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REPORT

Problem Statement: Exploratory Data Analysis for Charging Events

Introduction

This report provides a overview of the exploratory data analysis conducted on EV charging data. The goal is to understand, analyse and visualise the charging patterns, mainly focusing on energy consumption and charger utilization, to ensure efficient management of chargers.

Methodology

Descriptive Analysis

The dataset consists of records of charging events including timestamps, meter readings, and duration of charges. The data consists of 277 datapoints and 6 columns, with no duplicates. There are 4 numerical and 2 categorical columns (timestamp is later converted to date time).

Data Preprocessing

- Inconsistent Data: Identification and correction of anomalies within the dataset. After conducting a manual study of the data, I found out a few inconsistent data points. I filtered data where the total duration is 0 or the energy consumed is 0 because it doesn't make sense to have records where energy changes with no time passing, or no energy is used despite time passing. This suggests there might be errors during the charging instance or or issues with data collection. Left with 232 data points after this step.

- Missing Value Analysis: Missing values in 'Charger_name' were replaced with 'Unknown' to ensure consistency in analyses. The final data had 5.6% missing values (NaN) in the ‘Charger_Name’ data column and replaced it to ‘Unknown’, for simplicity.

- DateTime Handling: Conversion of timestamps into date time formats to perform time-based analysis and visualization. Mainly to perform daily, weekly and monthly analysis. I created a new column namely ‘Time Slot’ to segregate the charging start time into 4 categories - Morning (6:00 to 11:59), Afternoon (12:00 to 16:59), Evening (17:00 to 19:59) and Night (20:00 to 5:59). Lastly, also transformed time duration in seconds to hours for better readability.

Visualization and Inferences

- Weekly, Monthly, and Daily Trends in Energy Consumption and Number of Charges:

  From the graph below, we can infer that overall Tuesday’s see maximum energy consumed and number of charging events followed by Wednesday. However, the energy consumption is third highest on Monday’s indicating that there is a possibility that few users prefer using chargers just once a week, whereas the the second graph shows that the other half prefer charging twice a week.

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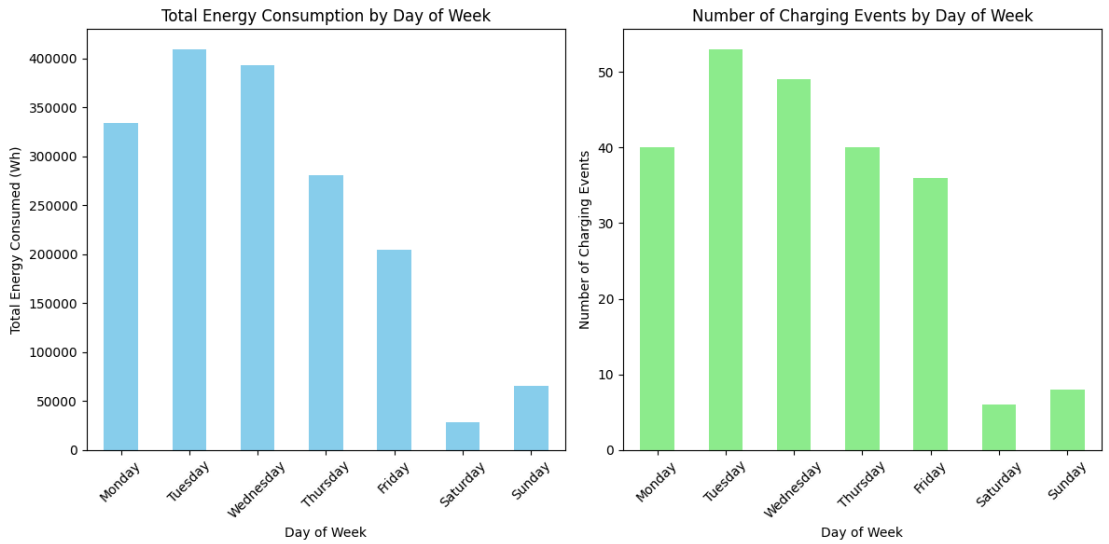

Fig. 1: Weekly energy and charging events plot

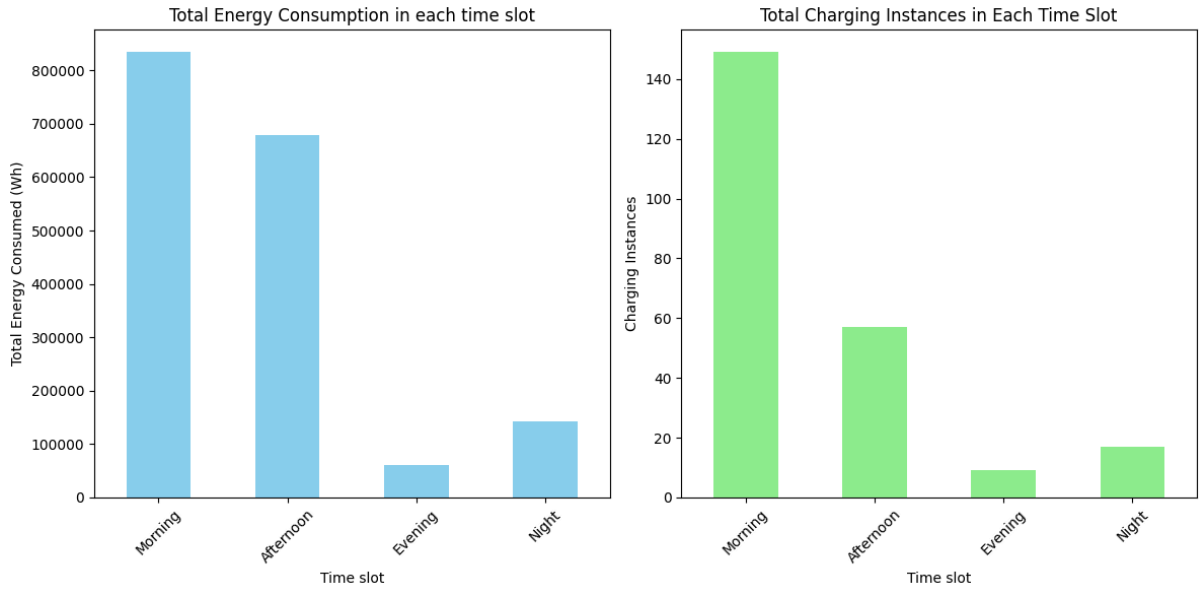

Fig. 2: Daily (time slot) energy and charging events plot

In Fig. 2, we can see that most of the people prefer charging their vehicles in the morning between 6:00 to 11:59, intuitively this makes sense because people might prefer recharging fully before heading to work. Whereas we can see a small percentage of people charging at night probably on their way back home to save time as there is a possibility of rush during the mornings and afternoons.

The give below figure (Fig. 3) shows monthly trends in the charging patterns. With September being significantly high.

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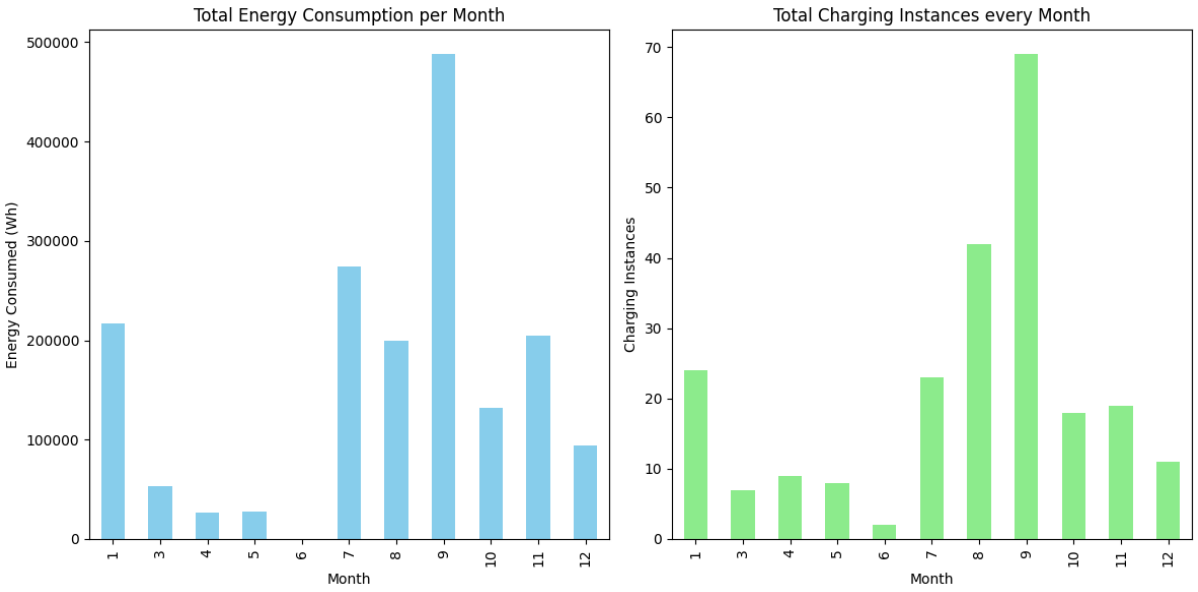

Fig. 3: Monthly energy and charging events plot

- Distribution of Chargers: Analysis of charger utilization across different chargers.

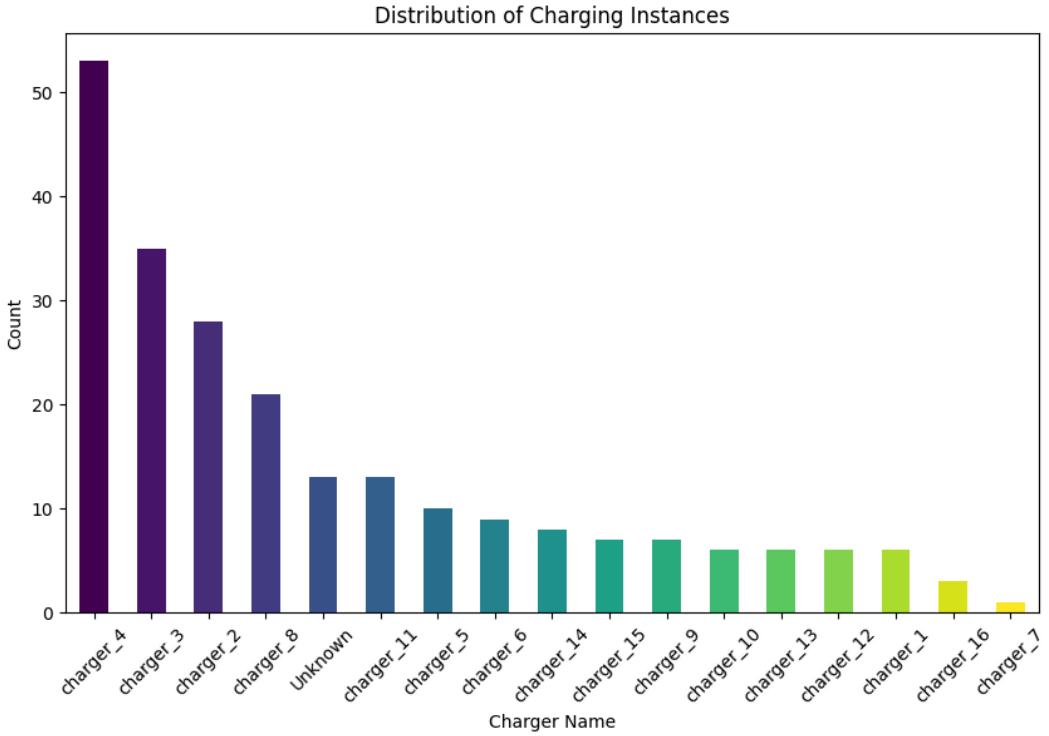

Fig. 4: Distribution of Charging Instances

Fig. 4 illustrates amount of charging instances at each charger. The top three charges are 4, 3, 2 and buttom three are 1, 16, 17. This might be due to various reasons such as geographic locations of these charges and ease of use.

- Average Time Spent at Each Charging Station: Bar plots indicating the average duration per charge for each charger.

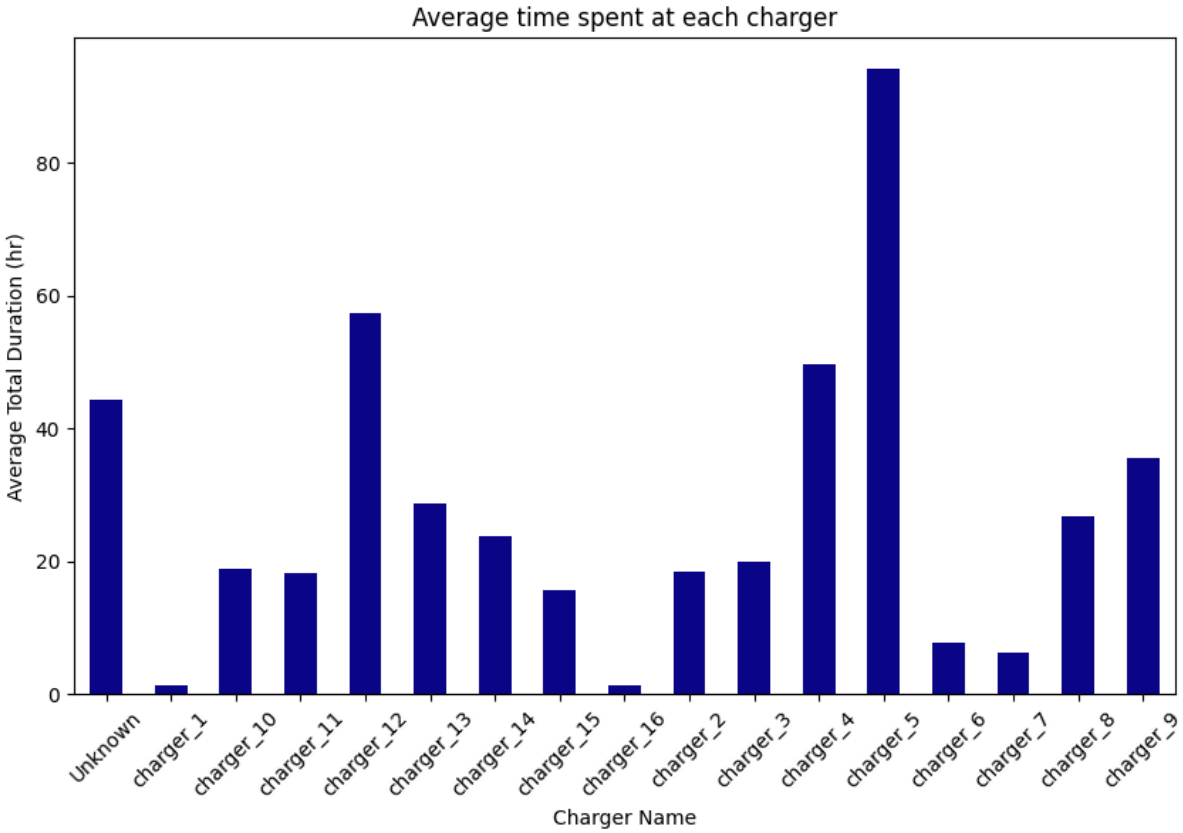

Fig. 5: Average time spent (in hours) at each charger

In Fig.5, we can see that the average time spent at each charger is highest at Charger 4 which is consistent with Fig. 4 showing that Charger 4 has the highest demand while Charger 1 and Charger 16 have the least demand.

- Energy Consumption and Daily Charging Instances Over Time: Trends showing the overall energy usage and the frequency of daily charging events.

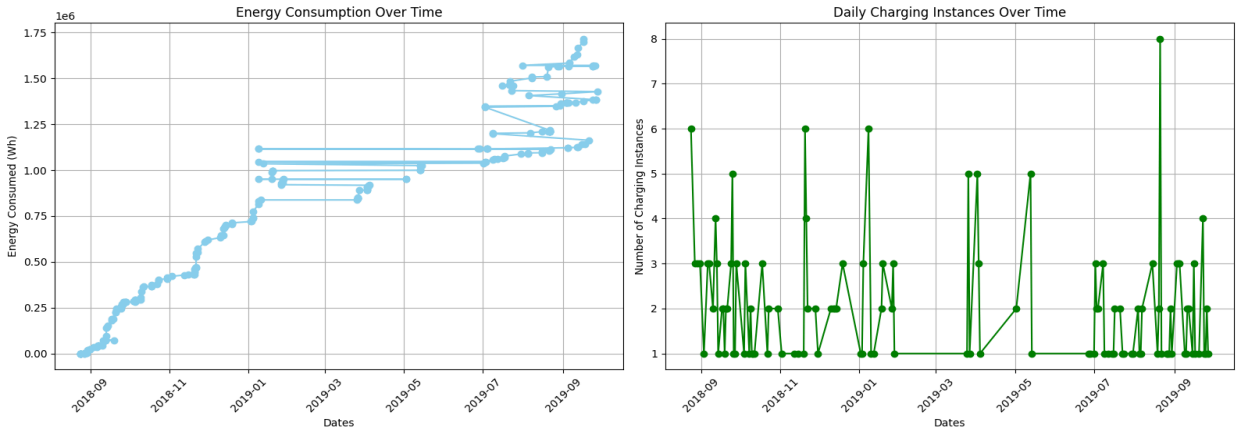

Fig. 6: Energy consumption and number of charging events over time

From Fig.6 we can infer that there has been a consistent increase in energy consumption from mid 2018 to start of 2019, but after that there have been few hiccups indicating need of maintenance or other external factors which impacted the usage. However, there was still an increase at the end. In the second subplot, we can see varied distribution of number of charging events over time.

- Scatter Plot of Meter Total vs Total Duration in Hours: Relationship between energy consumed and the duration of charging.

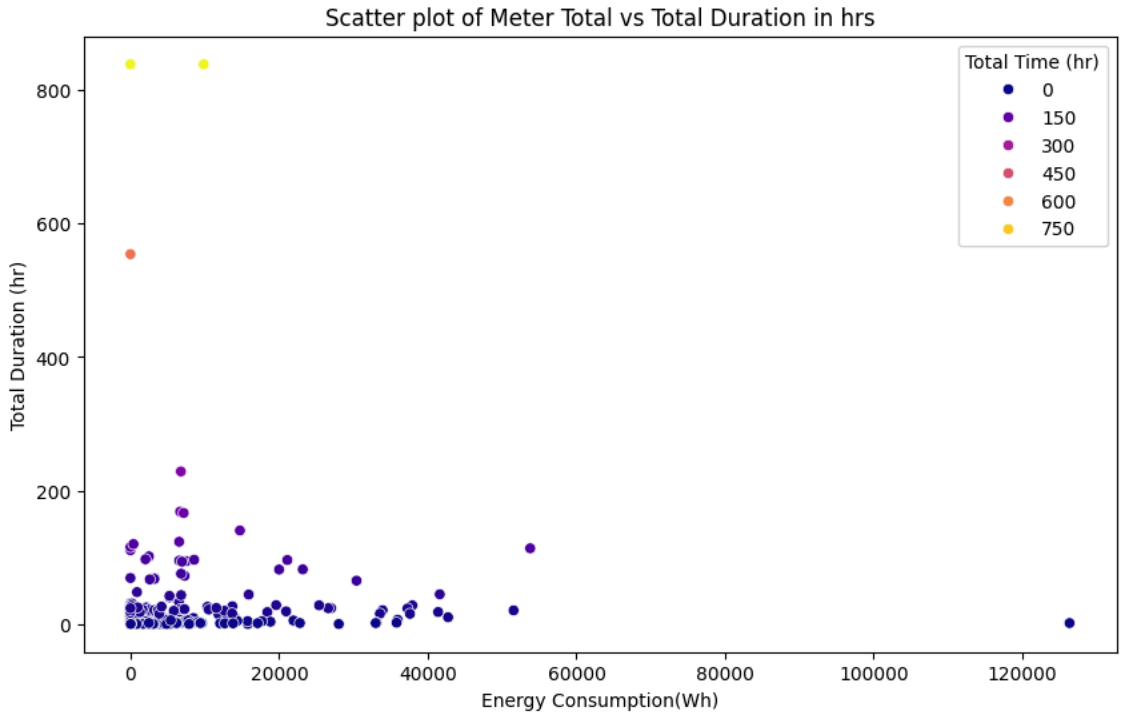

Fig. 7: Energy consumption vs Duration in hours scatter plot

In Fig. 7 we can see a cluster of charging events with lower energy consumption and duration, whereas we can see few outliers indicate charging instances with significantly higher energy use and longer durations. This shows varied charging patterns of users maybe because of different vehicle type and it's charger capacities.

- Outlier Analysis by Charger: Examination of unusual patterns (using IQR) in charge duration (29,11) and energy consumption (27,11) for each charger.

The given below subplots in Fig.8 tell us about the time duration and energy consumption at different chargers and analysing the outliers. Most chargers have similar use times and energy use, but can see some outliers because as the chargers might be overused or use a lot more energy than usual. This could mean some chargers are overworked, less efficient, or there might be some errors in data collection. This provides a very important view in the charger behaviour and can be studied more.

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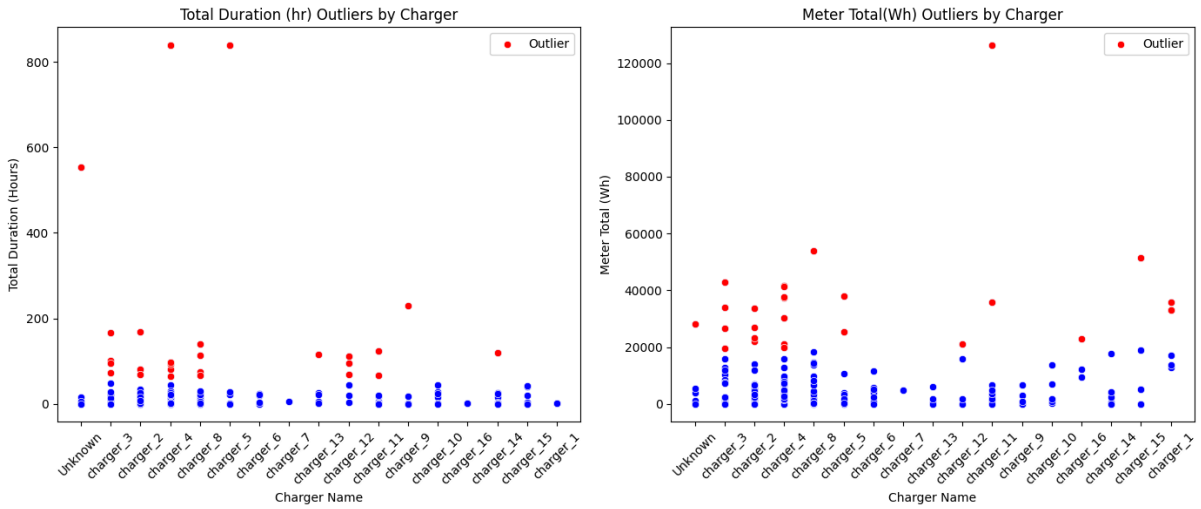

Fig. 8: Outlier Analysis for total time and energy consumption per charger

Insights

The study mainly consists of 4 main analysis which are temporal usage patterns, charger utilization analysis, duration and energy use and outlier detection. Through this study and the visualizations we can see clear patterns in energy consumption and charging events by day of the week, month and time slot of day. Giving us some insight into user behaviour and preferences. Analysis charger utilization tells us the importance of the influence of geographical location, ease of use and convenience of accessing the charger. Lastly, we also identified outliers by each charger which could help identify issues and how the chargers can be further optimized to find the perfect balance.
These insights can help in performing improvements, targeted maintenance, and strategic expansion of charging facilities to better meet user demand and. ensure efficient management of chargers.

Future Scope

This analysis can serve as a good basis and background to forecast demand of each charger based on the user and charger behaviour, this will help us to predict which chargers will be used the most and when, so that further steps can be taken to either perform maintenance or either scale up the infrastructure.

Conclusion

The exploratory analysis of the EV charging data has provided significant insights into the charging patterns. These findings can help in optimizing the operation of charging stations and enhancing user satisfaction by reducing wait times and ensuring availability.