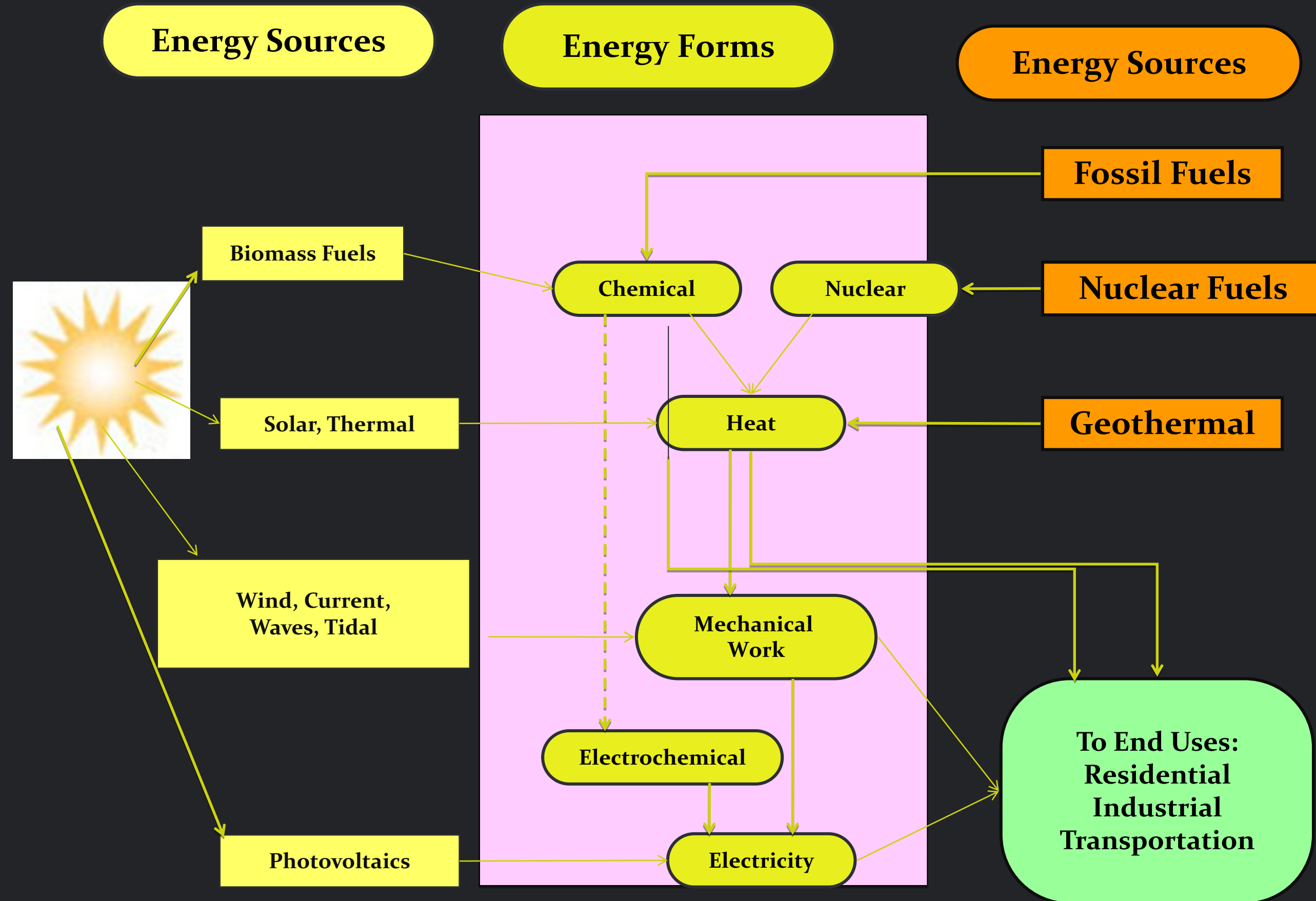




Energi Terbarukan

Pertemuan 3:
Energi Gelombang Laut

Dosen Pengampu:
Frida Hasana, S.Pd. M.Eng.



Prospect of Renewable Marine Energy



● Renewable Marine Energy

In the long term marine renewable energy could meet 15 to 20% of current UK electricity demand, with 3% to 5% coming from tidal stream and the remainder from wave energy (Carbon Trust, 2005).

➤ Tidal & Currents

➤ Wave

➤ Thermal

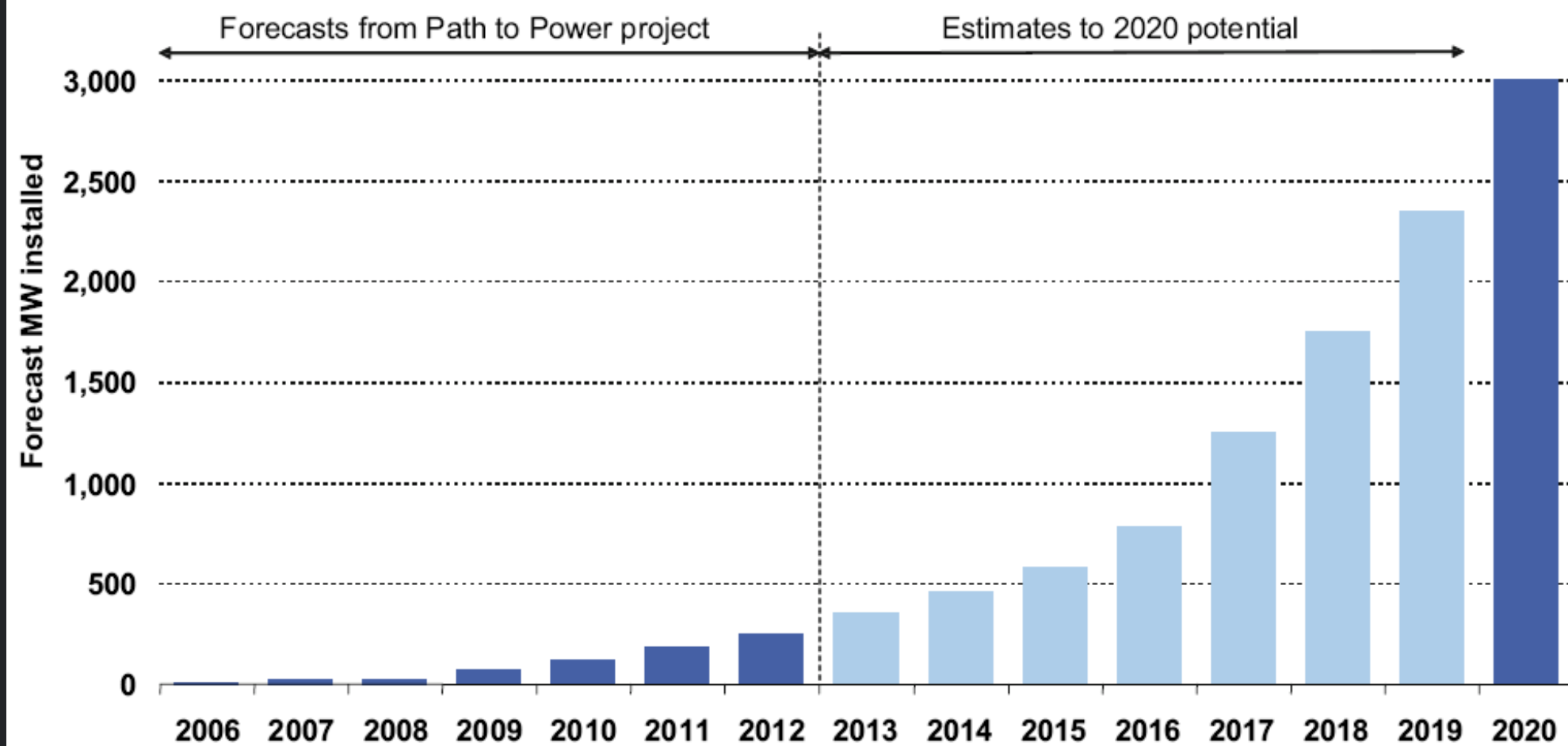
➤ Wind

➤ Solar

➤ Hydro

➤ Others

Figure 1: Deployment scenario for wave and tidal energy in the UK to 2020
BWEA (2006) Energy Review submission; Bond Pearce (2005) Path to Power: Stage 1 report; CCC



Prospect of Renewable Marine Energy at North Sea



 Negara	 Jenis Pembangkit	 Nama Proyek Utama	 Keterangan
 Inggris	Offshore Wind	- Dogger Bank Wind Farm (3,6 GW)- Hornsea Projects (Hornsea 1–4)- Seagreen (Skotlandia)	Dogger Bank akan jadi ladang angin lepas pantai terbesar di dunia
 Denmark	Offshore Wind, Hydrogen	- North Sea Energy Island- Thor Offshore Wind Farm	Energy Island akan menjadi hub pusat distribusi listrik dan hidrogen
 Jerman	Offshore Wind, Hydrogen	- Nordseecluster- Borkum Riffgrund 3- Amrumbank West	Fokus pada integrasi dengan sistem grid dan produksi hidrogen hijau
 Belanda	Offshore Wind, Hydrogen, CCUS	- Hollandse Kust (Noord/Zuid/West)- IJmuiden Ver- Porthos (CCUS)	Porthos adalah proyek penangkapan karbon di bawah Laut Utara
 Belgia	Offshore Wind	- Prinses Elisabeth Zone- Rentel- Northwester 2	Belgia memiliki salah satu zona offshore wind paling padat
 Norwegia	Floating Wind, CCUS	- Hywind Tampen- Northern Lights (CCS)- Utsira Nord (rencana)	Hywind Tampen adalah ladang angin terapung pertama untuk industri migas

Global **Marine** Renewable Energy Resources



OCEAN ENERGY RESOURCE	HOW TO HARNESS THE RESOURCE	THEORETICAL RESOURCE
Tides	Potential energy associated with tides can be harnessed by building barrage or other forms of construction across an estuary.	300+ TWh/year
Waves	Kinetic and potential energy associated with ocean waves can be harnessed using modular technologies.	8,000 to 80,000 TWh/year
Tidal (Marine) Currents	<IEA-OES Report 2008> Kinetic energy associated with tidal (marine) currents can be harnessed using modular systems.	800+ TWh/year
Temperature Gradients	Thermal energy due to the temperature gradient between the sea surface and deepwater can be harnessed using different Ocean Thermal Energy Conversion (OTEC) processes.	10,000 TWh/year
Salinity Gradients	At the mouth of rivers where fresh water mixes with salt water, energy associated with the salinity gradient can be harnessed using pressure-retarded reverse osmosis process and associated conversion technologies.	2,000 TWh/year



Marine Renewable Energy Resources

Ocean Tides: Potential energy associated with tides can be harnessed by building barrage or other forms of construction across an estuary.

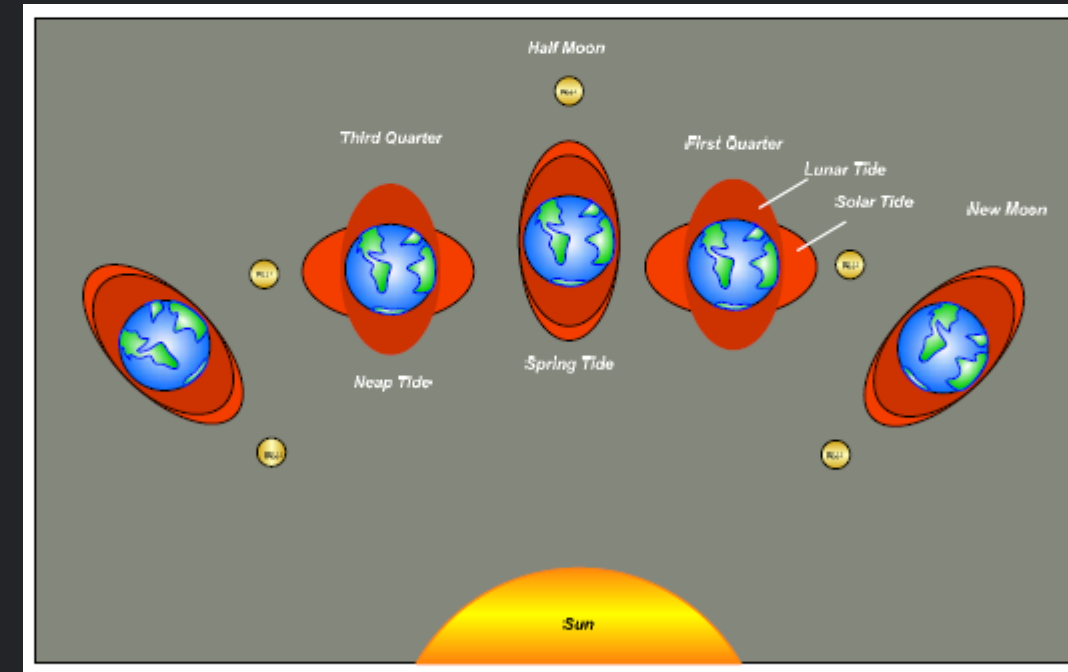
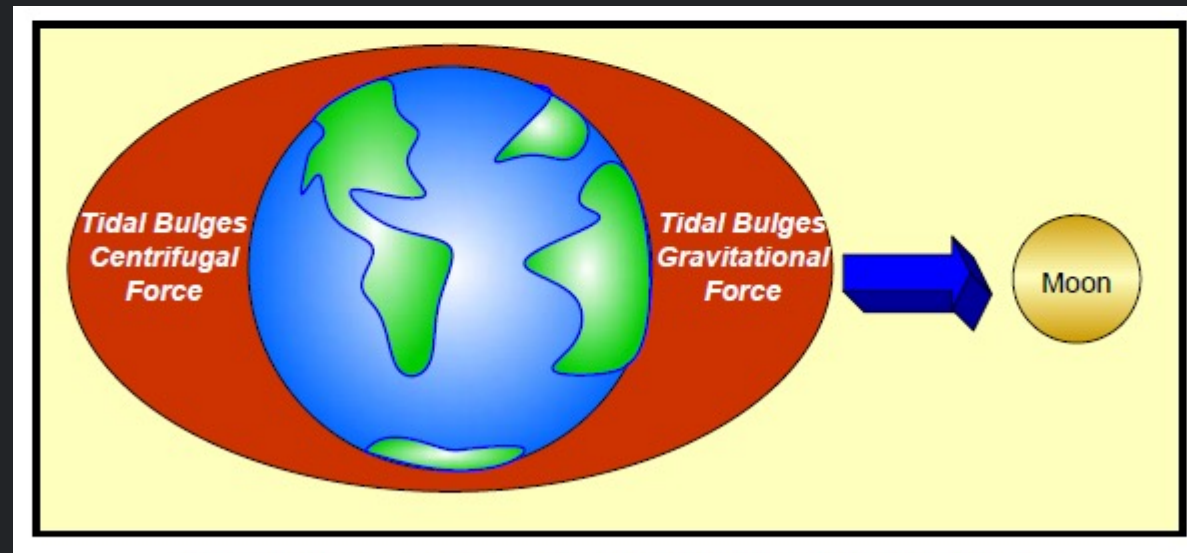
Ocean Waves: Kinetic & potential energy associated with ocean waves can be harnessed using modular types of technologies.

Marine Current: Kinetic energy associated with tidal/marine currents can be harnessed using modular systems.

Temperature Gradient: Thermal energy due to temperature gradient between sea surface & deep-water can be harnessed using different ocean thermal energy conversion (OTEC) processes.

Salinity Gradient: At the mouth of rivers where fresh water mixes with saltwater, energy associated with the salinity gradient can be harnessed using a pressure retarded reverse osmosis process and associated conversion technologies.

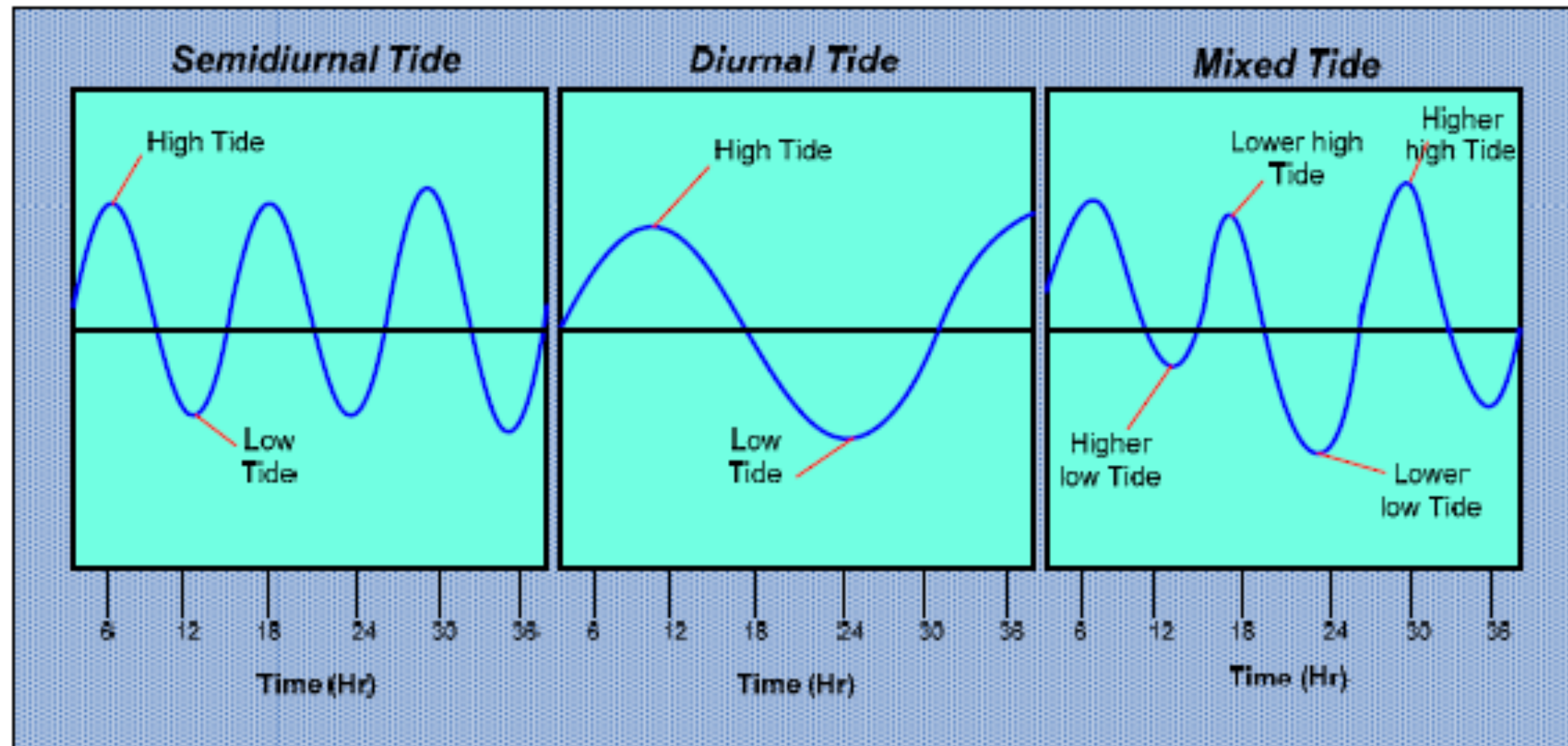
Tidal



Interaction of the sun-earth-moon causes the strongest tidal.

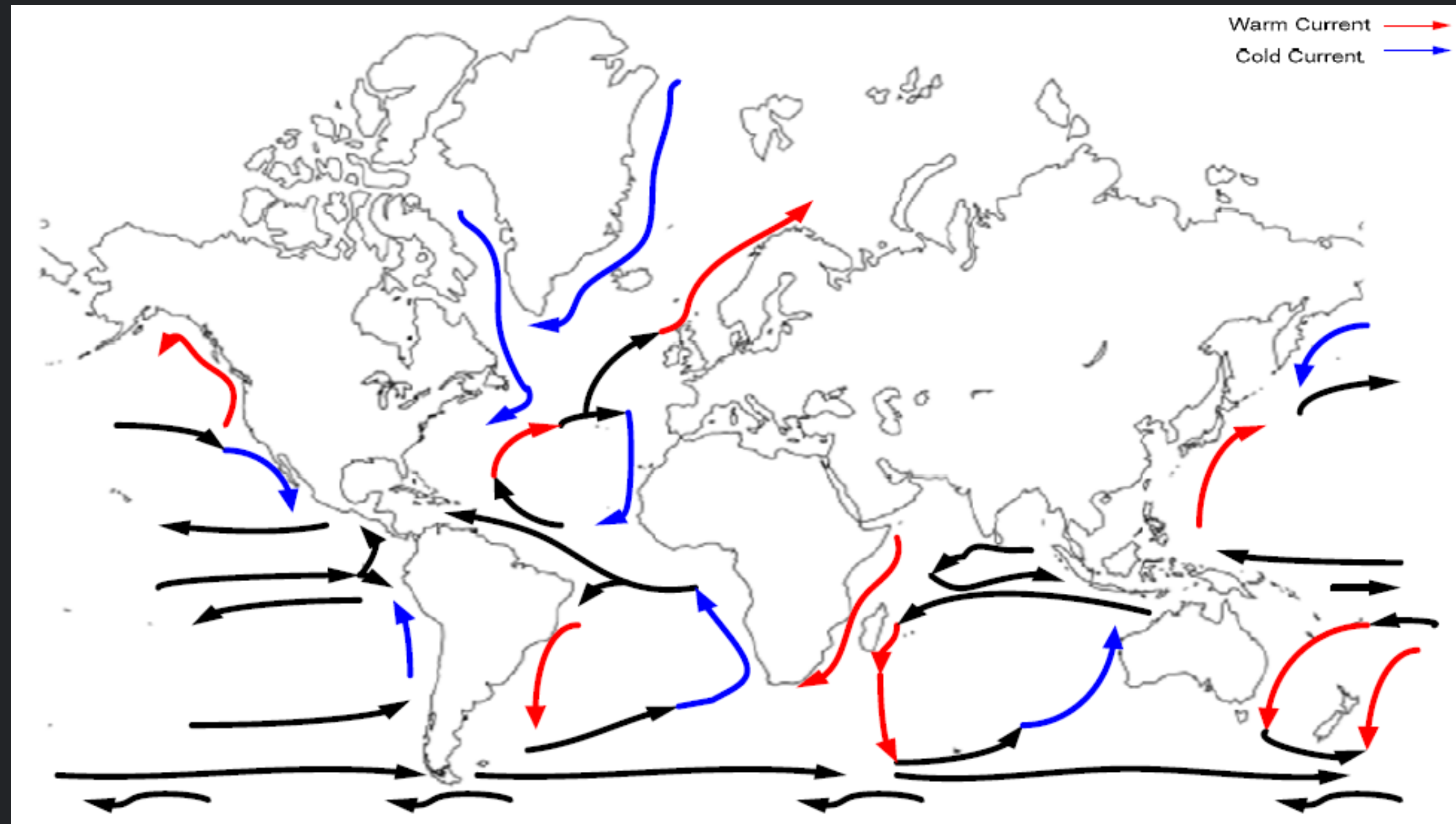
Tide rise and fall is the product of the gravitational and centrifugal force of primarily the moon and earth.

Type of Tide Wave



Kecepatan siklus: Semidiurnal Tide > Diurnal Tide

Distribution of Ocean Current



- Angin dingin berasal dari kutub dan Angin panas dari garis katulistiwa
- Pertemuan dari keduanya menandakan daerah tersebut memiliki potensi *wave energy* dan *wind energy* yang baik

Salinity Gradient Energy

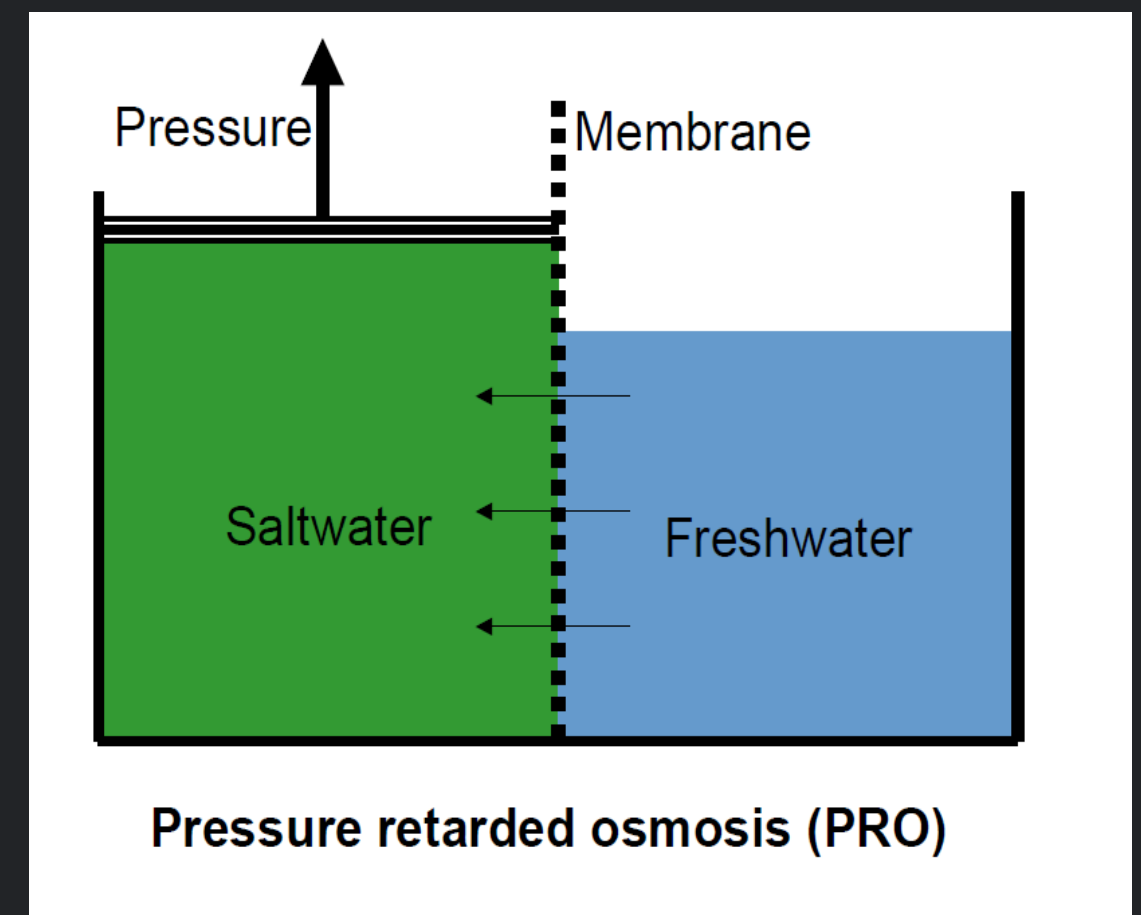
Two approaches

1. “Pressure Retarded Osmosis (PRO)”:

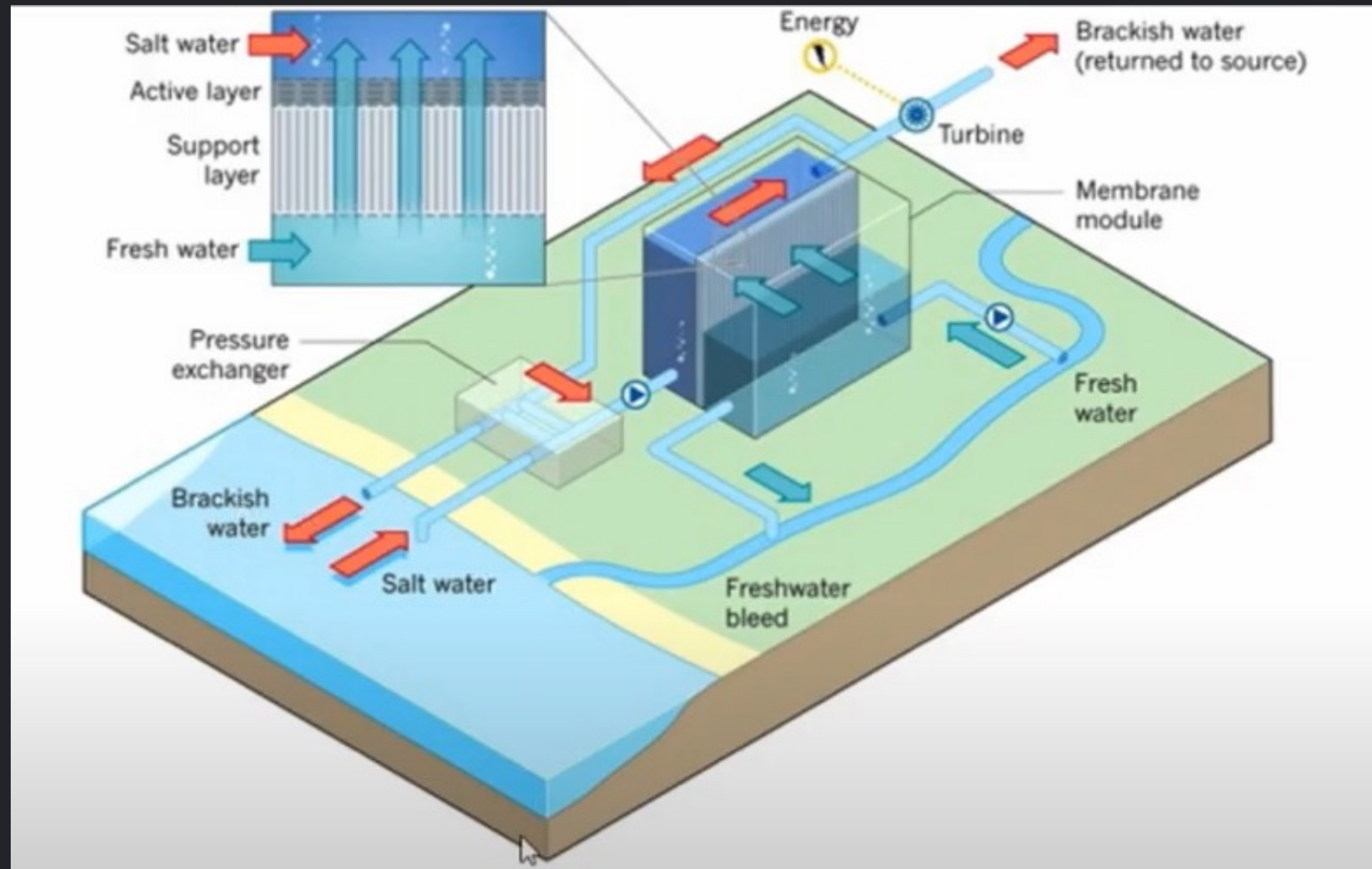
relies on water molecules moving through a membrane, which is semi-permeable. When salt water is contained on one side of the membrane & fresh water is on its other side, fresh water is osmotically drawn into the salty side.

This drives up the pressure in the “salty” chamber, and the sea water can then be sent through a turbine that generates power.

(Dr Rolf JarleAaberg Statkraft EnergiAS, Norway, 2004)



Pressure Retarded Osmosis



Salinity Gradient Energy

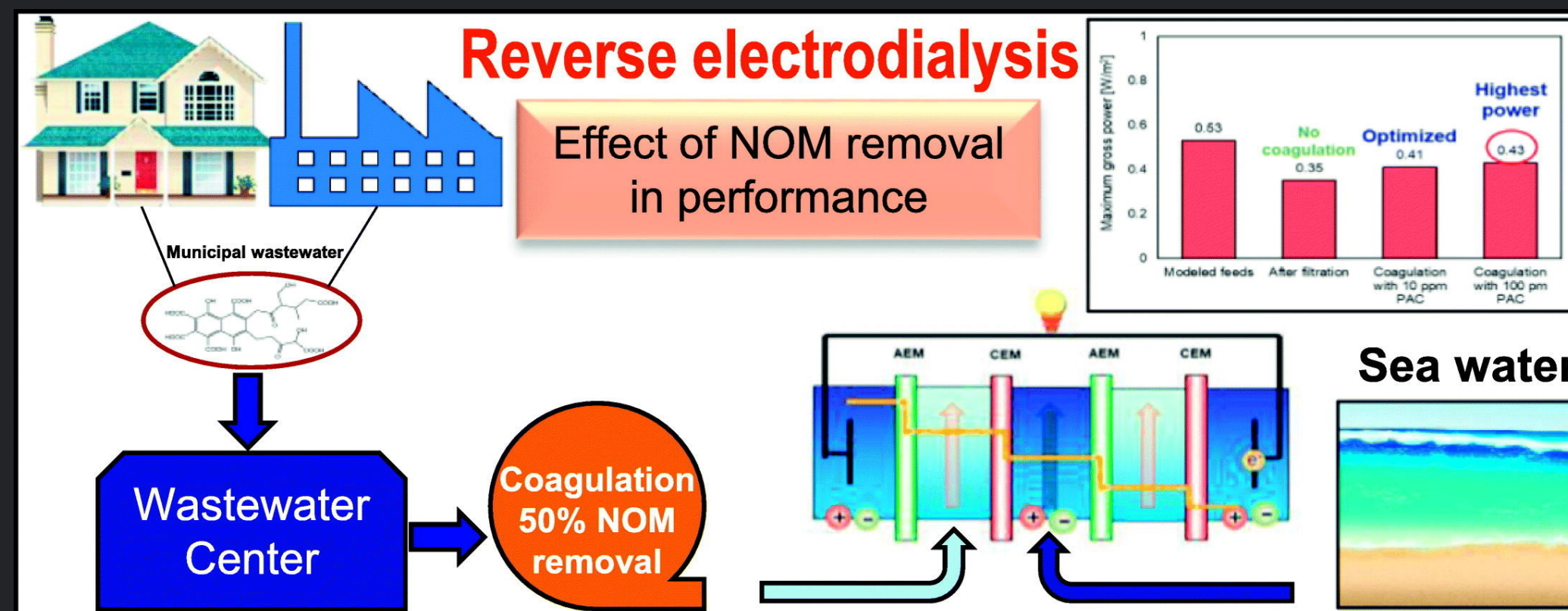
2. “Reverse ElectroDialysis (RED)”:

In RED, a concentrated salt solution & a fresh water are brought into contact through an alternating series of anion exchange membranes (AEM) and cation exchange membranes (CEM)

The difference in chemical potential between both solutions is the driving force for this process. The chemical potential difference generates a voltage over each membrane and the overall potential of the system is the sum of the potential differences over the sum of membranes.

Reference <http://mtg.tnw.utwente.nl/teaching/assign/blue/>

Google reverse electrodialysis power generation



Ocean Thermal Energy Conversion

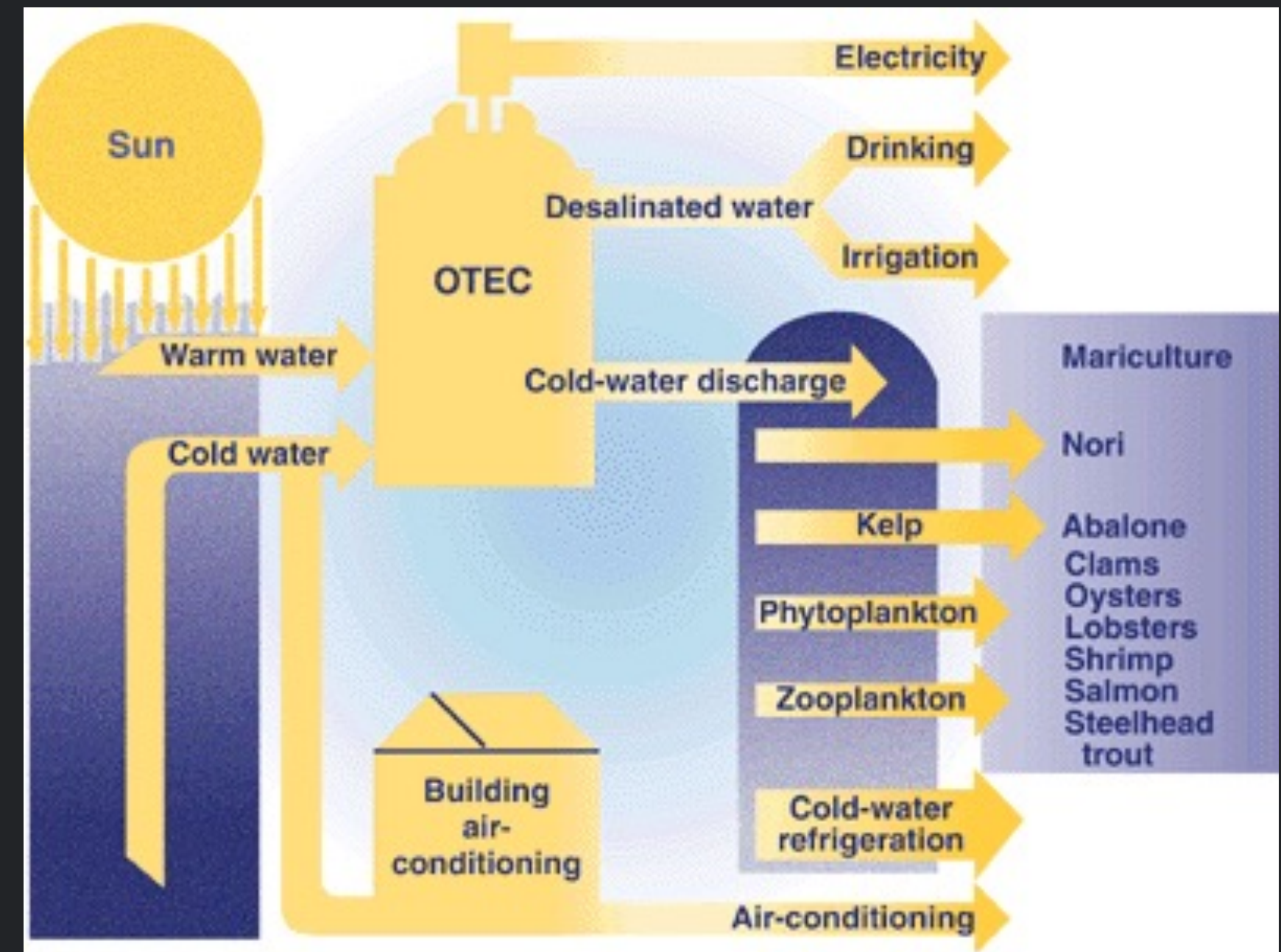
Applications

Ocean thermal energy conversion (OTEC) systems have many applications or uses. OTEC can be used to generate electricity, desalinate water, support deep-water mariculture, and provide refrigeration and air-conditioning as well as aid in crop growth and mineral extraction.

These complementary products make OTEC systems attractive to industry and island Communities.

<http://www.nrel.gov/otec/applications.html>

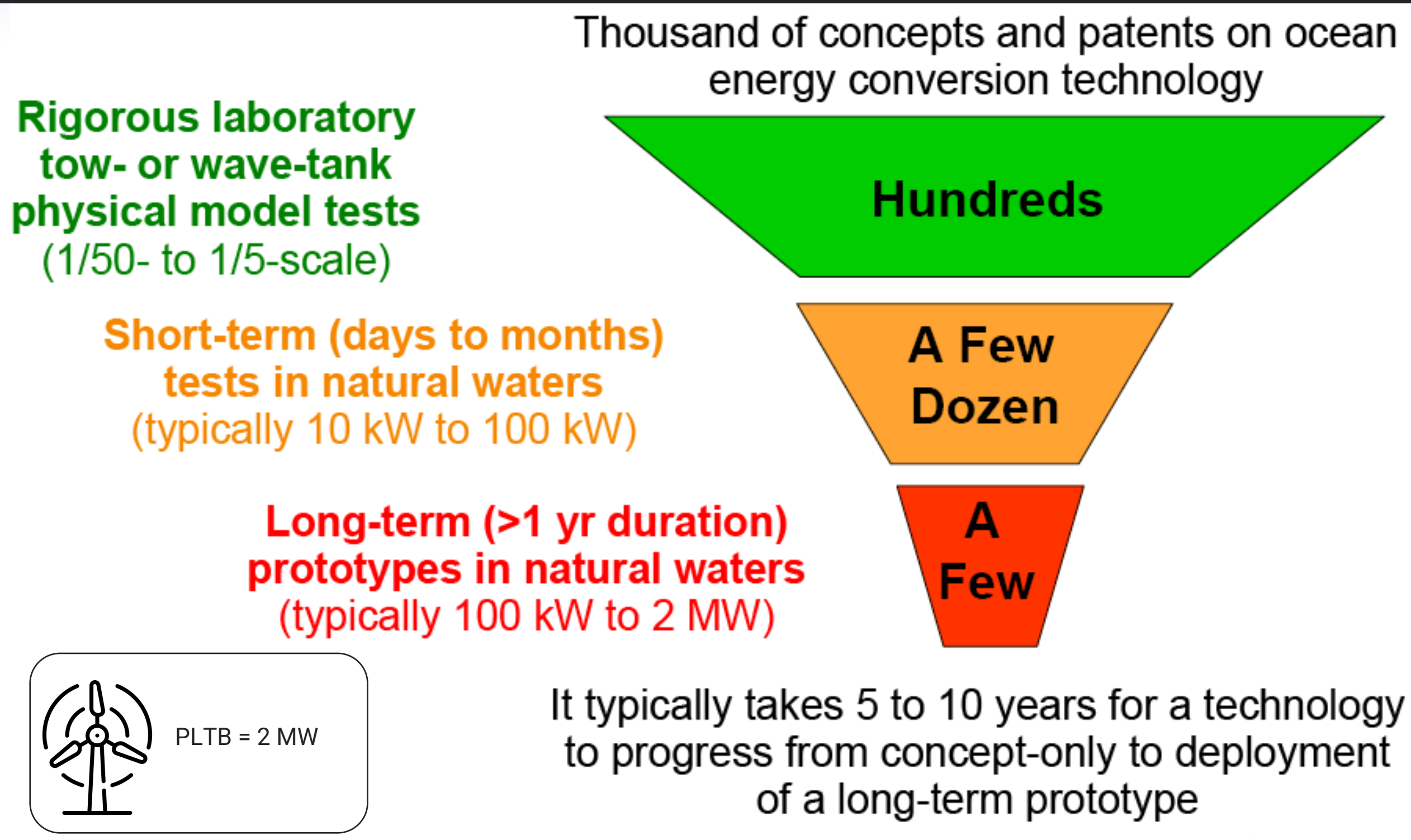
<https://www.youtube.com/watch?v=LJV4d4XtHuo>



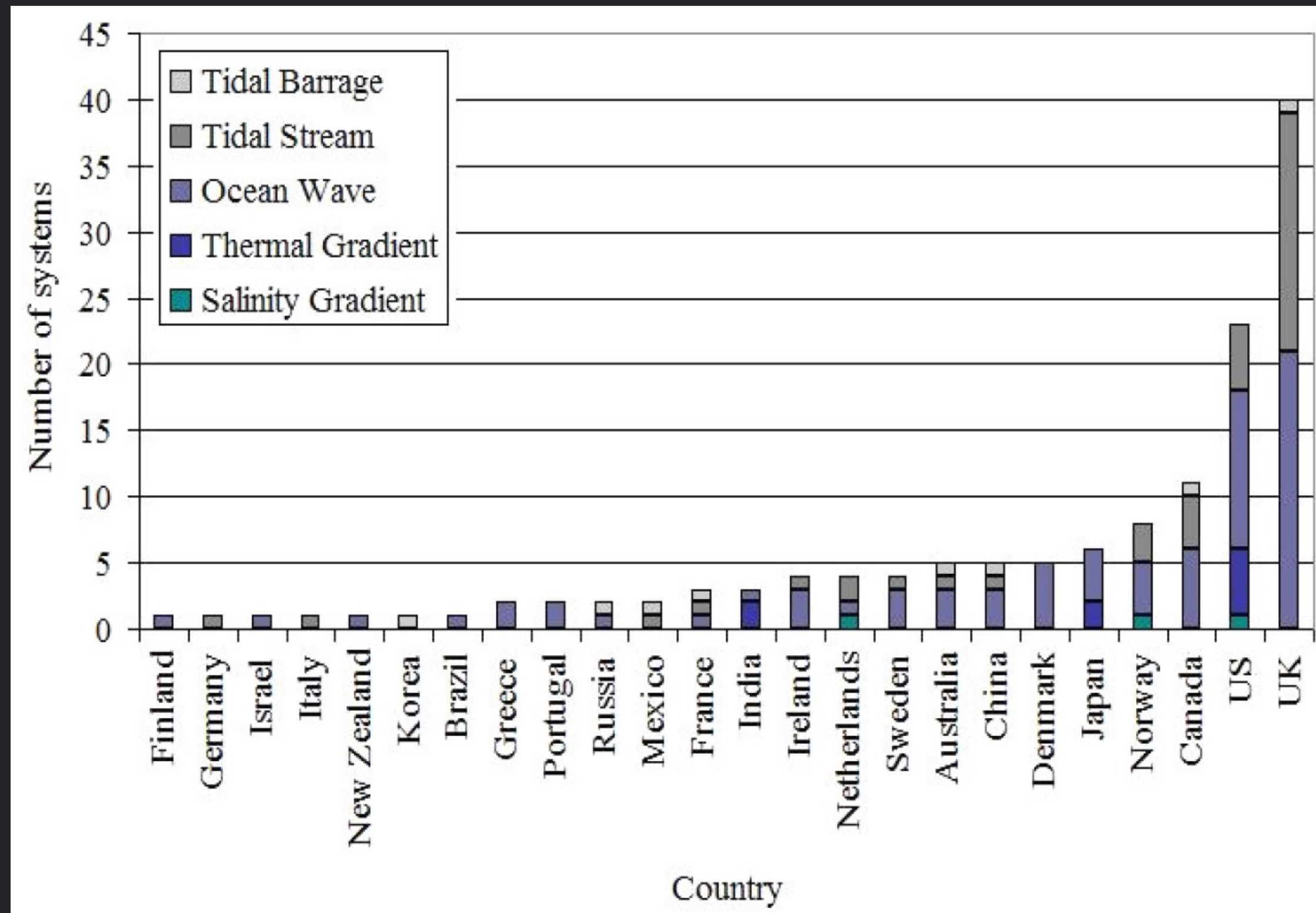
Current Status of Ocean Energy Technologies



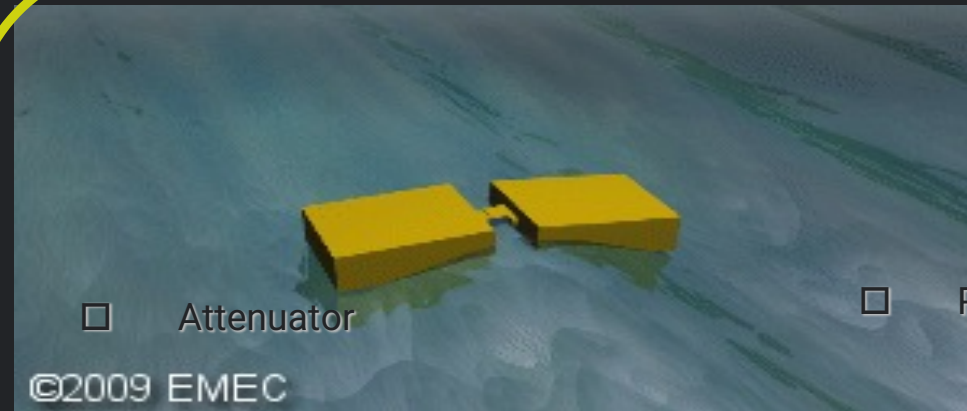
● Phases in Ocean Energy Technologies



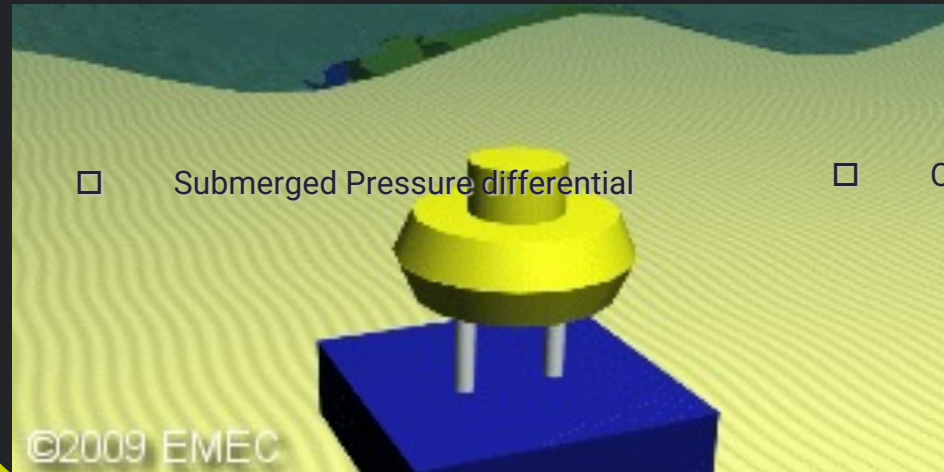
Country Participation in OE Development



● Classification of Wave Energy Conversion Technologies

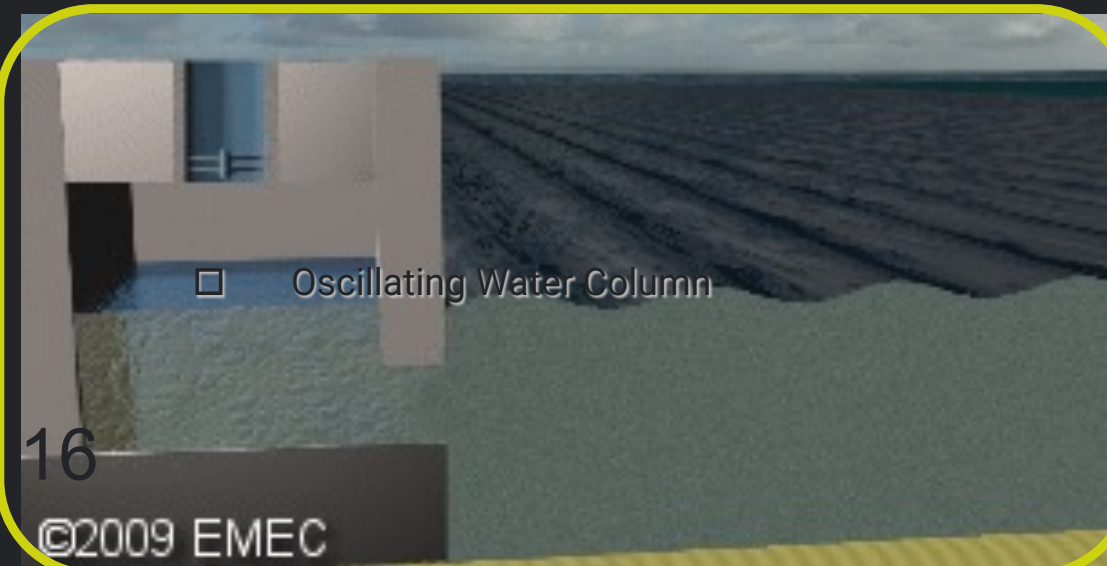


Wave Activated



OWC

Wave Overtopping



16





Examples

1. Attenuator ----- Pelamis **Pelamis Offshore Wave Energy in Portugal**
<http://www.alternative-energy-news.info/pelamis-offshore-wave-energy-portugal/>
2. Point Absorber ----- Power Buoy (OPT)
https://www.youtube.com/watch?v=WyiR_vtRR_M
3. Oscillating Wave Surge Converter
https://www.youtube.com/watch?v=D_lyJXFmEL0
4. Oscillating Wave Column (OWC) ----- (compress the air, near the shore line) <https://www.youtube.com/watch?v=vlt3GlePA8c>
5. Overtopping Device ----- Wave Dragon
http://www.wavedragon.net/index.php?option=com_content&task=view&id=6&Itemid=5

● Wave Devices in Deployment



Power Buoy, OPT



AWS
Ocean
Energy



Oyster, Aquamarine
Power



Pelamis Wave Power



LIMPET, Wavegen



Wave Dragon

<https://www.youtube.com/watch?v=sZuc4LMtHoY>

● Classification of Wave Energy Conversion Technologies



Examples

6. Aquamarine Power----- Oyster

<https://www.youtube.com/watch?v=HJiLWQnRMYI>

7. AWS Ocean Energy

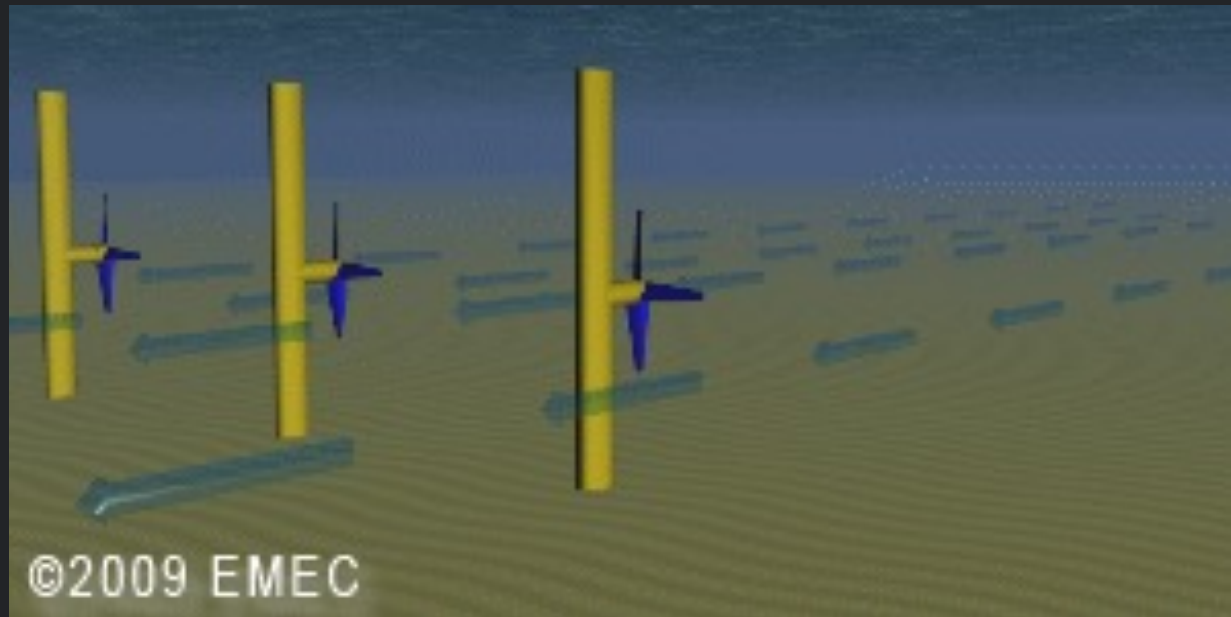
<http://www.awsocean.com/PageProducer.aspx>

8. Wavegen ----- LIMPET

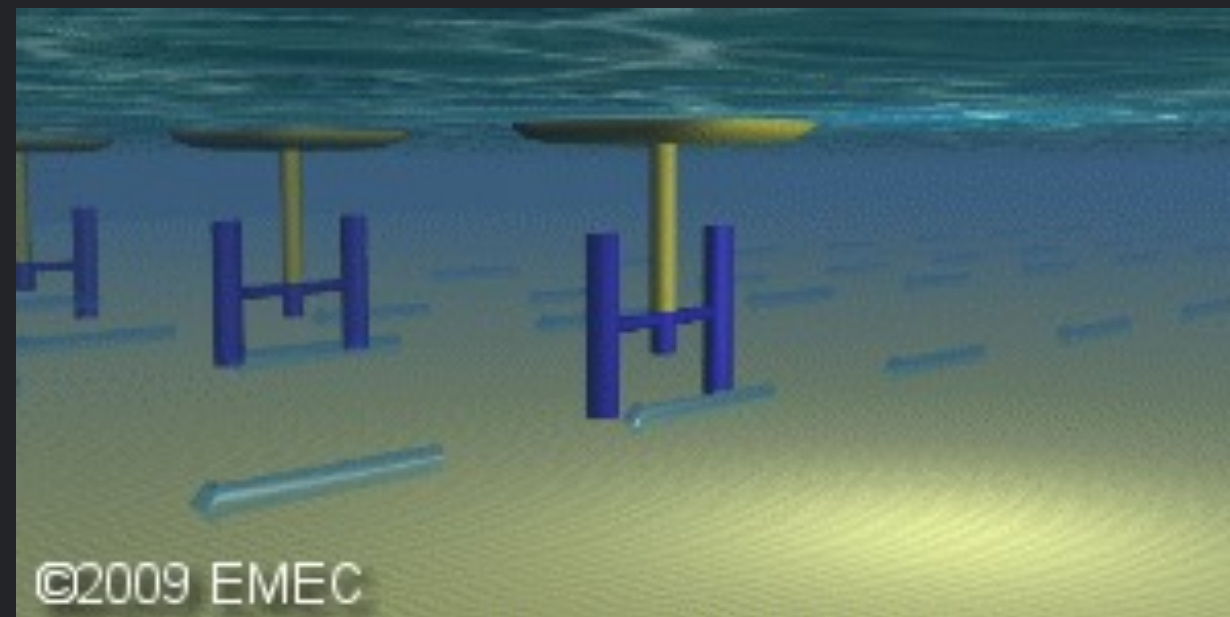
http://www.wavegen.co.uk/what_we_offer_limpet.htm

● Classification of Tide Energy Conversion Technologies

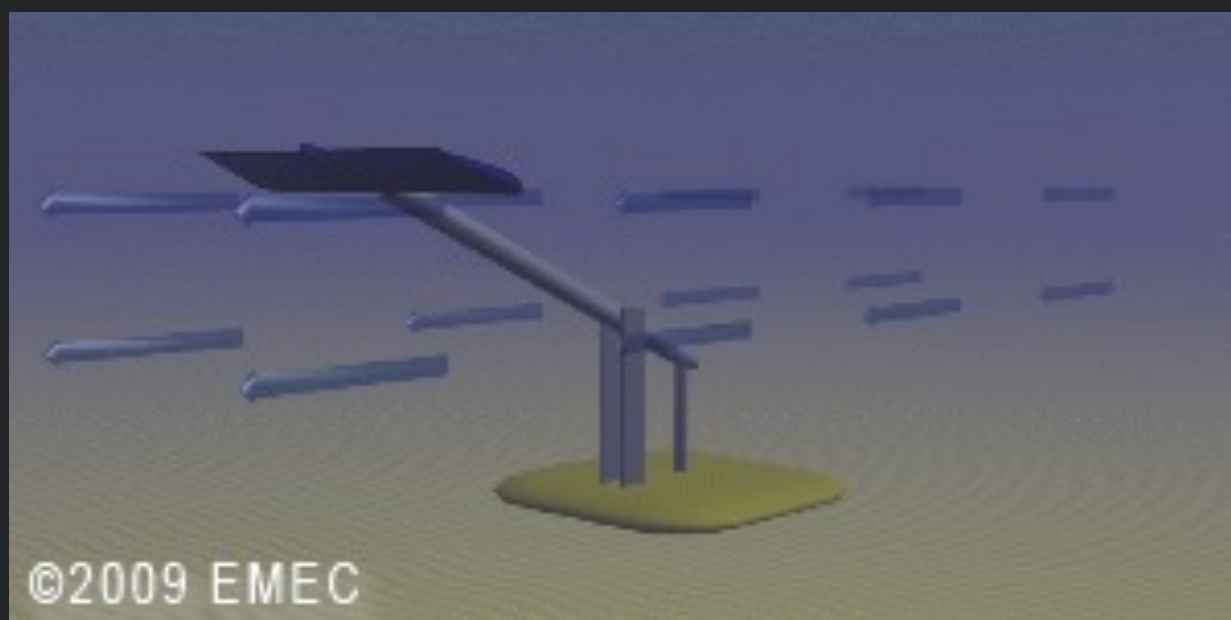
□ Horizontal Axis Turbine



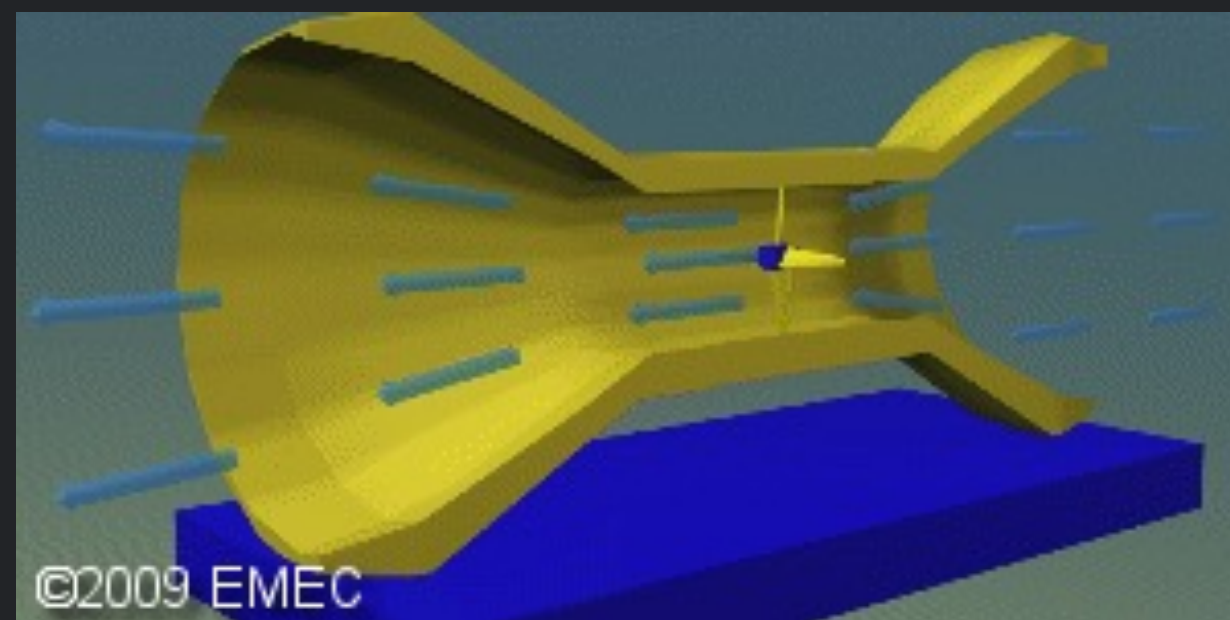
□ Vertical Axis Turbine



□ Oscillating Hydrofoil

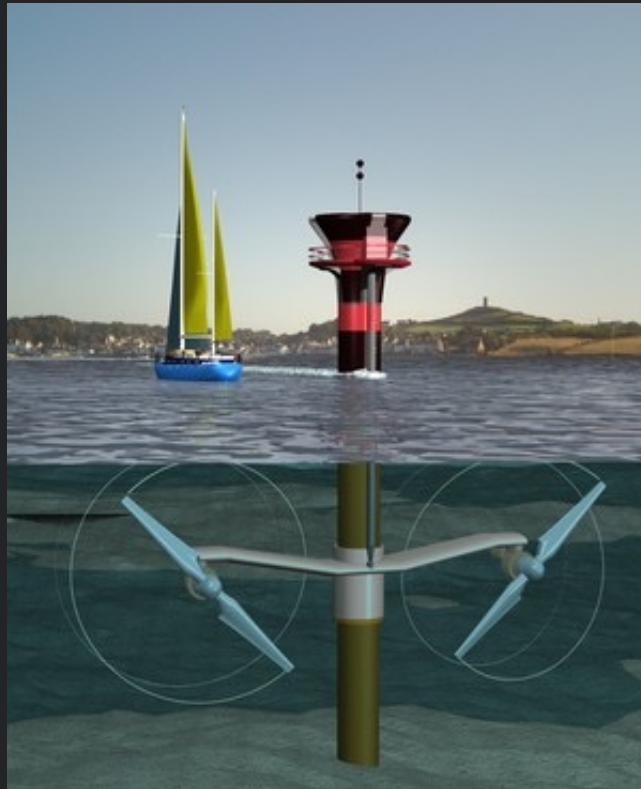


□ Venturi Effect



□ Others

Tidal Devices in Deployment



SeaGen, MCT Ltd



Uldolmok
Helical
Turbine,
KORDI



Stingray, EB



Lunar
Energy



Open
Hydro

● Classification of Tide Energy Conversion Technologies

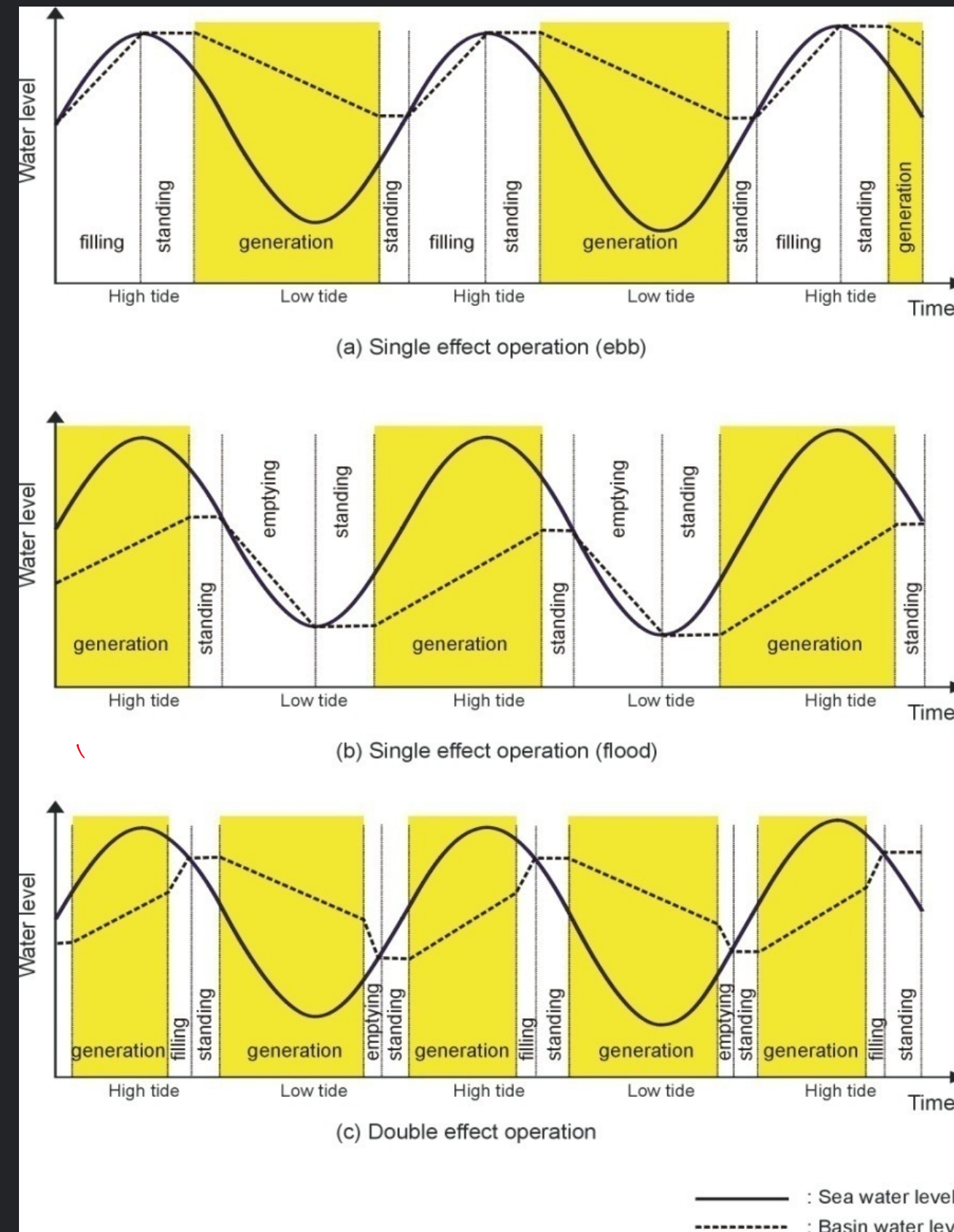
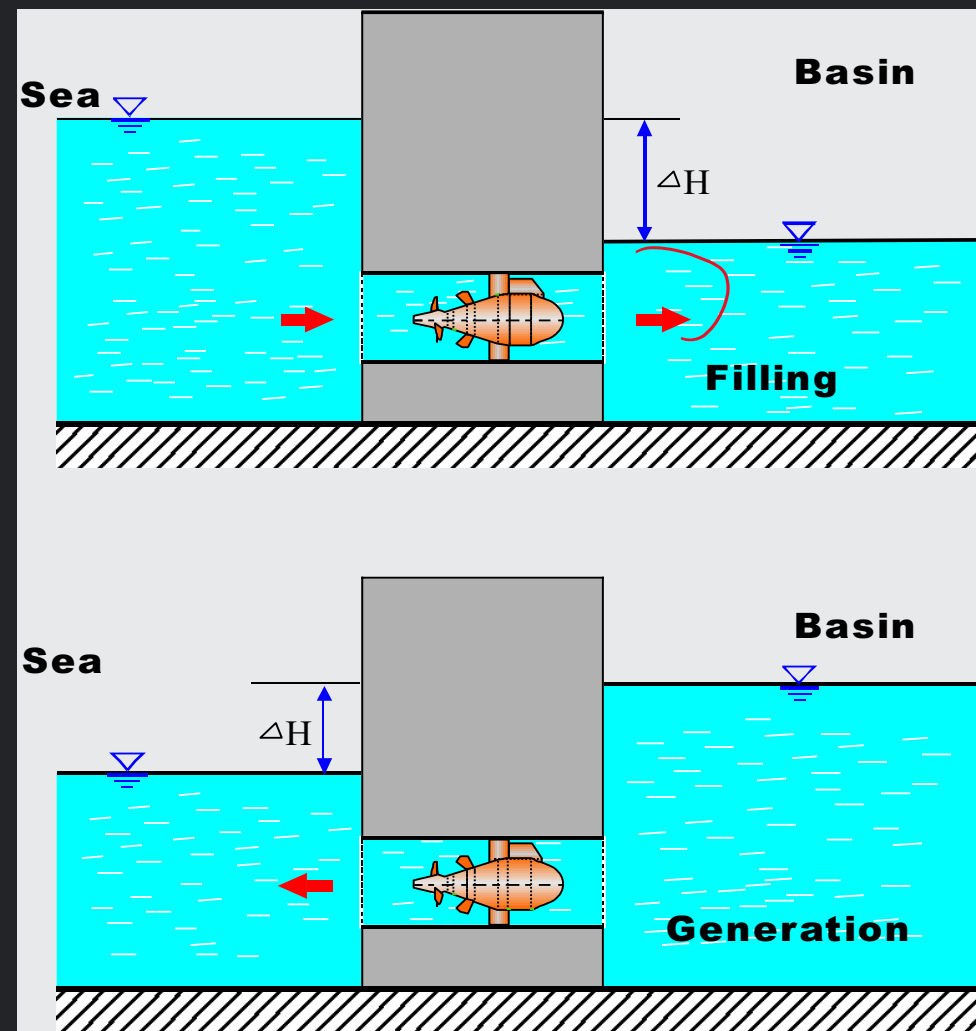


1. The European Marine Energy Center Ltd. <http://www.emec.org.uk/index.asp>
(information about marine energy) <http://www.emec.org.uk/marine-energy/wave-devices/>
2. Seagen MCT Ltd <http://www.alternative-energy-news.info/seagen-tidal-power-installation/>
3. Uldolmok Helical Turbine, KORDI (see Korea_tide_energy)
4. Stingray, EB <http://www.bwea.com/marine/devices.html>
5. Lunar Energy Ltd. <http://www.lunarenergy.co.uk/>
6. Openhydro Group
<http://www.snopud.com/PowerSupply/tidal/tidalbg/tidalopenhydro.ashx?p=1511>

● Tidal Range(Barrage) Energy Technologies



- ✓ Using the water level difference btw inside and outside of the basin
- ✓ Generation methods :
 - One way (ebb, flood)
 - Two way



● Sihwa Tidal Barrage Power Plant

➤ Site Conditions

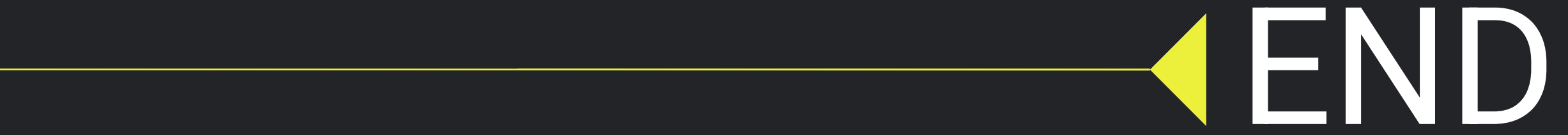
- ✓ Mean tidal range : 5.6m
- ✓ Basin area : 43km²(MSL)
- ✓ Capacity : 254MW
- ✓ Estimated annual output : 553GWh
- ✓ One-way flood generation



➤ Construction History

- ✓ Sea dyke of 12.7km completed in 1994
- ✓ Proposed as a counter measure to lake water pollution in 1997
- ✓ Feasibility study in 2002
- ✓ Plant construction 2004 to 2010





END