Electric Vehicle Usage & Charging Etiquette at the Workplace

Data visualization

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Summary

1) Brainstroming : study the dataset

2) Process : Trello, data cleaning

3) Visualization: build the code from scratch and create plots

The dataset

The dataset

The data contains sessions from 85 EV at 105 stations across 25 sites.

The charging locations include:
- Research and innovation centers,
- Manufacturing,
- Testing facilities,
- headquarters office

A	B	C	D	E	F							N
sessionId	kwhTotal	dollars	created	ended	startTime							
1366563	7.78	0	2014-11-18 15:40:26	2014-11-18 17:11:04	1							
3075723	9.74	0	2014-11-19 17:40:26	2014-11-19 19:51:04	1							46
4228788	6.76	0.58	2014-11-21 12:05:46	2014-11-21 16:46:04	12							46
3173284	6.17	0	2014-12-03 19:16:12	2014-12-03 21:02:18	19							46
3266500	0.93	0	2014-12-11 20:56:11	2014-12-11 21:14:06	20							56
4099366	2.14	0	2014-12-12 14:38:44	2014-12-12 15:04:04	14	15					911231	20
5084244	0.3	0	2014-12-12 15:08:40	2014-12-12 15:47:04	15	15					920264	46
2948436	1.82	0	2014-12-17 20:30:25	2014-12-17 21:31:04	20	21	1.010833333	Wed			431796	46
3515913	0.81	0	2014-12-18 17:53:19	2014-12-18 18:04:04	17	18	0.179166667	Thu	android	NA	35897499	134427	62
8490014	1.98	0	2014-12-18 18:06:49	2014-12-18 18:30:05	18	18	0.387777778	Thu	android	NA	35897499	207262	92
7075912	4.56	0	2014-12-18 18:31:54	2014-12-18 20:57:04	18	20	2.419444444	Thu	android	NA	35897499	280221	97
5226095	2.05	0	2014-12-19 14:30:37	2014-12-19 15:12:04	14	15	0.690833333	Fri	android	NA	35897499	371335	46
9342496	5.3	0	2015-01-07 17:52:53	2015-01-07 20:54:03	17	20	3.019444444	Wed	android	NA	35897499	405157	97
1853945	0	0	2015-01-09 13:59:09	2015-01-09 14:21:03	13	14	0.365	Fri	android	NA	35897499	355208	97
2113485	7.85	0.5	2015-01-12 17:39:36	2015-01-12 21:48:04	17	21	4.141111111	Mon	android	NA	35897499	944575	92
7492587	8.49	0	2015-01-16 17:23:35	2015-01-16 19:03:04	17	19	1.658055556	Fri	android	NA	35897499	582873	46
1111437	7.52	0	2015-01-16 19:04:38	2015-01-16 21:14:04	19	21	2.157222222	Fri	android	NA	35897499	500856	97
4716378	5.38	0	2015-01-21 18:01:25	2015-01-21 20:19:04	18	20	2.294166667	Wed	android	NA	35897499	250527	97
4187340	3.42	0	2015-01-29 16:34:34	2015-01-29 17:25:05	16	17	0.841944444	Thu	android	NA	35897499	623134	62
7934936	0.09	0	2015-01-30 18:47:08	2015-01-30 18:49:04	18	18	0.032222222	Fri	android	NA	35897499	801274	97
7073357	12.14	0	2015-01-30 19:50:01	2015-01-30 21:58:04	19	21	2.134166667	Fri	android	NA	35897499	801274	97

Replication Data for: A Field Experiment on Workplace Norms and Electric Vehicle Charging Etiquette

Version 1.0

Asensio, Omar Isaac; Apablaza, Camila Z; Lawson, M. Cade; Walsh, Sarah Elizabeth, 2020, "Replication Data for: A Field Experiment on Workplace Norms and Electric Vehicle Charging Etiquette", https://doi.org/10.7910/DVN/NFPQLW, Harvard Dataverse, V1, UNF:6:yEP3Tbw1njAaGtmlGucEZg== [fileUNF]

Cite Dataset ▾ Learn about Data Citation Standards.

Description This dataset contains information from 3,395 high resolution electric vehicle charging sessions. The data contains sessions from 85 EV drivers with repeat usage at 105 stations across 25 sites at a workplace charging program. The workplace locations include facilities such as research and innovation centers, manufacturing, testing facilities and office headquarters for a firm participating in the U.S. Department of Energy (DOE) workplace charging challenge. The data is in a human and machine readable *.CSV format. The resolution of the data is to the nearest second, which is the same resolution as used in the analysis of the paper. It is directly importable into free software. (2020-07-30)

Subject Business and Management; Earth and Environmental Sciences; Engineering; Social Sciences

Notes The code, data definitions and protocols for scientific replication have been deposited to the Github repository https://github.com/asensio-lab/workplace-charging-experiment

License/Data Use Agreement

Detail Compact Column 10 of 24 columns

About this file

This dataset contains information from 3,395 high resolution electric vehicle charging sessions. The data contains sessions from 85 EV drivers with repeat usage at 105 stations across 25 sites at a workplace charging program. The workplace locations include facilities such as research and innovation centers, manufacturing, testing facilities and office headquarters for a firm participating in the U.S. Department of Energy (DOE) workplace charging challenge. The data is in a human and machine readable *.CSV format. The resolution of the data is to the nearest second, which is the same resolution as used in the analysis of the paper.

sessionId	kwhTotal	dollars	created	ended	startTi
Charging session ID	Total energy use (kWh)	Amount paid by user (USD)	Charge start date and time (00YY-MM-DD HH:MM:SS)	Charge end date and time (00YY-MM-DD HH:MM:SS)	Charge st time)
1.00m 10.00m	0 23.7	0 7.5	Invalid date Invalid date	Invalid date Invalid date	0
1366563	7.78	0	0014-11-18 15:40:26	0014-11-18 17:11:04	15
3075723	9.74	0	0014-11-19 17:40:26	0014-11-19 19:51:04	17
4228788	6.76	0.58	0014-11-21 12:05:46	0014-11-21 16:46:04	12
3173284	6.17	0	0014-12-03 19:16:12	0014-12-03 21:02:18	19
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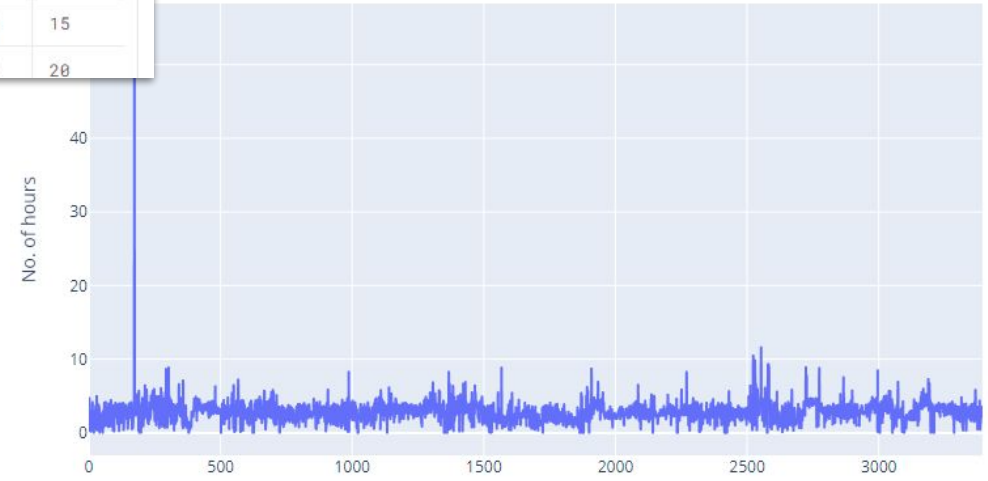
4099366	2.14	0	0014-12-12 14:38:44	0014-12-12 15:04:04	14
5084244	0.3	0	0014-12-12 15:08:40	0014-12-12 15:47:04	15
2948436	1.82	0	0014-12-17 20:30:25	0014-12-17 21:31:04	20

```
df,
x="Events",
y="chargeTimeHrs",
labels = {"Events" : "EV Charging instances", "chargeTimeHrs" : "No. of hours"},
title='Time consumed for EV Charging (hrs)')
```

Power c
Time co
Average

med for EV Charging (hrs)



Cleaning

- **Modify original dataframe:**
  - Drop certain columns “each day”
  - Create new column “facility type : office, manufacturing and R&D”

- **Modify columns**
  - ‘ weekdays' to 'day’
  - 'chargeTimeHrs' to 'Charge Time (h)’
  - 'facilityType' into values corresponding facility type.
  - Clean any other text artifacts.

- **Round floats to two decimals.**
- **New “Facility Name” column**

Projected visualizations

- **Per session Average charge duration per session**
  - Average charge duration per session according to week day
  - Average charge cost per session
  - Average charge power consumption per session

- **Per day / time Average number of charge sessions per week day**
  - Average time of charging sessions per week day (7 chars)
  - Average charge start time according to day
  - Average end charge time according to day

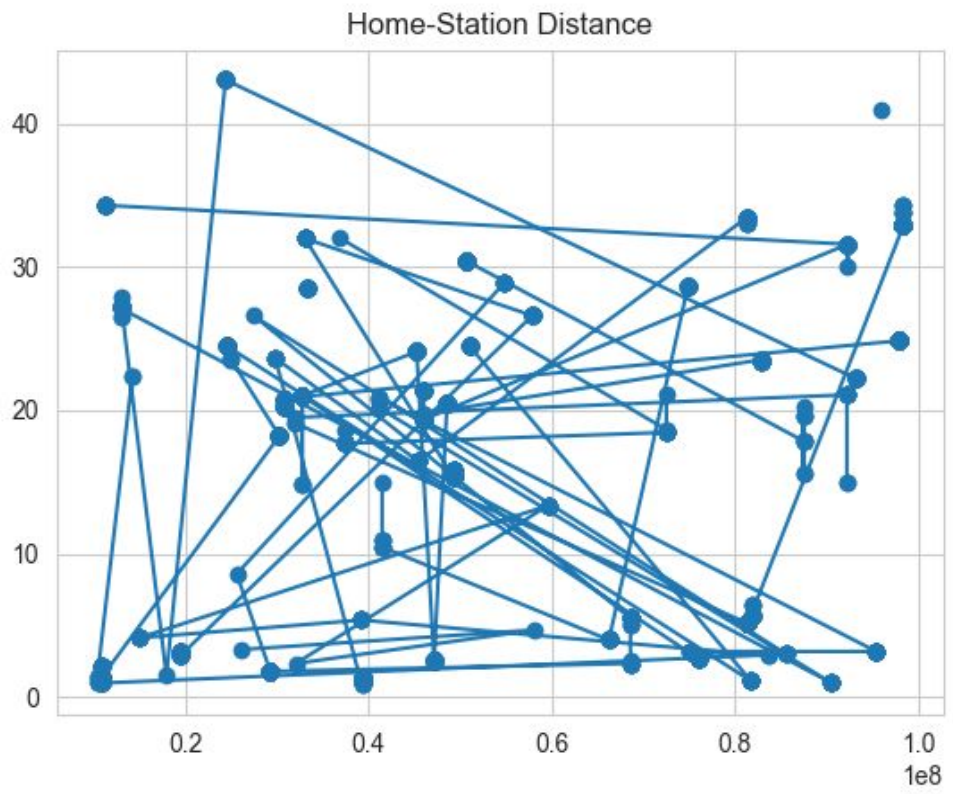
- **Per location Frequency of use of a specific charging location according to userId => hist**
  - Frequency of use of a specific charging location over time => line chart
  - Distribution stationId according to locationId => radar chart ?
  - Overall Average time of charging sessions

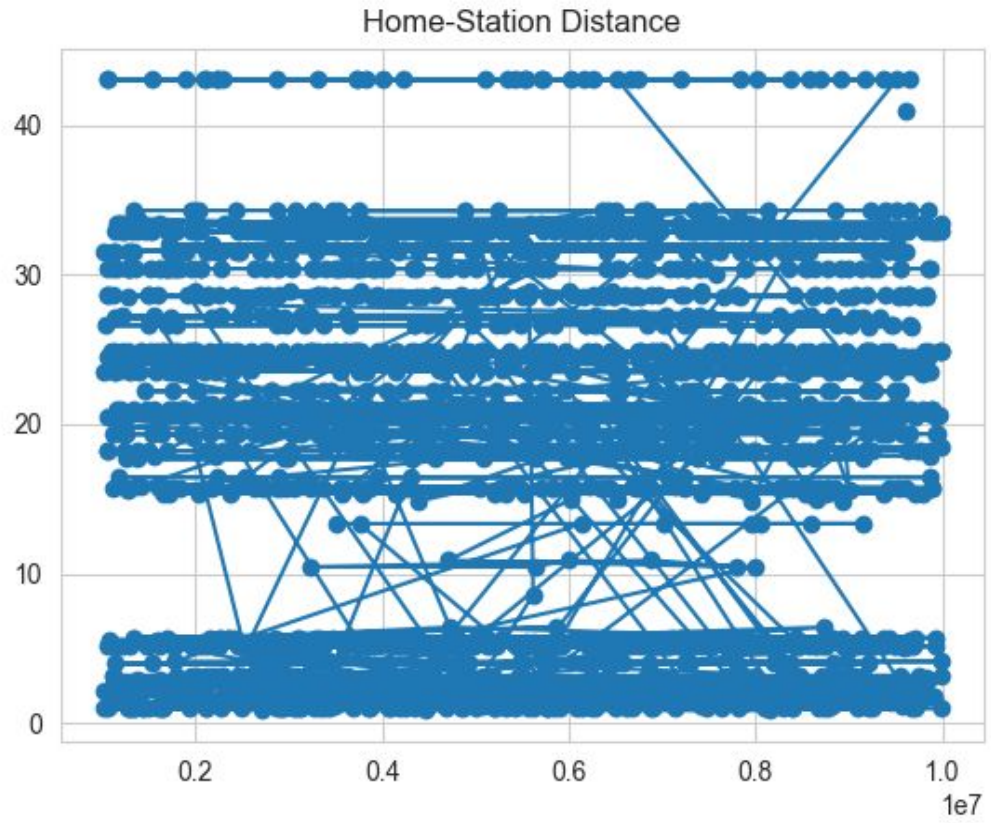
- **Repartition of platform used (Ios, Android, Other) on overall charge sessions => pie chart**
- **Fluctuation of energy consumption on the period (data description says period =) !!**

Challenges:

Exhibit A

- Review the number and the intricacy of visualizations according to time and technical limits.
- Still maintain relevance and volume to draw insights on the data.





Challenges:

Pricing discrepancies.

- Between charge time and cost
- Between cost and platform used to report data

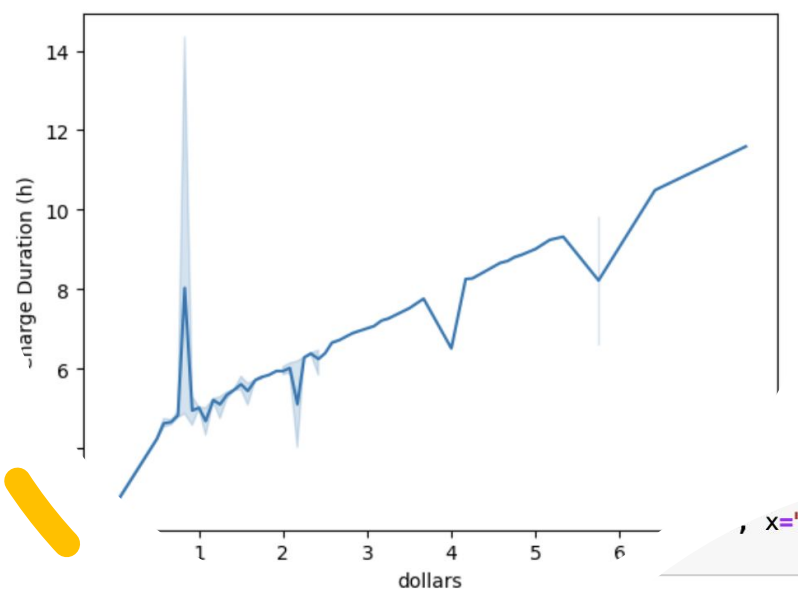
Further analysis or data collection needed to decipher the correlation and causality between those factors.

Further challenges:

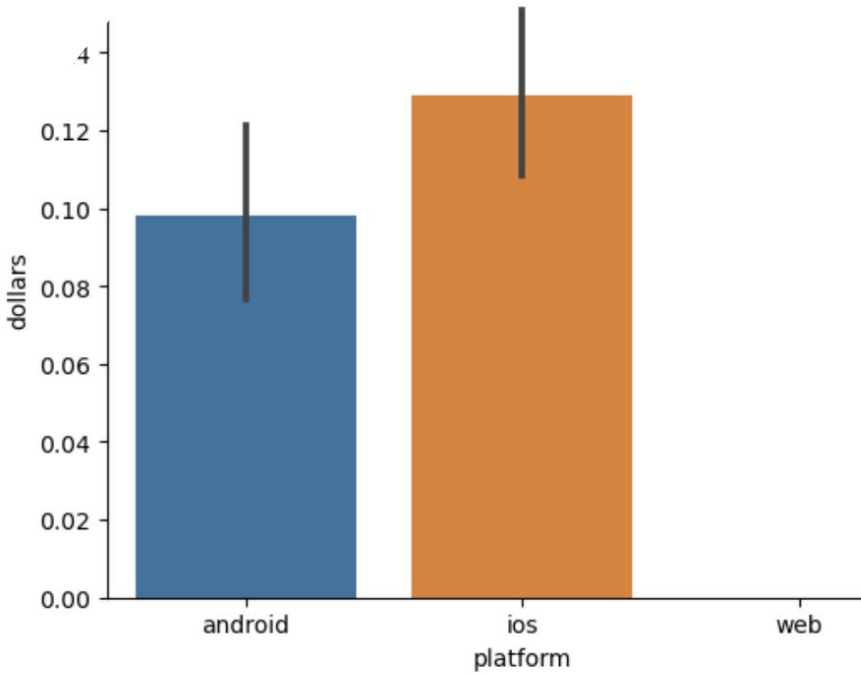
- Extracting new data from existing dataset
- Explaining outliers and anomalies

Exhibit B

```
neplot(data=df, x="dollars", y="Charge Duration (h)")
now()
```




```
, x="platform", y='dollars') # C
```



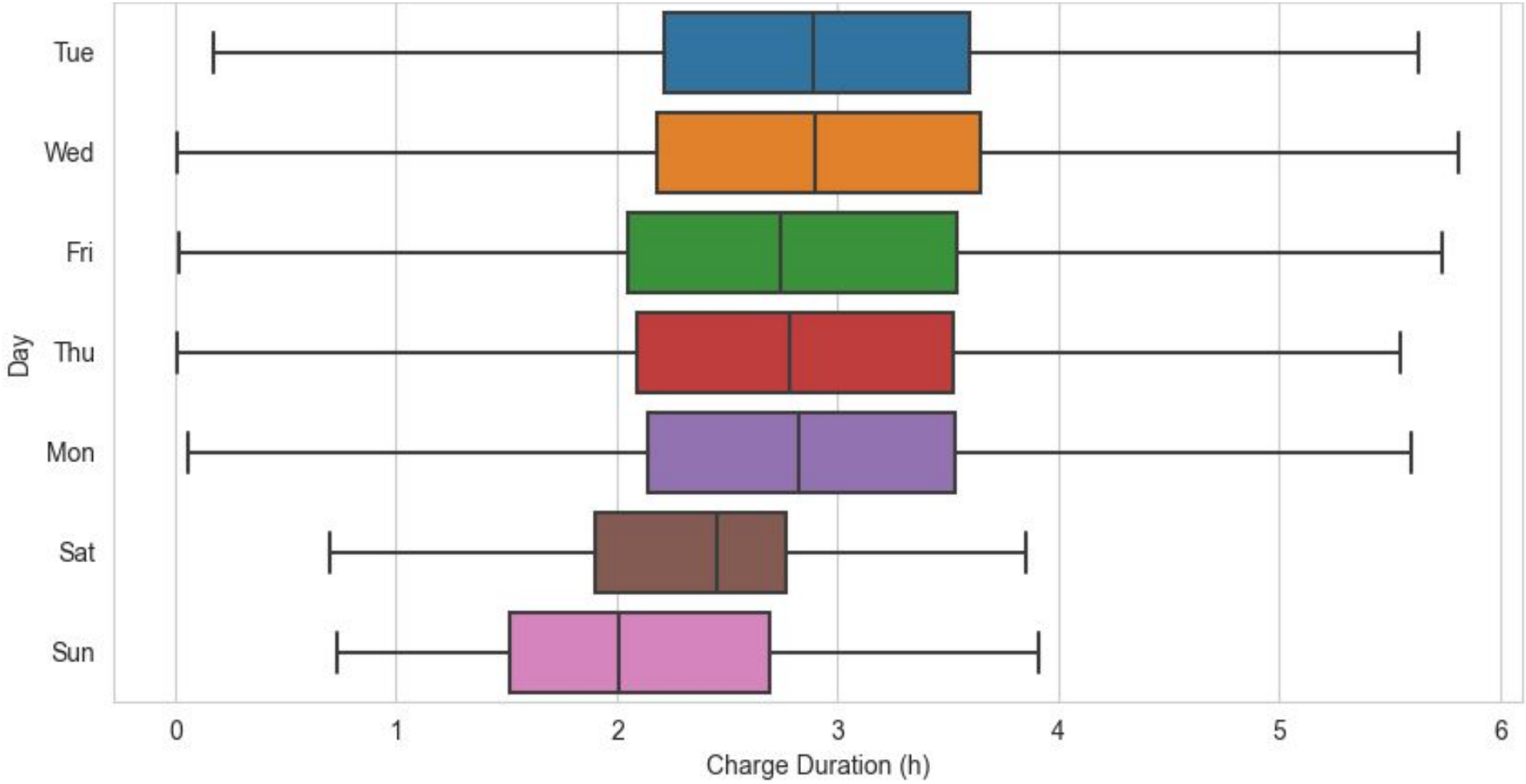
Insights & visualizations

Average Charging Duration per Day

Average charge duration is longer on weekdays than on weekends.

Since the average charge duration is around 2.8-3 hours, we can emit the following hypotheses, to be confirmed through further research:

- Most users charge their vehicles only during half the day.
- The outlier values create the impression that average charge duration is 2.8-3 hours, but that might not reflect reality. Some users might not charge at the office at all, whilst others might charge the whole day.



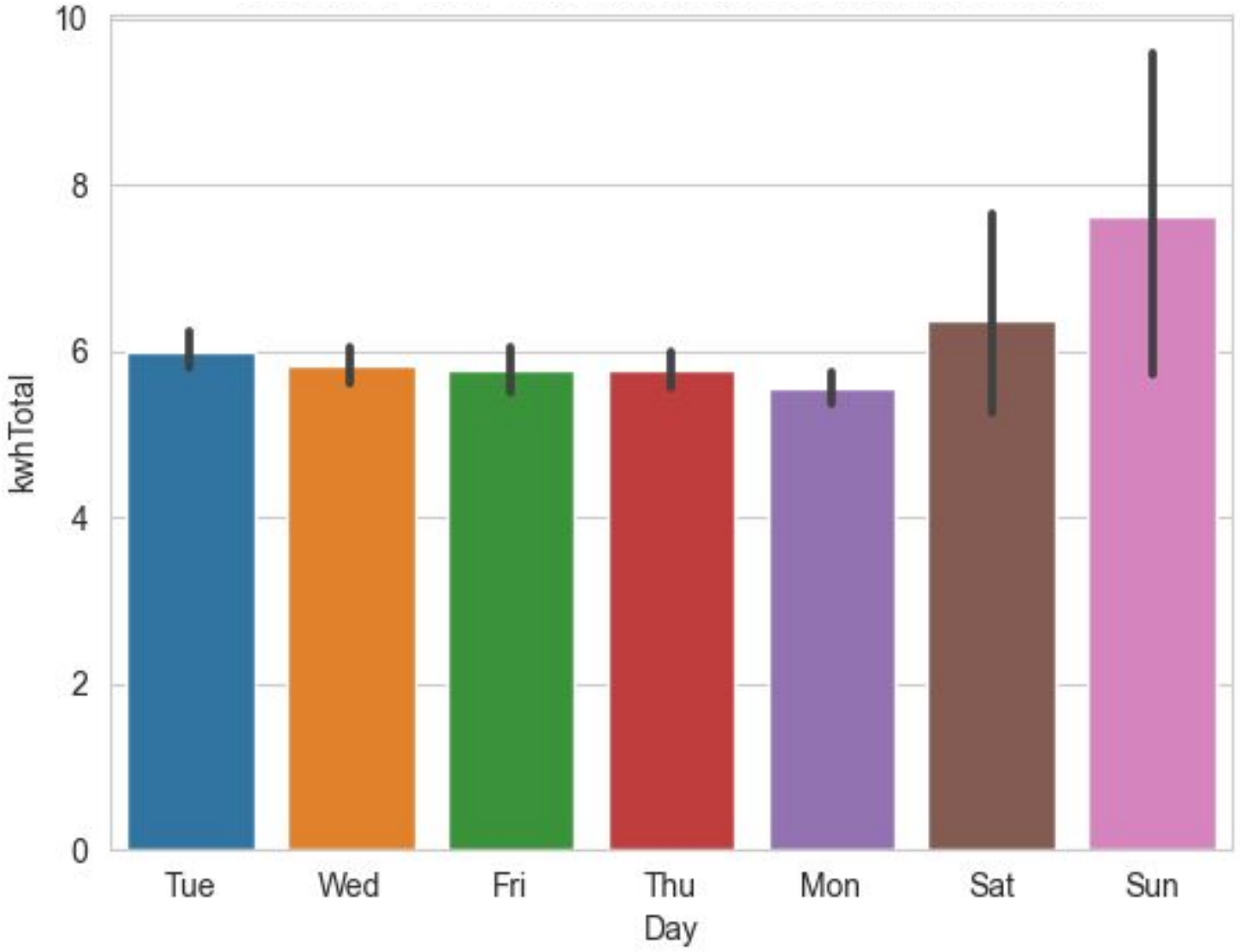
Average Consumption per Day

Although the charging time is much shorter on weekends, the users who do charge on weekends consum more power than those charging during the week.

Here are some thoughts, to be confirmed or negated with further analysis:

- Vehicles charging on weekends are lower on battery, perhaps due to the users only charging on weekend and therefore needing more power since they have used their vehicle all week long.

- Users who charge their vehicles at the office during weekdays consum less power during charge because they charge their vehicles more regularly.
  This could be an automatism due to their routine upon arrival at the office.



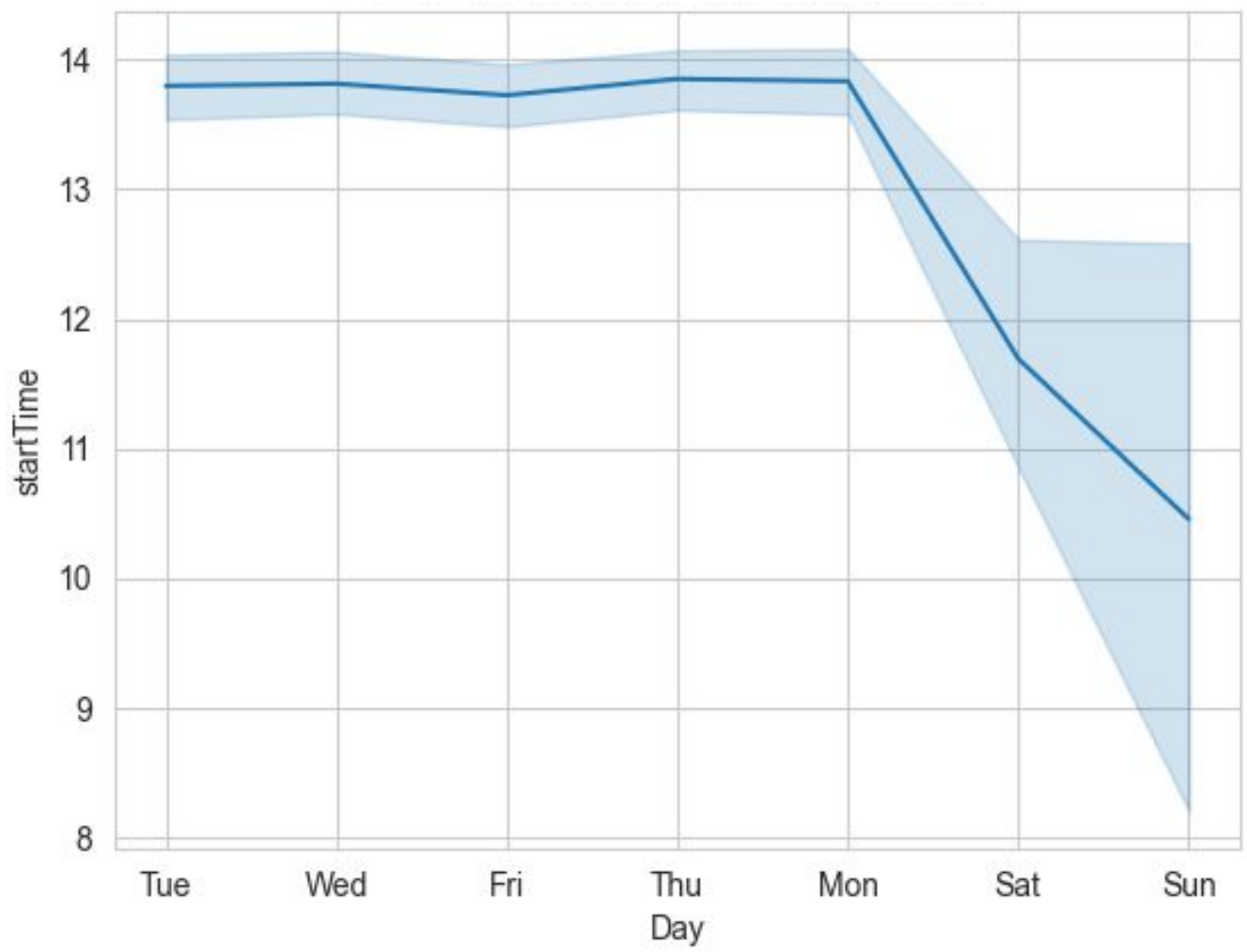
Charge Start time per day

The appended line chart mitigates some of the previous hypotheses by revealing the most common charging start time on a given day, on average.

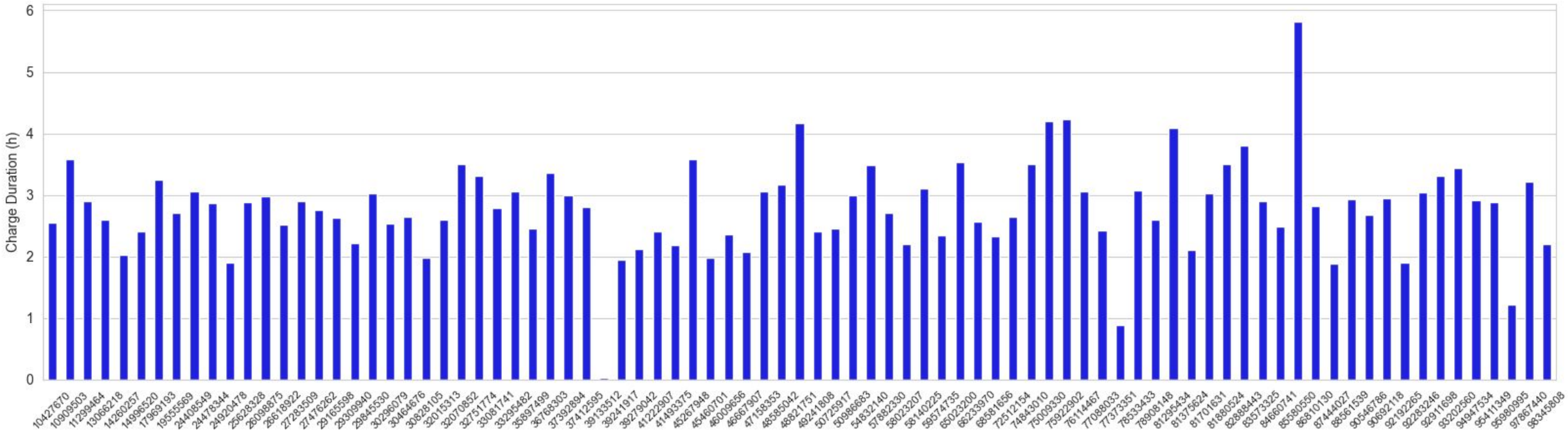
It seems most users charge their vehicles in the afternoon, sometime after lunch break.

Further analysis and user survey is necessary to understand what explains this trend.

Later charging time in the weekend might be explained by a later arrival at the workplace.



Average Charge Duration per User



Above are represented the average charge duration per user.

Although a superimposed line-chart of the overall average would have been keen, it is visible that most users charge between 2 & 3 hours per charge session on average, according to the total of their charging sessions.

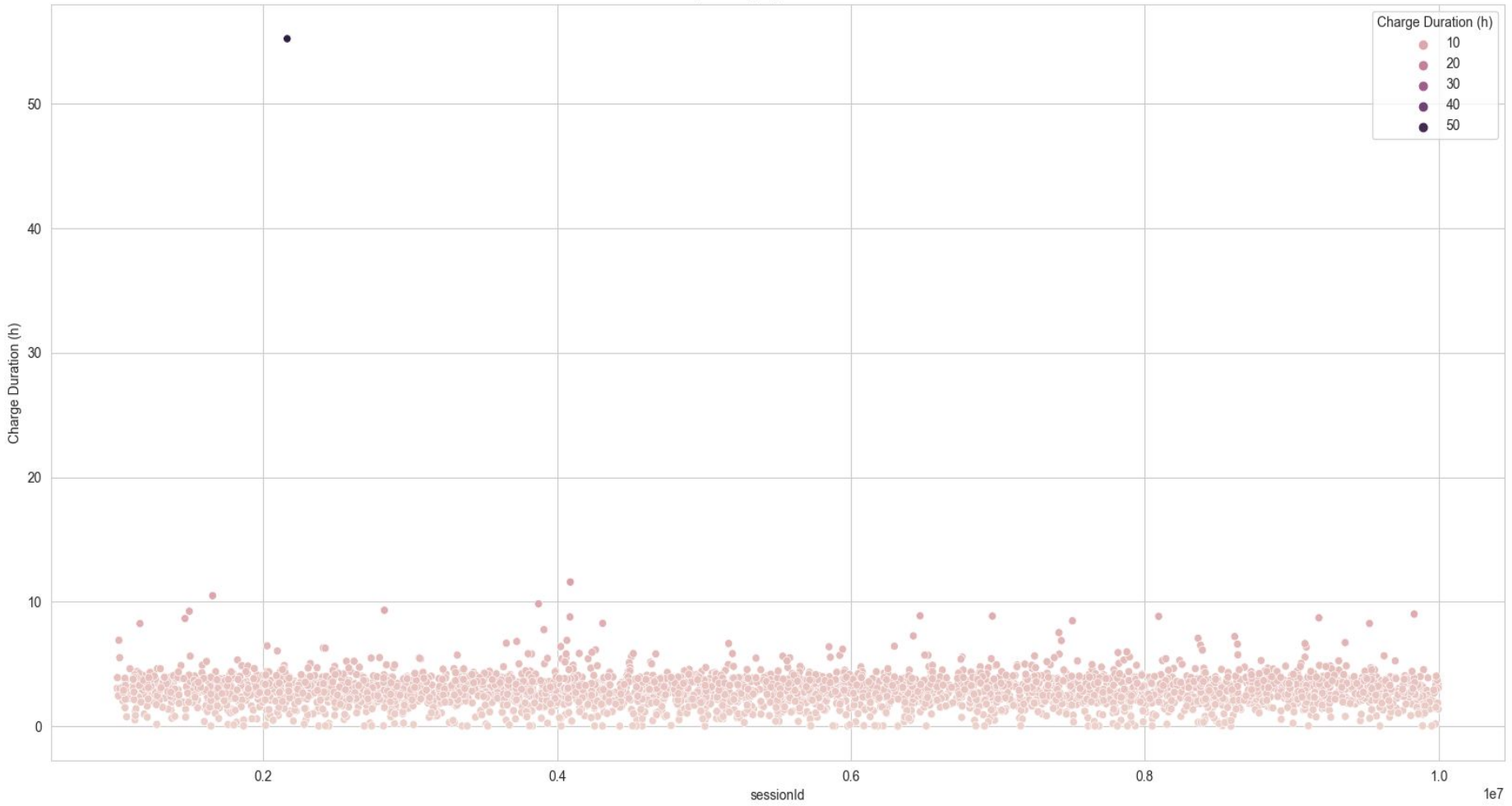
Noticeably low or high values could be explained by specific or exceptional users' situation on the period.

Average Charging Session Duration

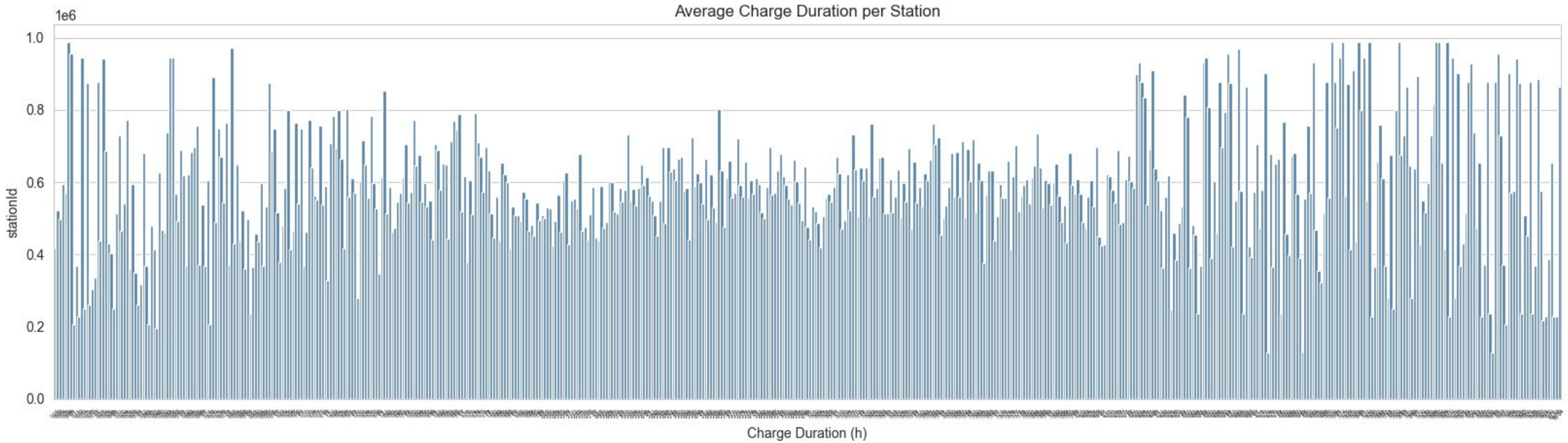
This charts the average charge duration per sessions.

A noticeable outlier has a 50h+ charge time. Perhaps due to a bug or a user having left their vehicle on the charge station.

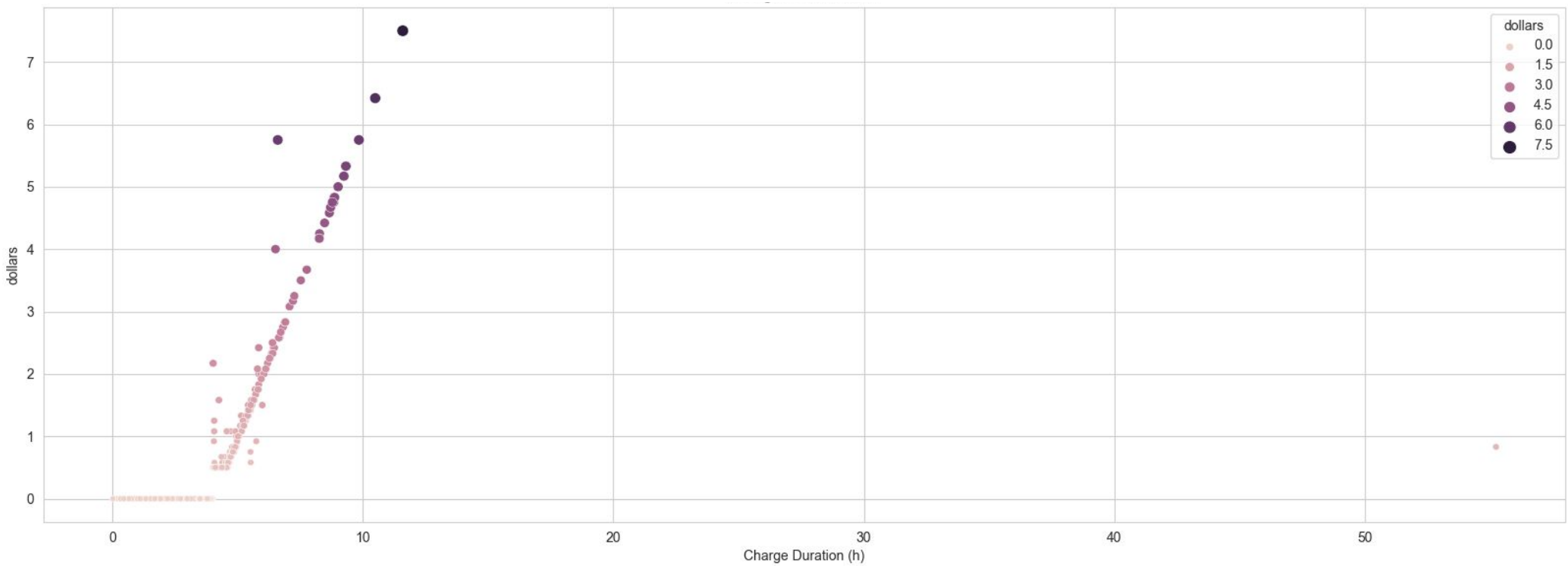
- Charge session durations are fairly evenly distributed.
- Charge sessions with a duration of “0” can not be considered as charge sessions. Perhaps the users plugged in their vehicles but those were already fully charged.



Average Charge Time per Station



Charge time vs cost



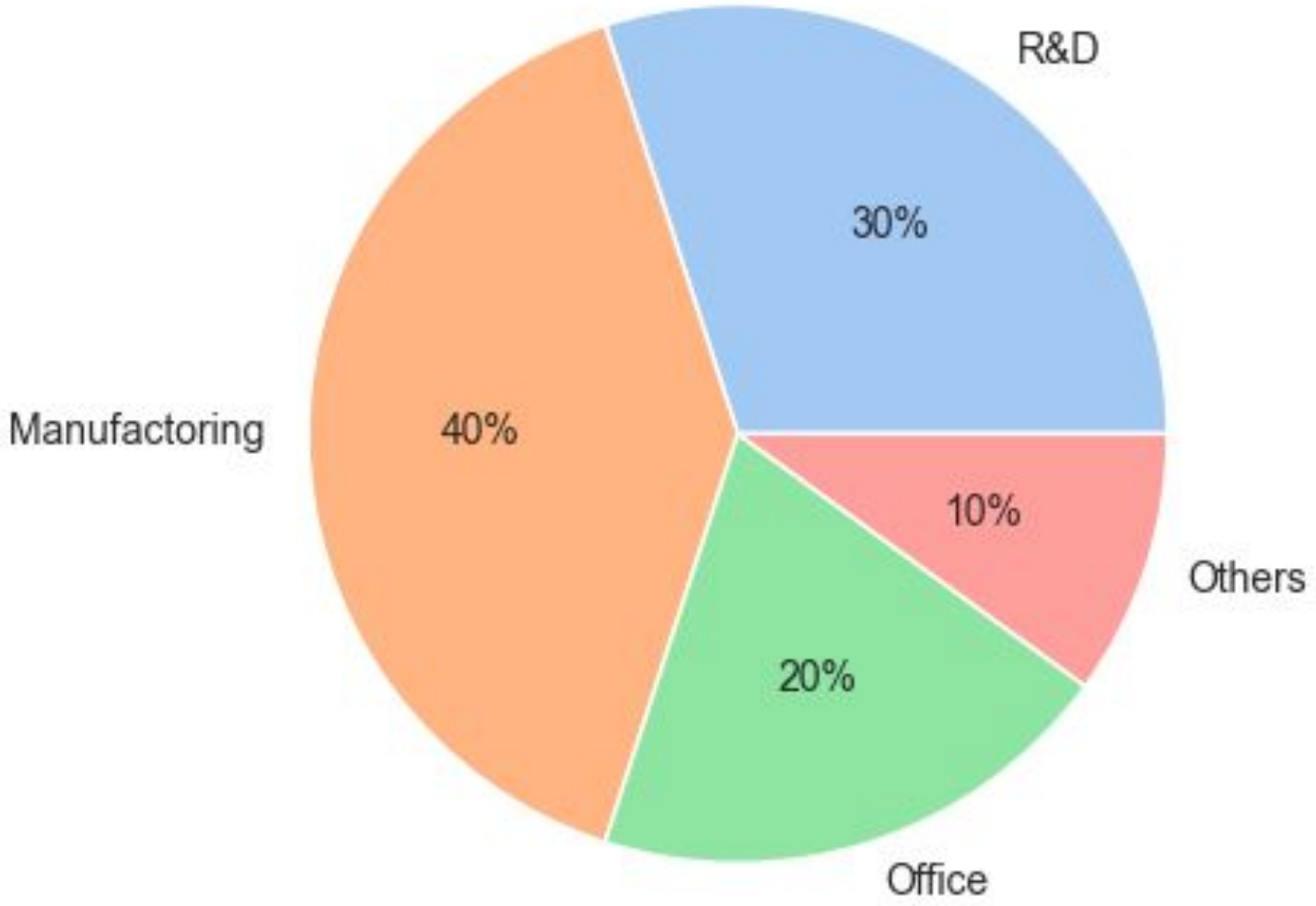
As we noticed earlier, there were some questions regarding the cost of charging, and some discrepancies between the duration and cost.

To single out a working hypothesis we could dive deeper into the cost of charging per station and compare.
Between different charging start time.
And to have more precise analysis, we should bring in the fluctuation of electricity cost over the period, which could explain some outliers and seeming anomalies.

Facility Type Repartition

The distribution of the number of charging sessions per facility is dominated by R&D and manufacturing facilities.

To better grasp the weight of this distribution, complementary data such as the number of employees using electric vehicles, and the total employees at each facility type would have to be collected.



Conclusions

Conclusions

- Electric vehicle charging at the workplace seems to respect a certain etiquette as **outliers are rare** and apart. These could also be explained by exceptional user situations

- **A comparison between at home charging habits** would help draw out these unspoken (if they are so) rules about vehicle charging at the workplace.

Extra toughts

The dataset, although quite clean and thorough, is **missing complementary information** to draw solid insights.

A **longer time frame** would have allowed us to draw more data from the existing (for example deduce at which facility does a certain employee work by his most used charging station), and refine our insights.

The produced plots give a certain amount of insight and information, yet they are **to be completed with further plotting and analysis.**