Tidal Energy

Definition of Tidal Energy

Tidal energy is energy derived from the movement of the ocean tides.

Water has mass. When it moves, it has kinetic energy which can be harnessed. Kinetic energy is the energy of motion.

What causes tides?

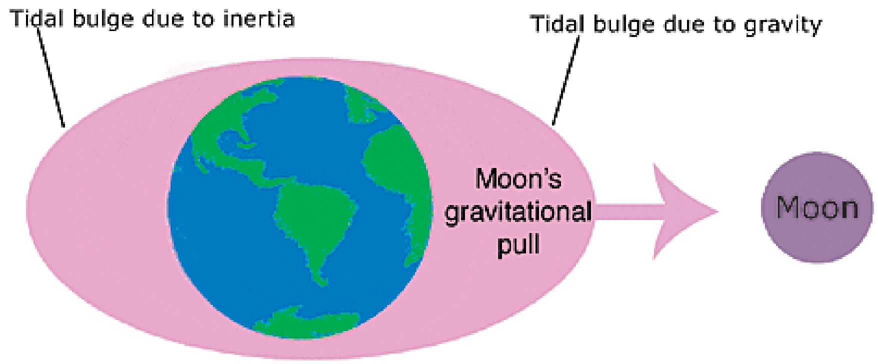
Ocean tides are the response of the ocean to the gravitational attraction of the moon as it orbits the Earth. Tides also respond to the gravitational attraction of the Earth as it orbits the Sun but to a lesser extent.

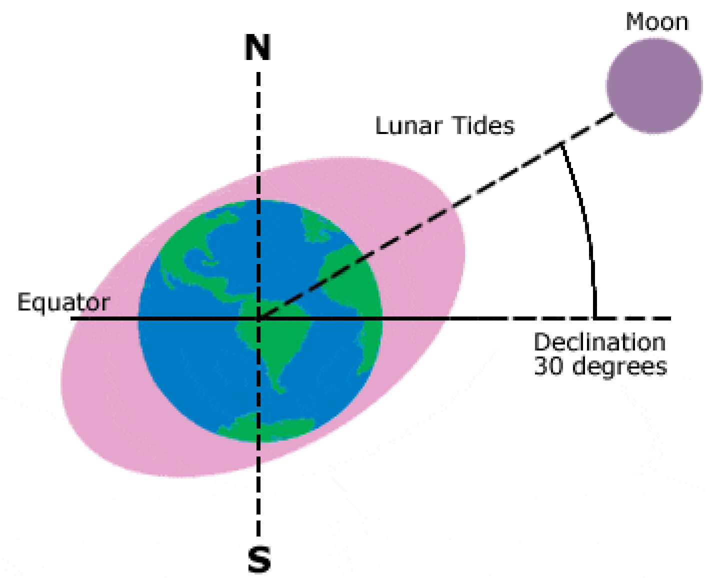
What is tidal energy used for?

Today, tidal power plants are being built to generate electricity

Tides on a Global Scale: Tidal Bulges

Due to the Moon's gravitational pull, tidal bulges develop. The tidal bulges move as the Earth rotates and the Moon changes position relative to the Earth.



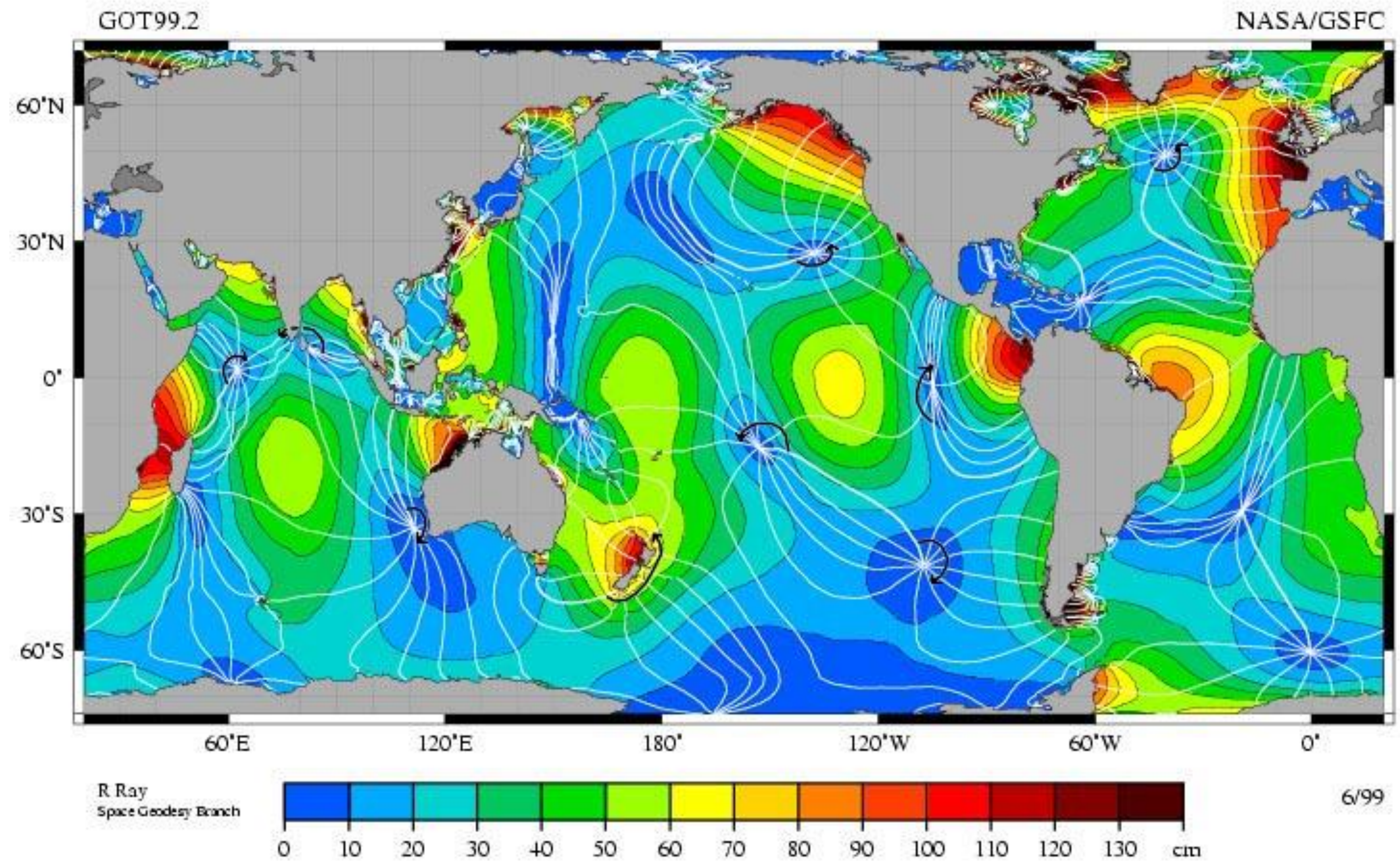


The part of the Earth closer to the Moon is more strongly attracted to the Moon than the part farther from the Moon which is less strongly attracted. So, the close part gets closer and the far part gets farther. This makes the elongation in both directions that we observe in the illustration above. It also causes there to be two high and low tides each day for most of the oceans of the world.

Since the Earth rotates a full turn every day, the point on the Earth that is being pulled toward the moon is constantly changing. As the angle changes between the Moon and the Equator, the tidal bulges change position on the Earth. Most places on Earth have two high tides and two lows every day because of the Earth's rotation and the Moon's change of position.

Tides on a Global Scale: Tidal Patterns

As water moves around the Earth, tidal patterns develop.



A tidal bulge moves around the Earth every day. Since the Earth has continents that disrupt the even flow of water, a complex pattern emerges. In some places, the water stretches out more toward the Moon. In other places, tidal nodes occur where the water does not really deform at all.

Brief History of Tidal Energy

People have harnessed the tides and used its energy for many centuries. Tide mills—which are the precursors to today's tidal power plants— have great similarity to water wheels. The difference is that water must first be collected from the incoming tide before it can be released to rotate the water wheel.

The oldest, excavated tide mill is dated to the year 619. It was discovered at Northern Ireland's Nendrum Monastery on Mahee Island in Strangford Lough. The power generated by this mill was probably used for grinding grain.

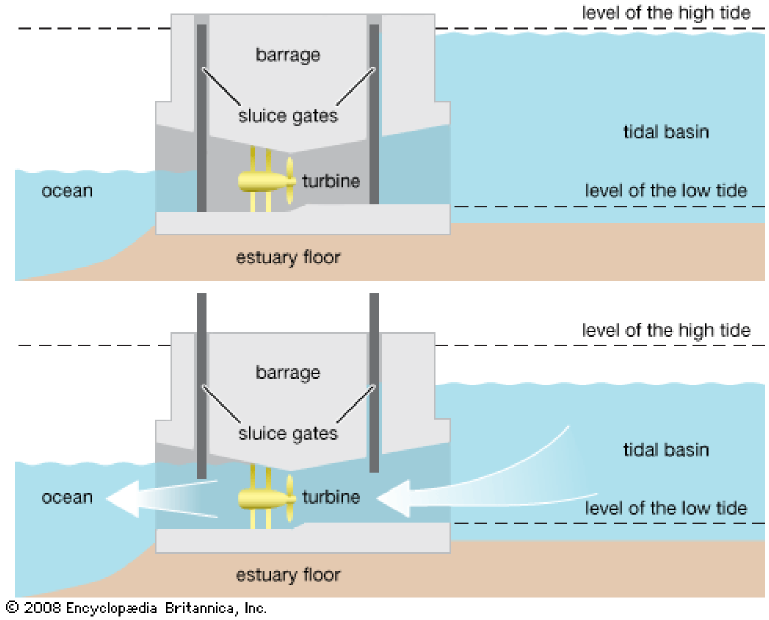
Tide mills became more common during the Middle Ages. A tide mill would have a storage pond which filled up as the tide came in. As the tide went out, the pond emptied and the moving water rotated a water wheel.

By the 18th century, 76 tide mills were being used in London alone. At one time there were about 750 tide mills in operation around the shores of the Atlantic Ocean. This included about 300 on North American shores, about 200 in the British Isles, and about 100 in France.

The Rance estuary in France was home to some of the historical tide mills. Now the Rance river has the world's first tidal power generating station. It opened in 1966. As an improvement to early tide mills, it generates power during high tide *and* low tide.

Harnessing Tidal Energy: Barrages

One method for harnessing tidal energy is a ***barrage,*** or tidal barrier, which is very much like a dam. When the water level is higher on one side of the barrage than the other, water is allowed to flow through the turbines to generate electricity.



How a tidal barrage works

During high tide the gates are closed and water is stored "upstream" of the tidal barrage. As the tide falls, the water level on the downstream side of the dam drops. When it's low enough, the valves are opened for water to flow from the higher, upstream side—through turbines—to the lower, downstream side. The movement of the water rotates the turbines to generate electricity.

Due to the design of the barrage, the reverse can also happen. When the tide reaches its low point and the water level behind the dam is at the low tide level, the valves are again closed and the tide rises again. Water rises on the "downstream" side and when the valves are opened, flows "upstream" where the water level is at low tide.

Thus, barrages can effectively generate power four main times during the day—during the two fall and the two rising tides.

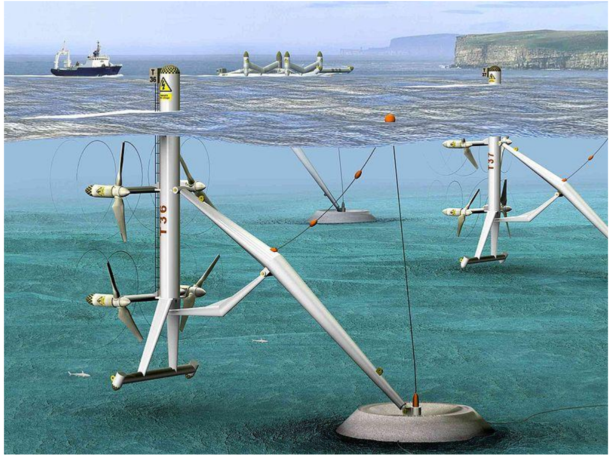
There are only a few operational tidal barrages in the world. The Rance River in France and the Bay of Fundy in Canada have the only large-scale barrages in the world with generating capacities of 240 MW and 20 MW respectively. There is a small scale plant in Kislaya Guba, Russia which generates 400 kW. A few countries have plans for other future projects.

Rance Tidal Power Station (France, 1966)

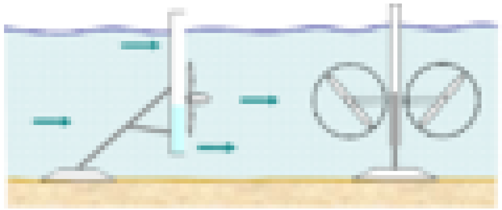
Annapolis Royal Generating Station (Canada, 1984)

Harnessing Tidal Energy: Tidal Stream Systems

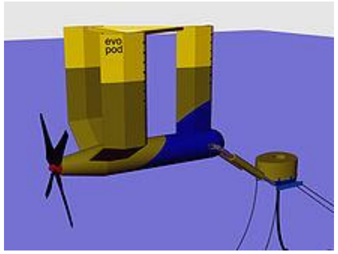
When there are obstructions such as continents, inlets, islands, etc., water piles up against the obstruction and flows rapidly past when and wherever it can. This makes tidal currents. These currents can be used to drive underwater turbines, which is another method for harnessing tidal energy.



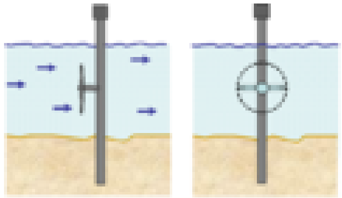
Underwater turbines are anchored to the sea floor so the moving water from tidal currents can rotate the blades. Just like wind turbines, the rotating motion of the blades generates electricity which can be sent to the utility grid.



Lots of underwater turbine designs are being prototyped. The Evopod began testing in June 2008. It uses a tether rather than a rigid anchor. The turbine is mounted on a floating, semi-submerged structure. This design is easier to maintain and can capture the fastest tidal currents which are just below the surface.

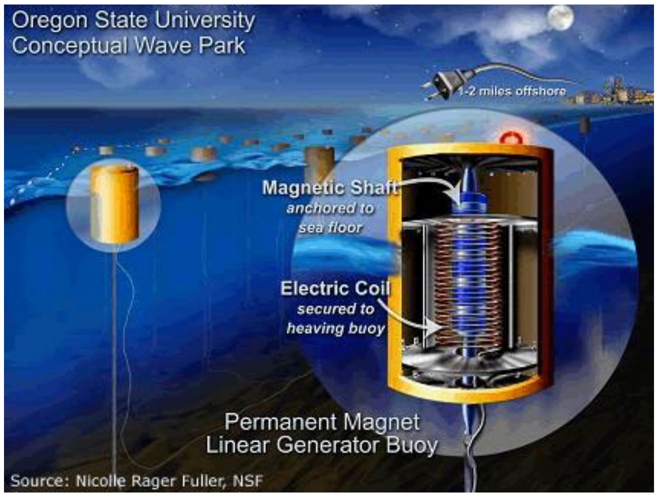


The world's first commercial tidal stream generator is SeaGen which was installed in Northern Ireland's Strangford Lough in April 2008 and started generating electricity for the grid in July 2008. SeaGen is an axial turbine, a tall tower bolted to the seabed. The blades can capture the motion of tides going in as well as out. There are discussions to build entire tidal farms using turbines like these.



A Relative of Tidal Energy: Wave Energy

Wave-driven power is a type of power generation related to tidal power. Rather than relying on the tidal movements in large bodies of water, wave energy is derived from wind-driven waves. It can be used to generate electricity.



Using buoys that float in the waves is one method for capturing wave energy. The buoys are anchored to the ocean floor, and as waves raise and lower the floating device, electricity is generated in an electric coil. The diagram depicts a prototype created by Oregon State University.

Using a surface following device is another method for capturing wave energy. An articulated 'snake' floats on the ocean surface. Its joints are connected to hydraulic rams that move with the wave motion, forcing hydraulic fluid to move small turbines that power generators. This is a picture taken at Portugal's Aguçadoura Wave Park, the world's first commercial wave farm.

Benefits and Challenges of Tidal Energy

BENEFITS

Tidal energy offers significant benefits, which include:

- Tides are more predictable than wind and sunlight. They have a consistent pattern.
- Tidal energy is a sustainable energy source and continuously available.
- Tidal energy is clean; it does not pollute the water or air.

CHALLENGES

There are challenges to using tidal energy, which include:

- Harnessing tidal energy can be expensive. Barrages are very expensive to construct.
- Although tides are predictable, there is only a short period of time when they yield the highest power.
- Installing and running a tidal power station can disrupt the balance of the local ecosystem.
- Equipment used to collect tidal energy is in contact with water so maintenance is difficult due to corrosion.
- Sometimes the best tidal currents are unavailable because they are located in shipping channels or they are too far from the grid.
- In general, a tidal range of at least 6 meters is required to make tidal power generation practical or economical.