Rothera Point Utilities (RPU) has data on the operation and input requirements of eleven different electrical generation plants it operated during. The dataset provides two outputs for each plant: the actual availability achieved throughout 2021, and the actual electricity (MWh) produced at each facility. The data set also provides readings on two important inputs: the total facility costs in 2021, and the amount of land occupied by each facility. Although they are important issues across the technologies, RPU doesn't normally consider achieved availability or land occupied when comparing the performance of its generation plants. Instead, RPU has used a simpler ratio of one output to one input, calculating MWh per dollar of cost, to judge which facilities perform better than others.

Part A: Rothera Point Data Envelopment Analysis

Question A.1: Using the two outputs and two inputs provided in *Rothera Point Plants DEA data.xlsx,* conduct a data envelopment analysis (DEA) to determine the relative efficiency of these eleven facilities.

Plant No.	Description	2021 Overall Availability	2021 Total Electricity Provided (MWh)	Acres Required	2021 Total Cost ('000s) ($)	Relative Efficiency
1	600 MW Ultra Supercritical Coal	0.9	4409300	5	282996	0.94279
2	650 MW Ultra Supercritical Coal with Carbon Capture	0.95	5408000	5	354752	1
3	550 MW Ultra Supercritical Coal	0.95	4577100	5	261223.3298	1
4	702 MW Natural Gas	0.96	4842044	5	930460	1

	Combined Cycle					
5	429 MW Advanced Natural Gas Combined Cycle	0.95	3570138	4	784660	0.98192
6	100 MW Gas Combustion Turbine	0.94	832200	2	120652	1
7	320 MW Advanced Gas Combustion Turbine	0.9	1972314	3	296600	0.91583
8	50 MW Biomass	0.91	406100	2	48327	1
9	100 MW Onshore Wind	0.515	451140	800	21952.7	1
10	223 MW Onshore Wind	0.48	1006013	1784	54203.79867	0.99865
11	150 MW Onshore Wind	0.55	604527	1200	35124.32	0.91712

Data envelopment analysis (DEA) is an application of linear programming used to measure the relative efficiency of operating units with the same goals and objectives. In this application of DEA, a linear programming model is developed for each plant whose efficiency is to be evaluated. Because the composite plant is based on all eleven plants, the plant being evaluated can be judged relatively inefficient when compared to the other plants in the group.

The objective function in a DEA model is to always Minimize E. The facility being evaluated (RPU plants) can be judged relatively inefficient if the optimal solution provides E less than 1, indicating that the composite facility requires less in input

resources. If E = 1, the composite plant requires as much input as each plant does. If E < 1, the composite plant requires less input to obtain the output achieved by the current testing plant.

Of the11 plants in RPU, 6 plants are found to be in optimal efficiency (E=1). They are:

- 650 MW Ultra Supercritical Coal with Carbon Capture (Plant 2)
- 550 MW Ultra Supercritical Coal (Plant 3)
- 702 MW Natural Gas Combined Cycle (Plant 4)
- 100 MW Gas Combustion Turbine (Plant 6)
- 50 MW Biomass (Plant 8)
- 100 MW Onshore Wind (Plant 9)

The other plants had efficiency factor, E<1 which is not optimal and operates below the efficiency level.

Question A.2: Your analysis in Question A.1 considers two inputs and two outputs simultaneously as it assesses the performance of an electrical generation facility. As mentioned in Context, RPU would normally just look at how many MWh were generated per dollar of cost, to declare "winners" and "losers" in terms of relative performance. Rank the plants according to RPU's method and prepare a discussion addressing these questions: How *different* is your advice in Question A.1 from the conclusions that RPU would arrive at, using its simpler method? Which, if any, plants and/or generation technologies are classified differently under the two competing performance evaluation methods? How would you explain this to RPU?

Considering, MWh generated per dollar of cost for all the eleven different electrical generation plants by ranking, 100 MW Onshore Wind**,** Plant 9, is the winner and 429 MW Advanced Natural Gas Combined Cycle, Plant 5 is the loser.

Plant No.	**MWh per dollar of cost**	**MWh per dollar of cost rank**
9	20.55054731	1
10	18.55982467	2
3	17.52178875	3
11	17.21106629	4
1	15.58078559	5
2	15.24445246	6
8	8.403170071	7
6	6.897523456	8
7	6.649743763	9
4	5.20392494	10
5	4.549917162	11

Comparing DEA analysis from Question A.1 and simpler ranking method in Question A.2, the perspective of choosing or recommending plants to use for RPU differs. However, plant 2 remains the perfect choice to be recommended for RPU as it functions in an optimal efficiency with efficiency factor and holds a rank 1 position with simpler method followed by Plant 3 holding 3rd position in both the methods.

All other plants are classified differently. For example, with the efficiency factor considered, plant 4 and plant 6 is in optimal condition. But, looking onto simpler method, these two plants lag in it's ranking with 1th and 8th positions respectively. In spite of that, most plants correspond to the order in simpler ranking method and efficiency factors more accurately. This can be explained to RPU by describing the performance evaluation in simpler methods by ranking positions and efficiency factors of the plants simultaneously. Majority of the plants correlate with recommendation in both the methods and can be prescribed for the evolvement of RPU.