EN671: Solar Energy Conversion Technology

Lecture 6: Solar Radiation Estimation

Dr. Pankaj Kalita
Associate Professor
School of Energy Science and Engineering
Indian Institute of Technology, Guwahati

Estimation of Solar radiation under different climatic conditions

Empirical equations for predicting the availability of solar radiation

Why?

- When Measurement of Solar Radiation over a period of time is not possible.
- Even if measurements of radiation are available, data may note be in the desired form.

Empirical relation relates the values of radiation (global or diffuse) with meteorological parameters like sunshine hours, cloud cover and precipitations

Need equations for Cloudy skies as well as cloud less skies

Weather classification

- Clear Day : Daily diffuse radiation to daily global radiation is $\frac{H_d}{H_g} \le 0.25$

And $S \ge 9h$

- Hazy Day (fully) : $0.25 < \frac{H_d}{H_g} < 0.5$ hr $7 < S < 9$
- Hazy and Cloudy (partially): $0.5 < \frac{H_d}{H_g} < 0.75$ hr $5 < S < 7$
- Cloudy day (fully): $\frac{H_d}{H_g} \ge 0.75$ hr $S \le 5$

Relationships for Cloudy skies

- Monthly average daily global radiation
- Monthly average daily diffuse radiation
- Monthly average hourly global radiation
- Monthly average hourly diffuse radiation

Relationships for Cloudy skies

- Monthly average daily global radiation

Angstrom correlation

$$\frac{\overline{H}_g}{\overline{H}_c} = a + b\left(\frac{\overline{S}}{\overline{S}_{\max}}\right)$$

Representative day of a month for Solar Radiation calculation

Month	n for ith Day of Month	For Average Day of Month		
		Date	n	δ
January	i	17	17	−20.9
February	$31 + i$	16	47	−13.0
March	$59 + i$	16	75	−2.4
April	$90 + i$	15	105	9.4
May	$120 + i$	15	135	18.8
June	$151 + i$	11	162	23.1
July	$181 + i$	17	198	21.2
August	$212 + i$	16	228	13.5
September	$243 + i$	15	258	2.2
October	$273 + i$	15	288	−9.6
November	$304 + i$	14	318	−18.9
December	$334 + i$	10	344	−23.0

Gopinathan

$$\frac{\bar{H}_g}{\bar{H}_o} = a_1 + b_1\left(\frac{\bar{S}}{\bar{S}_{\max}}\right)$$

$$a_1 = -0.309 + 0.539\cos\phi - 0.0693E_L + 0.290\left(\frac{\bar{S}}{\bar{S}_{\max}}\right)$$

$$b_1 = 1.527 - 1.027\cos\phi + 0.0926E_L - 0.359\left(\frac{\bar{S}}{\bar{S}_{\max}}\right)$$

Constants a and b (cities in India)

Location	a	b	Mean error (Per cent)
Ahmedabad	0.28	0.48	3.0
Bangalore	0.18	0.64	3.9
Bhavnagar	0.28	0.47	2.8
Kolkata	0.28	0.42	1.3
Goa	0.30	0.48	2.1
Jodhpur	0.33	0.46	2.0
Kodaikanal	0.32	0.55	2.9
Chennai	0.30	0.44	3.5
Mangalore	0.27	0.43	4.2
Minicoy	0.26	0.39	1.4
Nagpur	0.27	0.50	1.6
New Delhi	0.25	0.57	3.0
Pune	0.31	0.43	1.9
Shillong	0.22	0.57	3.0
Srinagar	0.35	0.40	4.7
Thiruvananthapuram	0.38	0.39	2.5
Vishakhapatnam	0.28	0.47	1.2

Data taken from book “solar energy principles of thermal collection and storage” by Sukhatme and Nayak, Tata McGrow Hill Education Private Limited, 2010

Q.M3.L1: Estimate the monthly average daily global radiation on a horizontal surface at Delhi $\left(28^{o}38'N, 77^{o}13'E\right)$ during the month of March if the average sunshine hours per day is 7.5 hr.

Summary

- Correlations
- Classification of weather
- Calculation of monthly average of daily extra-terrestrial radiation
- Different correlations for estimation of monthly average of daily global radiation.

Thank you