Data Visualisation Assignment

Brief

- 5000 kWh of electricity per year (13.7 kWh/d = 49320 kJ/d, 0.57 kWh/h = 2.05 MJ/h)
  - Assume PV cells can capture 15% of incident power
  - What area would be needed to capture sufficient power?
  - What storage is needed?
- 200m3 of water per year (0.55 m3/d)
  - What collection area is needed?
  - What storage capacity is need?
- Consider both seasonal and annual fluctuations

Notes

10 October 2023

- Issues importing data into python. This is due to the change in column size from 4 to 22 in the data
  - The data used in the example provided on MyPlace has empty columns included. Downloading the same file from the CEDA has the same issue as the other data I'm trying to use

11 October 2023

- Manually deleting the first 22 rows in the .csv file by using excel skips a step in the code but with more work. Ideally I'd find a way to do this in python
- My code was just wrong before. It is very easy to use python. By using:

```
df = pd.read_csv(io.BytesIO(uploaded['midas-open_uk-radiation-obs_dv-202107_lanarkshire_00987_drumalbin_qcv-1_1995.csv']), skiprows=[*range(75)], skipinitialspace=True)
```

- The code first skips the problematic lines before creating the data frame
- For the radiation

- Use columns:
    - ob_end_time, column
    - ob_hour_count, column
    - met_domain_name, column
    - glbl_irad_amt_q, column
  - Units of kJ/m2 (per hour, I assume)
- For the rain
  - Use columns:
    - ob_date (column 0)
    - met_domain_name (column 4)
    - ob_day_cnt (column 6)
    - prcp_amt (column 9)
  - Skip the first ~61 rows to avoid error
  - Remove final row to remove "end data"
  - There are the very rare 30 day total readings that need to be removed
  - The precipitation amount is in mm

13 October 2023

- Boxplots will be used to show monthly variations for the years selected

14 October 2023

- To simplify the process of selecting data, try to automate most of the process.
  - Use drive to upload files without have to manually select them
  - Could use a range of dates and loop to upload all the files. Use f'/x/y{year}'
  - Try to combine the dataframes into one to make things easier going forward
- I'm going to assume that water and energy consumption are constant daily and hourly
- I can work with daily averages in the background to get data, but I'm unhappy with how this looks in graphs. It's incoherent
  - Extract monthly averages for daily rainfall or irradiance, plots are clearer
  - Use this to calculate the required area (using the monthly averages). For a known consumption

$$A = \frac{Volume\ Consumed\ Daily}{mm\ rain\ daily}$$

$$A_{solar} = \frac{Power\ Consumption[kWh/h = 1000W]}{Irradiance[W/m2]}$$

15 October 2023

- I'm unhappy with the area plots. I don't think they're particularly useful
  - They don't really prove what area is needed, they work off monthly averages which are too vague
  - They don't account for storage required; there will be days with 0 rain
  - Could I try to relate storage volume/capacity to collection area?
- Try to plot area vs volume knowing the equations for area based on consumption and rainfall/irradiance

18 October 2023

- Storage size is based on the days where there is insufficient natural supply. This means we need enough stored to provide supply for a certain time period (t_{store})

$$V_{stored} = (\dot{V}_{consumed} - \dot{V}_{produced}) \times t_{store}$$

- Not based on individual days, this is a problem. What if there's a series of low production days?

19 October 2023

- I could create a loop in python to calculate the required volume
  - Required store is based on consumption and generation (found daily) terms, and the previous entries stored volume

$$V_n = V_{n-1} + [Gen] - [Con]$$

- What if the tank or battery is full?
  - Create an "if"
  - If tank is too full, then it just overflows or the feed stops
  - If $V_n > V_{store}$, then $V_n = V_{store}$
- The generation term is a function of area

20 October 2023

- Because of generation depending on area, I can find the size of storage required for different areas
- Automate by a for loop for area, and then a for loop for time
  - Extract the minimum stored volume value
  - Create a new list where this minimum value is stored
  - Find the battery/tank size where the minimum is 0
  - Plot to relate collection area with storage size
- Both battery size and panel area have associated costs, I can try to optimise this
  - I found battery data from a vendor, can plot capacity with cost
    - Using a function in python I can extract the line of best fit slope and intercept
    - Use this to find cost at different size
  - Plot cost for different areas and associate battery size, take the minimum
- I can show the stored energy in the battery with time for the period to prove there is always power supply

21 October 2023

- Similar method used for water tank, I don't think its required to find a cost by area for collection, a cheap tarp would do the job
- Relate area of collection to volume stored again so that the stored volume is never zero
  - No optimal point, I think it's reasonable to choose an area where the additional area has to be greatly increased for a small change in volume of storage (around 300 seems right)
- Plot water storage with time, same method as solar

22 October 2023

- I can find the cost of the water tank using:
  - Sinott-Towler cost estimation for a vertical vessel
  - ASME design equation (where I can find the water pressure)
  - A height-diameter ratio of 3:1 for a storage tank

$$V_{tank} = \pi\left(\frac{D}{2}\right)^2 h = \pi\left(\frac{h}{3}\frac{1}{2}\right)^2 h = \frac{\pi}{36}h^3$$

$$h = \sqrt[3]{\frac{36V_{store}}{\pi}}$$

$$P_{water} = \rho g h$$

$$thickness = x = \frac{PD}{2\sigma E - 1.2P} = \frac{P(h/3)}{2 \times 144 \times 0.85 - 1.2P}$$

$$V_{metal} = SA \times x$$

$$M_{metal} = V_{metal}\rho_{metal}$$

$$Ce = -10000 + 600M_{metal}^{0.6}$$

24 October 2023

- I have my doubts about the final values. The areas and storage are specified way above what would practically be needed. For the assumption about constant usage and no conservation of resources when supplies start to drop the values are accurate so it does match the criteria of being fully self sufficient
- The extra power generated could be sold as power to the grid, especially over the summer months. This can be calculated for each datapoint in python. The main part is:
  - If $E_n > E_{battery}$, then $E_{sold} = E_n - (E_{battery} - E_{n-1})$
  - Where the bracketed term accounts for power required to fully charge the battery
- In practice, if there was some small reliance on power from the grid or water from the mains, then a significantly reduced area and storage can be used
  - Even some reasonable resource saving habit changes would drastically reduce cost
- I'm going to add a section on wind power, probably more applicable for the west coast