

Marine and Hydrokinetic Energy

Introduction:

Marine and Hydrokinetic Energy (MHK) is the method of capturing energy from waves, tides, ocean currents, the natural flow of water in rivers, and marine thermal gradients, without building new dams or diversions. US has 95,471 miles NOAA shoreline and 50% of US population live within 50 miles of coast. Theoretically, US has a potential of 4666 TWh/year (1 TWh/year can power 90000 homes).

Table 1: U.S. Marine and Hydrokinetic Resource Potentials [1]

Resource Assessment	Resource Potential
Waves	Theoretical: 1,594–2,640 TWh/year Technical: 898–1,229 TWh/year
Tidal streams	Theoretical: 445 TWh/year Technical: 222–334 TWh/year
Ocean currents	Theoretical: 200 TWh/year Technical: 45–163 TWh/year
River currents	Theoretical: 1,381 TWh/year Technical: 120 TWh/year

Ocean Wave Energy

The available wave energy varies depending on the location. Winds are generated due to differential heating of the earth's surface. As the wind blows over the water surface, some energy is transferred to its surface due to friction between air and water molecules which generates waves with various frequencies and wavelengths. The waves are influenced by the water depth, seafloor topography, water density, wind speed, duration, and super positioning of different wavelength waves. The wave energy depends on the velocity of a collection of waves. The combined velocity of these waves is called group velocity denoted by C_g . The group velocity changes depending on the ocean depth.

Depending on the ocean depth, the surface ocean waves are classified as

1. **Deepwater waves:** Depth is greater than half the wavelength. Deep-water waves include all wind-generated waves moving across the open ocean.
2. **Shallow water waves:** Depth is less than one-twentieth the wavelength. Shallow-water waves include wind-generated waves that have moved into shallow, nearshore areas, tsunamis (seismic waves) generated by disturbances in the ocean floor, and tide waves generated by the gravitational attraction of the sun and moon.

Ocean Current Energy

The combination of wind friction, gravity, and water density variation causes ocean water circulations. These patterns of ocean water circulation exchange ocean-carrying variables such as temperature and salinity which is an important parameter in determining global temperatures. In this section, we identify different types of ocean currents and the different parameters related to waves to formulate equations that are necessary for the project.

Factors affecting ocean currents:

1. Pressure gradients
2. Coriolis effect (Coriolis force)
3. Frictional forces
4. Ekman layer

Depending on the depth, the ocean currents can be classified as

1. **Surface ocean currents:** The surface ocean currents are caused by the winds and earth rotation called gyres. These gyres push the water towards poles. Due to the earth rotation, the gyres in the northern hemisphere move in the clockwise direction whereas in the southern hemisphere they move in the anti-clockwise direction. These currents help in redistributing warmth around the globe.
2. **Deep ocean currents:** The cooling or evaporation of water causes the surface water to become dense. The dense water moves downwards causing the lesser dense water to move upwards. This movement is known as Thermohaline circulation which is driven by horizontal differences in temperature and salinity.

References:

1. "Marine and Hydrokinetic Resource Assessment and Characterization." Energy.gov, <https://www.energy.gov/eere/water/marine-energy-resource-assessment-and-characterization>