ANALYSIS OF ELECTRIC VEHICLE CHARGING STATIONS USAGE AND PROFITABILITY IN THE UK

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INTRODUCTION

The transportation sector in the UK is a major contributor to greenhouse gas emissions, significantly affecting climate change.[1] Electric vehicles (EVs) offer a sustainable alternative, producing zero emissions at the point of use. However, the adoption of EVs hinges on the development of a robust and efficient charging infrastructure.[2]

This research focuses on leveraging data analytics to analyse and predict EV charging patterns in the UK, aiming to balance convenience, economic feasibility, and environmental sustainability. The study uses real-time data on energy consumption, EV arrival times, charger occupancy, and profitability of public charging stations, along with carbon emissions data, to derive insights and develop models for optimising the charging infrastructure.

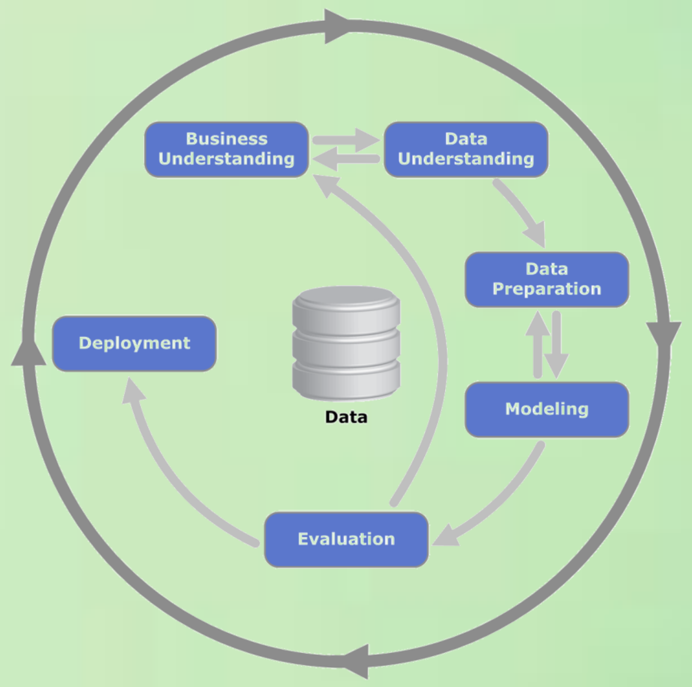


Fig. CRISP-DM cycle

METHODOLOGY

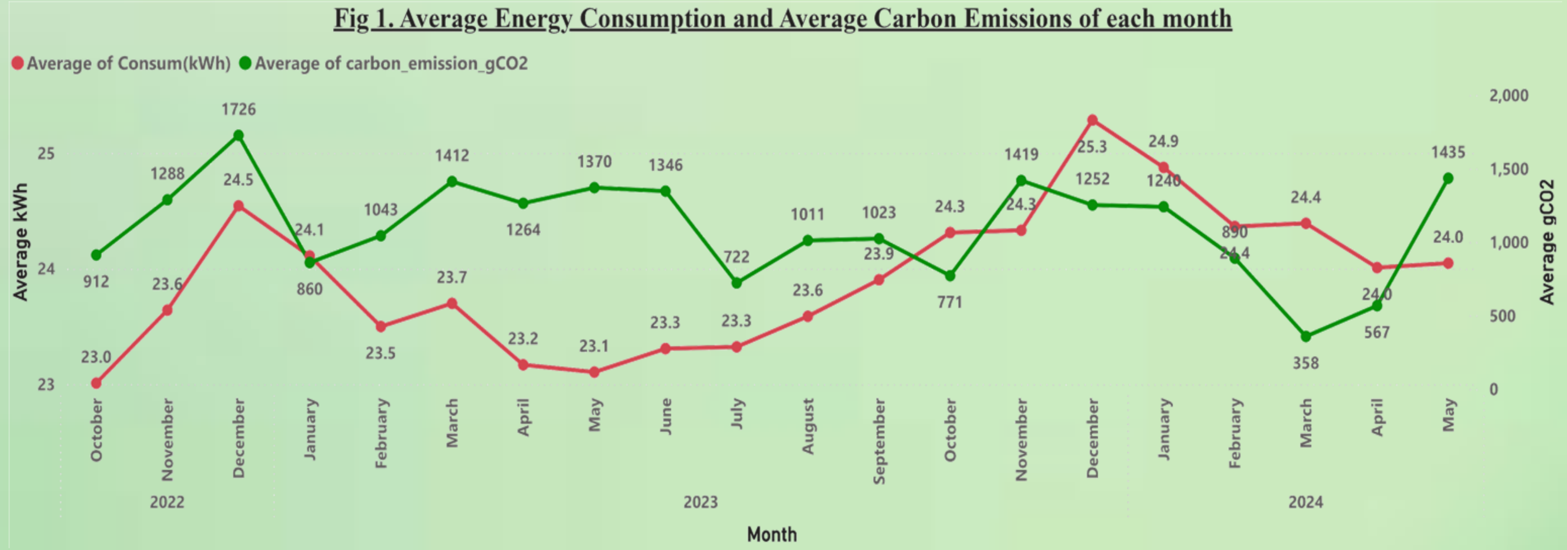
This research project follows the CRISP-DM reference model[3] with six phases:

1. Business Understanding -
   i. Understand usage trends of electric charging stations to optimise the EV grid infrastructure.
   ii. Assess the impact of EV charging on carbon emissions for sustainability.
2. Data Understanding –
   i. Data Collection – Based on availability, data was sourced from open websites for Scotland (2.74M sessions), London Borough of Barnet (6255 sessions), and Urban Science Building, Newcastle University (29.77K sessions).
   ii. Data Quality – Null values, illogical records, and inconsistent formatting in data were identified.
3. Data Preparation – Data was cleaned, wrangled, integrated, and constructed data for analysis.
4. Exploratory Data Analysis –
   i. Data Analysis Tools: Python, Power BI
   ii. Analysis Techniques: Exploratory Data Analysis (EDA) to identify trends and patterns in energy consumption, charger occupancy, and carbon emissions.
5. Evaluation – The insights helped to achieve the objectives set for this research. Refer Results section.
6. Deployment – The conclusion drawn from results and suggested future work.

RESULTS

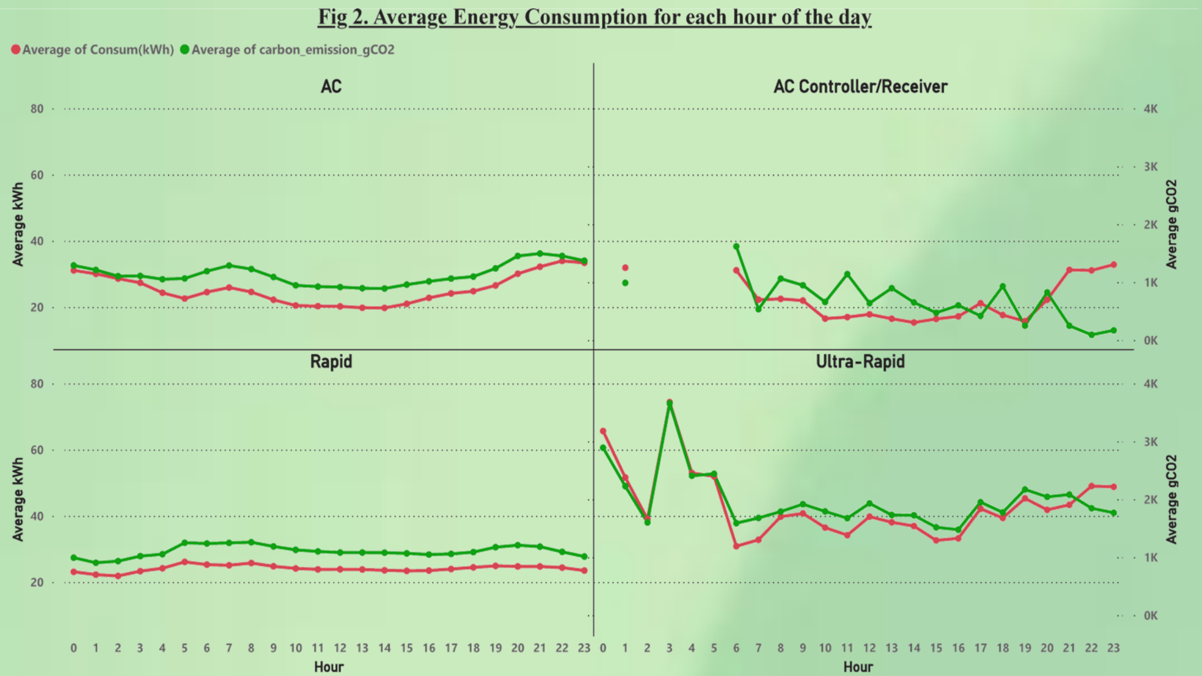
1. Country Level – Scotland:

Fig 1. Average Energy Consumption and Average Carbon Emissions of each month



- Peaks occur in December (up to 25.3 kWh and 1726 gCO2), while the lowest values are in summer months (as low as 23.3 kWh and 240 gCO2).
- Energy consumption is stable, but carbon emissions vary, highlighting the impact of electricity sources and charging efficiency.

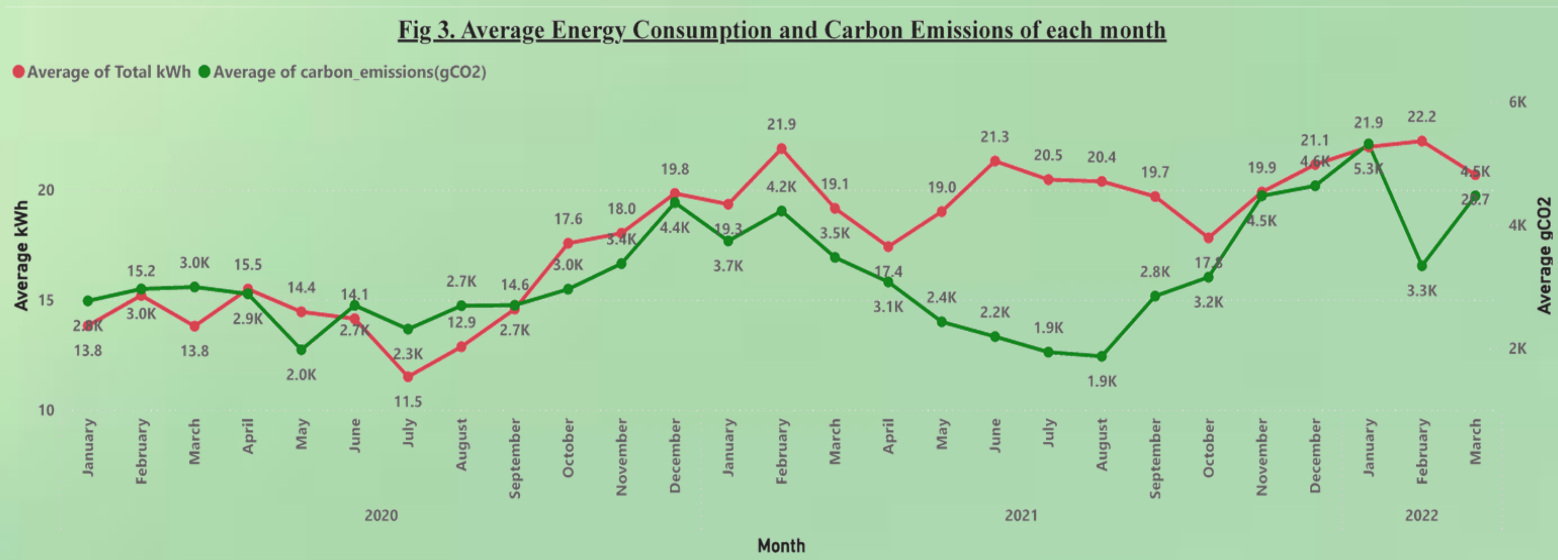
Fig 2. Average Energy Consumption for each hour of the day



- There seems to be a slight increase in energy consumption and carbon emissions towards the evening hours for all charger types.
- The data suggests that charging behavior differs significantly between charger types, with Rapid and Ultra-Rapid chargers likely used for shorter, higher-power charging sessions.

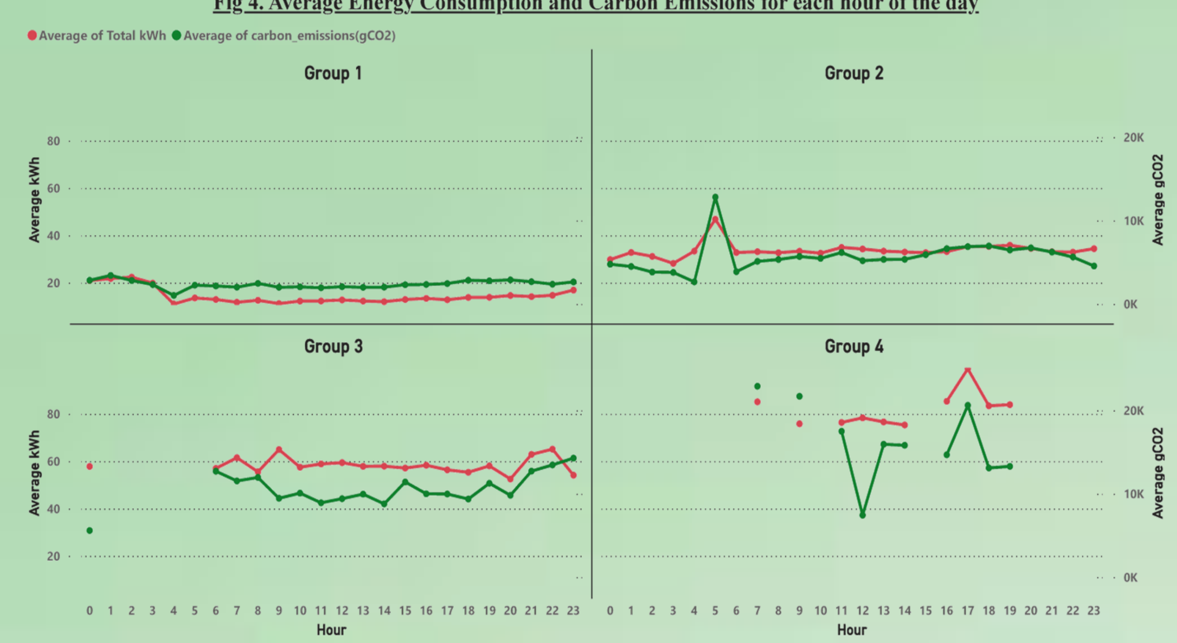
2. Regional Level – London Borough of Barnet

Fig 3. Average Energy Consumption and Carbon Emissions of each month



- Energy consumption and emissions exhibit a clear seasonal pattern, peaking in winter months (December to February) and declining in summer (June to August).
- A steady increase in both energy consumption and carbon emissions is evident over the three-year period, suggesting growing EV adoption and potential implications for grid infrastructure and environmental impact.

Fig 4. Average Energy Consumption and Carbon Emissions for each hour of the day

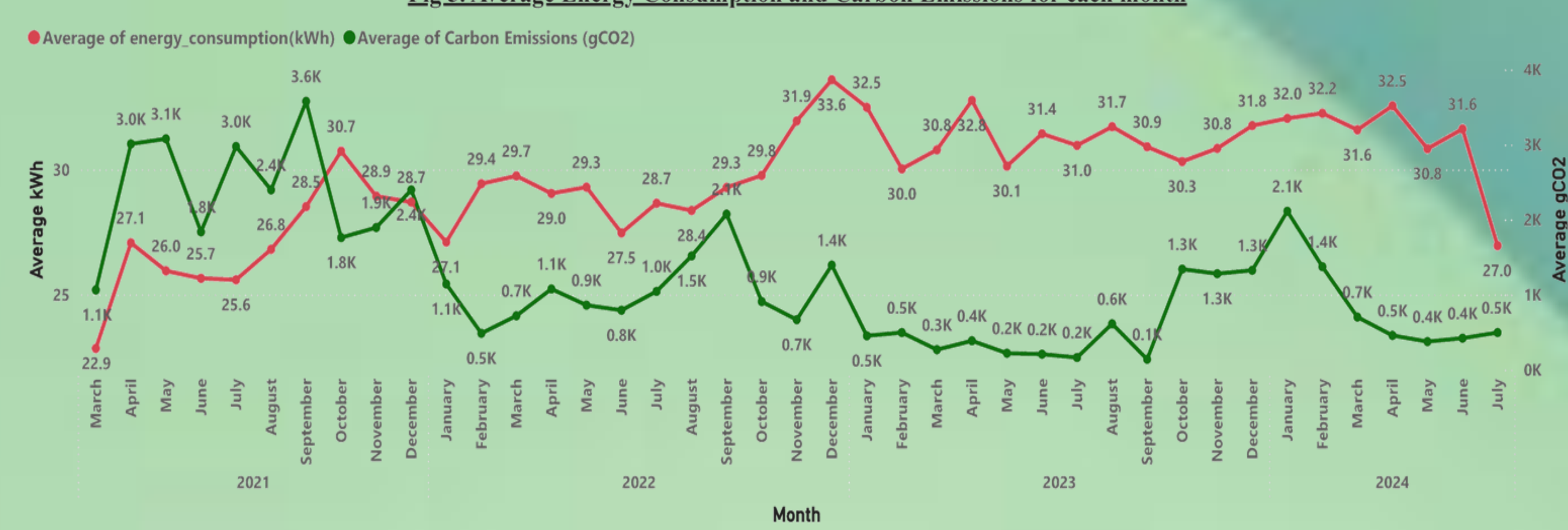


➢ Group 1 with 5 to 24.99 kWh, Group 2 with 25 to 49.99 kWh, Group 3 with 50 to 74.99 kWh and Group 4 with 75 to 100 kWh.

- Energy use peaks in the late afternoon and evening, with Group 4 having peak consumption.
- Carbon emissions align with energy consumption.
- This suggests varying charging patterns among groups, impacting grid load and environmental impact.

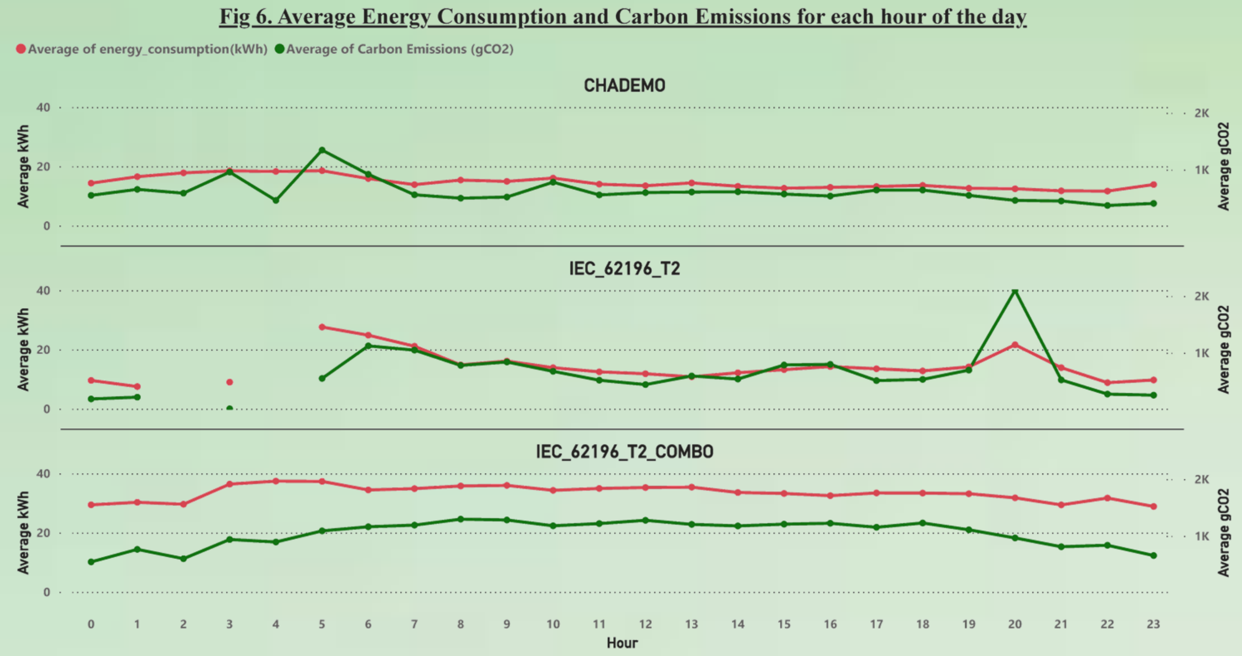
3. Institutional Level – Urban Science Building, Newcastle University

Fig 5. Average Energy Consumption and Carbon Emissions for each month



- Peak energy consumption and carbon emissions occur in the winter of every year and seem to decrease in the summer of that year.
- Overall average energy consumption seems to have increased all these years and carbon emissions show seasonal variation.

Fig 6. Average Energy Consumption and Carbon Emissions for each hour of the day



- Most of the energy consumption is done by COMBO connector type followed by CHAdeMO and T2.
  Carbon emissions almost closely follow the energy consumption patterns for all connector types.
- Overall, the energy consumption is more in the night-time and less in the daytime for all connector types.

CONCLUSION & FUTURE WORK

Energy consumption and carbon emissions have risen across all locations, indicating a growing demand for EV chargers. A notable increase has occurred post-COVID, especially after 2021, suggesting this period influenced the demand surge.[4] Winter peaks in energy use pose a significant challenge for EV charging, with carbon emissions closely mirroring energy consumption patterns. These trends highlight the need for sustainable public EV charging infrastructure. Future efforts should focus on predicting energy consumption and carbon emissions to plan EV infrastructure that meets growing demand strategically.

REFERENCES

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