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The Use of Tidal Energy in the World

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Abstract
In this work we tried to summarize the use of tidal energy in the world,
We also explained how these plants work and generate power.

Introduction
The earth surface consists of solid material and liquid (rivers, seas, and oceans) material, and it holds and attracts them by the gravity, on the other side the gravitational attraction force between the earth, the moon, and the sun perturb this material on the earth surface, as a result the solid material exposed to small deformation on its structure but clear impact in the liquid material because it's freer to move that cause the tides [1]. The attraction exerted by the moon is too larger than the attraction exerted by the sun according to the small distance between earth-moon with respect to sun-earth distance [2, 3], the earth side nearest the moon has created a bulge of water due to the gravitational force greater than the furthest side. Simultaneously, on the furthest side also bulge of water is created due to the centrifugal pull due to the rotation of the earth-moon system, As a result of the two forces; a resultant bulge is created around the earth [4] as it is illustrated in Figure (1) below:

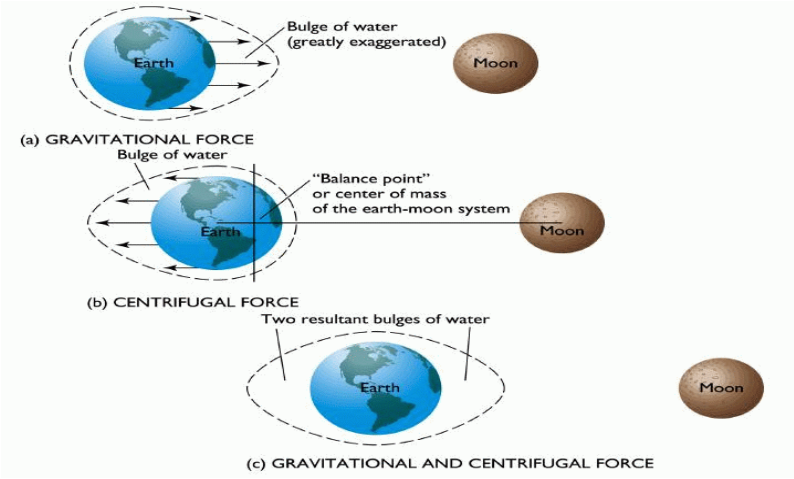


Figure (1): Tide phenomena

Tides are the periodic motion of the waters of the sea due to changes in the attractive force of moon and sun upon the rotating earth [5] high tides occur when the sun and the moon are in the line known as spring tides. Conversely, neap tide occurs when the moon and the sun are orthogonal, their gravitational forces pull water in different directions causing the bulges to cancel each other. Sea level observations show that there are regular water movement on all the shore of oceans, there are two main tidal

features of any sea level the first is the tidal range(R) which is the difference in high between two consecutive high and low tides [6], it important to distinguish between tidal range (vertical)and the horizontal movement of the water accompanying with the rise and fall of tides which is called tidal current .the second feature is the period which is the time between one high (or low) level and the next high (or low) level[7],there is two period of the tides diurnal (one high and one low tide per tidal day 24 h) and semidiurnal (two highs and two lows per tidal day12 h25 min), The tides appeared in the large ocean more than small river respect to the water level. Tides were exploited to produce power called tidal energy defined as the energy dissipated by tidal movements which directly derives from the interaction of the gravitational forces between the seas and the primary astronomical bodies of our system [6], it is a form of hydropower renewable energy source, tidal energy has a significant advantageous over the many forms of renewable energy source because it more controllable and predictable(depend on gravity –not on the weather), it has been used since the 11th Century in Britain and France, also now is taking place in Canada, China, Ireland, Japan, South Korea, Spain, and the united kingdom UK [8].The simplest system for generating electricity from the tides by use a dam across an estuary, Sluice gates on the barrage are opened to allow the tide to flow into the estuary on the incoming high tides, after that water flowing back on the outgo through the turbine system see figure (2)below, for instance, if an estuarine basin of area (A) of a dam and the water of density (ρ)runs out through turbines at low tide that the average power produced is:

$$P = \frac{\rho * A * R^2}{2 * \tau}$$

Where:

P	generated power, R	tidal range
ρ	Water density,τ	Periodic time

Obviously, tidal energy is directly proportional to the square of the tidal range (would generally the tidal range greater than 7 meters).

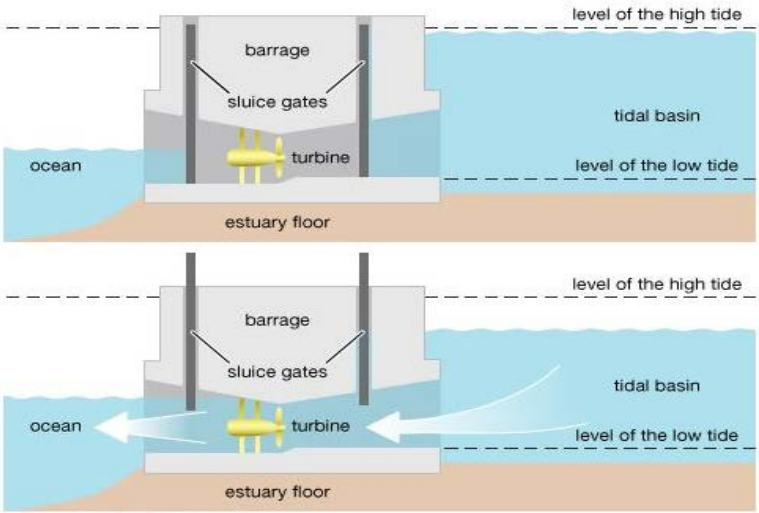


Figure (2) Tidal power plant

1. Tidal power station in the world

1.2 South Korea

Western and southern seaboards of Korea characterized of high tidal range and strong tidal current, then western coast exploit for (schwa, Garolim and Incheon tidal power plant) and uldolmok tidal current power on the southern coast [10]**.** On December 2004, Commencement of Construction of Sihwa Tidal Power Plant Project equipped with 10 turbines, total Capacity254MW and Annual generation 552.7 GW h, operated by one-way during flood tides. Figure show structure layout [11] Completed on 2009.

Figure (3) Sihwa Tidal Power Plant

Garolim tidal power project constructed on 2007-2012 and it is operated by one-way ebb tide .tidal range for 4.7m and basin area of 45.5 km^2, and installed capacity about 480MW. Incheon tidal power project has been established since 2009 and completed on 2015, it is operated by one-way ebb tide, tidal range for 5.3m and basin area of 106 km^2, installed capacity about 1000MW.but Uldolmok tidal current power, utilize triple helical turbine .as shown in figure below.

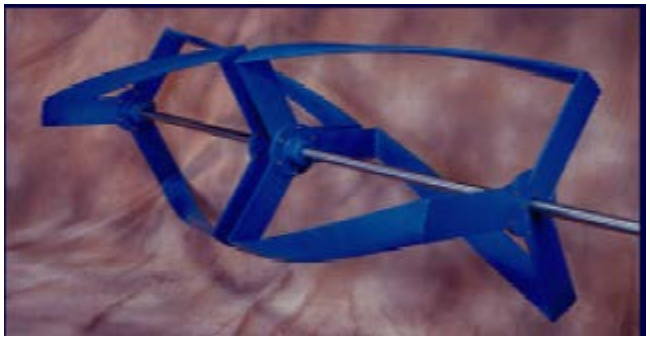


Figure (4) Helical turbine

Annapolis Tidal Generating Station installed in Canada since 1980, located between Granville Ferry and Annapolis River, has a capacity of 20 MW, Length of 46.5 m, and depth of 30.5 m [12].

1.3 China

China is one of the leading countries in harnessing tidal energy. It estimated that there are four coastal water exploitable for tidal power (the Bohai Sea, the Yellow Sea, the East China Sea, and the South China Sea) of around 110 GW ,east china sea has largest tidal energy capacity and the average tidal range is (4 – 5) m, and the maximum tidal range (7 – 8) m in these water, It utilize tidal energy resources since 1950 about 52 tidal power plants were built but most of them were deserted returned to many factors (insufficient maintenance and insufficient technology and high cost with less benefit) ,Now only two plants the Jiangxia and Haishan power plants, are in service[13]. The Jiangxia tidal Power Plant is largest one in china began to construct in(1974-1985) and fourth largest one in the world, located at Yueqing Bay, Zhejiang Province, followed after the Sihwa Tidal Power Plant in South Korea, the Rance Tidal Power Plant in France, and the Annapolis Tidal Power Plant in Canada [14].

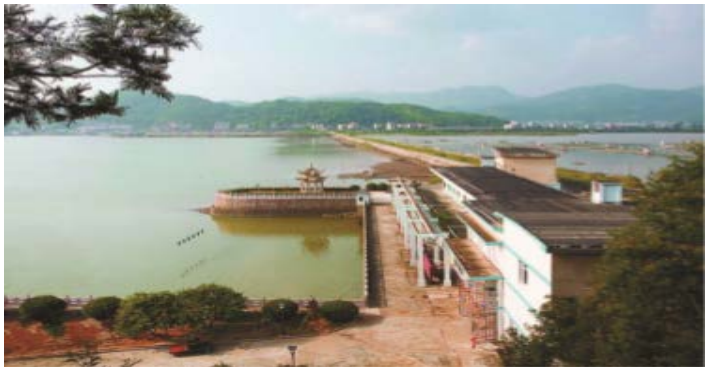


Figure (5) Jiangxia tidal Power Plant

The figure above shows Jiangxia tidal Power Plant, had total capacity of 3.2 MW, mean tide range 5.08 m, and reservoir area (137 X $10^6 m^2$) operate on the two-way system.

1.4 Franca

The first power station in the world is the Rance Tidal Power Station on the estuary of the Rance River in Saint-Malo, Brittany, France and it represents second largest tidal power station in the world. Established on the 26th November 1966 it is currently operated by Électricité de France EDF (French electricity). The plant consists of four main zones(the lock, the plant itself equipped with 24 bulb turbines, the dyke and the six gate barrage),tidal range in France average8.2m to maximum 13.5m, total installed capacity 240 MW(each turbine rated 10MW), it supplies 0.012% of the power demand of France. Giving an annual output of approximately 600 GW h, the barrage is about 750 m.

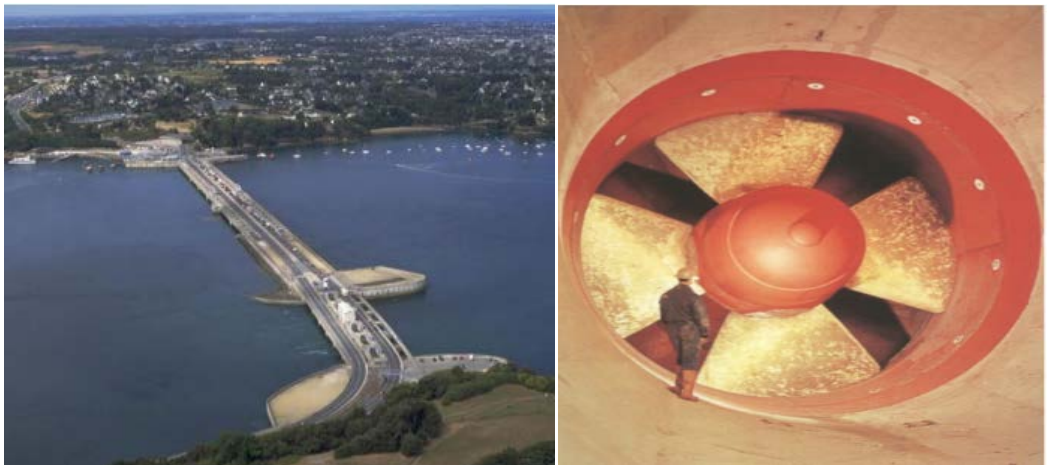


Figure (6) la- Rance Tidal Power Station

On the side of environmental impact during the 3-year of construction phases and closing of the estuary, disappearance of marine flora& fauna due to salinity fluctuations, and heavy sedimentation and accumulation of organic matter in the basin the Rance estuary was considered again as richly diversified a new biological equilibrium was reached and aquatic life was flourishing gain.

1.5 Russia

Located on the Arctic shoreline at Russia, providing ecologically safe and reliable power to the Russian electricity grid.

1.6 United Kingdom (UK)

In 2004, Marine Current Turbines (MCT) specified the Narrows of Stanford Laugh, Northern Ireland as their preferred location for the deployment of the Sea Gen tidal turbine. In 2008, Marine current turbine Stanford Lough Sea Gen power plant using the free stream tidal energy device to convert tidal flow into electricity , the device composed of twin 16m diameter rotors connected to a generator through a gearbox, with a rotor system supported on the end of a cross beam .the figure below shows the Sea Gen power plant.

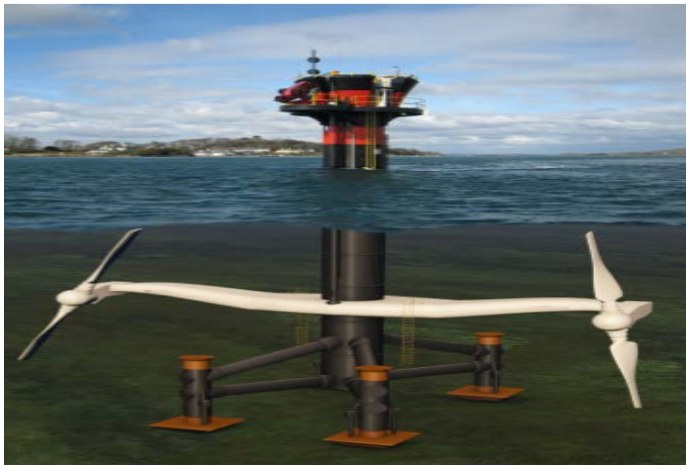


Figure (7) Sea Gen power plant.

2. Mechanism of Tidal energy

Operation Method

The method is similar to the wind energy technology which depends on extracting energy of the wind (air) but on the Tidal current technology it extracts energy ؤkinti from the water current where the water is 832 times denser than air then the water flow speed is much smaller due to different in, When the water flows through the blades cause the rotor to rotate the generator which is connected to the gearbox, and transmit the produced electricity through cable. There are three main type support structures for tidal current turbines which are gravity structure (big mass of concrete and steel attaché to the base to provide stability), piled structure(pinned to the seafloor using steel or concrete beams),and the floating found. As show in figure below

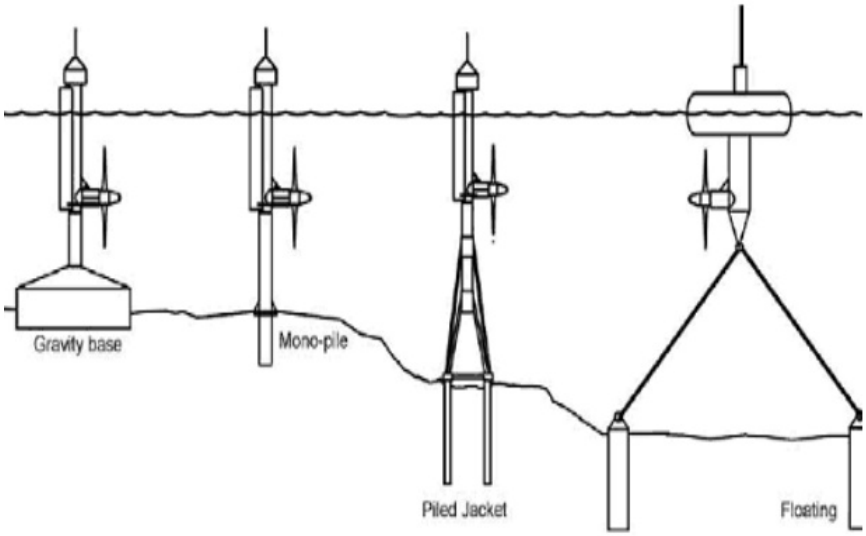


Figure (8) Type support structures

The maximum rate of generating power is during spring tide (few days of the month). For this reason, tidal power designer tends to install turbine rated at a lower level than the maximum power available because the potential of capture full energy just during the spring tide. This technique is known as Electrical Down Rating (EDR) figure below show tidal power over the spring-neap cycle.

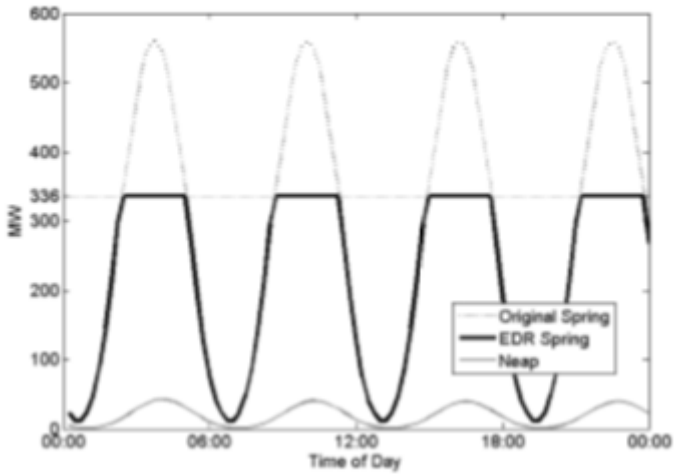


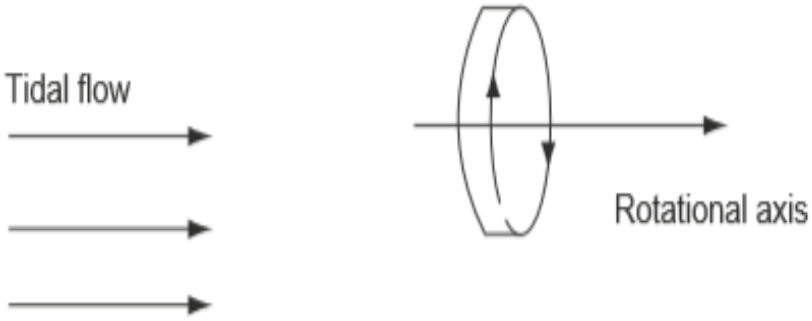
Figure (9) Tidal power over the spring-neap cycle

3. Types of turbines on tidal power current generation

There is two main type horizontal axis and vertical axis current turbine

Horizontal axis tidal current turbine

The feature of a horizontal axis turbine is consisting of turbine blades parallel to the direction of the water flow on a horizontal axis, then the rotation axis is parallel to the direction of water flow as shown in figure below, large rotor diameter, and high TSR (tip speed ratio) [15, 16].The turbine arranged in a row, similar to some wind farms and the ideal locations for tidal turbine farms are close to shore.



The most famous installation is the dual horizontal axis turbines MCT (Marine Current Turbines) made by Siemens for instance of real project Sea Gen with dual rotors in Stanford Laugh, Northern Ireland shows in figure below

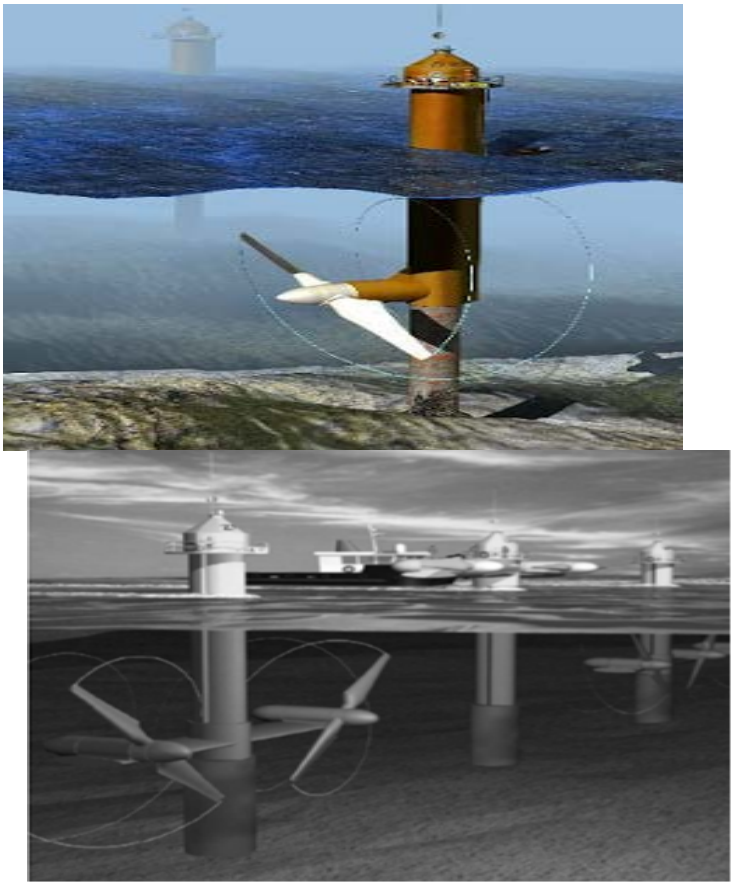
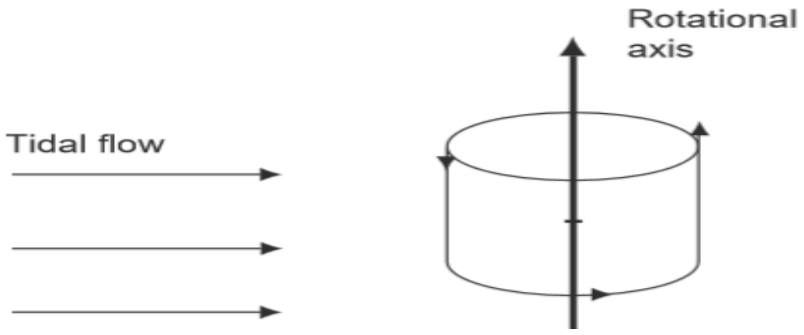


Figure (8): Horizontal axis turbine

Vertical axis tidal current turban

The vertical axis turbine characterized by turbine blade rotates on a vertical axis which is perpendicular to the direction of the water flow as shown in the figure property of vertical axis design it permits the harnessing of tidal flow below. The from any direction and the blades can easily build and easily to increase their span too. For instance of vertical axis turbine project the Kobold turbine and the Blue energy project.



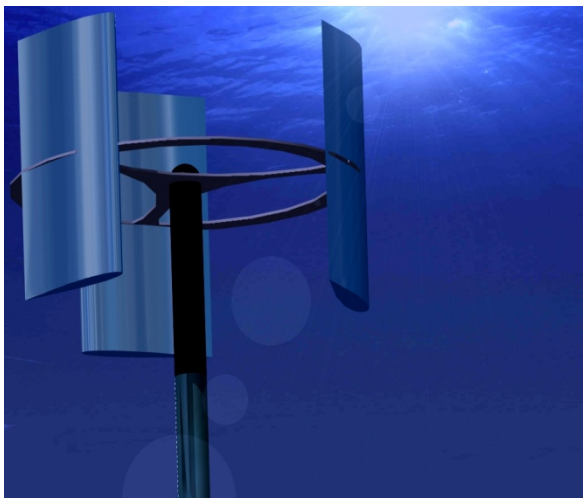


Figure (9) Vertical axis turbine

Both in the vertical axis turbines and in horizontal axis the rotation speed is very low, horizontal turbines have slightly higher efficiency than vertical turbines

3. Conclusion

Tidal power is a renewable energy source its distinction of being more predictable and cleaner energy source associated with the environment, therefore it becomes one of the more promising energy sources But the main obstacle behind development tidal power plant is the high capital cost, although plant has an average life in the range(75-100) years. Construction of tidal power plant bring huge and several benefits while operating such as allow of transportation between the coast (as a bridge) ,it can act as a barrier against the flood and may affect on the aquaculture, on the other hand, tidal power plant causes change on the estuary ecosystem. And some of the unpredicted effects occurred over long -term, all in all, the negative environmental impacts of tidal power plant are probably much smaller than those of other sources of electricity.
Comparison between two main tidal features tidal barrage and tidal current turbine . utilizing tidal current turbine much favored than tidal barrage to avoid most of the environmental impact. Tidal current devices have a lesser impact on the environment than tidal barrages.

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