University, Thomas Manns Vej 23, 9220 Aalborg, Demark, Received: 25 November 2018 / Revised: 17 January 2019 / Accepted: 21 January 2019 / Published: 29 January 2019.
[9] Tunde Aderinto, T.O.; Haces-Fernandez, F.; Li, H. Design and Potential Application of Small Scale Wave Energy Converter. In Proceedings of the ASME 2019 International Mechanical Engineering Congress and Exposition, Tampa, FL, USA, 3–9 November; p. V006T08A084, 2019.
[10] Eugen Rusu, E.Onea, F. Estimation of the wave energy conversion efficiency in the Atlantic Ocean close to the European islands. Renew. Energy,85, 687–703, 2018.
[11] http://www.sciencedirect.com
[12] http://ocsenergy.anl.gov
[13] http://www.physorg.com
[14] http://www.hydro.gov.my