EECE325 Fundamentals of Energy Systems
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Spring 2023

Homework 6 (100 points)

A. INSTRUCTION

(a) Due: 8:00pm (Check the webpage)
(b) Scoring Rubric

pts	Q1 - Q5
20	Correct answer with calculation details displayed
10	Incorrect answer with calculation details displayed
5	Correct answer with no calculation details
0	Incorrect answer without work displayed

(c) Late submission: 10% deduction of each day.

B. PROBLEM

1. Find the sun's altitude angle and azimuth angle at your hometown at 10:00 am on April 25. Find the latitude of your hometown from web sources such as www.latlong.net.

2. A PV panel is installed on top of Downing Hall. The panel faces south with tilt angle the same as the latitude of the building. The reflectance of the surface is 0.2. Calculate the (a) beam radiation on the PV panel, (b) diffusion radiation on the PV panel, and (c) the reflected radiation on the PV panel at 2:00pm on May 1.

3. The PV panel in problem 2 above is reinstalled on a single-axis polar mount. Find the total radiation on the PV panel at 2:00pm on May 1.

4. The PV panel in problem 3 above is further reinstalled on a two-axis tracking mount. Find the total radiation on the PV panel at 2:00pm on May 1.

5. A PV system is installed on top of a house in Boulder, CO. The PV system is composed of 20 solar panels. Each panel's dc rated power is 200 W. The average daily insolation energy on the PV system is, according to the NREL 5607 manual, 5.5 peak-sun hours. If the dc-to-ac converter efficiency is 85%, find the annual energy [in ac] generated by the PV system.

*** See the next page for clear-sky insolation equations**

Summary of Clear-Sky Solar Insolation Equations

I_0 = extraterrestrial solar insolation
m = air mass ratio
I_B = beam insolation at earth's surface
A = apparent extraterrestrial solar insolation
k = atmospheric optical depth
C = sky diffuse factor
I_{BC} = beam insolation on collector
θ = incidence angle
Σ = collector tilt angle
I_H = insolation on a horizontal surface
I_{DH} = diffuse insolation on a horizontal surface
I_{DC} = diffuse insolation on collector
I_{RC} = reflected insolation on collector
ρ = ground reflectance
I_C = insolation on collector
n = day number
β = solar altitude angle
δ = solar declination
ϕ_S = solar azimuth angle (+ = AM)
ϕ_C = collector azimuth angle (+ = SE)

$$I_0 = 1370\left[1 + 0.034\cos\left(\frac{360n}{365}\right)\right]\ (\text{W/m}^2)$$

$$m = \frac{1}{\sin\beta}$$

$$I_B = Ae^{-km}$$

$$A = 1160 + 75\sin\left[\frac{360}{365}(n - 275)\right]\ (\text{W/m}^2)$$

$$k = 0.174 + 0.035\sin\left[\frac{360}{365}(n - 100)\right]$$

$$I_{BC} = I_B\cos\theta$$

$$\cos\theta = \cos\beta\cos(\phi_S - \phi_C)\sin\Sigma + \sin\beta\cos\Sigma$$

$$I_{BH} = I_B\cos(90^\circ - \beta) = I_B\sin\beta$$

$$I_{DH} = CI_B$$

$$C = 0.095 + 0.04\sin\left[\frac{360}{365}(n - 100)\right]$$

$$I_{DC} = I_{DH}\left(\frac{1+\cos\Sigma}{2}\right) = I_B C\left(\frac{1+\cos\Sigma}{2}\right)$$

$$I_{RC} = \rho I_B(\sin\beta + C)\left(\frac{1-\cos\Sigma}{2}\right)$$

$$I_C = I_{BC} + I_{DC} + I_{RC}$$

$$I_C = Ae^{-km}\left[\cos\beta\cos(\phi_S - \phi_C)\sin\Sigma + \sin\beta\cos\Sigma + C\left(\frac{1+\cos\Sigma}{2}\right) + \rho(\sin\beta + C)\left(\frac{1-\cos\Sigma}{2}\right)\right]$$

$$\sin\beta = \cos L\cos\delta\cos H + \sin L\sin\delta$$

$$\sin\phi_S = \frac{\cos\delta\sin H}{\cos\beta}$$

$$\text{Hour angle } H = \left(\frac{15^\circ}{\text{hour}}\right)\cdot(\text{hours before solar noon})$$

Two-Axis Tracking:

$$I_{BC} = I_B$$

$$I_{DC} = C I_B \left[\frac{1 + \cos(90^\circ - \beta)}{2}\right]$$

$$I_{RC} = \rho(I_{BH} + I_{DH}) \left[\frac{1 - \cos(90^\circ - \beta)}{2}\right]$$

One-Axis, Polar Mount:

$$I_{BC} = I_B \cos\delta$$

$$I_{DC} = C I_B \left[\frac{1 + \cos(90^\circ - \beta + \delta)}{2}\right]$$

$$I_{RC} = \rho(I_{BH} + I_{DH}) \left[\frac{1 - \cos(90^\circ - \beta + \delta)}{2}\right]$$