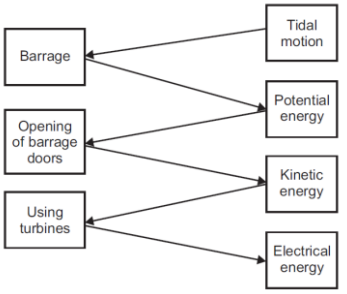
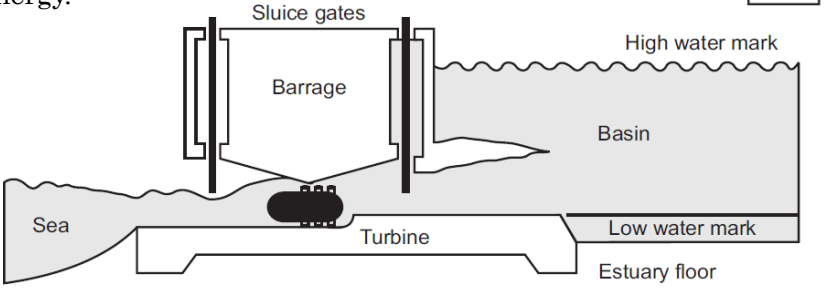
Tidal power

- Tidal power is the power inherent in tides at sea or oceans, that is the power of motion of water actuated by tides.
- Tides are defined as the increase and decrease in water levels due to the motion of water from one place to the other.
- This motion of water is actuated by large amounts of energy due to the movement of the Sun, Moon and Earth relative to each other and also to their rotational movement.
- Tidal energy offers an immense and reliable source of energy.
- The total energy flux of the tides is about 3 TW, however only a small fraction of this potential would be harnessed on the for useable future.
- This is due to the fact that the energy is spread over a wide area.
- The generation of electricity using tidal power is basically the transformation of tidal power found in tidal motion of water in seas and oceans into electrical energy.
- This is done using a very basic idea involving the use of a barrage or small dam built at the entrance of a bay where tides are known to reach very high levels of variation.

Tidal power

- This barrage will trap tidal water behind it creating a difference in water level, which will in turn create potential energy.
- This potential energy will then be used in creating kinetic energy as doors in the barrage are opened and the water rush from the high level to the lower level.
- This kinetic energy will be converted into rotational kinetic energy that will rotate turbines giving electrical energy.





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Water power

- The power available from falling water can be calculated from the flow rate and density of water, the height of fall, and the local acceleration due to gravity:

$$\dot{W}_{out} = -\eta \dot{m} g \Delta h = -\eta \rho \dot{V} g \Delta h$$

- Where;
- ✓ $\dot{W}_{out}$(work flow rate out) is the useful power output (in watts)
- ✓ η is the efficiency of the turbine (dimensionless)
- ✓ $\dot{m}$ is the mass flow rate (in kilograms per second)
- ✓ ρ is the density of water (in kilograms per cubic metre)
- ✓ $\dot{V}$ is the volumetric flow rate (in cubic metres per second)
- ✓ g is the acceleration due to gravity (in metres per second per second)
- ✓ Δh is the difference in height between the outlet and inlet (in metres)

Tidal power

- Tidal movements in seas are due to the increase of water levels at certain areas in the globe and the decrease of water levels at other areas.
- This is basically due to two factors:
- ✓ The gravitational forces between the Sun, Moon and Earth.
- ✓ The rotation of the Moon and Earth.
- As there are gravitational forces between the Moon and the Earth, seas or oceans water is pulled away from Earth toward the Moon at the area where the Moon and the Earth are in front of each other.
- At the opposite side of the Earth the water is being pushed away from the Earth due to centrifugal forces.
- There are two areas where the water levels are high and other areas where the water level is low.
- Thus, the tidal motion of water is created.
- This is called the lunar tide.

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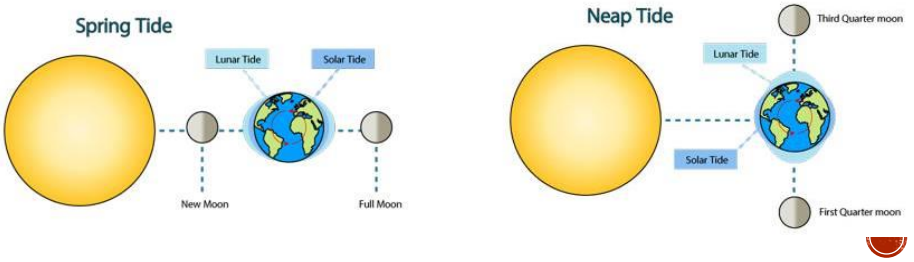
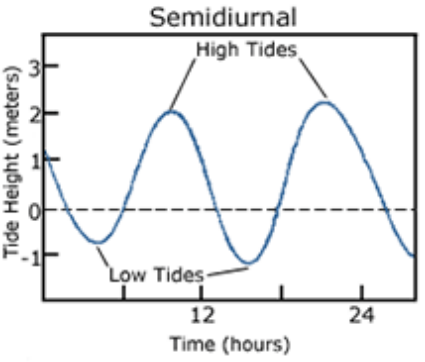
Tidal power

- The same concepts that apply for the Moon apply for the Sun, yet, the Sun has a smaller effect on the water levels but when that can only contribute or lessen the effect of the Moon gravitational power.
- This is described by 'spring tides' where the lunar tide and solar tide are aligned and contribute to each other and by 'neap tides' where the lunar and solar tides are at right angles of each other and lessen each other.



Tides

- **Semidiurnal tides:**
- This type of tide has a period of 12 h 25 min, due to the Earth rotation relative to both Sun and Moon.
- The amplitude of the tide varies according to the lunar month, with higher tidal range at full Moon and new Moon, when Sun and Moon are aligned.
- Neap tides occur during half-Moon as the resultant gravitational pull is minimum.
- However, one of the tides has greater range than the other, having a higher high and a lower low, therefore, a greater tidal flow while water is coming in and going out during the period between high and low level.
- Many areas on the eastern coast of North America experience these tidal cycles.



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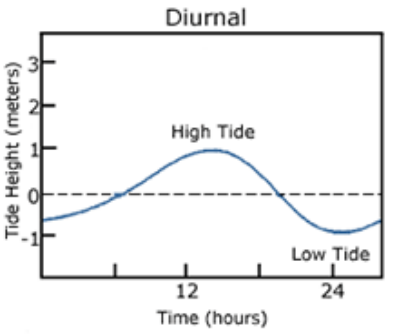
Tides

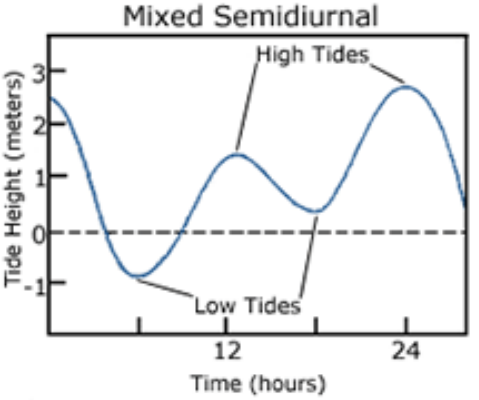
- **Diurnal tides:**
- This type of tide is found in China Sea and Gulf of Mexico.
- In this case, the tidal period is of 24 hr 50 min 28s, a full revolution of the Moon around the Earth.
- During each Earth rotation, a point of the Earth surface will pass through different parts of the equilibrium tide envelope and therefore experience a diurnal variation in tide levels.



- **Mixed tides:**
- This type of tides combines the characteristics of diurnal and semidiurnal tides.
- Moreover, they can also display monthly and bimonthly variation.

Tides

- Many areas on the western coast of North America experience these tidal cycles.
- Tidal currents occur in coastal areas and in places where the sea-bed forces the water through relatively narrow boundaries.
- The range of a spring tide is commonly about twice the neap tide range.
- The common tidal range is about 50 centimeters in the open ocean.
- However, the tidal amplitude can be increased by several local effects such as shelving, funnelling, reflection and resonance.



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Tides

- The shelving effect consists on increasing the deep water tidal wave height as the wave slows down when entering in shallow water areas.
- Funnelling effect occurs when the tidal bulge progresses into a narrowing estuary.
- Moreover, tidal wave can also be reinforced by reflections of the waves by the coastline.
- At some sites, the tidal flow can be heightened to more than 10 meters by resonance effects.
- Tidal currents can flow in two directions; the current moving in the direction of the coast is known as **flood current** and the current receding from the coast is known as **ebb current**.
- The zero current speed occurs between the ebb and the flood current.
- All tidal variations rise and fall can be utilized to generate electricity.

Components of tidal power system

- **Tidal barrages:**
  - ✓ A barrage is a small wall built at the entrance of a gulf in order to trap water behind it.
  - ✓ It will either trap it by keeping it from going into the gulf when water levels at the sea are high or it will keep water from going into the sea when water level at the sea is low.

- **Single basin tidal barrage:**
  - ✓ It consists of one basin and requires a barrage across an estuary or a bay.
  - ✓ There are three main operation patterns in which power can be generated within a single basin: ebb generation, flood generation and two-way generation.

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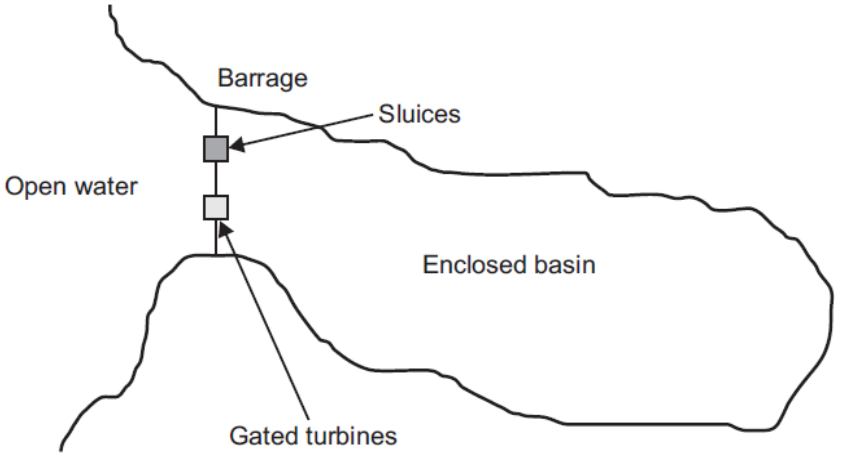
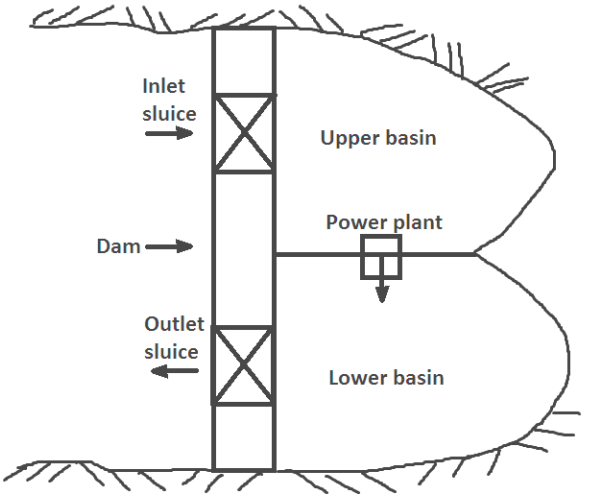
Components of tidal power system

❖ Single basin tidal barrage:



Components of tidal power system

❖ Double basin tidal barrage:



Tidal power plant : Double basin system

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Components of tidal power system

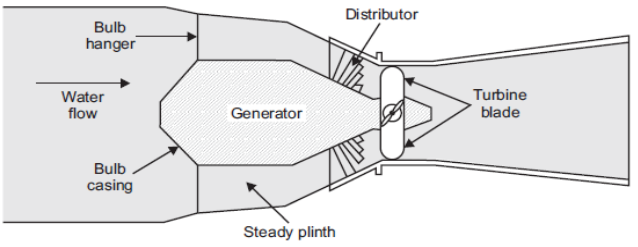
❑ **Turbines:**

- ✓ They are the components responsible for converting potential energy into kinetic energy.
- ✓ They are located in the passage ways that the water flows through when gates of barrage are opened.
- ✓ Turbines are one of the main elements for electricity generation in tidal barrages.
- ✓ The turbine choice will determined the operation conditions and the environmental impact.
- ✓ Nowadays, there are several types of turbines available; the most commonly used are bulb, rim and tubular turbines.

Components of tidal power system

❖ **Bulb turbines:**

- ✓ Its name comes from the shape of the upstream watertight casing which contains the generator mounted inside the water passageway as an integral unit with the turbine.
- ✓ This installation can offer significant reductions in size, cost and civil work.
- ✓ During its operation water floods around the turbine, its maintenance is difficult, as while it is carried out, water has to be prevented from flowing through the turbine.
- ✓ When inevitable maintenance of the turbine or/and the generator is needed, it has to be lifted off the water.



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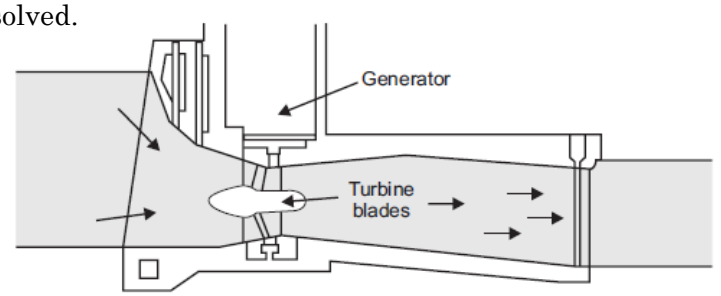
Components of tidal power system

❖ **Rim turbine:**

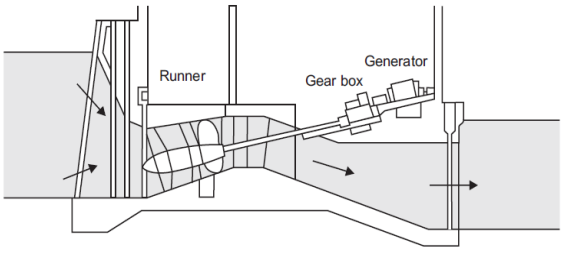
- ✓ Rim turbines generator is separate from the turbine itself.
- ✓ It is mounted on the barrage and is connected through a shaft that moves with the turbine; only the turbine is in water flow.
- ✓ Moreover, the rotor is protected from ingress of sea water by especially designed water seals.
- ✓ Need to remove them when turbine maintenance is required.
- ✓ Although the generator can be accessed when water inlet gate is closed and water drains off.
- ✓ As a result, the generator maintenance problem in bulb turbines is solved.



Components of tidal power system

❖ **Tubular turbines:**

- ✓ This type of generator is mounted on the top of the barrage at a 45 degree angle with the turbine, and the blades are connected to a long shaft.
- ✓ The real advantage that blades can be changed to meet electricity demand; smaller blades will generate less power while larger blades will generate more power.
- ✓ This allows the turbine to run more efficiently.
- ✓ This design gives some room to a gearbox, which allows more efficient operation of generators.
- ✓ Maintenance can take place in location as soon as water supply has been isolated.
- ✓ However, it presents some vibration problems of the long shaft.



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Tidal power

❑ **Advantages of tidal energy:**

- ✓ It is an inexhaustible source of energy.
- ✓ Tidal energy is environment friendly energy and doesn't produce greenhouse gases.
- ✓ As 71% of Earth surface is covered by water, there is scope to generate this energy on large scale.
- ✓ We can predict the rise and fall of tides as they follow cyclic fashion.
- ✓ Efficiency of tidal power is far greater as compared to coal, solar or wind energy; is around 80%.
- ✓ Maintenance costs are relatively low.
- ✓ Tidal energy doesn't require any kind of fuel to run.
- ✓ The life of tidal energy power plant is very long.
- ✓ The energy density of tidal energy is relatively higher than other renewable energy sources.

Tidal power

❑ **Disadvantages of tidal energy:**

- ✓ Cost of construction of tidal power plant is high.
- ✓ There are very few ideal locations for construction of plant and they too are localized to coastal regions only.
- ✓ Intensity of sea waves is unpredictable and there can be damage to power generation units.
- ✓ Influences aquatic life adversely and can disrupt migration of fish.
- ✓ The tides only happen twice a day so electricity can be produced only for that time.
- ✓ Frozen sea, low or weak tides, straight shorelines, low tidal rise or fall are some of the obstructions.
- ✓ More technological advancements are required to make it commercially viable.
- ✓ Usually the places where tidal energy is produced are far away from the places where it is consumed.
- ✓ This transmission is expensive and difficult.

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The End
Thank you all

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