Renewable Energy Systems (12210588)
Fall 2014

8. Tutorial 1
Solar System Orientation

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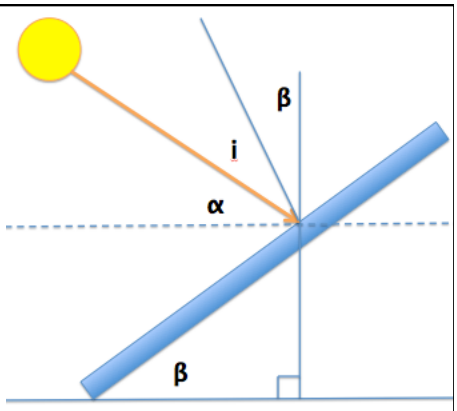
Lecture 8

Question 1

Compute the tilt angle β and a_s of the collector in order to receive the maximum solar radiation in Tulkarm on 2/3/2005 at local time 14.00.



LTD = -32°, LOD = -35°

d = 31 + 28 + 2 = 61

In order to receive the maximum solar radiation, the projection of the normal of the plane must be in the true south. For the collector, i must be zero°

α + i + β = 90° ➔ α + β = 90°

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$$\delta = 23.45^\circ \sin\left[\frac{360(284+61)}{365}\right] = -7.91^\circ$$

$$t_s = LMT + EOT + 4'(LTD - LOD)$$

$$Assume\ EOT = -12'$$

$$t_s = 14 + (-12') + 4'(-32^\circ - (-35^\circ))$$

$$t_s = 14 - 12' + 12' = 14\frac{0}{60} = 14.0$$

$$H_s = \frac{360^\circ}{24 hours}(t_s - 12) = 15^\circ(14.0 - 12) = 30.0^\circ$$

+ve H_s means PM

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$$\sin\alpha = \sin\phi\sin\delta + \cos\phi\cos\delta\cos H_S$$

$$\sin\alpha = \sin(32^\circ)\sin(-7.91^\circ) +$$

$$\cos(32^\circ)\cos(-7.91^\circ)\cos(30.5^\circ)$$

$$\alpha = 40^\circ \Rightarrow \beta = 90^\circ - \alpha = 90^\circ - 40^\circ = 50^\circ$$

$$\sin a_s = -\frac{\sin H_s \cos\delta}{\cos\alpha} = \frac{\sin(30.0^\circ)\cos(-7.91^\circ)}{\cos(40^\circ)}$$

$$\sin a_s = -0.65 \Rightarrow a_s = -41^\circ$$

where a_s= +ve when sun is in the east of south

a_s= -ve when sun is in the west of south

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The conclusion here is to tilt the collector by β = 50° from the plane and orient the collector to the angle of a_s = 41° to the west of the south.

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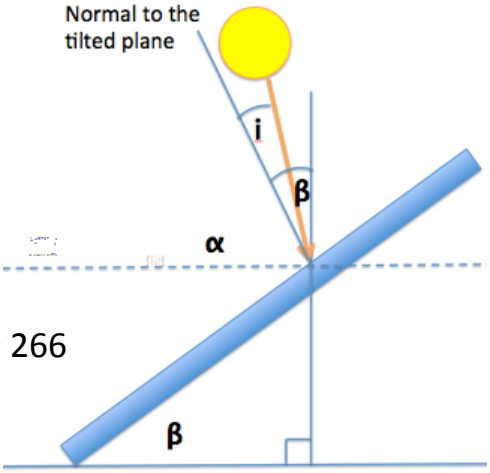
Question 2

Compute the tilt angle α, a_s, θ and i of a solar water heater in Tulkarm on 23/9/2013 at local time 11:20. The solar system is tilted 45° from plane.



LTD = -30°, LOD = -35°

d = 365 – (31+30+31+7) = 266

A - i + β = 90°

α + θ = 90°

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$$\delta = 23.45° \sin\left[\frac{360(284+266)}{365}\right] = -1°$$

$$t_s = LMT + EOT + 4'(LTD - LOD)$$

$$Assume\ EOT = 7'$$

$$t_s = 11:20 + (7') + 4'(-30° - (-35°))$$

$$t_s = 11:20 + 7' + 20' = 11\frac{47}{60} = 11.78 hour$$

$$H_s = \frac{360°}{24 hours}(t_s - 12) = 15°(11.78 - 12) = -3.25°$$

-ve H_s means AM

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$$\sin\alpha = \sin\phi\sin\delta + \cos\phi\cos\delta\cos H_S$$

$$\sin\alpha = \sin(30°)\sin(-1°) + \cos(30°)\cos(-1°)\cos(-3.25°)$$

$$\alpha = 57°$$

$$\sin a_s = -\frac{\sin H_s \cos\delta}{\cos\alpha} = \frac{\sin(-3.25°)\cos(-1°)}{\cos(57°)}$$

$$\sin a_s = 0.1 \Rightarrow a_s = 6° \text{ (east of south)}$$

$$\theta = 90° - 57° = 33°$$

$$\alpha + \beta - i = 90° \Rightarrow i = 12°$$

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