Energy Resources and Policy

Assignment:
Marine current turbines

First, find the value of N, the position in the English alphabet of the letter which begins your family name (for Anderson N = 1, for Brown N = 2 etc.).

A twin-rotor marine current turbine of the type shown has rotors of 20 m diameter. It is to be installed at a site where the maximum current speed under Spring tide conditions is [2 + 0.05N] m/s. In Ueap tides, the maximum speed is 1.65 m/s.

The turbine has a cut-in speed of 0.75 m/s, and a rated speed of 2 m/s. Between rated and cut-in speeds, it operates with a constant power coefficient of 0.39. The sea water has a density of 1025 kg/m^3.

Calculate the rated power output of the turbine, and determine the energy captured per cycle in Spring and Neap tides. Assume a period of 12 hours and 25 minutes for the twice daily cycle, and a sinusoidal variation in current velocity V, so that

$$V = V_{max} . \sin \omega t .$$

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

Assuming that the average energy captured per cycle is the mean of the values for Spring and Neap tides, estimate the amount of energy produced per year and the turbine capacity coefficient.

The estimated capital cost of the turbine, including the foundations and electrical connections, is £[1.6 + 0.025N]x10^6. If this money is borrowed from a bank, the annual repayment required is given by the formula

$$\frac{C\, r\, (1 + r)^n}{(1 + r)^n - 1}$$

Where C is the value of the capital loan, n the number of years to complete the repayment, and r the rate of interest on the loan.

Assuming annual maintenance costs of 4% of the capital cost of the turbine, calculate the cost of energy production, in pence per kWh. Use n = 15 years and r = 6%.

Discuss:

1. The nature of the variation of power output with respect to time. What opportunities and problems do marine current turbines present when integrated into an electricity supply network?
2. How accurate is the assumption that is made here in calculating the average energy produced per cycle?
3. What are the principal obstacles to widespread exploitation of this resource?

The report should contain full details of all calculations. A discussion of at least 600 words is required, in response to the questions posed above. The submission deadline will be announced in class.

External sources of information should be referenced in the usual way. You are reminded of our regulations about plagiarism – by all means refer to published articles on the subject, and quote from them if you wish. But this article must be your own work.