WAVE ENERGY HARVESTING SYSTEM

Department of Energy Science and Engineering

IIT Bombay

Aadya Pipersenia	**(20D170002)**
Atharva Chodankar	**(20D170008)**
Aastha Patel	**(20D170025)**
Ronak Matai	**(20D170035)**

ABSTRACT

The main aim of the project is to review the various types of Wave energy converter technologies and choose the system most suited to our country's wave energy generation potential.
Ocean wave energy has one of highest energy density among all forms of renewable energy, this coupled with the large 7500 km coastline of our country gives us a large source of untapped energy.

Making the technology cost effective and commercially viable is one of the main goals of people working in this field.

In this report we compare various Wave energy convertor devices, justify our design choices and show the various issues that Wave energy harvesting faces. An attempt is then made to estimate the energy generated by the device. We then describe economic and ecological issues with this method of energy harnessing.

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INTRODUCTION

Wind blowing over the surface of the ocean generates ocean waves with gravity acting as a restoring force. Wind energy essentially is originated from the sun's thermal radiation. The interesting thing to note here is that energy gets denser from solar to wind to wave energy

According to a paper by Falnes [1], per unit volume of energy in solar radiation is 0.1–0.3 kWm^{-2} which transforms to wind energy containing about 0.5 kWm^{-2} which finally causes the propagation of ocean waves containing 2–3 kWm^{-2} of energy. The high energy density of waves shows that it has a high amount of renewable energy waiting to be harnessed.

In this report, in the first part, we first highlight the challenges associated wave energy harnessing. In the second part of the report, we identify locations in India where wave energy harnessing is feasible. In the next two chapters, we justify the choice of our design and talk about how the design is mathematically modelled.

In the fifth part we make an attempt to calculate the energy output for this device. In the sixth part we talk about economic consideration and materials used for building our device and in the seventh part we highlight the environmental effects of wave energy harnessers.

Section 1

CHALLENGES OF WAVE ENERGY

- **Seasonal variations**:[2] A sea state is the general condition of the free surface of the ocean due to the wind waves, swell and other factors. The sea state is usually characterised by the height of waves, the time period of the ways and their power spectrums. Thus, in general sea states are very erratic and depend on the season, location, weather conditions and even time of the day. Sea states generally show trends for various seasons but change throughout the year. Thus, this variation in operation conditions makes it difficult to design a Wave Energy Converter (WEC) that operates efficiently and cope structurally with these erratic changes. The WEC design aims to match the peaks in its power-extracted frequency profile with the most common wave frequencies of the site, in order to maximize power extraction. These peak-power frequencies are related with hydrodynamic resonance frequencies and with the PTO performance.

- **Large wave periods**: most WECs rely on resonance to capture energy. Waves have generally larger time periods especially in highly energetic locations such as in Australia. High mass is required for the natural frequency of the WEC to match with that of the incoming wave, which causes the cost to skyrocket and causes design, maintenance, transport and mooring difficulties.

- **Theoretical difficulties**: WEC development is a very interdisciplinary field which incorporates control theory, hydrodynamics, finite element methods of fluid mechanics, mechanical to electrical energy transfer. This results in complicated modelling. Thus, in general location WEC Concept, Power Take-Off (PTO) type, control strategy and hydrodynamic resonance considerations are some of the critical aspects to take into account to achieve a good performance.

Figure 1

- **PTO mechanisms**: PTO stands for power-take off which is basically the process of how energy is converted from one form to another. Many forms of PTO exist such as linear generators, turbines and linear to rotary mechanisms. PTOs are generally designed for specific operating conditions which are unavailable in the ocean.

- **Survivability and Maintenance**: Harsh-sea conditions, storms and unconventional sea states with large wave heights bring about questions of structural integrity and survivability. Enough testing is not done in this area. One of the few buoys tested at such harsh conditions was the Power Buoy [**Figure1**]. Even maintenance of these devices is hard as they are generally placed 40-50km off the shore. More about the environmental impacts of WECs are highlighted in the seventh chapter.

- **Scalability**: The transition from design to testing to commercial manufacturing is extremely difficult for wave energy harvesters. There is a strong connection between wave energy at a given location and the geometrical design of a WEC. This implies that even for a WEC of the same type and power, the characteristics of its PTO and its geometry will have different designs for different locations under optimized design and operation conditions. Ruehl and Bull [**3**] [**Figure2**] suggested a design stage roadmap for WECs to transit from early design stages to full commercialisation. The iterations, developments, and optimization needed to reach commercialisation were detailed in the publication.

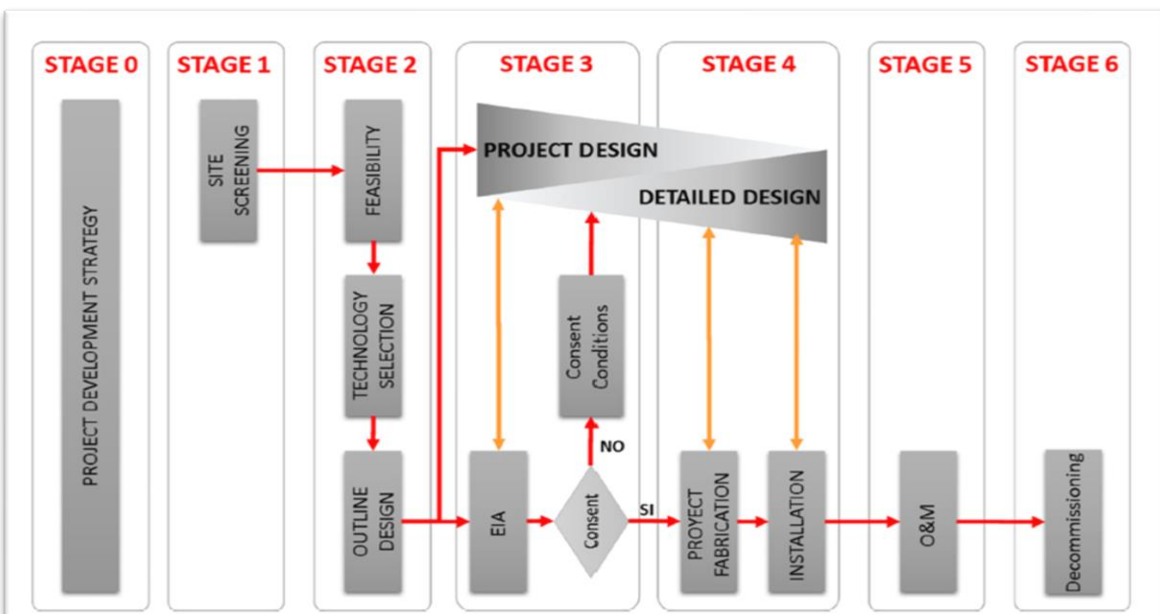

Figure 2

Section 2

LOCATION IDENTIFICATION

The power contained by a wavefront per unit wavelength in deep water.

$$J = \frac{1}{64\pi}\rho g^2 Hs^2 T_e \qquad (1)$$

ρ - the water density
g - gravitational constant
Hs - significant wave height
T_e - energy period

Ocean waves are a spectrum of regular waves with different heights and time periods. H_s defined as the mean wave height of the third highest waves, and mathematically calculated as four times the standard deviation of the ocean surface elevation. T_e is the energy period, it is defined as simulating an entire sea state with one sine wave, the energy period would be the period of this sine wave.

The wave patterns in India are not constant throughout the year, along the west coast of India, 83–85% of the annual wave power is during the summer monsoon period (June–September) whereas at Visakhapatnam (on the east coast), 55% of the annual wave power is during the summer monsoon period. The average wave power during the summer monsoon is high (15.5–19.3 kWm^{-1}) along the west coast of India. The annual average wave power (1.8–7.6 kWm^{-1}) along the locations in India is much lower than that available for temperate zones.

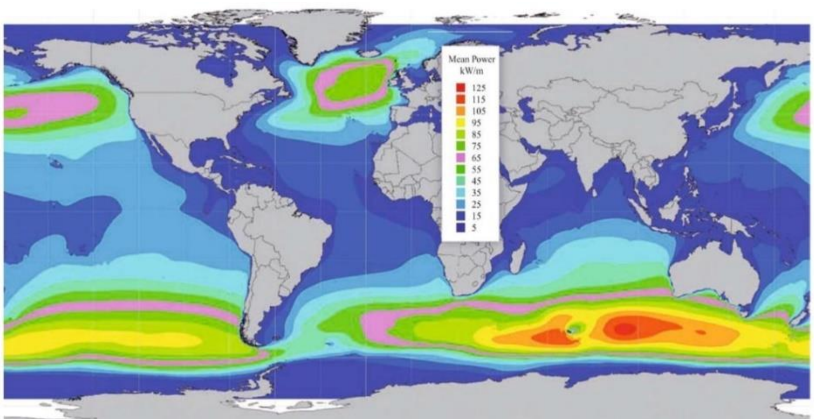

Figure 3

Analyzing wave power data from research papers, based on the distribution of available wave energy across the year, we decided that **Pondicherry** is an ideal location to set up a Wave energy harvesting farm, since it has the highest energy harvesting potential. [14,15]

For Pondicherry the significant wave height is 0.7m with an average wave period of 6.3s resulting in an average power generation of 1.8 kW/m. [**Figure 3**] gives us the wave power distribution across the world [**4**].

Section 3

POINT ABSORBER BUOYS

The most common technologies used for harvesting energy from the waves include

- Point absorbers
- Overtopping devices
- Attenuators
- Oscillating water column mechanism

In the wave energy research conducted by IIT Madras an oscillating water column mechanism was used to generate electricity from wave energy. However, we chose a point absorber buoy for the model design for quite a few designs.
Point absorber WECs contain a buoy which heaves up and down generating relative motion between a buoy and a fixed reference (one-body point absorber) [**Figure4**]. We

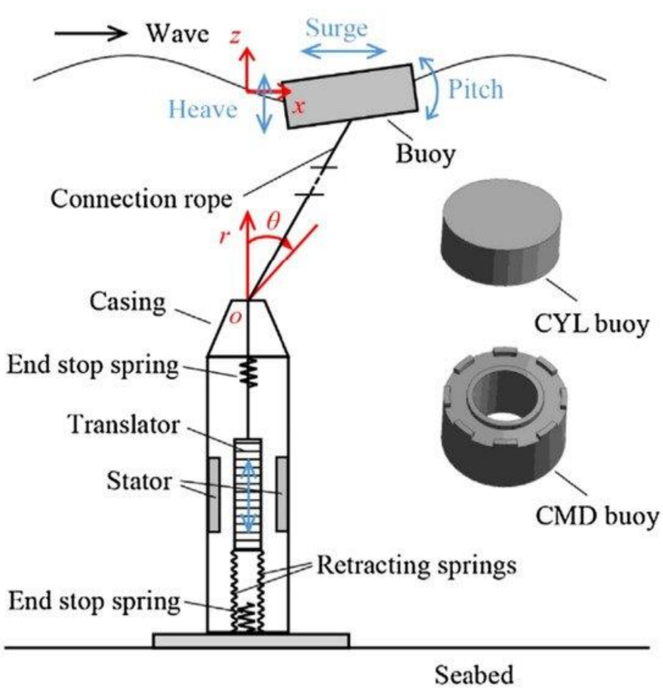

Figure 4

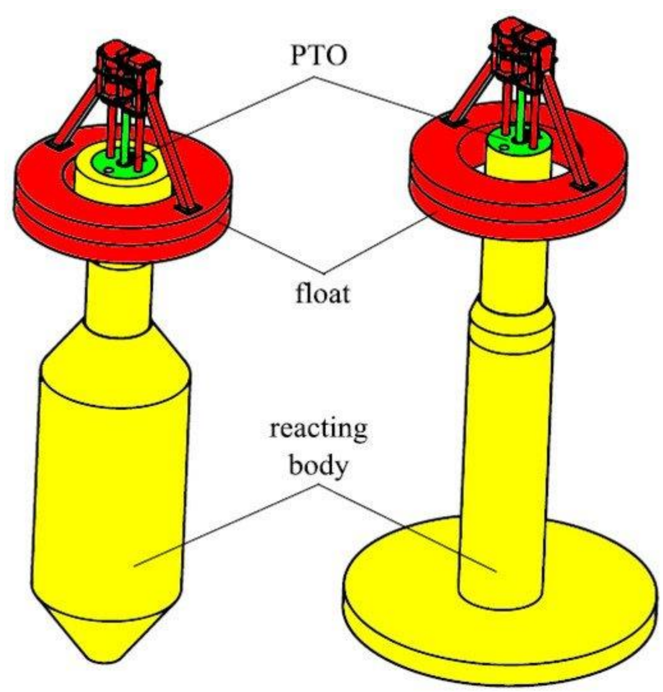

Figure 5

might, cause the buoy to have relative motion between itself (two-body point absorber) [Figure 5].

Point absorber buoys have been properly tested both scaled down models as well as large scale models in real seas [5,6,7]. Extensive papers have been written on the construction and modelling of such point absorber buoys [8]. In general this type of WECs have lesser complexity and thus are more easily optimised. It can harvest energy from various wave directions and offers high efficiency and reliability. We can also implement a range of control methods such as latching to optimise efficiency. Point absorber buoys are also easier to set up and very flexible. They also have space in the structure to incorporate other forms of auxillary energy. They can be set up in general almost anywhere in the ocean.

One-body point absorbers might present challenges in-order to combine natural frequency of the buoy with that of the incoming waves. To achieve such natural frequencies higher mass of the buoy Is required. The distance between the floater and the sea-bed is too big in energetic offshore locations.
A two-body point absorber tends to solve these issues with a submerged body below the oscillating buoy. The PTO is usually placed between the buoy and the submerged body therefore long connection is not required. However, these have not been as well optimised as one-body point absorber buoys.
Our model is a bit different then your conventional one-body point absorber. It has a series of buoys which are individually attached to their own rod. These rods run their own linear generator. These generators are held together by a structure. This entire structure floats on water. Since, the structure on top gives a flat area, there is also place to implement solar panels. We have taken inspiration for this model from SINN Power.[9]

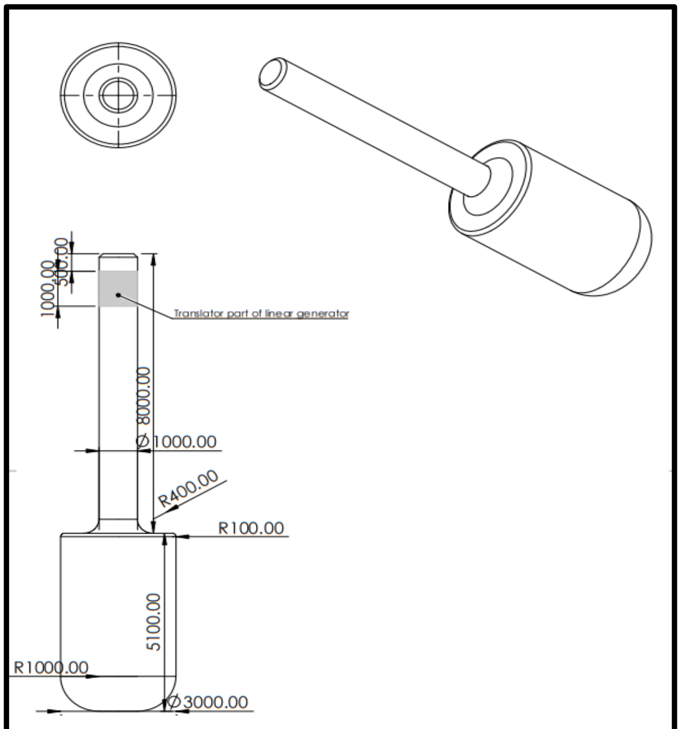

Figure 6: Dimensions of the Buoy

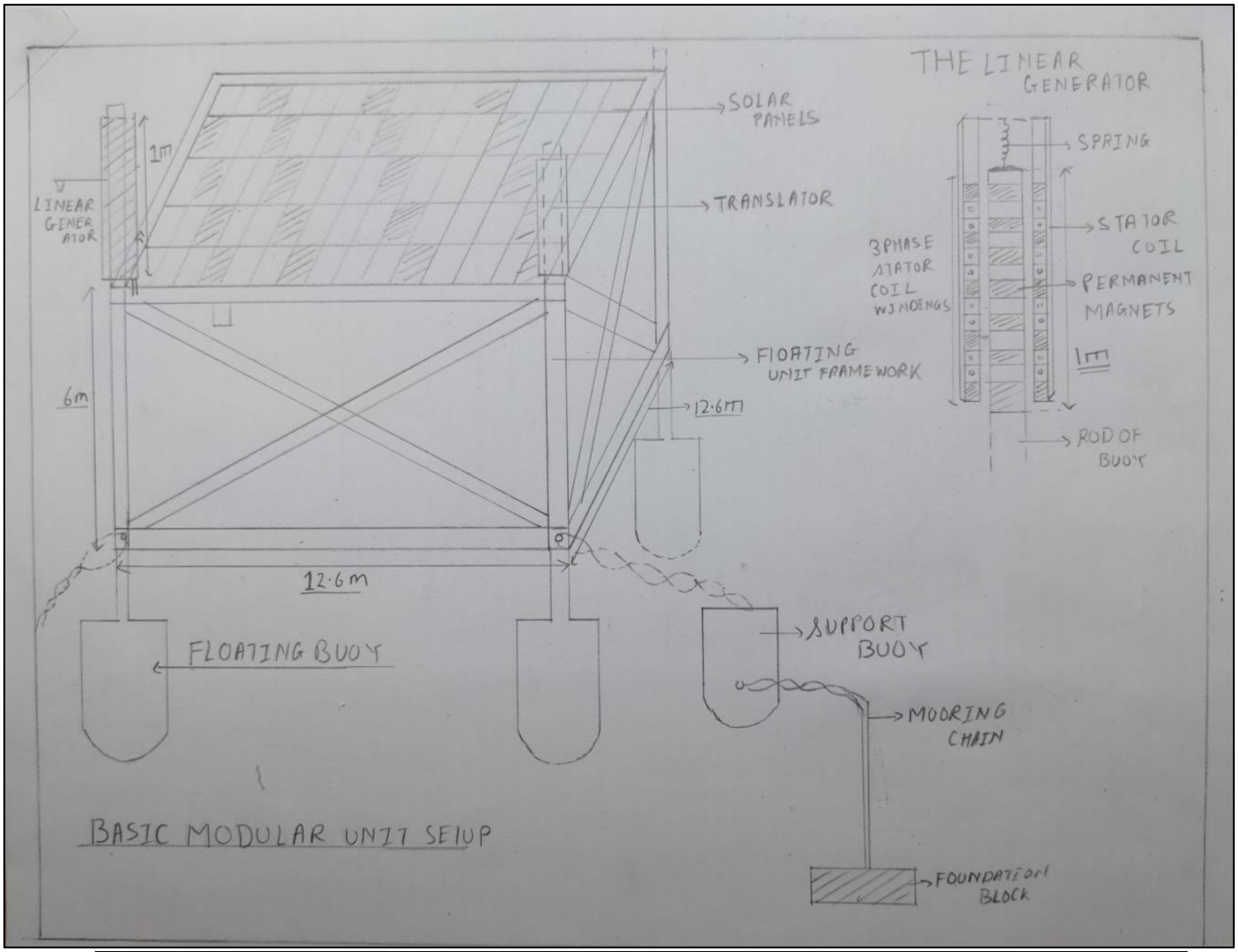

Figure 7: Basic modular unit set-up

Section 4

MODELLNG OF THE BUOY

Ocean Waves:

We use the following reference for a lot of explanation on how to model the buoy.[10] We first assume that the water flow is irrotaional and incompresible, which allows us to use potential flow theory.[11].Which basically means, we were able to write the velocity function of the water as a gradient of a function i.e. the potential. This then allows us to use linear wave theory to derive the equations of real waves. This process involves using the linearized unsteady bernoulli equation and other boundary conditions to solve the laplace equation that arises due to potential flow theory.[12,13]

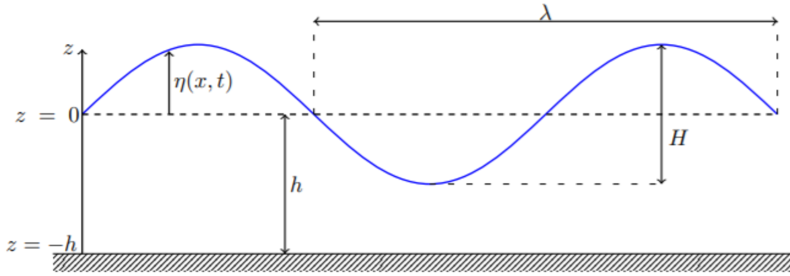

Figure 8: main parameters of the wave

- η(x,t) is the surface elevation.
- H is the wave height for the regular wave
- h is the depth of the water
- λ is the wavelength
- x is the direction of propagation of the wave

In [Figure 8] the set up of the linear regular waves of the ocean are described which using the above method gives the equation. It is important to note that this equaton of the linear wave is calcaulated by assuming that the water is deep which , which is ensured by taking the following assumption.
$h / \lambda >> 1$

$$\eta(x,t) = \frac{H}{2}\cos(\omega t - kx) \tag{2}$$

Irregular waves i.e a combination of the above regular waves are usually present in the ocean and their equation is therefore a superposition of the regular waves. For performing calculations with irregular waves we use terms like significant wave height Hs [average value of the highest one third heights of incoming waves] and energy period Te[wave period of a regular wave carrying the same amount of energy as the irregular wave].[16]

$$\eta(x,t) = \sum_{n=1}^{M} a_n \cos(\omega_n t - k_n x + \theta_n) \tag{3}$$

Here a_n, ω_n, k_n and Θ_n are the amplitude, angular frequency, wavelength and phase difference of each wave. In an attempt to mathematically describe this set of irregular waves we use an energy density spectrum, which describes the amount of energy transported in the wave per wave angular frequency ω_n. This spectrum depends on H_s and T_e. Two such common spectrums are the JONSWAP spectrum and the Pierson-Moskowitz spectrum, both of which are used under certain assumptions. [17] In this paper we did not have access to software such as WAMIT or ANSYS AQWA to set up such spectra and so have assumed a regular wave with wave height H_s and time period T_e.

The Buoy Motion:

The general buoy motion is defined by six degrees of freedom; the movement in x, y, z directions and the rotations around the x, y, z axes. By common notation we call these six degrees of freedom: surge, sway, heave, roll, pitch and yaw. [Figure 9] shows us the

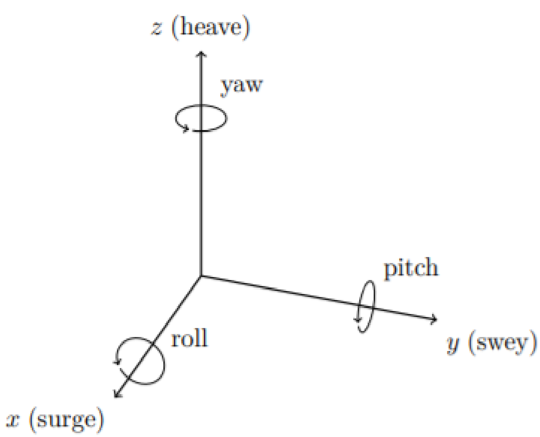

Figure 9

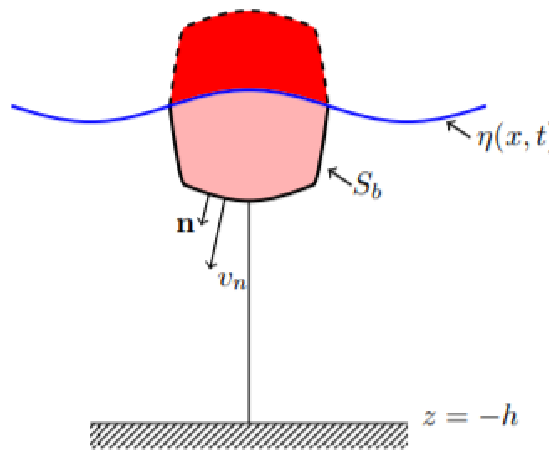

Figure 10

six degrees of freedom of the buoy and [Figure 10] is the representation of the buoy in a regular wave. In the assumptions the buoy only moves in the x-z plane and so the calculation can be simplified to three degrees of freedom namely heave, surge and pitch. Further calculation involves, using the linearized Bernoulli equation as before in combination with boundary conditions imposed by the buoy and the ocean to solve Laplace's equation for this new set up. The potential of water force is divided into 3 potentials which result in various forces. Essentially, the forces are split of by considering the potential as the sum of the potential due to the presence of the buoy in the wave and the potential generated due to the radiated wave generated by the buoy' s oscillation.

The Forces Acting on The Buoy:

The forces acting on the buoy can therefore by classified as:

1. **Hydrostatic force** - hydrostatic restoring force
2. **Radiation force** - due to radiating wave the oscillating buoy creates
3. **Excitation force -** due to fixed buoy in an incident wave
4. **Drag force** - due to water friction
5. **Mooring force**- force due to action of wires or other structures anchoring the buoy
6. **PTO force**- The power take-off unit generally has a spring and damper associated with it and this affects the motion of the buoy too.
7. **Other external forces**- these might include forces such as those required to clamp the buoy in case of latching

Note:

1. Hydrostatic, Radiation and Excitation force come out of the linearize Bernoulli equation by splitting the equation.
2. The excitation force is the force acting on the buoy assuming the buoy is at rest in an ocean of a particular sea-state.
3. The radiation force is the force acting on the buoy due to the oscillatory motion of the buoy in the still sea (i.e. it radiates waves outward).
4. Drag force has to be added separately because we have assumed non-viscous fluids in potential flow theory
5. The other forces should also be considered. However, in-order to simplify our calculation we have avoided it.

Phase Control and Latching:

The optimal movement of a buoy occurs when the natural frequency of the buoy is the same as frequency of the incoming wave so that buoy is in resonance with the wave. In-order for the natural frequency especially that of a one-body point absorber to match with that of an ocean wave, buoys with very high mass are required which leads to a whole lot of transportation, maintenance and cost issues.
In order to maximize power extraction from the waves, a latching mechanism can be used so as to match the frequency of oscillation of the bob with the natural frequency of ocean waves at that instant. The buoy is held and allowed to oscillate for specific

periods of time in-order to increase overall energy generated. This again is not implemented in our model.

Cylindrical Buoy:

For simplifying our calculations, we have assumed a cylindrical buoy structure. Calculating the above forces requires complicated integrals of software like WAMIT or ANSYS AQWA which we did not know how to use. We found a paper [18], in which the differential equation to model a cylindrical buoy is calculated and given. We thus, use these formulae to model the buoy. Considering, only the forces in the heave direction, we get the following differential equation.

$$(m + m_{33})y'' + B_{33}y' + C_{33}y = F_3(t) \tag{4}$$

The added mass m_{33}, the dumping coefficient B_{33} and the restoring coefficient c_{33} are given as

$$m_{33} = 0.167\rho D^3 \tag{5}$$

$$B_{33} = \frac{8}{3\pi}\frac{\Delta y}{0.5T}(0.5\rho C_D L_b D) \tag{6}$$

$$C_{33} = \rho g A_c \tag{7}$$

ρ is the density of water, D is the diameter of the bouy, T is the time period which we have taken as T_e, C_d is the drag coefficient, Lb is the draft length(i.e the length of the buoy in the water) and A_c is the area of cross section of the buoy with the water. The further constants are defined as

$$\Delta y = \frac{Fy/C33}{[1-\Omega^2]^2+[2\eta\Omega]^2}, \Omega = \frac{\omega}{\omega_n} \tag{8}$$

$$\omega_n = \sqrt{\frac{C_{33}}{m+m_{33}}} \quad \omega_d = \omega_n\sqrt{1-\eta^2} \tag{9}$$

$$\eta = \frac{0.5B_{33}}{(m+m_{33})\omega_n} \tag{10}$$

ω_n is the natural frequency of the buoy, ω is the frequency of the wave ,F_y is the vertical inertia force acting on the buoy and η is the damping ratio .$F_3(t)$ is the wave excitation force.

$$P_C = 0.5\rho g H_w e^{ky}\cos(kx - \omega t) \tag{11}$$

$$U_y' = 0.5H_w\omega^2 e^{ky}\cos(kx - \omega t) \tag{12}$$

$$F_y = F_{fy} + F_{ay} = P_C A_C + m_{33}U_y' \tag{13}$$

Section 5

CALCULATIONS

We therefore, take some initial values and model the equations in MATLAB and plot the displacement of the buoy with time using SIMULINK. In the above equations for estimating the wave excitation force we used formulae given in paper [19]. This paper gives us the estimation of heave excitation force in a water of infinite depth for a floating vertical cylinder. In combination with this formula and the theory in the previous section we wrote the following code. A link [20] to a github repository with the following code is also attached.

Mass of the buoy is taken as 6321.41 kgs which is calculated by using density of polyurethane and polyethylene. The cylinder is a buoy made of polyurethane with a 10cm cylindrical polyethylene coating.

Diameter of the buoy is taken as 3m and the length of the buoy is 5.1 m. Coefficient of drag is assumed to be 1.2 which is taken from an empirical relation given in paper [18].Draft length of the buoy in water comes out to be 0.78 m form using Archimedes principle

```
minus1=-1;
d=3;% diameter of the buoy
c_d=1.2;%coefficient of drag
rho=1020;% density of sea water
m=6321.41;% mass of buoy calculated
g=9.8;%gravity
A_c=pi*d*d*0.25;% area of intersection of buoy with the water
rho_al=2700;% density of aluminium rods
m_al=500;% mass of aluminium rod on top of buoy
m=m+m_al;% total floating mass in a buoy
H_s=0.7;% significant height of ways in puducherry
buoy_lenght=5.1;% length of the cylindrical buoy
T_e=6.3;% the energy period of waves in puducherry
lam=12.6;%approximate wave speed for puducherry is 2m/s ,therefore lambda is speed * Te
draft_l=0.78;% lenght of buoy in water
omega= (2* pi)/T_e;% angular frequency of the buoy
m33=0.167*rho*d*d*d;% added mass during oscillation
k=(2*pi)/lam;%wave number
c33=rho*g*A_c;%restoring coefficient
omega_n=sqrt(c33/(m+m33));%natural frequency of the buoy
ratio=omega/omega_n;
alpha= (8/(3*pi*T_e))*rho*c_d*draft_l*d;% alpha,beta, gamma and delta are just a few constants to make calculations ahead easier
beta= 0.5/(omega_n*(m+m33));
gamma= c33*c33*(1-(omega*omega))*(1-(omega*omega));
delta= c33*c33*4*omega*omega;
```

Figure 11: Part 1 of matlab code

```
% the following calcualtion is of the wave excitation force i.e. reference
% 19 of the report, these calculations involve bessel functions and
% integration to infinity which has been approximated ahead with the for
% loop to 900 because terms after that our considerably negligible
%the wave excitation force is varied for different points of the cylinder
%so its average complex value is taken
const=-11*pi*rho*omega*d*sqrt(2/pi);
j0=besselj(0,k*d*0.5);
j1=besselj(1,k*d*0.5);
y0=bessely(0,k*d*0.5);
y1=bessely(1,k*d*0.5);
q_real= -1*besselj(1,k*d*0.5)/((j1*j1)+(y1*y1)) *(j0*j1)+(y1*y0);
q_imaginary= -1*besselj(1,k*d*0.5)/((j1*j1)+(y1*y1))*(j1*y0-j0*y1);

f_avg_real=0;
f_avg_imaginary=0;
for x=-1.5:0.1:1.5
    imaginary_const=const*g*H_s*0.5*sqrt(2/pi)/omega*(j0+q_imaginary)*exp(-1*k*draft_l)*k/((x*x)+(k*k));
    real_const=const*g*H_s*0.5*sqrt(2/pi)/omega*q_real*exp(-1*k*draft_l)*k/((x*x)+(k*k));
    integrand_imaginary=@(c) imaginary_const.*(besseli(1,c*x)./besseli(0,c*d*0.5))./c;
    integrand_real=@(c) real_const.*(besseli(1,c*x)./besseli(0,c*d*0.5))./c;
    f_excitation_real=0;
    f_excitation_imaginary=0;
    for r=1:900
    f_excitation_real=f_excitation_real+integrand_real(r*0.01)*0.01;
    f_excitation_imaginary=f_excitation_imaginary+integrand_imaginary(r*0.01)*0.01;
    end
f_avg_real= f_avg_real+abs (f_excitation_real)/30;
f_avg_imaginary=f_avg_imaginary+abs(f_excitation_imaginary)/30;
%the values of forces sort of stabilize here after looping for 100000
%times now lets just avergae it out
end
% in order to see the output of the displacement of the buoy with time in
% the simulink model ,click on run and then the scope block connected to
% the y signal
```

Figure 12: Part 2 of matlab code

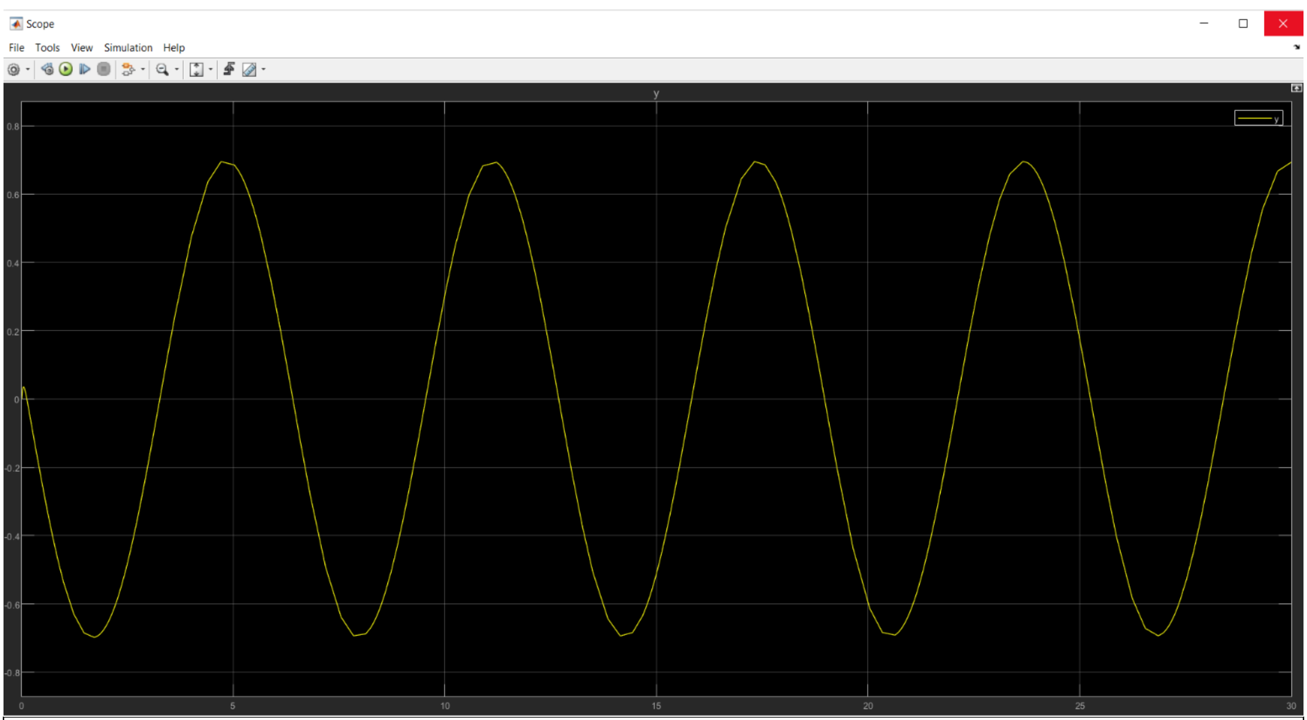

Figure 13: Displacement of buoy with time

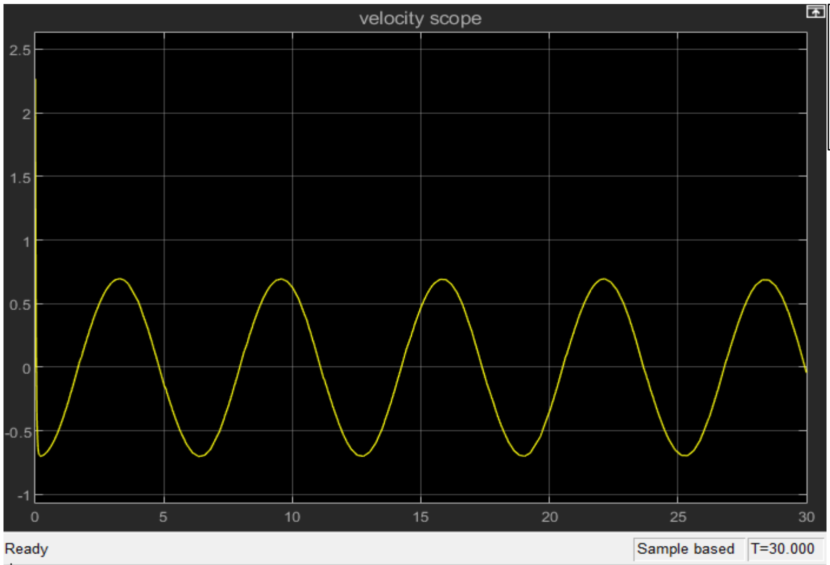

Figure 14: Velocity of the buoy with time

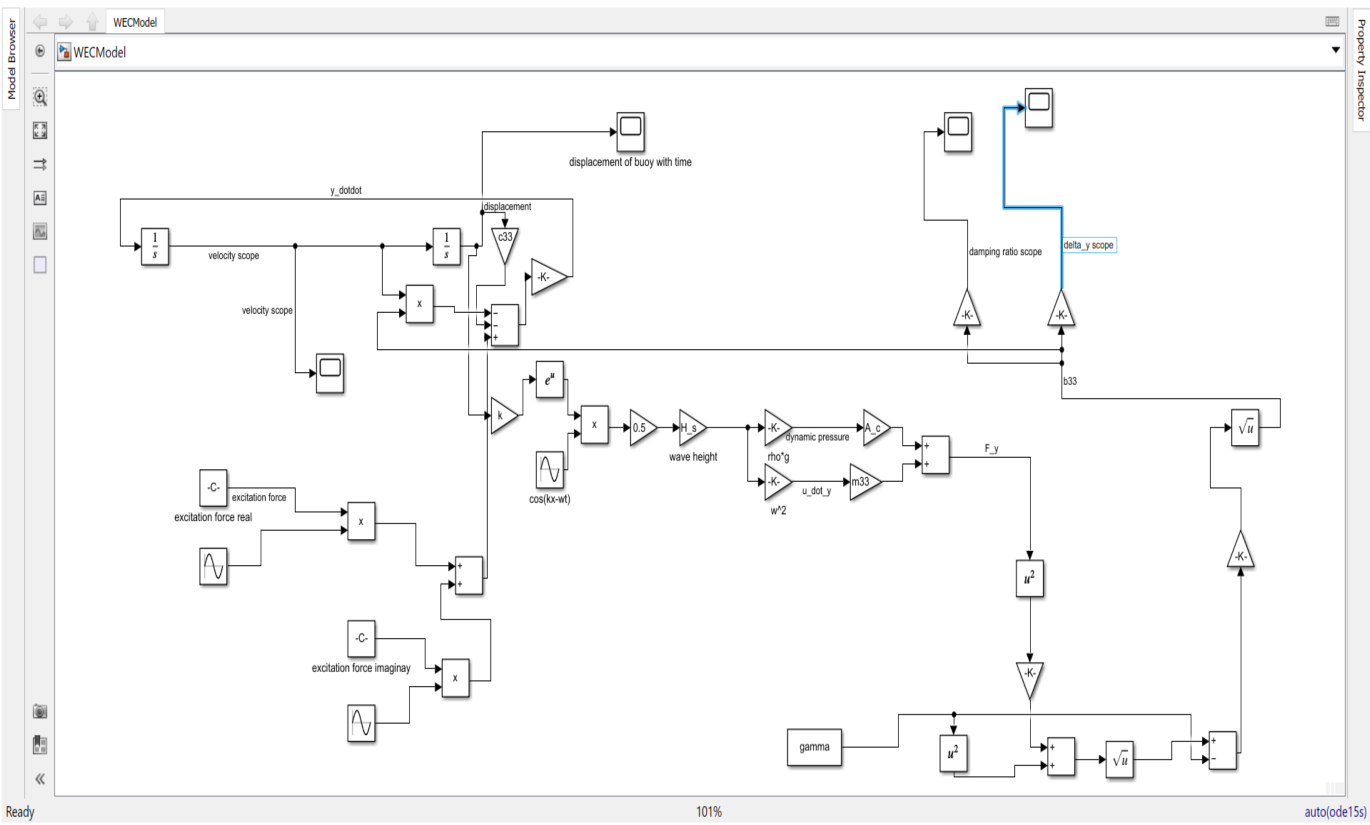

Figure 15: SIMULINK Model

PTO calculations:

Linear generators are the best form of PTO for a point absorber system. The basic concept is relative motion of a magnet in a stator generates an induced emf in the stator which gets converted to electric energy. These are the formula to calculate the power generated by the linear generator . B is magentic flux density. N_{pp} is number of turns per pole per phase. K_w is winding factor, q is the number of slots per pole and phase, ns is the number of conductors per slot, c is the number of parallel current paths per phase. I_{dens} is current density, H is the stator height l_s is the total stator length. τ_p is the pole pitch. We did not understand the formula properly and so assumed a motor of efficiency 75%

$$E_f = \sqrt{2}N_{pp}Bl_spv \qquad (14)$$

$$N_{pp} = \frac{k_w q n_s}{2c} \qquad (15)$$

$$P_f = E_f I = \frac{\sqrt{2}k_w}{81cq}BvI_{dens}n_sl_sH\tau_p \qquad (16)$$

On approximating the periodic curve of velocity on top we get a sine curve of the equation

$$v = -0.7 \cos t \qquad (17)$$

So kinetic energy input to the linear motor is

$\frac{1}{2}m_{tot}v^2$ = 0.5 x 6821.4 x (0.245) = 835.6215 J

Where m_{tot}= 6821.4 , v_{rms}=0.245

Energy output = 75 % of Kinetic energy= 626.7 J

We have assumed that waves are constant and therefore replenish the kinetic energy. Thus, 626.7 W is the power ouput of the WEC plant (approximately)

Solar energy generated calculations:

Size of PV module = **1239 x 329 x 34 mm**
Area of single module= **0.42 m^2**
Area available on the top of WEC= **144 m^2**
Number of modules installed = **343 (approx)**
Annual average solar radiation at puducherry = **5.5 kWh/ m^2/day** [23]
Incident energy = I x A x t = **5.5 x 144 x 365 kWh =289080 kWh/year**
(Where I is solar insolation , A is area of solar panels and t is time in days)
Considering, the efficiency of solar modules to be 15% , energy generated = **289080 x 0.15 = 43362 kWh**
For simple calculations it can be assumed that 1kWp plant generates approximately 120 units per month .[24]
Monthly generation = **3613.5 kWh**
Capacity of the solar part of the plant= 3613.5/120 = **30 kWp (approx)**

Section 6

ECONOMIC CONSIDERATIONS

References [21] and [22] are used for this section. The LCoE **[Levelized Cost of Energy Assessment]** represents the most important factor to efficiently compare different energy sources and evaluate the economic feasibility of new investments in the renewable energy sector. It accounts for capital, operating and decommissioning costs, experienced from the preliminary design up to the end of the plant lifetime.

The LCoE acts as an overall indicator of the economic aspects of the project, allowing investors to decide whether they should invest in the project, by relating the risk perceived by the investor to the rate of investment of the project.

Assuming that the yearly maintenance costs are constant during the plant lifetime, the LCoE is determined according to the following formula:

$$\mathrm{LCoE} = \mathrm{SCI}.(1 + \mathrm{r})^{n} + \frac{\mathrm{SDC}}{8760\mathrm{CF}} \frac{\mathrm{r}}{((1 + \mathrm{r})^{n} - 1)} + \frac{\mathrm{OM}}{8760\mathrm{CF}}$$

I. SCI, SDC and OM the ratios of capital, decommissioning and annual operating costs to the device rated power R in €/kW.
II. r the discount rate.
III. n and CF the device expected lifetime and capacity factor, respectively.

R&D Costs

Since technologies such as WECs are still in the early stage of development, the research and development costs which go into such project are also relatively very high.

Capital Costs

These are the basic infrastructure and material costs required to construct the project. In case of WECs the Buoy, and generator are the most expensive parts.

Decommissioning Expenses

It is assumed that both the electric generator and the floating buoy are not reusable, but rather recycled and sold for scrap. Hence, it is safe to assume decommissioning costs to be 20% of the capital ones, provided that they have not been experienced for wave energy plants.

Annual Operating Expenses

The average annual O&M costs for WEC systems is generally about 5% of the capital costs.

Item	Material	Current Unit Cost	Unit Cost Range
Permanent magnets	Neodymium-Iron-Boron	80 €/kg	60–100 €/kg
Stator	Electrical steel	2 €/kg	1.5–2.5 €/kg
Translator	Electrical steel	2 €/kg	1.5–2.5 €/kg
Rim	Aluminium alloy	5 €/kg	4–6 €/kg
Cables (16 mm2)	Electrical copper	5 €/kg	4–6 €/m
Foundation	Marine concrete	300 €/m3	200–400 €/m3
Manufacturing	-	25 €/h	-
Floating buoy	Normal Strength Steel	4 €/kg	3–4 €/kg

LCoE Assessment

Item	Symbol	Equation/Value
Capital cost to power ratio	SCI	$3500 + 500 + 40\pi\ D^2$ €/kW
Decommissioning cost to power ratio	SDC	0.20SCI €/kW
Annual operating cost to power ratio	OM	0.05SCI €/kW
Discount rate	R	0.07
Device expected lifetime	N	25 years

Costing of our designed buoy:

Material rates:

Polyurethane = Rs. 240 per kg ; Polyethylene = Rs. 120 per kg

Aluminum = Rs. 143 per kg

Total polyethylene cost = $940 \times 3.14 \times \{(1.6)^2 - (1.5)^2\} \times 5.1 \times 120$

= Rs 559977.55

Total polyurethane cost = $45 \times 3.14 \times (1.5)^2 \times 5.1 \times 240$

= Rs 389140.20

So **total cost of buoy** is about Rs. 949120

Cost of Aluminium Rod = 500 x 143

= Rs 71500

Total Cost of solar installation = Rs. 1320000 (Installed capacity – 30 kWp)[23]

Section 7

ENVIRONMENTAL IMPACT

Although Wave energy is usually considered a clean renewable energy source, there are a number of effects that a WEC can have on its immediate surroundings.

These can vary in nature and severity during the installation, operation, maintenance or decommissioning phase of the device life. There are some common environmental impacts of wave energy like impact on coastal erosion due to alteration of currents, waves, wave amplitude and water flow which may be altered in proportion to the scale of the array.

Also there are potential impacts associated with the release and leakage of hydraulic fluids, lubricating oils, anti-corrosion and biofouling paints and coatings into the surrounding seas.

Environmental effects can be separated into two parts:-

Effect on Abiotic System:-

Large wave energy harvesting farms may alter the water currents and hence change the sediment deposition patterns. Large seabed fixed devices or the moorings used for floating ones can also alter the seabed. The waves behind a WEC have 10-15% lower wave height, which can reduce coastal erosion and interfere with surfing. During the deployment and decommissioning phase increased presence of ships can temporarily increase the turbidity of the water body.

Effect on Biotic System:-

The marine life can be attracted or displaced by the noise a WEC emits. Electromagnetism from high voltage lines on seabed can affect the migration or feeding habits of some animals.

On the other hand, floating WEC devices can serve as artificial nesting locations for sea birds while bottom-fixed devices can act as artificial reefs. Restricted fishing in the area can also help the local fish population serving as sanctuary for vulnerable species.

What have we done to minimize these effects?

Some measures to mitigate negative impact include burying electricity cables in order to decrease the electromagnetic radiation. observation of installation phases by a marine life specialist who can delay the disturbing works (usually high noise levels are present) in case there are sensitive animals nearby, design of low-noise WECs, etc.

Effect on Human Activities:-

As the industry grows, wave energy can generate employment in many sectors such as production and services.

WECs can serve as guidance at night or they can be a navigational hazard for shipping.

Fishing can be negatively impacted if the WEC devices occupy a larger area. WECs can visually impact tourism as the floating ones could be seen from the shore.

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