Project Summary: EV Adoption in Washington and Data-Driven Recommendations

Summary:

This document details the analytical journey and strategic conclusions of a project undertaken to provide the Washington State Department of Transportation (WSDOT) with a data-driven strategy to increase new Electric Vehicle (EV) adoption by 25% over two years. The core of the work was to move beyond broad assumptions and pinpoint the specific, high-impact levers that could unlock the next wave of market growth.

Part 1: The Analytical Narrative & Strategic Conclusions

The project began with a series of foundational questions about the EV market's core drivers. Through a systematic, hypothesis-driven analysis, the study dismantled common assumptions to isolate the true, causal factors of EV adoption.

Initial Problem & Core Hypotheses

The central problem was one of strategic resource allocation for WSDOT. To guide investment, we set out to answer four primary questions:

1. Is the market's growth primarily driven by the general economy and vehicle affordability?
2. Is vehicle range still a primary barrier to adoption?
3. Is the current subsidy program a significant driver of sales?
4. Is a lack of charging infrastructure a key factor holding back growth?

Key Findings & Conclusions

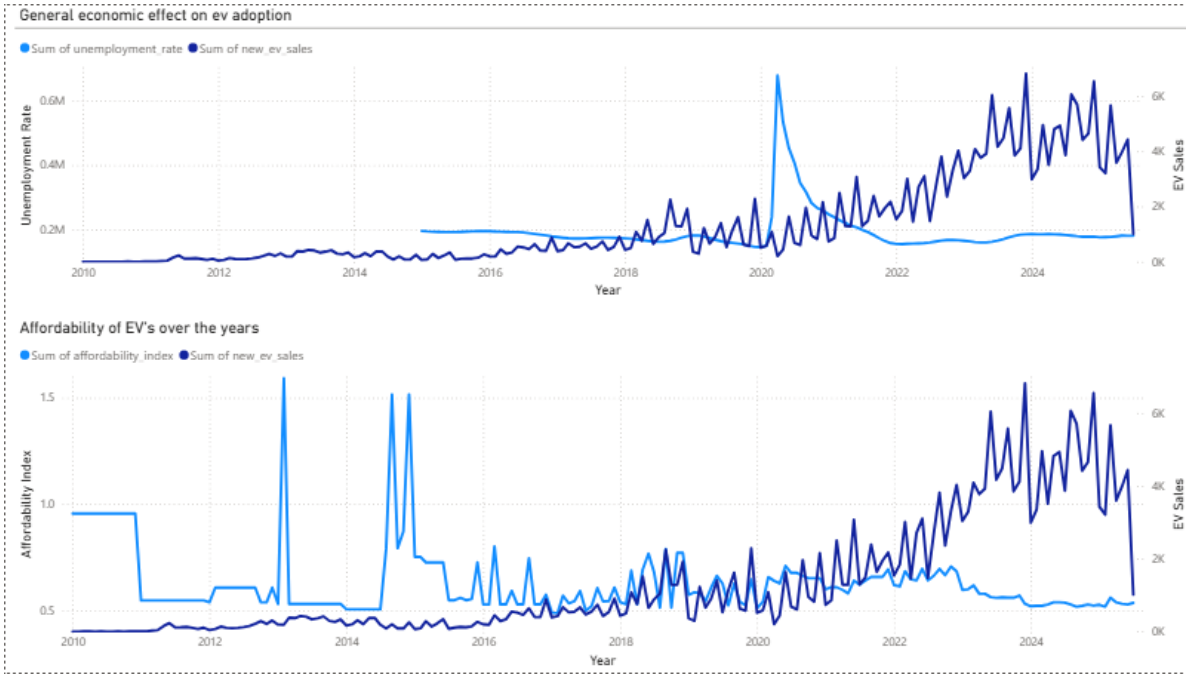
The analysis led to a series of definitive, and in some cases, counter-intuitive conclusions.

1. Insight: The EV Boom is a Unique Phenomenon, Not a Simple Reflection of the Economy or Affordability.

Hypothesis: A strong economy and improving affordability are the main drivers of the EV sales boom.

Analysis: A dual-axis time-series comparison was conducted between monthly EV sales and the statewide unemployment rate. Furthermore, a dynamic Affordability Index (Median EV Price / Year-Specific Median Income) was engineered to track the real financial burden over time.

Conclusion: The analysis proved that the market's exponential growth was **not strongly correlated** with general economic trends. Moreover, the boom occurred during a period where affordability was, at best, stable and often worsening in key segments. This **disproved the hypothesis** that broad-based affordability was the primary driver and allowed the project to focus on more powerful, non-price-related barriers.

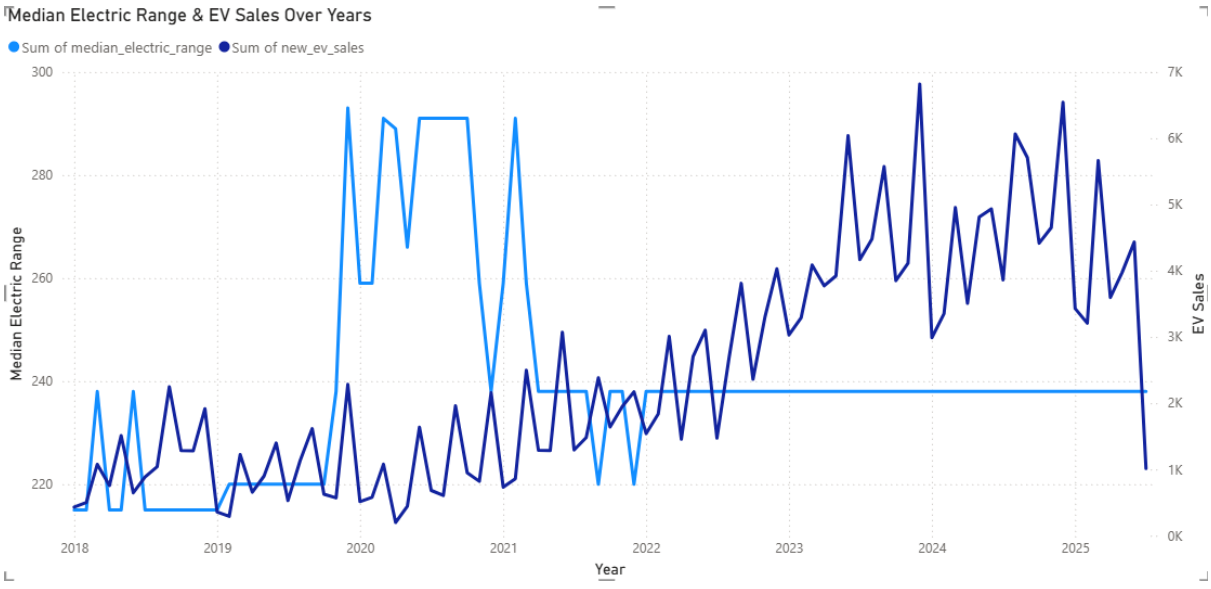


2. Insight: The "Range Race" is Over; The Strategic Focus Must Shift to the Ecosystem.

Hypothesis: Insufficient vehicle range remains a primary barrier to mainstream adoption.

Analysis: A time-series analysis of the median electric range of BEVs sold each month from 2018 to 2025 was conducted.

Conclusion: The analysis revealed a clear "Range Plateau" post-2022, with the median range stabilizing at a confident ~300 miles. A ~300-mile range has evolved from a competitive differentiator to foundational **"table stakes."** The automakers have solved the core vehicle problem, giving WSDOT a clear mandate to focus on the supporting ecosystem.

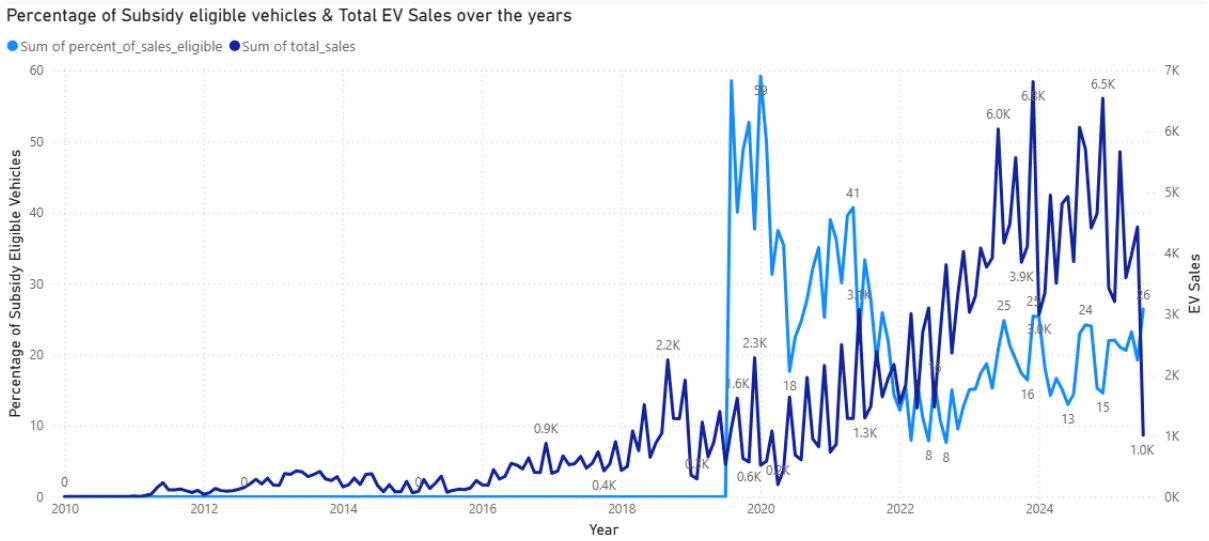


3. Insight: The State's Subsidy Program Has Failed to Keep Pace with the Market.

Hypothesis: State subsidies are a significant factor driving the current sales volume.

Analysis: A time-series chart was created to track the percentage of total monthly sales that were eligible for the state's CAFV subsidy.

Conclusion: The analysis showed that the program's influence has plummeted over time. The exponential sales boom occurred precisely as the percentage of eligible vehicles was declining. This is not because subsidies are ineffective, but because the program's outdated criteria are **misaligned with the modern "sweet spot"** of the market.

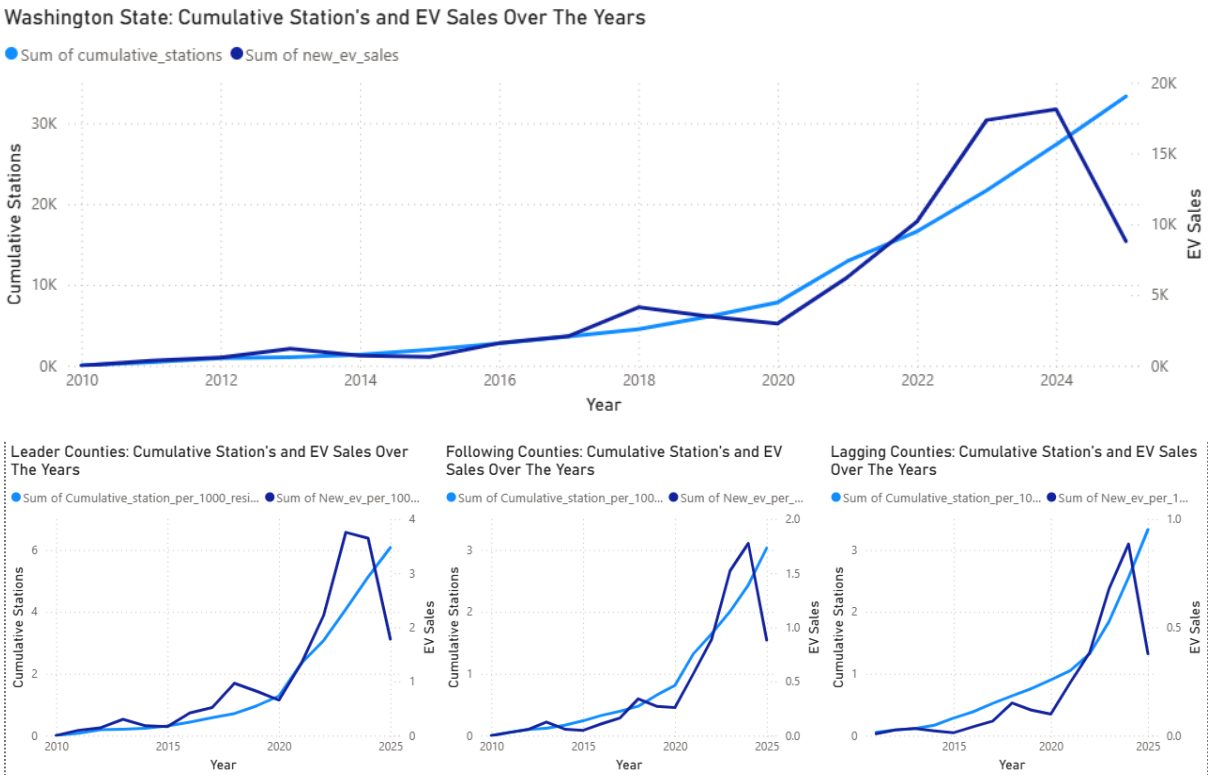


4. The "Smoking Gun": An Infrastructure Deficit is Throttling Growth in High-Potential Markets.

Hypothesis: The primary barrier holding back the next wave of adoption is a lack of charging infrastructure in willing and able communities.

Analysis: This was a multi-step process:

- **Framework:** A correlation analysis established a "Twin Engines" framework, proving that successful markets require both **Economic Potential** (Median_Household_income) and **Enabling Infrastructure** (stations_per_1000_residents).
- **Segmentation:** A **K-Means Clustering** model was built to segment Washington's counties into four strategic groups, identifying a key segment of 16 **"High-Potential Follower"** counties with strong economic potential but lagging performance.
- **Proof:** A final, normalized time-series analysis compared sales_per_1000_people vs. stations_per_1000_people for each cluster. The chart for the "High-Potential Followers" showed a clear and persistent consumer demand being visibly **throttled by a significantly flatter infrastructure curve.**



Definitive Conclusion:

The study proved that for these 16 target counties, a lack of charging infrastructure is the **primary, identifiable barrier** holding them back from "Pacesetter"-level growth.

Correlation Analysis

	Unemployment Rate	Electric Range	Affordability Index	Median House-Hold Income	Charging Stations	EV'S Per station
EV Registration/1000 Residence	-0.177	-0.056	-0.198	0.853	0.86	0.029

Part 2: Methodology & Analytical Assets in Detail

The project's conclusions are built on a foundation of rigorous data preparation and a systematic analytical process.

Data Assets Utilized

The analysis integrated several distinct datasets to build a comprehensive view of the market:

1. **EV Sales Data:** A transactional dataset from the Washington State Department of Licensing, containing detailed information on every new EV sale.

2. **EV Charging Station Data:** A dataset detailing the location and Open Date of public charging stations across the state.
3. **County-Level Demographic Data:** Two separate files containing yearly population and yearly median household income for each county.
4. **Statewide Economic Data:** A time-series dataset of the monthly unemployment rate for Washington.

Procedure and Key Techniques

1. **Data Integrity & Preparation:**

- The project's integrity was ensured by a strategic pivot to a high-fidelity transactional dataset.
- A key step was the methodical removal of ~22,000 anomalous records (e.g., leases, fleet sales) to ensure the analysis was a true reflection of the consumer market.
- A sophisticated, multi-layered hierarchical imputation was used to handle missing values for Sale Price and Electric Range, with the results visually validated to ensure no distortion of market realities.

2. **Engineered KPIs for Strategic Insight:** The study moved beyond simple metrics to engineer a suite of powerful KPIs, including:

- Sales/1000 residence & stations /1000 residence (Normalization)
- Sale price volatility (Proxy for Market Maturity)
- Affordability Index (Dynamic Median Price / Median Income)
- Battery Electric Vehicle to Plug In Hybrid Electric Vehicle's sales ratio (Consumer Preference)

3. **Analytical & Modeling Techniques:**

- **Exploratory Data Analysis (EDA):** The project utilized a full suite of EDA techniques, including time-series analysis, geographic mapping (choropleths), and statistical segmentation (scatter plots, box plots).
- **K-Means Clustering:** This unsupervised machine learni ng model was the engine for our strategic segmentation, creating the data-driven framework of "Pacesetters," "Followers," and "Laggers."
- **Correlation Analysis:** Pearson correlation was used to provide objective, quantitative measures of the relationships between key variables.

Next Steps:

- Forecast the current trend in next 2 years.
- Forecast the change in trend's with 5% increase in station's/1000 residence.
- Forecast the change in trend with 1% increase in median household income.