INFO 511 Project Report

Introduction

This project explores the usage of electric vehicles (EV) in Washington State by analyzing the datasets from the United States government's open data website, data.gov. We investigated trends in EV population growth, identified the most popular EV makes and models, examined geographic differences at the county level and analyzed the makes that potentially qualify for state tax exemptions. By using different visualizations, including a time-series line plot, a bar chart, a treemap, choropleth maps, and a word cloud, we provided insights into how the usage of electric vehicles in Washington State has changed from 2017 to early 2025.

Background

Washington State is a front-runner in using electric vehicles. Nearly one in five new cars sold in Washington in 2023 was an EV, far above the national average (~9.5%) (A Record Year for Electric and Plug-in Hybrid Vehicles in Washington, n.d.). This gave Washington the second-highest EV sales rate of any state, behind California (A Record Year for Electric and Plug-in Hybrid Vehicles in Washington, n.d.). Washington's EV market is also among the largest: it ranked fourth in the nation for total registered EVs on the road in 2023 (NEW ANALYSIS: Washington among National Leaders in Electric Vehicle Registration, 2024). Such leadership reflects years of growth – the state's EV registrations have increased 16-fold from 2014 to 2023 (NEW ANALYSIS: Washington among National Leaders in Electric Vehicle Registration, 2024).

Datasets and Preprocessing

The datasets that we used in this project are from the United States government's open data website: data.gov. The datasets are: electric vehicle population data (DATA.GOV, 2022), electric vehicle population size history (Data.gov, 2025), electric vehicle population size history by county (Electric Vehicle Population Size History by County, 2022), and WA tax exemptions - potential eligibility by make/model excluding vehicle price criteria (Data.gov, 2025).

The original "electric vehicle population data" dataset has 223,995 rows and 17 columns. There are 499 rows that have at least one missing value. The column that has the most missing values is "Legislative District", having 474 missing values. Other columns have 3 to 18 missing values. After looking through the subset that contains rows with any missing values, we realized that for the rows that have missing values for "Legislative District", the values for the column "Electric Utility" are mostly "NON WASHINGTON STATE ELECTRIC UTILITY". This makes sense because it might be difficult to track the legislative district if the electric utility is not from Washington state, since this dataset is collected from Washington. Since such connections exist, it would be information loss if we simply remove these rows with NA values for "Legislative District". Therefore, we decided to keep these rows but replace the NA values with a string "Missing" to indicate that there are no valid values from the original dataset. For other columns, however, the missing values have no visible connection or meaning. Since those are potentially individual mistakes while collecting the data, we decided to just remove these rows.

The original “electric vehicle population size history by county” dataset has 24,873 rows and 10 columns. There are 96 rows that have at least one missing value. The columns that have missing values are only "County" and "State". All other columns have no missing values. After examining these rows, there are no visible connections among other columns, except for the fact that all these rows have the value of "Passenger" for the column "Vehicle Primary Use". However, this is not a significant connection, because in the original dataset, there are only two distinct values for this column: "Passenger" and "Truck". And 84% of the rows have the values of "Passenger". So even though we can say that all "Truck" rows have valid data for "County" and "State", it is not a very significant observation that contributes to any of our research questions. Therefore, we simply removed the rows that have missing values from the original dataset.

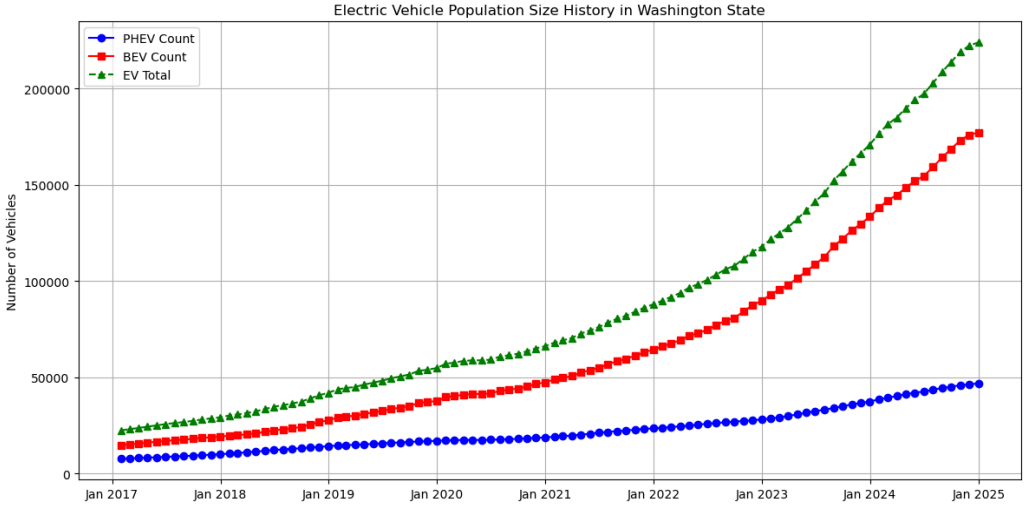
The original “electric vehicle population size history” dataset has 96 rows and 4 columns. The original “WA tax exemptions - potential eligibility by make/model excluding vehicle price criteria” dataset has 1,284 rows and 4 columns. There is not any row that has at least one missing value for these two datasets, so we did not need to deal with missing values for them.

Research Questions and Discussions

The main research question is how the electric vehicles in the state of Washington change across the years. We explored some sub-questions branched from the main question. We used different genres of visualizations to explore each sub-question.

Question 1: How does the population size of different types of electric vehicles in the state of Washington change, including plug-in hybrid electric vehicles and battery electric vehicles?

The "electric vehicle population size history" dataset was used for this question. We converted the data column to DateTime format. Then we created a time series line plot to illustrate population changes in Plug-in Hybrid Electric Vehicles (PHEV), Battery Electric Vehicles (BEV), and total Electric Vehicles (EV Total) from January 2017 to January 2025. The time series line plot is presented below. Each vehicle type was plotted with distinct colors and markers: blue circles for PHEV, red squares for BEV, and green triangles for the total EV count:

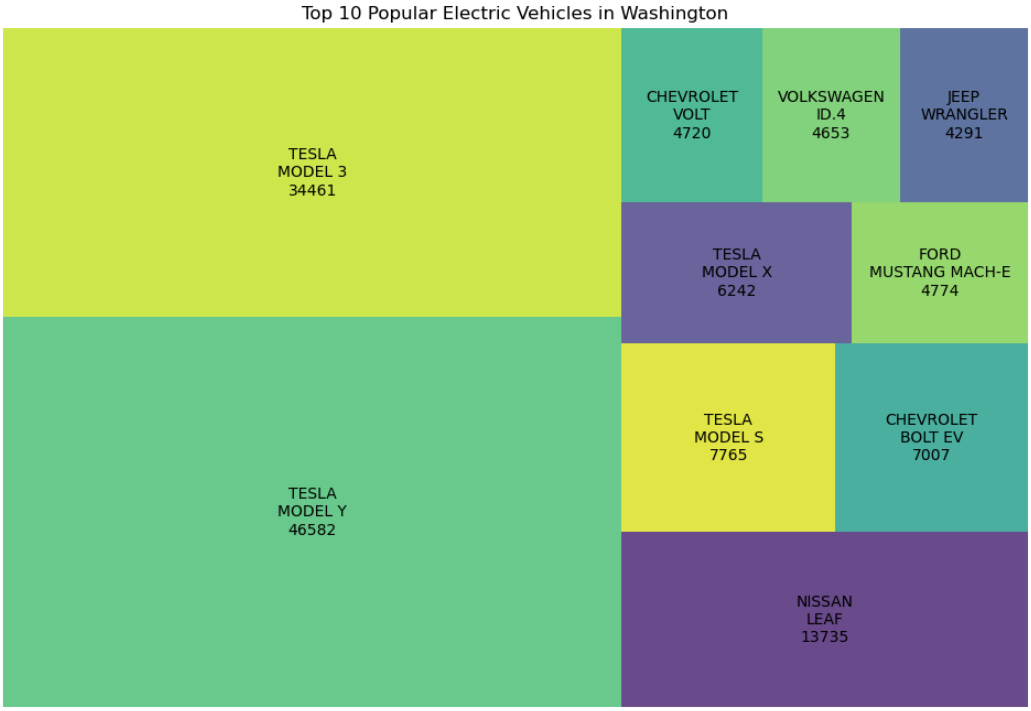


This plot demonstrates the increasing trend in electric vehicle populations over time. Initially, in January 2017, the number of PHEVs was 7,688, and BEVs were 14,741, making the total number of EV cars 22,429. As time went by, both vehicle types consistently increased, and notably, the growth rate of BEVs accelerated faster than the PHEVs, especially after 2020. By January 2025, BEVs had significantly outpaced PHEVs. The total number of electric vehicles also shows a substantial increase, demonstrating growing adoption rates within Washington State. Especially after Jan 2023, more and more people decided to choose EV cars.

Question 2: What makes and models are the most popular electric vehicles in Washington State?

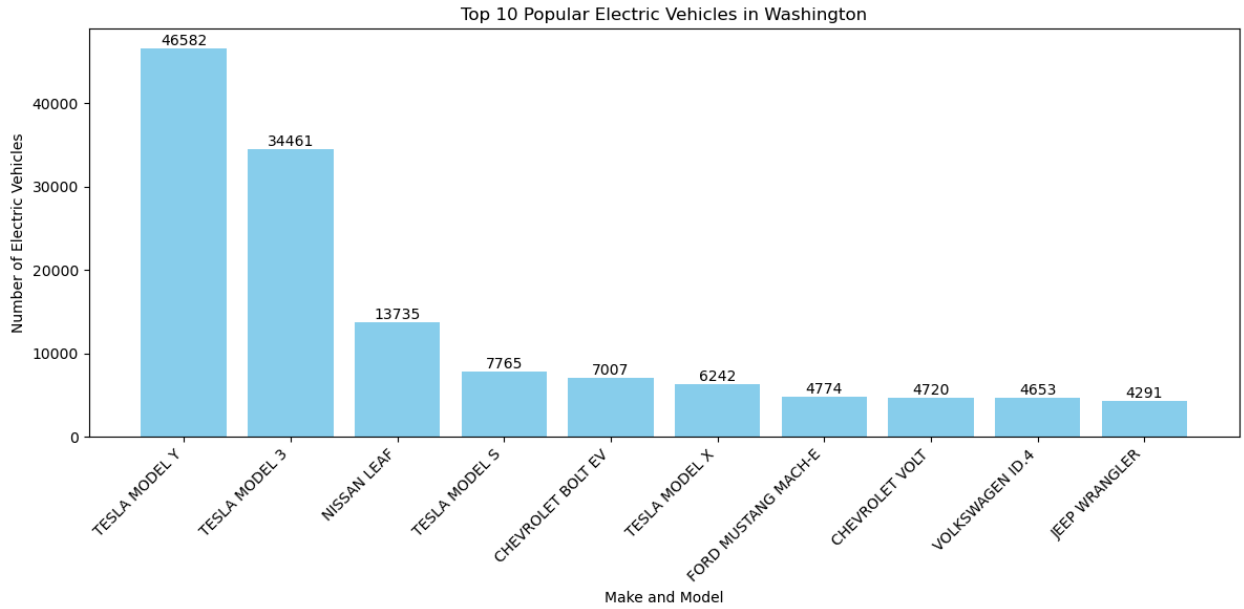
We used the "electric vehicle population data" dataset to explore this question. Two visualization methods were used: a grouped bar chart and a tree map. We grouped the data by car make and model and counted the frequency of each combination to identify the most popular EVs.

Based on the result, the ten most popular electric vehicle models in Washington State are Tesla Model Y, Tesla Model 3, Nissan Leaf, Tesla Model S, Chevrolet Bolt EV, Tesla Model X, Ford Mustang Mach-E, Chevrolet Volt, Volkswagen ID.4, and Jeep Wrangler. The Treemap is presented below:



The treemap provides an intuitive visualization of proportions. It used different sizes of rectangles to indicate the relative popularity of each vehicle model. The larger the rectangle, the more prevalent that vehicle is. From the graph, we can clearly observe the relative dominance of Tesla Model Y and Model 3 over other vehicles. It is visually apparent that these two models alone occupy more than half of the entire EV popularity landscape in Washington State.

The bar chart is presented below, directly displaying the exact count of each vehicle model above each single bar:



By using both visualization techniques together, we provide a comprehensive understanding of the data: the tree map delivers a quick, intuitive overview of the proportional dominance of each vehicle, while the grouped bar chart delivers precise numeric information.

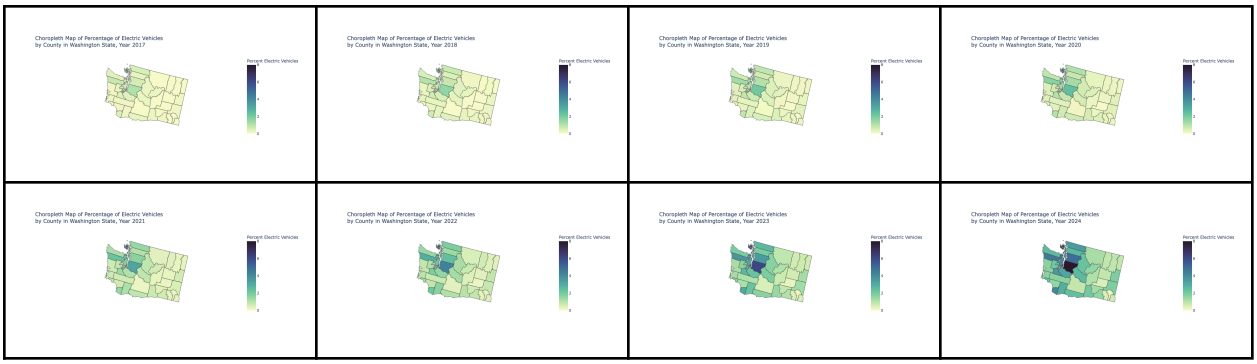
Question 3: How does the electric vehicle population differ by counties in Washington State?

The “electric vehicle population size history by county” dataset was used for this question. In order to compare the distribution of the differences, we created a set of choropleth maps to visualize the change of percentage of electric vehicles by county in the state of Washington from year 2017 to year 2024, which are the years of records provided in the dataset.

The original dataset contains 8 years of monthly records. Since the change in percentages would be more apparent by looking at yearly records, we decided to use the records from December for each of these 8 years as the values to do the visualization. In addition, there are two types of vehicle primary use, truck and passenger. However, as we looked through the dataset, the number of truck vehicles is very small compared to that of passenger vehicles. So we decided to remove the rows of truck vehicles because they contributed very little to our research question.

Across the dataset, the minimum value of the percentages of electric vehicles for the county is 0.07, and the maximum value of the percentages of electric vehicles for the county is 7.91. Therefore we set the color palette’s range to be correlated with the values ranging from 0 to 8.

The choropleth maps are presented below:



The plots were created using plotly and json libraries, and these are interactive plots. From the plot output in Jupyter notebook, we are able to move the cursor to a location within the map , and then the floating text box will appear, presenting the information of the county name and the exact percentage. As we can see from the plots above, there are two counties that always have the higher percentages than the other counties across the years, the county of San Juan and the county of King.

In the year of 2017, 1.25% of the total vehicles in the county of San Juan were electric vehicles; 1.15% of the total vehicles in the county of King were electric vehicles. There are several counties that had relatively higher percentages of electric vehicles: 0.8% for the county of Jefferson, 0.59% for the county of Snohomish, 0.52% for the county of Whatcom. All the other counties had percentages less than 0.5%, most of which were around 0.1~0.3%.

In the year of 2024, 7.31% of the total vehicles in the county of San Juan were electric vehicles; 7.91% of the total vehicles in the county of King were electric vehicles. Another three counties that also had relatively higher percentage of electric vehicles were: the county of Snohomish with 4.93%, the county of Jefferson with 4.65%, and the county of Clark with 4.09%. There were only 9 counties that had less than 1% of electric vehicles.

By looking at the maps sequentially, we can see that the percentages of electric vehicles for all counties have increasing trends, although some of which increased faster than others. The counties that are fond of electric vehicles the most are always San Juan and King. The county of San Juan had higher percentages of electric vehicles than the county of King from 2017 to 2022, but starting the year of 2023, the county of King surpassed the county of San Juan.

Question 4: What electric car makes have the highest appearances in the list of potential eligibility for the tax exemptions in Washington State?

The “WA tax exemptions” dataset was used for this question. In order to know what electric car makes appear with the highest frequencies in the list of tax exemptions in the state of Washington, we decided to use the word cloud visualization to present the information.

We used the wordcloud and matplotlib libraries to make the following visualization.

The higher the frequencies of the car makes appear in the dataset, the larger the font of the names in the word cloud. As we can see from this word cloud, the electric car makes Tesla, BMW, Rivian, Ford, Hyundai and Porsche are the most outstanding ones. We can also infer that the state of Washington permits tax exemptions for more electric vehicle models from these car makes, whether it be battery electric, plug-in hybrid or other types. For instance, from the year of 2025 alone, BMW has 34 models of electric vehicles, including i4 eDrive35 Gran Coupe (18 inch Wheels), i4 M50 Gran Coupe (19 inch wheels), i5 eDrive40 Sedan (21 inch Wheels), etc. However, we should not conclude from this visualization that these car makes produce more electric vehicle models than other car makes, because this is based on the tax exemptions list of the state of Washington, not a dataset that includes all electric vehicles makes and models from all over the world.

Conclusion

From this project, we explored how the electric vehicles in the state of Washington change across the years. Based on the visualizations, we can conclude that the electric vehicles population in the state of Washington has the increasing trend from 2017 to 2025. Especially starting from 2023, the slope of increasing is even higher than the years before. More specifically, the increasing rate of BEV (battery electric vehicle) is higher than the increasing rate of PHEV (plug-in hybrid electric vehicle), in the state of Washington. The top 10 popular electric vehicles in the state of Washington are Tesla Model Y, Tesla Model 3, Nissan Leaf, Chevrolet Bolt EV, Tesla Model S, etc. So we can see that Tesla is the most popular car make for electric vehicles in the state of Washington. The percentages of electric vehicles for all counties in the

state of Washington have increasing trends, although some of which increased faster than others. The counties with the highest percentages of electric vehicles are always San Juan and King. The car makes that appear the most frequently in the tax exemptions list from the state of Washington are Tesla, BMW, Rivian, Ford, Hyundai and Porsche, etc.

Future Works

Future research could focus on creating predictive models of the usage of EV using machine learning, evaluating the impact of policy changes on consumer behaviors, and examining socioeconomic factors influencing the usage of EV.

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