IE 453 Energy Systems Planning
HW2- Hybrid Energy System Modelling
Due date: April 2nd, 2023, 23:55

We imagine a small village where hydro and solar are two dominant energy sources to generate electricity. Within the village, we have hydro and solar stations already installed. The solar power station has an 80 km2 solar panel area, which works with 12% efficiency. The hydropower station has a 0.1 km3 reservoir, a 1.2 GW generator (90% efficiency), and a 100-meter head. Assume that the distribution network connecting power stations and demand points within the village has enough capacity, and there will be a 5% power loss during distribution. Power stations have no operating cost and as an alternative to solar and hydropower, electricity could also be purchased from the grid for 30 cents/kWh.

The 3-hourly stream flow, solar radiation and demand for one week in 2022 are provided in the file "HybridSystemData.xlsx".

At the beginning of the week, the amount of water stored in the reservoir is 50% of the reservoir capacity. We also want 50% of the reservoir to be filled up at the end of the week for some agricultural activities.

a) Formulate the problem as a linear program that minimizes the electricity cost for the given week.
b) Solve the problem using an LP solver and provide the output.
c) What would be the cost if there was no reservoir? What if the generator size was 0.015 GW?
d) Calculate the capacity factor of the power stations.
e) Instead of having a "big" conventional reservoir, suppose that we have a pumped hydro system with two-level reservoirs and the size of the lower-level reservoir is 0.05 km3. Extra solar energy can be transmitted to pumped hydro stations via bi-directional transmission lines and used to pump the water in the lower reservoir to the upper reservoir to be released again later. Assume that the lower reservoir is empty at the beginning of the week and generator can also be used as a pump and still works with 90% efficiency. Reformulate and solve this problem. How does the cost change in this case?
f) Propose a demand-side management strategy to reduce the cost of electricity. Update the model you proposed in e) to show the benefit.