Driving Net-Zero Future Energy Targets using Smart Sensors

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INTRODUCTION

In recent years, the growing impact of climate change on a worldwide scale has been widely recognised. Energy strategy is extremely important for developing countries. As the economy of these countries grow rapidly ,their energy consumption's increase substantially. In terms of material production, construction, operation, and end-of-life, the building sector was a major contributor to global carbon emissions and energy consumption. Recent interest has developed in using computer modelling and optimization to lessen the environmental impacts of a building's life cycle. The applications of artificial intelligence in sustainable architecture include energy-efficient building design, forecasting and reducing energy use, planning for mitigating impacts on the environment and climate, and improvements to the safety and comfort of the living environment.

In this study, we are analysing the excessive energy consumed in heating or cooling the building, thereby contributing to the construction of a sustainable structure that can reduce the carbon footprint and pave the way for Net Zero Emission. We have installed the IoT optical sensors that monitor the room's ambient temperature and humidity in multiple sites of the building. The sensors transfer data to the cloud platform which is the first platform in evaluating energy efficiency, which is the key in reducing carbon emissions. To combat climate change, we are developing a machine learning model to estimate energy consumption for heating and cooling (HVAC system).we have employed a comparison of multiple machine learning algorithms and predicted the energy demand of the building and increase the energy efficiency and cost effectiveness of buildings which are designed to provide occupants with a comfortable indoor living environment.

Keywords: Sustainable buildings, Net Zero, Internet of Things, HVAC systems, Environmental sensors, ML algorithms

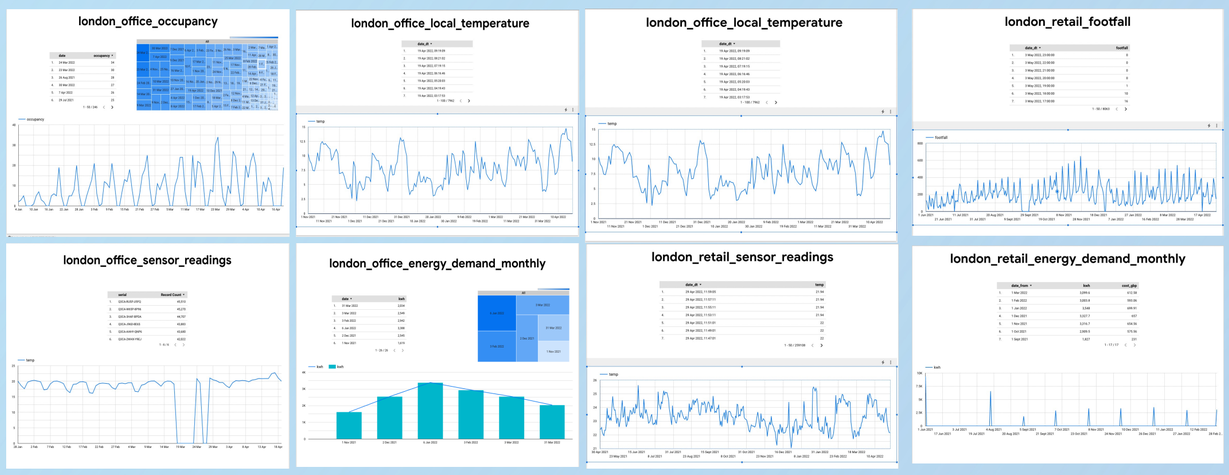
OBJECTIVES

- To Investigate the longitudinal relationships between these data sources
- Use predictive analysis and modelling techniques to pull out key patterns.
- Identify the concrete adaptations to heating/cooling practices which can optimise energy demand

DATASET AND DATA EXPLORATION

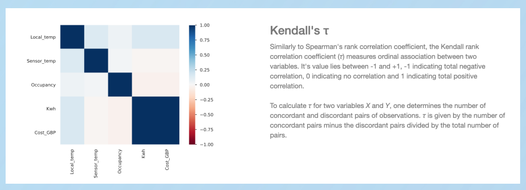
The data is from several locations i.e. London Office and Retail and Paris Lab.
The data consists of the following values:

- Environmental sensors (measuring temperature and humidity)
- Building energy usage at the location
- Space occupancy/utilisation
- Local weather data at the location

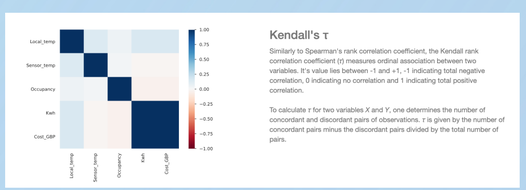


CO-RELATION IN DATASET

London GHD Office



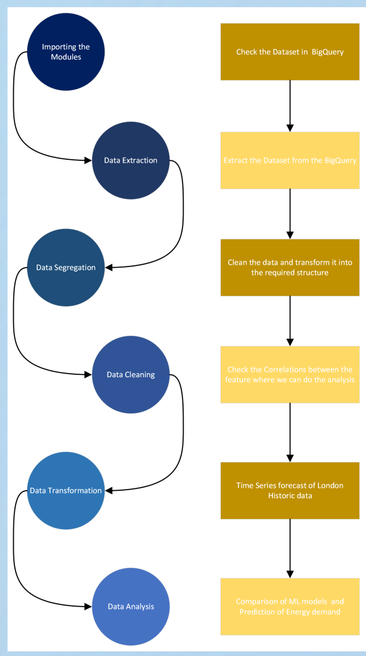
London Retail Store

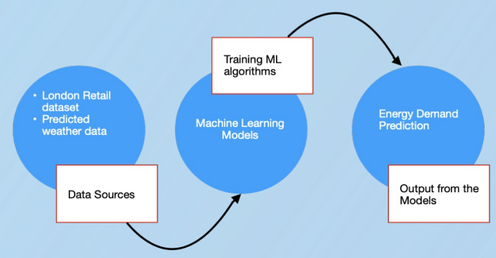


As the co-relation between the data is less, we are considering the local weather data and predicting the energy consumption of HVAC system. For this we used time series forecasting to observe the trends and patterns in the data and forecast the weather. Using this energy data and the forecasted local temperature, We tried to predict and observe how the climate can affect the HVAC system and what will be the energy consumption.

METHODOLOGY

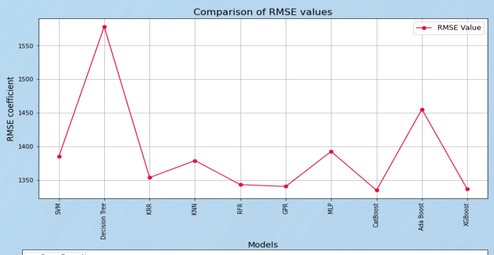
- **Importing useful Libraries and modules:** "Pandas" is used for data manipulation, "matplotlib" and "seaborn" are used for plotting data and a graphical representation, "NumPy" is used for array manipulation, and data profiling to generate the report and "stats models" for time series data analysis.
- **Data cleaning and Transformation**: The dataset records values for each day of every month. For easy analysis, the dataset is merged into aggregated value by taking the average temperature readings from the sensor
- **Data analysis and Visualization**: Data is analyzed based on plots and different visualizations using pyplot of matplotlib and seaborn library.
- **Data extraction and Conversion into a data frame**: Dataset is queried from Google Big Query and used as pandas data frame for easy manipulation.
- **Manipulating data for analysis of objective**: Based on the requirement of the objective, the data is grouped based on Local temperature, Sensor reading with time stamp, Power consumption and Occupancy.

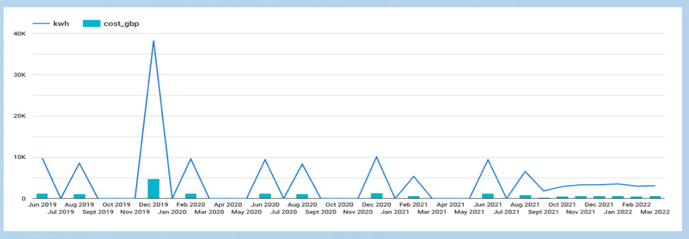


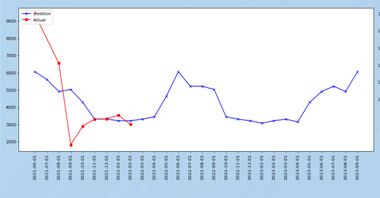


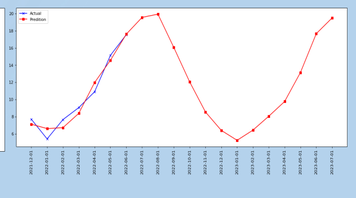
RESULTS

The Following are the results for Comparison of RMSE values for energy demand prediction, Energy demand and cost comparison and Time series weather forecast of London using SARIMAX model.









CONCLUSION

- Analysed the relationship between indoor temperature and design model in order to lower energy consumption for heating and cooling.
- Analysed the main trends in the data and how climate change influences energy demand for HVAC system.
- Uses of Predictive analysis and modelling approaches to design a system for sustainable buildings and open the way to future energy use that is net zero.
- Understanding of Dynamic thermal modelling for energy efficiencies, a tool for modelling building performance that creates a model of the structure, analyses how the building is heated and cooled, and determines what steps may be taken to achieve maximum efficiency.

REFERENCES

[1] I. E. Agency. Empowering cities for a net zero future. 2020.

[2] O. K. Akande, D. Odeleye, A. Coday, and C. JimenezBescos. Energy performance and improvement potentials for selected heritage building adaptation in england. 2015.

[3] A. Al-Sakkaf, T. Zayed, A. Bagchi, and E. Mohammed Abdelkader. Sustainability rating tool and rehabilitation model for heritage buildings. In CSCE Annual Con- ference, 2019.

[4] U. Berardi and P. Jafarpur. Assessing the impact of climate change on building heating and cooling energy demand in canada. Renewable and Sustainable Energy Reviews, 121:109681, 2020.

[5] S. E. Bibri. The iot for smart sustainable cities of the future: An analytical framework for sensor-based big data applications for environmental sustainability. Sustainable cities and society, 38:230–253, 2018.

[6] P. Chen, A. Niu, D. Liu, W. Jiang, and B. Ma. Time series forecasting of temperatures using sarima: An example from nanjing. In IOP Conference Series: Materials Science and Engineering, volume 394, page 052024. IOP Publishing, 2018.