Analysis of electric vehicle usage patterns in New Zealand

Summary Statistical Report

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Contents

1 Note

Based on and inspired by the UK DoT statistical report 2018.

This is a summary report. A discussion into the background around the effects of EV charging in New Zealand, as well as detailed information on data limitations and data cleaning procedure is given in the full report.

2 Data information

2.1 Background

The data consisted of 1291881 data points (of which 790391 were charging (power demand > 0)) from 50 vehicles over 8 months (April 2018 - January 2019) derived from FlipTheFleet's blackbox recorder. The recorder provided measurements at 1 minute frequency of charging behaviour and battery charge state.

Due to privacy considerations, the data is not publically available.

2.2 Definitions:

The capacity of most domestic charging is between 1.8kW to 7kW, whereas charging power above 7kW is available at purpose-built charging stations[@concept2018]. Each charging event was therefore seperated into "Fast" (> = 7kW) and "Standard" (below 7kW).

A charging event was defined as a continuous sequence of 1 minute observations per vehicle when > 0 kW of demand was observed.

2.3 Cleaning and Preparation

Perhaps for the summary report this entire subsection could be removed? There were 6 vehicles within the provided data that had no recorded charging occur. These were immediately discarded.

Some instances of charging power greater than 120kW were recorded. These were considered anomolies and discarded, as these exceed the capacity of the highest charging stations available in New Zealand[concept2018].

Instances of battery state of charge being greater than 100% or less than 0% were also discarded.

Standard charge durations of less than 8 minutes were frequently encountered near the end of a longer charging cycle, where the state of charge had reached it's maximum. These were assumed to be minor 'top-ups', and were discarded. In addition, slow charging events greater than 100 hours were discarded, as were fast charge durations greater than 14 hours. These were presumed anomolies as they exceed the battery capacity of electric vehicles commonly encountered in New Zealand.

For more detailed information on the data cleaning process refer to the main report.

3 Key Findings:

- *Power supplied*: The median power supplied during a standard charging was 1.78 kW. The mean was slightly higher at 2.12 kW. Fast charging observations had a higher median of 30.84 kW (mean = 30.68);
- *Charging duration*: Charging durations tended to fall into one of two groups - longer 'overnight' charges with a median of XX hours and shorter events during the day both at standard and fast charge rates with a median duration of XX hours.
- *Time of Day*: charging events were more frequent at specific times of the day and day of the week with more evening and over-night charging during weekdays and more day-time charging at weekends. The power demand also varied according to time of day and day of the week.

4 Observed demand

Figure 1 shows the distribution of observed charging kW demand by inferred charge type. This plot shows that fast charges are relatively rare in the dataset whilst standard charges are much more common, and are concentrated around 1.8kW, 3kW and 6kW.

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

75% of standard charging observations were 1.47 kW or more but the figure was 20.28 kW or more for fast charging

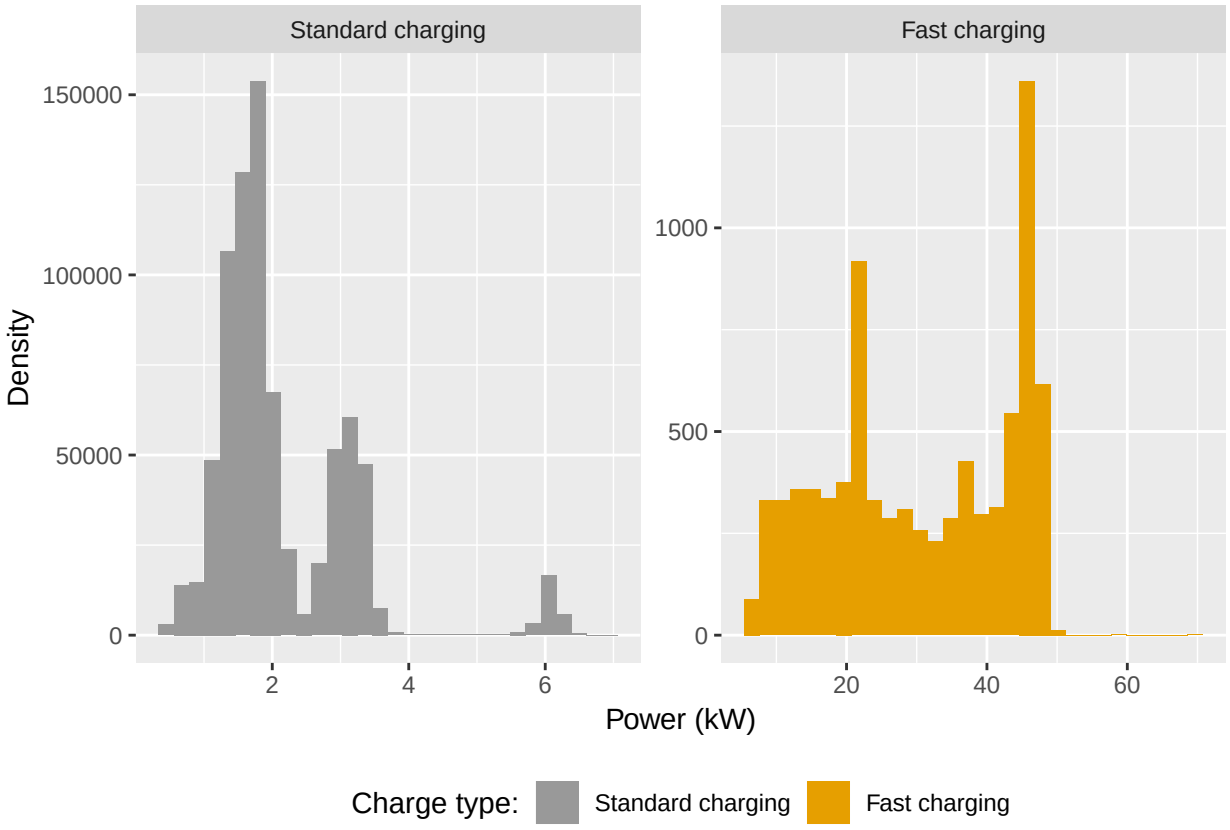

Figure 1: Observed power demand distribution by charge type

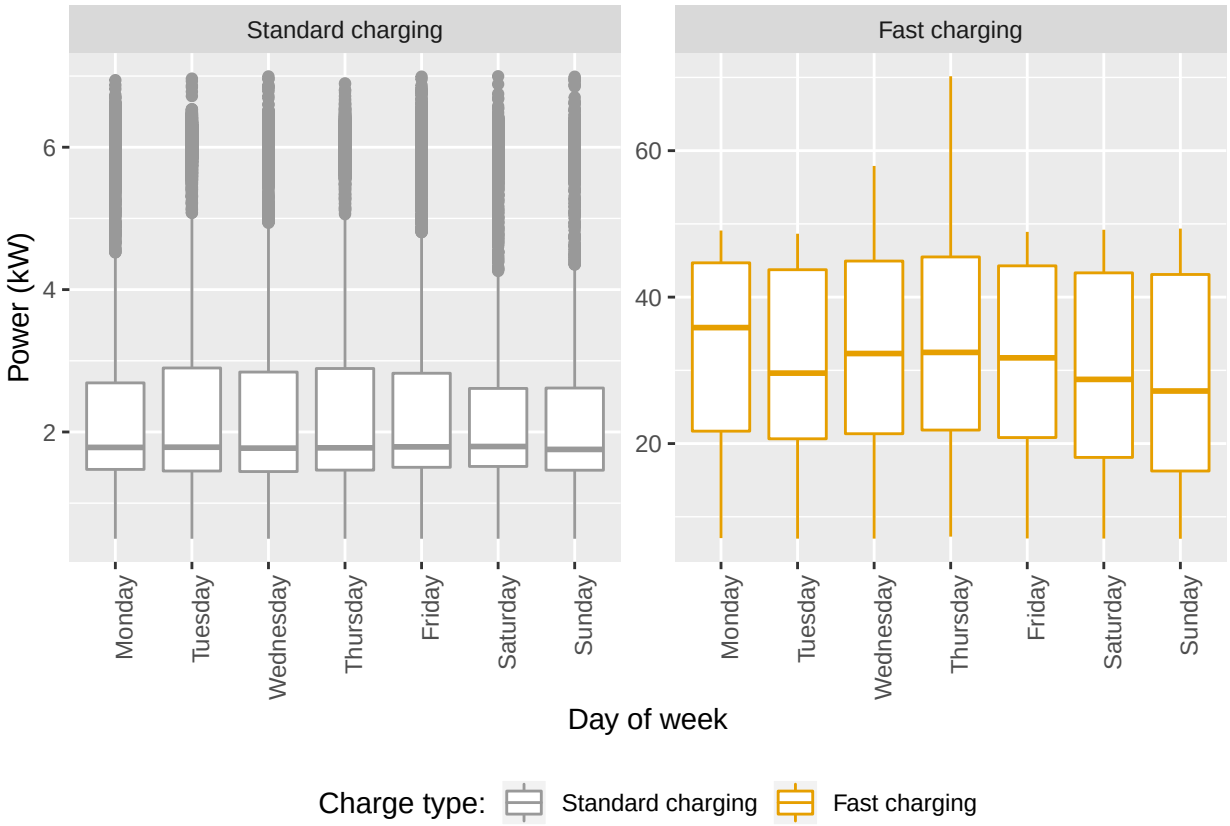

Figure 2: Observed power demand distribution by day of the week and charge type

Table 1: Duration (minutes) of charge sequences by charge type

chargeType	N	mean	median	min	max
Standard charging	2860	244.01	208.65	8.02	1616.72
Fast charging	277	17.74	15.50	8.05	80.27

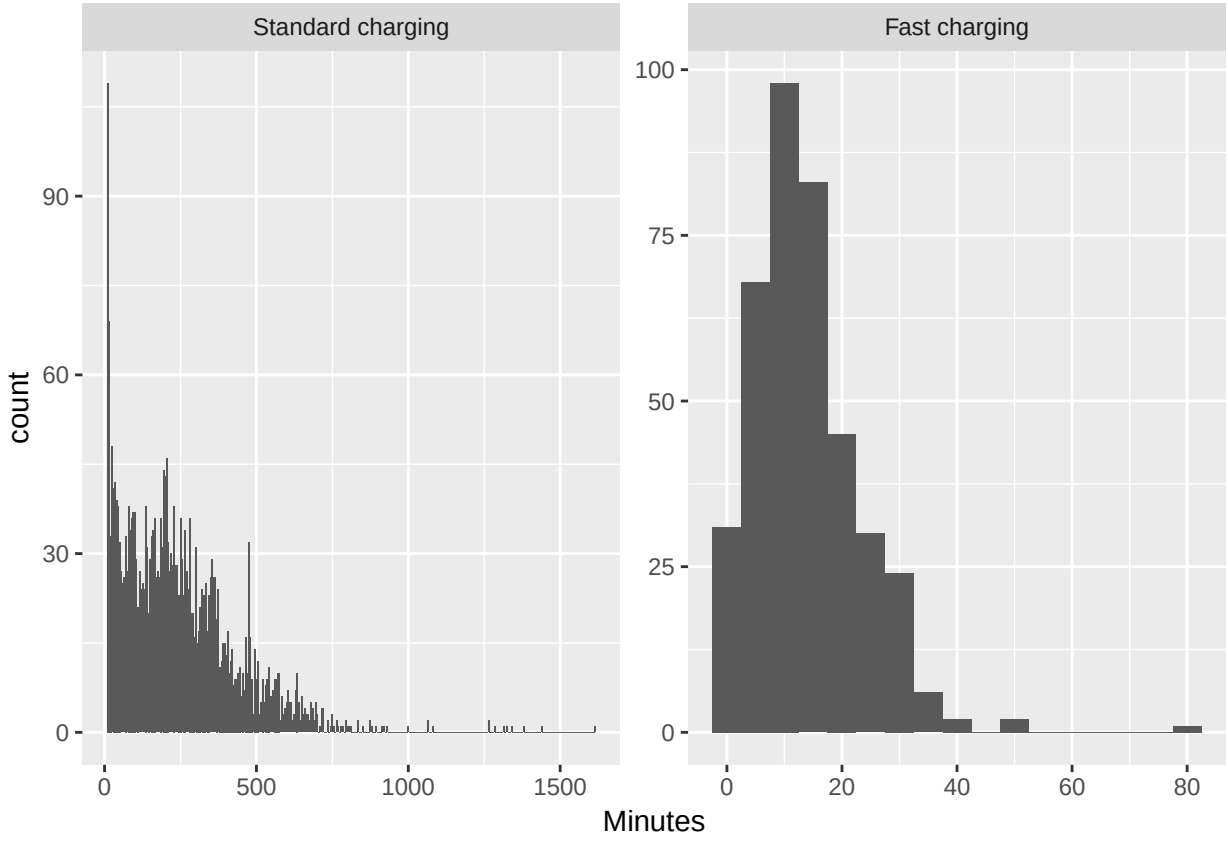

Figure 3: Duration of charging sequences

5 Daily demand

Figure 2 shows the distribution of observed charging kW demand by day of the week. We can see that fast charging varies in demand but standard charging is relatively constant across days.

6 Charging duration

Figure 3 shows the overall distribution of charging sequences. As would be expected, fast charging events tend to have a much shorted duration than standard charging.

7 Time of charging

Figure 6 shows the distribution of observed charging by time of day and day of the week. Aggregating counts in this way emphasises the times at which charging most commonly occurs and we can see...

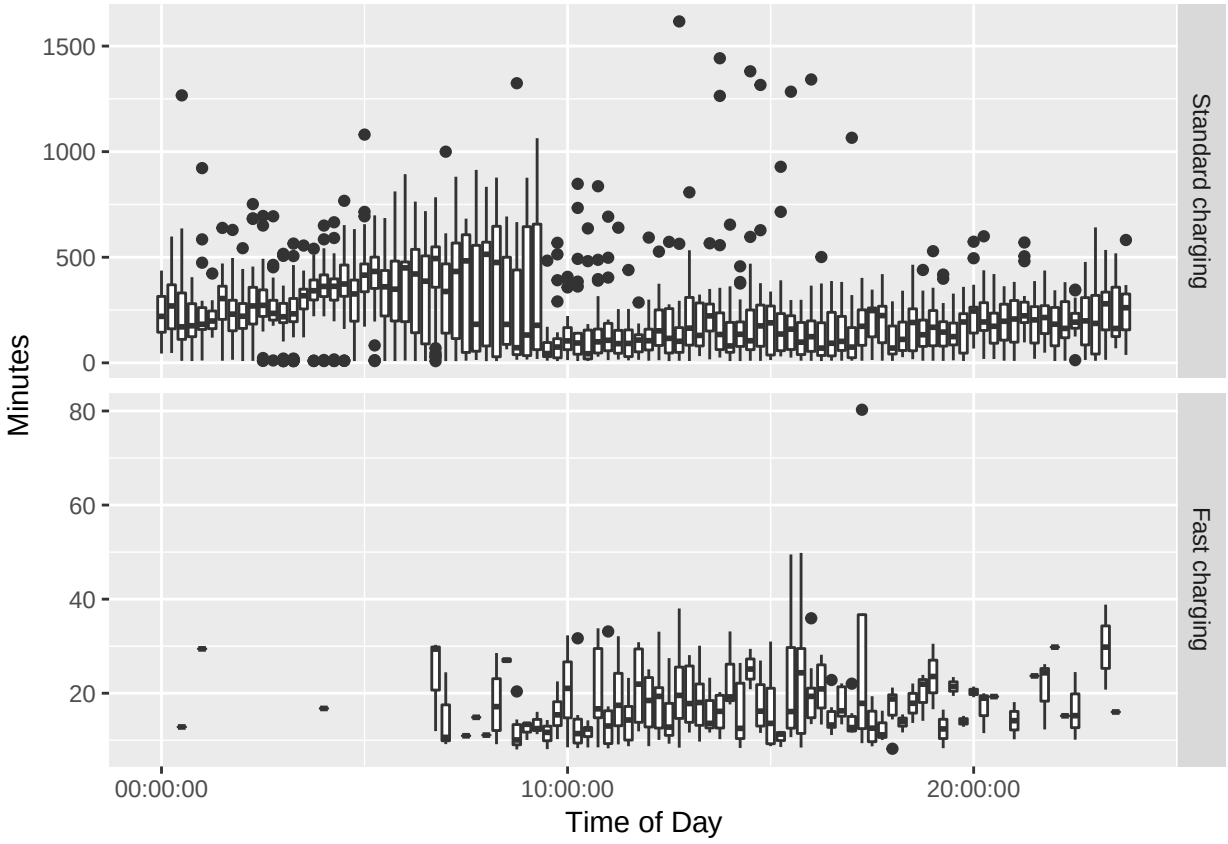

Figure 4: Duration by time of charging start for sequences > 8 minutes

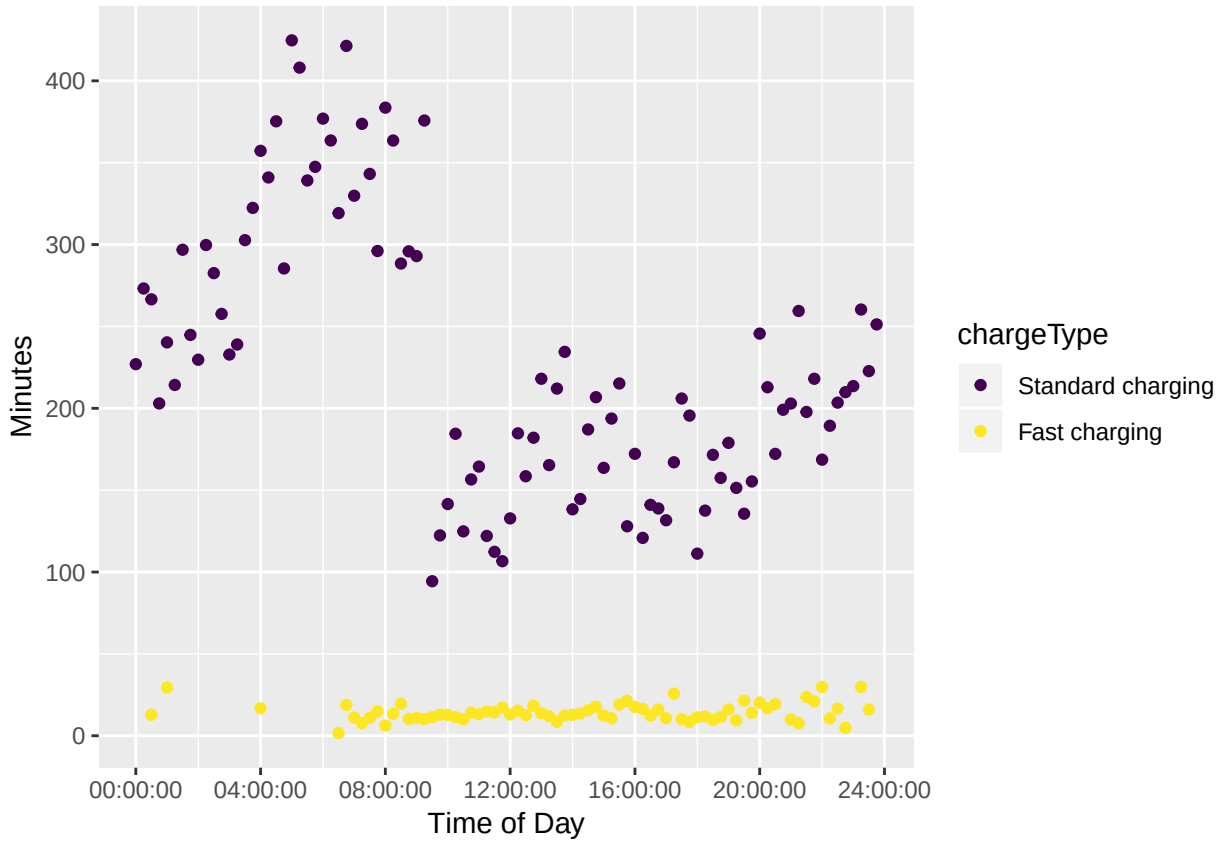

Figure 5: Mean duration (within quarter hours) by time of charging start for sequences > 8 minutes

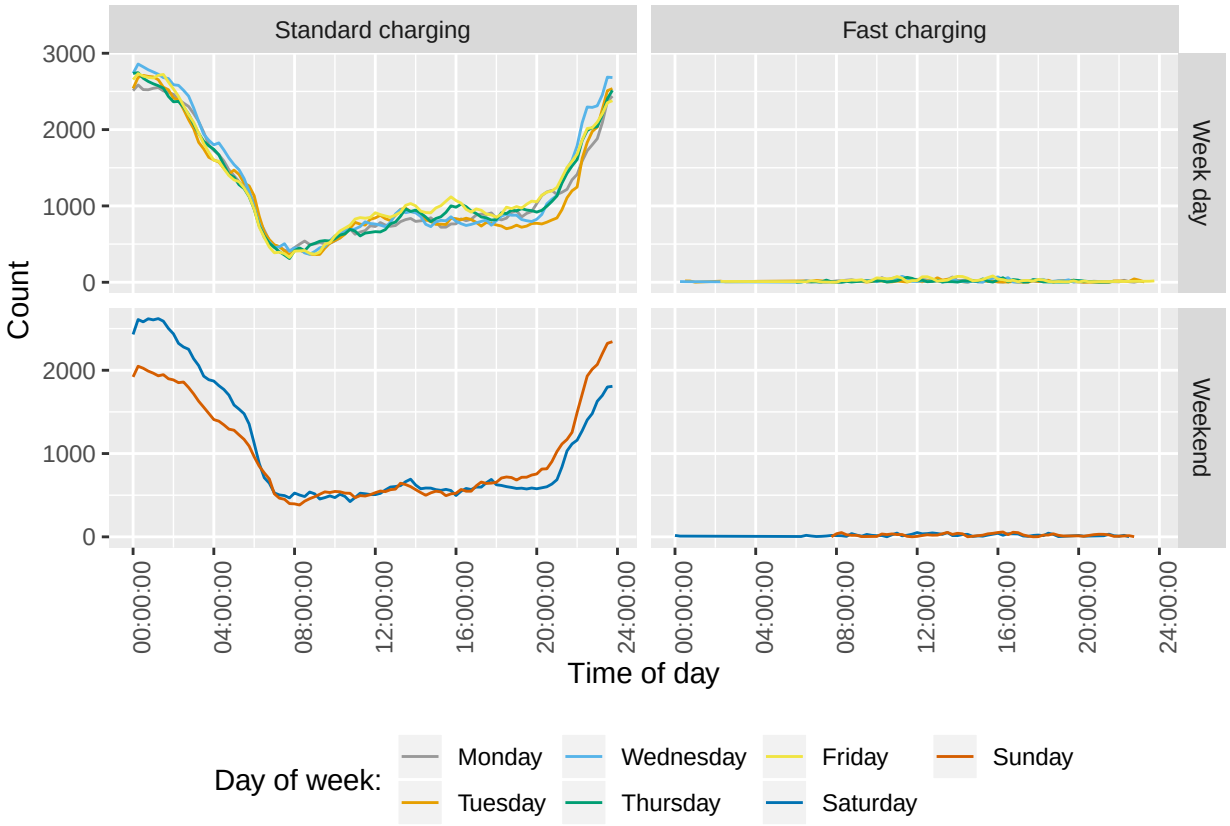

Figure 6: Count of observed charging events by type, day of week and time

Table 2: Mean duration of charge events by charge type

chargeType	N	mean	median	min	max
Standard charging	2860	244.00682	208.65	8.016667	1616.71667
Fast charging	277	17.73694	15.50	8.050000	80.26667

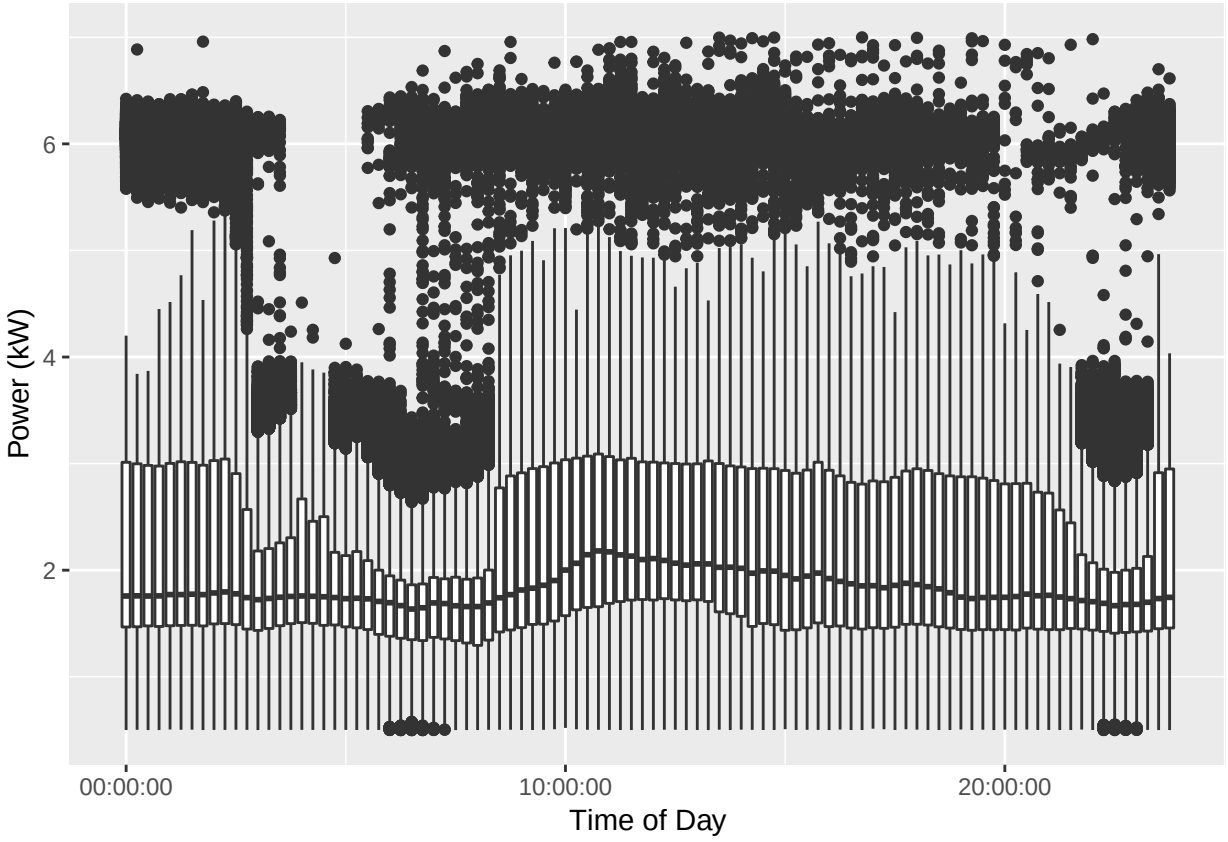

Figure 7: Boxplot of daily standard charging demand

Fig: profile of median charging demand by time of day and day of the week faceted by at home vs not at home

Charging demand varies somewhat by time of day and day of the week. Weekdays show ... whilst weekends show. Saturdays and Sundays vary with...

```
## <ggproto object: Class FacetGrid, Facet, gg>
##     compute_layout: function
##     draw_back: function
##     draw_front: function
##     draw_labels: function
##     draw_panels: function
##     finish_data: function
##     init_scales: function
##     map_data: function
##     params: list
##     setup_data: function
##     setup_params: function
##     shrink: TRUE
```

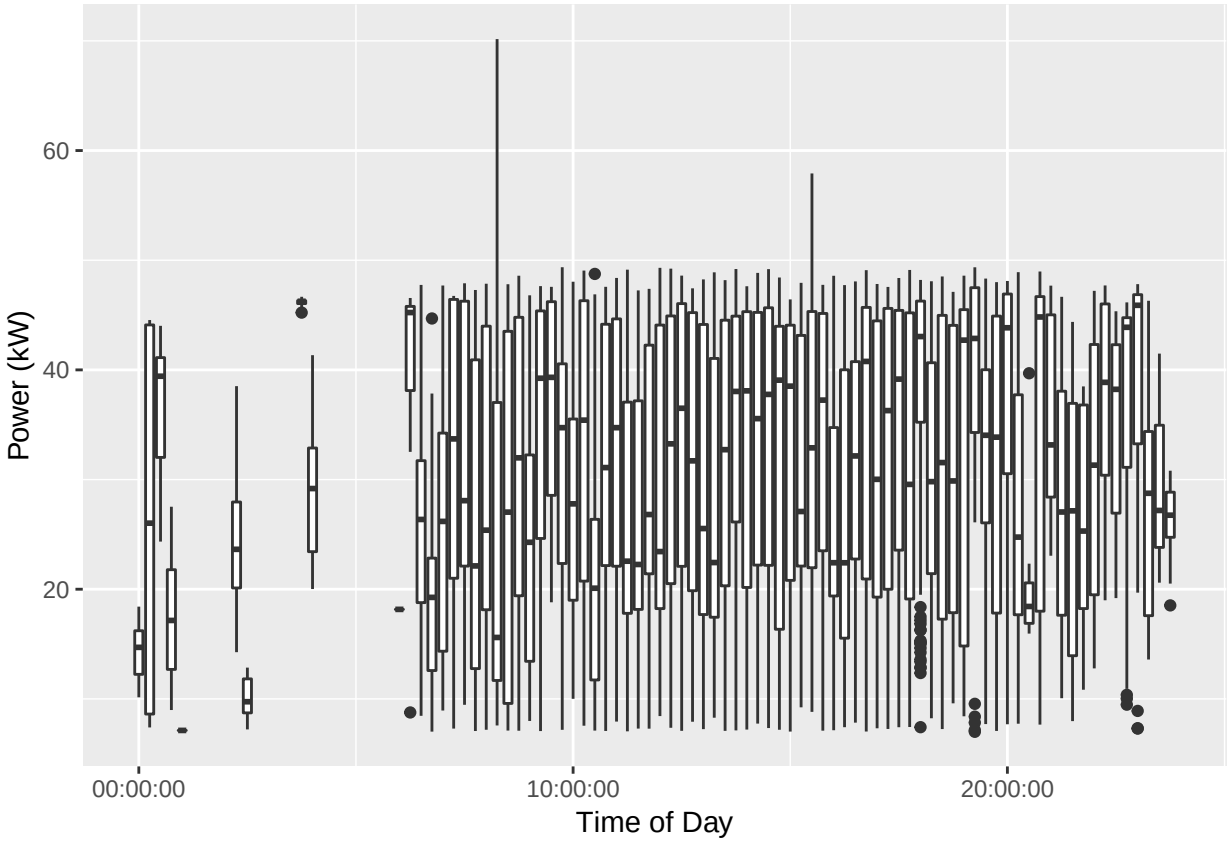

Figure 8: Boxplot of daily fast charging demand

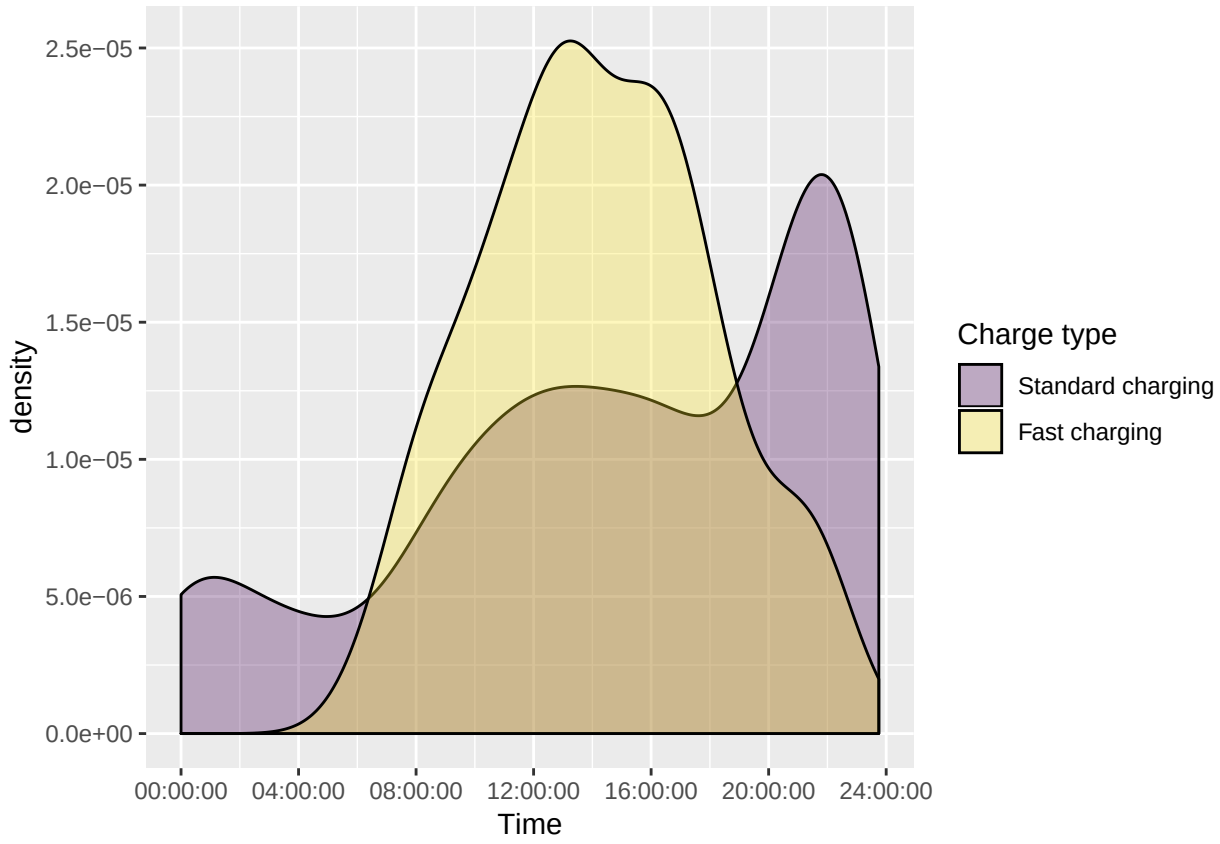

Figure 9: Density plot of charging start times during weekdays

```
##     train_scales: function
##     vars: function
##     super:  <ggproto object: Class FacetGrid, Facet, gg>
```

Standard charging events tended to begin at HH:MM during weekdays and HH:MM at weekends.

Standard charging has a noticeably different profile to charging patterns for fast charges. It suggests that it is common for plug-in vehicle owners to charge overnight at home, and perhaps use the more powerful public chargepoints to top up during the day.

Discuss any other patterns

8 State of charge

The duration of charging events (see Section 6) suggests that EVs may be 'plugged in' at home (and elsewhere) for considerable durations.

```
## Saving 6.5 x 4.5 in image
```

Figure 11 shows that many vehicles arrive home with greater than 50% charge remaining and would therefore be able to transfer energy to the home during the evening grid peak as a form of demand response.

Fig: Mean state of battery charge at the first 'at home' charging observation by hour and day of the week *No "at home" data with SOC*

should show the timing of 'coming home' battery state?

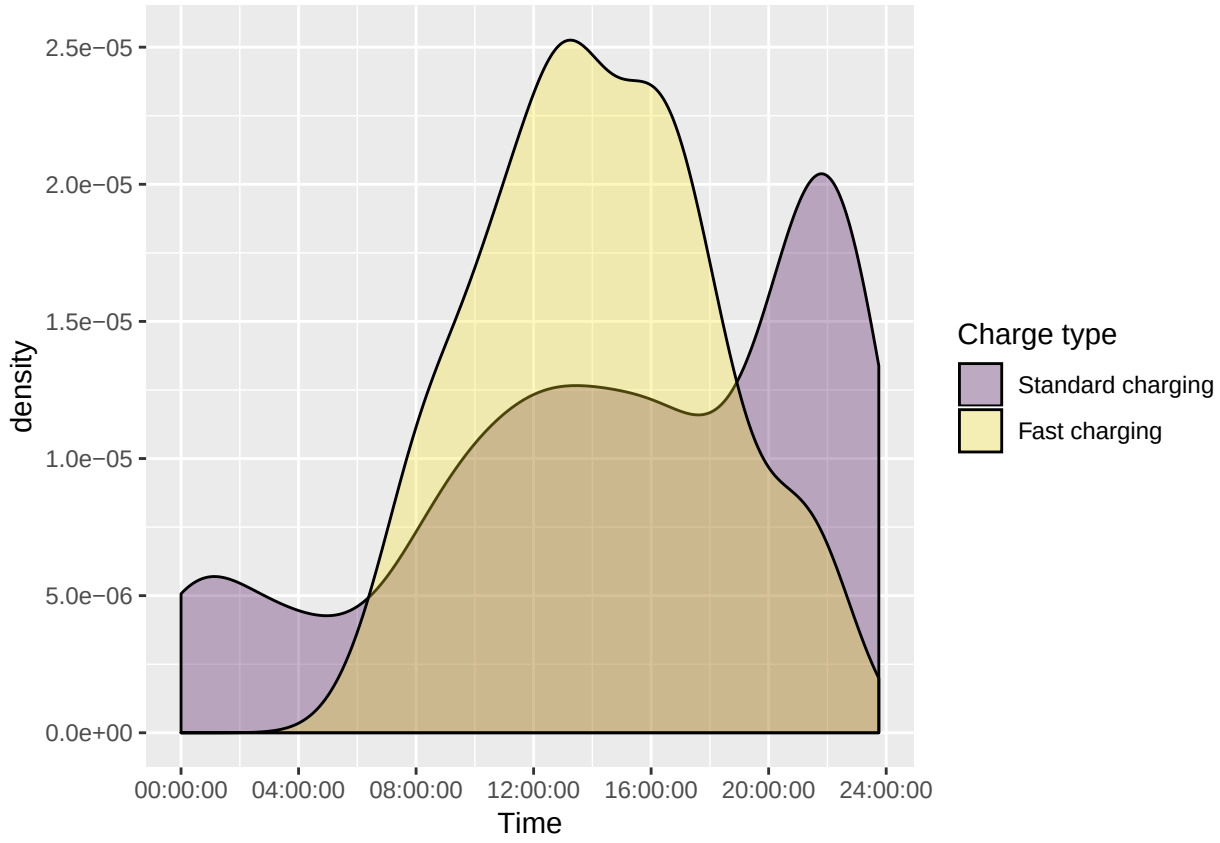

Figure 10: Density plot of charging start times during weekends

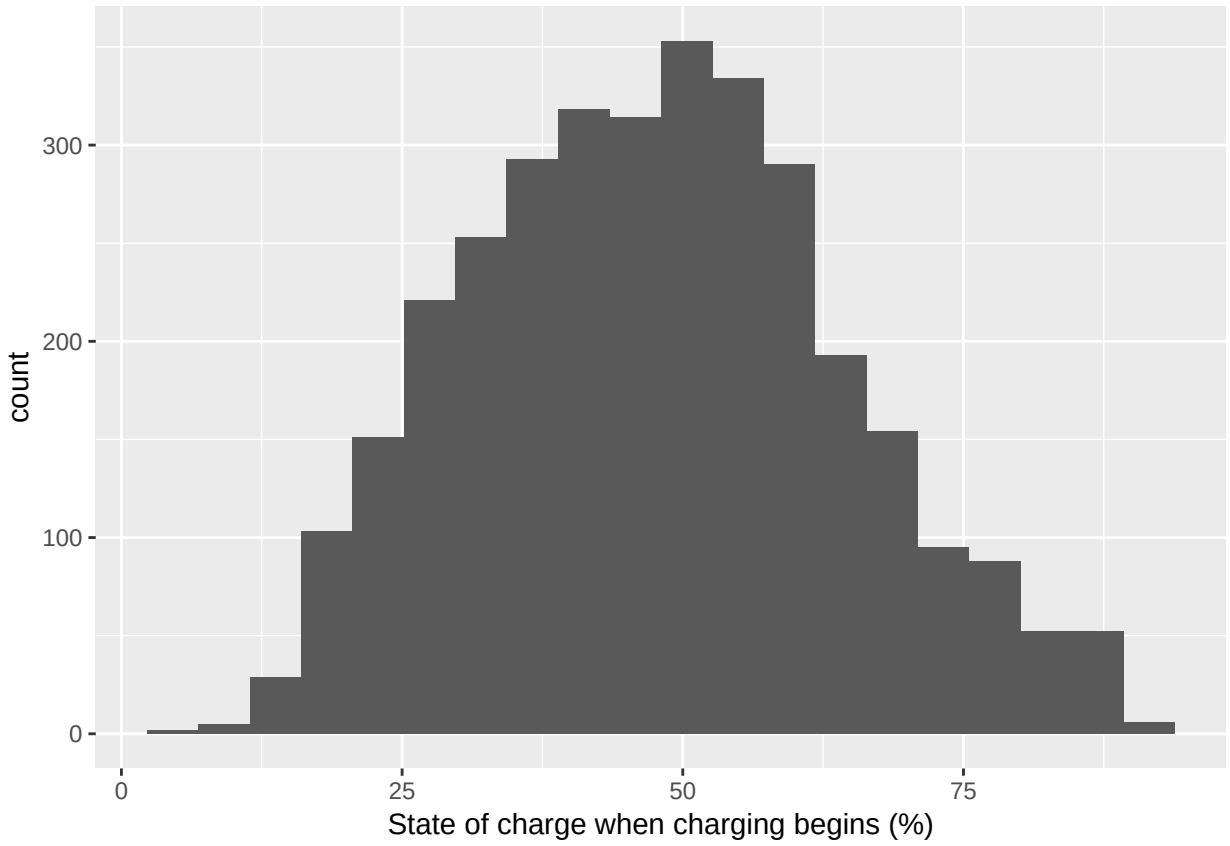

Figure 11: Value of state of charge at beginning of charge

Fig: Distribution of duration of charge events starting 'at home' in the evening (by day of the week) *Duration difficult to accurately determine without date due to charging occurring through the night*

The figure shows that vehicles may then be available for further demand response and/or re-charging for up to XX hours from this point.

Discuss any other patterns