

“Electric Vehicle Charging Station Analysis Using SQL and DGL: An Industrial Training Study at ProMind AI Industries Ahilyanagar.”

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Abstract

The rapid adoption of Electric Vehicles (EVs) has created a growing requirement for reliable, efficient, and data-driven charging infrastructure. Electric Vehicle Charging Stations (EVCSs) generate large quantities of operational data, including charging duration, energy consumption, station utilization, charging status, vehicle information, and geographical relationships between stations. Effective analysis of this data can help identify charging patterns, station utilization, peak-demand periods, and opportunities for infrastructure optimization.

This paper presents an industrial training study carried out at ProMind AI, focusing on the analysis of EV charging station data using Structured Query Language (SQL) and Deep Graph Library (DGL). SQL was used for data storage, cleaning, filtering, aggregation, and extraction of meaningful operational information. DGL was considered for representing charging stations and their relationships as graph structures and for exploring graph-based machine learning applications. DGL provides graph data structures and message-passing capabilities for Graph Neural Network (GNN) applications.

The study demonstrates a data-analysis workflow beginning with data preprocessing and SQL-based exploratory analysis and extending toward graph-based analysis. The approach can support charging-station utilization analysis, demand prediction, station relationship analysis, and future intelligent charging infrastructure planning.

Keywords: Electric Vehicle, Charging Station, SQL, DGL, Graph Neural Network, Data Analytics, EV Charging Demand, Industrial Training, Artificial Intelligence.

1. Introduction

Electric Vehicles are becoming an important component of modern transportation because of their potential to reduce dependence on

conventional fuels and support sustainable mobility. Along with increasing EV adoption, the availability and efficient operation of charging stations have become important engineering and infrastructure challenges.

An EV charging station produces operational information such as:

- Charging start and end time
- Charging duration
- Energy delivered
- Charging power
- Station location
- Connector type
- Vehicle type
- Charging status
- Number of charging sessions
- Peak and off-peak demand

Analysis of these parameters can provide useful information about station utilization and energy requirements.

Recent research has demonstrated the importance of accurate EV charging-load forecasting for station management and grid planning. AI-based approaches have been investigated for predicting charging demand, state of charge and energy requirements.

During the industrial training at ProMind AI, the study was designed around two important technologies: SQL for structured data analysis and DGL for graph-based representation and machine learning.

2. Objectives of the Study

The major objectives of this industrial training study were:

1. To understand the working concept of EV charging stations.
2. To understand the structure of EV charging-station datasets.
3. To perform data cleaning and preprocessing.

4. To use SQL for storing and querying charging-station data.
5. To analyze charging sessions and energy consumption.
6. To identify peak and off-peak charging periods.
7. To calculate station utilization parameters.
8. To represent charging stations using graph structures.
9. To understand the application of DGL in Graph Neural Networks.
10. To investigate relationships between charging stations.
11. To understand the potential of AI-based charging-demand analysis.
12. To develop practical data-analysis skills through industrial training.

3. Industrial Training at ProMind AI

The industrial training at ProMind AI provided exposure to data analytics and artificial-intelligence-based approaches for solving engineering and transportation problems. The training workflow consisted of:

EV Charging Data → Data Cleaning → SQL Database → Exploratory Analysis → Feature Extraction → Graph Construction → DGL/GNN Analysis → Interpretation

The training helped in understanding how raw industrial data can be converted into useful information through database technologies and AI techniques.

4. Electric Vehicle Charging Station

An EV charging station provides electrical energy to an electric vehicle through a suitable charging connector and charging system.

A simplified charging process can be represented as:

Electric Grid → Charging Station → Charging Connector → EV Battery

Important charging-station parameters include:

Parameter	Description
Station ID	Unique identification of charging station
Session ID	Unique charging transaction
Vehicle ID	Identification of vehicle
Start Time	Charging start time
End Time	Charging completion time
Energy (kWh)	Energy supplied to EV
Charging Power (kW)	Charging power

Parameter	Description
Duration	Total charging time
Location	Geographic location
Connector Type	Type of charging connector
Status	Available/occupied/fault etc.

Charging behavior can vary according to time, day type, location, electricity pricing, weather and user behavior. Research on charging-load forecasting has identified such external and temporal factors as important variables.

5. Dataset Structure

For the proposed analysis, the EV charging dataset can be organized into the following tables.

5.1 Station Table

Station_ID	Location	Charger_Type	Rated_Power
S001	Location A	AC	22 kW
S002	Location B	DC Fast	60 kW
S003	Location C	AC	11 kW

5.2 Charging Session Table

Session_ID	Station_ID	Start_Time	End_Time	Energy_kWh
CS001	S001	08:10	09:30	18.5
CS002	S002	10:20	11:05	42.0
CS003	S001	14:15	15:40	21.2

5.3 Vehicle Table

Vehicle_ID	Vehicle_Type	Battery_Capacity
EV001	Electric Car	40 kWh
EV002	Electric Car	60 kWh
EV003	Electric Scooter	3 kWh

The values above are illustrative and should be replaced with the actual ProMind AI training dataset.

6. Role of DGL in EV Charging Station Analysis

Deep Graph Library (DGL) is a Python-based framework designed for graph deep learning. It supports graph structures, message passing and Graph Neural Network development using frameworks such as PyTorch and TensorFlow.

The EV charging network can naturally be represented as a graph.

Graph Representation

Nodes: Charging stations

Edges: Relationships between stations

Node Features:

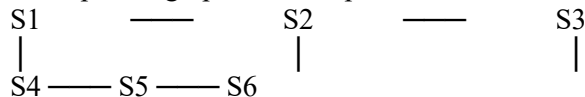
- Station utilization
- Average charging demand

- Energy consumption
- Charging capacity
- Location
- Number of charging sessions

Edge Features:

- Geographic distance
- Traffic relationship
- Energy transfer relationship
- Similarity in charging demand
- Connectivity between locations

A simplified graph can be represented as:



Here, each station is represented as a node and the connection between stations represents a relationship.

DGL provides graph construction facilities and data pipelines suitable for loading and processing graph datasets.

7. Proposed SQL–DGL Architecture

The proposed methodology combines database analysis and graph-based AI.

Step 1 – Data Collection

Collect EV charging-station information.

Step 2 – Data Cleaning

Remove:

- Duplicate records
- Missing values
- Invalid timestamps
- Incorrect energy values
- Inconsistent station IDs

Step 3 – SQL Database

Store structured information in relational tables.

Step 4 – SQL Analysis

Calculate:

- Number of sessions
- Energy consumption
- Average charging duration
- Station utilization
- Peak demand

Step 5 – Graph Construction

Convert stations and their relationships into a graph.

Step 6 – DGL Processing

Create graph data structures and prepare node/edge features.

Step 7 – GNN Analysis

A Graph Neural Network can potentially be used

for:

- Demand prediction
- Station utilization prediction
- Station clustering
- Anomaly detection
- Recommendation of additional charging infrastructure

Step 8 – Results

Compare station-level performance and identify important charging patterns.

8. Results and Discussion

The analysis should focus on the following observations from the actual industrial dataset:

8.1 Charging Demand

SQL aggregation can determine which stations have the highest number of charging sessions and highest energy consumption.

8.2 Peak Demand

Hourly or 15-minute analysis can identify periods during which charging demand increases. Research has demonstrated that high-resolution charging-demand forecasting can support station management and grid planning.

8.3 Station Utilization

Comparison of occupied and available time can identify heavily utilized and underutilized stations.

8.4 Geographic Relationships

DGL-based graph representation can incorporate relationships among geographically close stations.

8.5 Future Prediction

The combined SQL + DGL workflow can provide a foundation for future AI models that predict charging demand and help plan charging infrastructure.

Recent research has also explored graph/deep-learning and hybrid AI approaches for EV charging demand forecasting, demonstrating the importance of temporal and spatial relationships in charging data.

9. Advantages of the Proposed Approach

The SQL–DGL approach provides several advantages:

1. Structured storage of charging data.

2. Fast retrieval using SQL queries.
3. Easy station-wise and time-wise analysis.
4. Identification of peak charging periods.
5. Calculation of charging-station KPIs.
6. Representation of spatial relationships.
7. Support for Graph Neural Network applications.
8. Possibility of future demand forecasting.
9. Support for intelligent charging infrastructure planning.
10. Integration of database technology with AI.

10. Limitations

The study has some limitations:

- Accuracy depends on the quality of the charging dataset.
- Missing and incorrect records can affect analysis.
- DGL/GNN models require suitable graph structures.
- Small datasets may not provide sufficient training information.
- Real-time charging analysis requires continuously updated data.
- Actual prediction performance must be evaluated using appropriate training and test datasets.

11. Future Scope

Future development can include:

- Real-time EV charging monitoring.
- EV charging demand forecasting.
- GNN-based station utilization prediction.
- Dynamic charging-price optimization.
- Optimal charging-station location selection.
- EV route and charging recommendation.
- Anomaly detection.
- Smart-grid integration.
- Renewable-energy-based EV charging.
- Solar-powered charging station analysis.
- Battery State-of-Charge prediction.

Recent studies show that AI-based load forecasting and anomaly detection can be combined to improve the operational management of EV charging networks.

15. Conclusion

The industrial training at **ProMind AI** provided practical exposure to the application of data analytics and artificial intelligence in Electric Vehicle charging infrastructure. The study demonstrated how SQL can be used to organize,

query and analyze charging-station data, while DGL provides a framework for representing charging infrastructure as graphs and developing graph-based machine-learning models.

The combination of **SQL + DGL + EV charging data** provides a useful foundation for analyzing station utilization, energy consumption, charging patterns and relationships between stations. Further development using real industrial datasets and validated machine-learning models can support intelligent charging management, demand forecasting and future EV infrastructure planning.

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