

GE Energy Farm¹

GE Energy recently purchased 450 acres of land in California. They plan to utilize it as an energy farm, building either a solar farm or wind farm on each acre. Each acre used for a solar farm will bring \$2000 profit, requires 3 inverters and requires two tons of glass-fiber reinforced epoxy, used in building solar panels. Each acre used to build a wind farm will bring in \$3000 profit, requires 2 inverters and four tons of glass-fiber reinforced epoxy, used in building turbine blades. There are currently 1000 inverters and 1200 tons of glass-fiber reinforced epoxy available. Help GE Energy maximize profit from this land.

Discussion

Our objective is to maximize profit as mentioned in the problem statement. This profit is determined by the acres of solar farm and wind farm present. Suppose we feel that since the wind farm gives a larger profit per unit area, we build a wind farm on the entire plot. But looking further we see that in this case, the amount of glass-fiber epoxy needed on the wind farm if we built it on the entire plot of land would exceed the maximum tons of epoxy available. A similar scenario holds for solely building solar farms, but with inverters. Hence, we need to understand what combination of solar and wind farms can give us the maximum profit subject to the constraints of land, inverters and epoxy availability.

Therefore, our decision variable is how much land needs to be allocated for solar farms and wind farms respectively. In this problem, as the amount of land to be allocated to each increase to maximize the profit, the limit on the inverters available tends to give an upper boundary to the possible increase in the amount of land that can be allocated for each produce. Note that in the optimal solution, all the land available may not be utilized because of the inverter and epoxy availability constraints.

A factor to note is that in the Excel Solver, the constraint for land available must be **less than or equal to** 450 acres rather than equal to 450 acres; the latter might result in no feasible solution to be present. This is because we might not have enough inverters and epoxy to build with on more land. Our objective is only to maximize profit within the constraints present; we do not have to care whether the entire land is utilized or not.

¹ This exercise problem and related solutions were originally developed by Athira Praveen based on Practical Management Science 5th Edition. This current revision was revised by Nowed Patwary.

Mathematical Model

Parameters:

P_i : Profit margin for unit acre of farm i , where $i \in (\text{solar}, \text{wind})$

V_i : Number of Inverters required for unit acre of farm i , where $i \in (\text{solar}, \text{wind})$

E_i : Tons of glass-fibre epoxy required for unit acre of farm i , where $i \in (\text{solar}, \text{wind})$

V : Total number of Inverters available

E : Total tons of glass-fibre epoxy available

L : Total land available

Decisions:

x_i : Amount of land to be allocated to farm i , where $i \in (\text{solar}, \text{wind})$

Objective: Maximize profit

$$\max \sum_{i=\text{solar}, \text{wind}} P_i * x_i$$

Constraints:

- | | |
|---|--|
| $x_i \geq 0$ | (1) Land allocated cannot be negative |
| $\sum_{i=\text{solar}, \text{wind}} x_i \leq L$
exceed total land available | (2) Land allocated to solar farm and wind farm cannot exceed total land available |
| $\sum_{i=\text{solar}, \text{wind}} V_i * x_i \leq V$
exceed total inverters available | (3) Inverters allocated to for solar and wind farm cannot exceed total inverters available |
| $\sum_{i=\text{solar}, \text{wind}} E_i * x_i \leq E$
available Epoxy | (4) Epoxy used for solar and wind farm cannot exceed total available Epoxy |

Notes:

1. The constraints (2), (3), (4) ensures that the amount of land, inverters, and epoxy utilized stay within their respective availability.

Excel Solution

The following is the solution obtained from Excel Solver.

Input				
	Solar Farm	Wind Farm		
Profit Margin	2000	3000		
Inverters Needed	3	2		
Glass-fibre epoxy Needed	2	4		
Decision				
Area of land allocated	200	200		Constraint
	400		<=	450
Land available	450			
Tons of Epoxy available	1200			
No. of Inverters available	1000			
Constraints:				
Glass-fibre Epoxy used	1200	<=	1200	
Inverters utilized	1000	<=	1000	
Objective				
Total Profit	1000000			

The optimal solution is to allocate 200 acres to solar farm and 200 acres to wind farm to yield a maximum profit of \$1,000,000.