```
# Install necessary libraries (if not installed)
!pip install pandas numpy scikit-learn

# Import libraries
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestRegressor
from sklearn.metrics import mean_absolute_error, mean_squared_error,
r2_score

# Load dataset
file_path = "/content/corrected_ev_charging_data.csv"  # Update with
correct path if needed
df = pd.read_csv(file_path)

# Convert Timestamp to datetime format
df['Timestamp'] = pd.to_datetime(df['Timestamp'])

# Select relevant features for prediction
features = ['Queue_Time_mins', 'Latitude', 'Longitude']
target = 'Charging_Demand_kW'

# Handle missing values (if any)
df = df.dropna(subset=features + [target])

# Split data into training and testing sets
X = df[features]
y = df[target]
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.2, random_state=42)

# Train Random Forest Regression Model
model = RandomForestRegressor(n_estimators=100, random_state=42)
model.fit(X_train, y_train)

# Predict Charging Load
y_pred = model.predict(X_test)

# Evaluate Model Performance
mae = mean_absolute_error(y_test, y_pred)
rmse = np.sqrt(mean_squared_error(y_test, y_pred))
r2 = r2_score(y_test, y_pred)

print(f"Model Evaluation:\nMAE: {mae:.2f} | RMSE: {rmse:.2f} | R²
Score: {r2:.2f}")

# Save predictions to CSV for Tableau visualization
predictions_df = X_test.copy()
predictions_df['Actual_Charging_Load_kW'] = y_test
```

```
predictions_df['Predicted_Charging_Load_kW'] = y_pred

predictions_file = "charging_demand_predictions.csv"
predictions_df.to_csv(predictions_file, index=False)

# Auto-download the file in Google Colab
from google.colab import files
files.download(predictions_file)

print(f"□ Predictions saved and downloaded: {predictions_file}")
```

```
Requirement already satisfied: pandas in
/usr/local/lib/python3.11/dist-packages (2.2.2)
Requirement already satisfied: numpy in
/usr/local/lib/python3.11/dist-packages (1.26.4)
Requirement already satisfied: scikit-learn in
/usr/local/lib/python3.11/dist-packages (1.6.1)
Requirement already satisfied: python-dateutil>=2.8.2 in
/usr/local/lib/python3.11/dist-packages (from pandas) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in
/usr/local/lib/python3.11/dist-packages (from pandas) (2025.1)
Requirement already satisfied: tzdata>=2022.7 in
/usr/local/lib/python3.11/dist-packages (from pandas) (2025.1)
Requirement already satisfied: scipy>=1.6.0 in
/usr/local/lib/python3.11/dist-packages (from scikit-learn) (1.13.1)
Requirement already satisfied: joblib>=1.2.0 in
/usr/local/lib/python3.11/dist-packages (from scikit-learn) (1.4.2)
Requirement already satisfied: threadpoolctl>=3.1.0 in
/usr/local/lib/python3.11/dist-packages (from scikit-learn) (3.5.0)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.8.2-
>pandas) (1.17.0)
Model Evaluation:
MAE: 12.63 | RMSE: 14.95 | R² Score: -0.37

<IPython.core.display.Javascript object>

<IPython.core.display.Javascript object>

□ Predictions saved and downloaded: charging_demand_predictions.csv
```

```
# Install necessary libraries (if not installed)
!pip install pandas numpy matplotlib seaborn folium

# Import libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import folium
```

```
# Load predictions dataset
file_path = "/content/charging_demand_predictions.csv"  # Update if
needed
df = pd.read_csv(file_path)

# Display first few rows
print("📊 Dataset Preview:")
print(df.head())

# Set Seaborn style
sns.set_theme(style="whitegrid")

# 📈 Line Chart: Actual vs. Predicted Charging Load Over Time
plt.figure(figsize=(12, 5))
plt.plot(df.index, df['Actual_Charging_Load_kW'], label="Actual Load",
color='blue', linestyle='dashed')
plt.plot(df.index, df['Predicted_Charging_Load_kW'], label="Predicted
Load", color='red')
plt.xlabel("Index (Time-based)")
plt.ylabel("Charging Load (kW)")
plt.title("📈 Actual vs. Predicted Charging Load Over Time")
plt.legend()
plt.show()

# 📊 Bar Chart: Prediction Accuracy (Actual vs. Predicted)
plt.figure(figsize=(10, 5))
sns.barplot(x=df.index[:30], y=df['Actual_Charging_Load_kW'][:30],
color='blue', label="Actual")
sns.barplot(x=df.index[:30], y=df['Predicted_Charging_Load_kW'][:30],
color='red', alpha=0.7, label="Predicted")
plt.xlabel("Index (Time-based)")
plt.ylabel("Charging Load (kW)")
plt.title("📊 Comparison: Actual vs. Predicted Charging Load")
plt.legend()
plt.show()

# 🗺 Map Visualization: Charging Station Locations with Demand
if 'Latitude' in df.columns and 'Longitude' in df.columns:
    station_map = folium.Map(location=[df['Latitude'].mean(),
df['Longitude'].mean()], zoom_start=10)

    for _, row in df.iterrows():
        folium.CircleMarker(
            location=[row['Latitude'], row['Longitude']],
            radius=row['Predicted_Charging_Load_kW'] / 10,  # Scale
size by load
            color="red" if row['Predicted_Charging_Load_kW'] >
row['Actual_Charging_Load_kW'] else "green",
            fill=True,
            fill_opacity=0.6,
```

```
            popup=f"Predicted Load:
{row['Predicted_Charging_Load_kW']:.2f} kW\nActual Load:
{row['Actual_Charging_Load_kW']:.2f} kW"
        ).add_to(station_map)

    print("🗺️ Interactive Map of Charging Stations with Predicted
Demand")
    station_map
else:
    print("⚠️ Latitude & Longitude columns not found. Map visualization
skipped.")

# 📊 Display Summary Statistics
print("\n📊 Summary Statistics:")
print(df[['Actual_Charging_Load_kW',
'Predicted_Charging_Load_kW']].describe())

# 📉 Error Distribution: Histogram of Prediction Errors
df['Error'] = df['Actual_Charging_Load_kW'] -
df['Predicted_Charging_Load_kW']
plt.figure(figsize=(10, 4))
sns.histplot(df['Error'], bins=20, kde=True, color="purple")
plt.xlabel("Prediction Error (kW)")
plt.title("📉 Distribution of Prediction Errors")
plt.show()
```

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Requirement already satisfied: pandas in
/usr/local/lib/python3.11/dist-packages (2.2.2)
Requirement already satisfied: numpy in
/usr/local/lib/python3.11/dist-packages (1.26.4)
Requirement already satisfied: matplotlib in
/usr/local/lib/python3.11/dist-packages (3.10.0)
Requirement already satisfied: seaborn in
/usr/local/lib/python3.11/dist-packages (0.13.2)
Requirement already satisfied: folium in
/usr/local/lib/python3.11/dist-packages (0.19.4)
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/usr/local/lib/python3.11/dist-packages (from pandas) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in
/usr/local/lib/python3.11/dist-packages (from pandas) (2025.1)
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Requirement already satisfied: contourpy>=1.0.1 in
/usr/local/lib/python3.11/dist-packages (from matplotlib) (1.3.1)
Requirement already satisfied: cycler>=0.10 in
/usr/local/lib/python3.11/dist-packages (from matplotlib) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in
/usr/local/lib/python3.11/dist-packages (from matplotlib) (4.56.0)
Requirement already satisfied: kiwisolver>=1.3.1 in
/usr/local/lib/python3.11/dist-packages (from matplotlib) (1.4.8)
```

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Requirement already satisfied: packaging>=20.0 in
/usr/local/lib/python3.11/dist-packages (from matplotlib) (24.2)
Requirement already satisfied: pillow>=8 in
/usr/local/lib/python3.11/dist-packages (from matplotlib) (11.1.0)
Requirement already satisfied: pyparsing>=2.3.1 in
/usr/local/lib/python3.11/dist-packages (from matplotlib) (3.2.1)
Requirement already satisfied: branca>=0.6.0 in
/usr/local/lib/python3.11/dist-packages (from folium) (0.8.1)
Requirement already satisfied: jinja2>=2.9 in
/usr/local/lib/python3.11/dist-packages (from folium) (3.1.5)
Requirement already satisfied: requests in
/usr/local/lib/python3.11/dist-packages (from folium) (2.32.3)
Requirement already satisfied: xyzservices in
/usr/local/lib/python3.11/dist-packages (from folium) (2025.1.0)
Requirement already satisfied: MarkupSafe>=2.0 in
/usr/local/lib/python3.11/dist-packages (from jinja2>=2.9->folium)
(3.0.2)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.8.2-
>pandas) (1.17.0)
Requirement already satisfied: charset-normalizer<4,>=2 in
/usr/local/lib/python3.11/dist-packages (from requests->folium)
(3.4.1)
Requirement already satisfied: idna<4,>=2.5 in
/usr/local/lib/python3.11/dist-packages (from requests->folium) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in
/usr/local/lib/python3.11/dist-packages (from requests->folium)
(2.3.0)
Requirement already satisfied: certifi>=2017.4.17 in
/usr/local/lib/python3.11/dist-packages (from requests->folium)
(2025.1.31)
 Dataset Preview:
   Queue_Time_mins  Latitude  Longitude  Actual_Charging_Load_kW  \
0               11  6.833333   3.333333                34.859391
1               26  6.833333   3.333333                36.484825
2               11  7.500000   4.000000                26.086543
3                4  7.166667   3.666667                25.782322
4               12  6.944444   3.444444                 9.243760

   Predicted_Charging_Load_kW
0                   36.208018
1                   32.384380
2                   28.522607
3                   19.578187
4                   29.320017

/usr/local/lib/python3.11/dist-packages/IPython/core/
pylabtools.py:151: UserWarning: Glyph 128268 (\N{ELECTRIC PLUG})
missing from font(s) DejaVu Sans.
  fig.canvas.print_figure(bytes_io, **kw)
```
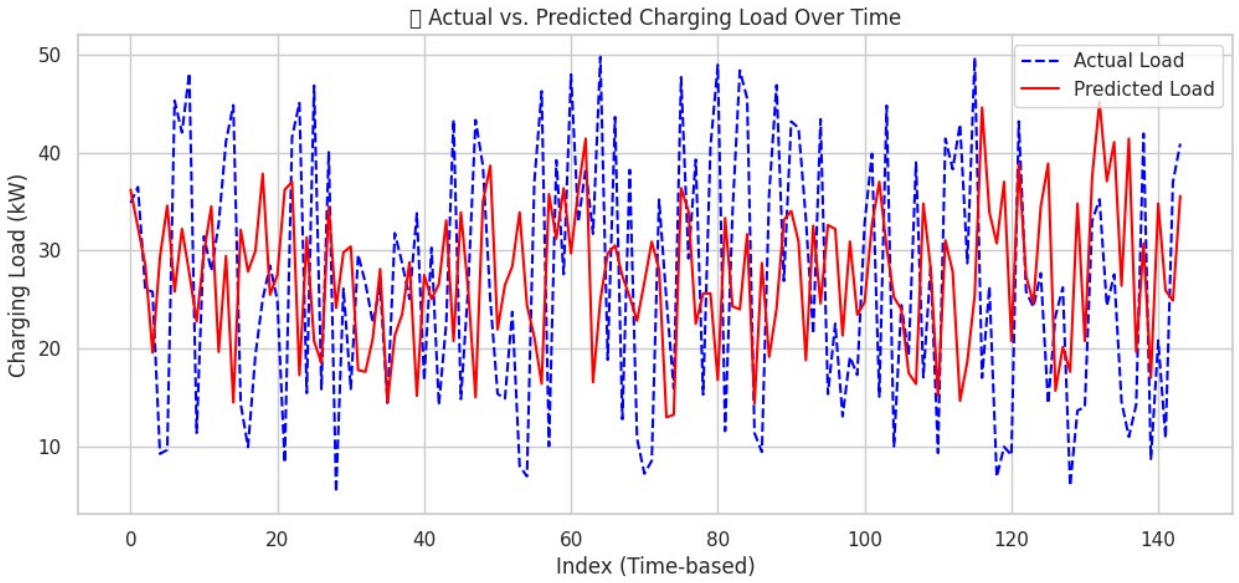
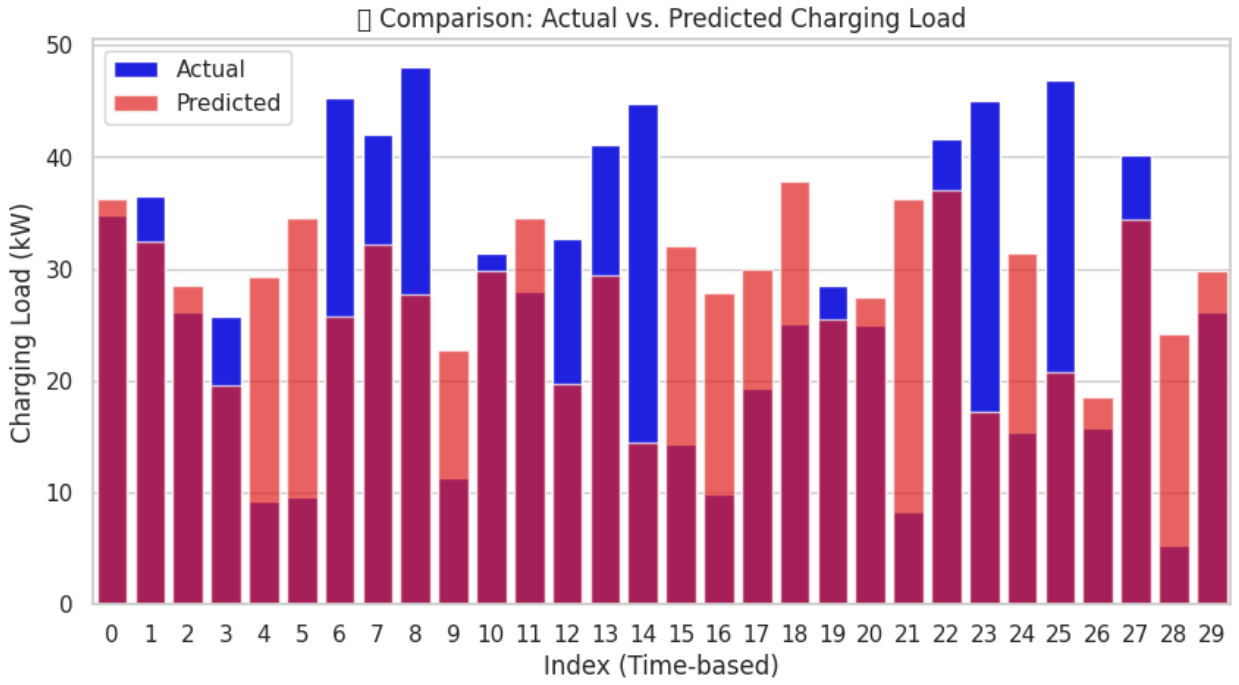




```
/usr/local/lib/python3.11/dist-packages/IPython/core/
pylabtools.py:151: UserWarning: Glyph 128269 (\N{LEFT-POINTING
MAGNIFYING GLASS}) missing from font(s) DejaVu Sans.
  fig.canvas.print_figure(bytes_io, **kw)
```




```
 Interactive Map of Charging Stations with Predicted Demand

 Summary Statistics:
       Actual_Charging_Load_kW  Predicted_Charging_Load_kW
```

```
count                144.000000                  144.000000
mean                  26.808966                   27.468566
std                   12.812219                    7.314823
min                    5.304332                   12.972451
25%                   15.030076                   21.786440
50%                   26.276542                   27.767382
75%                   38.439991                   33.083691
max                   49.772081                   45.177759
```

```
/usr/local/lib/python3.11/dist-packages/IPython/core/
pylabtools.py:151: UserWarning: Glyph 128201 (\N{CHART WITH DOWNWARDS
TREND}) missing from font(s) DejaVu Sans.
  fig.canvas.print_figure(bytes_io, **kw)
```