Medium Term Load Forecasting using Top Down Approach for Pakistan’s Power Sector

Supervisor: Dr. Naveed Arshad

Overview

- What is Forecasting and why is Forecasting needed in energy sector of Pakistan?
- Medium Term Load Forecasting
- Exploratory Data Analysis
- Parameter Selection
- Model Building
- Results
- Future Work
- Conclusion

Forecasting and its techniques

Process of making predictions based on the past or present data.

1. **Qualitative Forecasting**

- Relies upon experts judgement
- Often biased and comprised of personal judgements
- Can be inaccurate

1. **Quantitative Forecasting**

- Relies on numerical analysis
- Consistent and objective
- More accurate as compared to Qualitative Forecasting

Why forecasting needed?

- Predicting demands of new and existing products
- Anticipating customer’s need
- Predicting cost of materials
- Good usage of budget
- Timely procurement and good planning

Energy Forecasting

Reasons for Energy Forecasting

- Resource Allocation
- Resource Ordering
- Budget Planning

Types of Energy Forecasting:

- Short Term Load Forecasting (1-2 days)
- Medium Term Load Forecasting (1-2 years)
- Long Term Load Forecasting (5-10 years)

Medium Term Load Forecasting

- To forecast monthly energy demand and monthly peak power for the future span of one year.
- Predictions on monthly granularity.

Factors affecting Forecasting:

- Economic
- Population and living styles
- Geological
- Weather etc

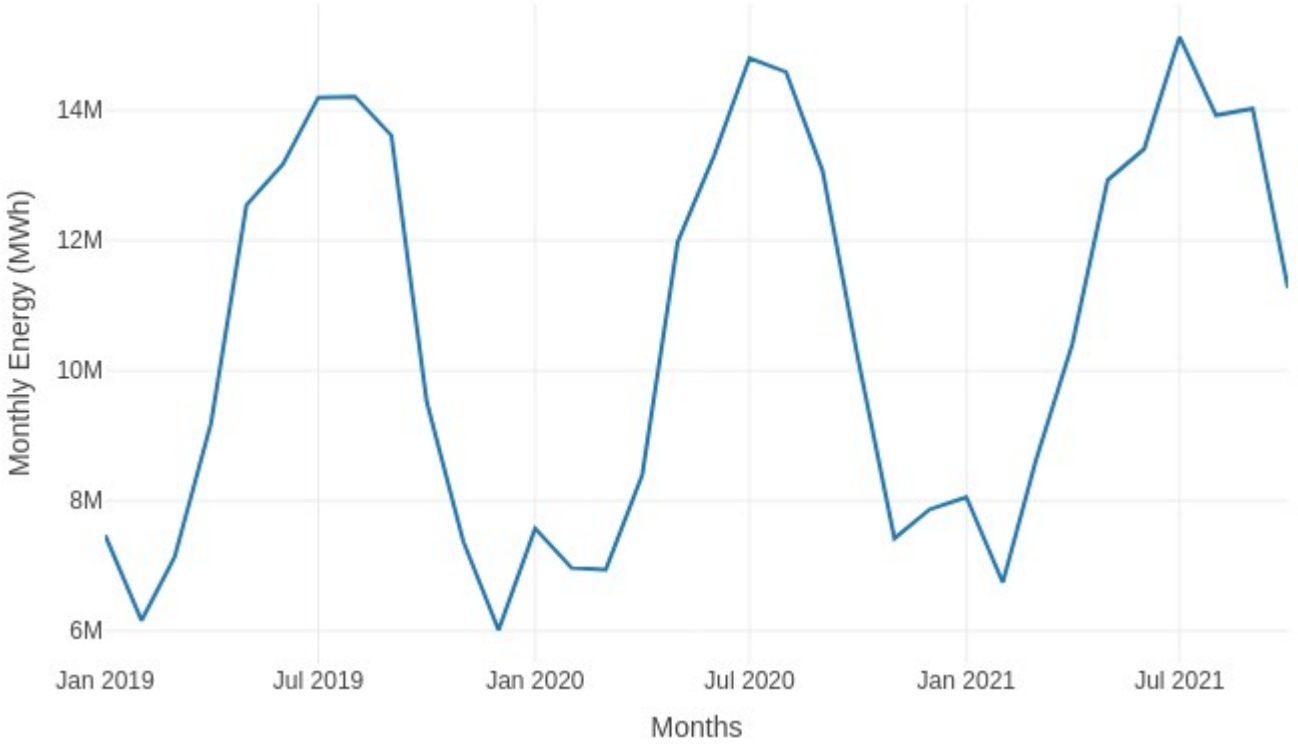
Data Availability:

1. NPCC Pakistan’s energy for 2019-2021
2. Weather attributes for nine major cities of Pakistan
    1. Lahore
    2. Multan
    3. Faisalabad
    4. Quetta
    5. Peshawar
    6. Gujranwala
    7. Hyderabad
    8. Sukkur
    9. Islamabad.

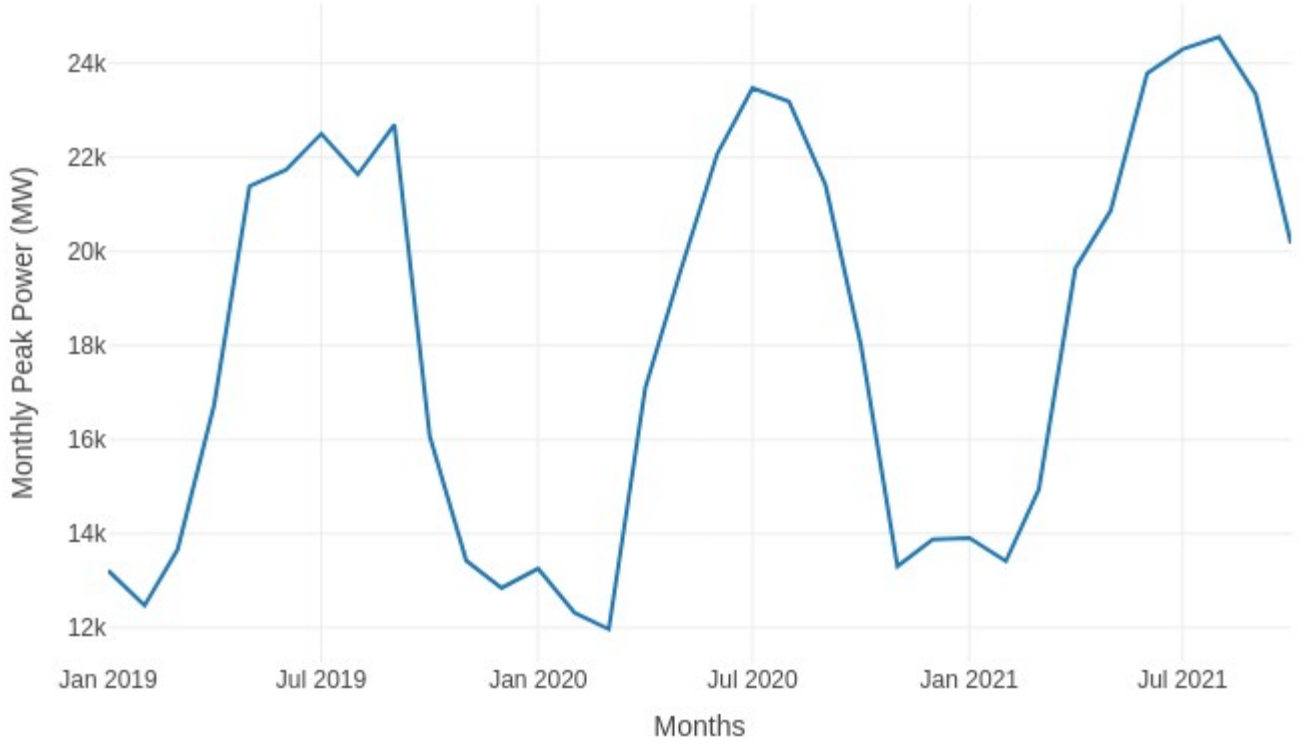
Weather parameters include Temperature, **Apparent Temperature**, Dew Point, Humidity, Pressure, Wind Speed, Wind Gust

Exploratory Data Analysis

Monthly Energy (MWh)



Monthly Peak Power (MW)



Parameters Selection

Independent Variables showing high correlation with Energy:

- Apparent Temperature (0.88)
- Temperature (0.83)
- Pressure (-0.86)

Multicollinearity

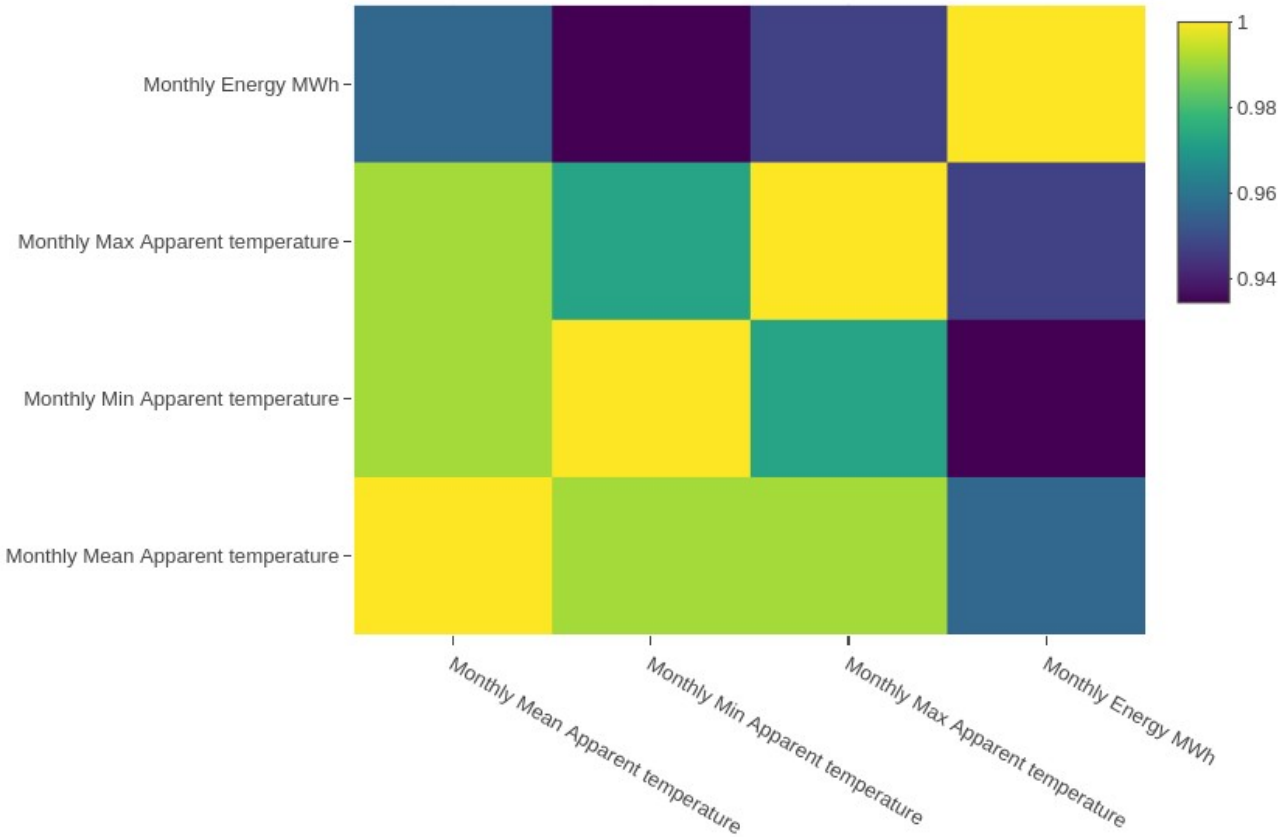
- The occurrence of high intercorrelations among two or more independent variables in a multiple regression model
- Change in one independent variable results in change in some other independent variable.
- Can lead to skewed or misleading results
- Perfect collinearity exist if correlation between two independent variables is 1 or -1.

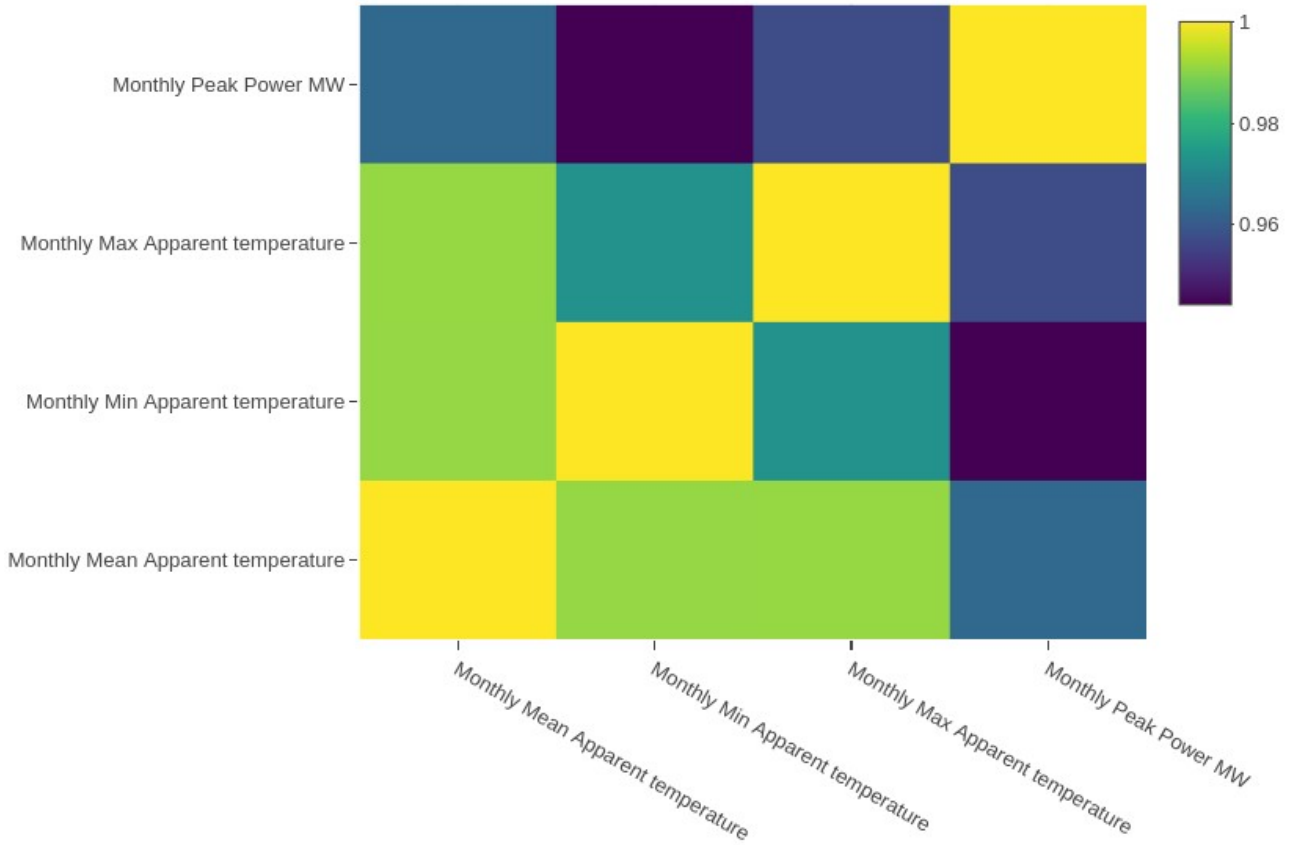
Apparent Temperature preferred to Temperature

- Checked multicollinearity for three aggregated features with monthly:

1. Mean Lahore Apparent Temperature
2. Min Lahore Apparent Temperature
3. Max Lahore Apparent Temperature

Heat Map for Multicollinearity




Monthly Peak Power MW
Monthly Max Apparent temperature
Monthly Min Apparent temperature
Monthly Mean Apparent temperature
1
0.98
0.96
Monthly Mean Apparent temperature
Monthly Min Apparent temperature
Monthly Max Apparent temperature
Monthly Peak Power MW

Model Building

- Used Linear Regression for forecasting monthly energy load and monthly peak power.

- **Monthly Energy Model:**
  - **Input parameters:** NPCC Monthly Mean Lahore Apparent Temperature
  - **Output Parameters:** Total Monthly Energy (MWh)

- **Peak Power Model:**
  - **Input parameters:** NPCC Monthly Mean Lahore Apparent Temperature
  - **Output Parameters:** Monthly Peak Power (MW)

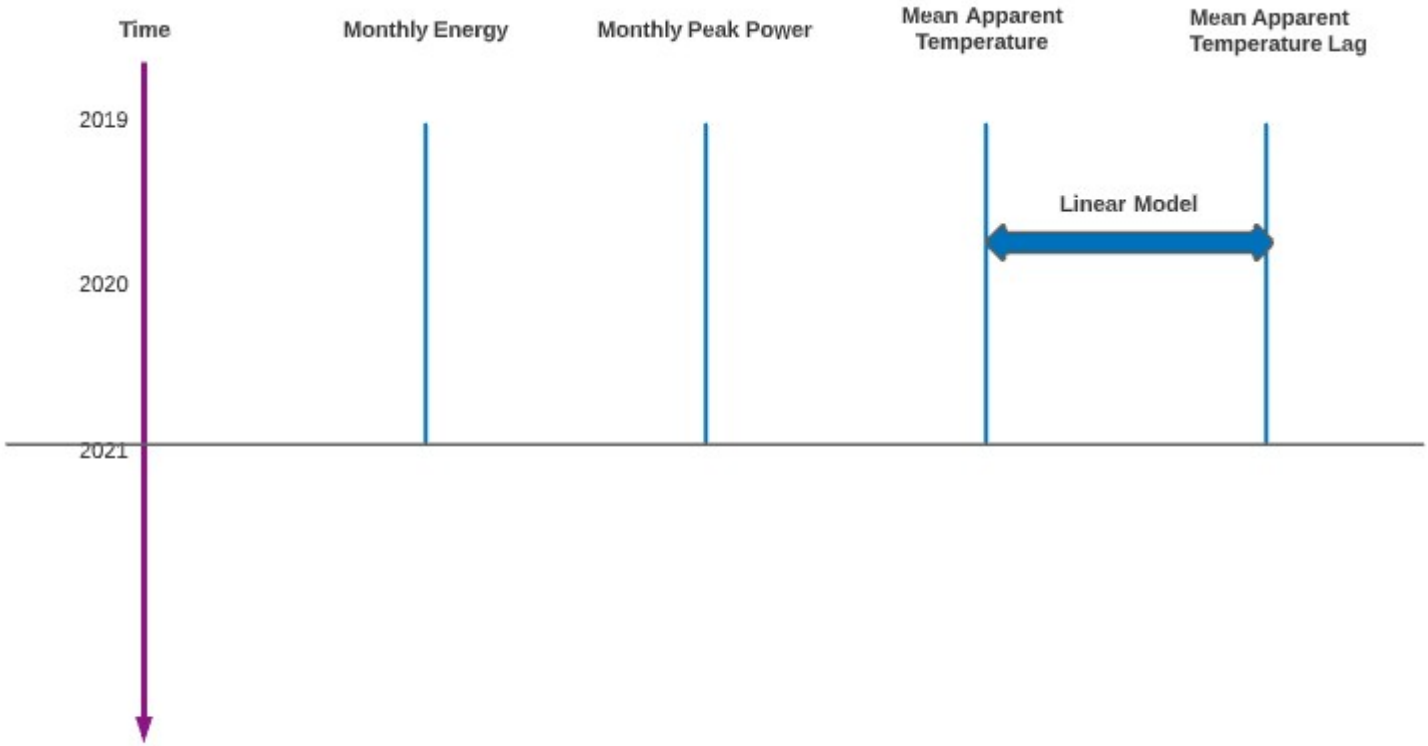
ARDL (Autoregressive Distributed Lag)

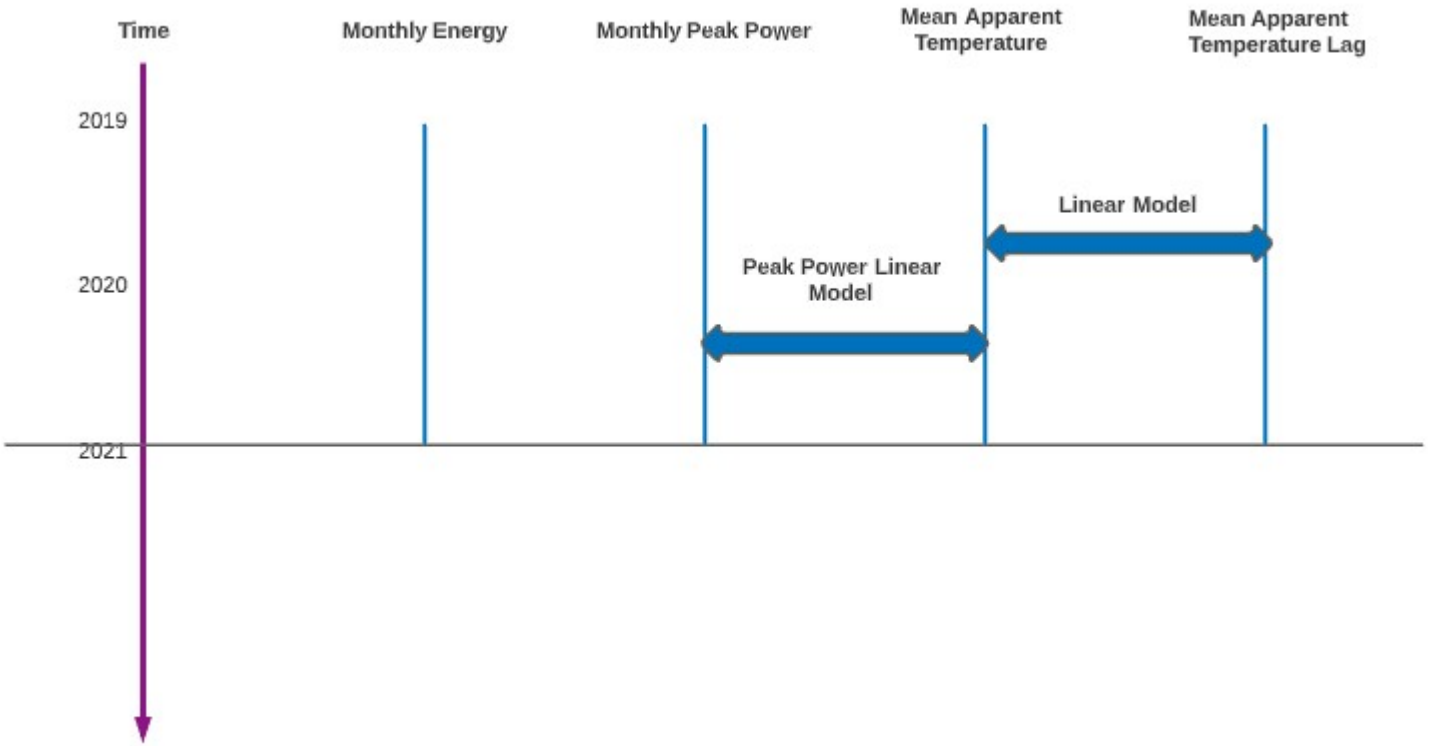
- Mean Apparent Temperature for year 2021 is predicted using lag of previous 11 months.

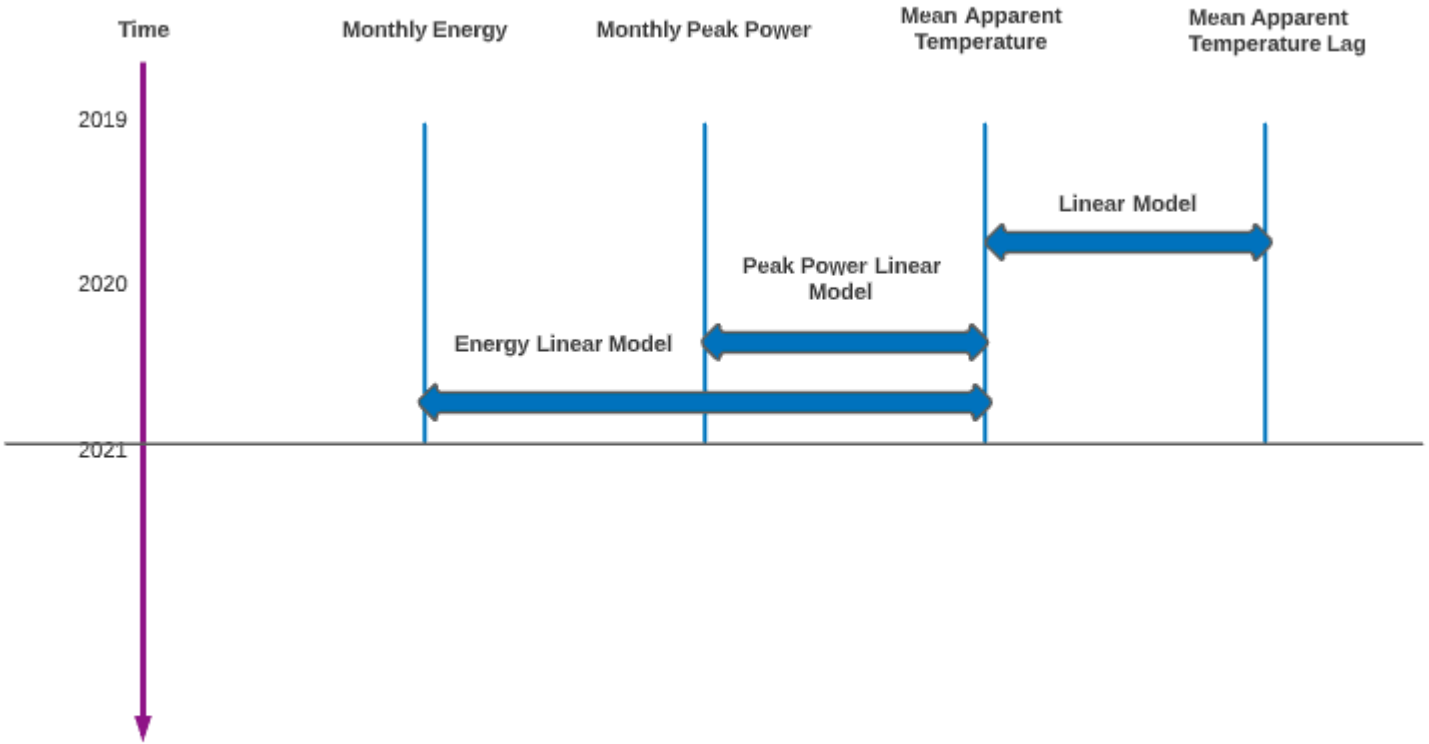
- Mean Apparent Temperature is used for building Monthly Energy Load and Peak Power Model.

- Predictions for Monthly Energy Load and Peak Power are made for 2021 using Predicted Mean Apparent Temperature

Model Building FlowChart




Time
Monthly Energy
Monthly Peak Power
Mean Apparent Temperature
Mean Apparent Temperature Lag
2019
2020
2021
Linear Model
Peak Power Linear Model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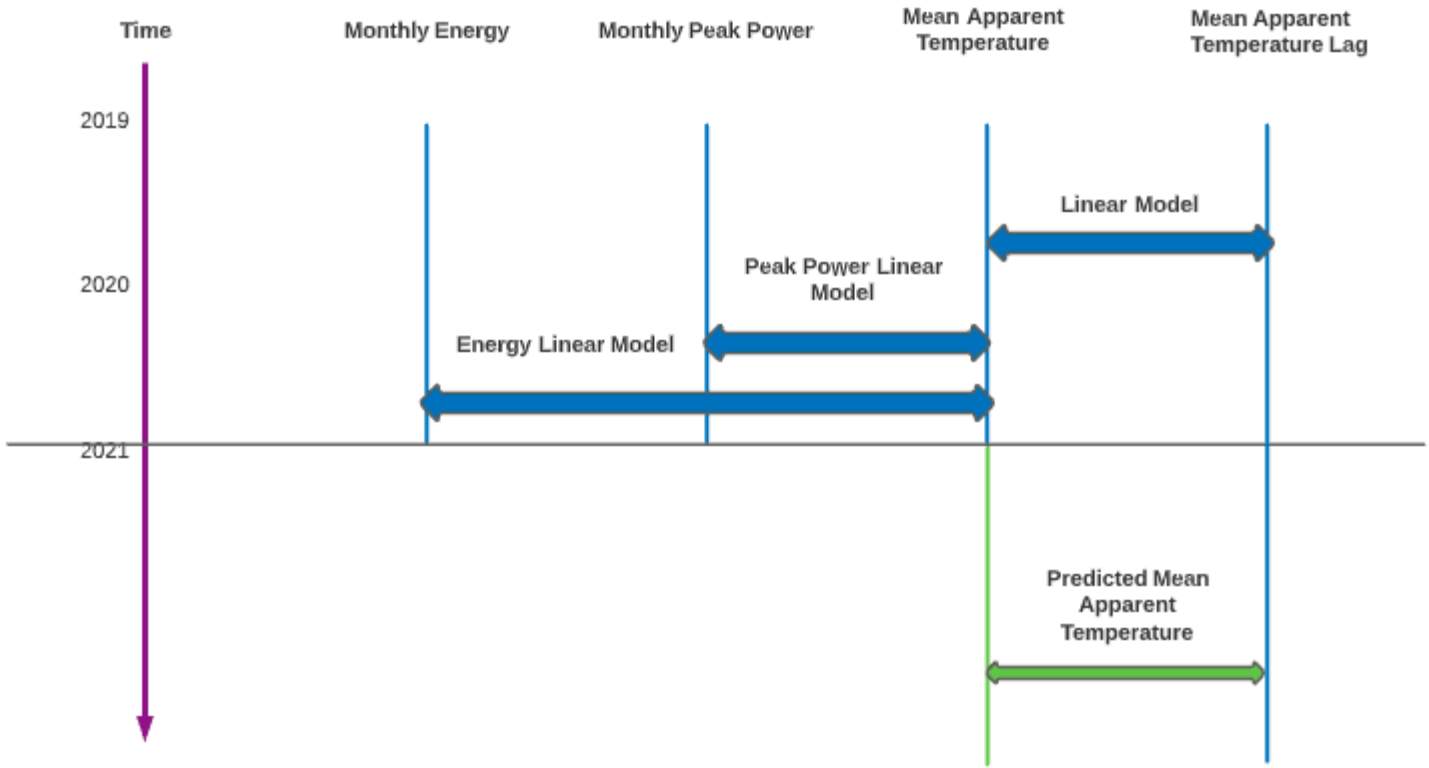
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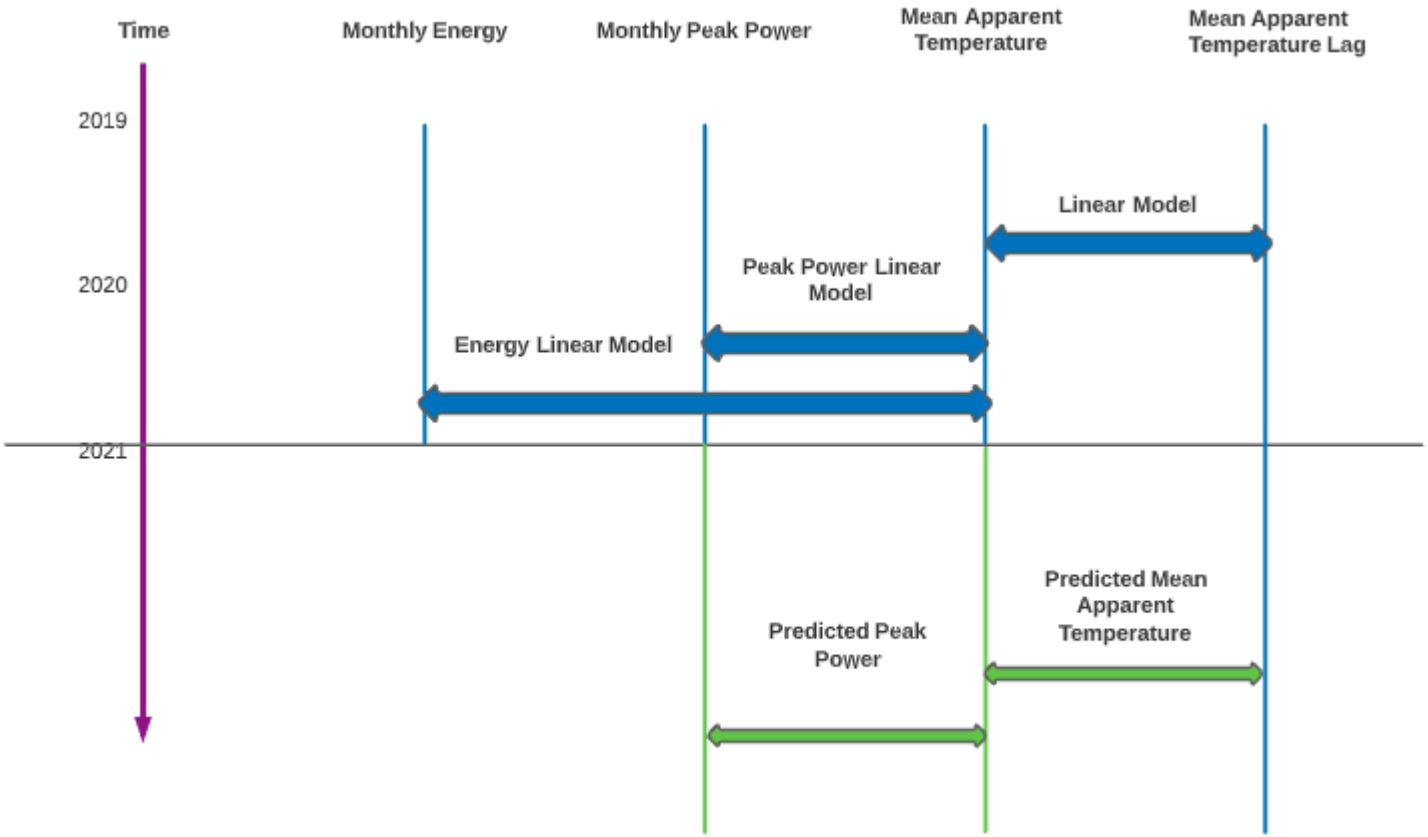
Predicted Mean Apparent Temperature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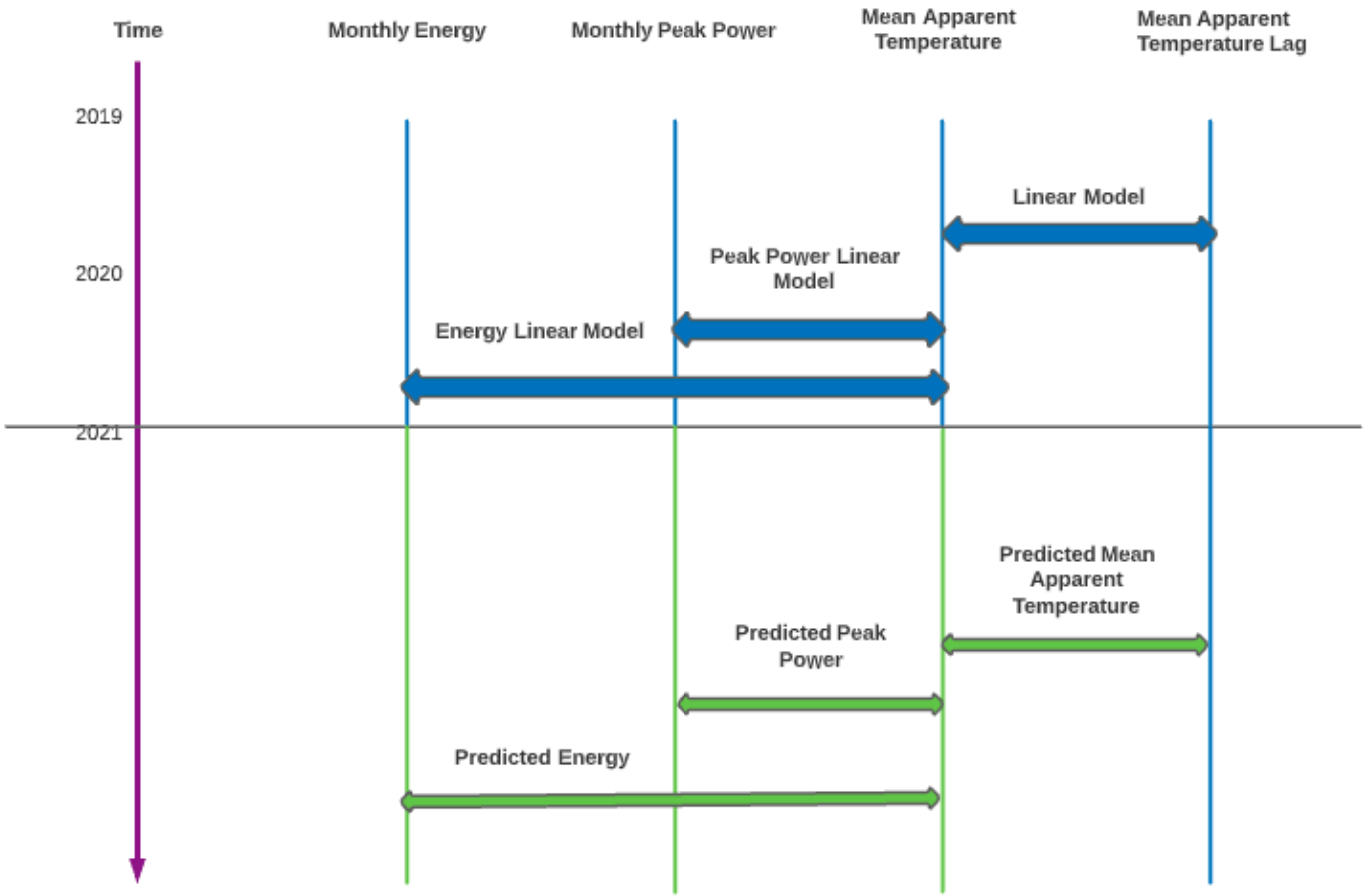
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Predicted Mean Apparent Temperature
Predicted Peak Power
Predicted Energy

Linear Regression Equation (Energy)

$$y = B_0 + B_1 * x$$

- Y: Dependent Variable (Energy)
- B0: Intercept
- B1: Gradient
- X: Independent Variable (Mean Apparent Temperature)

$$Energy\ MWh = 2531696 + 289197 * Mean\ Apparent\ Temperature$$

- For every 1 degree Celsius increase in Mean Apparent Temperature, the Energy increases by 289197 MWh on average.

Linear Regression Equation (Peak Power)

$$y = B_0 + B_1 * x$$

- Y: Dependent Variable (Peak Power)
- B0: Intercept
- B1: Gradient
- X: Independent Variable (Mean Apparent Temperature)

$$Peak\ Power\ MW = 6943.79 + 397.22 * Mean\ Apparent\ Temperature$$

- For every 1 degree Celsius increase in Mean Apparent Temperature, the Peak Power increases by 397.22 MW on average.

Results

- Results on test data for 2021 year are shown below:

1. Monthly Energy Forecast:
    a. MAPE: 13.9 %

2. Monthly Peak Power
    a. MAPE: 11.2 %

Future Work

- Dashboard for visualization.
- Use five different techniques for forecasting and compare their results.
- Forecasting for 10 Distribution Companies (DISCOs) operating in Pakistan.