Forecasting Energy Consumption using Exponential Models

This report presents an analysis of historical energy consumption data using three time series forecasting methods: Simple Exponential Smoothing (SES), Holt's Linear Method (Double Exponential Smoothing), and Holt-Winters Method (Triple Exponential Smoothing). The goal is to identify patterns in the data and forecast energy consumption for the next three years.

The dataset consists of historical data of monthly energy consumption from Jan 1939 till Sep 2019 and we try to forecast the demand for the next 3 years. We will use RMSE in order to assess model performance.

The summary statistics for the dataset is shown below:

	ENERGY_INDEX
count	969.000000
mean	54.657608
std	35.455379
min	3.384200
25%	19.581700
50%	54.763700
75%	87.729300
max	128.907100

Methodology

To analyze and forecast energy consumption, the following exponential smoothing techniques were applied:

- **Simple Exponential Smoothing (SES):**
  - Assigns exponentially decreasing weights to past observations.
  - Suitable for data with no trend or seasonality.
- **Holt's Method (Double Exponential Smoothing):**
  - Extends SES by incorporating a trend component.
  - Suitable for data with a linear trend but no seasonality.
- **Holt-Winters Method (Triple Exponential Smoothing):**
  - Extends Holt's Method by adding a seasonal component.
  - Suitable for data with both trend and seasonality.

Each model was optimized using smoothing parameters:

- **Smoothing Level (α):** Determines the weight given to recent observations.
- **Smoothing Slope (β):** Adjusts the trend component.

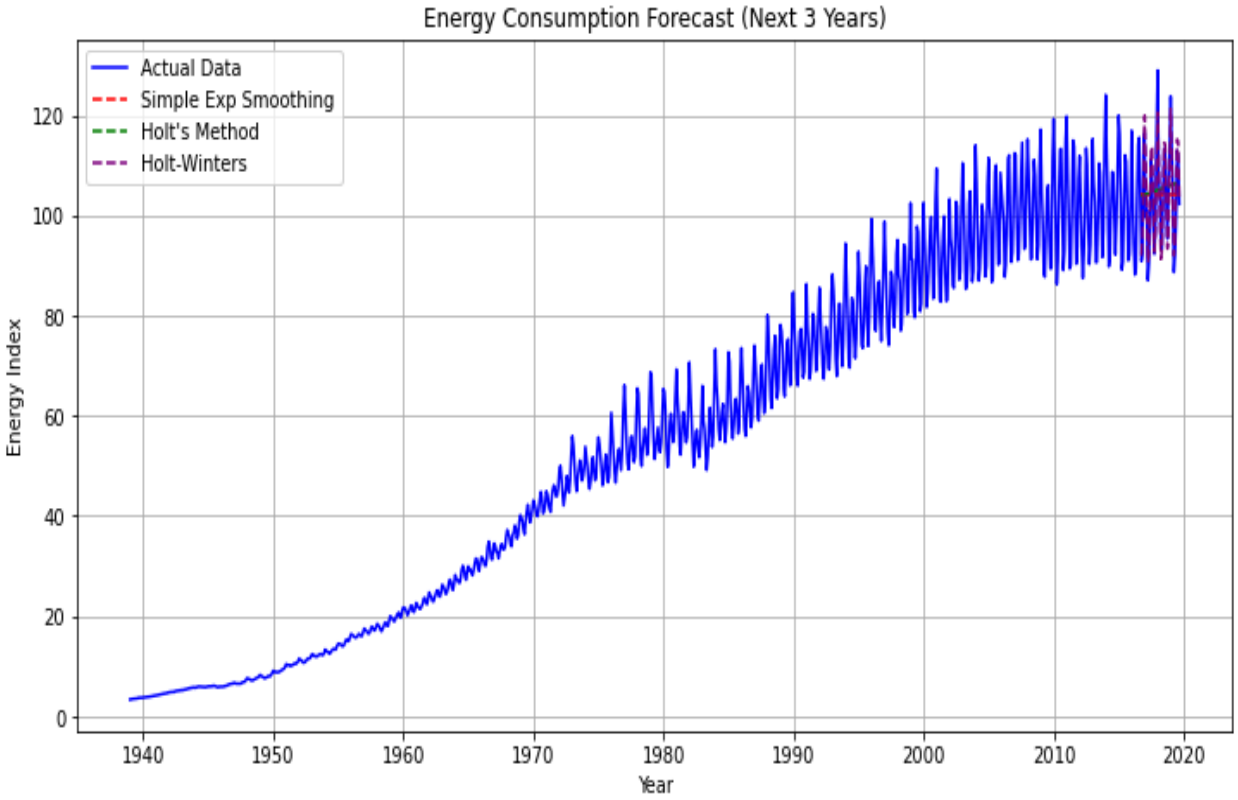
- **Seasonality Periods (γ):** Defines the seasonal cycle (set to 12 months).

Results

To assess model performance, Root Mean Squared Error (RMSE) was calculated using the last 36 months of data as a test set:

Method used	RMSE value
Simple Exponential Smoothing	10.2321
Holt's Linear Method	10.2266
Holt-Winters Method	4.1175

From the RMSE values, Holt-Winters provided the best performance, suggesting strong seasonality in the data.



The forecast plot above shows that while the SES model provides a baseline estimate, the Holt's Linear Method (Double exponential smoothing) captures the overall trend. However, the Holt-Winters model (Triple exponential smoothing) aligns more closely with historical fluctuations, reinforcing the presence of seasonality in energy consumption patterns.