Due: 7 Nov 2024

Energy: Science, Technology, and Society

Homework Set 4

1. Wind Power

Consider a modern, mid-sized wind turbine driven by a 3-blade rotor with a diameter of 40 m. It is characterized by a power coefficient of $\mathbf{C}_{Power}$=0.3 and an electric generator efficiency of $\boldsymbol{\varepsilon}_{Gen}$=0.9.

For the following assume an average wind speed of 8 m/s.

a) Calculate the mean electrical power generated by the turbine.

b) Assume an average electric power need of 2.4kW per household in the US-SW during daytime. How many households can one such turbine typically service?

c) How would the estimates change, if the rotor had only two instead of three of these blades? Explain your proposed scaling.

(Note: Air density ρ = 1.2 kg/m^3)

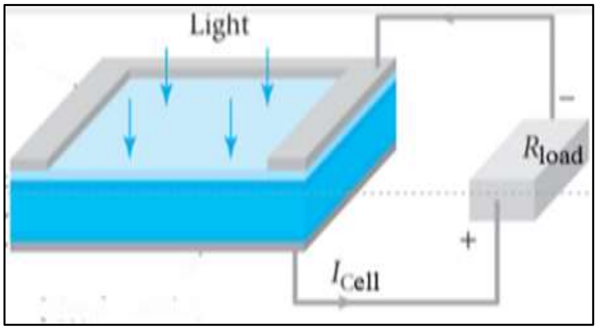
2. Ocean Current Power

An inventor proposes to utilize a surplus ship propeller of diameter d = 2 m as an underwater "wind turbine" power plant at a location where the tidal current flows at a mean speed of 2m/s. For water at 10^{0}C, this turbine would work at nominal power.

Calculate the maximum power that the power plant can produce. Saline ocean water has a 2.5 % higher density than fresh water.

3. PV Solar Cell Energy Conversion

Consider junction photocells made of different semi-conductor materials irradiated with blue light of wavelength $\lambda = 475$ nm.



a) Determine the maximum fraction of the light energy that can be converted to electrical current by a Si (ε_G=1.17eV) photocell.

b) Determine the maximum fraction of the light energy that can be converted to electrical current by a GaAs (ε_G =1.43eV) photocell.

c) Determine the maximum fraction of the light energy that can be converted to electrical current by a GaP (ε_G =2.32eV) photocell.

4. PV Solar Cell Performance

Consider a p-n silicon photocell with an area of 4cm^2 which is illuminated normally with (AM1.5) solar radiation. The measured short-circuit current is I_{sc} =160mA, and the saturation (dark) current is $I_{sat} = 4 \cdot 10^{-9}$mA.

a) Calculate the maximum of the output power, $P_{cell} = V_{cell} \cdot I_{cell}$.

b) Determine the size (in Ω) of the optimum load resistor that produces maximum power.