Final Report Group 5

BANA 571 Data Explore & Visualization

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1. Introduction

In a fast-paced era of EV-revolution in the U.S, the electric vehicles market has been growing from year to year. Due to the rising EV sales across the US economy brings the increase in overall demand for EV charging stations. Scoping it down to focus on the EV charging stations industry, which serves the needs of a charger of EV owners. The revenue model is based on collecting direct fees, service fees, and reservation fees. Currently, there currently are about 0.16 million public charging ports in the US, and about one-quarter of those are fast chargers. However, the density of electric vehicles is more than eighteen times (approximately 2.7 million cars). Range anxiety, the fear of not having access to a charger, has become a major obstacle to new and used EVs, and EV adoption. The electric charging stations need to focus on the electric vehicles' population in their areas, and the average electricity cost by state to set pricing and business plans to stay competitive and increase the density of EV Capacity of the charging service. Our business analytics project initially focuses on Seattle, Washington because of its visions to address climate change and reduce transportation pollution by commitment to have 30% electric vehicles on the road by 2030 and Portland, Oregon because this city committed to achieving at least a 50% reduction in carbon emissions below 1990 levels by 2030. To achieve this, it must utilize Seattle and Portland electric vehicles and their electric charging stations listing data by using the benchmark of San Jose, California which has the most public charging stations per capita of EVs and produce recommendations to develop utilization relationship with charging stations in their areas and EVs in Seattle and Portland. This business analysis report can support the electric charging station industry in Seattle and Portland, EVs owner and EVs potential buyer, companies such as Tesla, General Motors, or ChargePoint to ensure planning EV infrastructure, and concludes with policy recommendations that Seattle and Portland can

consider ensuring its continued success in the growing electric vehicle charging station sector for the future.

Executive Summary

Electric vehicles charging stations provide service for charger EVs. Due to the main concern for EV drivers with dead public EV charging stations in the past few years. In order to strengthen the electric vehicle charging station's business, a data-driven approach was taken to evaluate the current business issues for the EVs industry. There are three main areas that were identified as potential opportunities for the industry to improve its business strategy, enhance utilization rate of electric vehicles charging stations, expand the market, and budget to drive profit and maximize the company's growth. The main purpose of the report is to figure out Seattle and Portland EVs goal. Through data exploration and statistical approach in the Electric Vehicle population, Electric and alternative fuel charging station datasets, and the data findings suggest that Seattle should increase the utilization rate of electric vehicle charging stations in the specific area where the population of EVs exceeds the supply or charging ports by using the benchmark of San Jose. In conclusion, we draw the following conclusions and recommendations from the analysis to effectively evaluate Seattle and Portland EVs company's strategy and adapt to the current business problem challenges. Lastly, we believe that the current analysis needs to be constantly evaluated yearly to reach success in their 2030 EV Goals.

Industry Overview

The electric vehicle (EV) industry has been experiencing rapid growth and significant changes in the last decades. Customer behavior changes to care more about climate change, environment,

pollution, and clean energy. They are looking for alternatives in EV to reduce carbon pollution and save money from gas prices. It helps to save money from fuel costs up to $6,000 - $12,000 over the lifetime of an EV. This is the main reason that EVs are still rising in the upcoming future.

China is the biggest part of the EV market. Their EV sales increased by 82% in 2022, accounting for nearly 60% of global EV purchases. Most of the EV on the roads worldwide are found in China. The Chinese automaker BYD sold more electric vehicles than Tesla in Q4 2023.The EV market is very competitive because many automakers see an opportunity in the future growth and upcoming trends. The competition leads to creating a new technology in batteries to drive in a long range and charge faster. The companies that create better technology will get more chances to capture the customer group.

There are several main automakers for the EV market such as BYD, Tesla, VW, GM, and Stellantis. For example, the U.S. electric vehicles market size was valued at 49.1 billion in 2022 and is anticipated to register a CAGR over 15.5% between 2023 and 2032. This is the reason that pushes many automakers to become all-EV roughly 2030 to 2035 such as GM, Ford, Volkswagen, Mercedes, and Volvo to show their vision to the customer and join the market. Even the complete transition from combustion to EV is not easy for people and all the automakers and it needs to take more time.

U.S. Market

Everybody expects that electric vehicle sales in the U.S. will rise a lot in 2024 because in 2023 consumers bought 1.19 million all-electric vehicles. The leads on the growing U.S. electric

vehicles market are Tesla, Ford, Chevrolet, Hyundai, and Rivian. The main reason that many consumers purchased EVs is because the government encourages their people to adopt more EV and automakers to produce more EV by providing a purchasing incentive such as tax credit, charging infrastructure funding, federal fleet electrification funding, and EV manufacturing and supply chain funding and programs. It helps American people to afford EV and don't need to worry about where they need to charge. When the demand goes up the automakers will produce more EV. All these core factors will help to boost EV user population and charging stations.

Business Issues & Questions

To transform Portland, Oregon and Seattle Washington into a model city of electric vehicles (EV), a comprehensive business analysis is needed. Many people are willing to shift from combustion vehicles to electric vehicles, but they still have some concerns about charging stations. This is the key question that Seattle and Portland need to address for an efficient and effective EV environment.

"Are there enough charging stations in Portland and Seattle?"

By addressing this question, the city of Seattle and Portland can strategically optimize benefits for charging stations and electric vehicle (EV) companies. The strategic alignment has the potential to increase the installation of additional charging stations, attract more charging companies seeking increased profit, and encourage residents to embrace EV adoption.

2. Data Background

Population Datasets

The population datasets include "EV_Population_WA" and “EV_population_OR”. Since we needed to calculate the density ratio and visualization, we collected these datasets from data.wa.gov and data.or.gov. The datasets include information on the vehicle such as the VIN code and registration date.

We both selected columns “Zip”, “State”, and “City” from two original datasets. However, we need to find out the one and only one ID column for us to calculate the number of vehicles. Therefore, we used the “pandas” function to find the unique number compared to the row number and found “DOL Vehicle ID” and “Index” which individually mark the table's unique value.

Since we found the unique value, we can determine how many duplicate rows are in these tables. Fortunately, there aren’t any duplicate rows between the two of them. But we still do the whole dataset cleaning once to certain their quality data type.

In our analysis part, we will conduct the visualization and calculations which may need our data to stay “string”. Therefore, we find that “Zip”, “DOL Vehicle ID” and “Index” were originally imported as “float”. Therefore, to keep the datasets consistent, we change them to the “string” data type.

The missing value in datasets should also be considered. Fortunately, these datasets were collected by the state government, so the missing value is limited. Additionally, our data should

all be string which we can’t use average or other methods to fill the missing cells. Therefore, we directly deleted the missing value from our datasets.

For measuring outliers, we planned to use the draft dataset to run the sample visualization on Tableau. Since we needed to use “Zip” to create the population map, we conducted a map to find out the point out of the target city area. After visualization, we can easily find out the outliers and remove them from our dataset.

Charging Station Dataset

We found another set of information from Kaggle, "Electric and Alternative Fuel Charging Stations." It was a very extensive dataset, comprising a total of 65 columns and 70,406 rows. It recorded information about all "gas stations" in the United States in 2023, encompassing various fuel types such as CNG (compressed natural gas), E85 (flex fuel), LPG (liquefied petroleum gas), etc.

Due to the excessive number of columns, we chose 4 columns from the original CSV file, namely 'State', 'City', 'ZIP Code', and 'Fuel Type Code'. After importing the data into Python, we utilized filter and dictionary functions to extract relevant data concerning Seattle in Washington (WA) and Portland in Oregon (OR). Subsequently, we compared the amount of data with the original CSV file.

Following that, we employed the “drop_duplicates” function to eliminate duplicate entries from the filtered data. This process revealed the removal of several items.

Next, we utilized “dtypes” to inspect the data types of all columns. Only ‘Latitude’ and ‘Longitude’ were identified as floating numbers, while the others were classified as objects.

We applied the “dropna” function to eliminate any missing data. However, no missing information was detected.

Upon completing the aforementioned steps, we ultimately exported the data into a new CSV file and imported it into Tableau. We then checked for any information displayed outside of Seattle; if found, we considered it an outlier.

3. Research Model and Statistic

Variables

In the "Electric and Alternative Fuel Charging Stations" dataset, we chose 'State' and 'City' for the purpose of ensuring that the results we seek are specific to particular locations. By selecting both the 'State' and 'City' columns, we aim to avoid potential ambiguity that may arise if only the 'City' column is chosen. For instance, there are cities named Portland in different states, such as Oregon and Maine, and selecting only the 'City' column might lead to including data from multiple states. As for the "Fuel Type Code" column, it is to ensure that our data are focused on electric charging stations. There are many energy stations in the original dataset. Finally, the "ZIP Code" column allows us to subdivide small areas from a specific city. Through "ZIP Code" we can present the distribution of charging stations on a map visualization chart.

From the "EV_Population_WA" and "EV_population_OR" datasets, the reason why we selected the "State" and "City" columns is the same as the "Electric and Alternative Fuel Charging Stations" dataset. We want to make sure our data is in a specific location. The "ZIP Code"

column is also as described in the previous paragraph. We will finally use Tableau software to display the EV number in each small area.

Analysis Model

Since our question is "Do the two cities of Seattle and Portland have enough charging stations?" We need to display the number of EV vehicles and electric charging stations on a map and compare them. From this map, we can quickly know which area has more EV vehicles, or which area the charging stations are concentrated in. Based on the "ZIP Code", we can calculate the proportion of EV vehicles and charging stations in the area.

To complete our analysis, first, we opted for Tableau as our analytical model due to its compatibility with geographical data such as Zip code and City, which are essential for our charging station and EV population datasets. Tableau's mapping visualizations provide robust support for our analysis. Our primary objective is to compare the distribution of charging stations and population numbers. Utilizing map distributions enables us to easily identify areas with station shortages in specific zip codes within the city.

Furthermore, to enhance the clarity of our findings, we generated bar charts by zip code and number of population and stations. Tableau's capability to create charts with color gradients and filters enhances the visual representation of our mapping visualization.

Secondly, we will employ a key metric to gauge the density of EV capacity by dividing the EV population number by the charging station number. The formula is represented as follows:

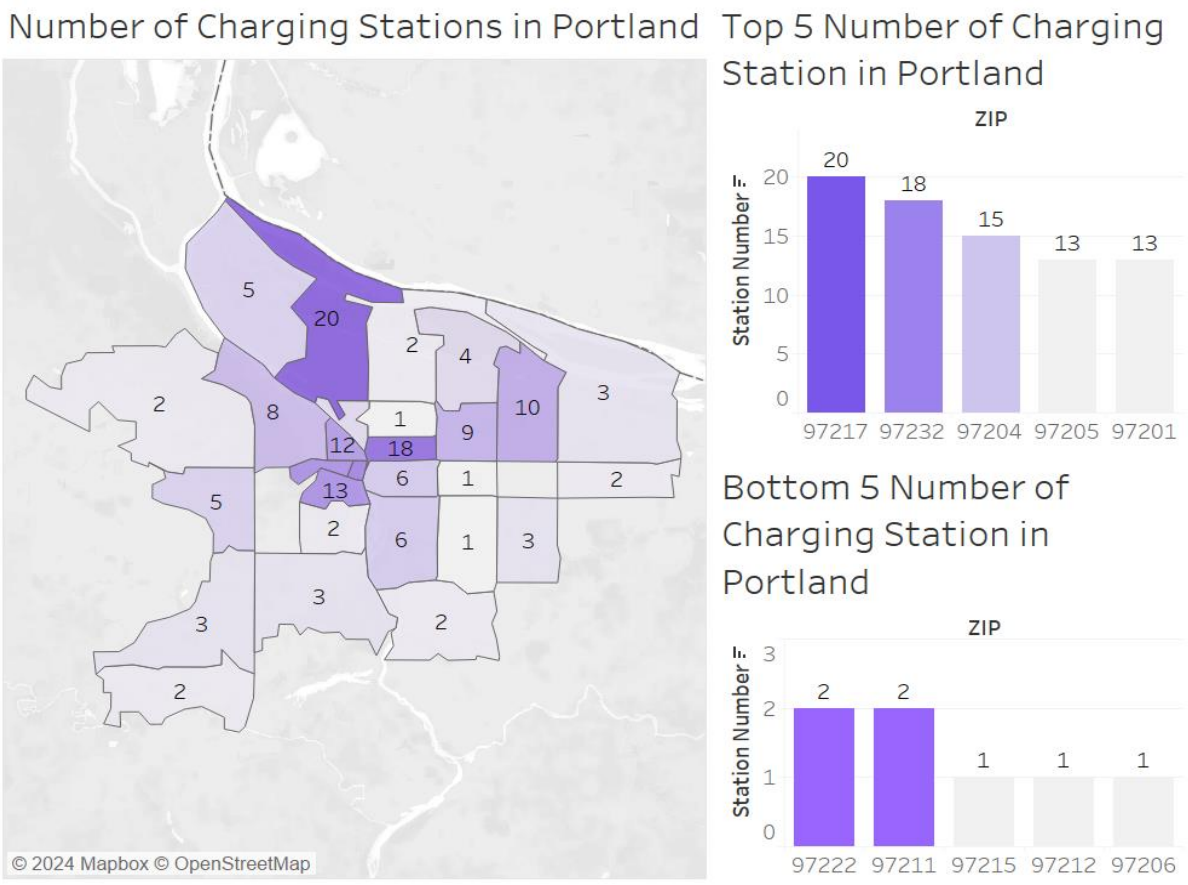
$$\textbf{Density of EV capacity} = \frac{\textbf{EV population number}}{\textbf{EV charging station number}}$$

The formula provides insights into the number of EV cars serviced per station, offering a measure of the station capacity for EV cars in a specific area. To align our data with zip codes, we employed Python's "groupby" and "merge" functions, facilitating the calculation of the density of EV capacity.

Armed with visualizations and a comparable density ratio, we can proceed to conduct our analysis and derive the results of this project.

4. Results and Recommendations

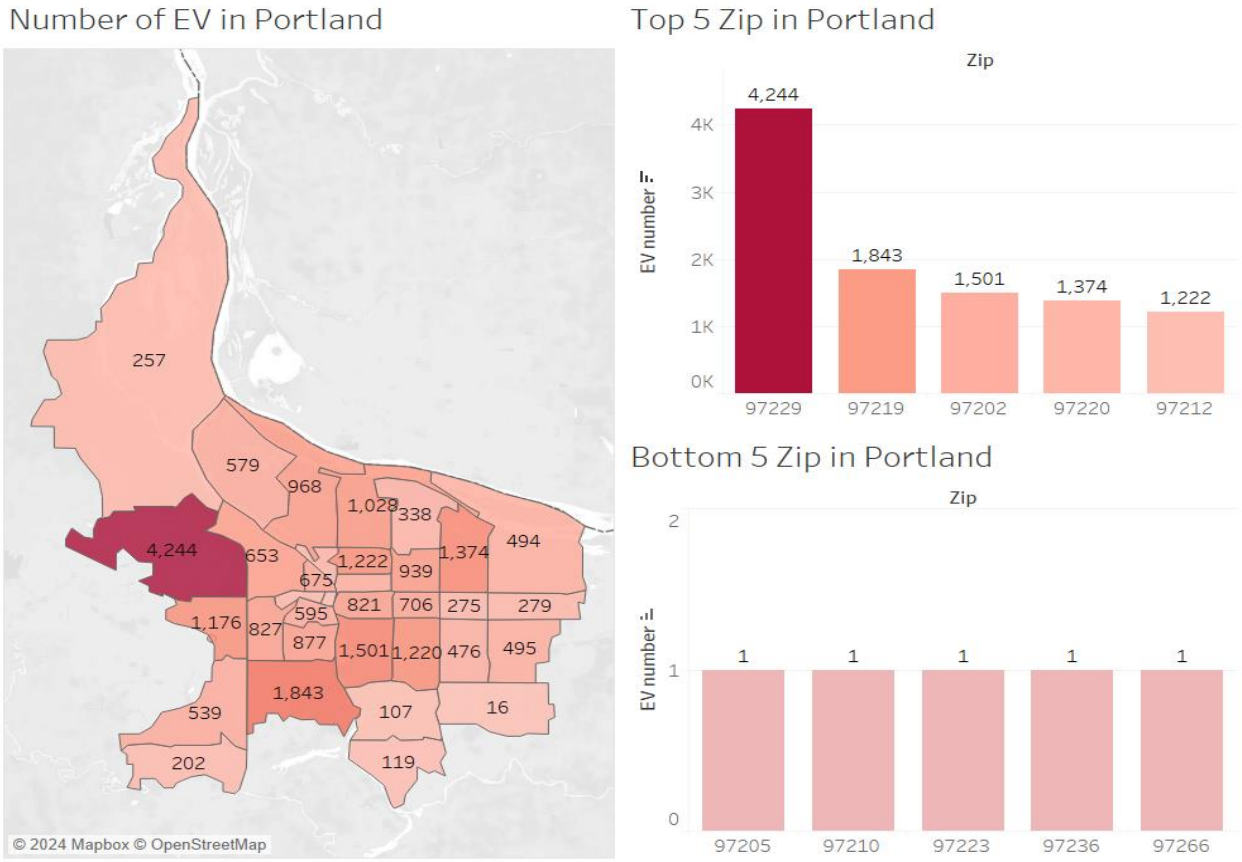
Visualization of Charging Station in Portland



This picture shows the current distribution of electric charging stations in Portland. It is known from the results that most charging stations are concentrated in the central part (97209, 97232,

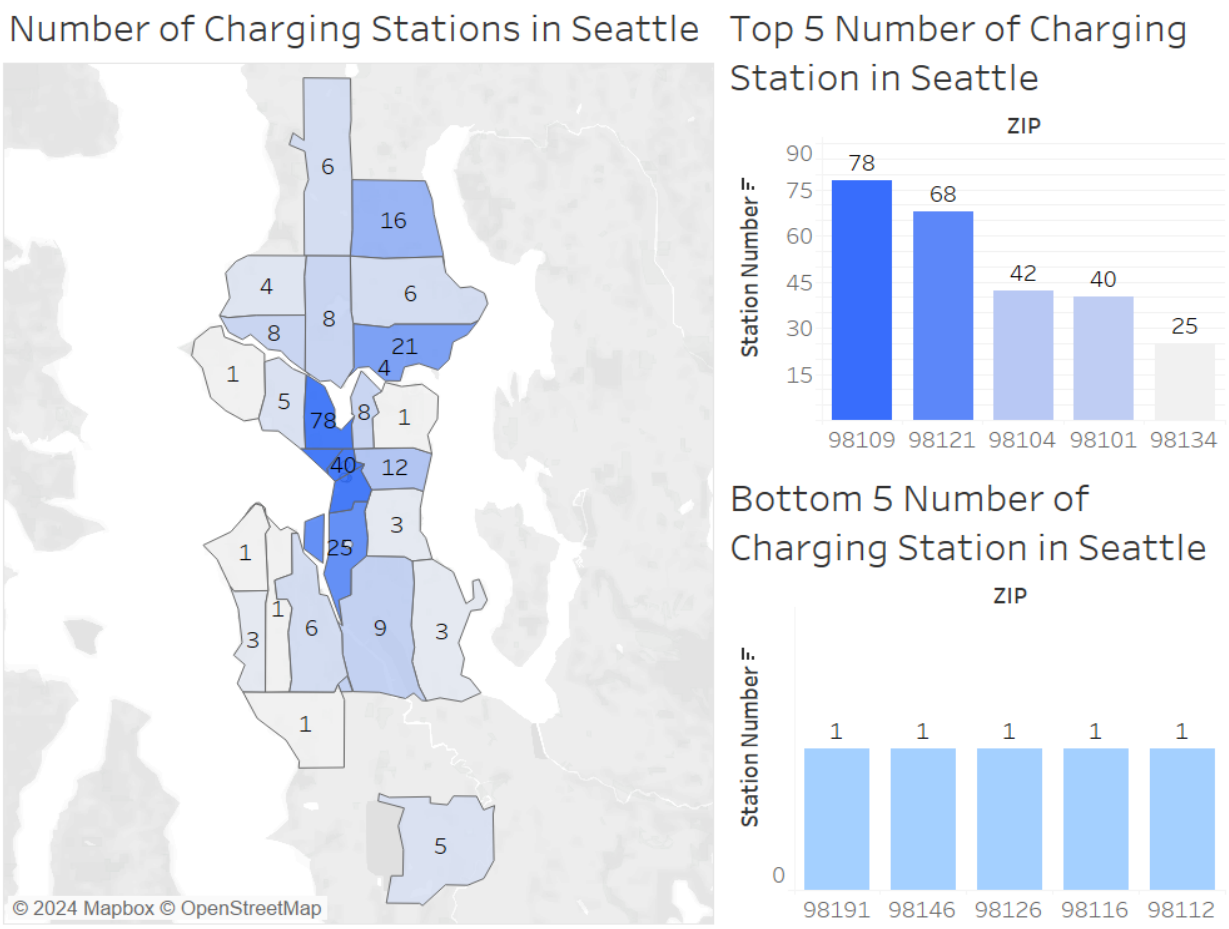
97201 and 97217). The further away from the central point, the fewer the number of charging stations. We found that the zip code with the most charging stations is 97217, which currently has 20 electric charging stations. However, the bottom five only have 1 or 2 charging stations.

Visualization of EV Population in Portland



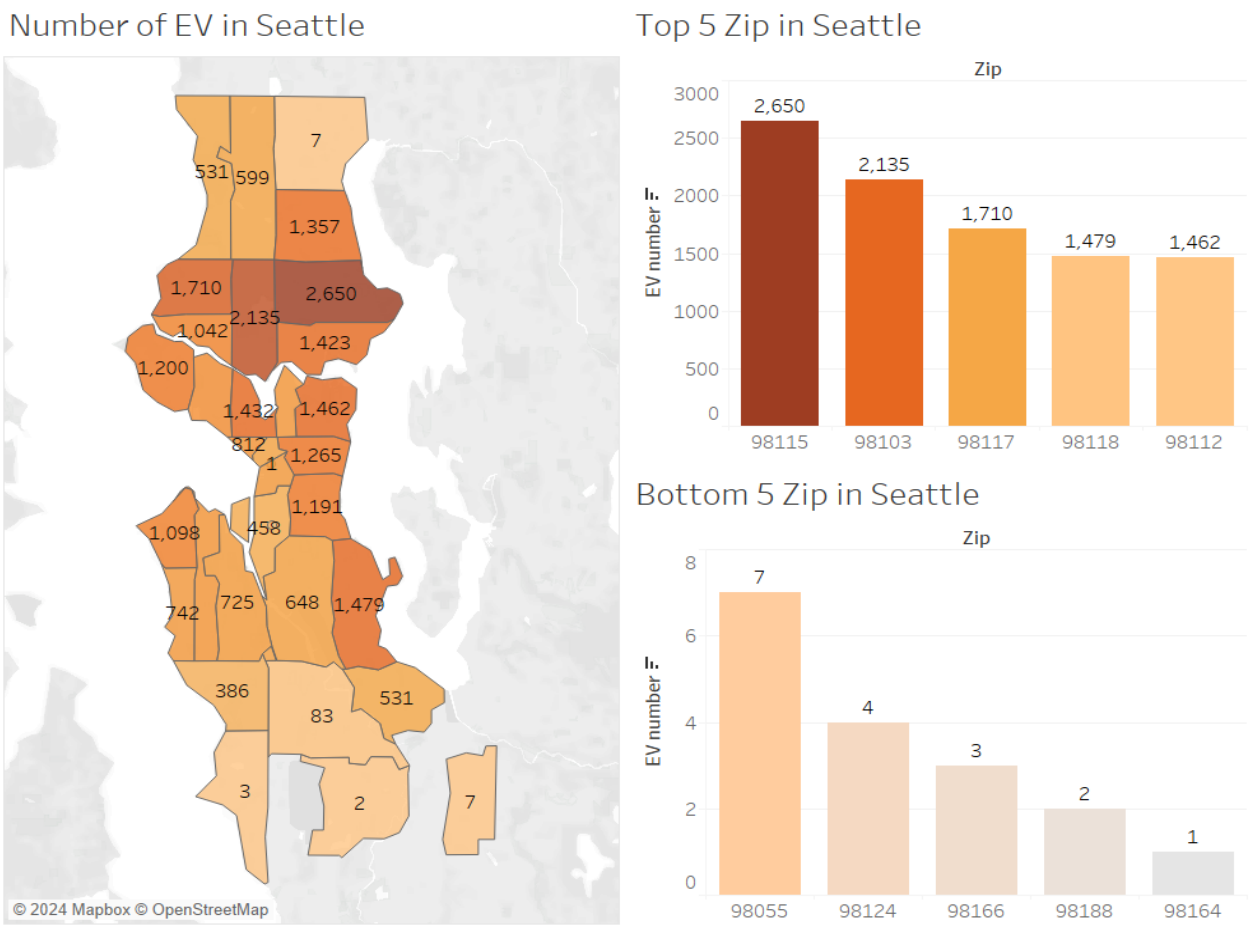
This picture shows the current distribution of all EV vehicles in Portland. In terms of distribution, there is no special pattern. Surprisingly, there are more than 4,000 EV vehicles in the west area (97229), which is 2.3 times that of the second place (97219). However, the top five regions all have more than 1,200 EV vehicles. However, the bottom five are almost all concentrated in the center of the city.

Visualization of Charging Station in Seattle:



This picture shows the current distribution of electric charging stations in Seattle. We found that the top three are concentrated in the center of the city (98109, 98121, 98104), and the first place is 3 times the fifth place. The bottom five areas all have only one charging station, and they are all located on the edge of the city.

Visualization of EV Population in Seattle



This picture shows the current distribution of EV numbers in Seattle. We found that most EVs are concentrated in the east, and there are more in the north than in the south. The data shows that the gap between the top five is not very large. However, the bottom five areas are in the southernmost or northernmost parts of the city.

Results of Visualizations

Upon scrutinizing our visual data, it became apparent that the electric vehicle (EV) population is significantly higher in the suburban areas compared to downtown Portland and downtown Seattle. Paradoxically, the majority of charging stations have been strategically placed in the

central downtown areas. This incongruity poses a substantial risk of charging station shortages, potentially causing frustration and anxiety among EV users. Furthermore, it is evident that the current quantity of charging piles in suburban areas is insufficient to cater to the demands of residents with electric vehicles, both in Portland and Seattle.

How to Deal with the Problem:

Based on our visualization, it is evident that certain zip code areas face either a shortage of charging stations or a lack of EV cars. Establishing the optimal benchmark for EV charging station capacity is crucial for devising an effective solution.

As reported by Kolomarsky (2021) in the New York Times, San Jose currently stands out as the most EV-friendly city in the United States, boasting over 70,000 EV vehicles and more than 2,500 charging stations. Calculations reveal that in San Jose, each charging station caters to an average of 31.3 EV vehicles. In other words, San Jose serves as the ideal "Density of EV Capacity" city in the US.

Consequently, we intend to employ San Jose's "Density of EV Capacity" ratio as our benchmark for a comparative analysis with Portland and Seattle. Utilizing Python, we will apply the "groupby" function to categorize EV populations in Portland and Seattle by zip code. Subsequently, we will compute the ratio of EVs to charging stations, grouping the results by zip code. Employing a logical function, we will classify the zip codes into two groups: those with ratios greater than the benchmark 31.3, indicating low charging station capacity, and those with ratios below the benchmark, suggesting a significant potential for increased EV sales. The outcome of this analysis is presented in the following tables (Binominal: 1=yes, 0=no):

Portland's ZIP Should Add Car:

ZIP	Add car
97204	1
97205	1
97232	1

From this table, Portland has 3 zip code areas need to adopt more EV population.

Portland's ZIP Should Add Station

ZIP	Add station	ZIP	Add station	ZIP	Add station	ZIP	Add station
97086	1	97213	1	97222	1	97236	1
97201	1	97214	1	97223	1	97239	1
97202	1	97215	1	97224	1	97250	1
97203	1	97216	1	97225	1	97266	1
97206	1	97217	1	97227	1	97267	1
97209	1	97218	1	97229	1	97298	1
97210	1	97219	1	97230	1		

97211	**1**	**97220**	**1**	**97231**	**1**		
97212	**1**	**97221**	**1**	**97233**	**1**		

From this table, Portland has 33 zip code areas needed to install more EV charging stations.

Seattle's ZIP Should Add Car

ZIP	Add car	ZIP	Add car
98101	**1**	**98154**	**1**
98104	**1**	**98164**	**1**
98109	**1**	**98188**	**1**
98121	**1**	**98191**	**1**
98124	**1**	**98195**	**1**
98134	**1**		

From this table, Seattle has 11 zip code areas need to adopt more EV population.

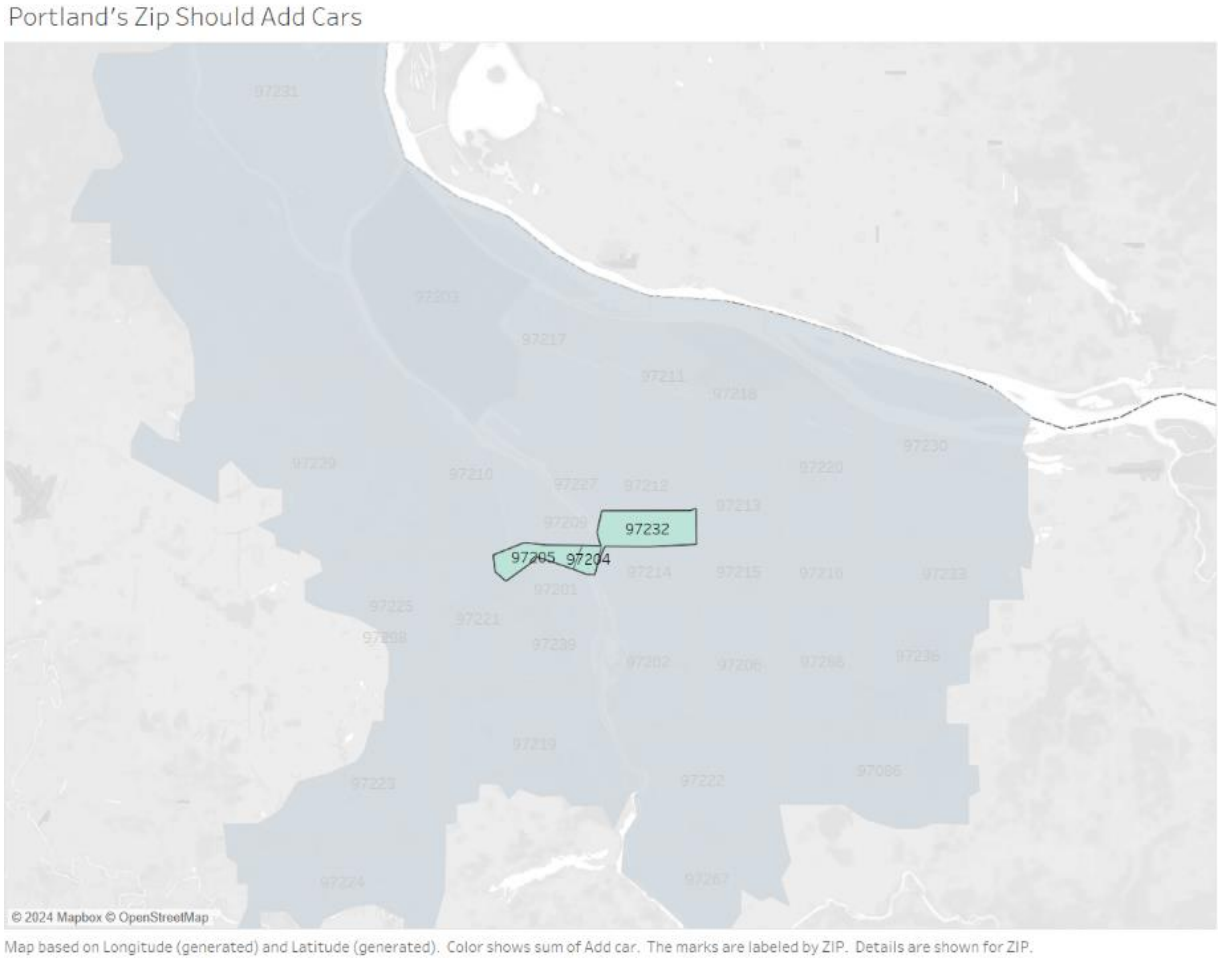
Seattle's ZIP Should Add Station

ZIP	Add station	ZIP	Add station	ZIP	Add station	ZIP	Add station
98055	1	98112	1	98125	1	98166	1
98102	1	98115	1	98126	1	98168	1
98103	1	98116	1	98133	1	98177	1
98105	1	98117	1	98136	1	98178	1
98106	1	98118	1	98144	1	98199	1
98107	1	98119	1	98146	1		
98108	1	98122	1	98155	1		

From this table, Seattle has 26 zip code areas need to install more EV charging stations.

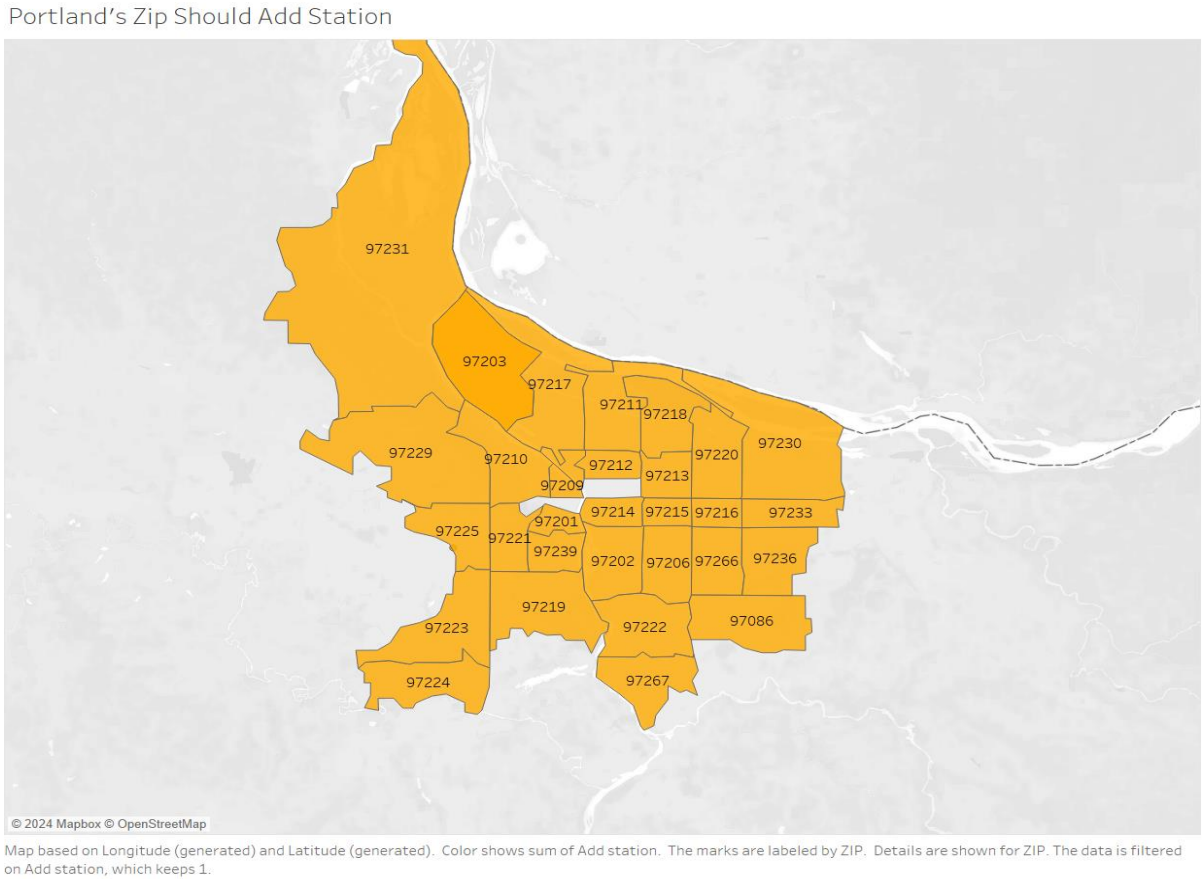
To make our data from the table above easy to understand and visualize, we use Tableau to show the visualization and identify which zip code area in Portland and Seattle should adopt more EV population and install more charging stations. Through the visualizations generated by Tableau, we also can identify trends and patterns in different regions. This analysis will help to decide which strategy should be used to approach those areas.

Visualization of Portland's ZIP Should Add Car



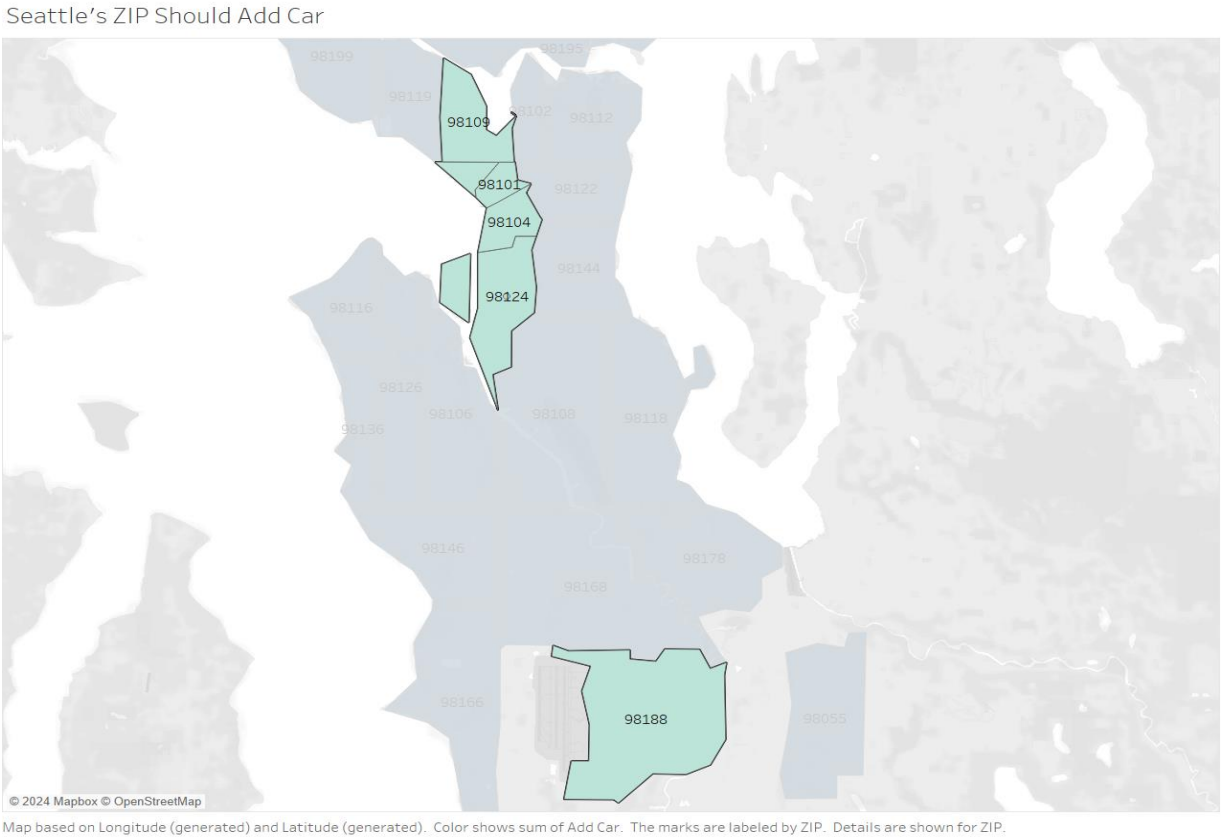
From this picture, Portland has 3 zip code areas need to adopt more EV population.

Visualization of Portland's ZIP Should Add Station:



From this picture, Portland has 33 zip code areas need to install more EV charging stations.

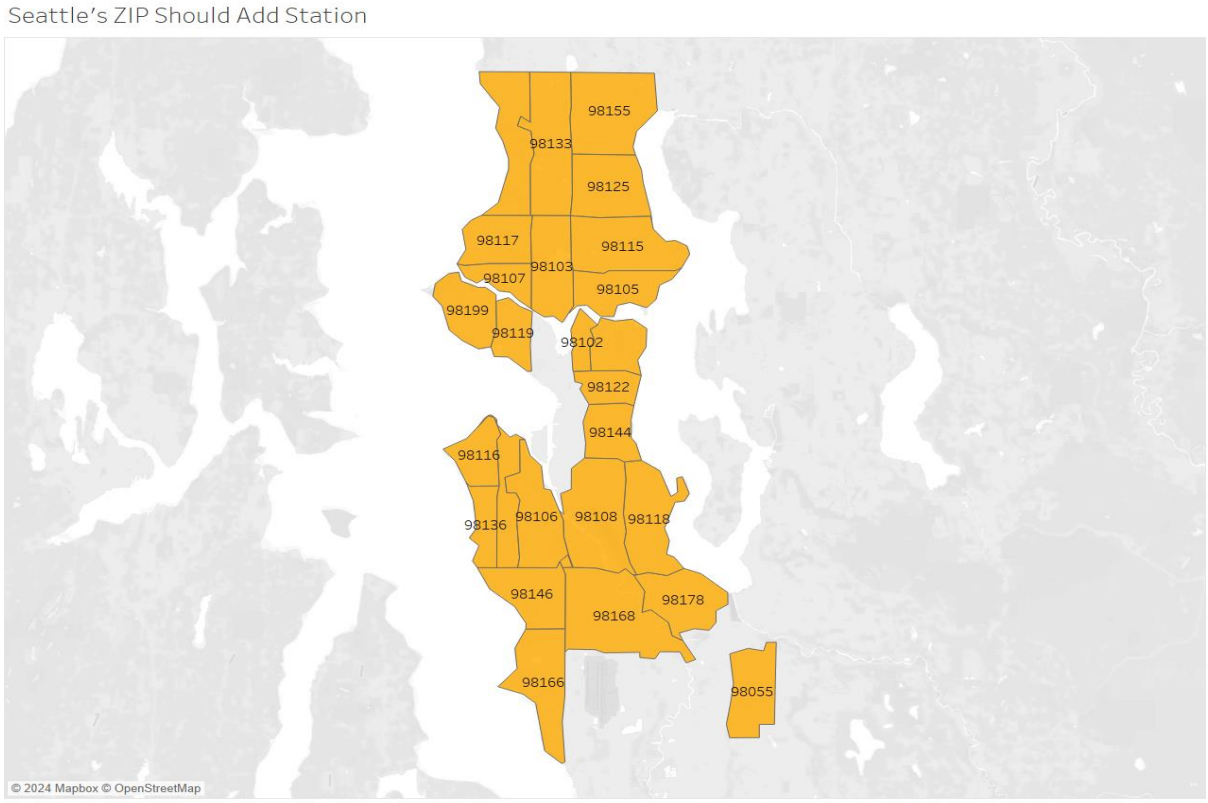
Visualization of Seattle's ZIP Should Add Car



From this picture, Seattle has 11 zip code areas need to adopt more EV population.

(*There are several sub-zip codes included in certain zip codes.)

Visualization of Seattle's ZIP Should Add Station:



From this table, Seattle has 26 zip code areas need to install more EV charging stations.

5. Discussion (Conclusion)

Business Applicability

In the final phase of our project, we have implemented the calculation to determine the density of EV capacity formula and the resulting recommendations regarding whether areas should add more cars or add more stations in focus cities: Seattle, Washington and Portland, Oregon. Currently, Seattle has 403 public electric charging stations and 28,857 electric vehicles. On the other hand, Portland has 175 charging stations and 26,007 public electric charging stations. As a

result, using the density of EV capacity formula, there has been an optimized quantity of electric charging stations to adapt the experts' forecast for the compound annual growth rate of the EV industry which will grow 18.6% from 2023 to 2029. Therefore, the EV charging station can get the benefits in the following year in terms of optimized capacity such as market share, improved cost efficiency, and enhanced customer satisfaction, and also EV companies can benefit in which area they could have the potential to add more sales or promotion, and partner opportunities such as Collaborating with charging station operators to increase utilization rates can create partnership opportunities for car sales companies.

Performance & Evaluation

Based on our project results from Seattle and Portland, we can benefit five groups of people.

- Electric charging stations companies: the charging stations company will gain business opportunities because they will become well known and involved in several projects related to building, operating, and maintaining charging stations due to the increased demand of their services.
- Electric vehicle companies: the increase in the EV population will boost the companies' revenue and expand their reach to customers that are interested in purchasing electric vehicles. The companies will experience market expansion by offering not only electric vehicles but include other products and services such as house chargers, batteries, software, insurance, finance, and rental services.
- City residents: the city residents will benefit in several ways. For example, the higher proportion of electric vehicles can help improve the air quality because the vehicle

produces zero emission. Additionally, noise reduction is another benefit, as electric vehicles are quieter than traditional vehicles.

- Electric vehicle owners and potential owners: the owners will pay less in operating and maintenance cost, as electric charging is cheaper than gasoline, and electric vehicles have fewer mechanical parts, eliminating the need for oil changes.
- Government: the growth of the electric vehicles industry will stimulate economic growth through job creation, associated sectors, as well as increased tax revenue from higher incomes, ultimately contributing to improved living standards.

After reviewing the results from Seattle and Portland, future work for charging stations and electric vehicles involves identifying areas that require additional charging stations and increasing the EV population. The initiative will enhance efficiency and customer satisfaction in each respective area.

Charging Stations

- Build more charging stations: the companies can identify specific areas for building and installing charging stations based on the results obtained.
- Develop charging infrastructure: invest in fast charge technology to reduce waiting and charging times.
- Maintain charging stations: maintenance and upgrade the existing charging station to ensure that it is reliable and efficient when customers book or come to use it.
- Enhance user experience: improve the user interface and payment system for a more seamless and user-friendly experience.

Electric Vehicle

- Affordability and incentives: reduce the price of EVs by utilizing incentives and subsidies.
- Improve battery technology: continue research and development to reduce battery cost, increase battery capacity, and extend battery life cycles.
- Variety of models: the electric companies should offer a diverse range of vehicle models to cater to customers with varying needs and preferences.

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