Climate change and domestic electricity consumption

An analysis of housing electricity demands based on climate factors

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"Electricity consumption is likely to be higher during the hotter months of April and May. This year, peak electricity demand increased by about 8% from 7.3GW in February to 7.9GW in May."

—**Mr Gan Kim Yong, 2023**

Problem Statement

With global warming leading to prolonged heat waves and intensified rainfall extremes, concerns have been raised during parliament:

How can **EMA's energy supply be better prepared for the increased electricity demand and grid stress** from climate fluctuations?

Objectives

Data analysis and methodology

Identify datasets required and briefly explain the analysis methodology

Climate conditions and electricity consumption

Identify and explain relationships between **local** climate conditions and **household** electricity consumption

Actionable insights

Based on the relationships found, what are the **takeaways** and **next steps** for EMA in management of electricity generation and distribution based on climate fluctuations?

Methodology

Datasets used

01

Climate data inclusive of:
(Provided)
- Rainfall
- Temperature
- Sunshine duration
- Humidity
- Wet bulb temperature

02

Energy consumption data:
(EMA: Singapore Energy Statistics)
- Electricity consumption by dwelling types

* Data from 2018 to 2022 August

Methodology

By combining the two datasets, we can identify relationships between electricity consumption and climate factors.

The data analysis is conducted on python's library of dataframe readers to generate charts that visualise the correlations.
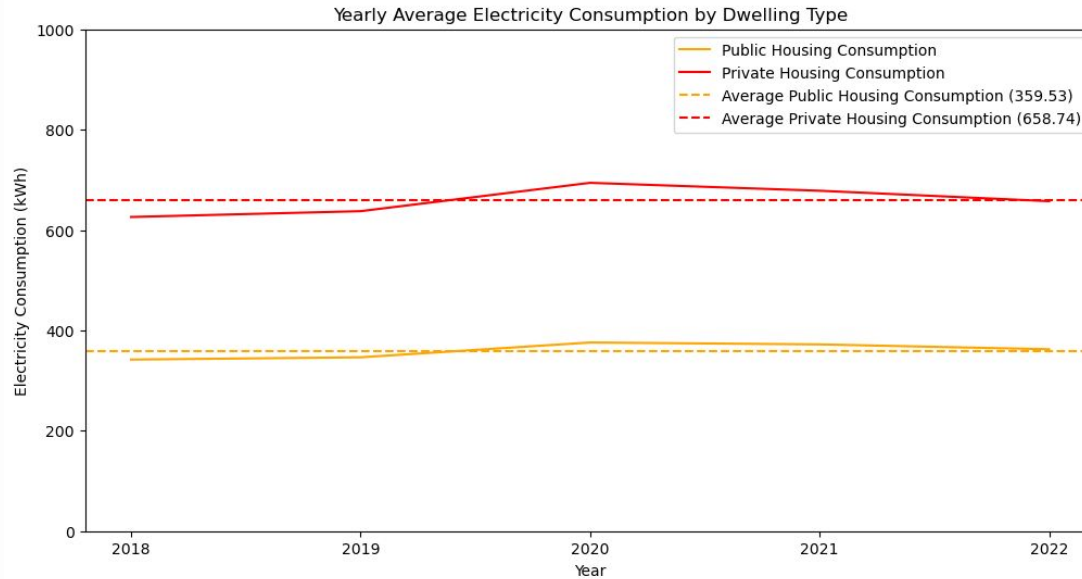
Average monthly household
electrical consumption

Electricity consumption range by dwelling types
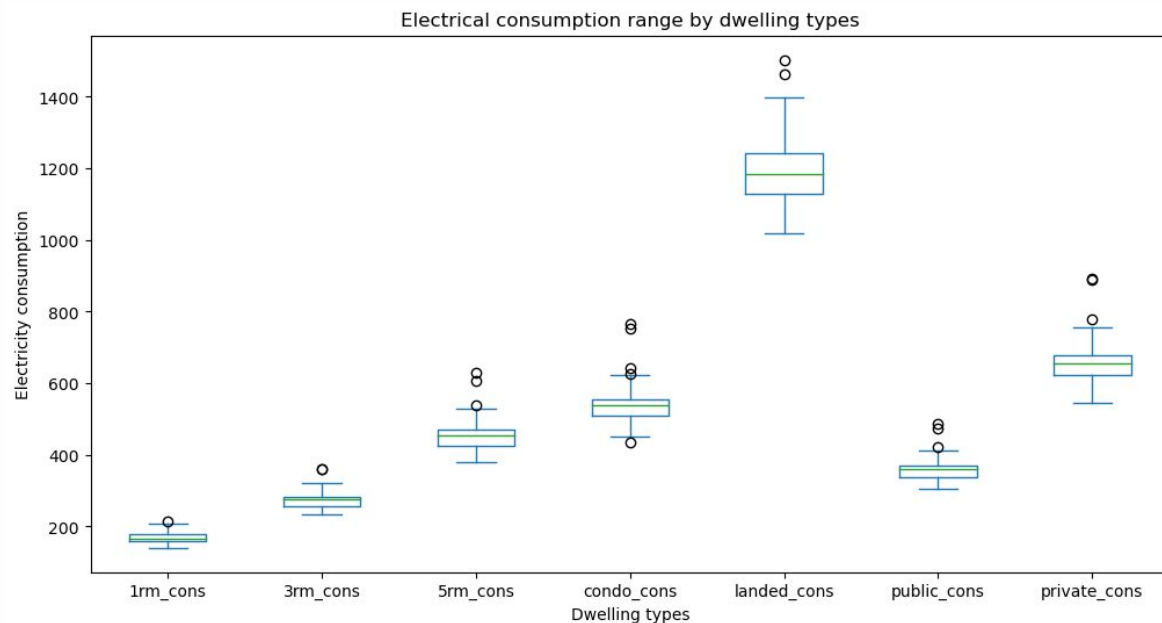
Electricity consumption <u>increases by residential size.</u>

<u>Landed properties use drastically more electricity</u> and have a higher variance.

Average monthly household electrical consumption

Yearly Average Electricity Consumption by Dwelling Type

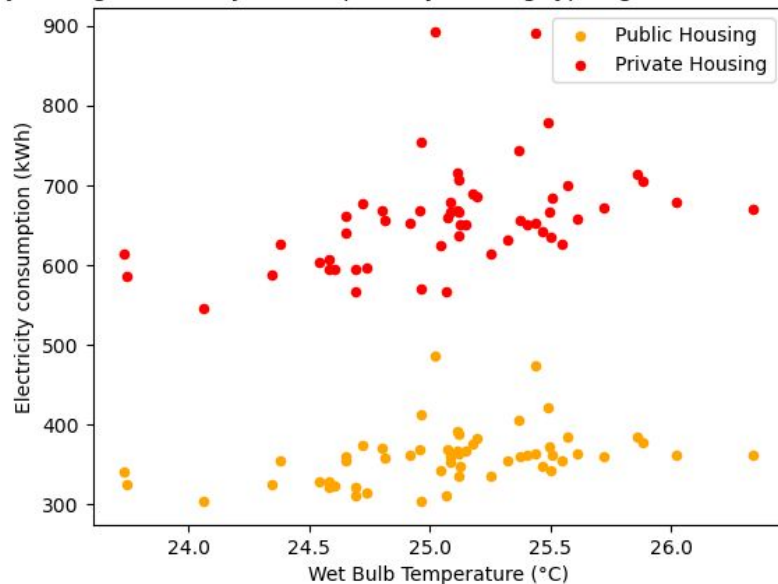Public household average = **359.5kWh**

Private household average = **658.7kWh**

Household electricity usage has <u>trended down slightly post covid</u>

Do we use more electricity when we're feeling hot?

Wet bulb temperature* against electricity consumption

Monthly average electricity consumption by housing type against wet bulb temperature
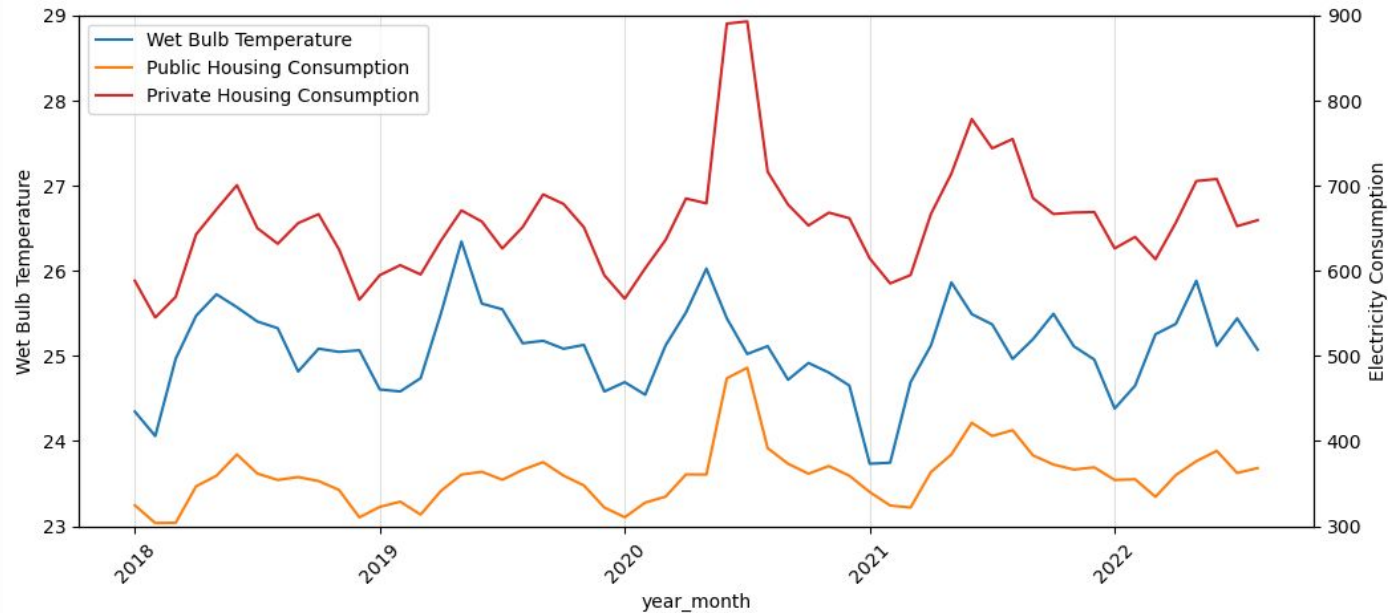
Observation:

There is a <u>moderately positive</u> correlation between wet bulb temperature and residential electricity consumption types.

A 1°C increase of wet bulb temperature correlates with an increase in electricity consumption of

- 39.59kWh (Public)
- 44.01kWh (Private)

* Composite measurement of temperature, humidity, wind and solar radiation
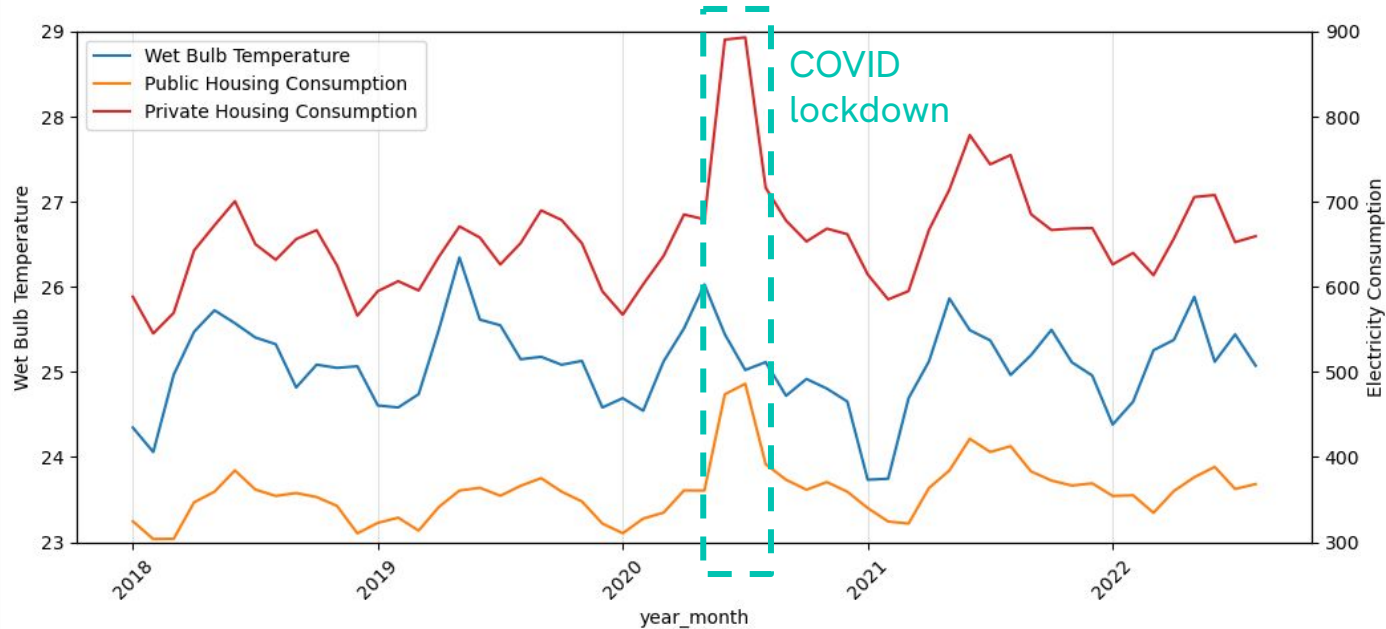
Household electricity consumption and wet bulb temperature trends together

Relationship between monthly household electricity consumption and wet bulb temperature over time

Household electricity consumption and wet bulb temperature trends together
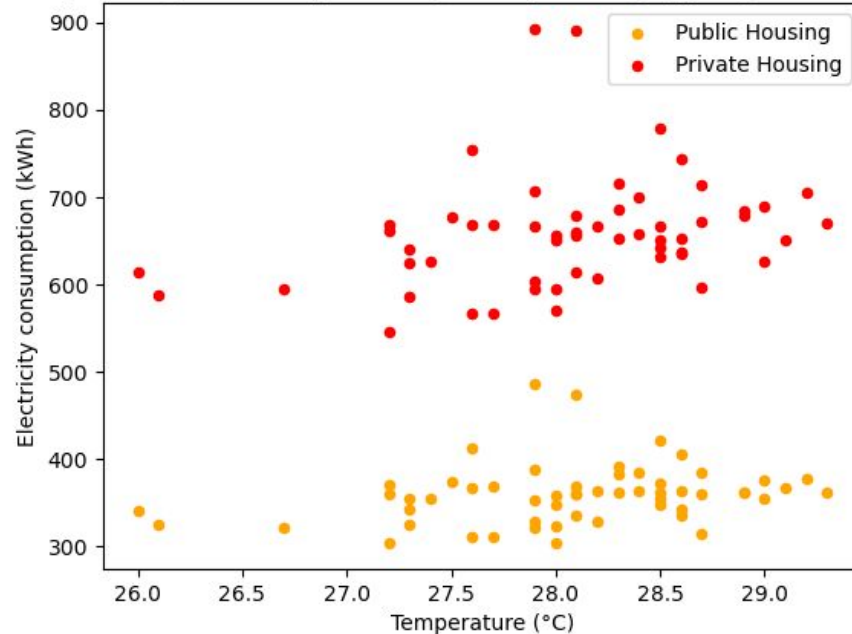

Relationship between monthly household electricity consumption and wet bulb temperature over time

How about true temperature measurements?

Temperature and Electricity Consumption

Monthly average electricity consumption by housing type against temperature
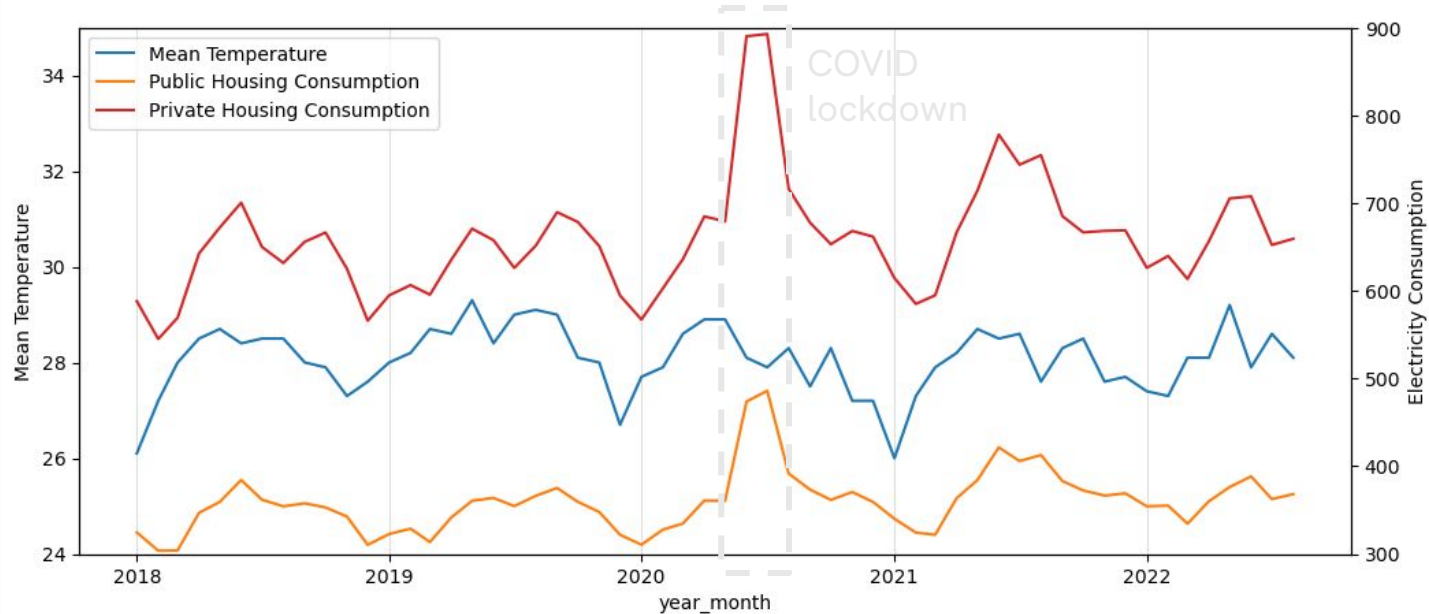
Observation:

There is a <u>mildly positive</u> correlation between temperature and residential electricity consumption types.

A 1°C increase of average monthly temperature correlates with an increase in electricity consumption of

- 23.89kWh (Public)
- 28.05kWh (Private)

# Household electricity consumption and temperature trends together

Relationship between monthly household electricity consumption and mean temperature over time

Low no. of rain days doesn't correlate with high consumption

Number of rain days per month and Electricity Consumption

Monthly average electricity consumption by housing type against rainy days
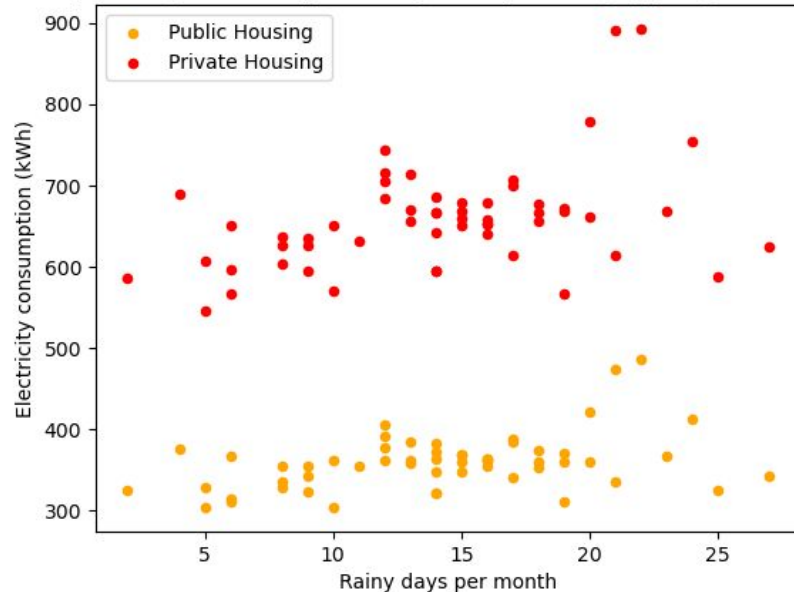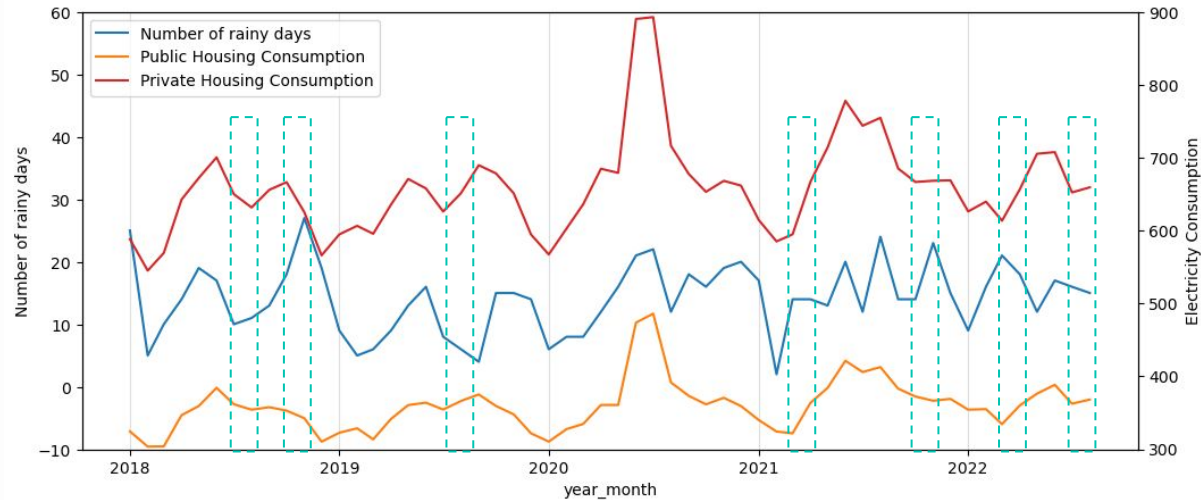
Observation:

There is a moderately positive correlation between number of rainy days and residential electricity consumption types. *(Instead of U shaped curve)*

A 1 day increase of rain in a month results in an increase in electricity consumption of

- 40.83kWh (Public)
- 40.86kWh (Private)

Consumption and rain days
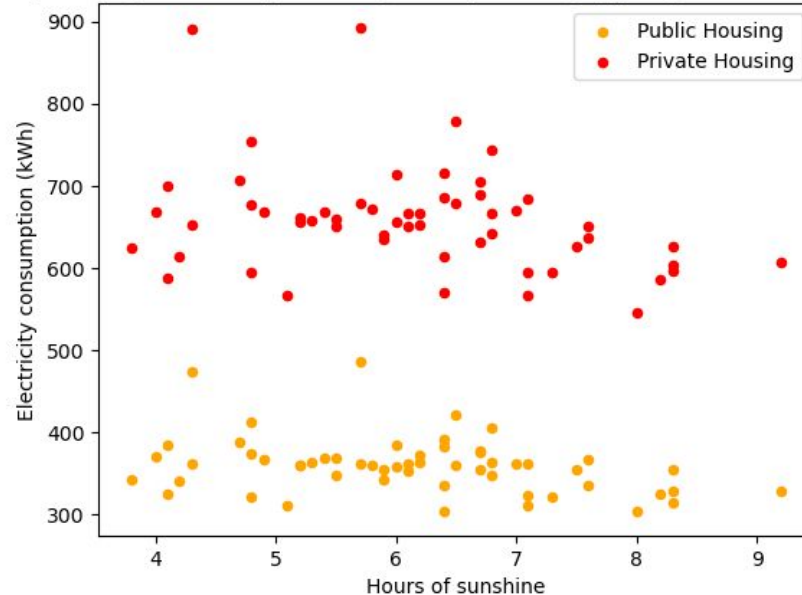## trends less apparent than temperature, despite stronger correlation

Relationship between number of rainy days and electricity consumption over time

Instances where consumption did not trend with number of rain days

More hours of sun -> Less consumption

Monthly average electricity consumption by housing type against hours of sunshine
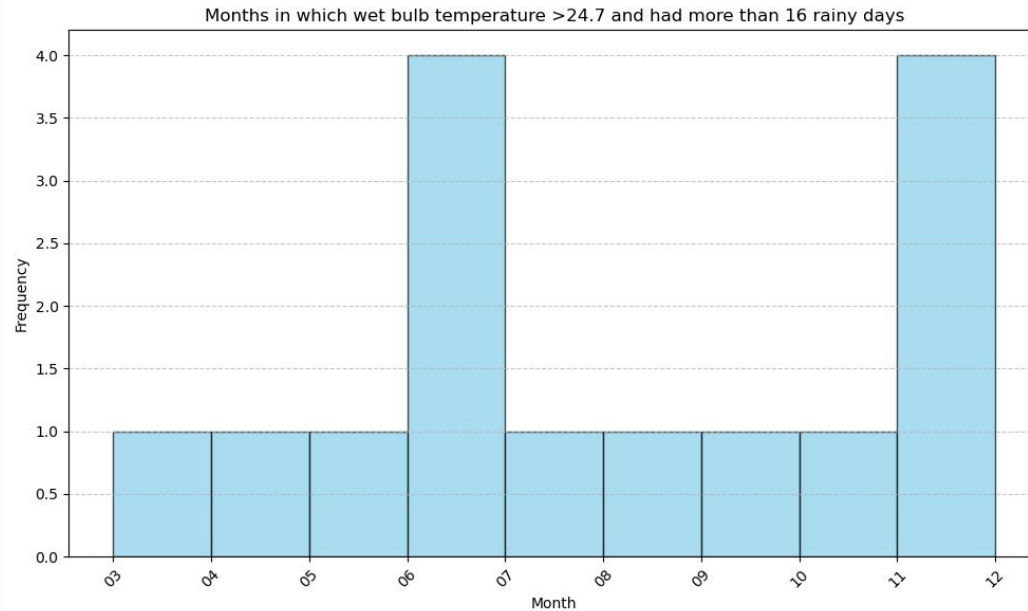
Observation:

There is a negative correlation between <u>hours of sunshine</u> and residential electricity consumption types.

A 1 hour increase of sunshine in a month results in an <u>decrease</u> in electricity consumption of

- 32.5kWh (Public)
- 30.5kWh (Private)

A combination of factors

Wet bulb temperature & rain days

Months in which wet bulb temperature >24.7 and had more than 16 rainy days

Observation:

June and November are months that tend to experience higher wet bulb temperatures and number of rain days.

Findings and Observations

- **2 variables** have shown **a stronger positive correlation** with household electricity consumption:
    a. Wet bulb temperature
    b. Number of rain days per month
- **Temperature also has a mild positive correlation**, a deeper dive has shown that consumption fluctuates together with temperature changes, despite a weaker correlation.
- **Anomalous situations** have to be taken into account where electricity consumption spikes despite gentle climate conditions.
- **June and November** are months to look out for where electricity consumption increases across households, due to high wet bulb temperature and number of rainy days.

Recommendations

Plan for 2030*

Taking population growth and global warming indicators into account, total electricity consumption expected to increase by ~27%.

* UN's checkpoint for global warming indicators

Cleaner fuel for energy

Meet increased demand with clean energy (Solar PV optimisation) instead of burning more fuel which leads to temperatures rising.

Test hypotheses

Test the observations as hypotheses. Build more accurate predictive models for demand planning.

Thank you