Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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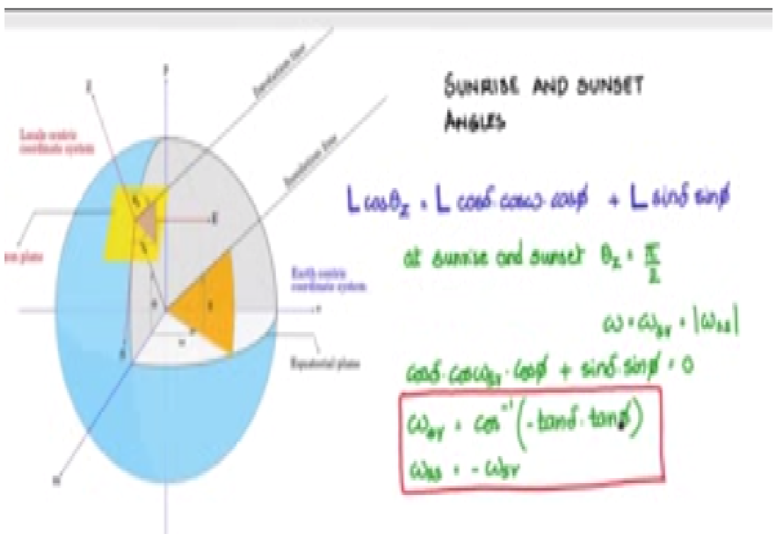

Let us now obtain the sunrise and sunset angles I have here the local cetera coordinate system and the eccentric coordinate system, and I have also written down the insulation equation $LCos\theta_Z$ the normal incidence insulation at a horizontal flat plate located at a point on this latitude fight at sunset and sunrise this θ_Z said will be 90^0C what it basically means is that the insulation line will be just along the horizon plane at Sun far at sunset it will be just along the horizon plane it will start to rise above the horizon plane and at sunset it will be along the horizon plane and start to go below the horizon plane.

Therefore at sunset or sunrise we have θ_Z at the angle equal to π / 2 90^0C this will be 90^0C because the insulation line is along the horizon plane and ω the our angle is the angle of interest to us the our angle, we will call it as ω_{sr} s our angle at sunrise and modulus of the our angle at sunset, so you see that when $\omega = 0$ the projection of the insulation line will be along the meridional plane that would be considered as noon for that particular Meridian our angle on to the east of the Meridian will be positive our angle to the west of the meridian is considered negative.

So sunrise is on this quadrant on to the east side of the original axis and therefore sunrise angle is considered positive and the sunset is to the west of the meridional axis and ω_{SS} is considered as negative but modulus of the sunset angle and our angle at sunrise will be the same applying $Cos\theta_Z = 0$ at sunrise and sunset, so you say Cos Δ Cosωsr there is sunrise angle and Cosπ+ Sin δ Sinπ = 0 because CosθZ is 0 θZ that being π / 2 and from here you can get Cosω at sunrise which is Cos inverse of – Tan of Tanф, so this is obtainable just directly from this step so you take Sin. Sin δ into this side and then Cosω is rs - Tans δ Tan / ωsr will be Cos inverse of - Tan δ Tan π and the sunset angle is nothing but minus sunrise angle.

Because it is on the west side of the original axis so these two angles our angles our angle sunrise our angle sunset are given by this relationship, entirely dependent on the declination and the latitude of the place.

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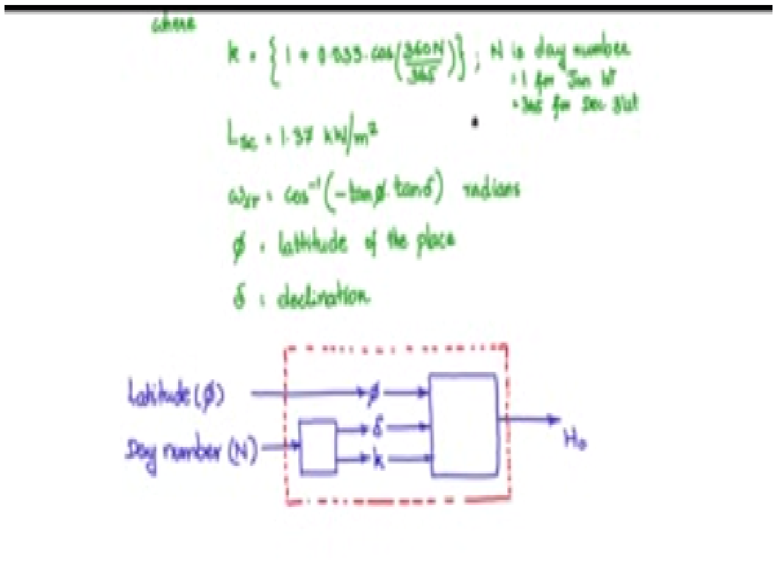

So now let us summarize the daily energy incident on a horizontal flat plate, so we know now H naught is the daily incident energy and this is given by this relationship 24K L_{SCD} solar constant by ϕ into Cosϕ Cos δ Sin ωsr + ω such Sinϕ Sin δ and this is expressed in the unit kilowatt hour per meter square per day where K is 1 + 0.03 3 + Cos360 N / 365 and n is the day number1 for January 1st 365 for December 31st, so now this K is an expression which is obtained empirically to obtain the insulation value at on a given day and L_{SC} is the solar constant mean solar constant.

Which is 1.3k kilo watt per meter square ωsr is the sunrise hour angle which we saw just now and this is given by Cos inverse of- Tanϕ Tan δ again in terms of latitude and declination only expressed in radians ϕ is the latitude and δ is the declination both of these can be in radians or degrees, now this can be considered as the model for obtaining the energy incident on a horizontal flat plate without having considered the effects of atmosphere till, now we have not considered atmospheric effects.

We will shortly discuss that also but right now this value is without any atmosphere by coming into the picture to put it in a block algorithmic form let us say we need two important inputs one is latitude ϕ another one is day number n that is we need the Dana Marion and the latitude ϕ remaining.

Everything else is determinable can be calculated using the equations that we just now discussed so the day from the day number we can get δ declination and this constant K using this relationship, so knowing ϕ as one of the inputs these 3 will be given to the model for estimating the energy and you will get H0 in kilowatt hours per meter square per day and this whole block algorithmically can be considered as the energy determining module for a horizontal flat plate.