



Insights and Trends: Exploratory Data Analysis of the Electric Vehicle Population

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Electric Vehicles (EVs) are rapidly transforming the automotive landscape. This presentation will delve into the **trends** and **insights** derived from exploratory data analysis of the EV population, highlighting their **growth, challenges,** and **opportunities**. Join us as we explore the future of sustainable transportation.

Introduction to Electric Vehicles



Abstract

Objective: To analyze EV adoption patterns, preferences, and trends in Washington State.

Dataset: Initially 200,049 records and 17 parameters, cleaned to 182,137 records and 11 parameters (includes 2 parameters which were created) for analysis.

VIN (1-10)	County	City	State	Postal Code	Model Year	Make	Model	Electric Vehicle Ty	Clean Alternative Fuel Vehicle (CAFV) Eligibility	Electric Range	Base MSRP	Legislative District	DOL Vehicle ID	Vehicle Location
5YJSE1EB0J	Thurston	Olympia	WA	98512	2018	TESLA	MODEL 3	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	215	0	35	104823078	JINT (-122.957046 46.3913 U
WA1AAAGE9M	Kitsap	Port Orchard	WA	98367	2021	AUDI	E-TRON	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	222	0	35	156660507	VT (-122.6530052 47.4739 U
5YJSE1EA2J	Yakima	Yakima	WA	98302	2018	TESLA	MODEL 3	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	215	0	14	263074108	CHINT (-120.530331 46.5353
5YJSE1EA4N	Yakima	Yakima	WA	98302	2022	TESLA	MODEL 3	Battery Electric Vehicle (BEV)	Eligibility unknown as battery range has not been researched	0	0	15	213363894	CHINT (-120.530331 46.5353
TSAYGAE2P	Snohomish	Bothell	WA	98012	2023	TESLA	MODEL Y	Battery Electric Vehicle (BEV)	Eligibility unknown as battery range has not been researched	0	0	1	223436046	HINT (-122.206146 47.8339 U
WBY124CS1E	Yakima	Yakima	WA	98308	2014	BMW	i3	in Hybrid Electric Vehicle (P	Clean Alternative Fuel Vehicle Eligible	72	0	14	8045817	HINT (-120.611068 46.5366-
5YJSA1DPXC	Thurston	Olympia	WA	98502	2012	TESLA	MODEL S	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	265	59300	22	188634442	HINT (-122.343445 47.0532 U
5YJSA1H2TF	Yakima	Yakima	WA	98308	2015	TESLA	MODEL S	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	208	0	14	109175566	HINT (-120.611068 46.5366-
7FCTGBAA7P	Kitsap	Poulsbo	WA	98370	2023	RIVIAN	R1T	Battery Electric Vehicle (BEV)	Eligibility unknown as battery range has not been researched	0	0	23	262803131	VT (-122.6368884 47.7463 U
3C3CFFGETH	King	Seattle	WA	98103	2017	FIAT	500	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	84	0	43	3411343	NT (-122.3493053 47.6735 U
1FMCU0L24M	Kitsap	Silverdale	WA	98363	2021	FORD	ESCAPE	in Hybrid Electric Vehicle (P	Clean Alternative Fuel Vehicle Eligible	38	0	23	260383366	NT (-122.7035285 47.6602 U
5YJSA1H14E	Snohomish	Snohomish	WA	98296	2014	TESLA	MODEL S	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	208	69300	1	225773271	CHINT (-122.121841 47.8410 U
5YJYGDEEXL	Snohomish	Everett	WA	98208	2020	TESLA	MODEL Y	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	231	0	44	121781950	VT (-122.2032343 47.8356 U
1G1RD6E42C	Yakima	Yakima	WA	98301	2012	CHEVROLET	VOLT	in Hybrid Electric Vehicle (P	Clean Alternative Fuel Vehicle Eligible	35	0	14	222080204	NT (-120.4688151 46.6046-
1FADP5CU9G	Thurston	Olympia	WA	98502	2016	FORD	C-MAX	in Hybrid Electric Vehicle (P	Not eligible due to low battery range	19	0	22	201044532	HINT (-122.343445 47.0532 U
1N4AZ1CP3J	Island	Coupeville	WA	98233	2018	NISSAN	LEAF	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	151	0	10	230902181	NT (-122.6591616 48.1982 U
5YJSE1EB3N	Yakima	Yakima	WA	98302	2022	TESLA	MODEL 3	Battery Electric Vehicle (BEV)	Eligibility unknown as battery range has not been researched	0	0	15	201331504	CHINT (-120.530331 46.5353
WA1AAAGE2P	Thurston	Yelm	WA	98591	2023	AUDI	E-TRON	Battery Electric Vehicle (BEV)	Eligibility unknown as battery range has not been researched	0	0	2	221506191	HINT (-122.5715161 46.3035 U
1FADP5E44D	Kitsap	Poulsbo	WA	98370	2013	FORD	FOCUS	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	76	0	23	121433046	VT (-122.6368884 47.7463 U
5YJSE1EB3J	Island	Greenbank	WA	98253	2018	TESLA	MODEL 3	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	215	0	10	127200512	HINT (-122.566315 48.0896 U
1N4AZ2CP7F	Thurston	Olympia	WA	98506	2015	NISSAN	LEAF	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	84	0	22	103818438	CHINT (-122.36431 47.0750 U
5YJSE1EB3J	King	Issaquah	WA	98029	2018	TESLA	MODEL 3	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	215	0	5	475802505	VT (-122.0203893 47.5632 U
5YJSE1EA3J	King	Renton	WA	98055	2018	TESLA	MODEL 3	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	215	0	11	261038384	VT (-122.2003346 47.4487 U
1G1FW5S03L	Kitsap	Port Orchard	WA	98367	2020	CHEVROLET	BOLT EV	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	259	0	26	264657851	VT (-122.6530052 47.4739 U
EV1SE1E1M	Yakima	Yakima	WA	98302	2020	TESLA	MODEL 3	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	215	0	15	2045443	NT (-122.6591616 48.1982 U

	County	Model Year	Make	Base MSRP	Model	Electric Vehicle Type	Clean Alternative Fuel Vehicle (CAFV) Eligibility	Electric Range (MILE)	Electric Utility	Electric Utility Type	Urban/Rural
0	Thurston	2018	TESLA	47200	MODEL 3	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	215	PUGET SOUND ENERGY INC	Investor Owned	Urban
1	Kitsap	2021	AUDI	65900	E-TRON	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	222	PUGET SOUND ENERGY INC	Investor Owned	Urban
2	Yakima	2018	TESLA	47200	MODEL 3	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	215	PACIFICORP	Investor Owned	Rural
3	Yakima	2022	TESLA	48190	MODEL 3	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible (Manua...	383	PACIFICORP	Investor Owned	Rural
4	Snohomish	2023	TESLA	48630	MODEL Y	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible (Manua...	328	PUGET SOUND ENERGY INC	Investor Owned	Urban

Tools: Google Colab, Python (Pandas, NumPy, Matplotlib)

Outcome: Insights into EV sales, battery range, utility contributions, and manufacturer trends.

Introduction

Background: Electric vehicles (EVs) are vital for sustainable, environmentally-friendly transportation. Growing climate change awareness and advancements in technology drive EV adoption.

Objective: Analyze a dataset of Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) from Washington State. Provide insights into EV sales, consumer behavior, and manufacturer performance.

Scope: Focuses on 182,137 records and 11 parameters after data cleaning. Includes both whole dataset and company-wise analyses to identify adoption patterns and manufacturer trends.

Significance: Offers critical insights into market trends and consumer preferences. Guides EV manufacturers and policymakers in improving EV offerings and infrastructure.

Impact: Supports informed decision-making for a greener, more sustainable future.



Problem Faced During Analysis

Challenge: Analyze a large dataset of BEVs and PHEVs registered in Washington State, addressing missing data, misclassifications, and complex attributes like electric utility types.

Goal: Clean and analyze data to provide actionable insights for organizations and EV makers.

Relevance:

- Vital for understanding EV adoption and performance in the transition to clean energy.
- Supports informed decisions for manufacturers, government bodies, and consumers.

Scope:

- Focus on parameters like electric range, MSRP, make, and county.
- Includes company-wise and county-wise analysis of top EV makers.
- Excludes global EV trends and focuses solely on Washington State data.

Challenges:

- Data Integrity: Significant missing values, requiring manual corrections.
- Misclassification: Errors in vehicle types (e.g., BEVs marked as PHEVs).
- Complex Attributes: Handling single and multiple utility names in the 'Electric Utility' column.
- Model Variants: Ensuring correct analysis of PHEV/BEV variants.
- Limited Data: Insufficient information for newer models (2024–2025).

Electric Range
215
222
215
0
0
72
265
208

Model Year	Make	Model	Electric Vehicle Type
2010	WHEEGO ELECTRIC CARS	WHEEGO	Plug-in Hybrid Electric Vehicle (PHEV)
2010	WHEEGO ELECTRIC CARS	WHEEGO	Plug-in Hybrid Electric Vehicle (PHEV)
2010	WHEEGO ELECTRIC CARS	WHEEGO	Plug-in Hybrid Electric Vehicle (PHEV)

Clean Alternative Fuel Vehicle (CAFV) Eligibility
Clean Alternative Fuel Vehicle Eligible
Clean Alternative Fuel Vehicle Eligible
Clean Alternative Fuel Vehicle Eligible
Eligibility unknown as battery range has not been researched
Eligibility unknown as battery range has not been researched
Clean Alternative Fuel Vehicle Eligible
Clean Alternative Fuel Vehicle Eligible
Clean Alternative Fuel Vehicle Eligible
Eligibility unknown as battery range has not been researched

Problem solving methods

Approach:

- Preprocessed the dataset to handle null values and inconsistencies.
- Conducted whole-dataset and manufacturer-wise analyses to extract insights.

Design & Architecture:

- Added new columns, "Urban/Rural" and "Electric Utility Type," to simplify analysis.
- Corrected missing and inaccurate values in columns like "Base MSRP" and "Electric Range (MILE)" through web research.
- Manually updated the CAFV eligibility column based on researched electric ranges.

Tools & Technologies:

- Microsoft Excel: Removal of parameters and Initial Data cleaning and manipulation (Data Insertion in 2 parameters "Base MSRP" and "Electric Range (MILE)")
- Google Colab: Collaborative environment for data analysis.
- Python: Core programming for analysis and visualization.
- Pandas: Data manipulation and cleaning.
- Matplotlib: Visualizations like bar and pie charts.

Workflow:

- Cleaned data using Excel and Python.
- Performed question-based analysis at both dataset and manufacturer levels.
- Visualized findings with pie charts and bar graphs to simplify insights.

Electric Range (MILE)	Base MSRP
215	47200
222	65900
215	47200
363	

```
def get_utility_type(utility_entry):
    types = []
    utilities = utility_entry.replace('||', '|').split('|')
    for utility in utilities:
        utility = utility.strip()
        types.append(utility_type_mapping.get(utility, 'Unknown'))
    return ', '.join(types)
ev_filtered.loc[:, 'Electric Utility Type'] = ev_filtered['Electric Utility'].apply(get_utility_type)
ev_filtered.head(5)
```

```
[ ] urban_counties = ['Thurston', 'Kitsap', 'Snohomish', 'King', 'Whatcom', 'Clark', 'Pierce', 'Spokane', 'Benton']
rural_counties = ['Yakima', 'Grant', 'Whitman', 'Skagit', 'Stevens', 'Cowlitz', 'Jefferson', 'Klickitat', 'Clallam', 'Chelan',
                  'Pacific', 'Franklin', 'San Juan', 'Mason', 'Walla Walla', 'Lewis', 'Grays Harbor', 'Okanogan',
                  'Kittitas', 'Douglas', 'Skamania', 'Lincoln', 'Adams', 'Pend Oreille', 'Wahkiakum', 'Asotin', 'Columbia',
                  'Ferry', 'Garfield', 'Island']

def classify_county(county):
    if county in urban_counties:
        return 'Urban'
    elif county in rural_counties:
        return 'Rural'
    else:
        return 'Unknown'
ev_filtered['Urban/Rural'] = ev_filtered['County'].apply(classify_county)
ev_filtered.head()
```

Electric Utility Type	Urban/Rural
Investor Owned	Urban
Investor Owned	Urban
Investor Owned	Rural
Investor Owned	Rural
Investor Owned	Urban

```
[ ] incorrect_phev_cars = ev_filtered[
    (ev_filtered['Make'] == 'WHEEGO ELECTRIC CARS')]
ev_filtered.loc[incorrect_phev_cars.index, 'Electric Vehicle Type'] = 'Battery Electric Vehicle (BEV)'
updated_cars = ev_filtered.loc[incorrect_phev_cars.index, ['Make', 'Model Year', 'Electric Vehicle Type']]

[ ] ev_filtered[ev_filtered['Make'] == 'WHEEGO ELECTRIC CARS']
```

	County	Model Year	Make	Base MSRP	Model	Electric Vehicle Type	Clean Alte
45451	Thurston	2010	WHEEGO ELECTRIC CARS	32995	WHEEGO	Battery Electric Vehicle (BEV)	
170472	Spokane	2010	WHEEGO ELECTRIC CARS	32995	WHEEGO	Battery Electric Vehicle (BEV)	
183392	Pierce	2010	WHEEGO ELECTRIC CARS	32995	WHEEGO	Battery Electric Vehicle (BEV)	

Summary of Work: This project analyzed the electric vehicle (EV) population in Washington State, focusing on adoption patterns, preferences, and trends. The analysis involved cleaning and preprocessing the dataset, correcting missing values, categorizing electric utilities, and exploring key metrics such as county-level EV sales, manufacturer dominance, CAFV eligibility, vehicle types, and electric ranges. Relationships between electric range, MSRP, and model years were also explored.

Key Findings

1. EV Adoption Patterns:

- King County led with 56% of EV sales, followed by Snohomish (13%) and Pierce (8%).
- Tesla accounted for 44% of EVs.

2. Vehicle Types and Preferences:

- BEVs made up 79%, while PHEVs were 21%.
- Snohomish County had the highest mean electric range at 240 miles.

3. CAFV Eligibility:

- 90% of EVs were CAFV-eligible after manual corrections.

4. Utility Analysis:

- Puget Sound Energy Inc. and the City of Tacoma served 40% of EVs, emphasizing the role of infrastructure.

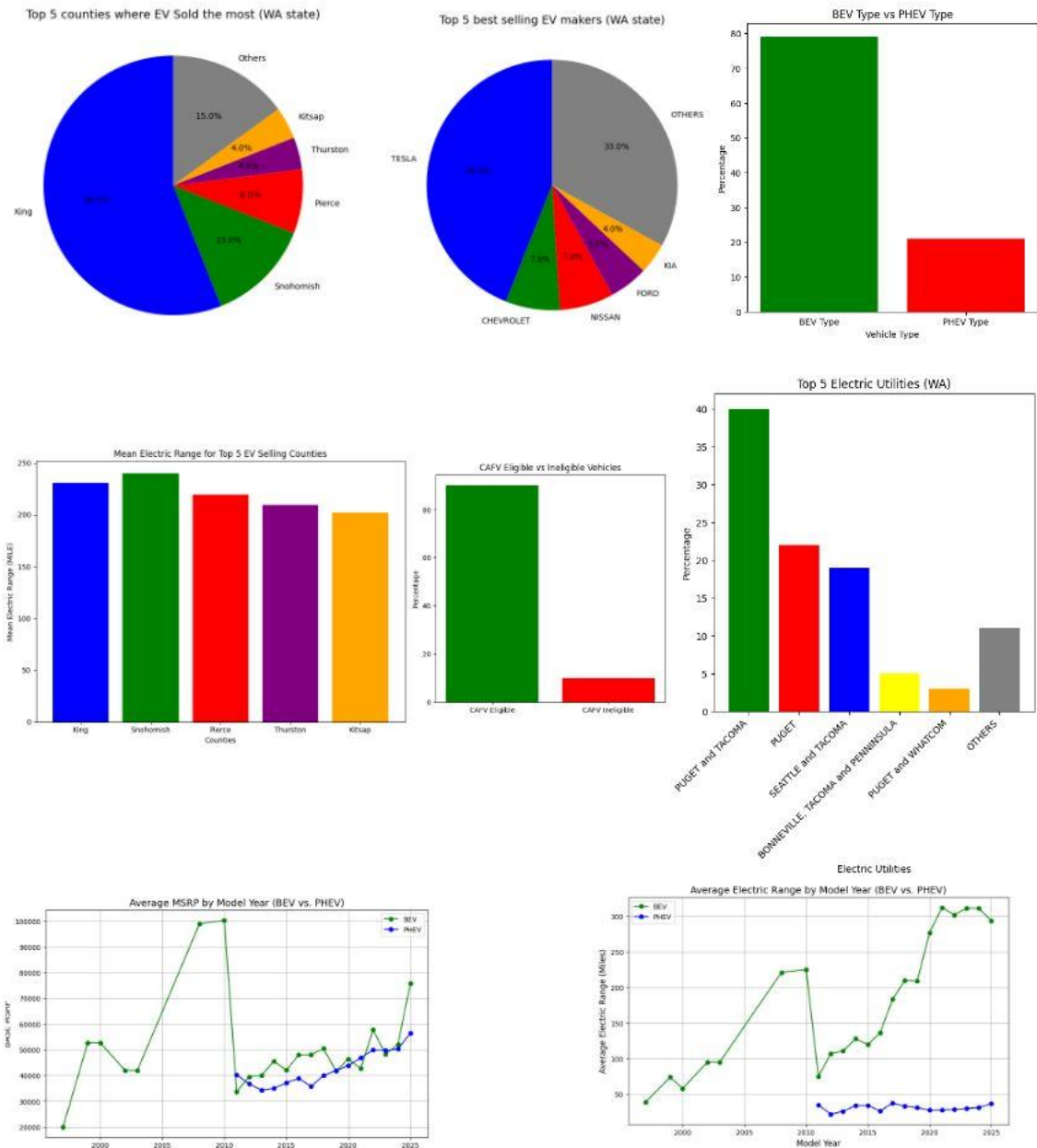
5. Trend Analysis:

- BEVs showed increased electric range due to battery advancements, while PHEVs remained stable.
- BEVs had higher MSRP, reflecting better technology and range.

Limitations:

- **Data Quality:** Missing or inaccurate values required manual corrections.
- **Geographical Scope:** The analysis focused only on Washington State.
- **Unexplored Parameters:** Factors like charging infrastructure and consumer income were not analyzed.
- **Temporal Data:** The dataset did not account for future trends.

Key findings and Limitations of Analysis



Future Scope

1. Possible Enhancements:

- Include additional parameters like recharge time, safety ratings, and vehicle types (e.g., sedan, SUV) for deeper insights.
- Complete missing values in critical columns like "Base MSRP" for more accurate analysis.

2. Interactive Dashboards:

- Develop dynamic dashboards for real-time exploration and visualization.

3. Machine Learning Applications:

- Use predictive models to analyze trends and forecast future EV adoption patterns.

4. Real-World Applications:

- Insights can guide EV manufacturers in improving product performance and safety.
- Policymakers can leverage findings to promote EV infrastructure and adoption strategies.

5. Research Challenges:

- Address missing or zero values in key columns like "Base MSRP" and "Electric Range."
- Handle larger datasets requiring advanced tools and algorithms for analysis.

FUTURE OF ELECTRIC VEHICLE



References

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- https://www.solarwa.org/utilities_washington_state
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THANK YOU