Spring 2006 **EE 3120** Complete by Feb 8, 1:00pm

Homework Set for Week 4

Comments and Background: Refer to the handout on introduction to photovoltaics and the handout on practical design information. Let's go through several short design calculatioins to learn the basic engineering issues involved in solar generation. Note that we are focused here just on the PV panels, and don't extend our design to include optimal matched design of solar panels, batteries, load (or DC-AC inverter/grid interface), and overall controller.

H4.1 If we assume that Houghton receives incident solar energy of AM1 (1000 W/m^2) when the sun is directly overhead (perpendicular to the ground), how many W/m^2 strike the ground when the angle of the sun's rays are inclined 20° from perpendicular?

H4.2 The illumination intensity of the light striking a solar panel is measured to be 5 foot-candles. If we assume that this is entirely yellow-green at a wavelength of 560 nm, how many watts per square meter are striking the panel?

H4.3 Referring to the solar panel specification sheet that was handed out in class, and assuming we are using the PL-110 panel at 25°C operation,

a) How many of the PL-110 solar panels would be required to replace the peak power output of a 1000 MW coal-fired power plant?
b) Assuming that the sun is directly overhead and the panels are positioned horizontally, how much real estate will this huge solar array occupy? (The dimensions of each panel are 25.7" x 50.5")
c) How does this compare with the space taken up by the power plant (typically 1-2 square miles)? Which has the worse environmental impact?
d) Would replacing the power plant with this solar array be acceptable to electrical consumers? What problems might there be? How could you solve them?

H4.4 What is the fill factor FF for the solar panels used in Problem 3? Is this fill factor within the expected range?

H4.5 The panels are composed of 72 cells, each being 10 cm x 10 cm. What is the short circuit current density J of each cell? (Hint: the panel has 6 parallel strings of 12 cells each).

H4.6 For a 53-volt 25-amp load that only needs to be supplied during peak sun conditions (i.e AM1), how many panels are needed and what is their series/parallel connection? Sketch it out. Can you think of an electrical load that a consumer needs to operate only on sunny days?

H4.7 (optional problem, it is similar to H4.3 above) Assume the peak demand for electrical power in the US is 1.0 TW. It could be interesting to calculate how many solar panels would be required to replace all of our existing generation. Assuming: a) an ideal afternoon with AM1 sun directly overhead, b) use of PL-100 panels positioned normal to the suns rays, and c) assuming the system is optimally designed to operate at the peak power point, how many square miles would the panel cover? How does this compare to the area of US states? What happens to the land area that is covered/shaded by these panels?