Homework 3

BEE 4750/5750

Due: Oct 20, 2022 by 9:00pm ET

1 Overview

1.1 Learning Objectives

Homework 3 is focused on assessing your ability to formulate and implement linear programming models.

1.2 Background Information

You have been asked to develop a generating capacity expansion plan for the utility in Riley, NY, which currently has no existing electrical generation infrastructure. The utility can build any of the following plant types: geothermal, coal, natural gas combined cycle gas turbine (CCGT), natural gas combustion turbine (CT), solar, and wind.

Each of these plant types has the following generation data (**disclaimer**: these are not real), given in Table 1.

Assume that all 365 days in a year are equivalent in terms of demand and wind and solar capacity factors (**disclaimer**: this is obviously stylized and not reflective of reality, but it makes the problem simpler). These are given in Table 2.

The utility will also penalize any non-served demand at the cost of non-served energy, which is set at $9000/MWh.

Type	**Investment Cost ($/MW-yr)**	**Operating Cost ($/MWh)**	**Capacity Factor**	**CO_2 Emissions (tCO_2/MWh)**
Geothermal	557000	0	0.95	0
Coal	268000	24	1	1
CCGT	85000	28	1	0.43
CT	62580	45	1	0.55
Wind	91000	0	see below	0
Solar	53000	0	see below	0

Table 1: Generation data for the available plant types.

Hour	**Demand (MW)**	**Wind CF**	**Solar CF**
1	1517	0.58	0
2	1486	0.57	0
3	1544	0.55	0
4	1733	0.28	0
5	2058	0.14	0
6	2470	0.21	0
7	2703	0.03	0.20
8	2842	0.04	0.57
9	2957	0.01	0.80
10	3074	0.04	0.93
11	2929	0.04	0.99
12	2691	0.01	0.99
13	2653	0.04	0.99
14	2591	0.04	0.99
15	2521	0.01	0.95
16	2487	0.01	0.81
17	2628	0.01	0.55
18	2696	0.13	0.12
19	2626	0.30	0
20	2554	0.45	0
21	2249	0.44	0
22	1933	0.57	0
23	1684	0.55	0
24	1563	0.58	0

Table 2: Demand (MW) and solar and wind capacity factors by hour for the representative day.

2 Problems

2.1 Problem 1: Minimizing Cost

Your first task is to find a capacity expansion plan which minimizes total costs of investment and operation.

2.1.1 Problem 1.1: Identify Decision Variables

Identify and define all relevant decision variables and their notation.

2.1.2 Problem 1.2: Formulate Objective

Formulate the objective function. Make sure to include any needed derivations or justifications for your equation(s).

2.1.3 Problem 1.3: Formulate Constraints

Derive all relevant constraints. Make sure to include any needed justifications or derivations. Why is your set of constraints complete?

2.1.4 Problem 1.4: Implement in `JuMP`

Implement your optimization problem in `JuMP`. For this sub-problem, you only need to provide a code block with the problem formulation.

2.1.5 Problem 1.5: Find the solution

Find the optimal solution. How much should the utility build of each type of generating plant? What will the total cost be, and how much electricity will be generated each year by each type of plant? How much CO_2 will be produced each year? How much energy will be non-served and what what times would this occur?

2.2 Problem 2: Minimizing CO_2

Next, the utility would like to know how to build capacity to minimize annual CO_2 emissions.

2.2.1 Problem 2.1: Identify Changes from Problem 1

What changes are needed to your linear program from Problem 1? Formulate any different variables, objectives, and/or constraints.

2.2.2 Problem 2.2: Implement in `JuMP`

Implement your optimization problem in `JuMP`. For this sub-problem, you only need to provide a code block with the problem formulation.

2.2.3 Problem 2.3: Find the solution

Find the optimal solution. How much should the utility build of each type of generating plant? What will the annual CO_2 emissions be, and how much electricity will be generated by each type of plant? What are the costs of this plan? How much energy will be non-served and what what times would this occur?

2.3 Problem 3: Comparison of Plans

Compare the two plans you produced in problem 1 and 2. What are the key differences? Which plan would you recommend the utility adopt and why?

2.4 References

List any external resources consulted, including classmates.