Energi Terbarukan

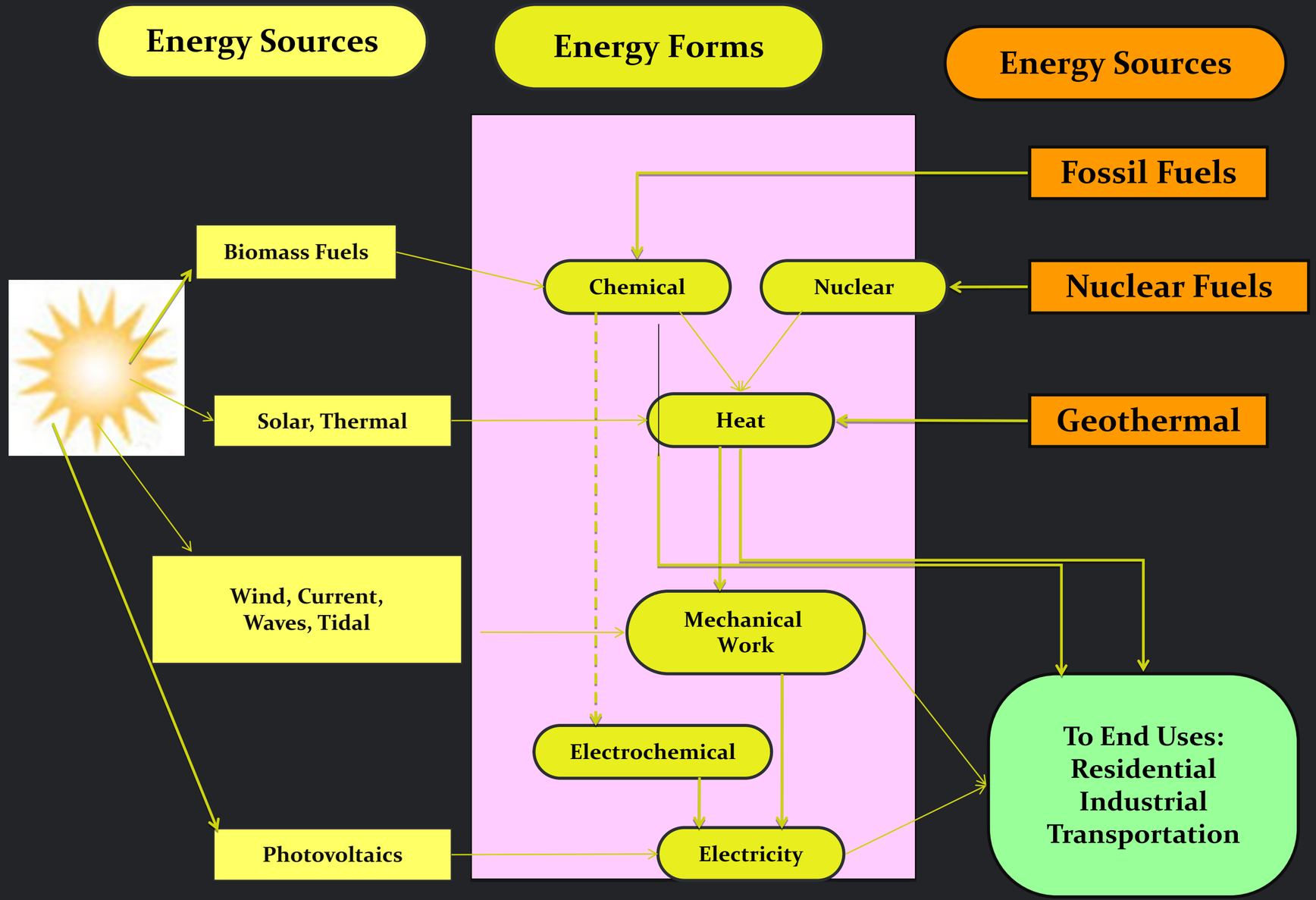
Pertemuan 3:
Energi Gelombang Laut

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

Wave Energy

Acquired and Modified from:

Master of Electrical Engineering – UGM, Husni Rois Ali, , S.T., M.Eng., Ph.D., DIC., SMIEEE.

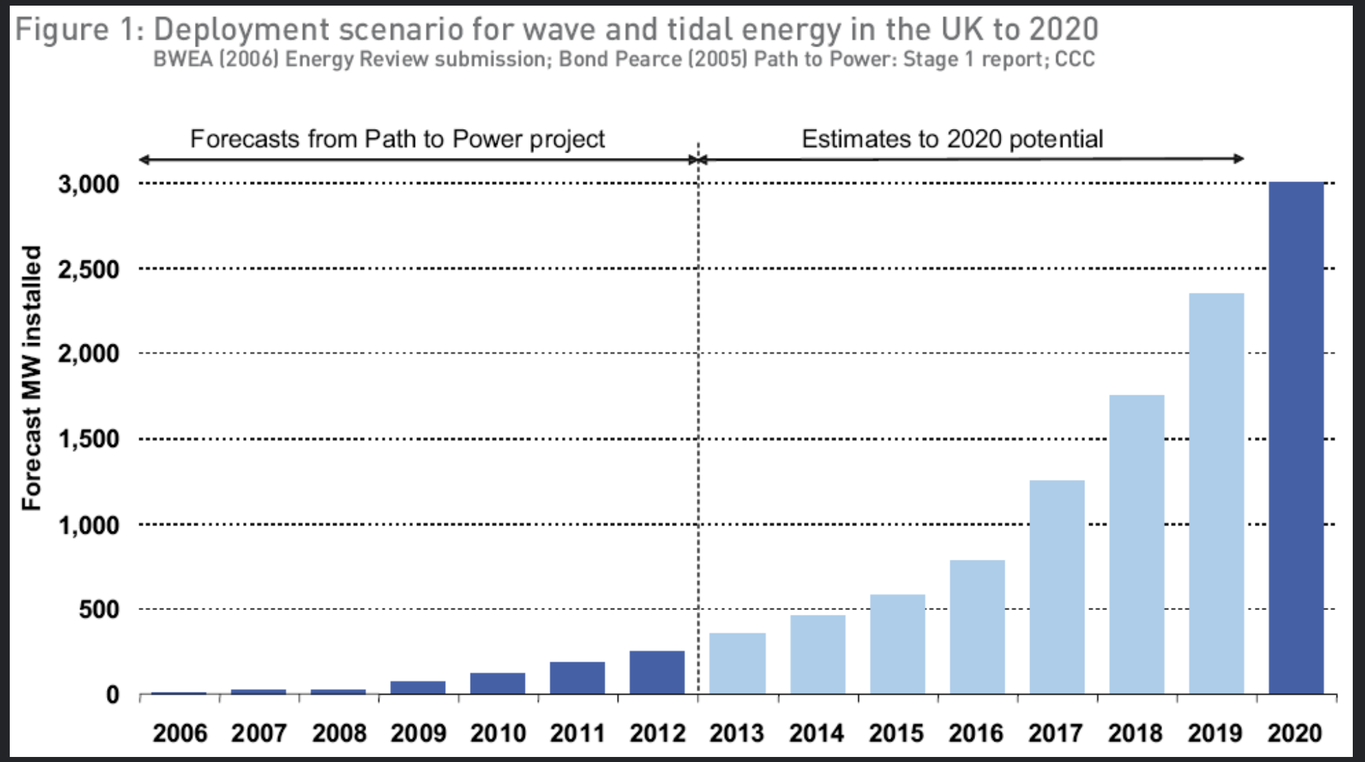

Energy Sources
Energy Forms
Energy Sources
Fossil Fuels
Biomass Fuels
Chemical
Nuclear
Nuclear Fuels
Solar, Thermal
Heat
Geothermal
Wind, Current,
Waves, Tidal
Mechanical
Work
Electrochemical
To End Uses:
Residential
Industrial
Transportation
Photovoltaics
Electricity

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



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	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

<IEA-OES Report-2008>

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.

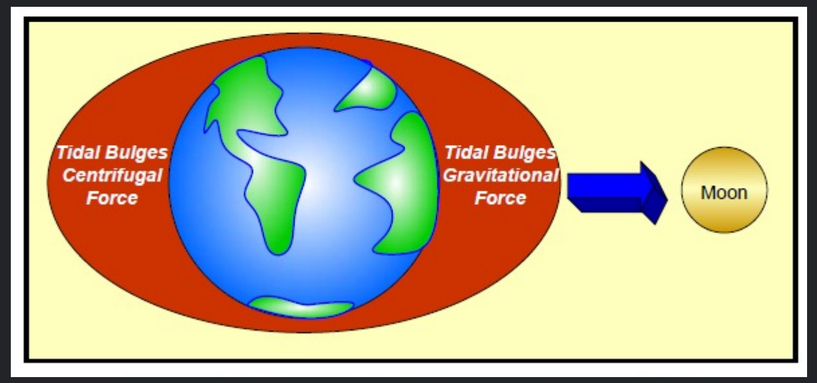
Ocean Waves: Kinetic & potential energy associated with ocean waves can be harnessed using modular types of technologies.

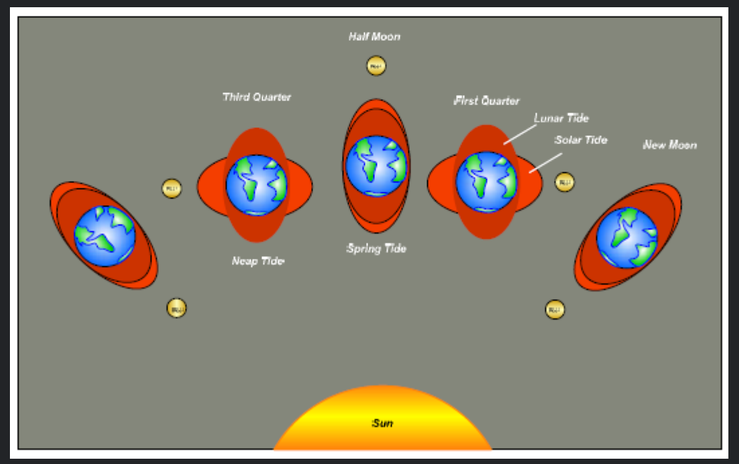
Marine Current: Kinetic energy associated with tidal/marine currents can be harnessed using modular systems.

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

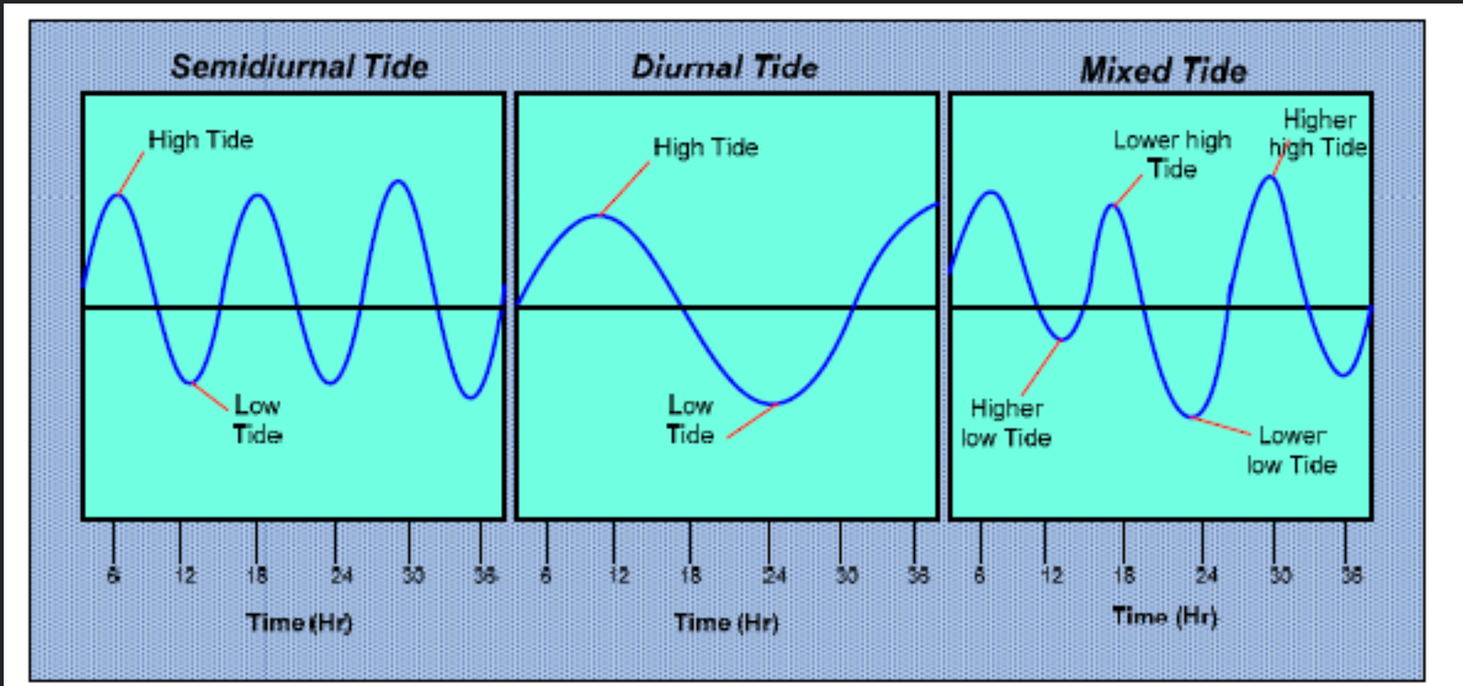




Interaction of the sun-earth-moon causes the strongest tidal.

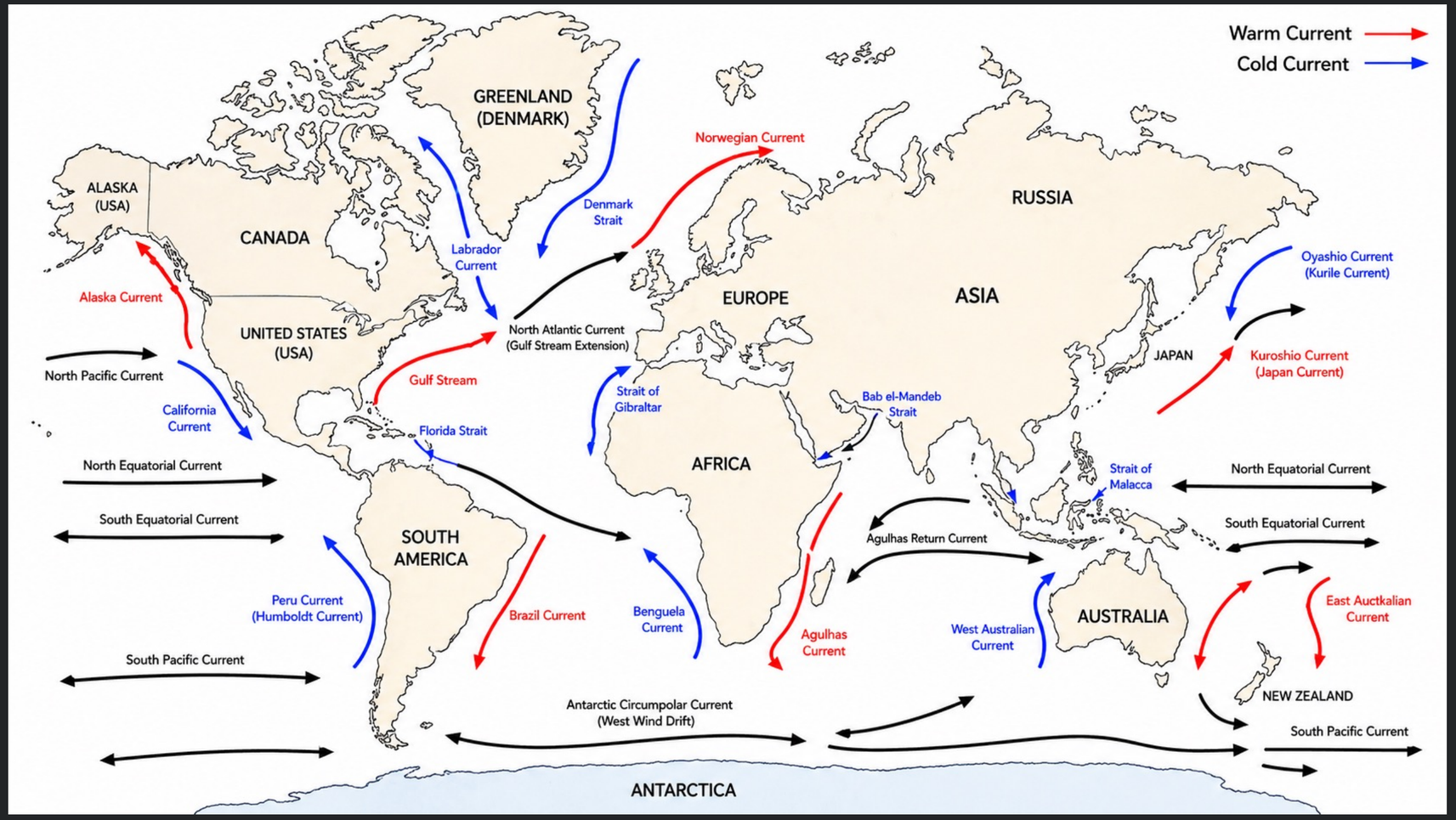
Tide rise and fall is the product of the gravitational and centrifugal force of primarily the moon and earth.

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
- Petemuan dari keduanya menandakan daerah tersebut memiliki potensi *wave energy* dan *wind energy* yang baik

Salinity Gradient Energy

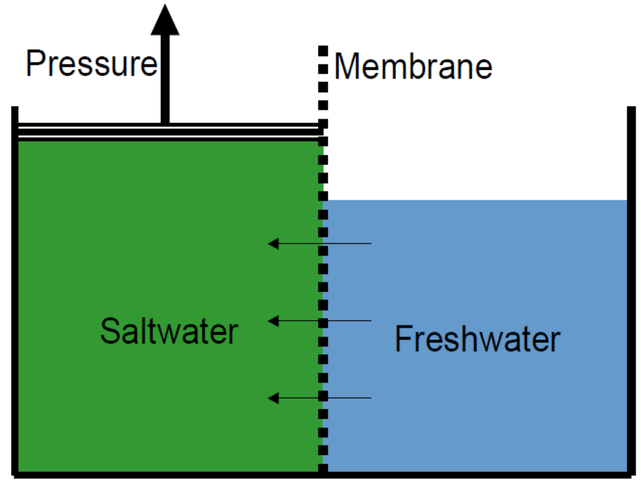
Two approaches

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.

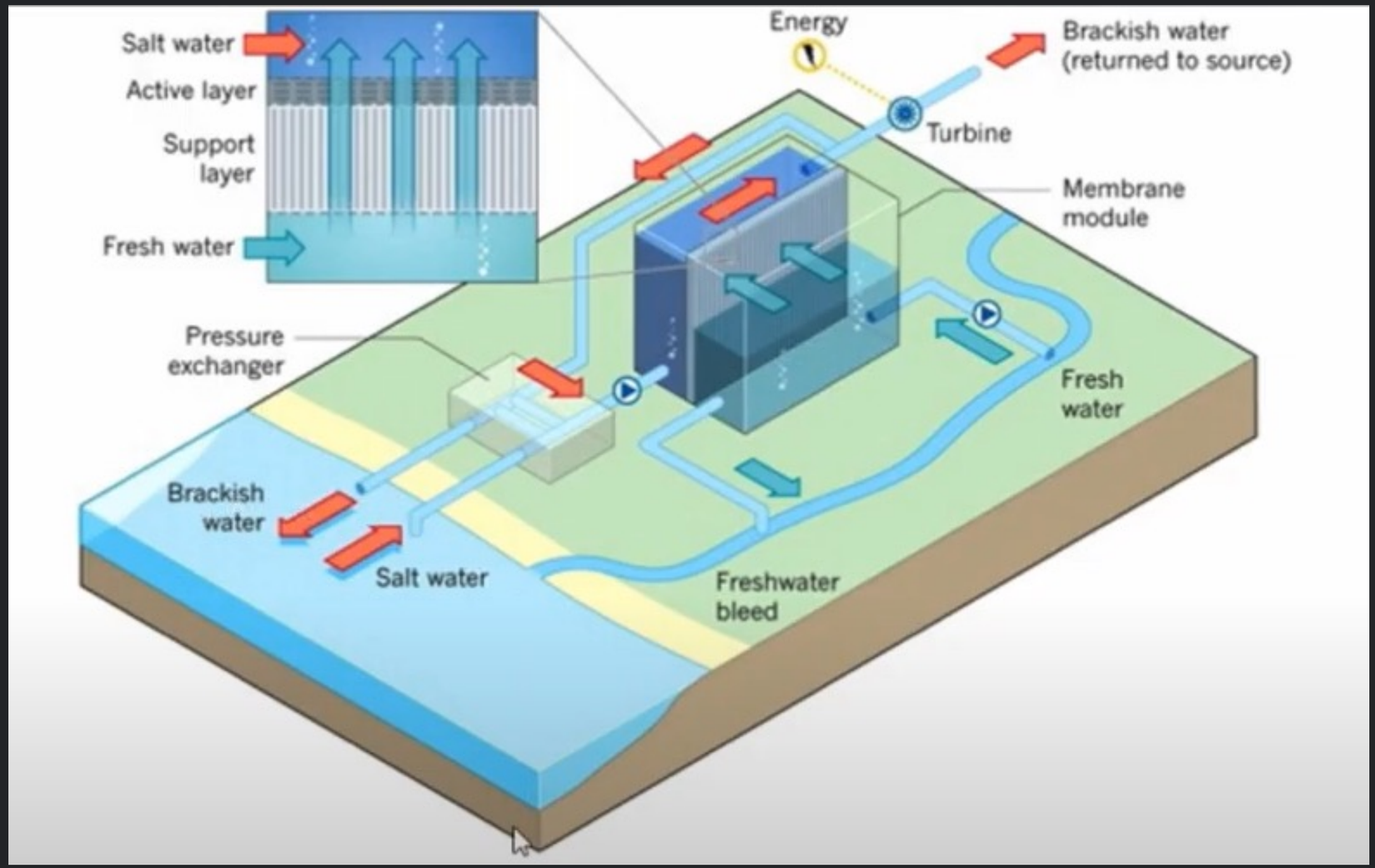
This drives up the pressure in the "salty” chamber, and the sea water can then be sent through a turbine that generates power.

(*Dr Rolf JarleAaberg* Statkraft EnergiAS, Norway, 2004)



Pressure retarded osmosis (PRO)

Pressure Retarded Osmosis



Salinity Gradient Energy

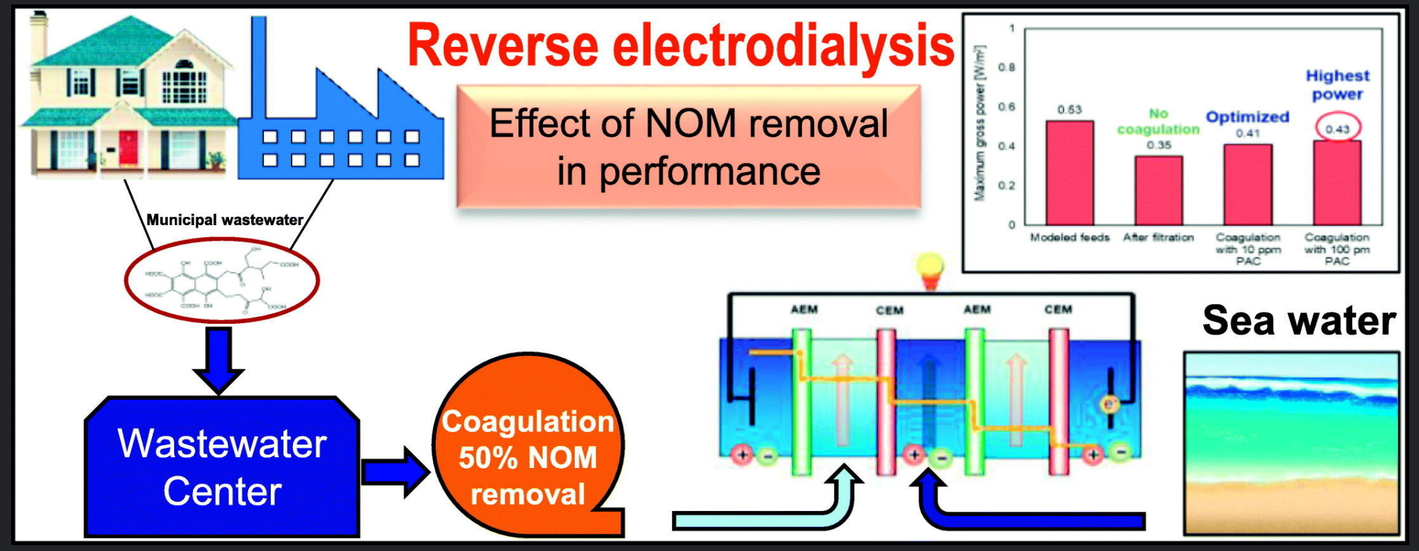
2. “**Reverse ElectroDialysis (RED)**”:

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



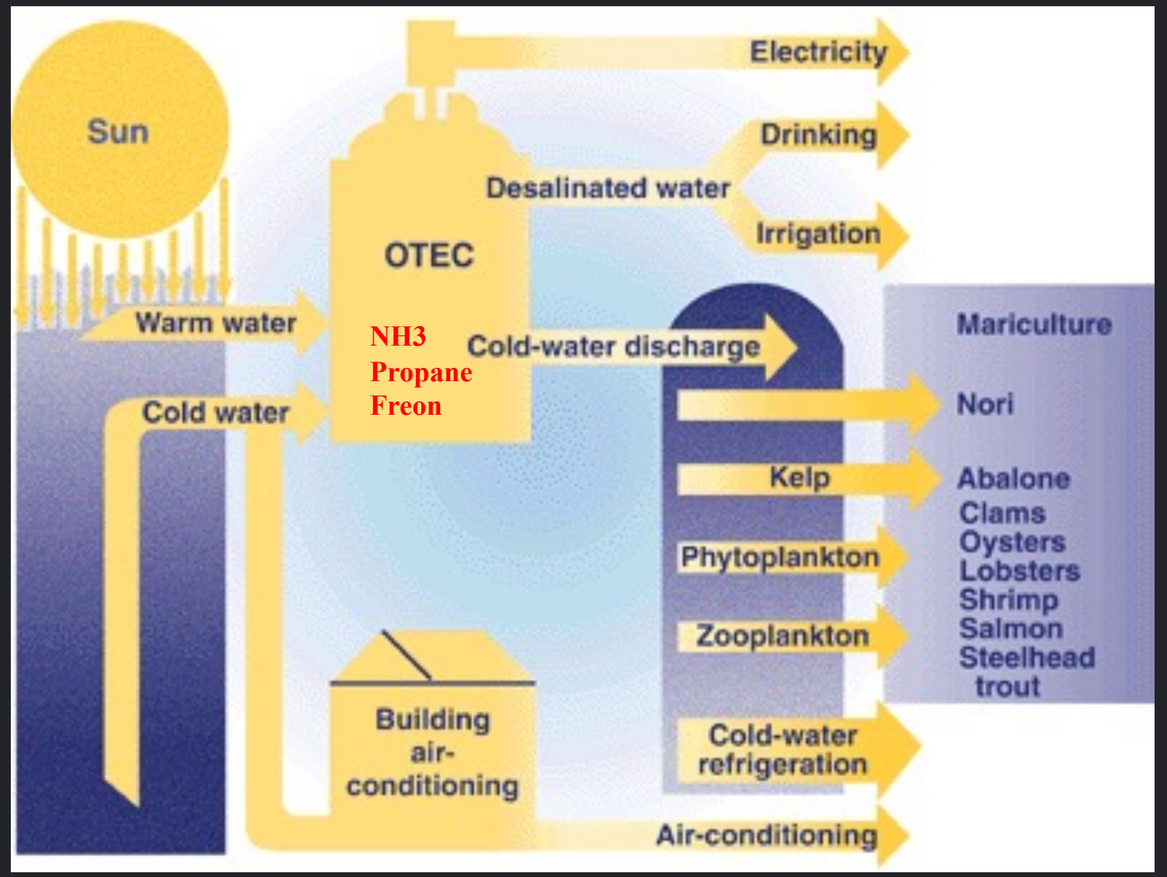
Ocean Thermal Energy Conversion

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

Thousand of concepts and patents on ocean energy conversion technology

Rigorous laboratory tow- or wave-tank physical model tests
(1/50- to 1/5-scale)

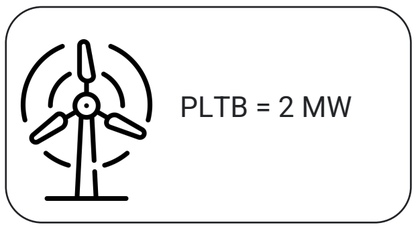
Hundreds

Short-term (days to months) tests in natural waters
(typically 10 kW to 100 kW)

A Few Dozen

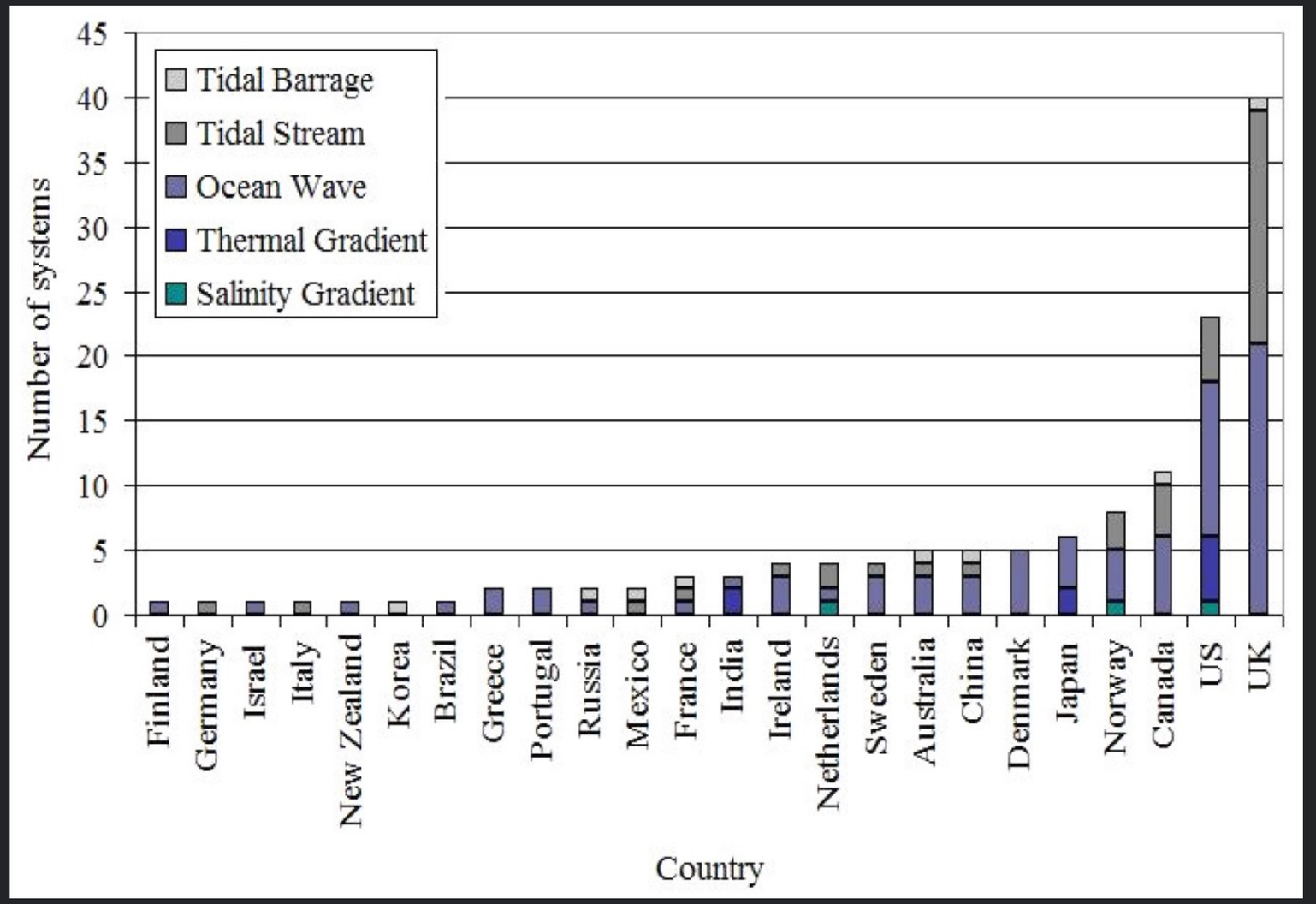
Long-term (>1 yr duration) prototypes in natural waters
(typically 100 kW to 2 MW)

A Few

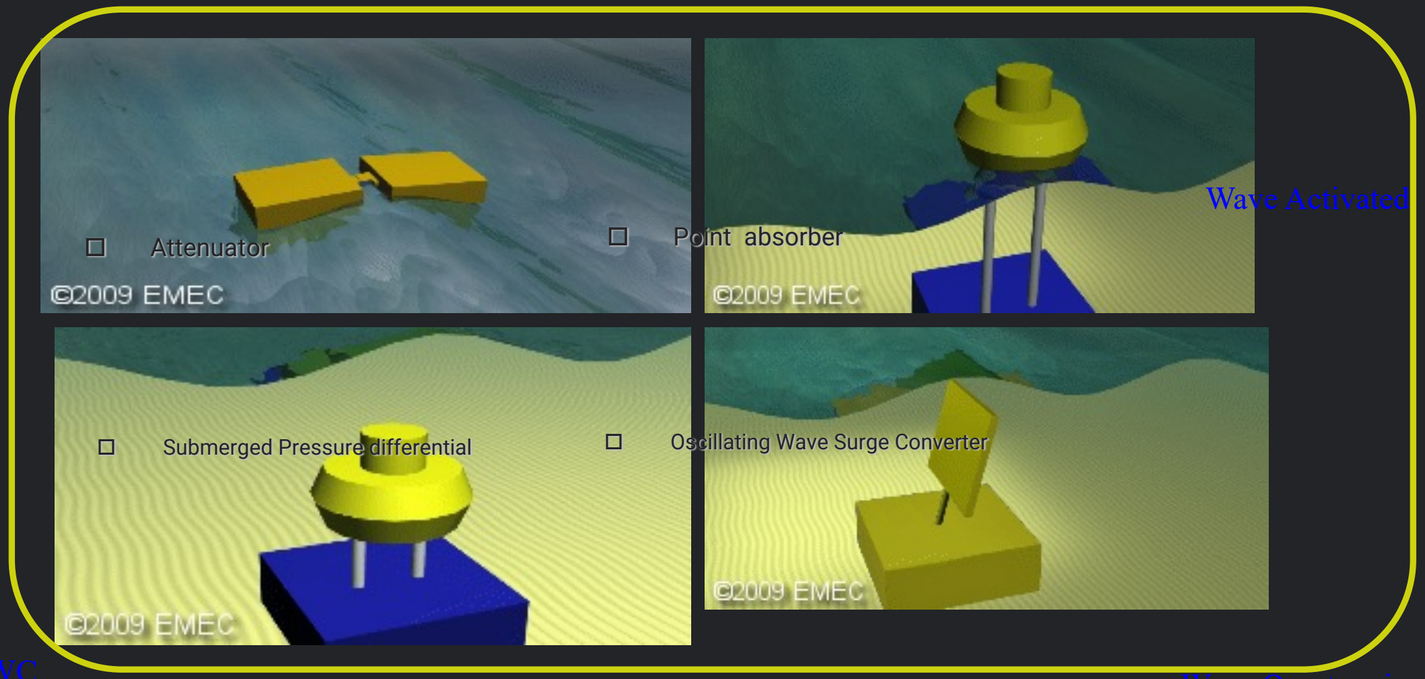


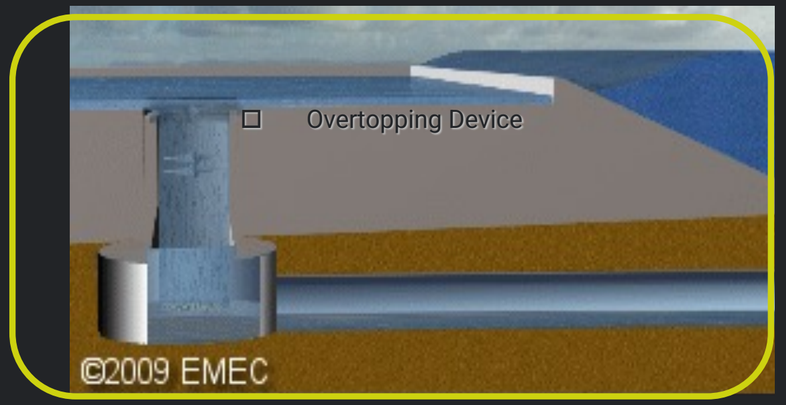
It typically takes 5 to 10 years for a technology to progress from concept-only to deployment of a long-term prototype

Country Participation in OE Development



Classification of Wave Energy Conversion Technologies





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Classification of Wave Energy Conversion Technologies

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_IyJXFmEL0

4. Oscillating Wave Column (OWC) ----- (compress the air, near the shore line) https://www.youtube.com/watch?v=vIt3GIePA8c
5. Overtopping Devise ------ 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

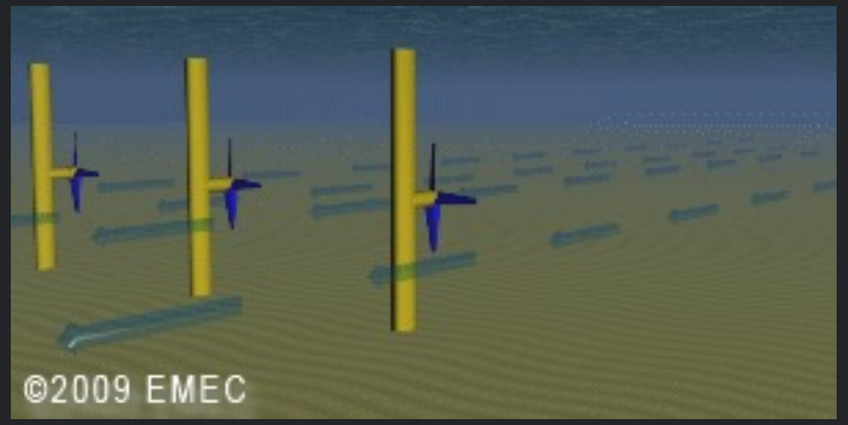
6. Aquamarine Power------ Oyster
   https://www.youtube.com/watch?v=HJiLWQnRMYI

7. AWS Ocean Energy
   http://www.awsocean.com/PageProducer.aspx

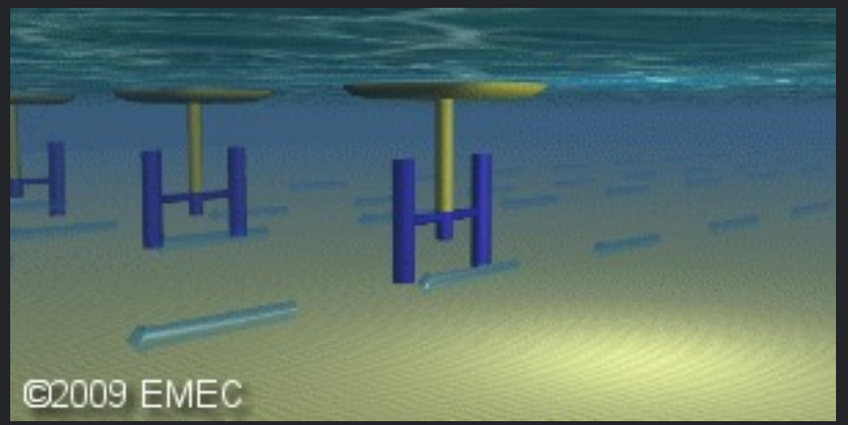
8. Wavegen ----- LIMPET
   http://www.wavegen.co.uk/what_we_offer_limpet.htm

Classification of Tide Energy Conversion Technologies

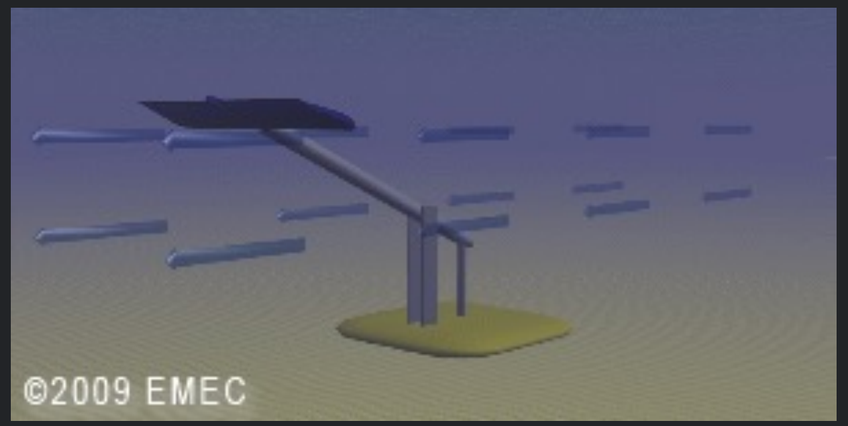
- Horizontal Axis Turbine



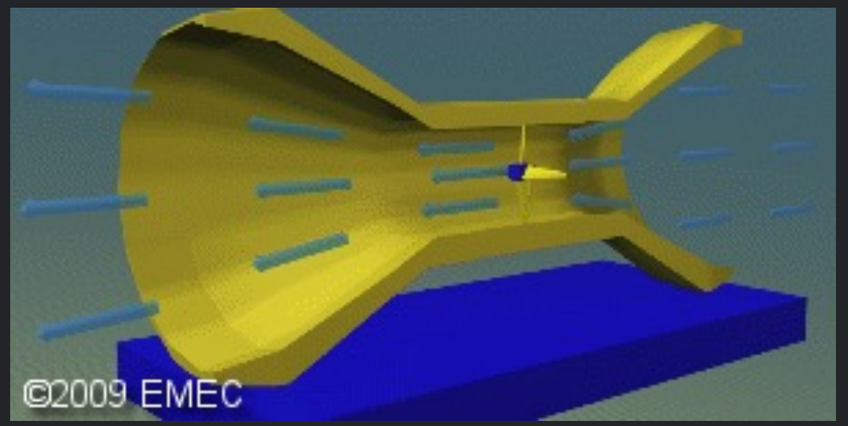
- Vertical Axis Turbine



- 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)

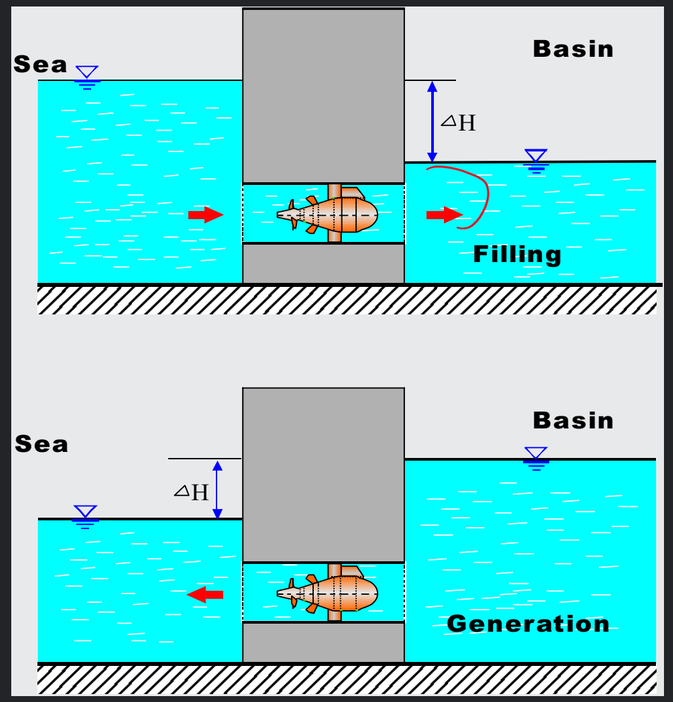
4. Stingray, EB http://www.bwea.com/marine/devices.html

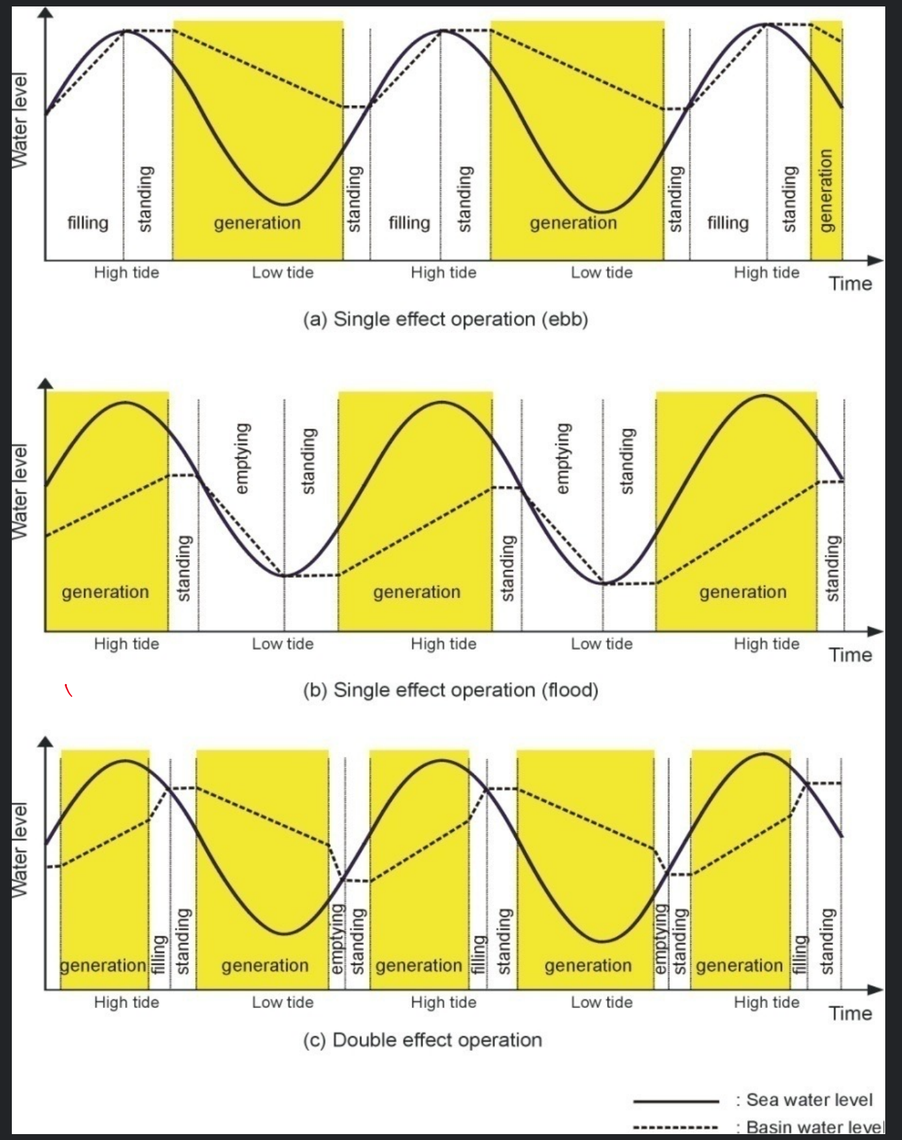
5. Lunar Energy Ltd. http://www.lunarenergy.co.uk/

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 :
  - 0ne 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