AIT580 PROJECT REPORT

Title: Analysis of patterns and trends of EVs in Washington state

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Abstract:

Utilizing electric vehicles (EVs) on a large scale is more important than ever to reduce greenhouse gas emissions and improve air quality. The primary subjects of this paper are the distribution, characteristics, and factors influencing the adoption of electric vehicles in Washington State. Using data from the EV Program of the Washington State Department of Ecology, the study analyses the spatial distribution of EVs by county, make, and model and explores the relationship between EV ownership and legislative districts. Areas with the highest concentration of electric vehicles (EVs) and possible sites for further research are noted. Understanding the trends and factors driving Washington State's increasing adoption of electric vehicles is essential to facilitating future growth and removing any roadblocks. The analysis in this report was carried out using a cross-sectional analysis of EV registration data from the EV Program of the Washington State Department of Ecology. For data cleaning and analysis, the Python programming language and data visualization tools were employed. The report's conclusions show that government incentives, the availability of charging infrastructure, and socioeconomic factors all have a significant influence on the adoption of EVs.

Keywords: EVs, greenhouse gas emission, potential barriers, government incentives, charging infrastructure availability, and socioeconomic factors.

Introduction:

As the ideas surrounding contemporary transportation rapidly shift, electric vehicles (EVs) are becoming crucial to sustainable mobility [1]. At a time when environmental preservation is becoming increasingly important, understanding the EV landscape is crucial to shifting our understanding of vehicle transportation [2]. Given this, Washington State has become a pivotal player in this emerging narrative, expected to register over 130,000 electric vehicles by 2022 [2]. This increase highlights the state's dedication to environmental sustainability and highlights the need for a detailed analysis of the intricate dynamics surrounding the adoption of electric vehicles.

Even though the increase in EV registrations creates a favorable impression, a deeper examination of the underlying facts is necessary. Research on the particular difficulties and chances that Washington State's electric vehicle ecosystem presents is still required [1]. By examining more than just the raw data, we intend to identify the intricate patterns that define the state's EV adoption and gain insight into the infrastructure, legal, and socioeconomic factors that support the EV environment.

It is important to look closely at Washington State's EV landscape for reasons unrelated to numbers. It provides a framework for understanding the intricate interplay of factors affecting the local adoption of electric vehicles [2]. This knowledge is not merely theoretical; according to [1], it can guide urban planning initiatives, impact policy frameworks, and encourage prudent investment in EV infrastructure. Washington is setting the standard for environmentally friendly transport; states that care about the environment should take note.

Formulate Research Question(s):
In this context, our research endeavors to answer pivotal questions that transcend statistical figures:

1. How are EVs distributed across counties in Washington State?
2. What are the most popular EV makes and models in Washington State?
3. Does a discernible relationship exist between EV ownership and legislative districts in Washington State?
4. Which specific areas within Washington State exhibit the highest concentration of EVs?

These questions serve not only as guideposts for our investigation but also as a promise to uncover insights that go beyond the surface, contributing to the broader discourse on sustainable mobility.

Literature Review:

Electric vehicles, or EVs, are becoming more and more popular around the world due to environmental concerns and technological advancements. Electric vehicles (EVs) have several advantages over traditional gasoline-powered cars, including reduced operating costs, reduced emissions, and improved air quality. Washington State will rank among the top states in the nation for EV adoption in 2022 with over 130,000 EVs registered there. This study aims to provide insight into the characteristics and distribution of EVs in Washington State.

A growing body of research has examined the factors that affect the uptake of electric vehicles. A review of the literature was conducted by [1] to identify the primary factors influencing the adoption of electric vehicles. They found that several important factors, such as customer preferences, the accessibility of charging infrastructure, government incentives, and socioeconomic considerations, have an impact on the decisions made about EV adoption. The incentives and barriers to the adoption of EVs were examined by [2]. They found that concerns about range anxiety, high vehicle costs, and a lack of infrastructure for EV charging are common barriers to EV adoption. Nevertheless, with the help of government incentives, increased infrastructure for charging, and positive customer attitudes, these challenges can be overcome and EV adoption promoted.

Studies that have examined the geographic distribution of EVs have also revealed trends in urbanization, environmental consciousness, and socioeconomic factors. Based on the spatial distribution of EVs in China, they have also found that most EV ownership is concentrated in higher-income and higher-education cities. They also found a positive correlation between owning an electric vehicle (EV) and air pollution, indicating that individuals who reside in areas with higher levels of air pollution are more likely to adopt EVs as a way to reduce their emissions. [3] used a spatial econometric model to investigate the factors influencing the adoption of EVs in China. They found that spatial spillover effects play a significant role in EV adoption, suggesting that EV adoption is more common among residents of areas with a high concentration of other EV owners.

Methodology:

Dataset Description:

Column Names	Data Type	Column Names	Data Types
VIN (1-10)	Nominal	Model Year	Ratio
County	Nominal	Make	Nominal
City	Nominal	Model	Nominal
State	Nominal	Electric Vehicle Type	Ordinal

Postal Code	Ratio	Clean Alternative Fuel Vehicle (CAFV) Eligibility	Ordinal
Electric Range	Ratio	Electric Utility	Nominal
Base MSRP	Ratio	2020 Census Tract	Interval
Legislative District	Interval		
DOL Vehicle ID	Ratio		
Vehicle Location	Nominal		

Table 1: NOIR datatypes of the dataset.

```
11 •  SELECT make, model, COUNT(*) AS count_by_make_model
12    FROM ev
13    GROUP BY make, model;
14
```

Result Grid | Filter Rows: | Export: | Wrap Cell Content:

make	model	count_by_make_model
TESLA	MODEL Y	30790
TESLA	MODEL 3	28505
NISSAN	LEAF	13296
TESLA	MODEL S	7626
CHEVROLET	BOLT EV	6105
TESLA	MODEL X	5306
CHEVROLET	VOLT	4862
VOLKSWA...	ID.4	3345
KIA	NIRO	3029
FORD	MUSTANG MA...	2933
JEEP	WRANGLER	2892
CHRYSLER	PACIFICA	2844
TOYOTA	PRIUS PRIME	2560
BMW	X5	2201
HYUNDAI	IONIQ 5	1981
BMW	I3	1913

Result Grid | Form Editor | Field Types | Query Stats

Figure 1: No of models sold concerning count.

```
In [17]: df[numerical].describe()
```

Out[17]:

	Postal Code	Model Year	Electric Range	Base MSRP	Legislative District	DOL Vehicle ID	2020 Census Tract
count	159463.000000	159467.000000	159467.000000	159467.00000	159106.000000	1.594670e+05	1.594630e+05
mean	98170.373635	2020.192510	64.283319	1227.63716	29.261675	2.140242e+08	5.297287e+10
std	2453.354932	3.010564	94.634277	8930.03468	14.843878	7.959275e+07	1.621526e+09
min	1730.000000	1997.000000	0.000000	0.00000	1.000000	4.385000e+03	1.081042e+09
25%	98052.000000	2018.000000	0.000000	0.00000	18.000000	1.731016e+08	5.303301e+10
50%	98122.000000	2021.000000	14.000000	0.00000	33.000000	2.198450e+08	5.303303e+10
75%	98370.000000	2023.000000	84.000000	0.00000	43.000000	2.448363e+08	5.305307e+10
max	99577.000000	2024.000000	337.000000	845000.00000	49.000000	4.792548e+08	5.603300e+10

Figure 2: Univariant analysis for the numerical columns

Univariate and multivariant analyses are performed using Python and a visualization is performed using r results are shown below. Correlation is performed among the numerical columns as you can see, the highest correlated value is 0.51, which is between the 2020 census Tract and Postal code.

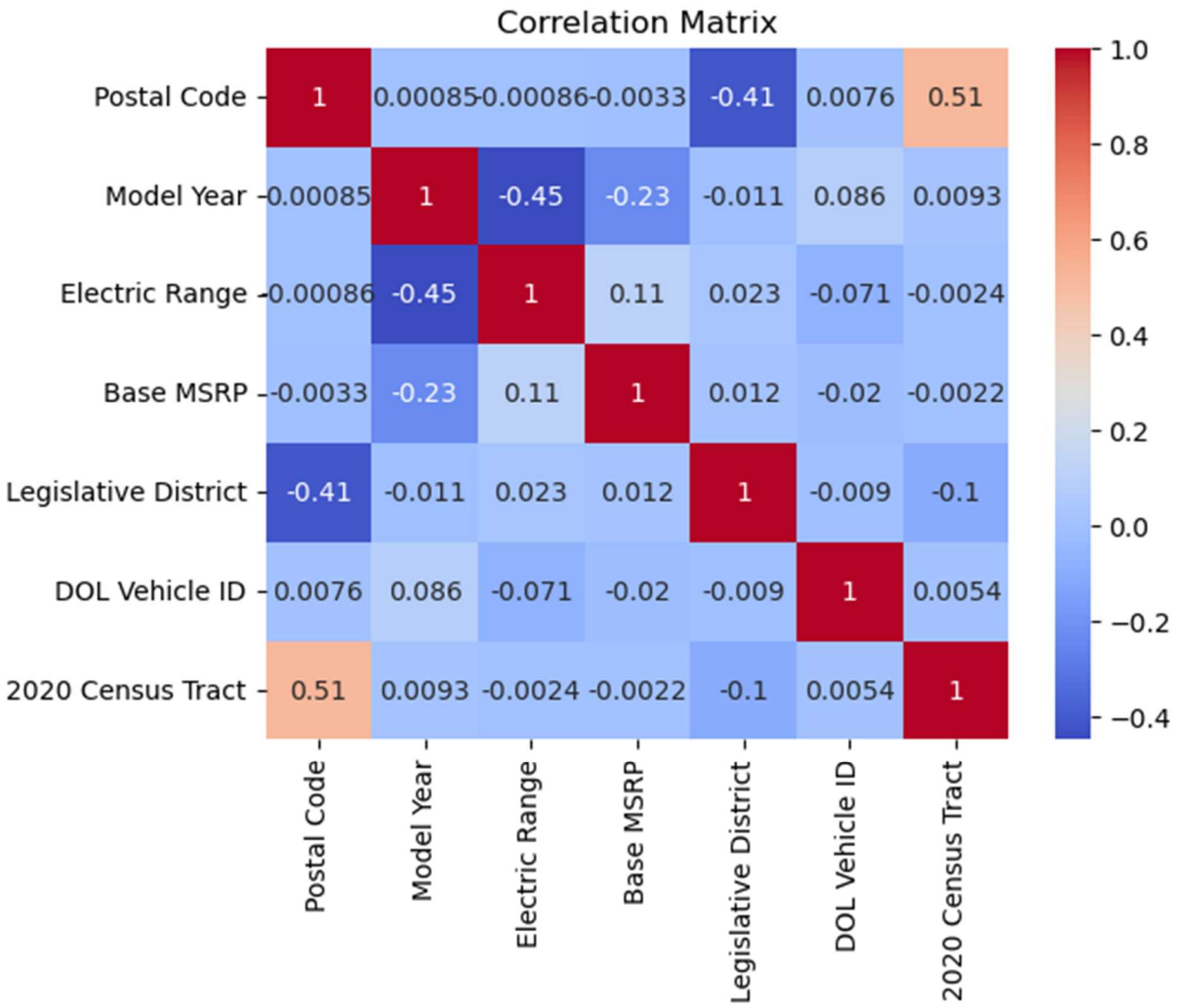

Figure 3: Correlation matrix(Heat map) of the numerical values in the dataset.

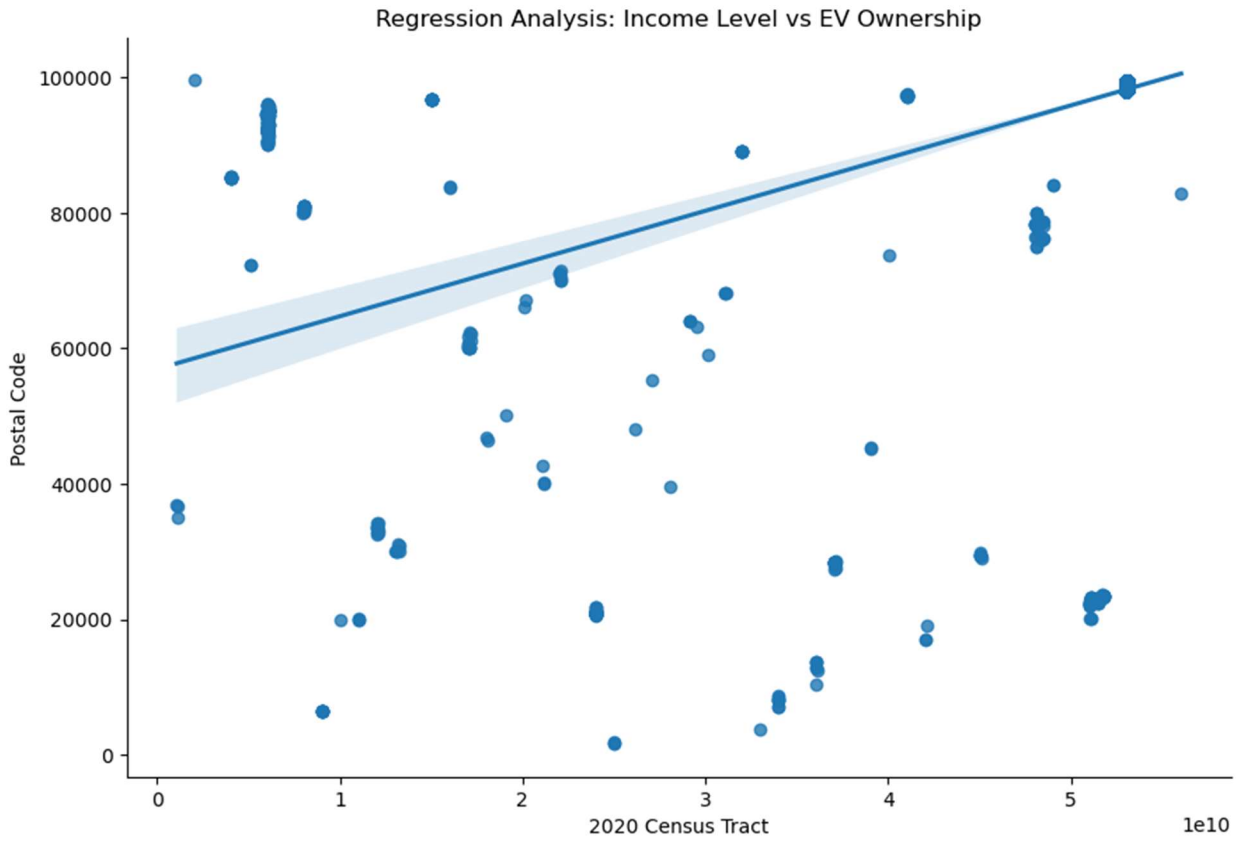

Figure 4: Regression graph for the highly correlated value in the dataset.

And also plotted the regression plot for the highest-correlated value. Since there is very little correlation value, there is no possibility of prediction.

The analysis in this report is based on data from the Washington State Department of Ecology's EV Program. The data includes information on EV registrations, including make, model, county, postal code, and legislative district. Data cleaning and analysis were conducted using Python programming language and data visualization libraries.

Results:

```
7 •   SELECT county, COUNT(*) AS countcounty
8     FROM ev
9     GROUP BY county;
10
11
```

Result Grid | Filter Rows: | Export: | Wrap Cell Conten

county	countcounty
King	83413
Snohomish	18544
Pierce	12315
Clark	9364
Thurston	5711
Kitsap	5216
Spokane	4016
Whatcom	3865
Benton	1941
Skagit	1759
Island	1721
Clallam	965
Chelan	926
Jefferson	904
Yakima	882
San Juan	875

Figure 5: Statistics of most of Ev's bought by county.

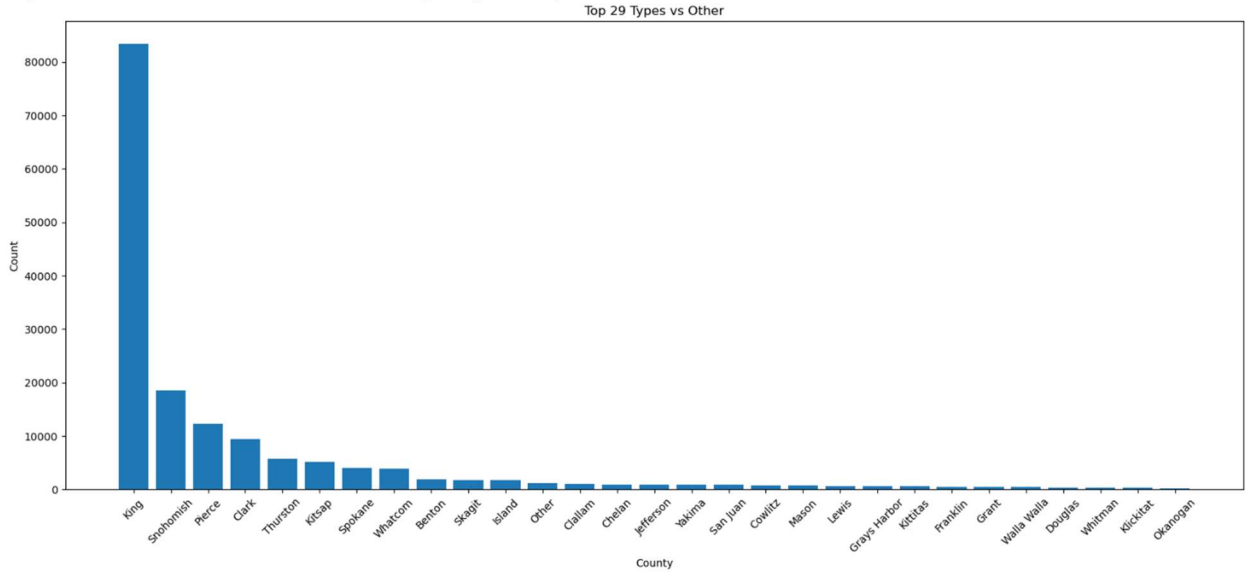

Figure 6: Graph for the most no of Ev's bought by county.

From the figure, we can interpret the top 29 counties in Washington State with the highest number of electric vehicles (EVs), as well as a category for "Other". The chart shows that King County has the highest number of EVs, followed by Snohomish County, Pierce County, Clark County, and Thurston County. These five counties represent over 70% of the total EV population in Washington State.

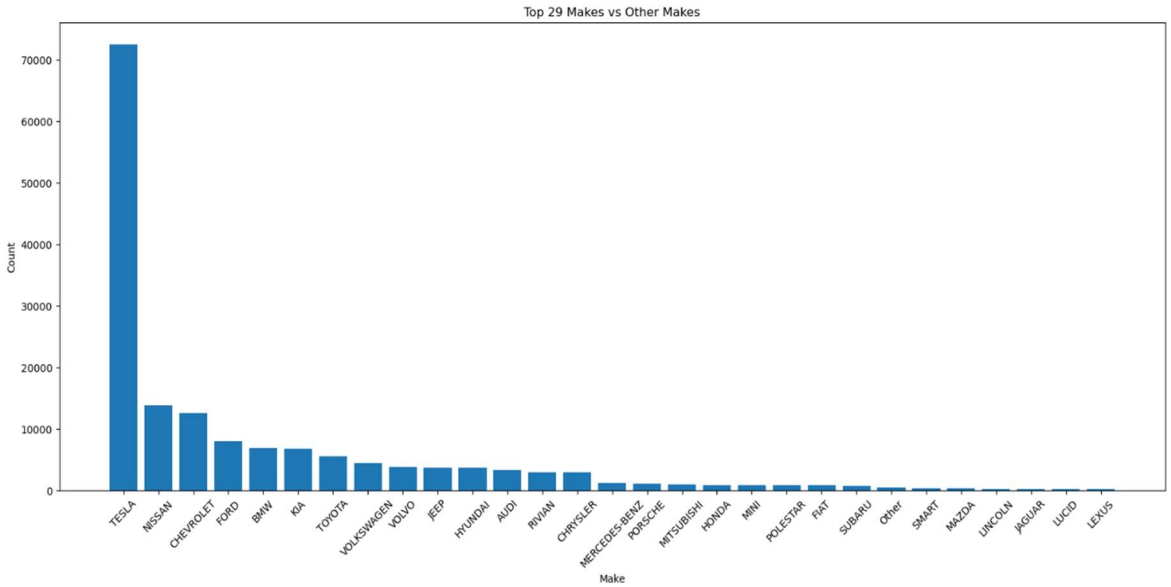

Figure 7: Graph for the most no of Ev's bought by make.

From the figure, we can interpret that the top 29 makes in Washington State with the highest number of electric vehicles (EVs), as well as a category for "Other". The chart shows that Tesla has the highest number of EV sales, followed by Nissan, Chevrolet, Ford, and BMW.

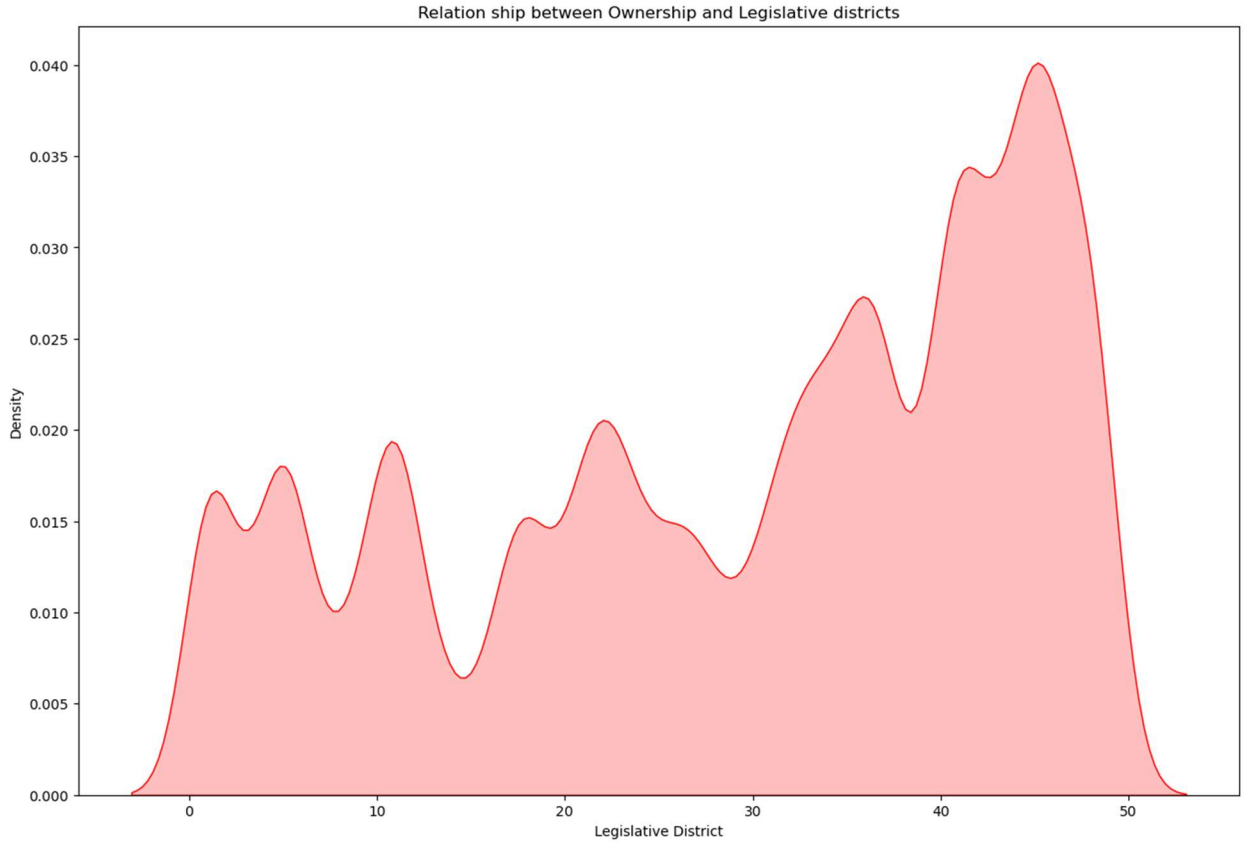

Figure 8: line graph for the correlation between legislative districts and EV ownership.

From the above figure, we can interpret that, there is a positive correlation between EV ownership and legislative districts with higher income levels and higher educational attainment.

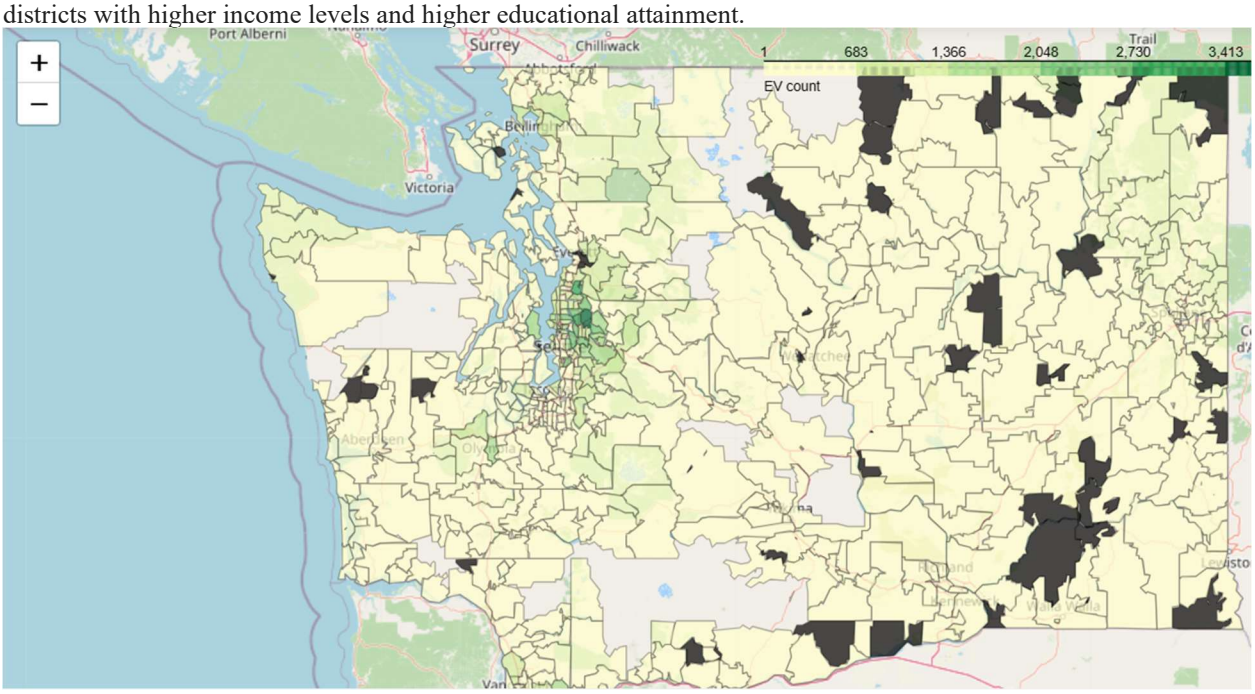

Figure 9: Density of the Ev's bought and used in the locations of Washington state.

From the above map, we can interpret that the areas with the highest concentration of EVs are clustered around Redmond, Kirkland, Mercer Island, Bellevue, North Creek, Seattle, Tacoma, and Everett, reflecting the higher population density and urban infrastructure in these regions.

Discussions:

This result is consistent with the report's findings, which show that Washington State's EV distribution is concentrated in and around cities with higher population densities and easier access to infrastructure for charging. Additionally, the study discovers a favorable correlation between EV ownership and legislative districts with greater incomes and educational attainment levels. This suggests that socioeconomic factors have a major impact on the adoption of electric vehicles.

Overall, the image highlights how EVs are concentrated in wealthy and urban areas of Washington State and provides additional proof to back up the report's findings.

Here is a more detailed interpretation of the image:

- All five of the counties with the highest percentage of electric vehicles are located in the Seattle metropolitan area. Over 3.5 million people live in these counties collectively, which is about half of all people in Washington State.
- The densely populated urban areas are also home to the other counties with notable populations of electric vehicles. These counties include Tacoma, Everett, Spokane, and Bellingham.

- The "Other" category includes counties with a low number of EVs. The majority of these counties are located in rural areas with sparser populations and limited access to charging infrastructure. The image suggests that the following factors are important for EV adoption:

- Population density: Because they offer more potential customers and more opportunities for charging infrastructure, higher population densities raise the likelihood of EV adoption.
- Access to charging infrastructure: EV adoption is more likely in locations with readily available infrastructure for charging. This includes outlets for charging that are located in public areas, offices, and homes.

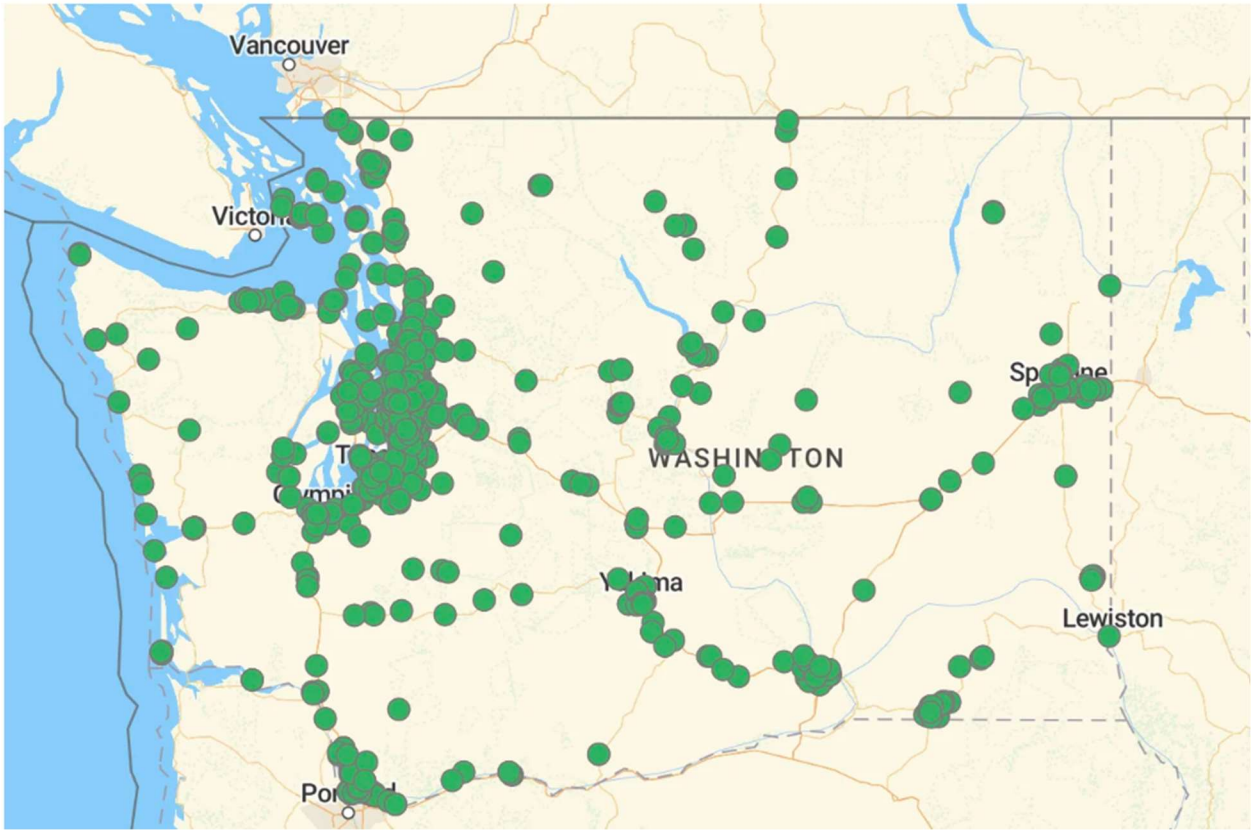

Figure 10: charging stations in Washington states.

Source: Adapted from [3]

- Socioeconomic factors: Higher income and educational levels are associated with higher rates of electric vehicle adoption. This demonstrates how socioeconomic factors affect the adoption of EVs, including one's ability to pay for an EV and awareness of its benefits. [4]

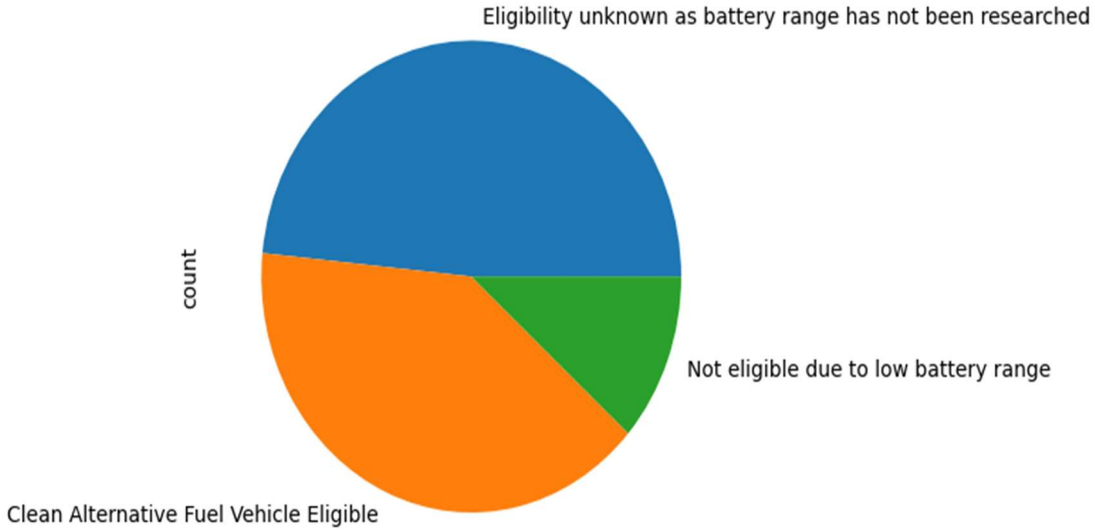

Figure 11: Pie Chart of Eligibility types for government incentives.

- The pie chart, shows the eligibility of electric vehicles (EVs) in Washington State. The chart shows that the majority of EVs in Washington State are eligible for a federal tax credit of up to $7,500. This is because the vast majority of EVs on the market meet the criteria for the tax credit. [5]

- This finding is consistent with the report's findings on government incentives, which show that the majority of EVs in Washington State are eligible for government incentives. The report also notes that government incentives play a significant role in promoting EV adoption. [5]

Limitations and Future Research:
This report is based on a cross-sectional analysis of EV registration data, which does not capture the dynamic nature of EV adoption. Future research could utilize longitudinal data to examine trends in EV adoption over time and identify factors influencing individual adoption decisions. Additionally, research could explore the impact of EV ownership on transportation patterns, energy consumption, and air quality.

Conclusion:
Electric vehicles are gaining traction in Washington State, with a distribution that reflects the state's geographic and socioeconomic landscape. The analysis in this report provides insights into the current state of EV adoption and highlights areas for future research. As EV technology continues to evolve and government incentives remain in place, EV adoption will likely continue to grow, with significant implications for transportation, energy, and the environment.

References

[1] M. Coffman, P. Bernstein, and S. Wee, "Electric vehicles revisited: a review of factors that affect adaptation.," *Transport Reviews,* vol. 37, pp. 79-93, Aug. 2016.

[2] Z. Rezvani, J. Jansson and J. Bodin, "Advances in consumer electric vehicle adoption research: A review and research agenda," *Transportation Research Part D: Transport and Environment.,* vol. 34, pp. 122-136, Jan. 2015.

[3] "Washington Electric Vehicle Trends," Recurrent, [Online]. Available: https://www.recurrentauto.com/research/washington-electric-vehicles#:~:text=There%20are%201%2C820%20charging%20stations,to%20surpass%20that%20in%202023..

[4] J. Sabel and D. McDermot, "Socioeconomic," Washington State Department of Health, [Online]. Available: https://doh.wa.gov/sites/default/files/legacy/Documents/1500//Context-SEP2016-DU.pdf.

[5] "WHAT ARE THE WASHINGTON STATE EV TAX CREDITS?," BMW, [Online]. Available: https://www.bmwseattle.com/electric-vehicle-tips/washington-state-ev-tax-credits/#:~:text=So%2C%20does%20Washington%20State%20have,to%20%247%2C500%20in%20tax%20credits.

[6] H. Gu and C. Han, "Analysis of China's Pure Electric Vehicle Sales Based on Spatial Econometric Models," *ResearchGate,* 2020.