```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
from sklearn.ensemble import RandomForestRegressor
from sklearn.metrics import mean_squared_error, r2_score
from xgboost import XGBRegressor


# Load a limited sample of the dataset
df = pd.read_csv('/content/drive/MyDrive/Full_Merged_AllCities_Energy_Weather.csv', nrows=50000)

# Parse datetime and set index
df['time'] = pd.to_datetime(df['time'], errors='coerce')
df.set_index('time', inplace=True)

# Drop columns with all missing values
df.dropna(axis=1, how='all', inplace=True)
print(df.head(5))
print(df.columns)
```

```
2014-12-31 23:00:00                4844.0                        4821.0

                     generation fossil oil  generation fossil oil shale  \
time
2014-12-31 23:00:00                  162.0                          0.0
2014-12-31 23:00:00                  162.0                          0.0
2014-12-31 23:00:00                  162.0                          0.0
2014-12-31 23:00:00                  162.0                          0.0
2014-12-31 23:00:00                  162.0                          0.0

                     generation fossil peat  generation geothermal  \
time
2014-12-31 23:00:00                     0.0                    0.0
2014-12-31 23:00:00                     0.0                    0.0
2014-12-31 23:00:00                     0.0                    0.0
2014-12-31 23:00:00                     0.0                    0.0
2014-12-31 23:00:00                     0.0                    0.0

                     generation hydro pumped storage consumption  ...  \
time                                                              ...
2014-12-31 23:00:00                                        863.0  ...
2014-12-31 23:00:00                                        863.0  ...
2014-12-31 23:00:00                                        863.0  ...
2014-12-31 23:00:00                                        863.0  ...
2014-12-31 23:00:00                                        863.0  ...

                       temp_min    temp_max  pressure  humidity  wind_speed  \
time
2014-12-31 23:00:00  270.475000  270.475000      1001        77           1
2014-12-31 23:00:00  267.325000  267.325000       971        63           1
2014-12-31 23:00:00  269.657312  269.657312      1036        97           0
2014-12-31 23:00:00  281.625000  281.625000      1035       100           7
2014-12-31 23:00:00  273.375000  273.375000      1039        75           1

                     wind_deg  rain_1h  rain_3h  snow_3h  clouds_all
time
2014-12-31 23:00:00        62      0.0      0.0      0.0           0
2014-12-31 23:00:00       309      0.0      0.0      0.0           0
2014-12-31 23:00:00       226      0.0      0.0      0.0           0
2014-12-31 23:00:00        58      0.0      0.0      0.0           0
2014-12-31 23:00:00        21      0.0      0.0      0.0           0

[5 rows x 38 columns]
Index(['generation biomass', 'generation fossil brown coal/lignite',
       'generation fossil coal-derived gas', 'generation fossil gas',
       'generation fossil hard coal', 'generation fossil oil',
       'generation fossil oil shale', 'generation fossil peat',
       'generation geothermal', 'generation hydro pumped storage consumption',
       'generation hydro run-of-river and poundage',
       'generation hydro water reservoir', 'generation marine',
       'generation nuclear', 'generation other', 'generation other renewable',
       'generation solar', 'generation waste', 'generation wind offshore',
       'generation wind onshore', 'forecast solar day ahead',
       'forecast wind onshore day ahead', 'total load forecast',
       'total load actual', 'price day ahead', 'price actual', 'city_name',
       'temp', 'temp_min', 'temp_max', 'pressure', 'humidity', 'wind_speed',
       'wind_deg', 'rain_1h', 'rain_3h', 'snow_3h', 'clouds_all'],
      dtype='object')
```

```
# Feature Engineering
df['Hour'] = df.index.hour
df['Day'] = df.index.day
df['Month'] = df.index.month
df['DayOfWeek'] = df.index.dayofweek
```

```
df['DayOfYear'] = df.index.dayofyear
df['Sin_DayOfYear'] = np.sin(2 * np.pi * df['DayOfYear'] / 365.0)
df['Cos_DayOfYear'] = np.cos(2 * np.pi * df['DayOfYear'] / 365.0)
df['Lag_1'] = df['total load actual'].shift(1)
df['Lag_7'] = df['total load actual'].shift(7)
print(df.head(5))
```

```
                     generation fossil coal-derived gas  \
time
2014-12-31 23:00:00                                 0.0
2014-12-31 23:00:00                                 0.0
2014-12-31 23:00:00                                 0.0
2014-12-31 23:00:00                                 0.0
2014-12-31 23:00:00                                 0.0

                     generation fossil gas  generation fossil hard coal  \
time
2014-12-31 23:00:00                 4844.0                       4821.0
2014-12-31 23:00:00                 4844.0                       4821.0
2014-12-31 23:00:00                 4844.0                       4821.0
2014-12-31 23:00:00                 4844.0                       4821.0
2014-12-31 23:00:00                 4844.0                       4821.0

                     generation fossil oil  generation fossil oil shale  \
time
2014-12-31 23:00:00                  162.0                          0.0
2014-12-31 23:00:00                  162.0                          0.0
2014-12-31 23:00:00                  162.0                          0.0
2014-12-31 23:00:00                  162.0                          0.0
2014-12-31 23:00:00                  162.0                          0.0

                     generation fossil peat  generation geothermal  \
time
2014-12-31 23:00:00                     0.0                    0.0
2014-12-31 23:00:00                     0.0                    0.0
2014-12-31 23:00:00                     0.0                    0.0
2014-12-31 23:00:00                     0.0                    0.0
2014-12-31 23:00:00                     0.0                    0.0

                     generation hydro pumped storage consumption  ...  \
time                                                              ...
2014-12-31 23:00:00                                        863.0  ...
2014-12-31 23:00:00                                        863.0  ...
2014-12-31 23:00:00                                        863.0  ...
2014-12-31 23:00:00                                        863.0  ...
2014-12-31 23:00:00                                        863.0  ...

                     clouds_all  Hour  Day  Month  DayOfWeek  DayOfYear  \
time
2014-12-31 23:00:00           0    23   31     12          2        365
2014-12-31 23:00:00           0    23   31     12          2        365
2014-12-31 23:00:00           0    23   31     12          2        365
2014-12-31 23:00:00           0    23   31     12          2        365
2014-12-31 23:00:00           0    23   31     12          2        365

                     Sin_DayOfYear  Cos_DayOfYear    Lag_1  Lag_7
time
2014-12-31 23:00:00   6.432491e-16            1.0      NaN    NaN
2014-12-31 23:00:00   6.432491e-16            1.0  25385.0    NaN
2014-12-31 23:00:00   6.432491e-16            1.0  25385.0    NaN
2014-12-31 23:00:00   6.432491e-16            1.0  25385.0    NaN
2014-12-31 23:00:00   6.432491e-16            1.0  25385.0    NaN

[5 rows x 47 columns]
```

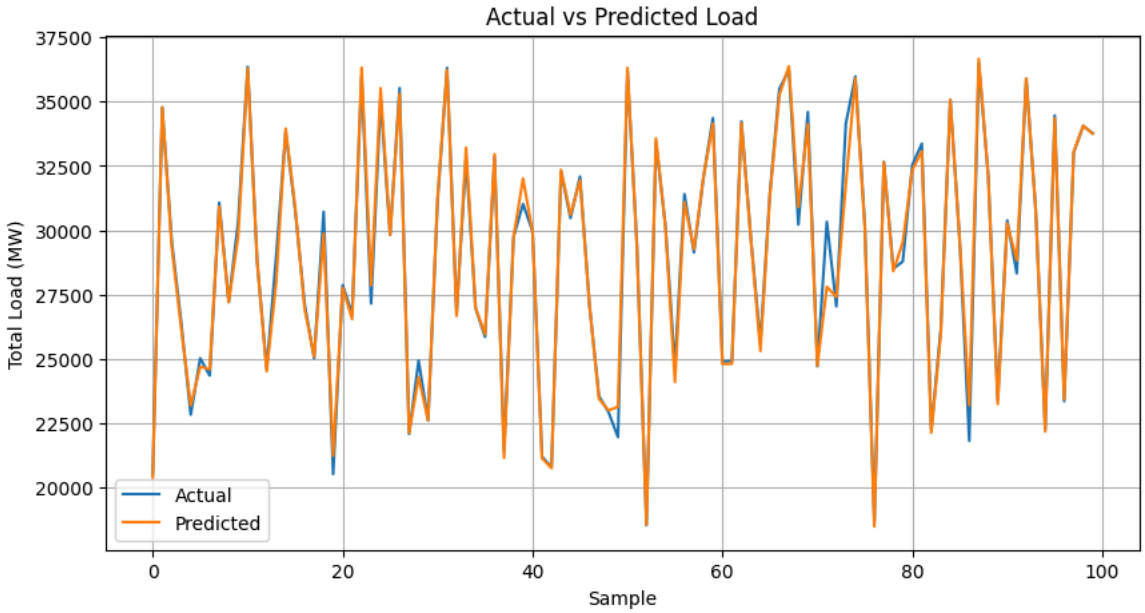
```
# Drop missing rows
target = 'total load actual'
features = ['Hour', 'Day', 'Month', 'DayOfWeek', 'DayOfYear', 'Sin_DayOfYear', 'Cos_DayOfYear',
            'Lag_1', 'Lag_7', 'temp', 'humidity', 'wind_speed', 'clouds_all']
df.dropna(subset=features + [target], inplace=True)

# Define input and output
X = df[features]
y = df[target]

# Normalize features
scaler = MinMaxScaler()
X_scaled = scaler.fit_transform(X)

# Split into train and test
X_train, X_test, y_train, y_test = train_test_split(X_scaled, y, test_size=0.2, random_state=42)

# Train model
model = RandomForestRegressor(n_estimators=100, random_state=42)
model.fit(X_train, y_train)
```

```
# 📉 Residual Error Plot
residuals = y_test - y_pred

plt.figure(figsize=(10, 5))
plt.scatter(range(len(residuals)), residuals, alpha=0.5, c='red', label='Residuals')
plt.axhline(y=0, color='blue', linestyle='--', linewidth=2)
plt.title('Residual Error Plot')
plt.xlabel('Sample Index')
plt.ylabel('Prediction Error (y_test - y_pred)')
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```


```
# Predict and evaluate
y_pred = model.predict(X_test)
rmse = np.sqrt(mean_squared_error(y_test, y_pred))
r2 = r2_score(y_test, y_pred)

print(f"RMSE: {rmse:.2f}")
print(f"R² Score: {r2:.2f}")
```

```
RMSE: 511.67
R² Score: 0.99
```

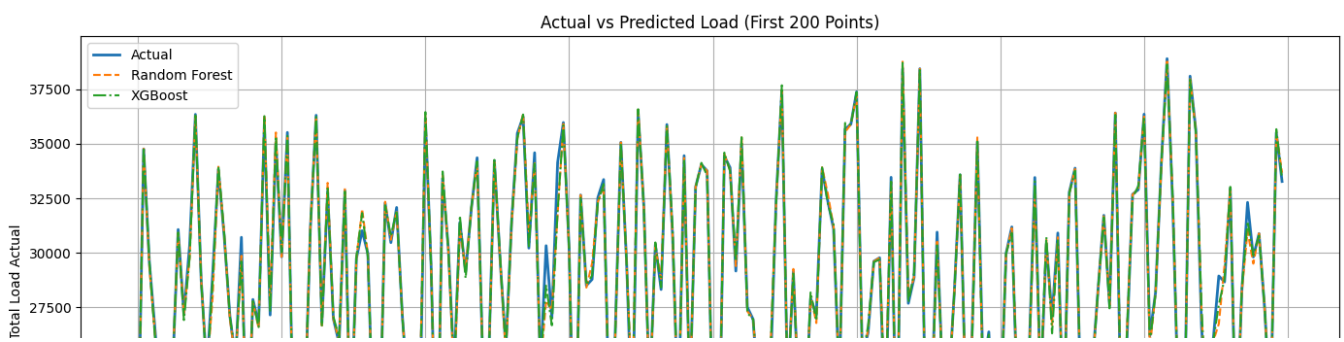
```
# Plot
plt.figure(figsize=(10,5))
plt.plot(y_test.values[:100], label='Actual')
plt.plot(y_pred[:100], label='Predicted')
plt.title("Actual vs Predicted Load")
plt.xlabel("Sample")
plt.ylabel("Total Load (MW)")
plt.legend()
plt.grid(True)
plt.show()
```




```
# 🌲 Train Random Forest
rf = RandomForestRegressor(n_estimators=100, random_state=42)
rf.fit(X_train, y_train)
rf_pred = rf.predict(X_test)
rf_rmse = np.sqrt(mean_squared_error(y_test, rf_pred))
rf_r2 = r2_score(y_test, rf_pred)


# Train XGBoost
xgb = XGBRegressor(n_estimators=100, random_state=42)
xgb.fit(X_train, y_train)
xgb_pred = xgb.predict(X_test)
xgb_rmse = np.sqrt(mean_squared_error(y_test, xgb_pred))
xgb_r2 = r2_score(y_test, xgb_pred)

# Create results table
results_df = pd.DataFrame({
    'Model': ['Random Forest', 'XGBoost'],
    'RMSE': [rf_rmse, xgb_rmse],
    'R² Score': [rf_r2, xgb_r2]
})
print(results_df)
```

```
            Model        RMSE  R² Score
    0  Random Forest  511.669628  0.988187
    1        XGBoost  447.678664  0.990957
```

```
# Plot predictions
plt.figure(figsize=(14, 6))
plt.plot(y_test.values[:200], label='Actual', linewidth=2)
plt.plot(rf_pred[:200], label='Random Forest', linestyle='--')
plt.plot(xgb_pred[:200], label='XGBoost', linestyle='-.')
plt.title("Actual vs Predicted Load (First 200 Points)")
plt.xlabel("Time Step")
plt.ylabel("Total Load Actual")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```


Actual vs Predicted Load (First 200 Points)
Actual
Random Forest
XGBoost
Total Load Actual
37500
35000
32500
30000
27500