Citi Logik

Electric Vehicles

Optimising the selection of charging station's locations

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1 Introduction

A need for increased charging infrastructure remains a significant barrier to EV adoption. To locate the optimum locations for new charging points, data about EV usage patterns is required, however, gathering this data has historically been challenging.

Citi Logik use Mobile Network Data (MND) to analyse people movement on foot, in a vehicle, or by train. Mobile network data can be anonymised and processed to provide insights into traffic volumes and the origin and destination of trips. By understanding patterns of movement, Citi Logik therefore have the potential to help inform the optimal locations for EV charging points.

Electric Vehicles (EVs) charging stations serve a surrounding area usually referred to as catchment area. This area could be predominantly residential, urbanised, rural, next to major road links and many other categories. The selection of the location and type of charging stations should take this information into account. Thankfully, this is readily available in multiple sources on the net.

Citi Logik can enhance the process of selecting and sizing charging stations, especially for rapid en-route chargers, by providing detailed information on travellers that traverse or dwell in the catchment area. Using this information wisely could give an estimate of potential customers per day in the present and in a future year.

This note presents a simplistic approach to such estimation. The process could be refined by close collaboration with the EV charger stops developer. Nevertheless, it shows the potential and capabilities of Citi Logik's trip analysis expertise in this realm.

2 How is MND used?

2.1 Mobile Phone Data

Citi Logik and mobile network operators work with the RAW data events generated by the mobile network, each time a mobile device carries out any number of communication activities with the network, whether in passive or active modes and across all three data bearers of 2G, 3G or 4G. These events are captured to ensure the smooth working of the network and for billing and quality assurance purposes, the latter typically using probes.

The activities that generate an event with the network are numerous but can be summarised into the following group functions. Each group function in itself can generate multiple events.

Typical Event Groups:

- SMS, sending and receiving;

- MMS, Sending and receiving;
- Data interchange and setup – from applications, browsing etc…;
- Voice calling, setup, handover, signalling (multiple events), completion;
- Maintaining mobile connection e.g. LAC Change, HLR update, Periodic; or
- Polling, and event update.

For each event generated, the following information is recorded within the network and after encryption and anonymisation is passed to Citi Logik for processing. Citi Logik receives the following data from each event:

- Anonymous ID for the device;
- Time stamp for the event; and
- Cell identity information.

Working with Vodafone as a data provider, this equates to billions of transactions per day for a busy study area, which are extracted from a large pool of mobile devices on a permanent basis, in the 10 to 15 million devices range. This is the RAW data.

2.2 Geo Locating

The RAW data then needs to be correctly geo located. This is a process carried out by Citi Logik using an advanced processing engine that takes data on the underlying mobile network cell coverage and detailed cell configuration for each cell to build optimised locations for each cell.

2.3 Journey Paths

The data is then tied to journey movements for each device to build a complete journey path record for every device within the capture area. This is then stored in a database for use in further analytics.

2.4 Journey Path Database

The database holds all of the movements of a device at level of cell resolution. By understanding the characteristics of each bearer type (2G, 3G, 4G) and the cell footprint together with the device movement path the Citi Logik engine optimises the device location. This will be at a variable accuracy from 50m to 1km+ depending upon the environment (dense urban to rural) and coverage of each cell. By running Citi Logik's journey regenerator, the events are separated into trips and dwells.

Within the database, and for each journey of every device, key metrics are also recorded including path taken (cells), timestamps, mode identified through algorithms, journey speed and timings as well. This allows for detailed future analysis.

Through long trend analysis, Citi Logik can also generate additional anonymous information about each recorded device. This allows for the identification of regular home and work locations through its inferred night and day locations for each device allowing the further breakdown by journey purpose. E.g., Home Based Work trip, Home Based Other trip, Non-Home Based trip etc. By using this information, full trip chain understanding can be identified.

2.5 Population Expansion

The data collected will only cover the proportion of the population using the select mobile operator devices (for example about approximately 1/3rd of the population in the UK for our main partner Vodafone). Hence it is important to expand this sample to the full UK population, this process is called expansion.

In principle, expansion factors are calculated by comparing the numbers of users identified to have a home location (based on number and duration of hours stayed in a place

overnight) and the total population, in a given geographic area. The size of geographical areas used to estimate expansion factors has a significant effect on the outcome of expansion. The expansion factors should represent variation in market share of the mobile data provider as well as mobile phone penetration. It is therefore important to calculate and use expansion factors to a disaggregate spatial level to account for variation in market share across various areas.

Citi Logik has developed a complex mechanism to undertake the expansion. The number of device's homes is estimated at cell level. At the same time population is obtained and an expansion factor derived for each mobile device.

Expansion will thus be completed using factors derived at client zone level. Considering each client zone, the factor will be applied to the entire trip chain made by the devices whose homes are in this zone.

All data produced is aggregated, fully GDPR compliant and respecting individual privacy. Studying these data can help answers questions such as:

- Who travels? Their home/work location. From where, where to?
- Why? Commuting trips, repeat trips, work trips?
- When? Day/Time…
- How? Car, rail, HGV, active mode?
- What route?
- ….

3 Locating EV charging points - A Case Study

3.1 Area selection

The charging stops developer may want to understand the difference between several potential locations or identify locations that could be profitable. Citi Logik could provide assistance in analysing the trip profile of each zone.

For this show case Milton Keynes was chosen. The zone shown in read in Figure 1 has a high number of traversing trips over the course of a day, this is not surprising as it is the main access point from the M1 to Milton Keynes (A421) as well as a key junction on the A5. The zone size, and shape could be optimised for EV charging location studies.

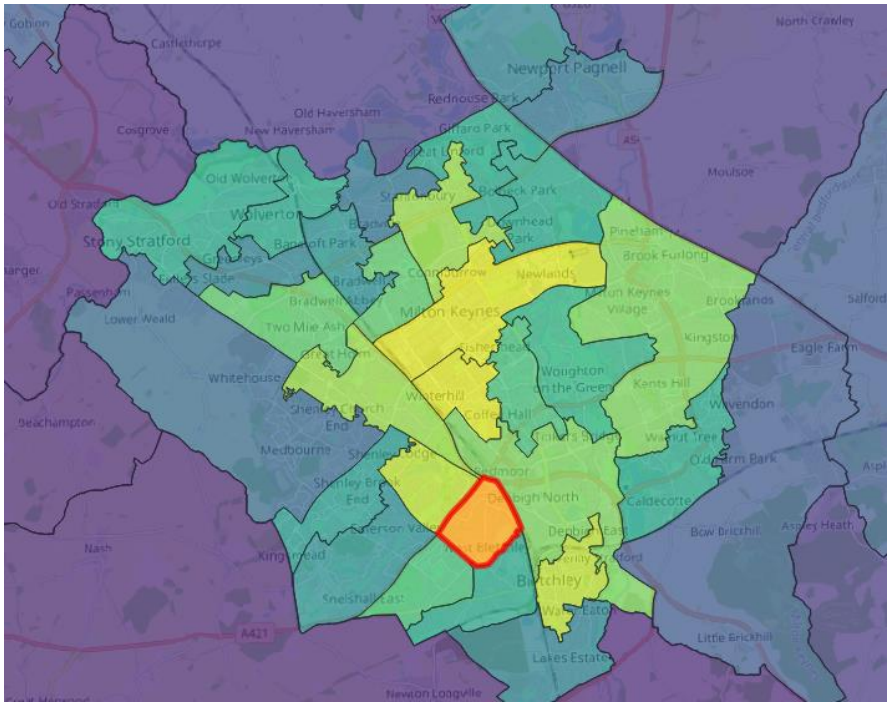

Figure 1 Traversing flow per area unit

3.2 Traversing Trip Analysis

3.2.1 Trip Purpose Analysis

Traversing trip analysis suggests that around 91,700 person trips traverse the zone by car on an average Monday to Thursday. 10,400 of these are categorised as commuters, 65,600 as not commuting trips but with their home as either the origin or the end of their trip. 2,200 are traveling to or from work from or to a location different to their home, and 13,500 people are making trips between non-work non-home locations.

A first attempt to narrow the focus would be to only consider trips that are non-work related, i.e., 79,100 trips, as commuters are likely to already have charging points at either end of their trips.

3.2.2 Trip Distance Analysis

Not all Plug-in electric vehicles (PEV) traversing the zone would benefit from making a charging stop at the pointed location. Naturally, primarily those running on a low battery would make a stop to be able to comfortably finish their trip. An easy way to estimate this is by looking at the distance the stop is from the trip's origin and its destination. For the purpose of this study, it was decided that a PEV that is at least 100 km away from its origin and destination would be most likely to make a stop in the traversed zone and hence could be a potential customer.

Figure 2 shows the trip length distribution by kilometres from origin and by kilometres to destination. As can be observed, only trips at least 100 km away from origin and destination. The number of trips reduces as longer trips are considered as one would expect.

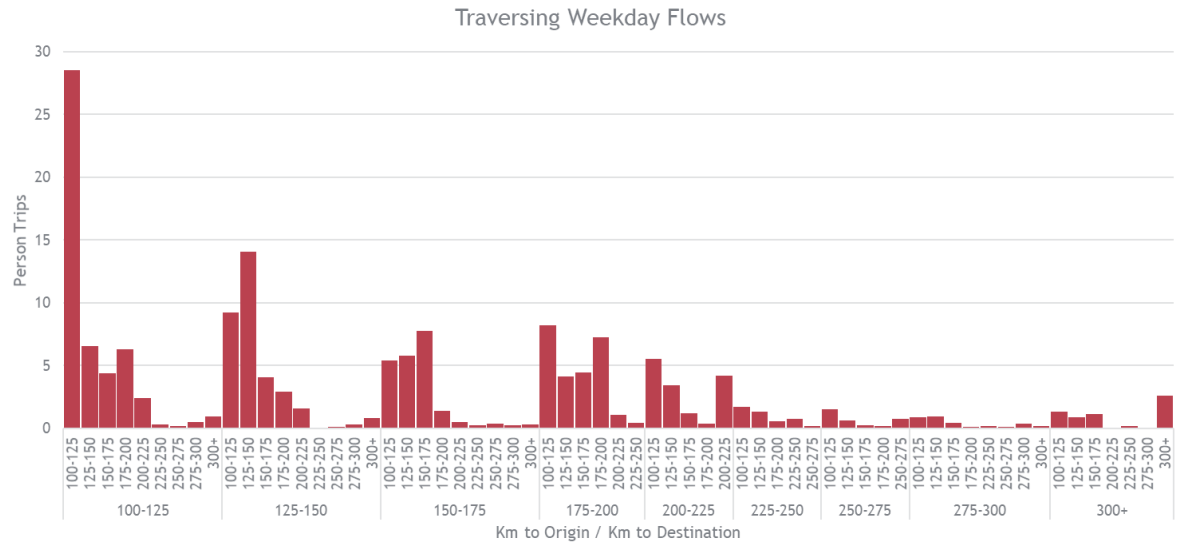

Figure 2 Trip Length distribution from Origin to destination

Figure 3 shows how the number of likely 'charging' traversing trips diminishes as successive filters are applied. The purpose filter applied (explained in the previous section) reduces the number by about 14%. However, that is negligible compared to the next filter, the distance to and from destination filter. More than 99% of the trips selected by purpose are not predicted to need a charging stop even if they all were EVs. However, this might change drastically if considering another area such as a major junction on a motorway. A known example could be along the M6 between Birmingham and Manchester as on that section of motorway, 20% of vehicle are known to drive the whole section of motorway.

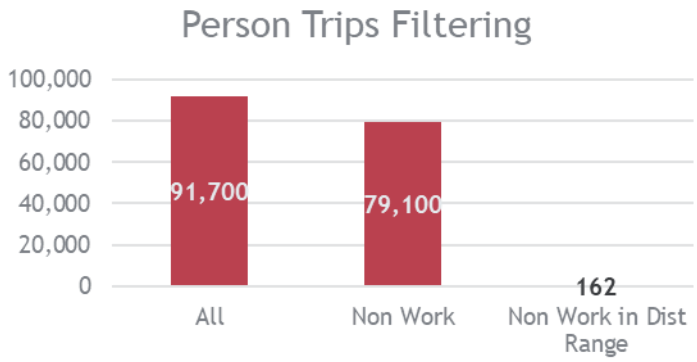

Figure 3 Person Trips under successive selection filters

3.2.3 Home location

Another refinement can consider the home location. Knowing the home location can give valuable information about the potential customer. The level of affluence, likelihood of owning an EV and likelihood of visiting nearby shops and restaurants while the car is charging, could be used to inform models that would estimate the final number of potential customers in a horizon year. Table 1 shows the estimated share proportion of non-work trips traversing the zone and are at least 100km away from the origin and destination by home district. 2.9% of the person trips filtered have a home location in Manchester. If 2% of the cars in Manchester are PEV then 0.058% of the filtered trips are estimated to have a home location in Manchester and have made the trip on a PEV.

Table 1 Trip Share by Home District and PEV Proportion in District

Home District	Trip Proportion	PEV Proportion*
Milton Keynes	3.1%	1.2%
Manchester	2.9%	2.0%
Cheshire East	2.3%	2.1%
Liverpool	2.3%	1.7%
Brighton and Hove	2.1%	1.4%
Shepway	2.0%	1.9%
Cheshire West and Chester	1.9%	1.7%

**Simulated EV proportion not based on observed data.*

3.3 Putting it all together

In this exercise, we found that on an average Monday to Thursday day 91,700 person trips traverse the zone. 79,100 of these are non-work trips, which are thought to be more likely to make a stop to charge. In a few years' time, PEVs could reach 5% of all the cars in the UK. Applying that proportion to the above figure the number of future person trips on PEVs traversing the zone could be around 3,900. Accounting for car occupancy that could be about 2,600 PEVs.

Of those 2,600 PEVs only 5 are at least 100km from their origin and destination. Therefore 5 would be a first conservative estimate of the number of daily potential customers that a charging station could attract on the zone selected on the year where the PEVs reach 5%.

3.3.1 Short comings of the estimation

In this exercise, several choices were, made, which could be adjusted differently. This section highlights some of the shortcomings to the approach taken. Firstly, the zone system selected and shown in Figure 1 may not be the most appropriate. A zone system that follows the main roads or isolates attracting points such as shopping malls could be more appropriate.

In practice several zones would be studied simultaneously and the comparison of the results for each of the zones would yield the most profitable sites.

The decision to only consider traversing trips may not be entirely correct as it is a residential area, and it could attract people currently starting or ending their trip there. Similarly, the approach only considers the on-going trip and not all the previous or following trips that may be done on the same day. If an EV is doing consecutive trips with short dwells or dwelling in areas without charging points, then it will be more likely to be in need of charging when traversing the zone.

Only considering non-work trips could be another underestimation as there maybe trips travelling from work to home or to another location that could 'spare' the time for a charging stop.

Using the home location to inform the likelihood of the trip being an PEV trip was presented but not used in the calculations.

All these can be adjusted based on requirements which may be highlighted to Citi Logik.

3.4 Conclusion

The methodology explained previously results on a rough estimate of the number of most likely prospective customers and must be taken as a show case of the capabilities of Citi Logik's processing power.

Close collaboration between Citi Logik and industry experts has the potential to greatly increase the accuracy of these estimates, based on information held by Citi Logik, but processed to EV experts' specification, making them an invaluable source of information for the developer.