The Battle of Neighborhoods
The Electric Vehicle City

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Abstract

The report is the study of the strategic locations of electric charging stations for the use of Electric vehicle charging around the city state of Singapore. Using the location data provided by Foursquare, an analysis of the city of Oslo, Norway and Singapore is done in comparison to identify ideal locations where such charging stations should be located.

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1 Introduction

1.1 Background

Climate change is no longer an issue that can be ignored. The effects of Greenhouse emissions as a byproduct of modernization is known to be the main source of the problem. The Paris Agreement, *Accord de Paris*, has been the world's greatest and concerted effort to deal with greenhouse-gas-emissions mitigation, adaptation, and finance.

The agreement within the United Nations Framework Convention on Climate Change (UNFCCC) was signed in 2016. It is a long-term goal to keep the increase in global average temperature to well below 2°C above pre-industrial levels; and to limit the increase to 1.5°C, since this would substantially reduce the risks and effects of climate change.

The reduction of greenhouse emissions is a problem which requires a fundamental shift in the way we live our lives as such detailed analysis using the abundant volume of data analysis is required to target areas of industry or lifestyle that can be changed in order to make significant impact.

The reduction of carbon emissions from petrol vehicles has been a common place to start by many countries. The potential of its reduction in major cities all around the world can be achieved by improving transportation systems and the vehicles themselves. The shift from the use of conventional cars with internal combustion engines to hybrid vehicles to electric vehicles (EV) has already begun. Norway is one of the top countries who are adopting electric vehicles as such the capital city of Oslo is chosen as an example of a model city for the adoption of electric vehicles.

With many companies causing this disruption in the vehicle industry, major players in car manufacturing have followed suit and thus the infrastructure must meet this shift. As cities aim to shift to EV vehicles to combat climate change, consumers must have access to the facilities to meet these changes. The convenience of petrol stations to pump for gas must now shift to the convenience of charging an EV vehicle.

1.2 Aim

The aim of this project is to use location data provided by Foursquare to determine the best locations for EV charging stations in the city of Singapore. Using location data from Oslo, Norway, analysis can be done to determine if there are determining factors that would make ideal locations. Such analysis will be of great interests to governments, vehicle manufacturers as well as service providers to strategically plan for the coming disruption of transportation trends in different cities.

1.3 Data

The data source for location data will be obtained from Foursquare. The Singapore vehicle population number is obtained from data.gov.sg and the vehicle population data for the city of Oslo, Norway is obtained from Statistics Norway (ssb.no).

Exploratory data analysis is used to determine the similarity in Oslo and Singapore's transport data. The datasets will then be used to determine the ratio of petrol stations to consumer vehicles to project the potential number of charging stations to EV vehicles required. Using the location data, ideal locations for the EV charging locations can then be determined.

2 Methodology

Based on definition of our problem, factors that will influence our decisions are:

- number of existing petrol cars and electric cars there are both in Oslo, Norway as well as Singapore
- number of EV charging stations
- locations surrounding current EV Charging stations within Oslo
- clusters where EV charging stations can be placed in Singapore using supervised Machine Learning k-cluster algorithm.

Following data sources will be needed to extract/generate the required information:

- number of EV charging stations and their type and location surrounding every charging station will be obtained using Foursquare API
- coordinates of charging stations using OpenStreetMap Nominatim: Search

2.1 Data Cleaning

2.1.1 Car Data

Car data is downloaded from Statistics Norway for Oslo car data and from data.gov.sg for Singapore car data. The data were presented into Panda data frames. NA and incomplete data were removed.

2.1.2 Oslo EV Station Location Data

A data frame of known addresses for over 80 charging station of a known 200 charging stations was created along with their address. OpenStreetMap was used to obtain the respective coordinates. Foursquare API was used to obtain local venues around such stations.

2.1.3 Singapore EV Charging Station Location Data

A data frame of 24 known locations of the stations with latitude and longitude. Singapore neighborhood list was scrapped from Wikipedia from the 5 regions East, North-East, North, Central and West. The neighborhood latitude and longitudes were obtained using OpenStreetMap.

Multiple tries were attempted to obtain the data all at once but with Service Errors as such the data was collected by batches. The venue location around these neighborhoods were obtained using Foursquare API.

2.2 Feature Selection

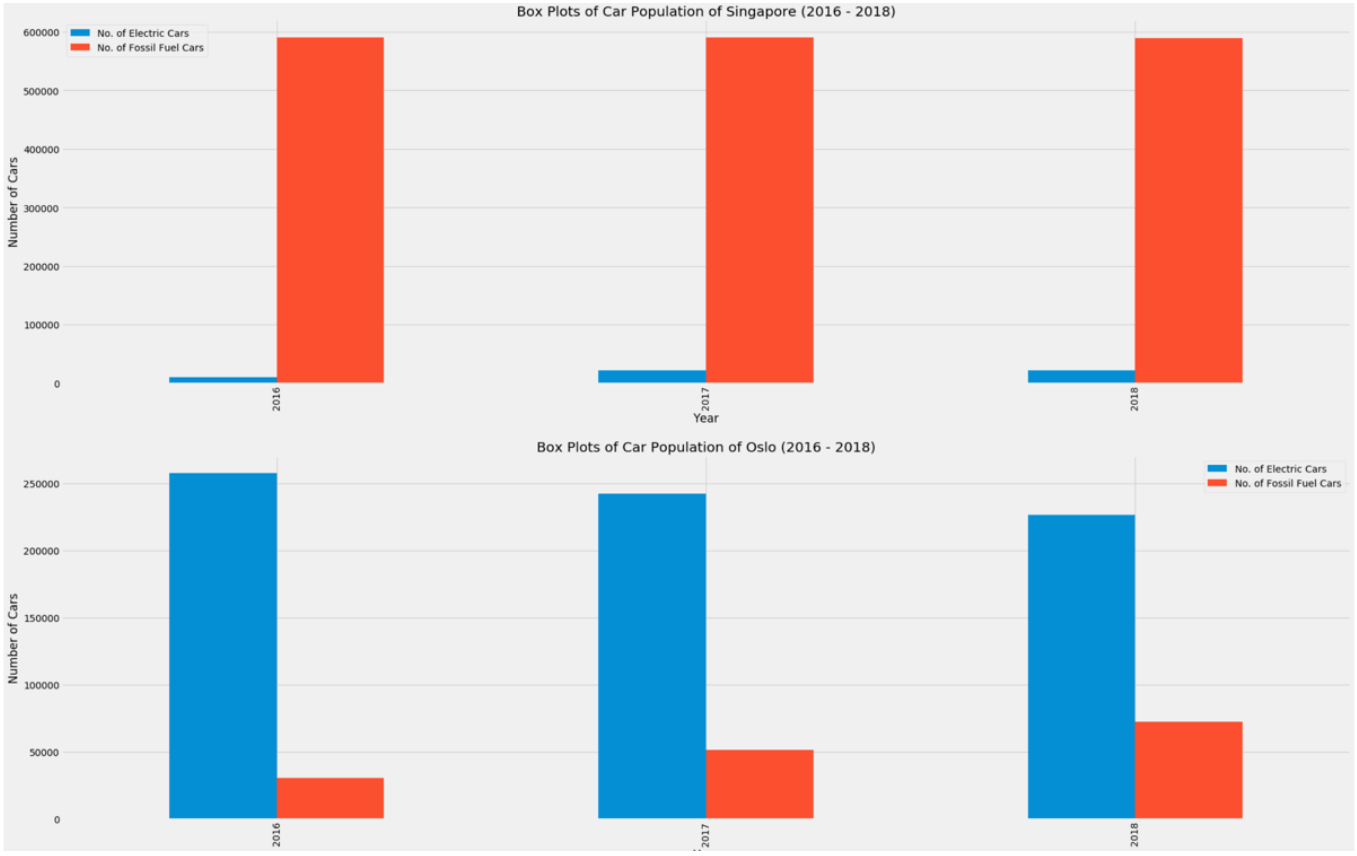
The data was extracted for appropriate feature selection. Sums of petrol and electric vehicles were done and presented into tables and bar plots.

Venue Types were extracted from location data were done and the popularities ranked for Oslo around the EV stations. This would produce 5 clusters with features that can be used as a model for Singapore.

For Singapore' venue data, an overlap of current EV stations and clustering of venues were also done to spot patterns of less served areas with lesser charging stations.

3 Exploratory Data Analysis

3.1 Car Population Singapore vs Oslo



Oslo's superior population size as compared to Singapore's, accounts for the greater total number of cars in Oslo. It must also be noted that Singapore's strict control of the vehicle population is enforced through costly Certificate of Entitlement (COE) for each vehicle as such the vehicle population is expectedly lower.

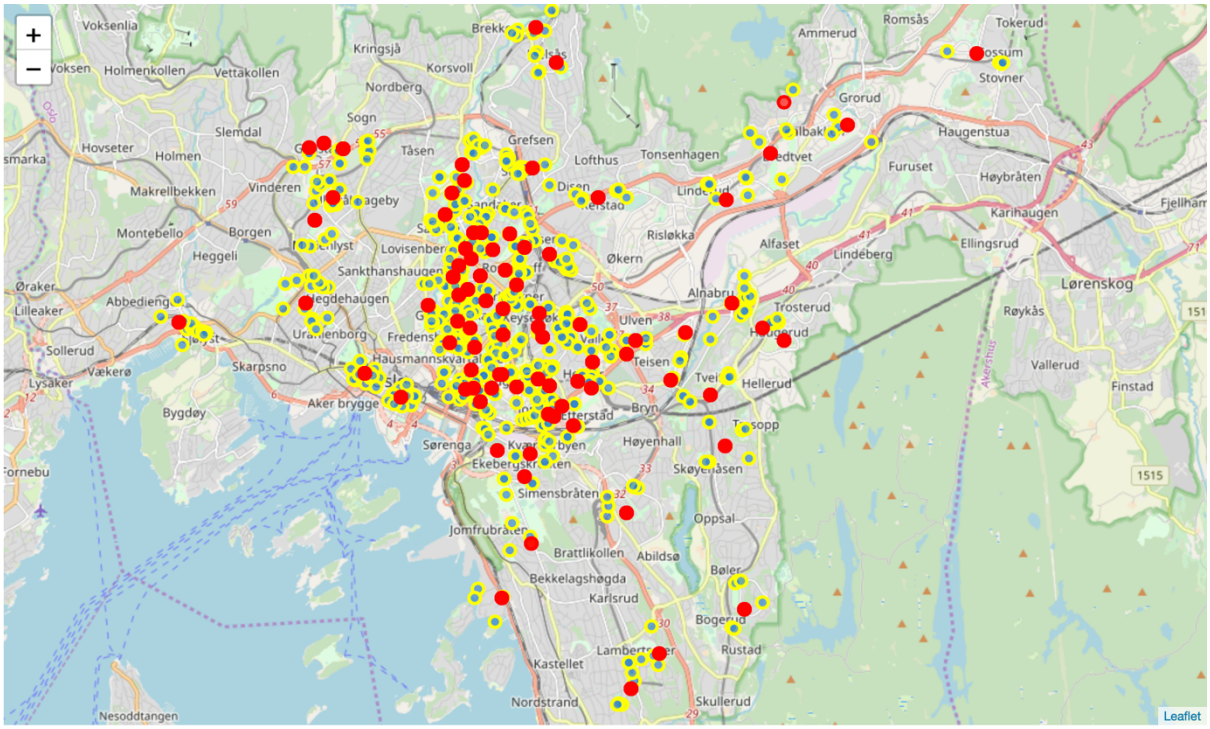
The majority population of cars in Oslo are made of electric cars. The proportion of electric to fossil fuel cars are significantly greater than Singapore's.

3.2 Electric Vehicle charging stations

In Oslo, there 200 known EV charging stations (EVCS) as compared to Singapore's 24. This is not surprising given that these stations cater to the needs of the far greater number of electric cars in their city.

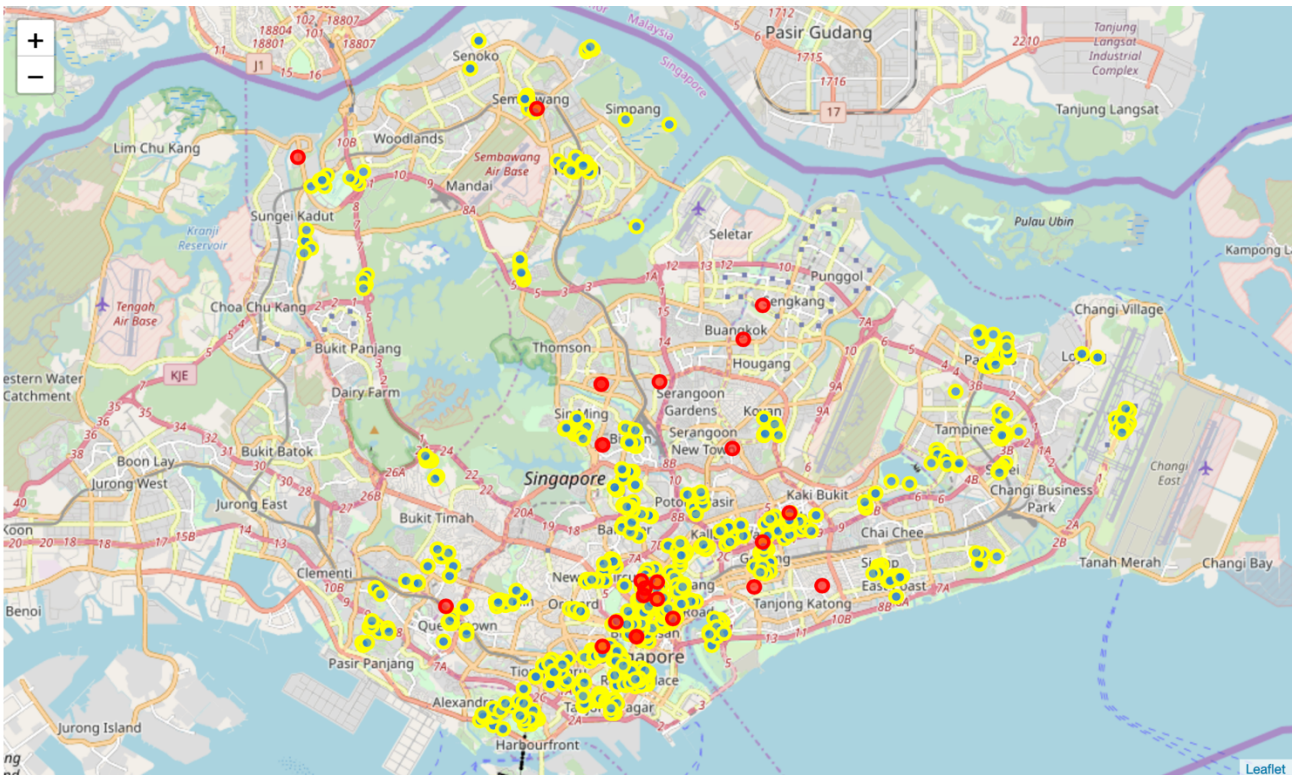
In conclusion, should Singapore want to do their part in combatting Global Climate Change through reduction of carbon emissions and choose future conversions from fossil fuel vehicles, they can model EV charging stations locations in Oslo to Singapore.

Mapping current EVCS in Oslo and the locations surrounding it would give us a visual representation of how the stations are spread out or strategically placed.



Visualy the stations are spread along major roads, but a large number are located in the city itself. These stations have been strategically placed within clusters of different categories of venues

The following map is the map of Singapore neighborhoods and the relevant venues surrounding them. The spots in red are the current EV charging stations in Singapore. These stations are mainlu from a single car sharing electric cars vehicle BlueSG to serve customers who use the company's vehicle and services.



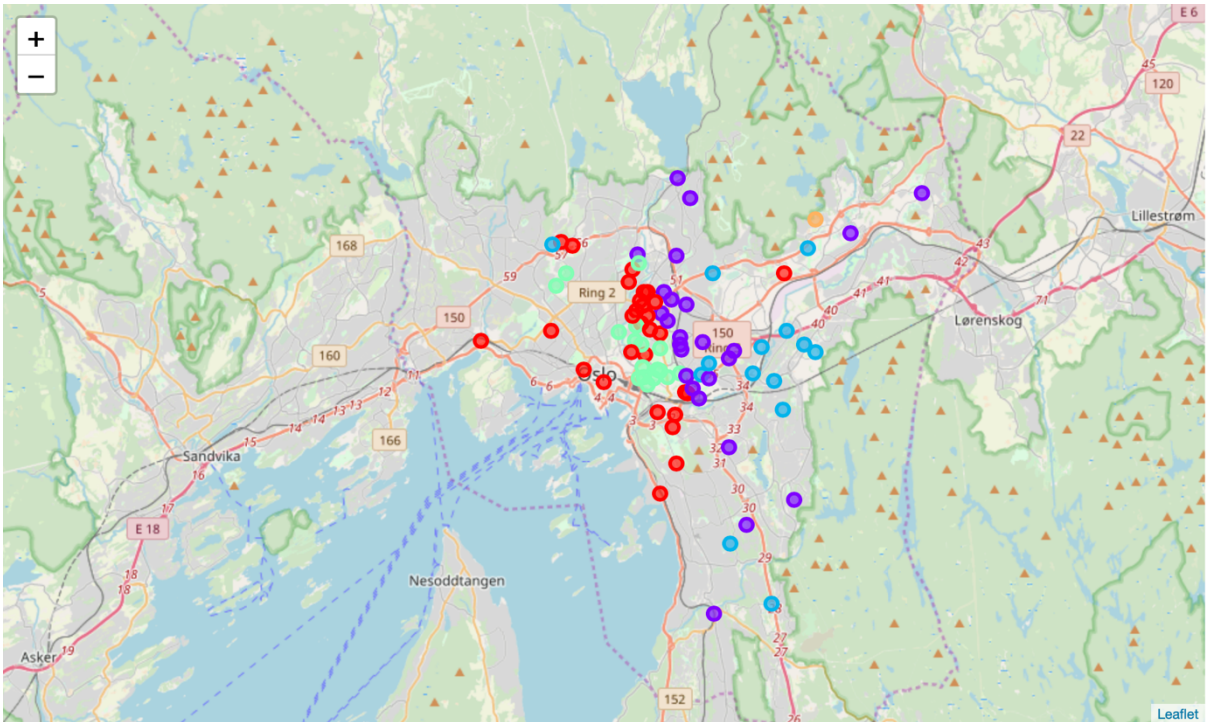
Should Singapore see in consumer demand for electric vehicles, the number of stations must increase to serve their needs. To improve competition and prevent monopolization of this sector of transport, other companies can strategies as to possible locations they can better provide charging station services.

4 Predictive Modelling

The chosen predictive model used in this analysis is k-means clustering. Using the explore function, the most common venue categories in each neighborhood are determined and using these features to group the neighborhoods into clusters using k-means cluster algorithms.

4.1 Oslo Venue Analyzation

The Oslo venues surrounding each station are grouped by venue type. A function is used to rank the venues into top 10 most common venues. These venues are then run through the k-means cluster algorithm with a setting of 5 clusters. These clusters are then inserted into the table with listed charging stations to determine their cluster category. Folium is then used to visualize their cluster.



The markers in red are the location of charging stations.

4.1.1 Oslo Clusters

Cluster 0 (Red)

Cluster zero is made of venues that are meant for sports activities such as Gym, Soccer Field and Athletics & Sports. This cluster are also surrounded with a wide variety of bars, cafes and restaurants. The charging station is strategically placed to serve the needs of Gym goers and those who do sports.

Cluster 1(Purple)

Cluster 1 has the 1st common venue for all charging stations in the cluster as Grocery stores. The EV stations there are strategically placed for commuters who enter these cluster locations for groceries.

Cluster 2 (cyan blue)

Cluster two is located close to Bus stations and metros. Surrounding this convenient and accessible locations are food and beverage establishments, malls and areas of leisurely activity. These areas will see high daily traffic as such drivers with EV can conveniently charge their vehicle whilst running errands or shopping.

Cluster 3 (green)

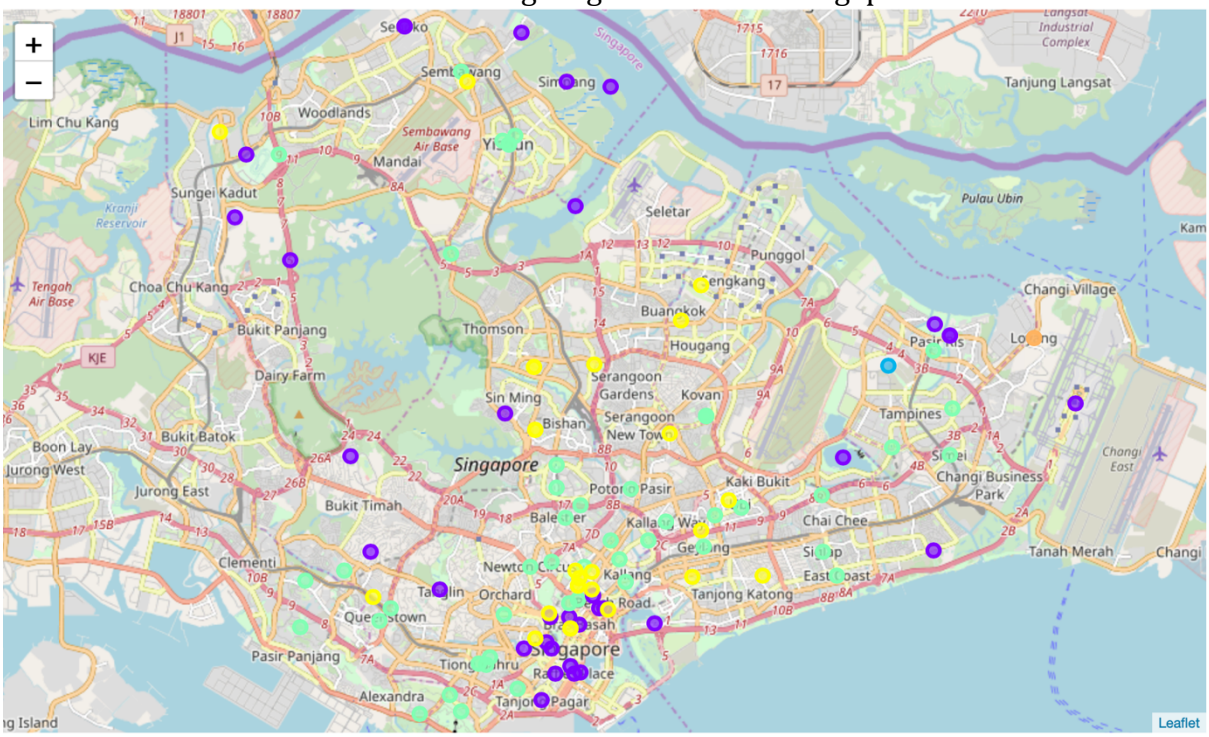
Cluster 3 is a location filled with a variety of food and beverage establishments. These are areas people visit for meals and gatherings. Strategically EV charging stations can serve commuters needs as they frequent such cluster locations.

Cluster 4 (orange)

Cluster 4 has a single station which serves primarily the crowds that go to the soccer stadium. Since games are hosted on weekends the peak periods are presumably on weekends as such a single station should suffice the neighbourhood's needs. Grocery store shoppers who live in that area have the station to depend on as well.

4.2 Singapore Venue Analysis

Similar ranking and k-cluster algorithms were done on Singapore venue data sets however these venues are surrounding neighborhoods in Singapore.



4.2.1 Singapore Cluster
Cluster 0

Cluster zero is the farming area of Singapore. This cluster has no charging stations for EV cars due to its isolated location. Should Singapore convert their delivery trucks to and from the farms to electric, this cluster could be a potential area for installation. Just like in Oslo where the single cluster (cluster 4) with the stadium has a single electric charging station, this particular structure could use at least 1.

Cluster 1(Purple)

In cluster 1, the cluster includes multiple hotels and amenities for tourists. The area is surrounded with food and beverage establishments. Pharmacies, gyms and shopping centers are located within this cluster. BlueSG has strategically placed multiple stations here for ride sharing purposes. Should ride sharing companies enter the competition with EV cars, this cluster should be the focus. This cluster is similar to Oslo's cluster 3

where there are multiple restaurants which is a proven case where larger numbers of charging stations can be focused.

Cluster 2 (cyan blue)

Cluster 2 is a cluster with a football stadium and Yoga Studio which stands out the most. These locations have restaraunts and eateries to meet the needs of physical activities. The East location has 0 EV charging stations and the least represented in Singapore. These towns have parks and beaches which would promote lesser car use and are popular bicycle towns. To improve the environment in that area promotion of elctric cars and the installation of more charging stations within park and beach areas.

Cluster 3 (green)

Cluster 3 are areas with eateries and restaurants. These locations are food and beverage clusters. BlueSg has EV stations within these clusters however some areas are underserved however should alternative companies plan to enter the market for more electric cars and stations, these areas could be potential areas for expansion.

Cluster 4 (orange)

Cluster four is a cluster for local delicacies, coffee shops and cafes. These locations do not have enough stations to serve an increase in electric car increase. Similar to cluster 3 in Oslo these locations are possible locations to increase charging stations to serve the needs of consumers.

5 Conclusion

Oslo is a proven model city should Singapore choose to adopt electric vehicles. Just like many modern cities their clusters are very similar in terms of favored venues of visit as such the characteristics of the clusters are fairly similar. Using clustering would ease the process of decision making should the Singapore governments and companies plan for future cites for EVCMs.

Other factors that may affect these EVCM locations are availability in housing areas. In land scarce nations such as Singapore EVCMs should be placed in widespread locations to avoid traffic jams and congestion but with multi story housing apartments, housing areas could be possible locations. This assuming the prices of EVs become are more affordable than fossil fuel vehicles.

The number of electrical charging stations should however be an area of further analysis. On top of location data, many other factors can affect a model of the number of EVCMs required. A growth model based on EV car numbers and EVCMs can be easily modeled with regression models however factors such as GDP, taxes for such vehicles, COE prices and governmental legislation also come into play.