Daffodil International University
Sagar Mozumder
Lecturer, ESDM, DIU

Tides

- Tides are caused by gravitational forces between the sun, moon and bodies of water on the earth
- The flow of a rising tide is the **flood**; the flow of a falling tide is the **ebb**
- The difference in height between high and low tide is called the **range**
- The change in gravitational potential energy of bodies of water due to tides provides tidal range energy
- The motion of water as it responds to tidal influences provides tidal stream energy

Daily Tides

- The moon and earth rotate (within the frame of reference of the earth) around a point just below the surface of the earth
- The reaction to the centripetal force from this rotation causes the seas on the side furthest from the moon to bulge up (rising tide) more than on the side closest the moon
- There is also a gravitational attraction towards the moon, which acts more strongly on the side closest the moon than the other side
- There are therefore always 2 high tides taking place at any one time across the earth
- As the earth rotates every 24 hours there will generally be 2 tides experience. Basically its every 25 hours. Tidal cycle is 12 hr 25 mins.

Tidal Power

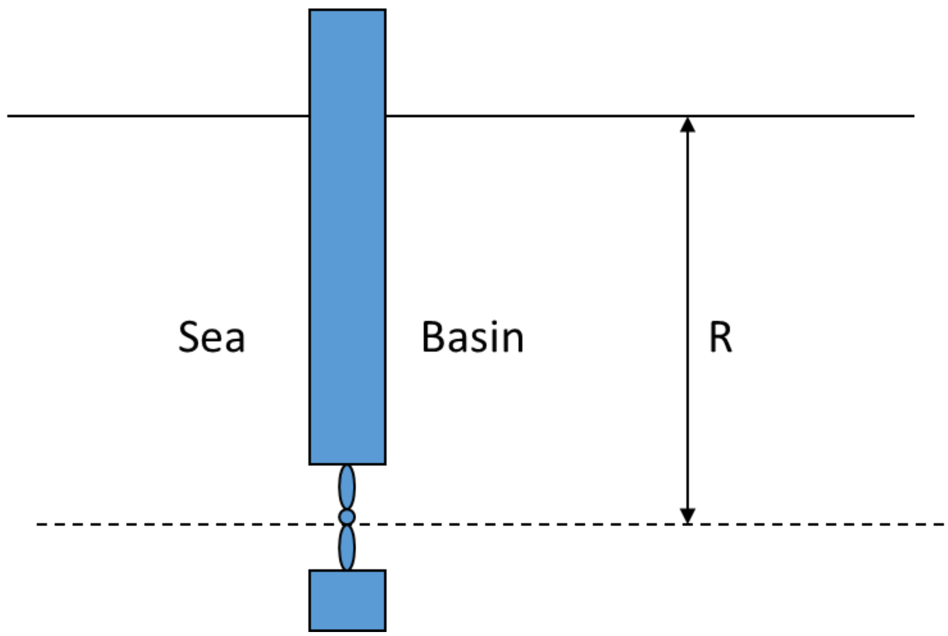
- The energy we get by exploiting tides. Theoretically any tide at any location can be used to produce electricity, but practically not possible.

Daffodil International University
Sagar Mozumder
Lecturer, ESDM, DIU

- There are two ways in which we can exploit the energy of the tides
- These are
  - Tidal Range Schemes/ Tidal Barrage
    - Exploits the gravitational potential energy difference between high and low tide
    - Analogous to dam based hydro scheme
  - Tidal Stream Schemes
    - Exploits the kinetic energy in the tides
    - Analogous to a wind turbine

Tidal Range/Barrage scheme

- By placing a barrage across an estuary we can trap water in the estuary at high tide and then release it at low tide
- Tidal Range Schemes exploit the difference in Head between the high and low tides.

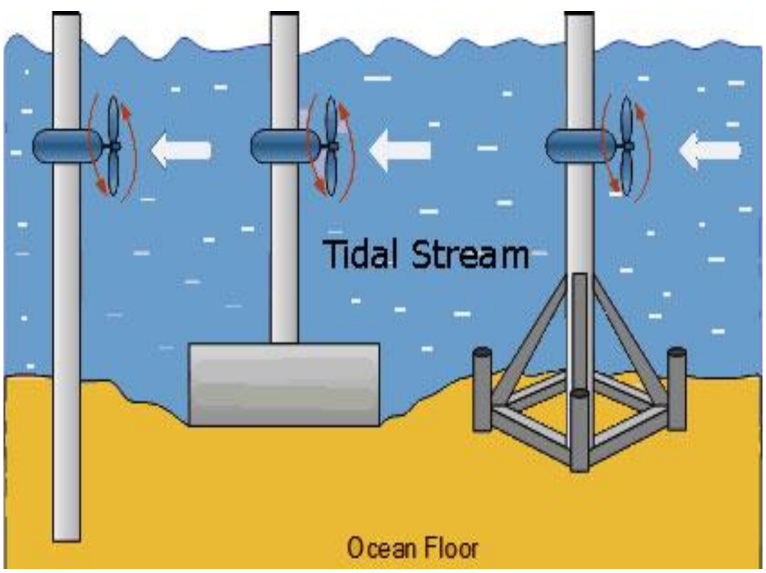


Tidal Range

Pros	Cons
Highly predictable	High capital cost
Similar in principle to large hydroelectric schemes (known technology)	Visually intrusive
Provides protection against flooding	Severely disruptive to ecology (intertidal regime)
Potential road/rail transport infrastructure	Silting potentially a large problem
Potentially a very large and reliable energy source	Highly variable output
	Barrier to shipping
	Tidal regime downstream can be altered
	Reduces upstream tidal range and current by about 50%

Tidal Stream

- Requires large tidal ranges moving through constrained channels, has similarity with run off river hydro
- Modular deployment of multiple devices
- Analogous to wind turbines



Highly predictable	High capital cost
Low disruption to ecology	Highly variable output
Very low visual impact	Devices still at an early stage of development
Potentially a significant and reliable energy source	

Comparisons

Attribute	Tidal stream	Tidal range
Predictability	Hundreds of years	Hundreds of years
Energy source	Kinetic	Potential (gravitational)
Civil engineering	Significant; structures weighing many hundreds of tonnes need to be manufactured, manouvered and installed	Massive; potentially some of the biggest building projects on the planet
Power generation	Insignificant on an individual scale; potentially large when scaled up in number of devices	Potentially very large generation at particular sites
Capital cost	Currently high but likely to decrease	Currently high and unlikely to change
Maintenance	Can be performed on individual units	Can be performed on individual turbines
O&M costs	Comparitively high	Comparitively low
Susceptibility to major outages	Low; modular units provide security of supply	Low; individual turbines could fail, but mass failure highly unlikely
Environmental impact	Low	Huge
Impact on shipping	Low; another navigation point to be avoided	Potentially large; requires locks to allow shipping to pass

Tidal Range/Barrage Equation

- Gross mean tidal power
- not all of the water will fall a distance R before it passes through the turbine. So R/2 is used (center of the mass modelling) in stead of R for better calculation.

$$P_{GM} = \frac{\rho A g R^2}{2T}$$

- Tidal cycle has period of approx 12.5 hours

ρ = Water density ($kg \cdot m^{-3}$)
A = Basin surface area (m)
g = Gravitational Constant ($m \cdot s^{-2}$)
R = Tidal Range (m)
T = Period (s)

Tidal Stream Equation

- Power available in the tidal current is modelled in the same way as that for wind power
- Power is defined as the rate of change of kinetic energy of the tide.
- Power extracted is proportional to cube of velocity

$$P = C_P \frac{1}{2} \rho A V_\infty^{\ 3}$$

P = power available in the tide (W)
C_P = power coefficient
ρ = density of sea water ($kg \cdot m^{-3}$)
A = swept area of rotor (m^2)
V_∞ = undisturbed tidal velocity ($m \cdot s^{-1}$)

Example Question

- If the tidal range at a site is 12 m and the surface area of the straight sided basin is 20 km^2, what is the gross mean power that can be generated from the site?
  - Density of water is 1000 $kg \cdot m^{-3}$
  - Gravitational constant is 9.81 $m \cdot s^{-2}$
  - Tidal Period is 12.5 hrs

Tidal Energy in Bangladesh

Bangladesh has almost 710 kilometres long coastal line. Generally, the tidal heads rise and fall ranging from 2 to 8 meters. So, it is assumed that tidal wheel technology in the sluice gates can be useful there. There hasn't been any detailed study or experiment on tidal energy in the country. The ISTP of Murdoch University, Australia planned for a demonstrative tidal plant in Swandip, a coastal area in Bangladesh. But it didn't go ahead.