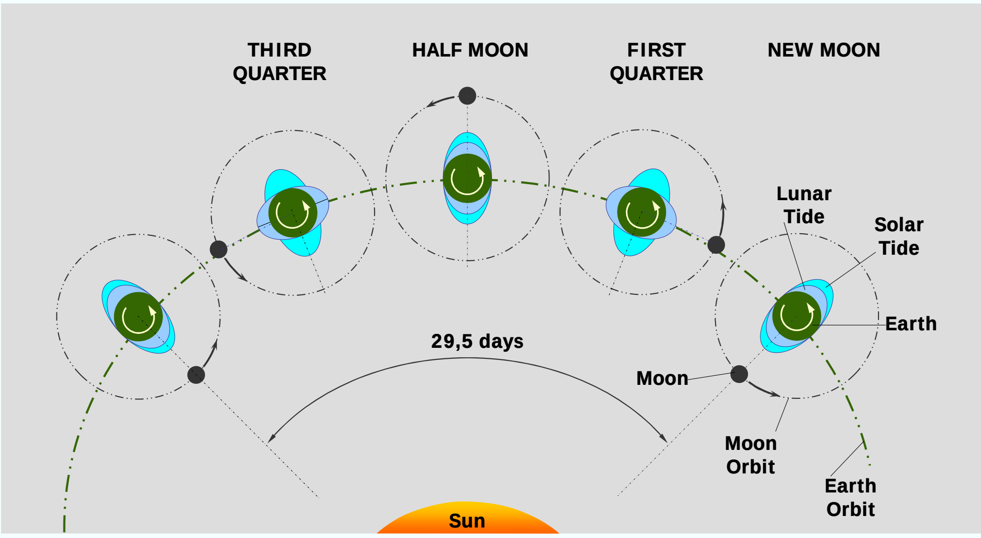
TIDAL ENERGY

Tidal Energy Physics and Resource

Tidal energy conversion techniques exploit the natural rise and fall of the level of the oceans caused principally by the interaction of the gravitational fields in the planetary system of the Earth, the Sun and the Moon. The main periods of these tides are diurnal at about 24 h and semidiurnal at about 12 h 25 min. During the year, this motion is being influenced by the positions of the three planets with respect to each other. Spring tides occur when the tide-generating forces of the Sun and the Moon are acting in the same directions. In this situation, the lunar tide is superimposed to the solar tide. Some coastlines, particularly estuaries, accentuate this effect creating tidal ranges of up to ~17 m. Neap tides occur when the tide-generating forces of the sun and the moon are acting at right angles to each other.

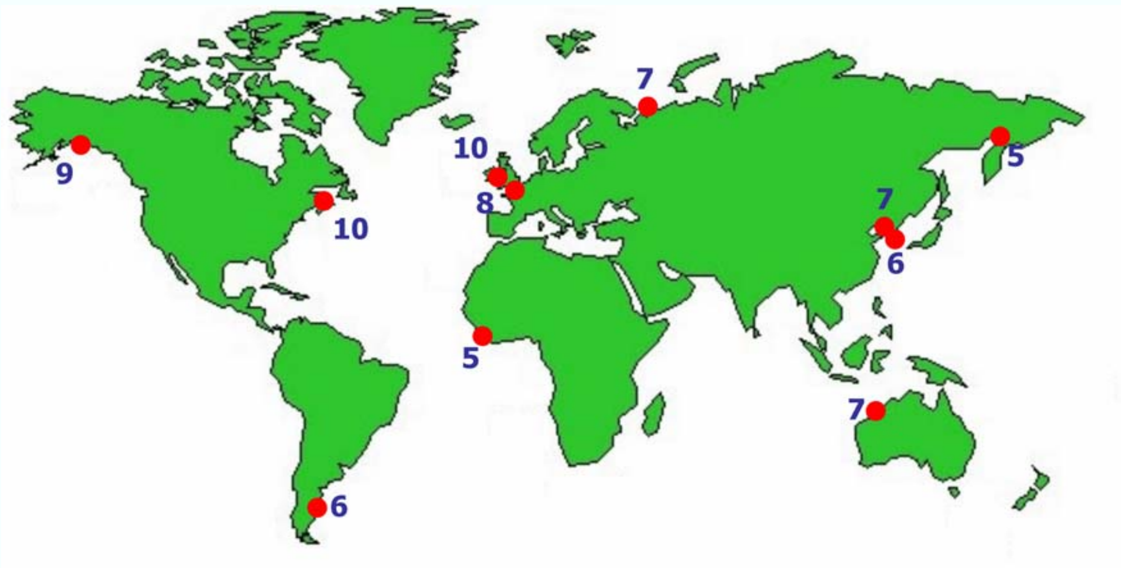


The vertical water movements associated with the rise and fall of the tides are accompanied by roughly horizontal water motions termed *tidal currents*. It has therefore to be distinguished between *tidal range energy*, the potential energy of a tide, and *tidal current energy*, the kinetic energy of the water particles in a tide.

Tidal currents have the same periodicities as the vertical oscillations, being thus predictable, but tend to follow an elliptical path and do not normally involve a simple to-and-fro-motion. Where tidal currents are channelled through constraining topography, such as straits between islands, very high water particle velocities can occur. These relatively rapid tidal currents typically have peak velocities during spring tides in the region of 2 to 3 ms^{-1} or more.

Currents are also generated by the winds, and temperature and salinity differences. The term "marine currents", often met in literature, encompasses several types of ocean currents. Wind driven currents affect the water at the top of the oceans, down to about 600-800 m. Currents caused by thermal and salinity gradients are normally slow, deep water currents, that begin in the icy waters around the north polar ice. Wind driven currents appear to be less suitable for power generation than tidal currents, as they are in general slower. Moreover, tidal currents exhibit usually their maximum speed at comparably shallow waters accessible for large engineering works.

The global tidal range energy potential is estimated to be about 3 TW, about 1 TW being available at comparably shallow waters. Within the European Union, France and the United Kingdom have sufficiently high tidal ranges of over 10 metres. Beyond the European Union, Canada, the CIS, Argentina, Western Australia and Korea have potentially interesting sites, which have been periodically investigated. Some regions with exceptional tidal range are shown on the next figure (annual average tidal range in meters).



Recent studies indicate that marine currents have the potential to supply a significant fraction of future electricity needs. The potential for marine current turbines in Europe is estimated to exceed 12,000 MW of installed capacity. Locations with especially intense currents are found around the British Islands and Ireland, between the Channel Islands and France, in the Straits of Messina between Italy and Sicily, and in various channels between the Greek islands in the Aegean. Other large marine current resources can be found in regions such as South East Asia, both the east and west coasts of Canada and certainly in many other places around the Globe that require further investigation.

Principles and Aspects of Tidal Energy conversion

Tidal Range Energy

The technology required to convert tidal range energy into electricity is very similar to the technology used in traditional hydroelectric power plants. The first requirement is a dam or "barrage" across a tidal bay or estuary. At certain points along the dam, gates and turbines are installed. When there is an adequate difference in the elevation of the water on the different sides of the barrage, the gates are opened. The "hydrostatic head" that is created, causes water to flow through the turbines, turning an electric generator to produce electricity.

Tidal range energy conversion technology is considered mature, but, as with all large civil engineering projects, there would be a series of technical and environmental risks to address. One major environmental risk is associated with the changes of water levels which would modify currents, and sediment transport and deposit. However, there are regional development benefits as well, for example the La Rance plant in France, the only commercial sized tidal range conversion scheme so far, includes a road crossing linking two previously isolated communities and has allowed further development of the distribution network for raw materials and developed products.

Tidal Current Energy

Tidal currents can be harnessed using technologies similar to those used for wind energy conversion, i.e. turbines of horizontal or vertical axis (“cross flow” turbine). Some other techniques have either been abandoned or are at an early stage of development.

Several types of tidal current conversion devices, particularly fully submerged devices, are subject to the corrosive effects of seawater. This leads to high material and construction costs. In addition, maintenance is difficult because divers are needed to access submerged machinery. While placing the drive train above water can minimize the need for divers, maintenance costs would remain higher than e.g. in wind turbines.

In contrast to atmospheric airflows the availability of tidal currents can be predicted very accurately, as their motion will be tuned with the local tidal conditions. Because the density of water is some 850 times higher than that of air, the power intensity in water currents is significantly higher than in airflows. Consequently, a water current turbine can be built considerably smaller than an equivalent powered wind turbine.

Another specific advantage of tidal current devices is the limited environmental impact. Their installation requires minimal land use, and fully submerged devices will not affect optically or acoustically their surroundings. Their effects on flora or fauna have not been studied extensively yet, but it is unlikely that they will be of significance. Finally, submerged marine current converters are considered to operate in safe environment: disturbances caused by extreme weather conditions are significantly attenuated to the depths of about 20-30 metres where the devices will normally operate.

Tidal Energy Development Status

Tidal Range Energy

Tidal range energy projects require normally high capital investment at the outset, having relatively long construction periods and long payback periods. Consequently, the electricity cost is highly sensitive to the discount rate used. Access to suitable funding is thus a serious problem, and is unlikely without public intervention.

The first large scale, commercial plant was built on the Rance estuary in France during the 1960's and has now completed over 40 years of successful operation. The La Rance station is still the only industrial-sized tidal power station worldwide. Its 240