Electric Vehicles Market Size Analysis

Dataset: Ev_Population_US(WA).csv

Github Link: *https://github.com/asim9996/Electric-Market-Analysis.git*

The dataset provides comprehensive information on electric vehicles (EVs) registered in Washington state. It includes over 205,000 entries, detailing vehicle types, electric ranges, manufacturers, and geographic locations.

Key Insights:

- Types of EVs: Primarily two types: Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs).
- EV Adoption Over Time: Analize the growth of the EV population by model year.
- Make and Model Popularity: Identify the most popular makes and models among the registered EVs.
- Manufacturers: Brands like Tesla, Nissan, Chevrolet, and Toyota are prevalent.
- Electric Range: The electric range varies significantly, with some vehicles having ranges over 200 miles.
- Geographic Distribution: EVs are registered across various cities and counties, with specific utility providers serving these regions.
- Estimated Growth in Market Size: Analize and find the estimated growth in the market size of electric vehicles.

This dataset offers rich opportunities for further analysis on EV adoption trends, geographic distribution, and market shifts over time.

1. Introduction

Washington State is a leader in the adoption of electric vehicles (EVs) in the United States due to a combination of strong government incentives, environmental awareness, and growing charging infrastructure. Understanding the segmentation of the EV market within Washington State is vital for stakeholders such as policymakers, automakers, and businesses to tailor their strategies to meet specific market needs. This report will explore the segmentation of the electric vehicle population in Washington based on key factors like demographics, vehicle types, geographical distribution, and customer motivations.

2. Importance of Market Segmentation

Market segmentation helps to divide the total EV market into distinct groups of consumers with shared characteristics. These segments can then be targeted with customized marketing strategies, service offerings, and policy interventions. This ensures that the efforts of stakeholders are more efficient and effective in accelerating the adoption of electric vehicles.

3. Segmentation Criteria

Several factors are typically used to analyze the EV population, including:

- **Demographic Segmentation**: Age, income level, education, and occupation of EV owners.
- **Geographic Segmentation**: Urban versus rural areas, regions with high EV adoption, and access to charging infrastructure.
- **Psychographic Segmentation**: Lifestyle, environmental concerns, technology adoption willingness.
- **Behavioural Segmentation**: Usage patterns, charging behaviour, vehicle range needs.

Each of these segmentation criteria plays a role in how the market is structured and addressed.

4. Demographic Segmentation

Washington's EV market varies significantly by demographic factors such as age, income, and education.

- **Income Level**: EV ownership is often concentrated among higher-income individuals due to the high upfront costs of vehicles. However, with new models entering the market at lower price points, this segment is expanding. Financial incentives (like tax credits) also contribute to more diverse income segments adopting EVs.
- **Age**: Younger consumers, especially millennials and Gen Z, show greater interest in EVs, particularly due to concerns about climate change and sustainability. On the other hand, middle-aged and affluent individuals may prefer luxury EVs, such as Tesla.
- **Education Level**: Consumers with higher education levels tend to be more aware of environmental issues and advanced technology, leading to a higher adoption rate of EVs among this group.

5. Geographic Segmentation

Geographical factors play a significant role in the adoption of EVs in Washington State:

- **Urban vs. Rural Areas**: Urban areas like Seattle, Bellevue, and Redmond see higher EV penetration rates due to better access to charging stations and shorter average commute distances. Rural areas, with limited infrastructure, may face challenges such as "range anxiety" (fear of running out of battery without nearby charging stations).
- **Infrastructure Density**: Certain counties have invested heavily in EV infrastructure. For example, King, Snohomish, and Pierce counties have a denser network of public charging stations, making them more attractive for EV ownership.

6. Vehicle Type Segmentation

EVs can be categorized into different types based on consumer preferences and vehicle usage needs:

- **Battery Electric Vehicles (BEVs)**: These vehicles run solely on electric power and are more popular in densely populated areas with extensive charging infrastructure. They appeal to environmentally conscious consumers who value zero-emission transportation.
- **Plug-in Hybrid Electric Vehicles (PHEVs)**: These vehicles combine electric propulsion with a gasoline engine, providing more flexibility and range. They tend to be more popular in regions where charging infrastructure is less developed or among consumers concerned about long-distance driving.

- **Luxury vs. Affordable EVs**: Tesla dominates the luxury EV segment in Washington, while more affordable brands like Nissan (Leaf) and Chevrolet (Bolt) appeal to middle-income consumers.

7. Psychographic Segmentation

Psychographic factors reflect the attitudes, values, and motivations of EV consumers in Washington:

- **Environmental Consciousness**: Many EV buyers in Washington are motivated by the desire to reduce their carbon footprint and contribute to sustainability efforts. This segment is particularly strong in urban areas where environmental awareness is higher.
- **Tech Enthusiasts**: EVs, especially those from brands like Tesla, appeal to tech-savvy individuals who are early adopters of new technologies. These consumers are drawn to features such as autopilot, connectivity, and performance.
- **Cost-Conscious Consumers**: With rising fuel prices and EV incentives (rebates, tax credits), some consumers are drawn to EVs for economic reasons. These buyers are often looking for affordable EV models with low running costs.

8. Behavioral Segmentation

Understanding how consumers use their electric vehicles and the behavior surrounding charging is essential for segmentation.

- **Usage Patterns**: Consumers who commute short distances, particularly in urban areas, tend to opt for smaller, lower-range EVs. In contrast, those with long commutes or who frequently travel opt for vehicles with longer ranges or plug-in hybrids.
- **Charging Behavior**: Home charging is common among urban homeowners with access to garages, while urban apartment dwellers may rely more on public or workplace charging. The availability of fast chargers along highways is crucial for long-distance drivers.

9. Key Market Segments

Based on the above segmentation criteria, Washington's EV market can be divided into distinct groups:

1. **Affluent Tech Enthusiasts**: Predominantly middle-aged, higher-income consumers residing in urban areas who prefer luxury EVs with advanced technology.
2. **Environmentally Conscious Millennials**: Younger consumers, living in urban centers, who are drawn to affordable EVs due to environmental concerns and sustainability motivations.
3. **Practical Rural Consumers**: Rural consumers who may opt for PHEVs or longer-range EVs to mitigate concerns over charging infrastructure. They tend to be more price-conscious and may require financial incentives to make EV ownership more appealing.
4. **Cost-Sensitive Suburban Families**: These consumers are motivated by the lower operating costs of EVs and are likely to choose affordable models or hybrids.

10. Challenges and Opportunities

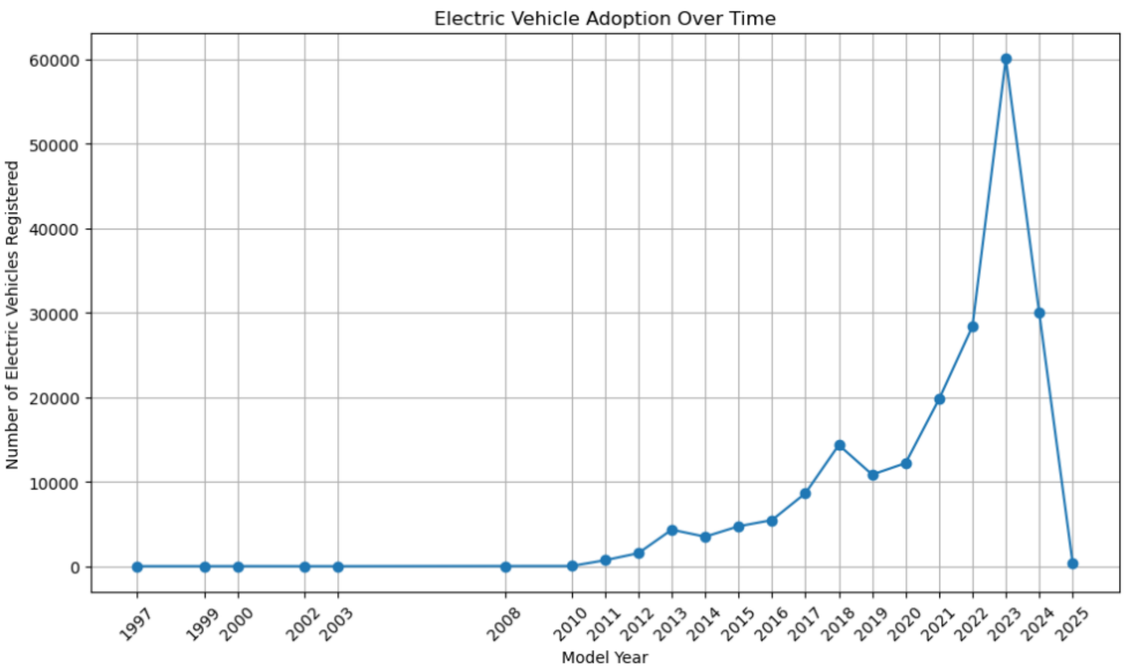
- **Challenges**: Key challenges include the development of charging infrastructure in rural areas, overcoming the upfront costs for lower-income segments, and educating the public on the benefits of EV ownership.
- **Opportunities**: With continued expansion of Washington's charging infrastructure, particularly in suburban and rural areas, and as battery technology improves (leading to lower costs), EV adoption is expected to increase across more diverse market segments.

11. Recommendations

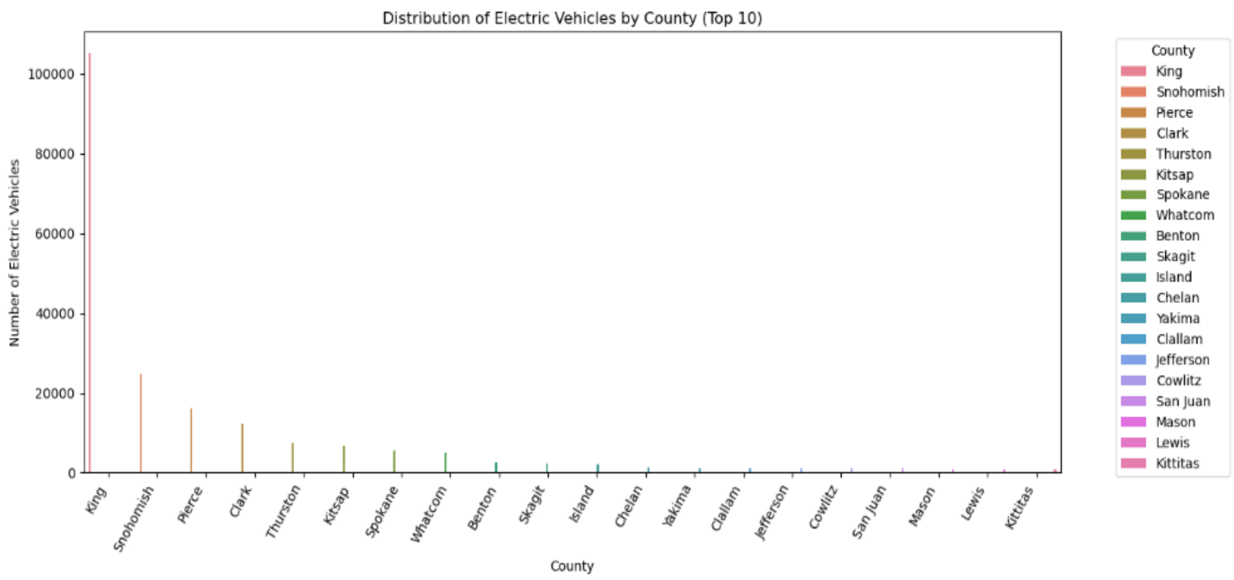
- **Expand Incentives**: Provide additional financial incentives targeted at middle and lower-income households to make EVs more accessible.
- **Develop Charging Infrastructure**: Increase the number of fast-charging stations in rural and suburban areas to alleviate range anxiety and encourage EV adoption outside urban centers.
- **Education Campaigns**: Promote the long-term economic and environmental benefits of EV ownership to segments with low awareness, particularly in less urbanized regions.

12. Visualization

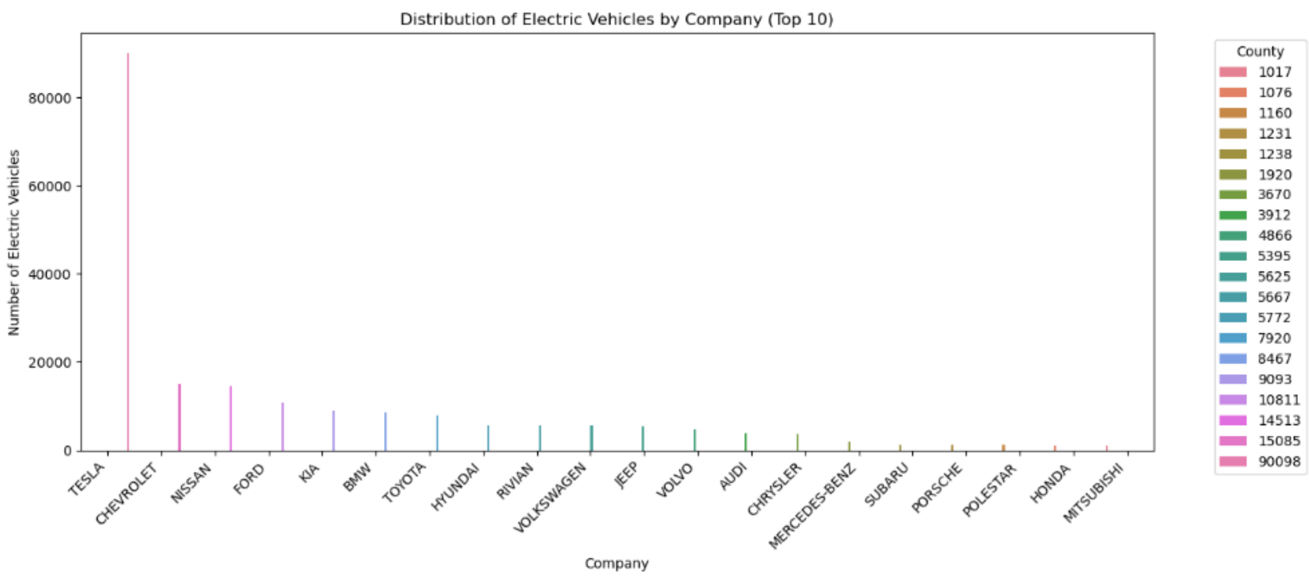
the number of electric vehicles registered each year



Number of electric vehicles by county:

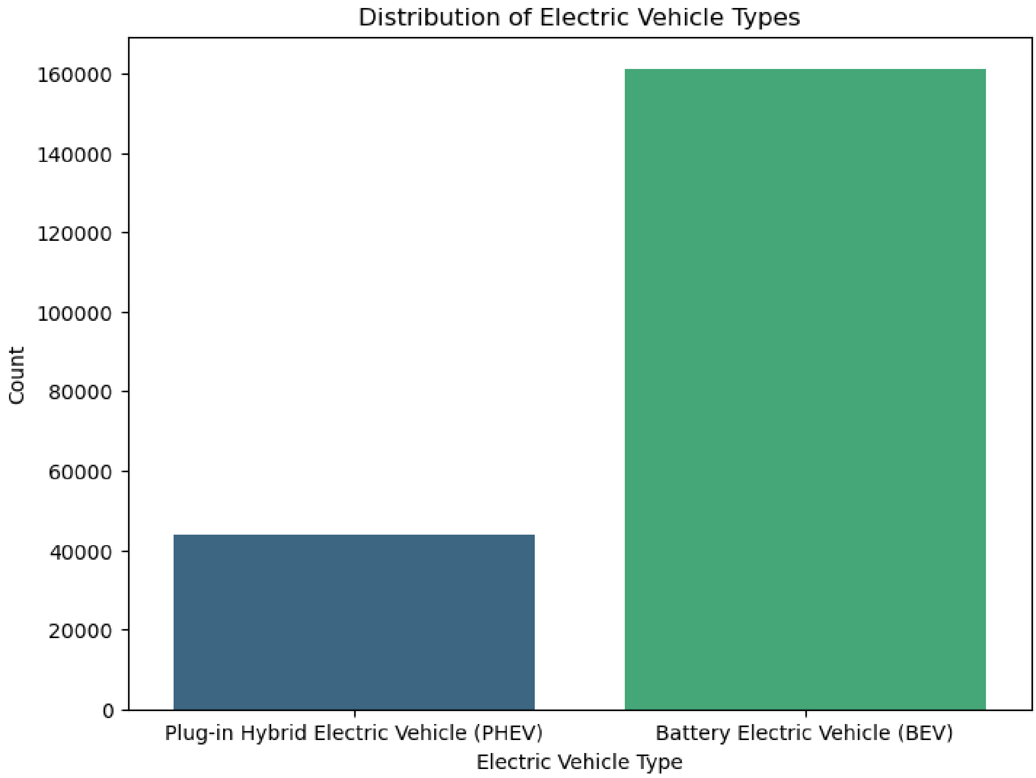


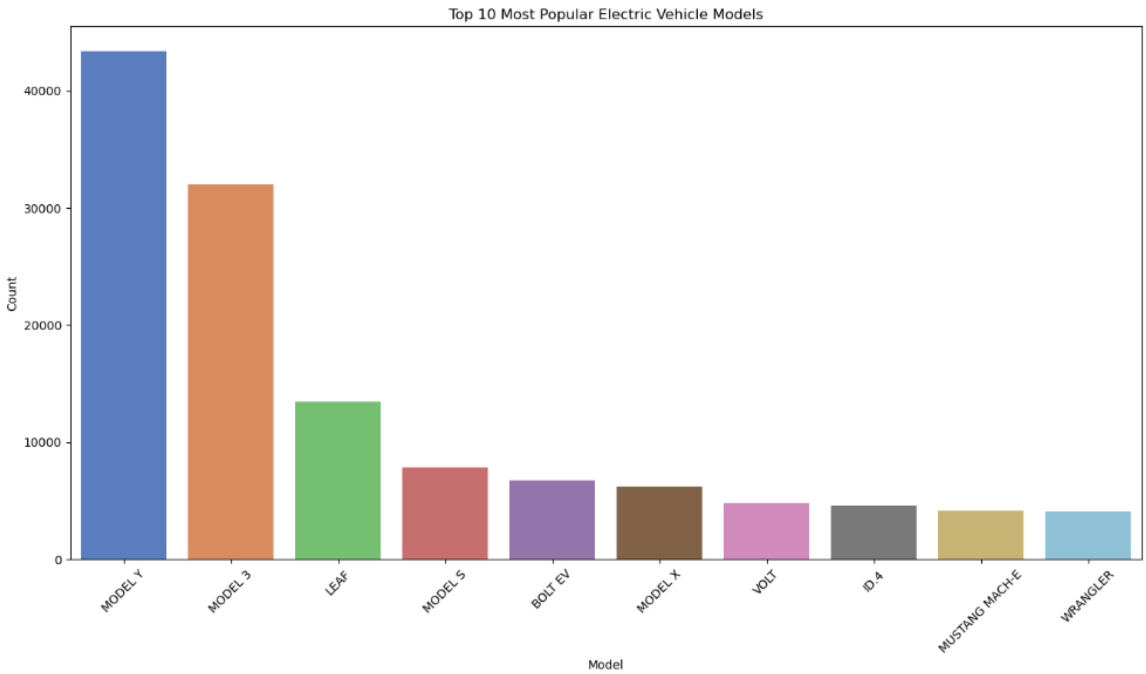
Number of electric vehicles by Company



The above chart shows that:

- TESLA leads by a substantial margin with the highest number of vehicles registered.
- NISSAN is the second most popular manufacturer, followed by CHEVROLET, though both have significantly fewer registrations than TESLA.
- FORD, BMW, KIA, TOYOTA, VOLKSWAGEN, JEEP, and HYUNDAI follow in decreasing order of the number of registered vehicles.

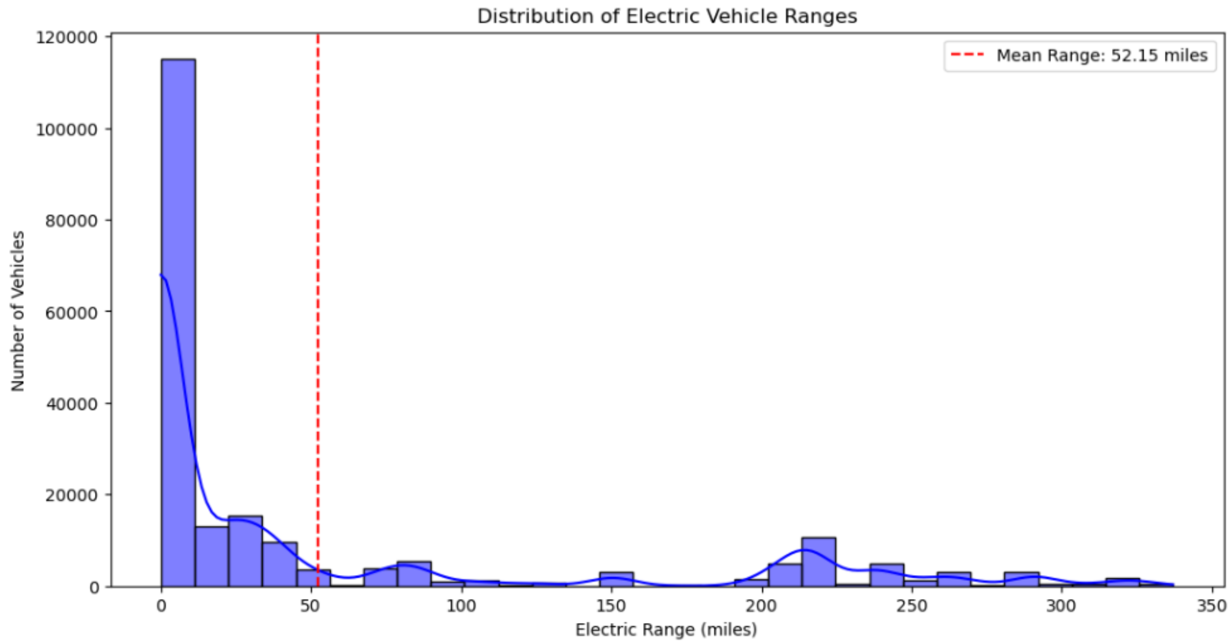




The above graph shows the distribution of electric vehicle registrations among different models from the top three manufacturers: TESLA, NISSAN, and CHEVROLET. Here are the findings:

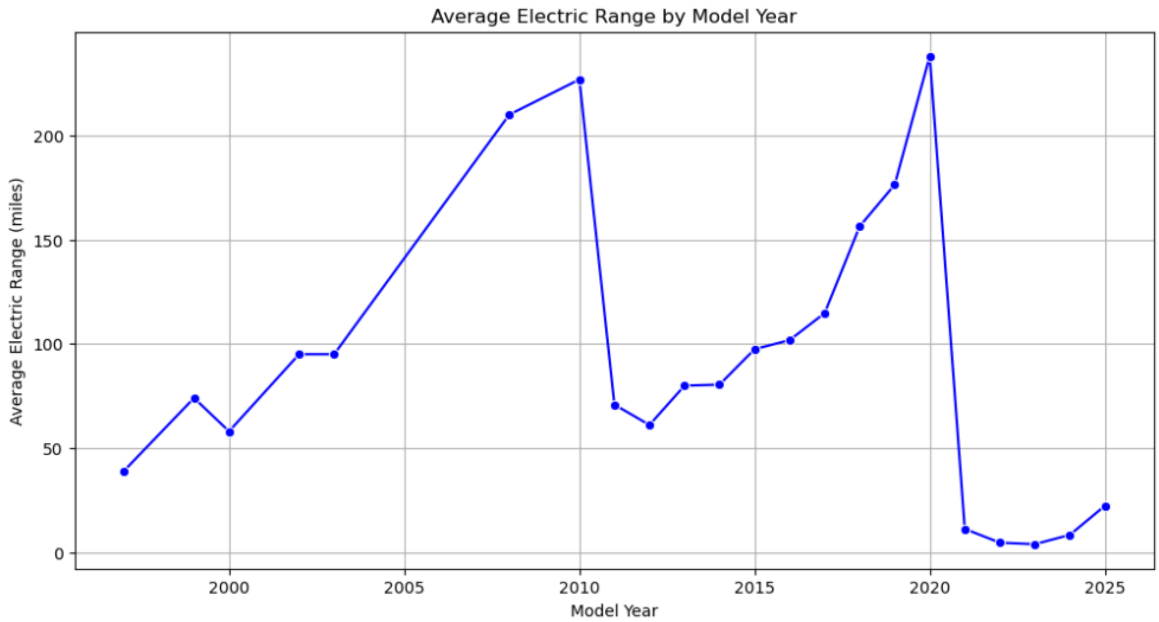
- TESLA's MODEL Y and TESLA MODEL 3 are the most registered vehicles, with MODEL Y having the highest number of registrations.
- NISSAN's LEAF is the third most registered model and the most registered non-TESLA vehicle.
- TESLA’s MODEL S and MODEL X also have a significant number of registrations.

- CHEVROLET's BOLT EV and VOLT are the next in the ranking with considerable registrations, followed by BOLT EUV.
- NISSAN's ARIYA and CHEVROLET's SPARK have the least number of registrations among the models shown.



The above graph shows the mean electric range. Key observations from the graph include:

- There is a high frequency of vehicles with a low electric range, with a significant peak occurring just before 50 miles.
- The distribution is skewed to the right, with a long tail extending towards higher ranges, although the number of vehicles with higher ranges is much less frequent.
- The mean electric range for this set of vehicles is marked at approximately 58.84 miles, which is relatively low compared to the highest ranges shown in the graph.
- Despite the presence of electric vehicles with ranges that extend up to around 350 miles, the majority of the vehicles have a range below the mean.



The above graph shows the progression of the average electric range of vehicles from around the year 2000 to 2024. Key findings from the graph:

- There is a general upward trend in the average electric range of EVs over the years, indicating improvements in technology and battery efficiency.
- There is a noticeable peak around the year 2020 when the average range reaches its highest point.
- Following 2020, there's a significant drop in the average range, which could indicate that data for the following years might be incomplete or reflect the introduction of several lower-range models.
- After the sharp decline, there is a slight recovery in the average range in the most recent year shown on the graph.

Estimated Growth:

Estimated Market Size Analysis of Electric Vehicles in the United States

Now, we can calculate the compound annual growth rate (CAGR) of electric vehicle registrations over a certain period to estimate the growth in the market size. It will provide insights into the pace of market expansion and help forecast future market size.

We use the formula to calculate the compound annual growth rate (CAGR):

CAGR = ((EV(initial) / EV(final))n/1)−1

Where:

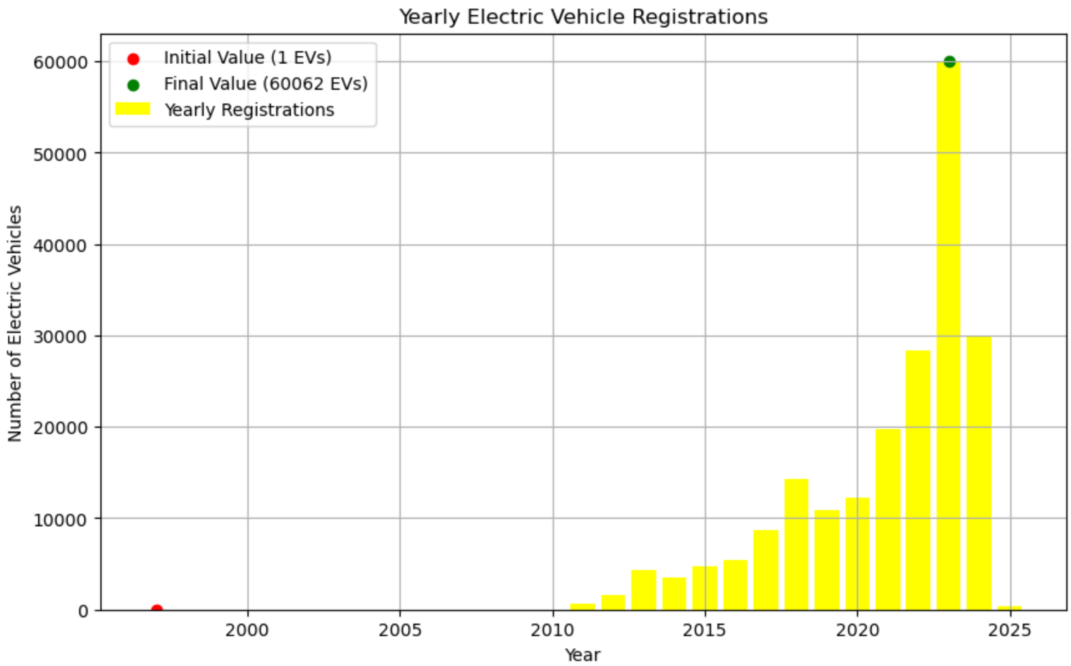
EV(initial): is the number of electric vehicles at the beginning of the period.

EV(final): is the number of electric vehicles at the end of the period.

n: is the number of years in the period.

```
data_copy = data.copy()

# Convert 'Model Year' to datetime and extract the year
data_copy['Model Year'] = pd.to_datetime(data_copy['Model Year'], format='%Y')
data_copy['Year'] = data_copy['Model Year'].dt.year

registrations = data_copy['Year'].value_counts().sort_index()

initial = registrations.min()
final = registrations.max()

n_years = len(registrations)

# Calculate CAGR
cagr = ((final / initial) ** (1 / n_years)) - 1

print("Compound Annual Growth Rate (CAGR): {:.2%}".format(cagr))
```

```
Compound Annual Growth Rate (CAGR): 64.90%
```

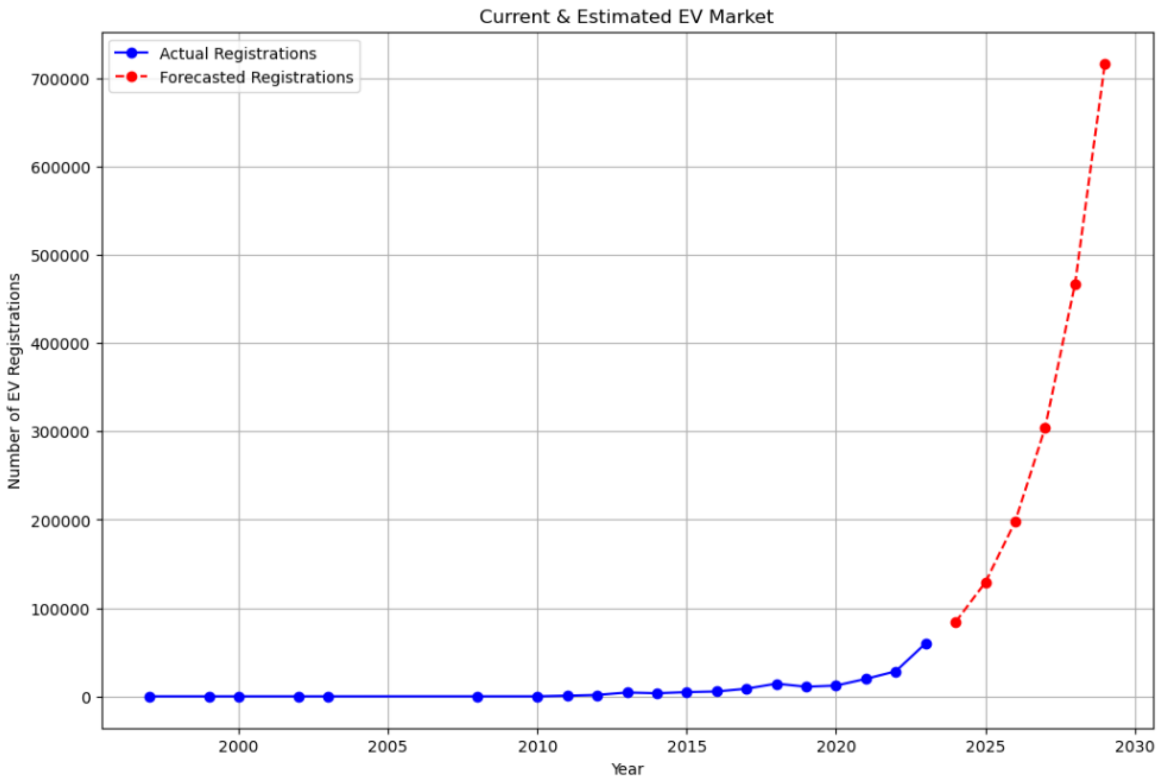


We'll calculate the Compound Annual Growth Rate (CAGR) between a recent year with complete data (2023) and an earlier year to project the 2024 figures. Additionally, using this growth rate, we can estimate the market size for the next five years.

```python
# filter the dataset to include years with complete data, assuming 2023 is the last complete year
filtered_years = registrations[registrations.index <= 2023]

# define a function for exponential growth to fit the data
def exp_growth(x, a, b):
    return a * np.exp(b * x)

# prepare the data for curve fitting
x_data = filtered_years.index - filtered_years.index.min()
y_data = filtered_years.values

# fit the data to the exponential growth function
params, covariance = curve_fit(exp_growth, x_data, y_data)

# use the fitted function to forecast the number of EVs for 2024 and the next five years
forecast_years = np.arange(2024, 2024 + 6) - filtered_years.index.min()
forecasted_values = exp_growth(forecast_years, *params)

# create a dictionary to display the forecasted values for easier interpretation
forecasted_evs = dict(zip(forecast_years + filtered_years.index.min(), forecasted_values))

forecasted_evs
```

```
{2024: 84099.60239781695,
 2025: 129089.30173223234,
 2026: 198146.57081123002,
 2027: 304146.5326514074,
 2028: 466851.95179078367,
 2029: 716597.8286547337}
```

Now, let’s plot the estimated market size data:

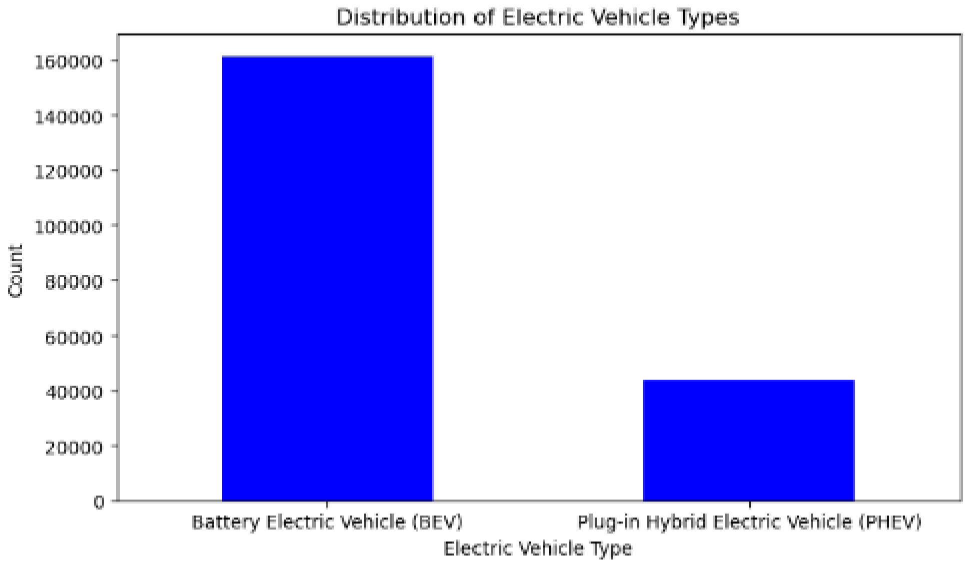


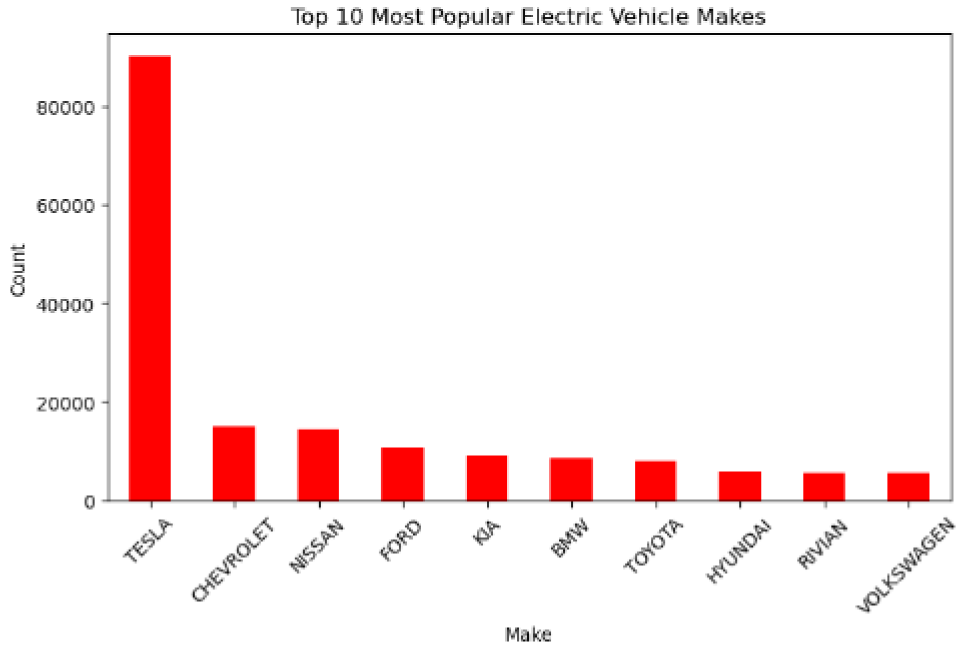
From the above graph, we can see:

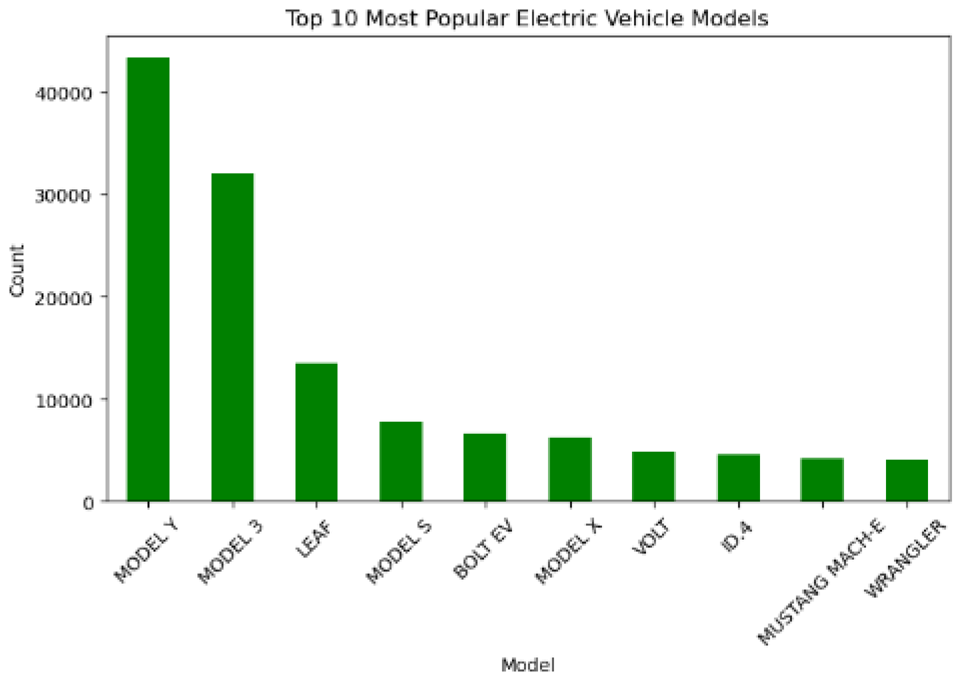
- The number of actual EV registrations remained relatively low and stable until around 2010, after which there was a consistent and steep upward trend, suggesting a significant increase in EV adoption.
- The forecasted EV registrations predict an even more dramatic increase in the near future, with the number of registrations expected to rise sharply in the coming years.

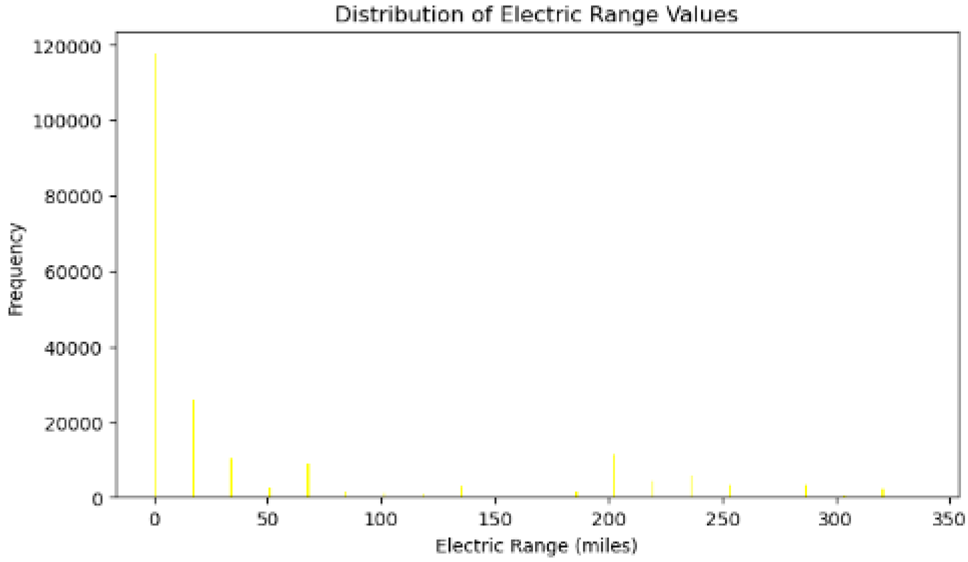
Given the growing trend in actual EV registrations and the projected acceleration as per the forecast data, we can conclude that the EV market size is expected to expand considerably. The steep increase in forecasted registrations suggests that consumer adoption of EVs is on the rise, and this trend is likely to continue. Overall, the data point towards a promising future for the EV industry, indicating a significant shift in consumer preferences and a potential increase in related investment and business opportunities.

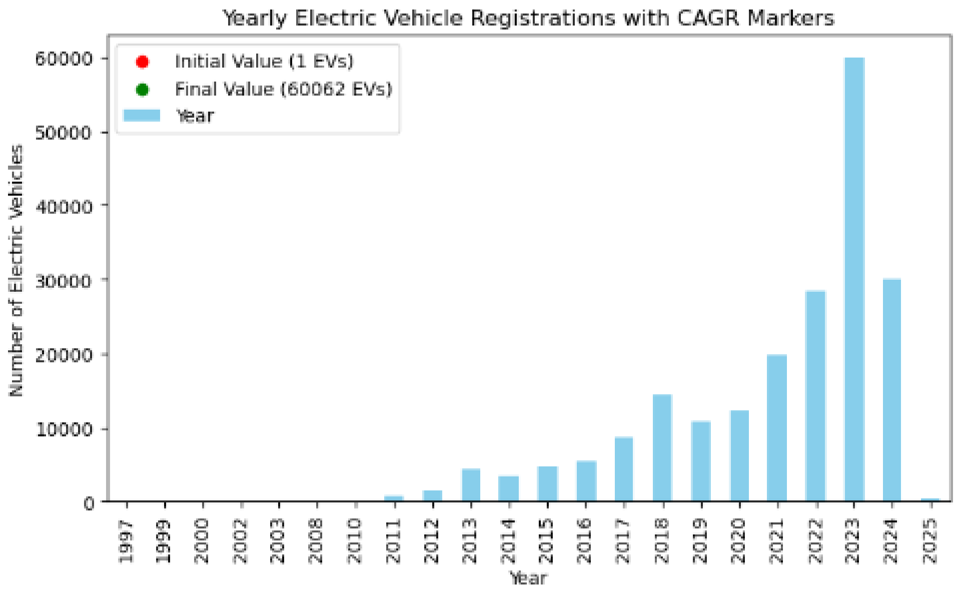
```
fig, axes = plt.subplots(3, 2, figsize=(15, 15))

# Distribution of Electric Vehicle Types
data['Electric Vehicle Type'].value_counts().plot(kind='bar', ax=axes[0, 0], color='blue')
axes[0, 0].set_title('Distribution of Electric Vehicle Types')
axes[0, 0].set_xlabel('Electric Vehicle Type')
axes[0, 0].set_ylabel('Count')
axes[0, 0].tick_params(axis='x', rotation=360)

# Top 10 Most Popular Electric Vehicle Makes
data['Make'].value_counts().head(10).plot(kind='bar', ax=axes[0, 1], color='red')
axes[0, 1].set_title('Top 10 Most Popular Electric Vehicle Makes')
axes[0, 1].set_xlabel('Make')
axes[0, 1].set_ylabel('Count')
axes[0, 1].tick_params(axis='x', rotation=45)

#Top 10 Most Popular Electric Vehicle Models
data['Model'].value_counts().head(10).plot(kind='bar', ax=axes[1, 0], color='green')
axes[1, 0].set_title('Top 10 Most Popular Electric Vehicle Models')
axes[1, 0].set_xlabel('Model')
axes[1, 0].set_ylabel('Count')
axes[1, 0].tick_params(axis='x', rotation=45)

# Distribution of Electric Range Values
data['Electric Range'].plot(kind='hist', ax=axes[1, 1], bins=20, color='yellow', edgecolor='none', width=0.8)
axes[1, 1].set_title('Distribution of Electric Range Values')
axes[1, 1].set_xlabel('Electric Range (miles)')
axes[1, 1].set_ylabel('Frequency')

#early Electric Vehicle Registrations with CAGR Markers
registrations.plot(kind='bar', ax=axes[2, 0], color='skyblue')
axes[2, 0].scatter(registrations.idxmin(), initial, color='red', label='Initial Value ({} EVs)'.format(initial))
axes[2, 0].scatter(registrations.idxmax(), final, color='green', label='Final Value ({} EVs)'.format(final))
axes[2, 0].legend()
axes[2, 0].set_title('Yearly Electric Vehicle Registrations with CAGR Markers')
axes[2, 0].set_xlabel('Year')
axes[2, 0].set_ylabel('Number of Electric Vehicles')

fig.delaxes(axes[2, 1])
plt.tight_layout()
plt.show()
```




Top 10 Most Popular Electric Vehicle Makes
Count
0
20000
40000
60000
80000
TESLA
CHEVROLET
NISSAN
FORD
KIA
BMW
TOYOTA
HYUNDAI
RIVIAN
VOLKSWAGEN
Make


Top 10 Most Popular Electric Vehicle Models
Count
0
10000
20000
30000
40000
MODEL Y
MODEL 3
LEAF
MODEL S
BOLT EV
MODEL X
VOLT
ID.4
MUSTANG MACH-E
WRANGLER
Model





Conclusion

So, market size analysis is a crucial aspect of market research that determines the potential sales volume within a given market.

- It helps businesses understand the magnitude of demand, assess market saturation levels, and identify growth opportunities.
- From our market size analysis of electric vehicles, we found a promising future for the EV industry, indicating a significant shift in consumer preferences and a potential increase in related investment and business opportunities.
- Market segmentation analysis of the EV population in Washington State reveals that a one-size-fits-all approach is inadequate to meet the diverse needs of different consumer groups.
- Understanding these segments allows policymakers and businesses to address the barriers faced by each group and design programs that encourage wider EV adoption. With Washington's strong commitment to reducing greenhouse gas emissions and expanding

clean transportation, there is significant potential for the growth of the electric vehicle market across all segments.