MODELING ELECTRICITY CONSUMPTION IN COMMERCIAL BUILDINGS USING MATLAB

1. Overview

Client:

A commercial real estate management firm operating 18 office buildings across the US East Coast

Objective:

To develop a regression-based model using MATLAB to predict weekly electricity consumption, helping the client understand key consumption drivers and optimize energy usage.

2. Background

The firm faced rising energy costs and lacked a precise model for explaining or forecasting electricity usage. They collected building-level utility data but had not used it beyond simple historical comparisons. The goal was to quantify how usage varied with environmental and operational factors and support smart scheduling of energy-intensive systems.

3. Data Summary

Dataset:

Hourly utility readings aggregated into weekly totals across 18 buildings over 52 weeks (1 year)

Key Variables:

Variable	Type	Description
Electricity_kWh	Continuous	Weekly electricity consumed (dependent variable)
Avg_Outdoor_Temp_C	Continuous	Mean weekly outdoor temperature
Occupancy_Rate	Continuous	Proportion of building occupancy (0–1 scale)
Week_Number	Integer	Calendar week (1–52)
Building_Age	Integer	Years since last renovation
Smart_HVAC_Installed	Binary	1 = Yes, 0 = No
Occupancy × Temperature	Interaction	Captures joint effect on energy use

4. Methodology

Software Used:

MATLAB R2023b

Workflow:

1. **Data Preprocessing:**

   o Aggregated hourly data into weekly summaries

   o Cleaned outliers and missing values using fillmissing() and isoutlier()

   o Created interaction term using vector multiplication

2. **Model Construction:**

   o Used fitlm() for multiple linear regression

   o Formula:
   Electricity_kWh ~ Temp + Occupancy + Age + HVAC + Week + Occupancy*Temp

3. **Diagnostics & Validation:**

   o Residual analysis to check for homoscedasticity and normality

   o VIF for multicollinearity

   o RMSE and Adjusted R^2 for model accuracy

   o 70:30 train-test split

4. **Reporting and Visualization:**

   o Plotted marginal effect of temperature and occupancy

   o Highlighted weeks with >15% deviation from prediction

   o Developed custom forecasting tool using MATLAB App Designer

5. Key Results

Metric	Value
Adjusted R^2	0.873
RMSE on Test Set	3,420 kWh

Occupancy Impact	+2,150 kWh per 0.1 increase in rate
Temperature Impact	+145 kWh per °C above 22°C
Interaction Significance	$p < 0.01$

Insights:

- Buildings without smart HVAC used **~11% more energy**, controlling for all else

- **Interaction term** confirmed that warmer weeks with higher occupancy disproportionately increased electricity use

- Older buildings (>20 years since renovation) showed higher unexplained variability

6. Visual Outputs (MATLAB):

- Coefficient bar chart with 95% confidence intervals

- Actual vs. predicted electricity scatterplot

- Interaction effect heatmap (Occupancy vs. Temperature)

- Weekly residual plots with flagged anomalies

7. Deliverables

- Final model as .mat file

- Custom MATLAB function for forecasting based on user input (temperature and occupancy)

- 15-page analytical report:
  - Interpretation of coefficients
  - Forecasting scenarios
  - Strategic recommendations

- Visualization set for internal presentation

8. Application & Outcome

- Management implemented staggered HVAC scheduling in high-occupancy weeks

- Forecasts used to guide energy procurement contracts

- Model integrated into monthly energy audit routine

- **7.4% cost savings** achieved in first quarter after implementation

9. Strategic Value Delivered

- Provided **clear, actionable insight into consumption drivers**

- Demonstrated **impact of operational and environmental factors**

- Enabled **predictive control** of electricity use in commercial buildings

- Supported the client's sustainability reporting with quantitative evidence