Austin Schaefer

Ampcontrol EV Charging Report

This comprehensive report aims to analyze charging events at various charging stations. Included are visualizations, descriptive statistics, and insights.

The dataset provided by Ampcontrol contains 6 features:

- **Start Time**: date and time of charging event
- **Meter Start**: initial value of energy meter, in watt-hours.
- **Meter End**: final value of energy meter, in watt-hours.
- **Meter Total**: difference between meter end and start.
- **Total Duration**: total time duration of event in seconds
- **Charger name**.

We will analyze **charger related trends** such as their efficiency and total usage. We will also identify **patterns in user behavior** by analyzing the distribution of charging times and energy consumption. Lastly, we will analyze **seasonal & time related trends**.

Page 9 contains **key takeaways** summarizing the report.

Preprocessing

- To more easily conduct our analysis, we create a new "efficiency" column by dividing Total Energy by Total Duration, to get **Efficiency in Wh/s**.

- We extract the month, day, and time from the "Start Time" column to allow more granular analyses.

- We also keep missing values to see if the missing chargers have their own pattern

	Start Time	Meter Start (Wh)	Meter End(Wh)	Meter Total(Wh)	Total Duration (s)	Charger_name	Total Duration (h)	Efficiency	year_month	day	is_weekday	hour
0	2018-08-24 09:50:00	50	50.00	0.00	37	Missing	0.010278	0.000000	2018-08	24	Yes	9
1	2018-08-24 09:51:00	50	50.00	0.00	38	Missing	0.010556	0.000000	2018-08	24	Yes	9
2	2018-08-24 09:51:00	73	118.52	45.52	56	Missing	0.015556	0.812857	2018-08	24	Yes	9

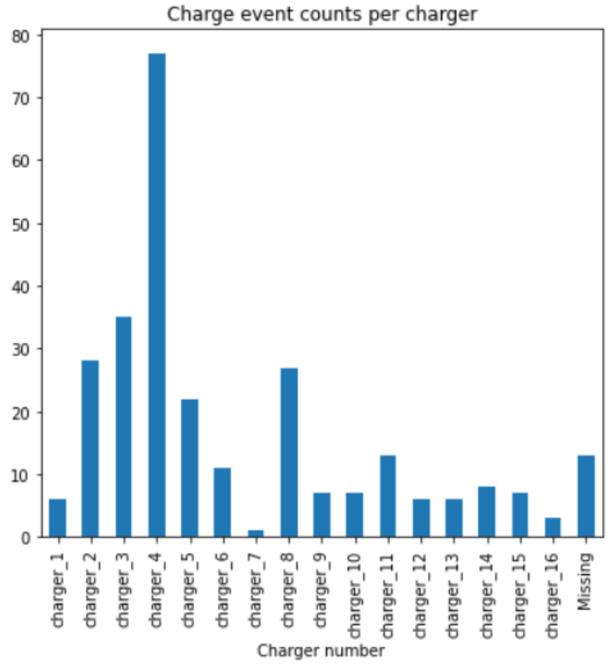
- When doing feature engineering for efficiency, some values are 0 or infinity.

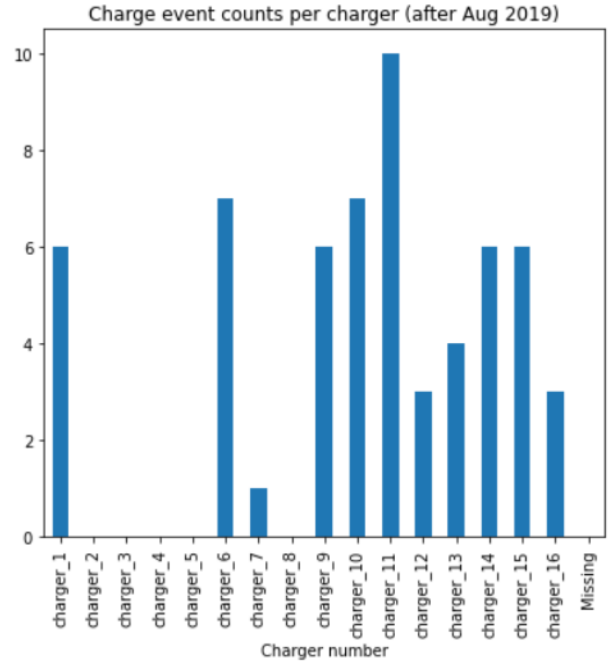
- 0 occurs when there is a time duration recorded, but no energy recorded. Infinity occurs when there is charge recorded but no time duration for it.

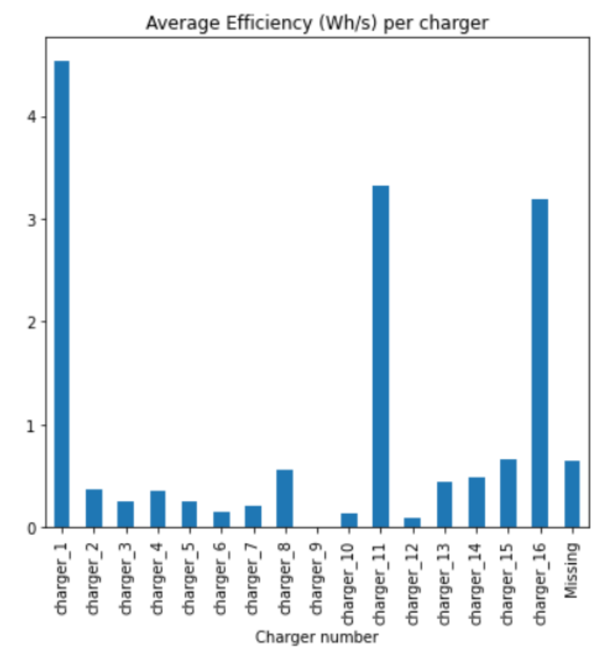
- It is possible either the data is faulty or the charger is faulty. To confirm we would need more information. Maybe charge events are not necessarily "triggered" by charging.

- If it is possible for a person to "trigger" a charge session without actually charging (like if simply parking their car would trigger a session) then this would explain why there are durations recorded but no charge.

Chargers







- Charger 4 is utilized significantly more compared to other chargers, and some chargers are utilized less.

- This could indicate a few things, such as popular charge spots or traffic. Charger 4 is probably in an area with a lot of traffic, such as a city, and charger 7 could be in a place with less traffic, like in the suburbs. This is an opportunity to optimize placement of chargers.

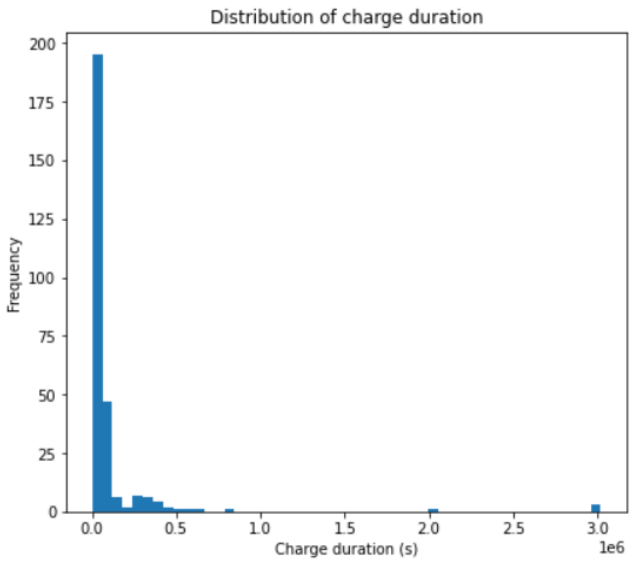
- Alternatively, charger 7 could have some flaws. Maybe it is hard to find, for example it could be in a concealed spot in the parking lot. Or perhaps it broke after a few uses and needs maintenance.

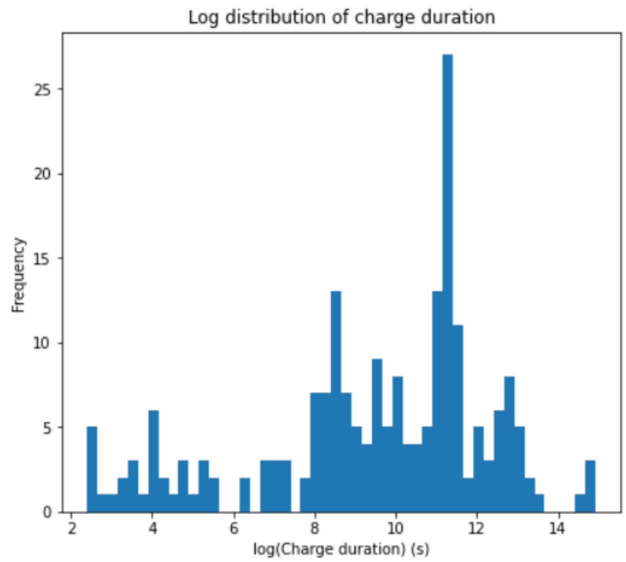
- On the other hand, these chargers could be new and there just hasn't been enough data collected yet. However this is unlikely - when accounting for charge events only after Aug 2019, chargers 7 and 16 still have lower numbers compared to other chargers.

- With some feature engineering, we can also see that chargers 1, 11, and 16 have much higher charging efficiency compared to other ones. These could be special "super chargers" designed for faster charge times. On another possibility is the other chargers are old and need to be updated.

- Missing chargers don’t have an obvious pattern that sets them apart from other chargers, though most of the data falls in Aug 2018. This could be a flaw in the early stages of the data collection process.

Charge Duration and Energy Distributions





- We apply a log transformation to the data values since the original distribution is so highly skewed.

- There are **two outliers**, with the largest one having a duration of 839 hours. This may indicate a mistake in the data, or the battery was faulty and wouldn't charge, or the charger was faulty. Or someone possibly left their car in the charging station for a few weeks. This is dependent on the programming of the charger and how it records this data.

- The median charge time is approximately 1.5 hours, mean is approximately 27 hours (influenced by large outlier), standard deviation is 9.65 hours. The large variance indicates either high variability in user charging behaviors or differences in EV battery needs. Charging stations should be ready and equipped to handle a variety of charging patterns.

- There are a lot of charging events with a duration of 0, which is odd. This could be a result of flawed data, or a flawed charger, or simply drivers parking without charging, "triggering" a charge without actually charging. This could happen if simply parking your car could “trigger” a charge event. This would need more investigation on how the charger records the data.

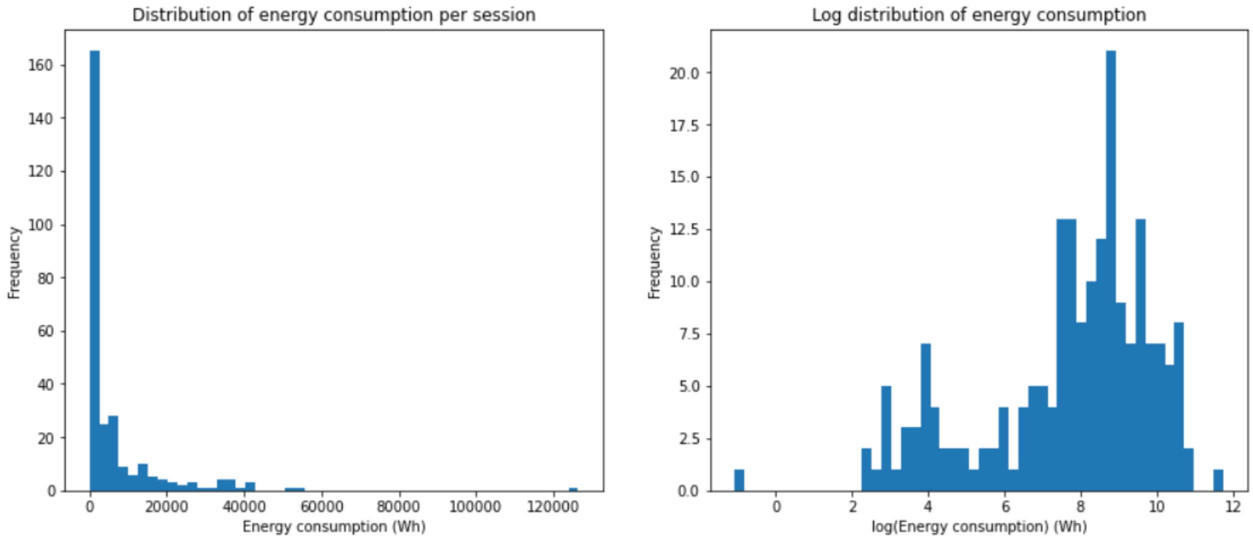
- Charge duration is highly skewed to the right, indicating people frequently charge for short durations.

- This could indicate people often "top up" their battery, leading to shorter charge sessions. This is common if people have access to charging stations near their homes and charge on a daily basis.

- Or perhaps people are charging on the go, stopping for a quick charge before hitting the road again.

- This could also indicate high availability - if charging stations are easily accessible, drivers would be less inclined to charge for longer times.

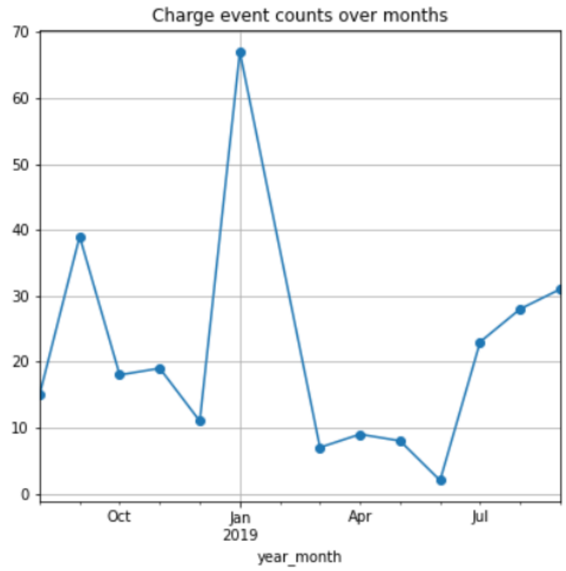
- This is less likely, but maybe people believe that charging for a long time could degrade their battery quality, prompting them to charge for shorter times.

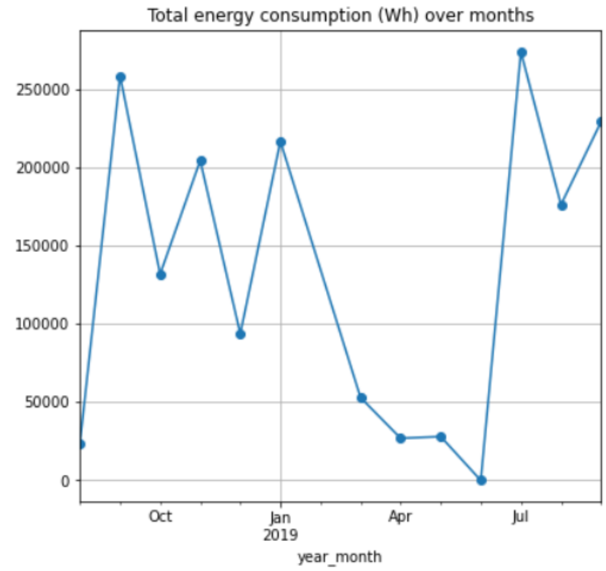


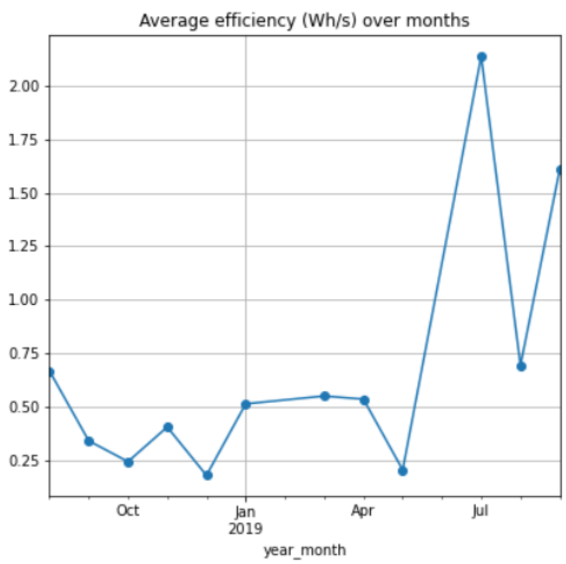
- The findings with energy consumption are consistent with charge duration.

- There is also one significant outlier here, at 126351Wh. The median is 1380Wh, mean is 6197Wh (influenced by far outlier), and standard deviation is 12260.

Seasonal & Time Analysis





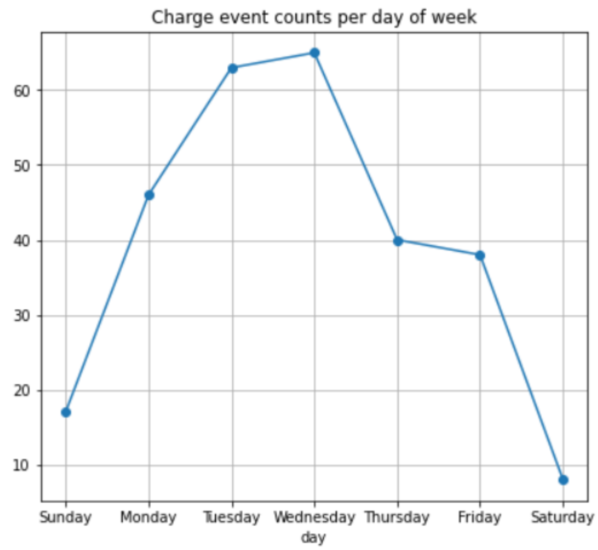


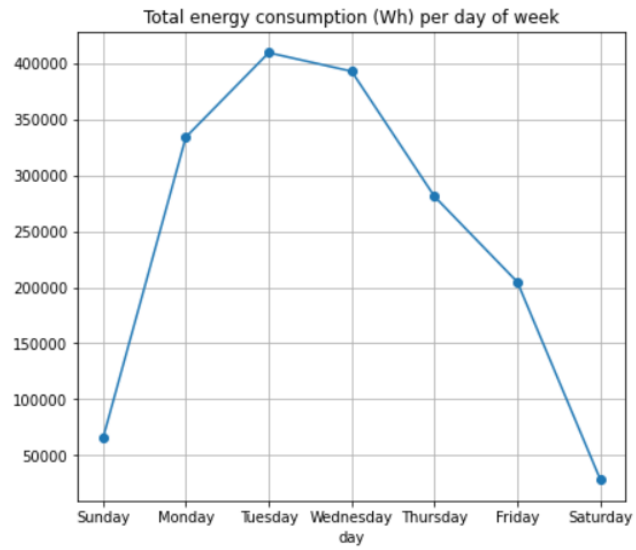
- Efficiency is higher during the summer months compared to the winter, most likely due to the cold conditions impacting the charging technology. Upgrading equipment to withstand cold conditions may improve efficiency.

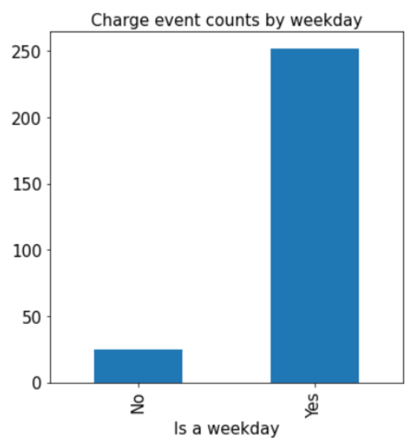
- January sees a spike in charge events and higher energy consumption. This could be due to people traveling during the holidays. It could also be due to special events, such as people receiving new EV cars for Christmas.

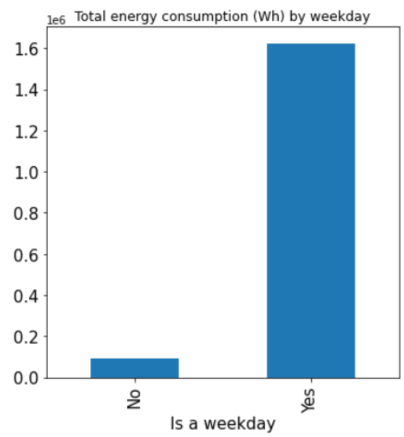
- September also sees higher charge counts and energy consumption, possibly indicating the beginning of school sessions.

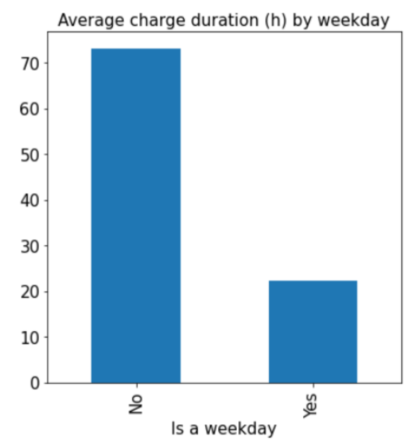
- Charge event counts and energy consumption rises through July-September of 2019, could be an indication of people traveling throughout the summer.





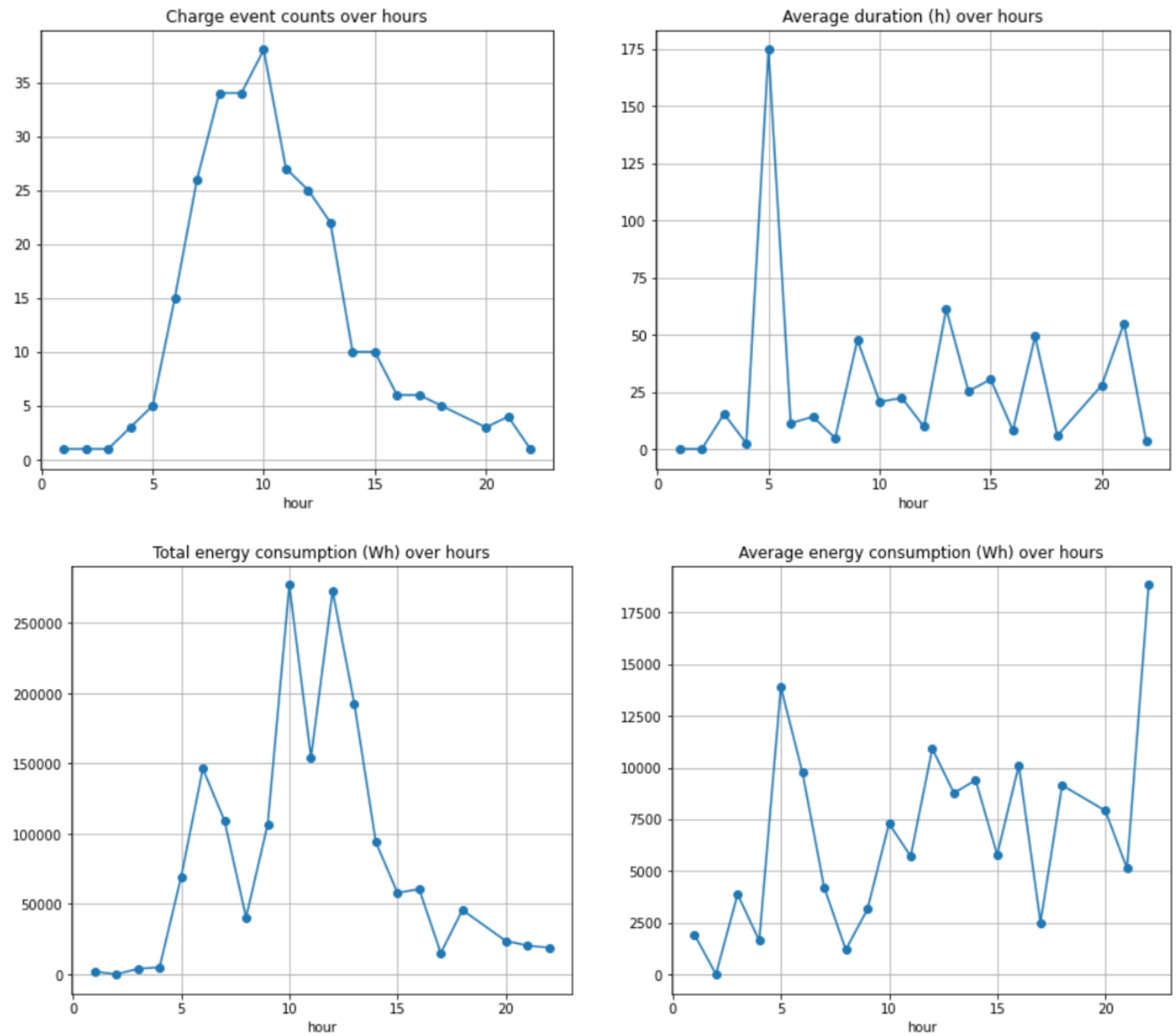






- Drivers tend to charge at the beginning of the work week. Weekdays see more charge events and more energy consumption, which makes sense considering people have to drive to work.

- The average charge duration is much longer on weekends, probably because people have more time to charge. On weekdays people are more likely to charge on the go.



- The number of charge events throughout the day has a unimodal distribution, peaking at 10am. People tend to charge their vehicles throughout the day for shorter durations. Total energy consumption is higher throughout the day.

- But at night, on average, an individual driver tends to use more energy per charge event. This could be an indicator of overnight charging.

- Looking at average energy consumption and charge duration, individual drivers tend to charge for longer durations early before work at 5am.

Key takeaways

- We should consider the usage rates of different chargers. Whether this is due to areas with higher traffic or flawed chargers, this should be looked into. This is an opportunity to optimize the placement of chargers.

- It is also worth investigating why some chargers have much higher efficiency, since chargers 1, 11, and 16 are way more efficient, assuming these are not super-chargers.

- Most of the time, drivers charge for short durations, so chargers should be ready to handle constant usage. Chargers should also be able to handle longer charge sessions - drivers tend to charge for longer durations in the early morning and, very likely, at night during overnight charging. The data suggests a high variability in user behavior or battery designs.

- Winter, Summer, and Fall have higher energy consumption and charge event counts, it should be ensured chargers are in good condition before these peak seasons. Data suggests chargers are negatively impacted during winter months, so extra maintenance during this time may result in better efficiency.

- Drivers tend to charge more frequently for shorter durations during weekdays, but for longer durations on the weekends. Chargers are utilized the most from Monday through Wednesday. The data suggests weekends during spring season is the best time to do maintenance, as it is the least busy time.

- Finally, the data collection process is also worth investigating – why are some chargers missing labels, and why do some data rows contain a time duration, but have 0 charge output? Why is there an outlier with a duration of 839 hours? Do chargers stop data collection once the battery is full? Investigating the outliers and how the chargers collect data is worth looking into.