Indian Institute of Science

Design of photovoltaic systems

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We shall now write some scripts in octave to estimate the clearness index for a given place and also to estimate the coefficients of the Fourier series curve rate model for clear mass index and also the water vapor content then we shall also see how we use the estimated value of the clearness index in order to estimate the energy incident on a tilted slightly collector in the presence of atmosphere atmospheric effects.

I have here in this folder QM files we have already seen error M minor at V dot Mealier in an earlier discussion I have three other files KT underscore India dot m WV underscore India dot M and hat estimate dot M so KT underscore India dot n is a script file which will provide you the coefficients of the Fourier series carpet model for Katie and WV underscore India dot M will provide the coefficients for the Fourier series carpet model for the water vapor content in the atmosphere.

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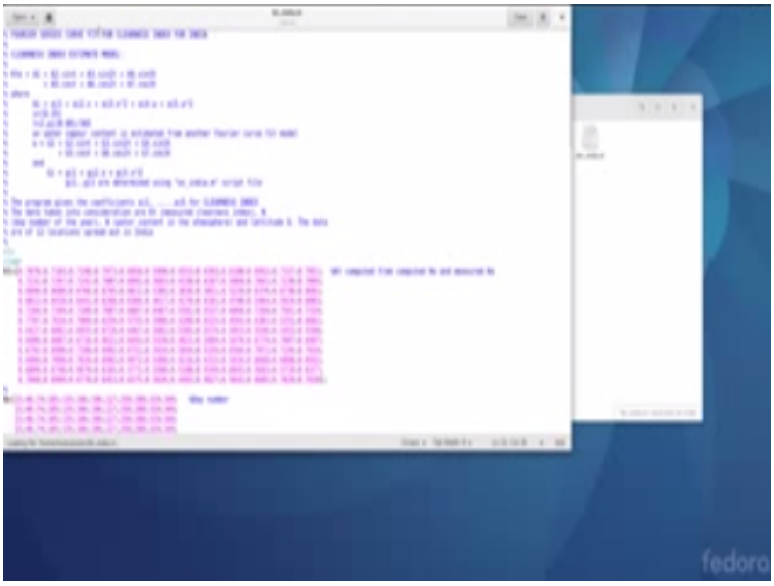

We shall then later on use the H eighty estimate script file to estimate the energy incident on a tilted flat plate collector with atmospheric effects so first let me open the clearness index script file the model is given here you can read this model let me probably increase the size of the font okay slightly so this is the model which we already discussed you see that KT model is a Fourier series model and we have gone up to the third harmonic in we need to estimate these coefficients and we have used up to the second power of X and the second power of W the water vapor current content the water vapor itself is found from another Fourier series curve.

It model I will go into that shortly and that is in WV Indian otm script file okay so what are the inputs the data are like this we have the latitude given here and for the corresponding latitudes and the corresponding D numbers we have the KD value of the measured KT value which is basically the ratio of the H a measured by H naught computed now this is done for around twelve places distributed all over the country and you can probably check the latitudes of the twelve places here and check it on the map of India.

And which all places fall in that latitude and we have also taken theater vapor content values as input data now you think this X is Phi minus 35 taxis being represented with T and we are using a i1 plus a I 2x plus a I 3 X square plus the a I for the W but the a W square for the based model and then how sine T sine 2t and sine 3tgetting multiplied in cos t cos 2 T cos3t also coming into the picture and thenweformulate the matrix and then take the matrix inverse to get the coefficients.

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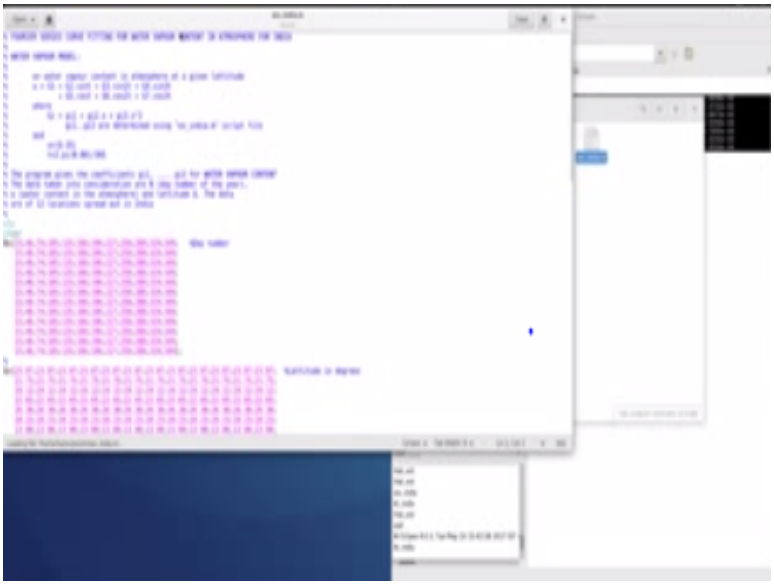

Let us execute this to find out the coefficients of KT so let me go into octave so in the octave let me clear the screen let me go into the folder of interest and I will execute this KTunderscore India 80 and school yeah like so on executing the script file you get this matrix this will be AI 1 AI 2 so this will be a 1 1a 1 2 A 1 3 a 1 4 a 1 5 a 2 1 - 2 - 3 -4 - 5 so on so this will be the coefficients for the Fourier series perfect model for likewise.

If I look into the WV underscore India dot M you will see the perfect model for theater vapor content just like as we discussed you can see the carpet model given here and the data is the day number which is taken as these values here and the middle of the month and for these latitudes for the same 12 cities and the water vapor content input data measure data is here and then here were using the model AI 1 plus AI 2 X to the I 3 X square so it is a three term second-order polynomial we do the matrix inverses generate the matrix and then find out G.

So when you execute this WV India we get the coefficients of the G matrix which will fit into this model so this would be GI one GI to n GI 3 so you can then get this model so now we know how to get water vapor and we can also get the clearness index next we shall look at this file this file issued for estimating the incident energy on a horizontal or a tilted surface now with atmospheric effect we saw without that most Vedic effects it is a modification of that file now you have few things added to it so this is the latitude.

I am using twelve point nines even Bangalore and I'm giving the tilt factor as ten which we saw as optimal under the without atmospheric conditions you still factor of that of that condition one without atmosphere and there is this row the reflection coefficient I am taking it a point to in the plane G is the G is the coefficient matrix for the water vapor content a the coefficient matrix the clearness index and the rest of this equation remain the same as before the new portion that I have introduced is here introducing atmospheric effects the estimation of the water vapor.

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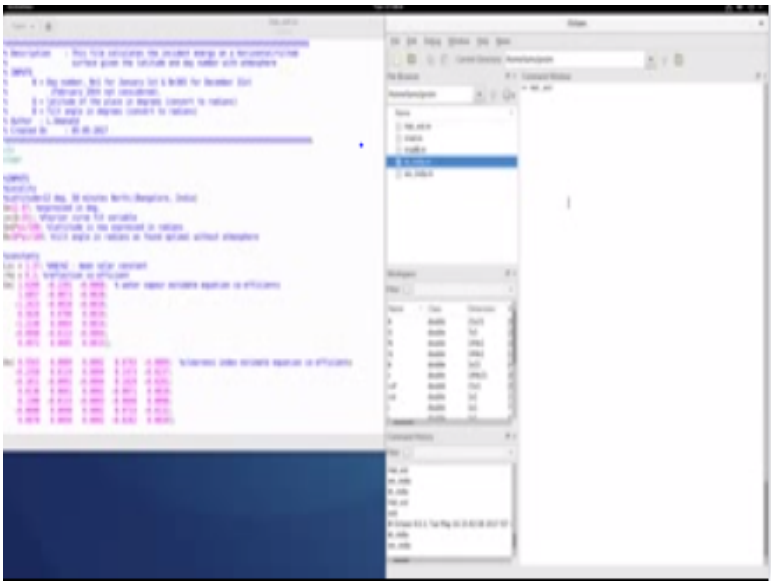

So those coefficients are put in this model form and this G is the one that is estimated this is the one that is estimated using WV underscore India dot M this a was obtained from KT underscore India dot M and that we use it one time and we use it only when we have fresh data are probably more other more number of places to include in the input data sousing that data we can get water vapor content and then use the water vapor content estimated into the FX equation of the clearness index which is 1x x square W Square and then you will get KT.

Estimate from the kissed KT estimate equation then find out Rd the tilt factor H so T by H naught then KD which is basically HD by H a the diffused radiation factor it is approximately given by 1 minus 1 point 1 3 2 KT RT the overall tilt factor is given by this relationship which we discussed all earlier from there we have these 2h-e-a-t directs that is without the diffuse and reflected radiation and the other one is H 80 which is with thatmysteric effects including the diffusion reflected radiation affecting the tilted surfaces.

These are the formulas that we have used and we will just run this and then see what is the result that we would get so going back to the octave and clearing the word space I will now execute a CIT esters the end so see here that we get this result is this new line is the H not kilowatt hour per meter square per day without atmospheric effects on a horizontal flat plate this Green Line is tilted flat plate collector with atmospheric effects.

So you see that this is actually very significantly attenuated from the one without the atmospheric effects and this is basically due to the clearness index I will see that for Bangalore see around here around 80 which will be March 21stregion we see clear sky and very intense radiation intensity radiation decreases here you will see lot of cloud because this is the monsoon region in Bangalore and you see the intensity reduced and you see that a minimum value is around4.6 or so and so on.

It will it reaches around 6 towards the December months they are a key in we see clear sky so the due to KT that is the clearness index we will see the local atmospheric effects getting reflected nicely in this fashion it is interesting to see plot the days versus Rd this is the tilt factor and versus RT the overall tilt factor so you will see that this Rd blue line is the tilt factor and the Green Line is the overall tilt factor RT lowercase R T.

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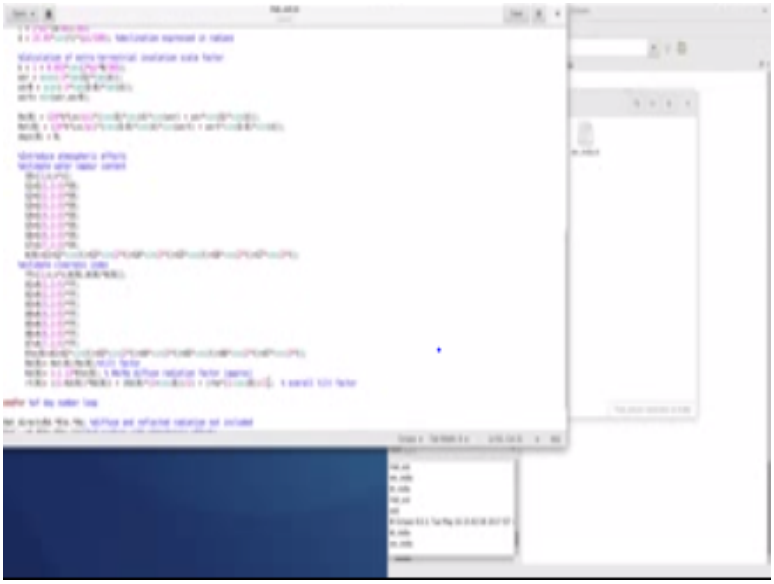

\So this is actually though it looks similar in shape this is actually lower the value is lower than Rd in the earlier months and the later month sand during the monsoon months you see that the Rd is lower and the overall tilt sector is having a better value due to the diffuse because of the cloud the diffused part is more and therefore thirty becomes higher it also be interesting to plot days anthem clearness index how it varies and you will see that the variation of the clearness index with day January 1st to December 31st.

How it is varied again you see that the clearness index is very nice and better it is reaching 0.75during the March months when the sky is clear in Bangalore and it is reaching Avery low figure around 0.45 during the monsoon months these are the monsoon months from June to around September October and then it picks up again so okay the clearness index actually reflects the atmospheric conditions of that locality there so the important conclusion is that if you run this hade estimate you will get this green line here which is H 80 the energy instant on the tilted flat plate collector with atmospheric effects.

And this is what you have to use for designing the PV panel now take in a year what is the minimum value you look at that so this minimum value here for example here the place where I kept the cursor is around 4.6and that value is the one which you need to take for designing all your applications because you are guaranteed four point six kilowatt hour per meter square per day of energy this much amount of energy every day of the yearend in other days you have excess so the worst case would this value pointed I by the cursor which is a jetty minimum and this we will use for designing and sizing the TV parents.