Team Project

ISyE 6669

Fall 2023

Introduction

You are in charge of power supply to a large manufacturing plant which requires both electricity and hydrogen. These can both be purchased on an hourly basis, the hydrogen at a fixed price and the electricity at the real time market price. The company has an on-site solar farm rated at 2MW which may be used at zero-cost, any excess solar is wasted.

You are tasked with making hourly purchasing decisions to minimize costs while ensuring that the plant has the required energy sources. Assume you are able to buy any quantity of both, including non-integer amounts.

- The hourly hydrogen requirements of the company for the next three days are provided in `Hydrogen_Demand.csv`
- Hydrogen can be purchased at a fixed price of $10/kg
- Hydrogen can be stored on-site, assume that space is not a limiting factor.
- The hourly electricity requirements of the company for the next three days are provided in `Electricity_Demand.csv`.
- Assume that any electricity generated from the solar power is zero cost.
- The hourly capacity factor for the solar array is provided in `Solar_Forecast.csv`. These give the percentage of the rated power output to expect - i.e. a value of 1 indicates for that hour the solar will output its rated power.
- The company buys electricity at the wholesale prices, provided in `Electricity_Prices.csv`. Currently the plant has no ability to store electricity on-site.

Rules

This project should be completed in teams of up to three. There are two parts to this project, which should be submitted separately at the following dates:

Part	Submission Deadline (end of day)	Points
A	October 6th 2023	20
B	November 17th 2023	40

You will receive feedback from your first submission which may well be useful for the second part.

Each team should submit **once** in an email sent to the instructor (ccrozier8@gatech.edu). The submission should be in the form of a <u>typed</u> pdf document accompanied by a single `python` file and any requested data. A short description should be included describing how tasks were allocated between team members. Please zip these files together to prevent issues with emailing `.py` files.

Part A

1. Formulate a linear programming problem to determine the required purchase of electricity and hydrogen over the next N hours. (Assume the hydrogen stores start empty). Clearly define all variables and parameters. [7pts]
2. Implement this LP using Python code. Solve to find the minimum operational cost over the next 72 hours. Your code should read in the input data – hard coded data will be **heavily** penalized. Your code should output the required hourly purchases of electricity and Hydrogen over the next 72 hours. [10pts]
3. Discuss your solution and which constraints are active in the optimal solution. Would your solution be different if you solved it for a shorter time-horizon (fewer than 72 hours)? [3pts]

Part B

The company is considering ways in which it could reduce its operational running cost. You have been asked to consider the economic-case for the following options:

(a) Purchasing a 0.5 MW electrolyser such that hydrogen can be produced on-site.

(b) Purchasing additional solar power

(c) Purchasing a 0.5 MWh battery such that electricity can be stored on-site

The following technical information is available from potential suppliers:

- Running the electrolyser for 1hr uses 0.5 MWh of electricity and produces 9kg of Hydrogen. The electrolyser can not operate at lower powers, so must be either on or off for the whole hour.
- Solar panels can be purchased in 0.2 MW blocks which cost \$0.9m
- The Battery can store up to 0.5 MWh of electricity, can be fully charged in 1hr, and is assumed to be loss-less so any stored energy will be totally recovered.

1. Assume that the electrolyser is added but no other changes are made
   (a) How does the LP change to include the electrolyser in operation? [4pts]
   (b) Implement your new model in Python (it is recommended that you use logic to make the new terms removable). Your code should also output the forecast electrolyser user in a csv file called `Electrolyser_Use.csv` [6pts]
   (c) Comment on how your solution and costs have changed. [2pts]
2. Now assume that **instead** the company decides to purchase additional solar.
   (a) Alter the original LP to determine assuming two additional blocks of solar are purchased. How does this change the optimal operational cost? [2pts]
   (b) Now alter the problem to determine the optimal amount of new solar to purchase. You need to include the cost of the panels, for this purpose you can assume that the costs will be evenly distributed over 3.5 years (ignoring inflation/interest). [5pts]
   (c) Implement your new problem in Python and determine the optimal solar installations and new **operational** cost over the three days. [5pts]
3. Finally **instead** consider the purchase of the battery.
   (a) How does the LP change to include the battery in operation? Assume the battery starts with no stored energy. [6pts]
   (b) Implement the altered LP in Python. [5pts]
   (c) Comment on how your solution and costs have changed. [1pt]

4. The company wants to make the investment which can be recovered as quickly as possible. Calculate the buy-back times for each technology, and make a recommendation to your employer. The costs of the electrolyser and battery are shown below. [2pts]

Component	**Cost**
0.5 MW Electrolyser	$500,000
0.5 MWh Battery	$75,000

Note: The remaining 2pts are used to assess the quality of the write up. Well-typed, formatted, and concise write ups will score highest. [2pts]