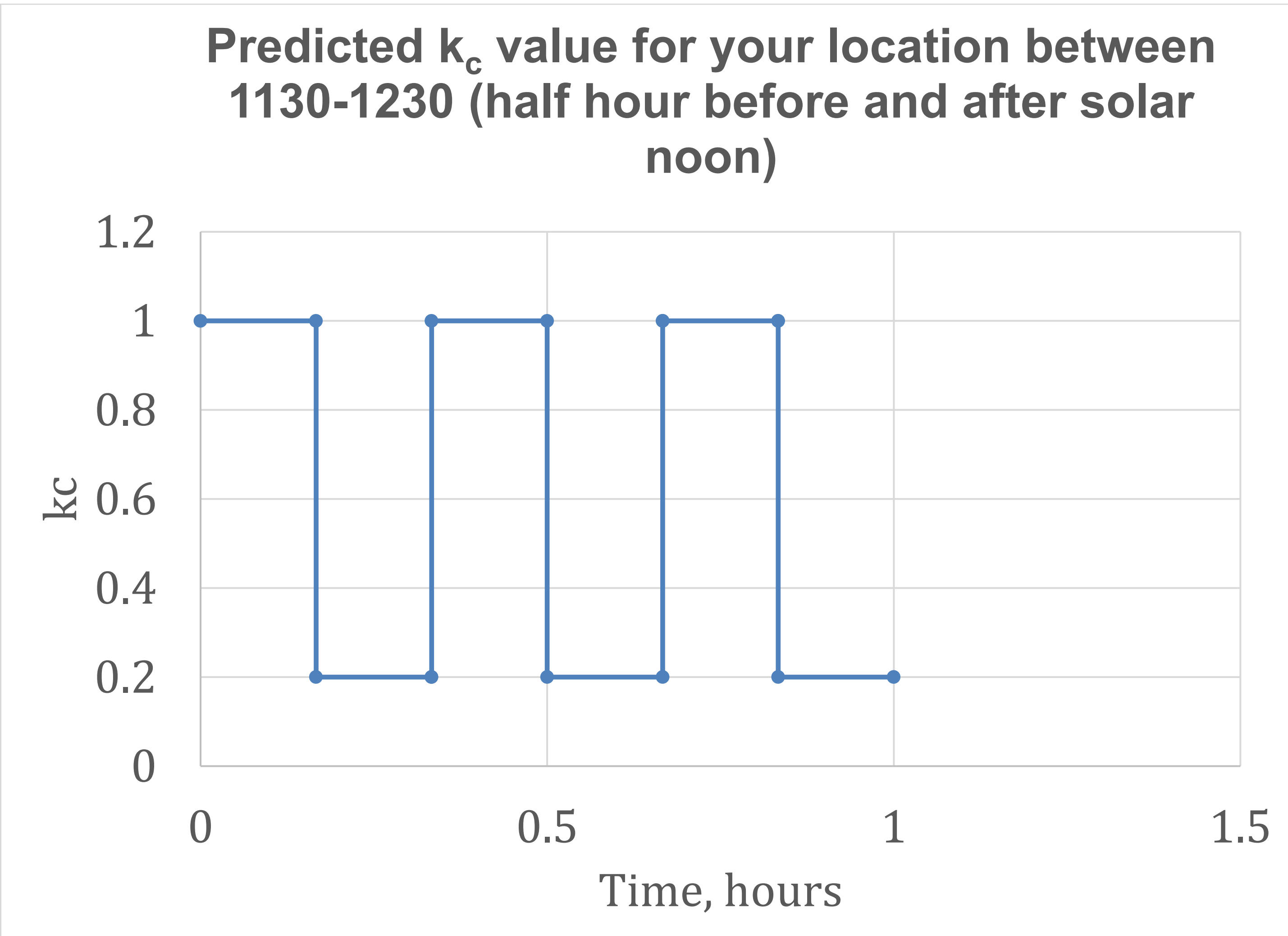
Special Topics Course ME 5374 "APPLICATIONS OF CONCENTRATING SOLAR THERMAL TECHNOLOGIES"
Spring 2024

Please submit electronic copies of the homework to CANVAS under assignment 4.

Read Chapter 3.0

4.1 You are operating a CSP plant as described in Homework 2 in your home location. You have received the received the following k_c (Cloudiness factor) (see graph below) for July 15 for the time 11:30-12:30, where 12:00 is solar noon. Assuming that you can neglect transient heating effects, the quasi-steady state assumption, calculate the produced energy from your CSP plant for this one hour period and compare it to the amount of energy you would produce using the incident solar radiation based on the clear sky estimates for half hour estimates. This assignment combines Assignment 3, the incident solar calculator, and the material in Chapter 2. The integration of the weather prediction, the k_c value, and the simulation model and the corrections made to your assignment 2, allow you as the operator to inform the electric grid operators of the energy you will be providing for this one hour period. This information is important for you and the electric grid operators in order to satisfy the load demand for that hour.



4.1.a The above calculation is an energy based measure. Compare the power output from your CSP plant during the time period 11:30-12:30 to that based on your half hour estimate for clear sky. This information also relates to the load demand for power and both may have implications based on the contract agreement with the electric grid utility and on implementing energy storage strategies.

4.1.b Using the above information write a brief discussion on how you would incorporate average yearly weather data in a simulation of a CSP plant during the design process and negotiations with the electric grid utility. This question requires no calculations.

4.2 Using the excel solar calculator or one of your choice, calculate the incident angle on a horizontal surface for your home location between the hours 10:30 to 12:00 (solar noon) in 6 minute intervals. Plot the incident angle, the solar zenith angle (altitude) and solar azimuth angle as a function of time for this period on a single graph. This graph will allow you to observe the rate of change of these angles with respect to time and will provide you with information for how fast a control system must respond to these changes in order to properly track the sun to maintain its focus on a receiver area.

4.3 In the sketch below the position of two heliostat mirrors are shown relative to the CSP tower and the center of the receiver volume. The heliostat mirrors are shown in their horizontal position to illustrate their relative location. The CSP tower and mirror centers are in a common line pointing due south, ie at solar noon the tower and two heliostats will lie on common line with the sun. The position of the sun in the drawing is also arbitrary for the sake of illustration and all heliostats are in a northern field. The mirrors measure 3 x3 m, an area of 9 m^2. The center of the mirror is located 2 m from the horizontal plane at the foot of the tower. Calculate the azimuth and zenith angle that these collectors must be positioned in order to focus the image of the sun onto the receiver surface for your home location at the following times: 10:00, 12:00 (solar noon) and 1400 hours. You can assume clear sky radiation, a k_c = 1value, a mirror reflection of 0.96 and that the solar receiver is cylindrical in shape and large enough to accommodate the reflected image of the sun. The incident beam radiation can be considered to be parallel rays. For these three times calculate the projected area of the mirror with respect to the incident solar radiation and the reflected solar radiation onto the receiver. Summarize your results in a table.