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**University**

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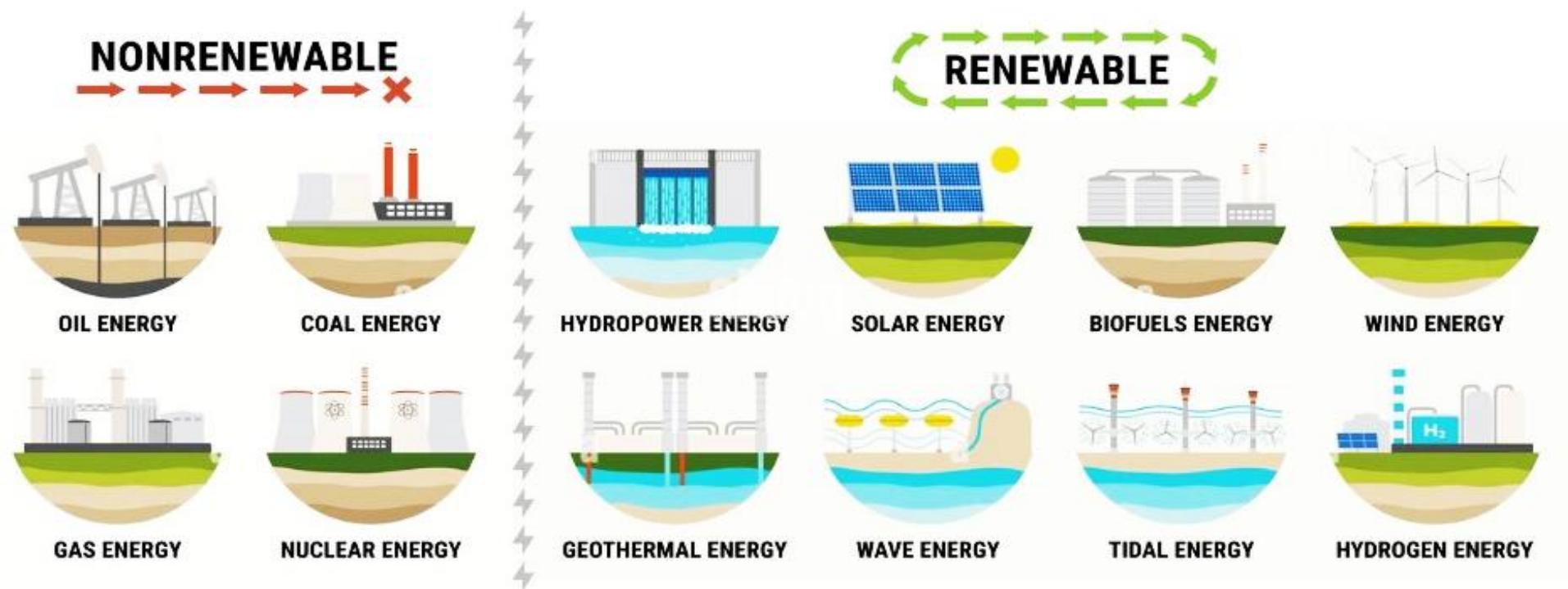
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# WAVE ENERGY

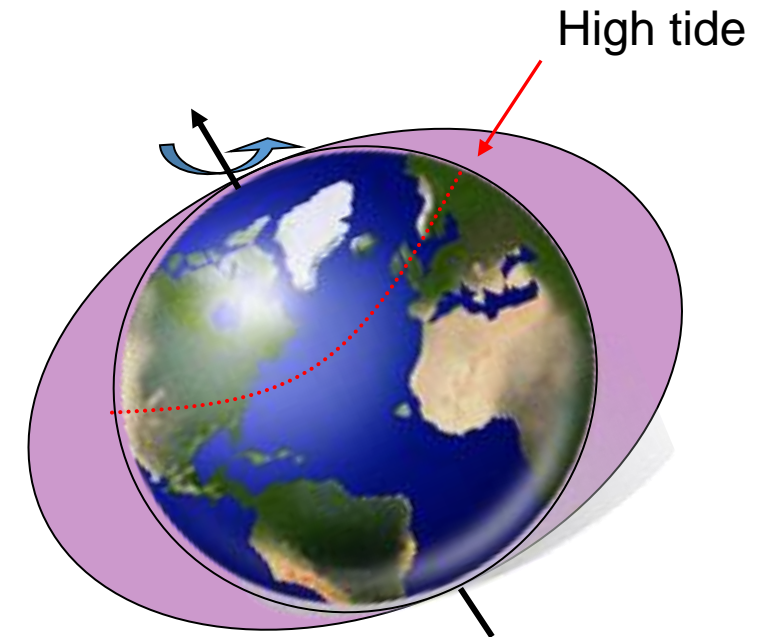
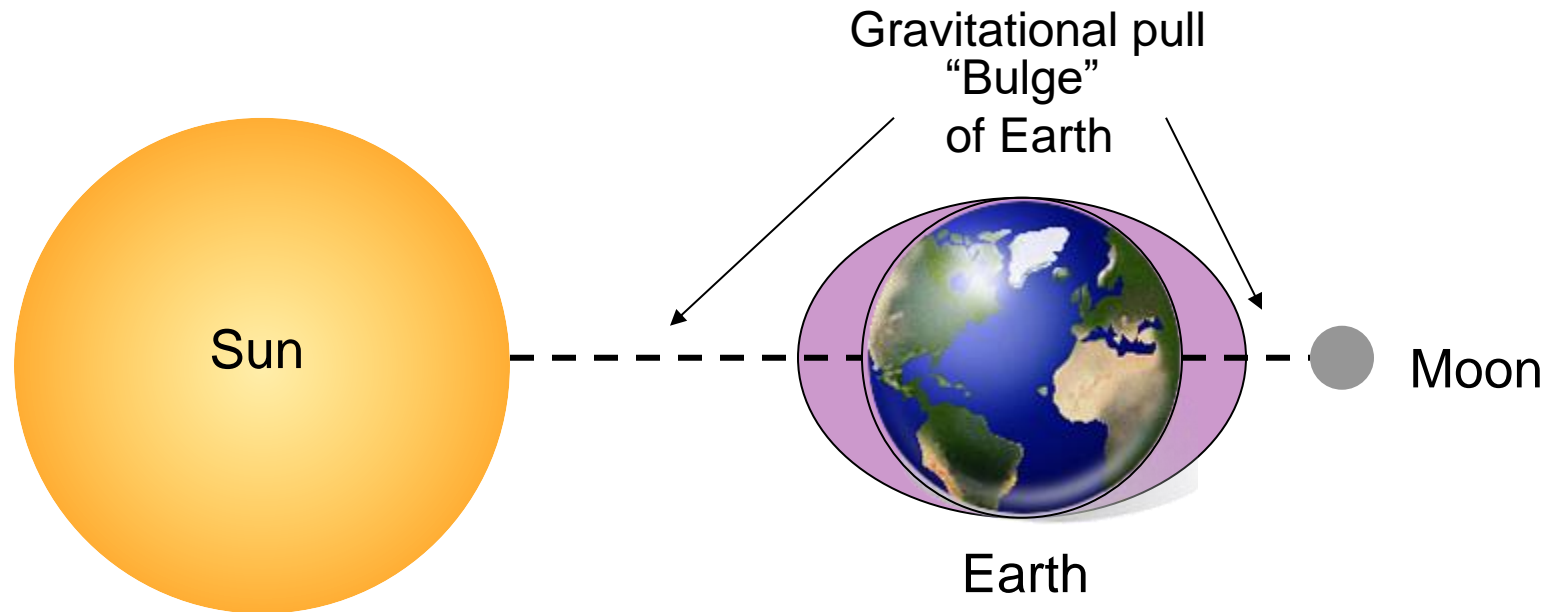




# WHAT CAUSES TIDES?

The gravitational pull of the sun and the moon causes “bulges” on Earth that move as we rotate

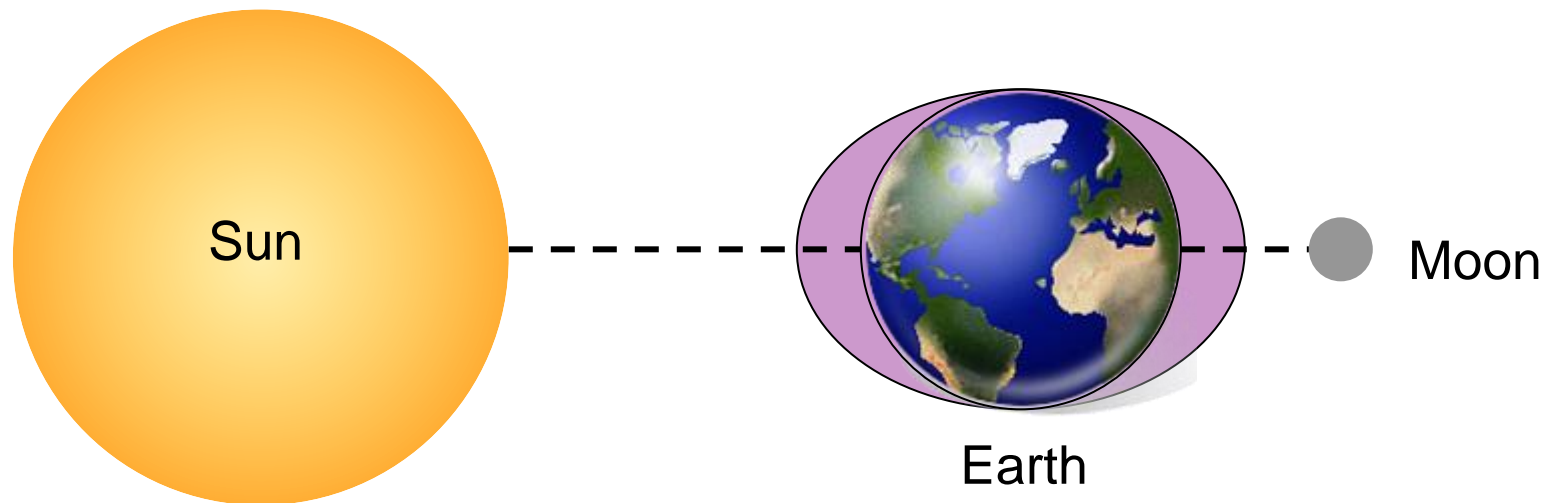
The tide rises when coastline enters the bulge and falls when it rotates out



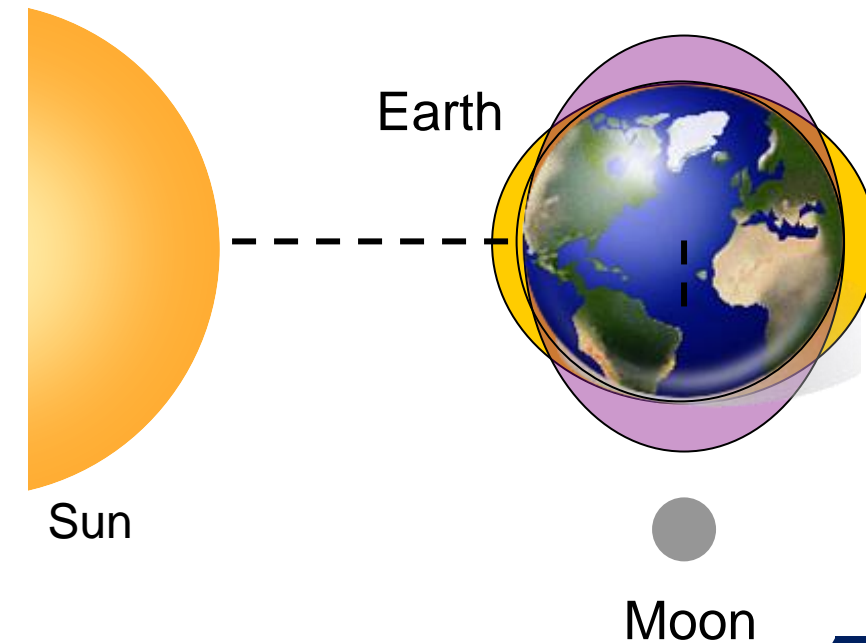


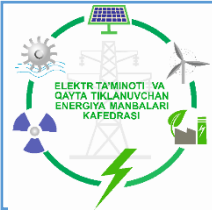
# DIFFERENT TYPES OF TIDE

- **Spring tides** occur when the sun and moon are in a straight line
- The tidal range is typically highest during spring tides



- **Neap tides** occur when the sun and moon form a right angle with Earth
- Low tides are typically *higher* and high tides are *lower*
- Why is the moon's pull greater than the sun's?





# HOW WAVES FORM?

## Renewable Energy Resources

- Ocean waves are both clean and renewable sources of energy with a tremendous worldwide potential of generating electricity.
- If fully exploited, about 40% of the world's power demand could be supplied by this resource – equivalent to as much as 800 nuclear power plants.
- Wave power is the transport of energy by ocean surface waves, and the capture of that energy to do useful work – for example, electricity generation, water desalination, or the pumping of water (into reservoirs).
- Differential warming of the earth causes pressure differences in the atmosphere, which generate winds.
- As winds move across the surface of open bodies of water, they transfer some of their energy to the water and create waves.
- A few factors determine how strong an individual wave will be. These include:
  - ✓ **Speed of wind**: The faster the wind is traveling, the bigger a wave will be.
  - ✓ **Time of wind**: The wave will get larger the longer the length of time the wind is hitting it.
  - ✓ **Distance of wind**: The farther the wind travels against the wave (known as fetch), the bigger it will be.



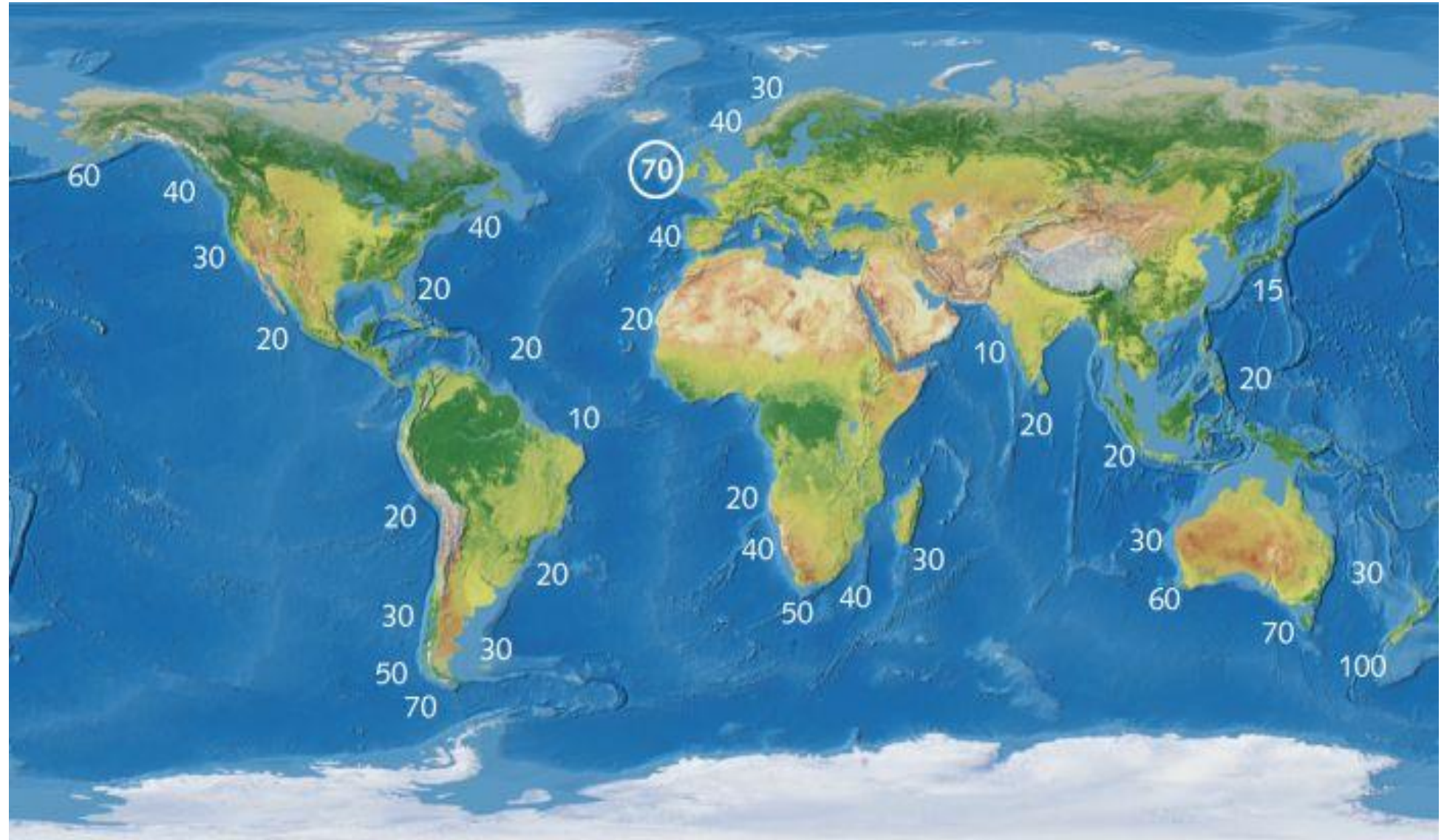


# WAVE ENERGY ENVIRONMENTS

## Renewable Energy Resources

The strongest winds blow between  $30^{\circ}$  and  $60^{\circ}$  in latitude.

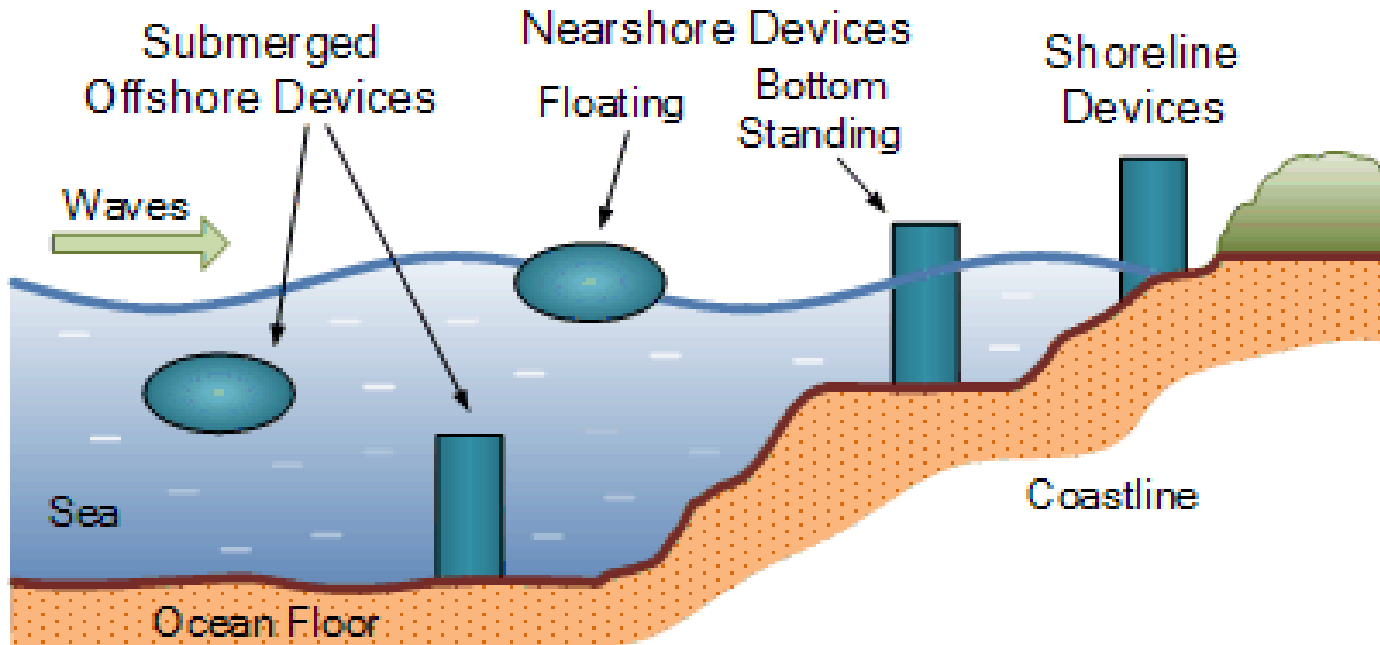
**Western coastlines** at these latitudes experience the most powerful waves.





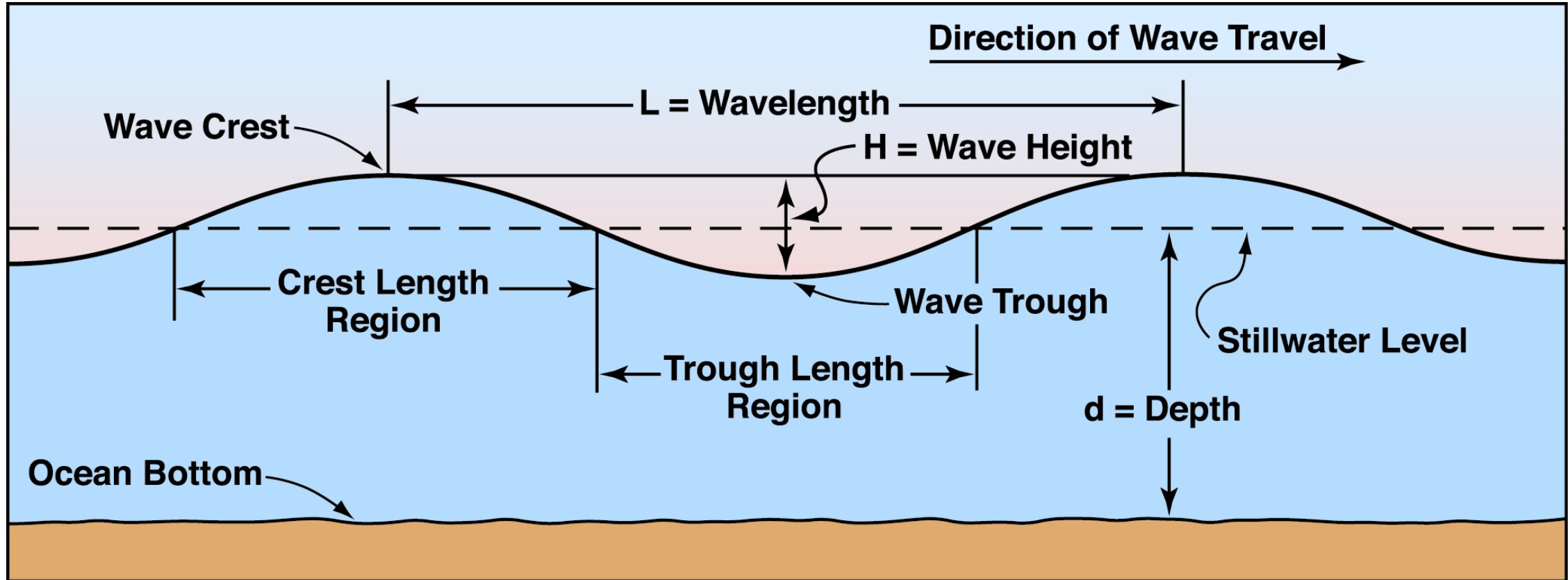
# THREE BASIC KINDS OF SYSTEMS

- **Offshore** (deals with swell energy not breaking waves)
- **Near Shore** (maximum wave amplitude)
- **Embedded devices** (built into shoreline to receive breaking wave – but energy loss is occurring while the wave is breaking)



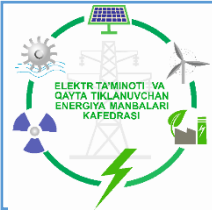


# WAVE CHARACTERISTICS

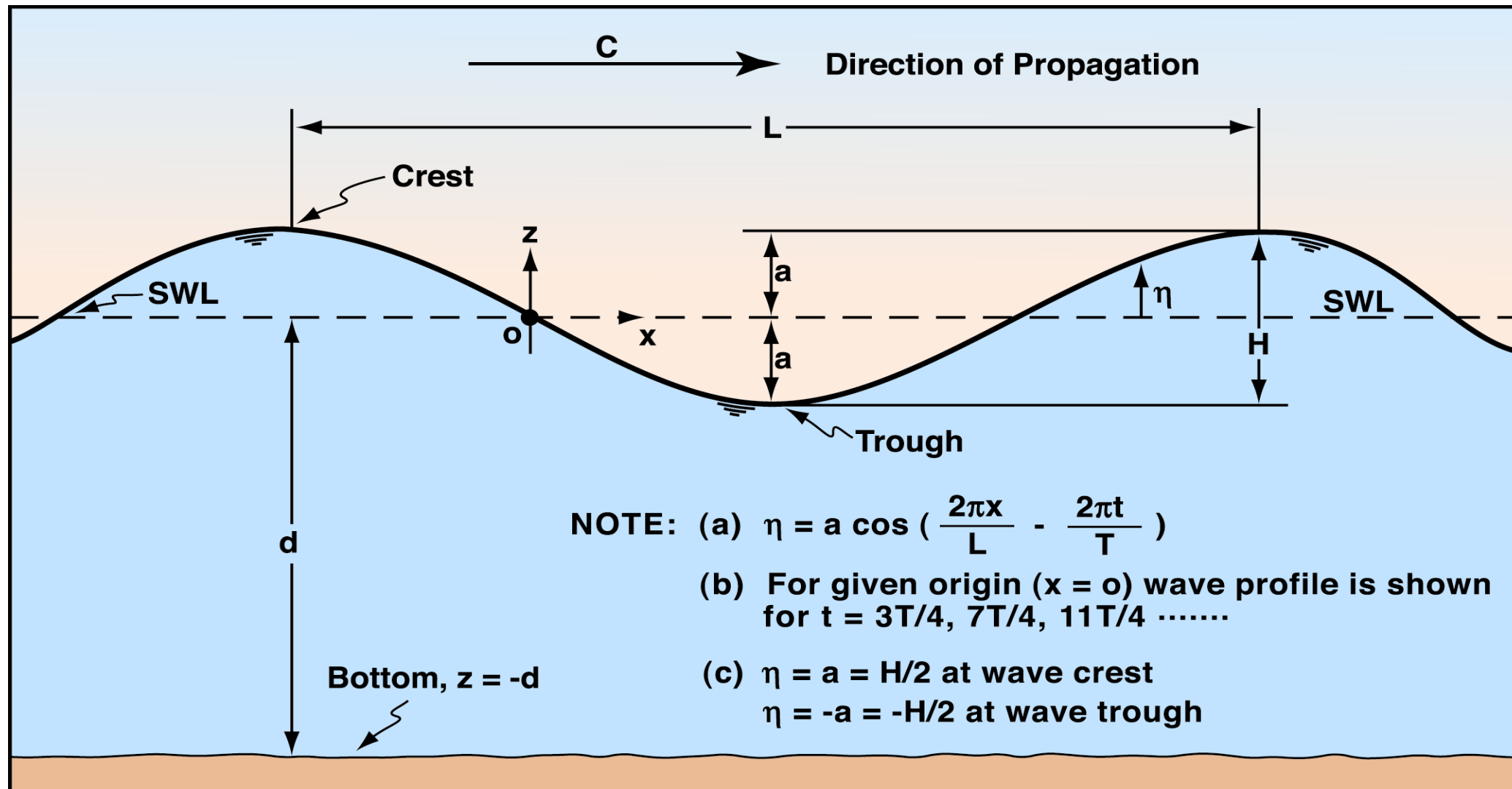


**$T = \text{WAVE PERIOD}$**

**Time taken for two successive crests to pass a given point in space**



# WAVE CHARACTERISTICS



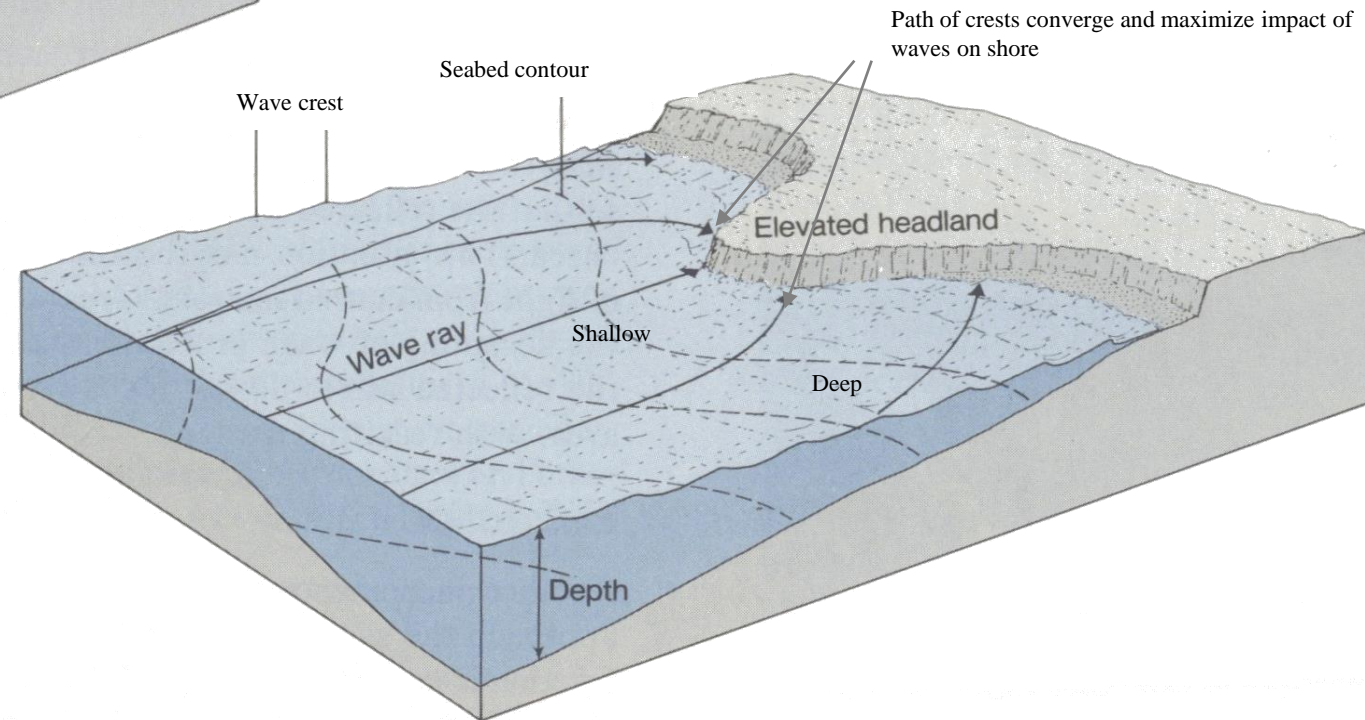
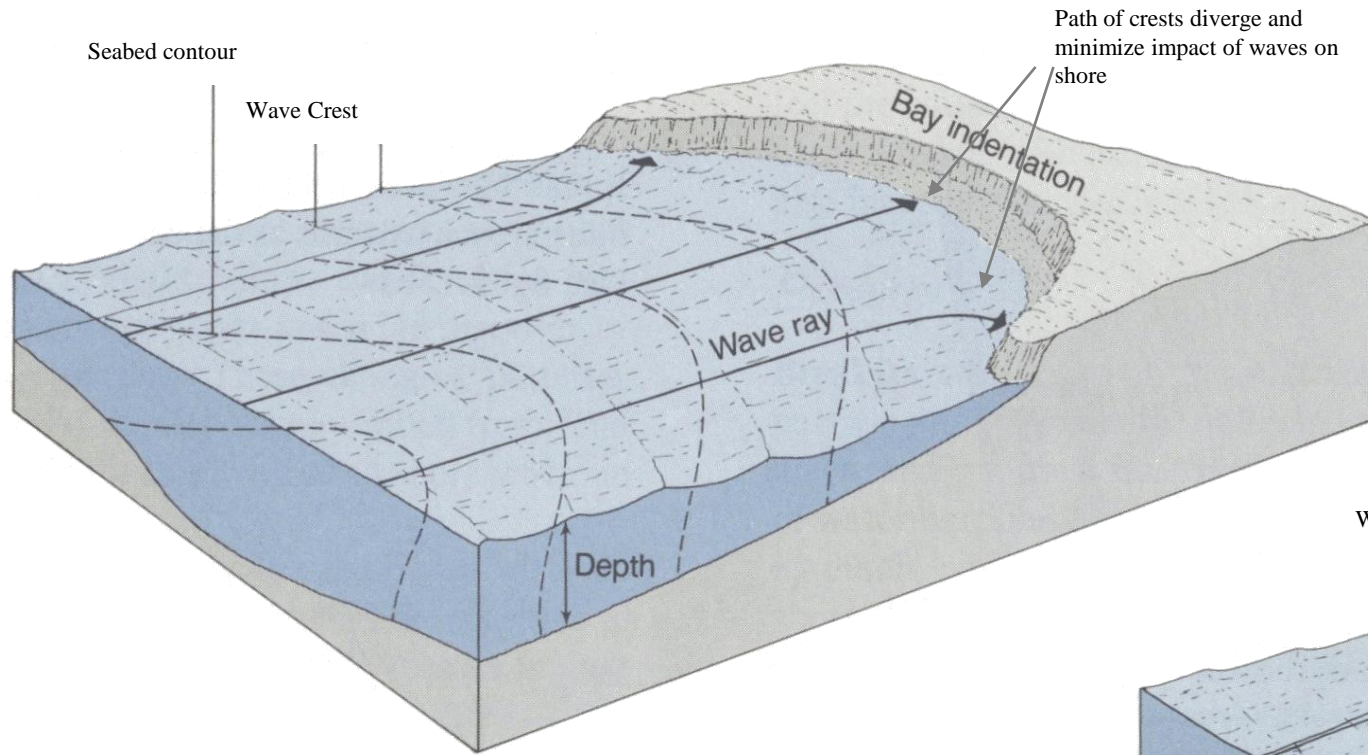
**ELEMENTARY, SINUSOIDAL, PROGRESSIVE WAVE**





# WAVE REFRACTION

## Renewable Energy Resources



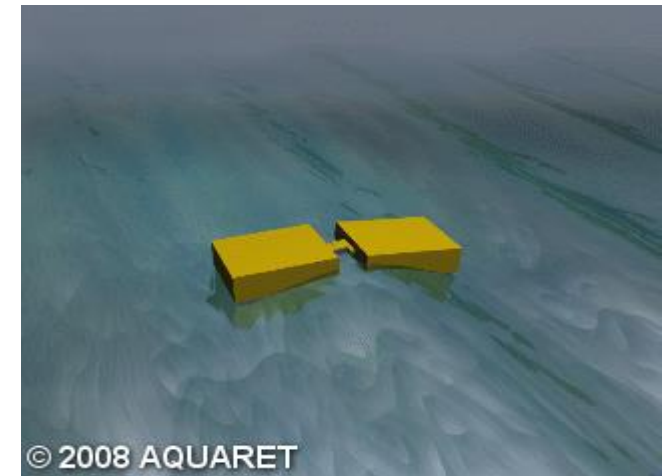


# WAVE PROFILE DEVICES

- If the physical size of the wave profile device is **very small compared to the periodic length of the wave**, this type of wave energy device is called a "**point absorber**".
- If the size of the device is **larger or longer than the typical periodic wavelength**, it is called a "**linear absorber**".
- More commonly they are collectively known as "**wave attenuators**".



**Point Absorber**



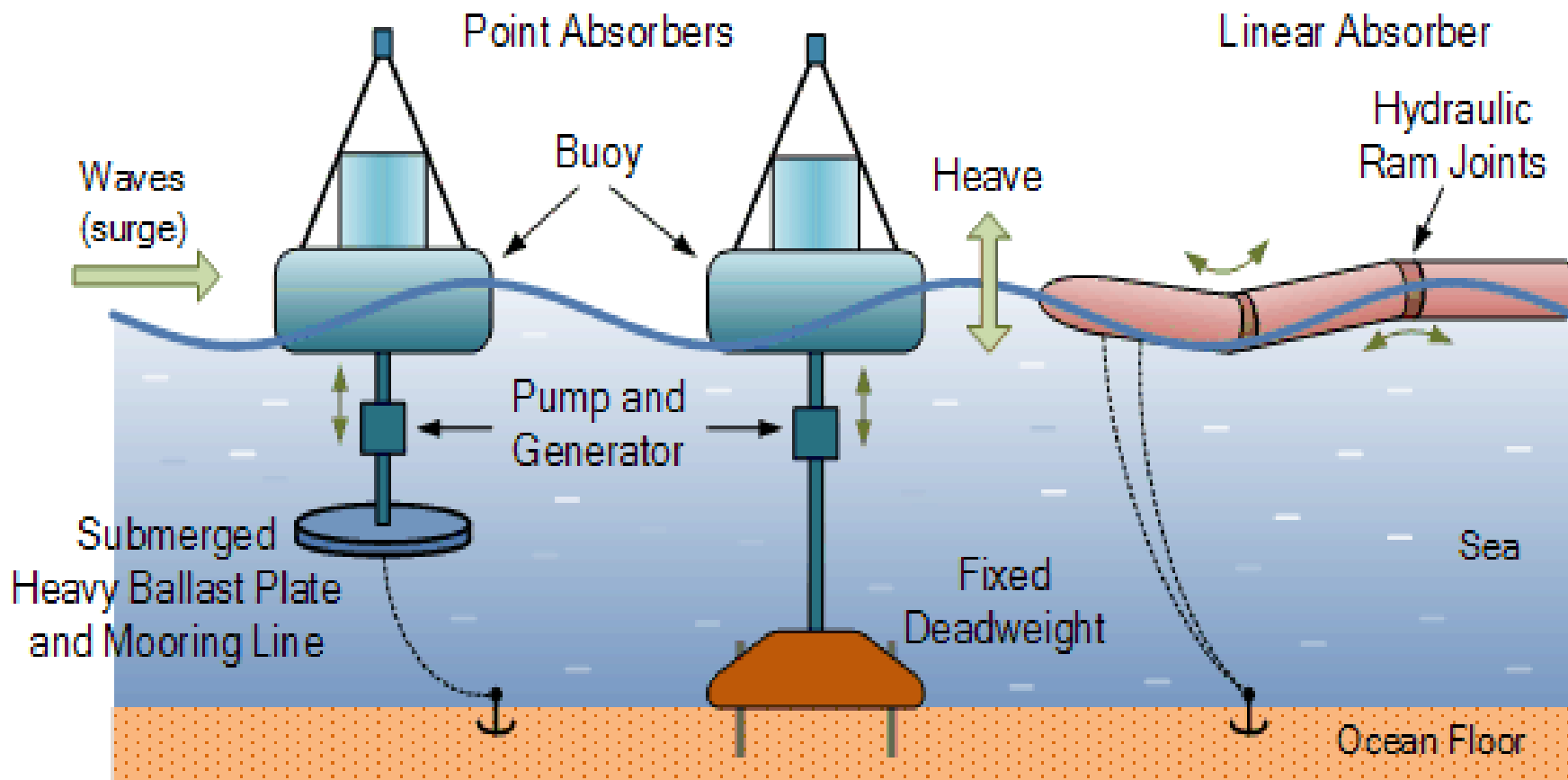
**Wave Attenuators**



## WORKING

## Renewable Energy Resources

- To make efficient use of the force generated by the wave, we need some kind of **force reaction**.
- In other words, we want the waves force on the float to **react against another rigid or semi-rigid body**.
- Reaction points can be **inertial masses** such as **heavy suspended ballast plates**, **sea-floor anchors** or a **fixed deadweight** or **pile** as shown.







# EXAMPLES

## Renewable Energy Resources

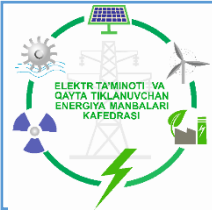


PB150 PowerBuoy with peak-rated power output of 150 kW. USA



750 kW Pelamis Wave Energy Converter, Scotland





# EXAMPLES

## Renewable Energy Resources

Oceanlinx's world's first 1MW wave energy converter unit 'green WAVE, Australia



LIMPET (Land Installed Marine Powered Energy Transformer), Scotland, Capacity-500 kW







# WAVE CAPTURE DEVICE

## Renewable Energy Resources

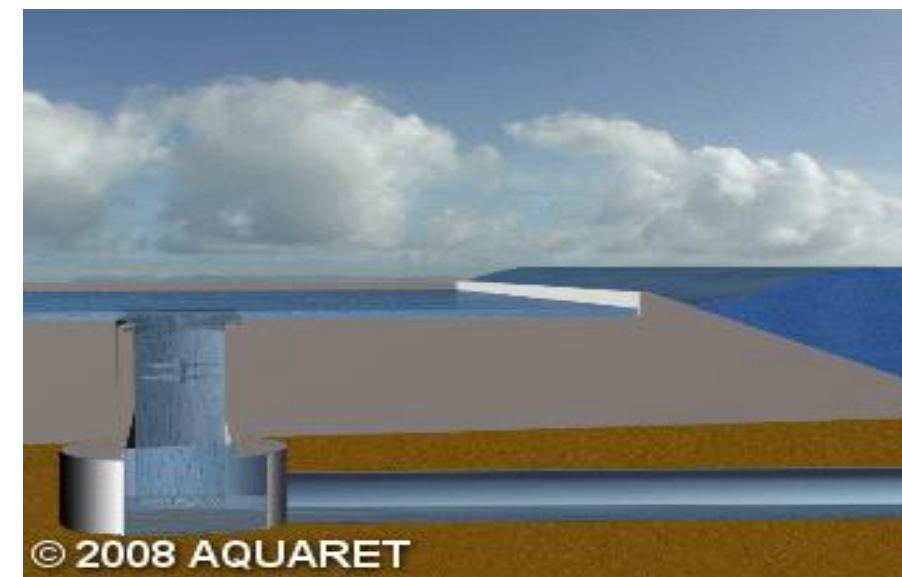
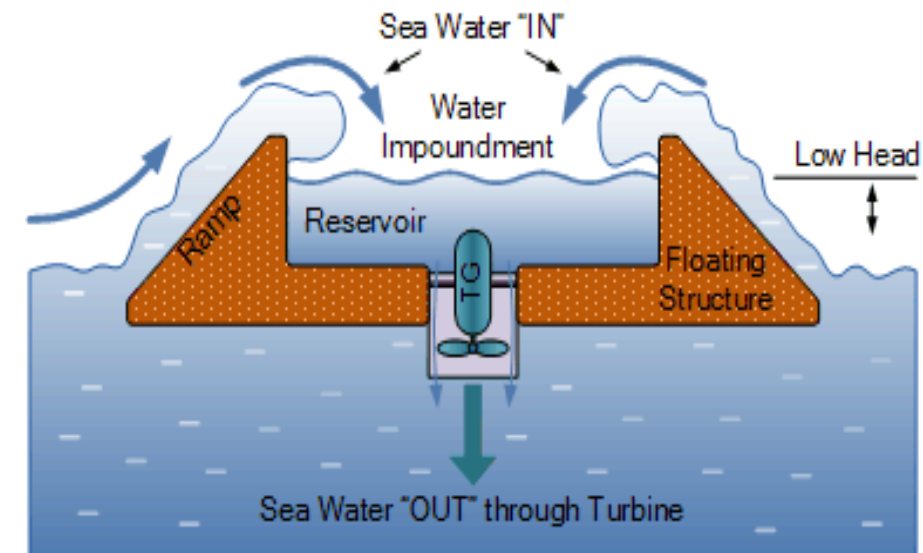
- A Wave Capture Device also known as a **Overtopping Wave Power Device**, is a **shoreline to nearshore** wave energy device that captures the movements of the tides and waves and converts it into **potential energy**.
- Wave energy is converted into potential energy by **lifting the water up onto a higher level**.
- The wave capture device, or more commonly an overtopping device, elevates ocean waves to a holding reservoir above sea level.
- It require sufficient wave power to fill the impoundment reservoir.



## WORKING

## Renewable Energy Resources

- As the **waves hit the structure** they flow up a ramp and over the top (hence the name "overtopping"), into a raised **water impoundment reservoir** on the device in order to fill it.
- Once captured, the potential energy of the trapped water in the reservoir is extracted using gravity as the **water returns to the sea** via a low-head **Kaplan turbine generator** located at the bottom of the wave capture device.





## EXAMPLES

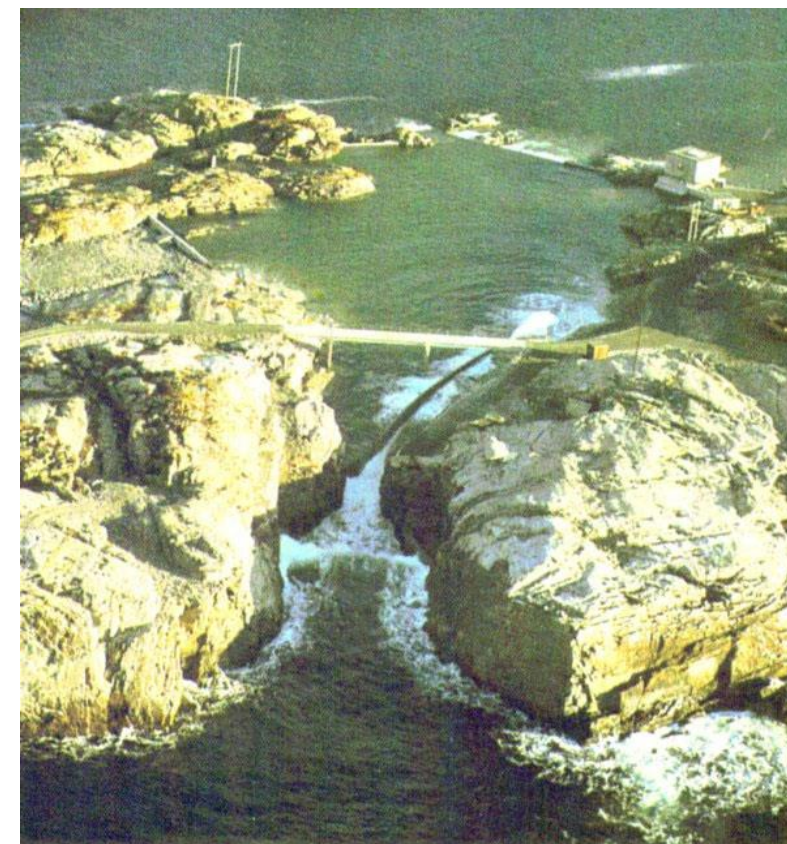
## Renewable Energy Resources

- The TAPCHAN is designed by a company called **Norwave**, and a **350kW prototype** commenced operation in 1985 on a small Norwegian island.
- The principle behind the design is to **capture waves in a raised reservoir** (about 3 metres above the mean sea level) and then extracting useful work as the **water is allowed to flow back to the sea**.

**Wave Dragon Overtopping Device, Denmark**  
**1.5 to 12 MW of capacity**



**Toftestallen Wave Power Plant, TAPCHAN, Norway**  
**500 kW**



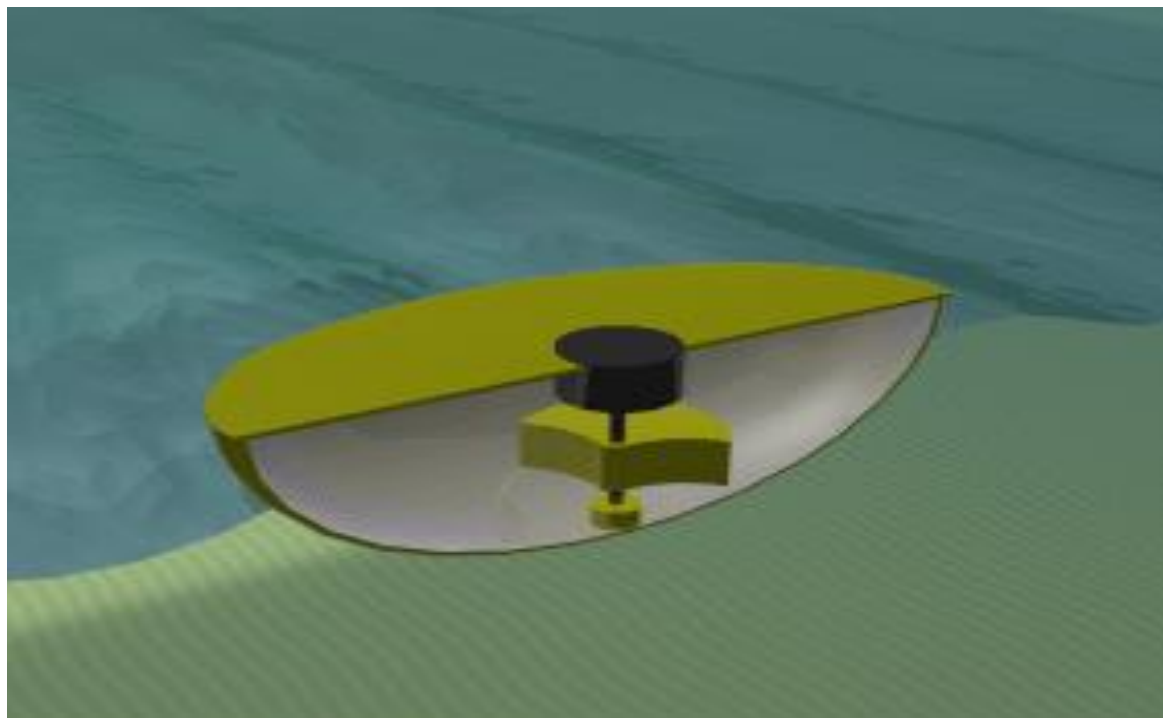


# EXAMPLES

## Renewable Energy Resources

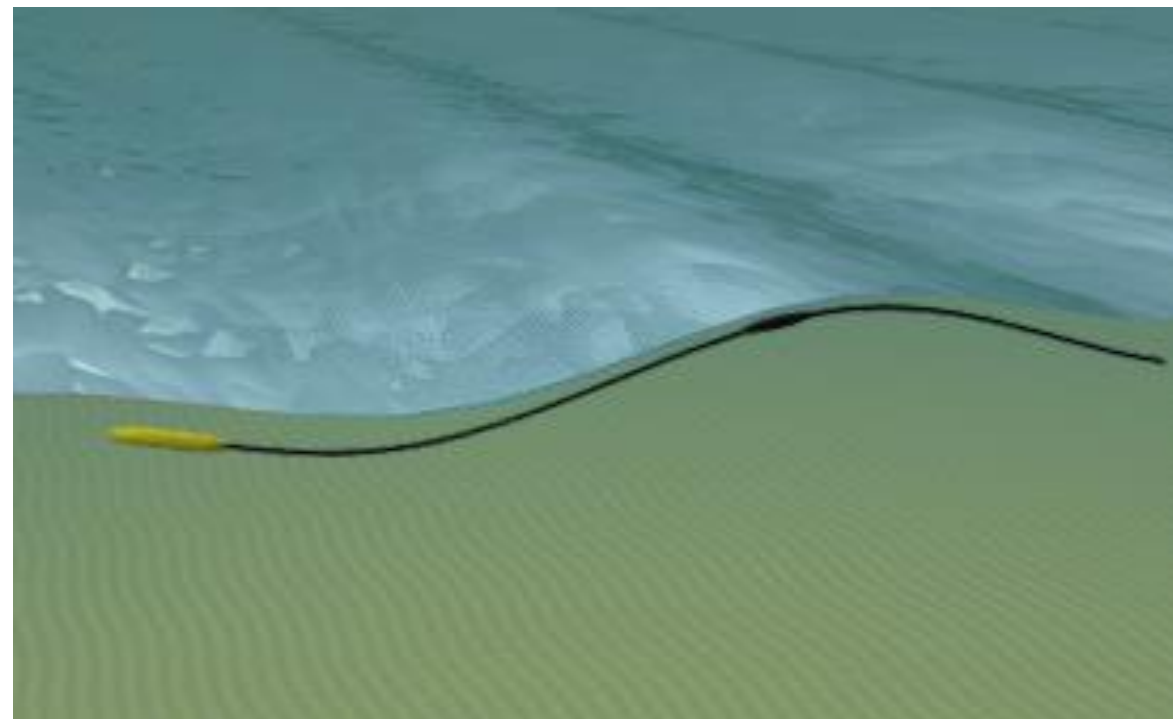
### ROTATING MASS

Two forms of rotation are used to capture energy by the movement of the device heaving and swaying in the waves. This motion drives either an eccentric weight or a gyroscope causes precession. In both cases the movement is attached to an electric generator inside the device.



### BULGE WAVE

Bulge wave technology consists of a rubber tube filled with water, moored to the seabed heading into the waves. The water enters through the stern and the passing wave causes pressure variations along the length of the tube, creating a 'bulge'. As the bulge travels through the tube it grows, gathering energy which can be used to drive a standard low-head turbine located at the bow, where the water then returns to the sea.







# CONCLUSION

## Renewable Energy Resources

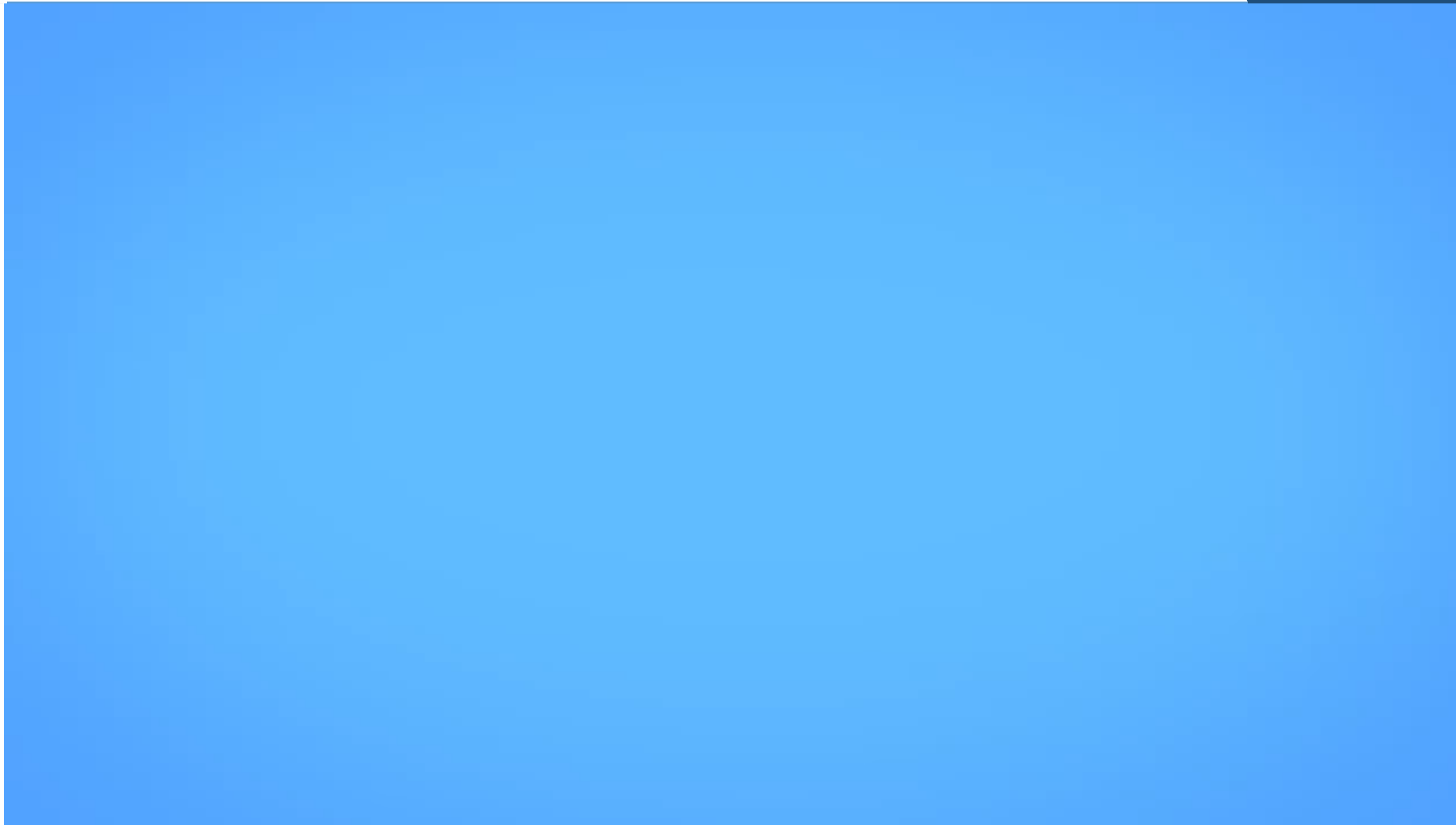
- There is **much potential** in worldwide wave energy; 1000 TerraWatts available.
- Capturing wave energy and converting that into electricity is difficult **but this allows for innovate devices to be designed**
- Technology produces **no greenhouse gas emissions** making it a **non-polluting and renewable source of energy**.
- The technical challenges are solvable.
- The problems lie in facilitating the testing and development of the technology to make it more affordable
  - Need government funding
  - Need a regulatory process conducive for rapid deployment of prototypes and research equipment.





# HOW DOES IT WORK?

Renewable Energy  
Resources





# Thank you very much for your attention!

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