Energy Resources and Policy

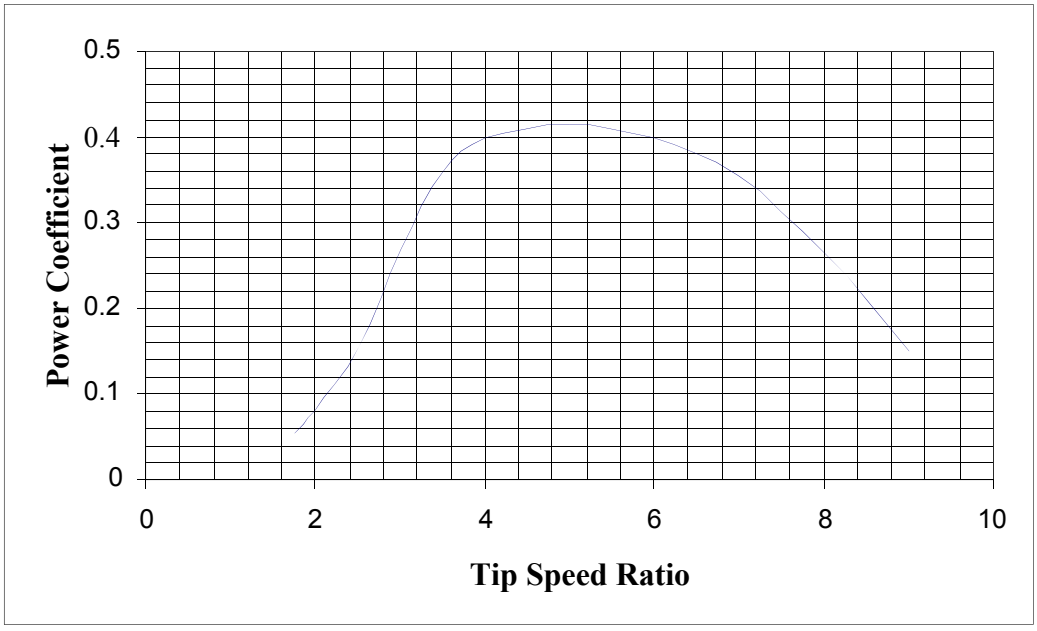
Tutorial:
Tidal power

Density of water is 1000 kg/m^3 unless otherwise stated

1. A turbine to generate power from marine currents is based upon a wind turbine rotor specification, for which the variation of power coefficient C_P with tip speed ratio X_T is shown in the figure below. It is desired to produce 10 kW from a stream velocity of 2 m/s, with the turbine running at a tip speed ratio of 5. Specify the rotor diameter and its speed of rotation. [Hint: source the formula for tip speed ratio.]

   The turbine is to operate at constant speed, and to shut down when its output falls below 2 kW. Use an iterative procedure to estimate the stream velocity at which this will occur. Assume a water density of 1060 kg/m^3 throughout.

   [2.69 m; 71.0 rev/min; 1.31 m/s]



2. At a site for a tidal current turbine, the water velocity varies sinusoidally with a period of 12 h 25 min. The turbine has a rotor of 15 m diameter and a rated power output of 600 kW. It has a cut-in current speed of 0.5 m/s.

   For a tidal steam with a maximum current velocity of 2.5 m/s, determine whether the turbine will reach its rated power output. Assume a power coefficient of 0.39 and a water density of 1025 kg/m^3.

   Determine the energy captured by the turbine over a full tidal cycle, for the above conditions. Note that

$$\int \sin^3 \omega t \;=\; \frac{1}{\omega}\left[\frac{1}{3}\cos^3 \omega t \;-\; \cos \omega t\right].$$

During the tidal cycle, there are periods when the turbine produces zero output. These periods will be longest for neap tides. If the smallest neap tide at the site gives a maximum current velocity of 1.7 m/s, calculate the length of the corresponding zero-output period.

[No; 2907 kWh; 1h 10.8 min]

3. The energy produced per cycle in a tidal power plant, E is a function of the tidal range (2a), the tidal basin area B, the water density ρ and the gravitational constant g. A non-dimensional energy parameter Φ_E may be produced, where

$$\Phi_E = \frac{E}{(2a)^2 Bg\rho}.$$

For La Rance tidal barrage system, the mean tidal range is 8.0m and the basin area is 22 km^2. The annual energy produced from the plant is 544 GWh. Compute a value for Φ_E, and hence estimate the annual and time-averaged outputs from a system where the mean tidal range is 5.2 m and the basin surface area is 1.8 km^2. Take the water density as 1025 kg/m^3.

[0.197; 18.77 GWh; 2.143MW]