ECE 333 Green Electric Energy - Quiz 6 Solutions

Tuesday, November 28, 2017

Duration: 20 minutes

Name: _____ **last 4 digits of your UIN:**_____

Closed book, closed notes, cell phones are not allowed.
Show all you work and always indicate the units, as appropriate.

Problem 1 [65 points]:

Consider a *PV* system with *stc* rated *DC PV* system power output of $p_{DC,stc} = 3\ kWp$, installed in a site in Durham with a 0.8–*sun* and 32 ℃ ambient temperature. The *PV* system has a temperature coefficient of -0.6%/℃, and τ_n=45 ℃. Take the derate factor χ equal to the default derate factor in *PVWATTS*, $\chi = 0.77$.

a. **[35 points] Calculate** χ', (temperature-related derate factor).

Solution:

$$\tau_{cell} = \tau_a + \left(\frac{\tau_n - 20}{0.8}\right)(insolation) = 32 + \left(\frac{45-20}{0.8}\right)(0.8) = 57\ ^\circ C.$$

$$\chi' = \chi\,[1 + z(\tau_{cell} - 25)] = (0.77)[1 - (0.006)(57 - 25)]$$
$$\chi' = (0.77)[1 - (0.006)(32)] = (0.77)(0.808) = 0.622$$

b. **[30 points] Calculate** the *AC* power delivered by the *PV* system.

Solution:

$$p_{AC} = (p_{DC,stc})(\chi') = (3)(0.622) = 1.866\ kW$$

Problem 2 [35 points]:

Calculate the solar altitude angle at solar noon on a clear January 9 in Istanbul at latitude l=0.716 radians.

Solution:

$\delta|_d = 0.41\ x\ \sin\left(2\pi\frac{(d-81)}{365}\right)$. For d=9,

$$\delta|_9 = 0.41\ x \sin\left(2\pi\frac{(9-81)}{365}\right) = 0.41\ x \sin\left(2\pi\frac{(-72)}{365}\right) = 0.41\ x \sin(-1.2394)$$

$$\delta|_9 = 0.41\ x\ (-0.9456) = -0.3877\ radians$$

$\beta(0)|_d = \frac{\pi}{2} - l + \delta|_d$. For $d = 9\ and\ l = 0.716\ radians$

$$\beta(0)|_9 = \frac{\pi}{2} - 0.716 + (-0.3877) = 0.467\ radians$$

Formulae:

The apparent solar irradiation is given by the formula: $a|_d = 1{,}160 + 75\ x \sin(2\pi \frac{(d-275)}{365})]$.

The solar declination angle is given by the formula: $\delta|_d = 0.41\ x \sin(2\pi \frac{(d-81)}{365})]$.

The air mass ratio is given by the formula:

$r(h)|_d = \sqrt{[708 \sin(\beta(0)|_d)]^2 + 1{,}417} - 708 \sin(\beta(0)|_d)$.

The clear-sky direct beam radiation is given by the formula: $i_b(h)|_d = a|_d\ e^{-k|_d r(h)|_d}$.

The solar altitude angle at solar noon is given by the formula: $\beta(0)|_d = \frac{\pi}{2} - l + \delta|_d$.

The optical depth is given by the formula: $k|_d = 0.174 + 0.035 \sin(2\pi \frac{(d-100)}{365})]$.