POWER OPTIMIZATION OF A POINT ABSORBER WAVE ENERGY CONVERTER

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GTIndia2021

WHAT IS WAVE ENERGY?

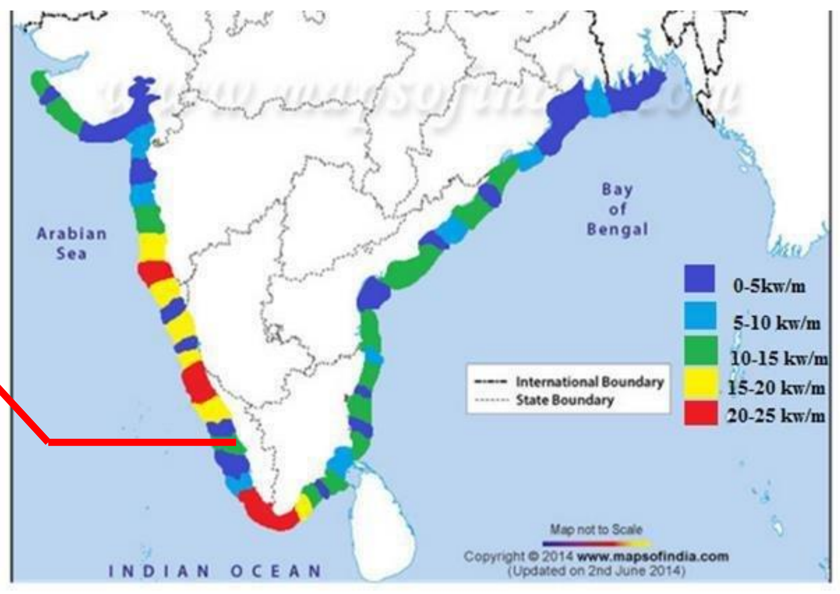
- Condensed form of solar power produced by the wind action blowing across the ocean water surface.

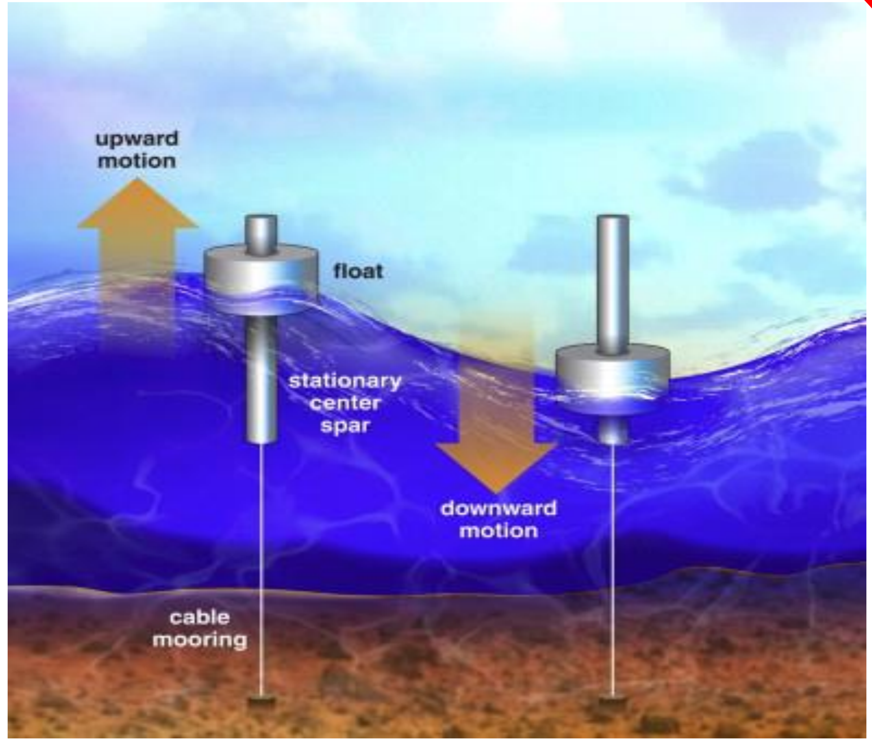
Increasing Energy Density Potential

Solar (0.2 kW/m^2) → Wind (0.5 kW/m^2) → Wave (3 kW/m^2)

An average **3 feet 10 second wave** striking a coast puts out approx. **4 MW** power per km of the coast.

India has a coast of length **7500 km**, having a total potential of over **50 GW** [1].



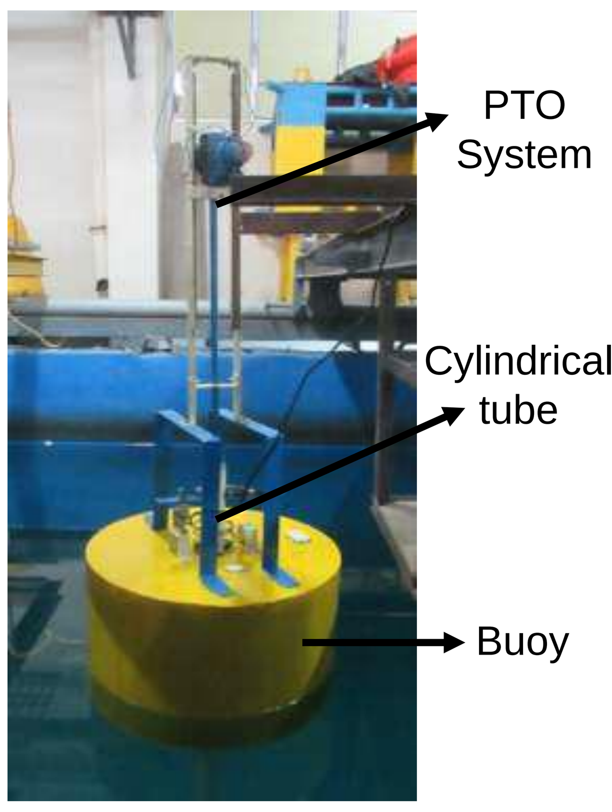


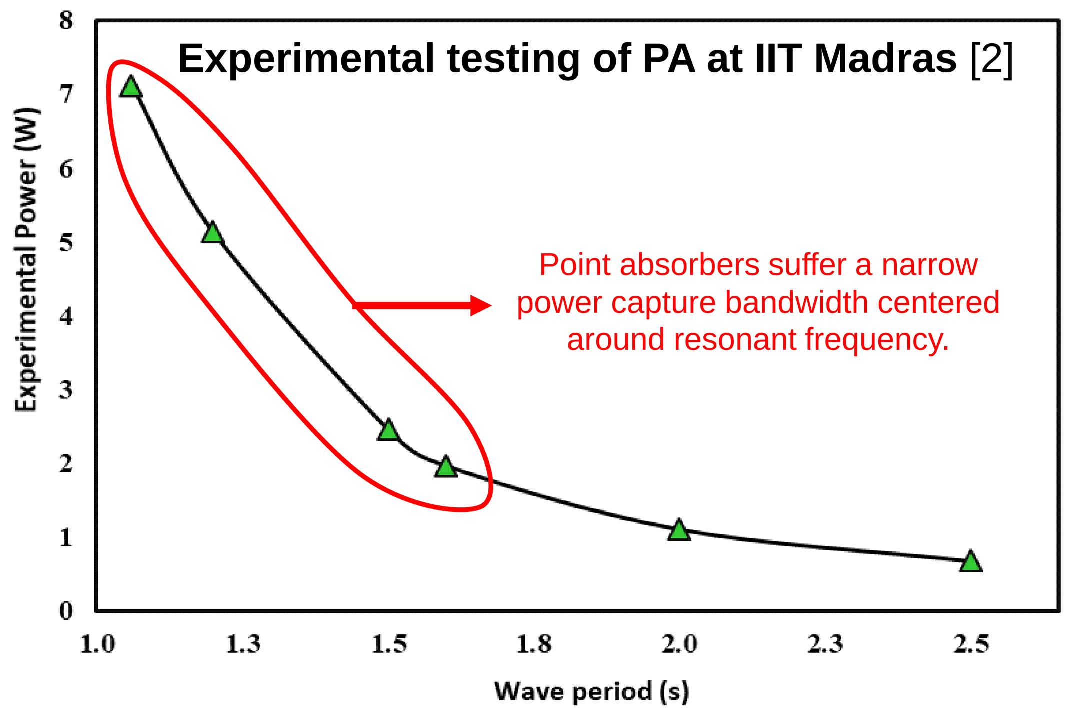
Waves are **Powerful, Cheap & Clean**
Why not use them?

$$Wave\ power\ (P_{wave}) = \frac{\rho g^2 T H^2}{32\pi}$$

Kinetic energy → Power Take-Off → Electricity

POINT ABSORBER (PA) FOCUS – Motivation



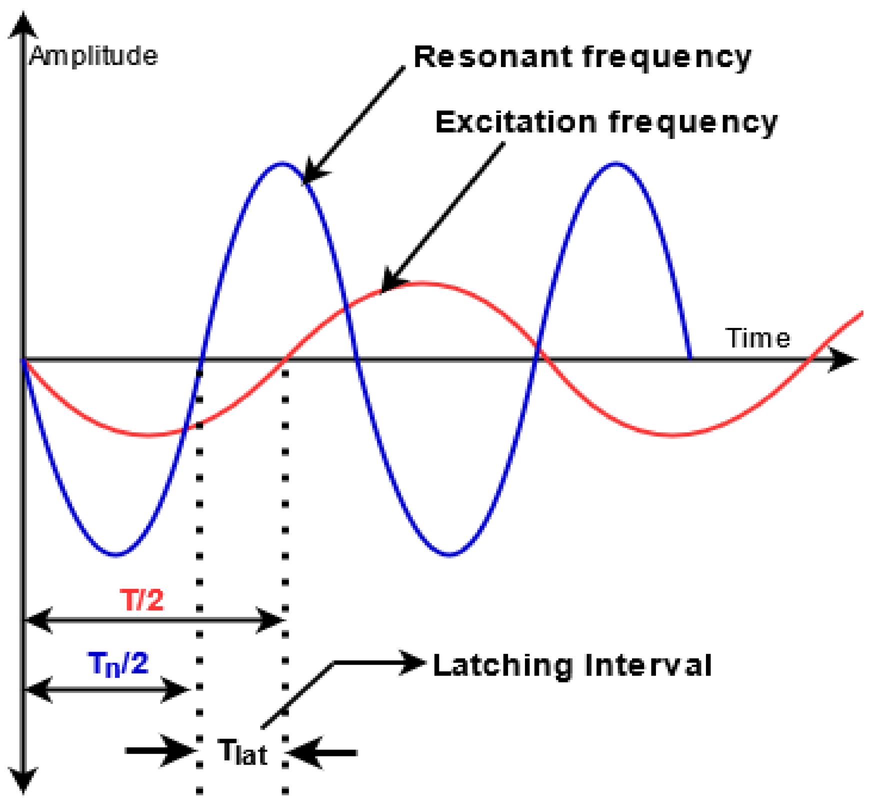


Latching- A novel phase control strategy to improve the efficiency of the device

System specifications

Total mass	40 kg
Float diameter (D_p)	0.6 m
Draft	0.4 m
Power Take-Off	Rack & Pinion
Generator Power	25 W

Latching Interval: $\Delta t = \frac{T - T_n}{2}$



Exaggerated buoy motion due to latching results in **viscous drag**.

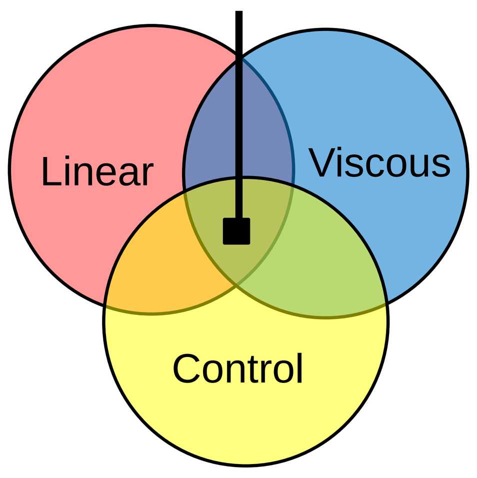
OBJECTIVES & METHODOLOGY

- Aim is to enhance the energy capture bandwidth of PA using latch control & compare it with an uncontrolled device.

- To investigate the influence of viscous forces on modulating the optimized power.

Superposed Hydrodynamic Model

Governing eqn.: $m\ddot{z} = f_{exc} + f_{hyd} + f_{PTO} + f_{vis} + f_{con}$



Hydrodynamic coefficients → Superposed Hydrodynamic Model → Latch controlled Output

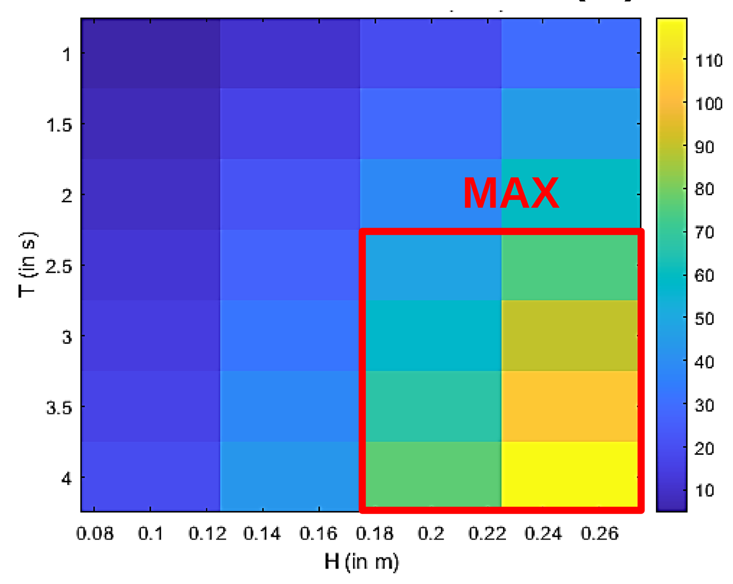
Ansys AQWA

Solved using 4th R-K in MATLAB

Heave/ Velocity, Power

RESULTS

Available Wave Power (W)



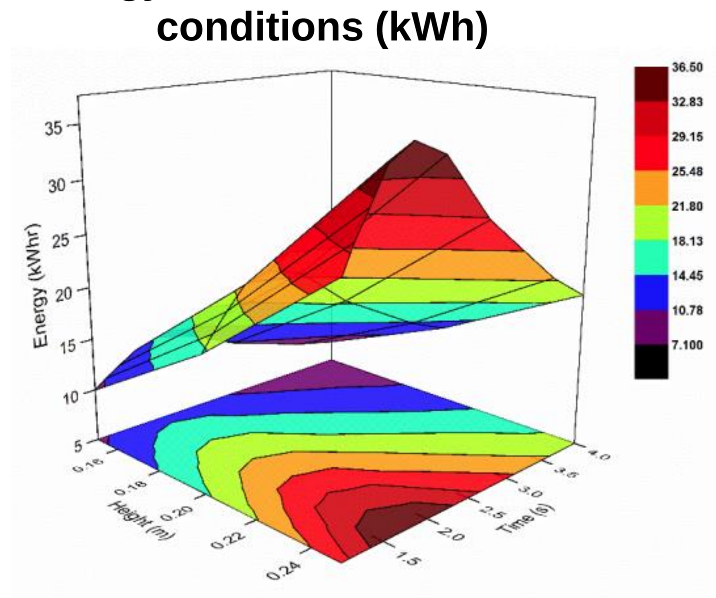
Average power absorbed by the PTO mechanism per cycle (W):

$$\bar{P} = \frac{1}{T}\int_0^T b_{PTO} \times \dot{z}\, dt$$

Absorption efficiency:

$$P_{eff} = \frac{\bar{P}}{P_{wave}}$$

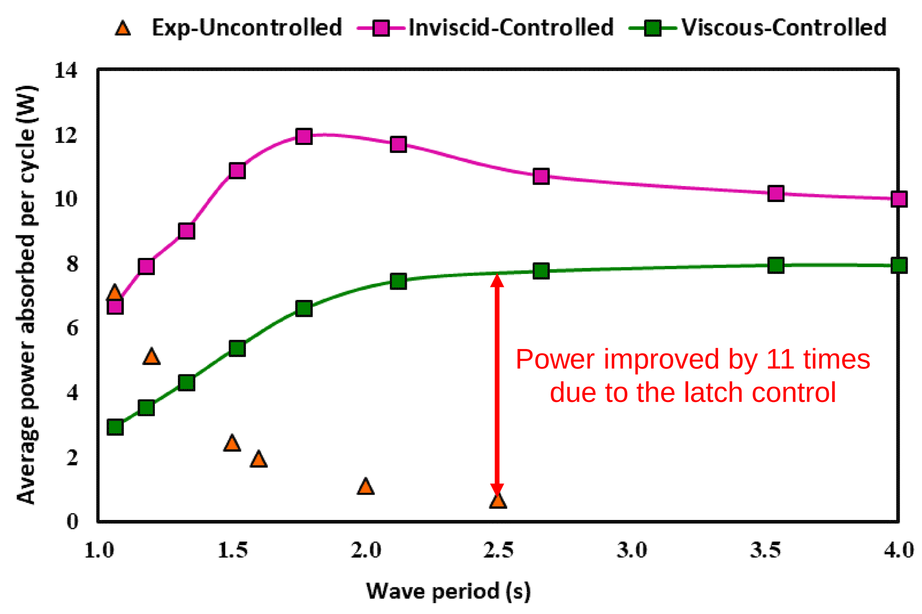
Energy absorbed at controlled conditions (kWh)



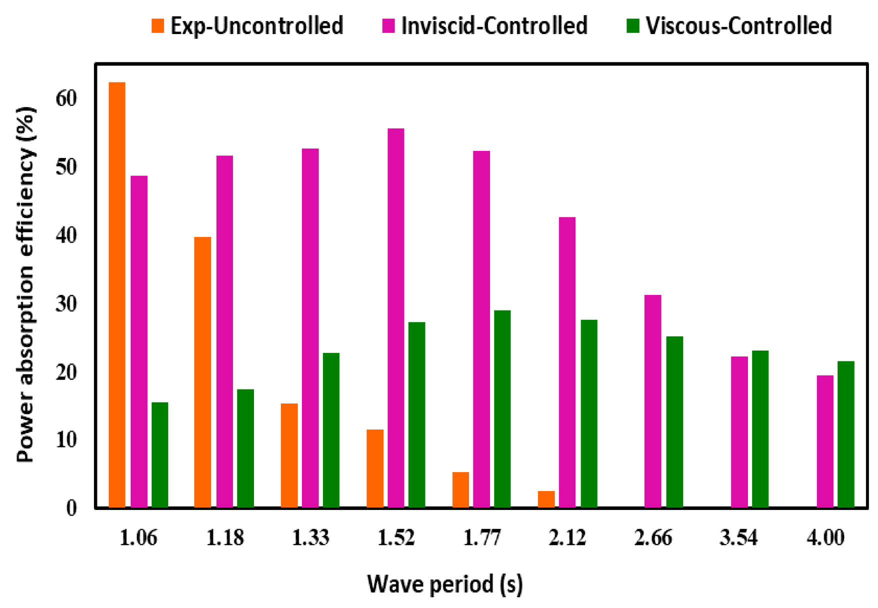
$$\varepsilon = \frac{D}{D_p} = 3.33$$

Scaling factor for power: $\varepsilon^{3.5}$

Absorbed Power (W) at H=15cm



Absorption efficiency at H=15cm



Energy (E) produced by the prototype in kWh:

$$E = \frac{3.6 \times \bar{P}}{T}$$

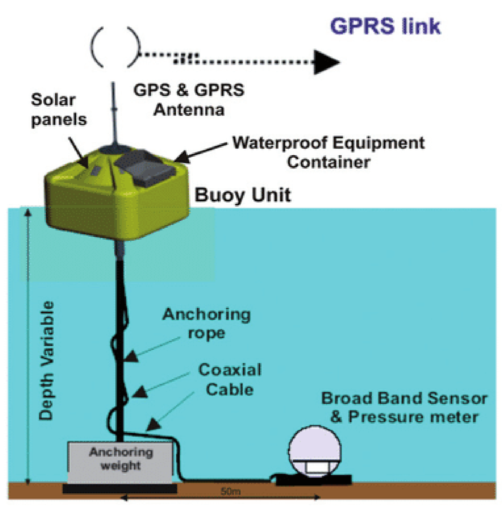
Power produced by the full-scale device of diameter 'D' is estimated using Froude's similarity parameter 'ε'.

Max. Power per cycle (W)

Model	Prototype	Full-scale
Uncontrolled	7	480
Latch-controlled	12	805

APPLICATIONS

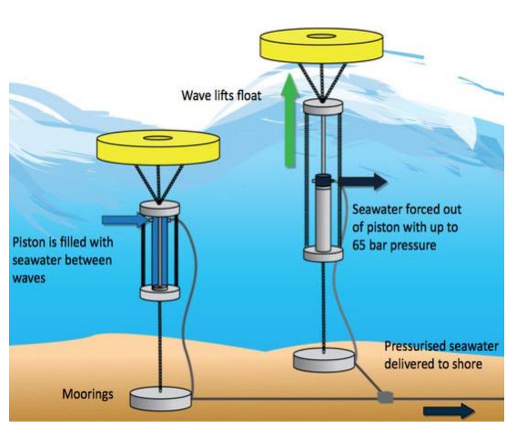
Weather monitoring



Communication Network

Power for offshore drilling/ oil & gas production units

Offshore Surveillance



Desalination plant

CONCLUSION

- **Latching enhances the power by 11 times** at off-resonant states resulting in roughly uniform power production for a wide range of sea-states.

- Inviscid-Controlled model exaggerates the power absorption capacity of PA, whereas Viscous model results in realistic optimization.

- Viscous latching produces **1.5 times higher energy** compared to an uncontrolled device.

- Latching aims to commercialize PAs which is estimated to produce electricity at the cost of **₹1-₹3 per unit** [1] **(71% lower than the conventional cost)**.

REFERENCES

[1] Ravindran, M., and Paul Mario Koola. "Energy from Sea Waves—the Indian Wave Energy Programme." *Current Science*, vol. 60, no. 12, Temporary Publisher, 1991, pp. 676–80,

[2] Vijayasankar, V., Amarnath G., S. S A, and Samad, A., Experimental Investigation Of A Novel Direct Mechanical Drive Wave Energy Converter.4th *Asian Wave And Tidal Energy Conference,* Taiwan 2018.

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