

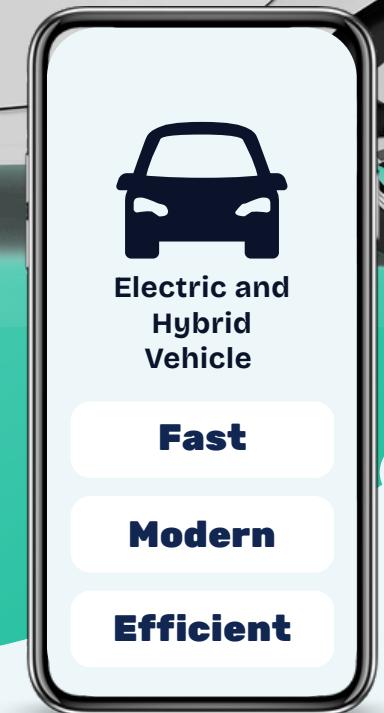
:: GROUP 1 (B.E.A.N.N.S TEAM)

# Analysis & Visualization of Electric and Hybrid Vehicle

Adoption in Washington State, USA

**ITCS495 Special Topics in Databases and Intelligent Systems**

Faculty of Information and Communication Technology  
Mahidol University





# BUSINESS DOMAIN

- Project domain lies at the intersection of

01

**Automotive**

02

**Energy & utilities**

03

**Public policy**

- EV adoption is reshaping transportation, reducing dependence on fossil fuels.
- **Washington State is a strong case** due to CAFV incentives, climate goals, and consumer demand.
- **Utilities** face challenges of grid stability and charging infrastructure planning.
- **OEMs & dealerships** must track market share and consumer shifts.



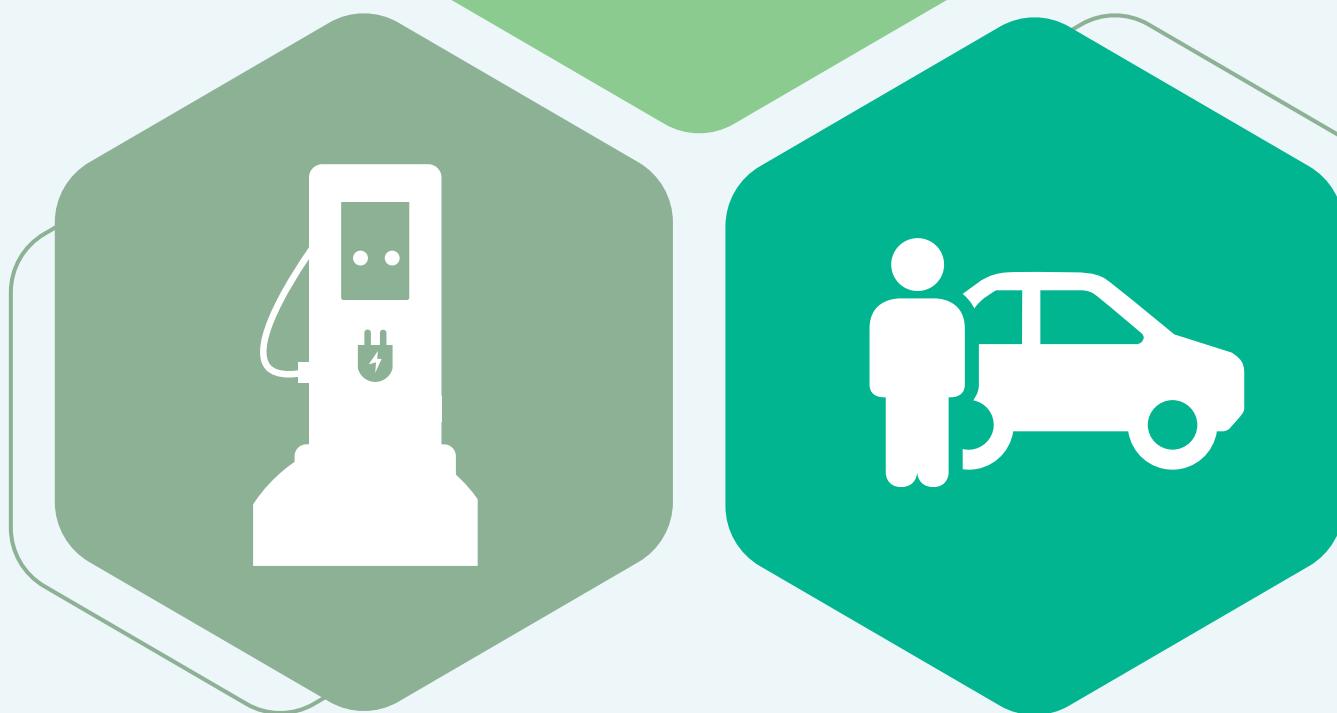
# TARGET USER GROUPS



**Policy Makers  
& Regulators**



**Electric Utilities &  
Charging  
Operators**



**OEMs &  
Dealerships**



# TARGET USER GROUPS



## 01 Background

- Need to monitor EV and PHEV adoption to guide environmental policy and programs like CAFV.
- Plan charging infrastructure and track emission reduction goals.

## 02 Example Scenarios

- Identify counties or cities with the highest and lowest EV adoption.
- Assess if CAFV eligibility correlates with higher registration numbers.
- Track the long-term shift from PHEVs to BEVs.

## Policy Makers & Regulators



## 03 Objective & Scope

- Refine EV incentive policies.
- Allocate funding for charging stations and grid expansion.
- Measure progress toward clean energy targets.



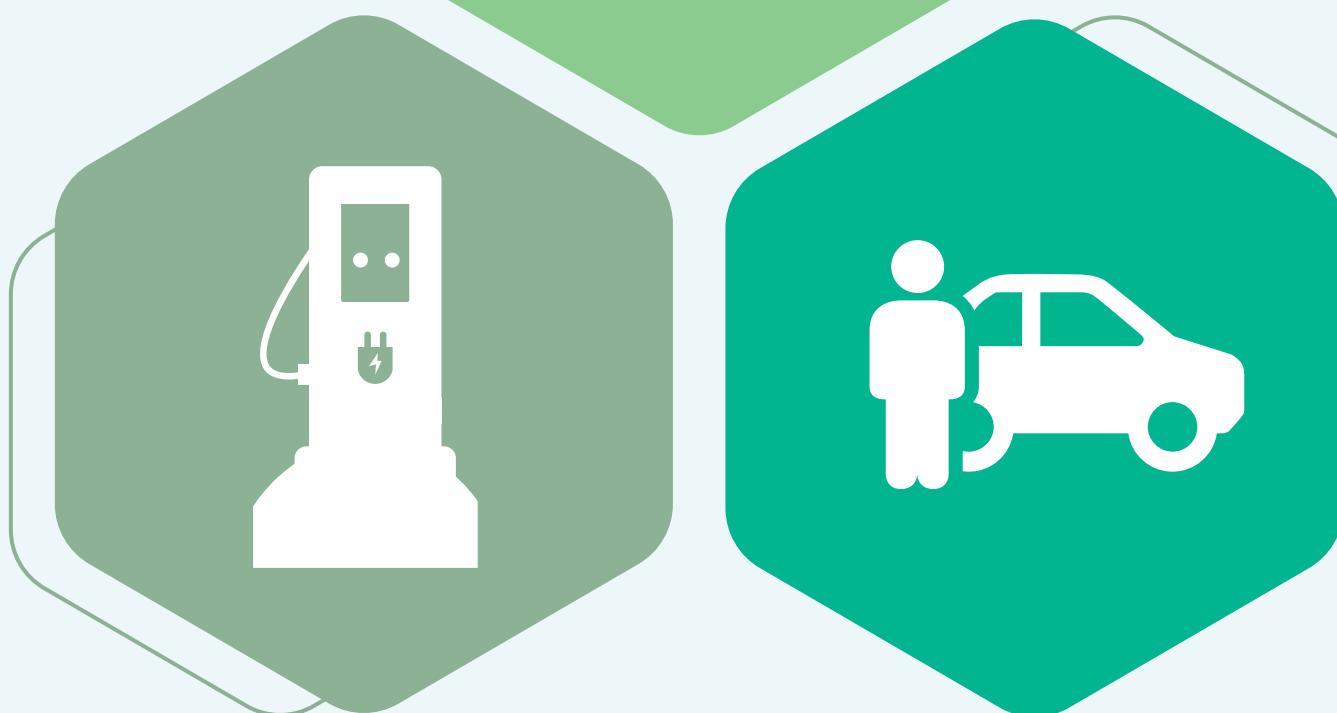
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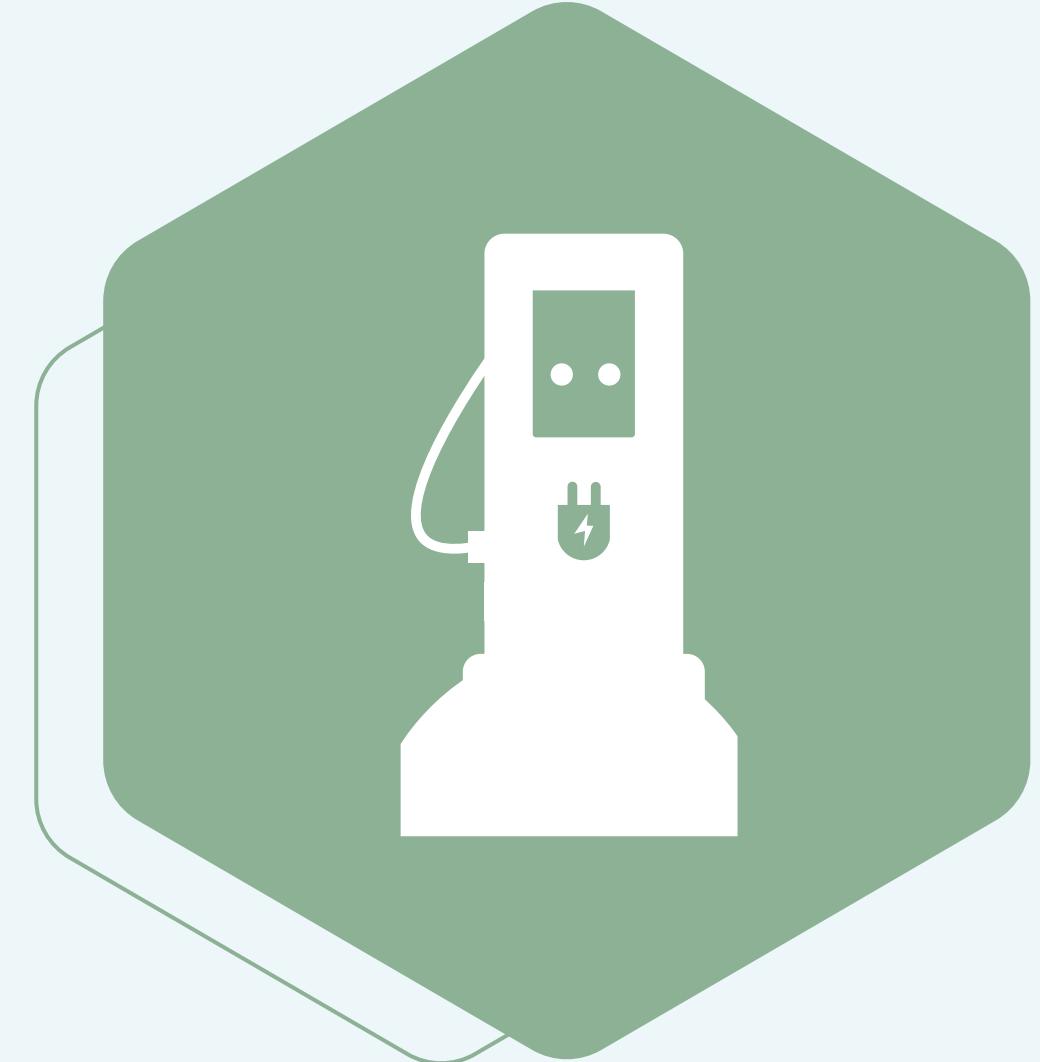
# TARGET USER GROUPS



## 01 Background

- Need to prepare for rising EV penetration, which impacts electricity demand and grid stability.
- Geographic EV density informs investment planning.

## Electric Utilities & Charging Operators



## 02 Example Scenarios

- Estimate EVs connected to each utility (e.g., Seattle City Light vs Puget Sound Energy).
- Predict peak charging demand in urban vs rural areas.
- Decide where to install additional fast-charging stations.

## 03 Objective & Scope

- Support load forecasting and ensure grid reliability.
- Guide charging infrastructure investment.
- Align energy planning with state clean energy policies.



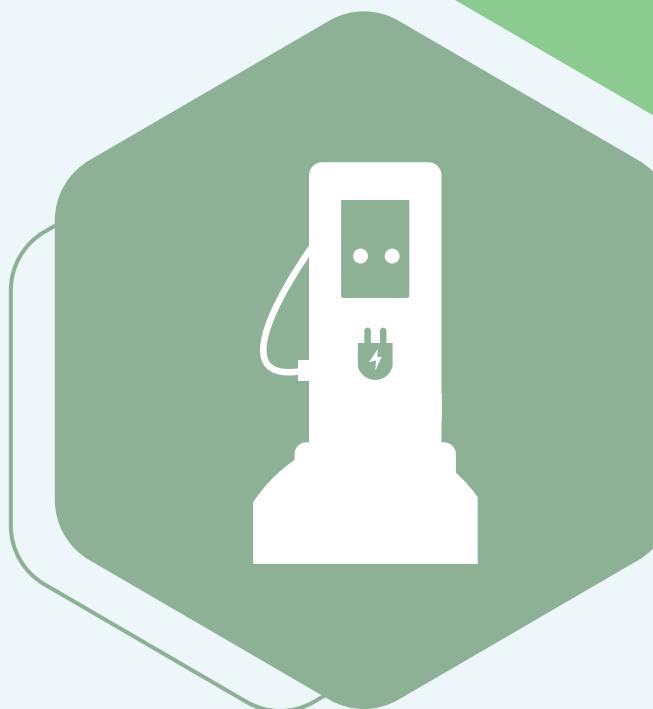
# TARGET USER GROUPS



**Policy Makers  
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# TARGET USER GROUPS



## OEMs & Dealerships

### 02 Example Scenarios

- Compare Tesla's market share with Nissan, Chevrolet, and Ford.
- Identify most popular models across price segments.
- Monitor consumer shift from PHEVs toward BEVs.

### 01 Background

- Want to understand adoption of brands and models to benchmark against competitors.
- Use insights to refine product strategies and align with consumer demand.

### 03 Objective & Scope

- Map Washington's competitive EV landscape.
- Guide marketing and dealership positioning.
- Adjust product roadmaps to meet local demand.



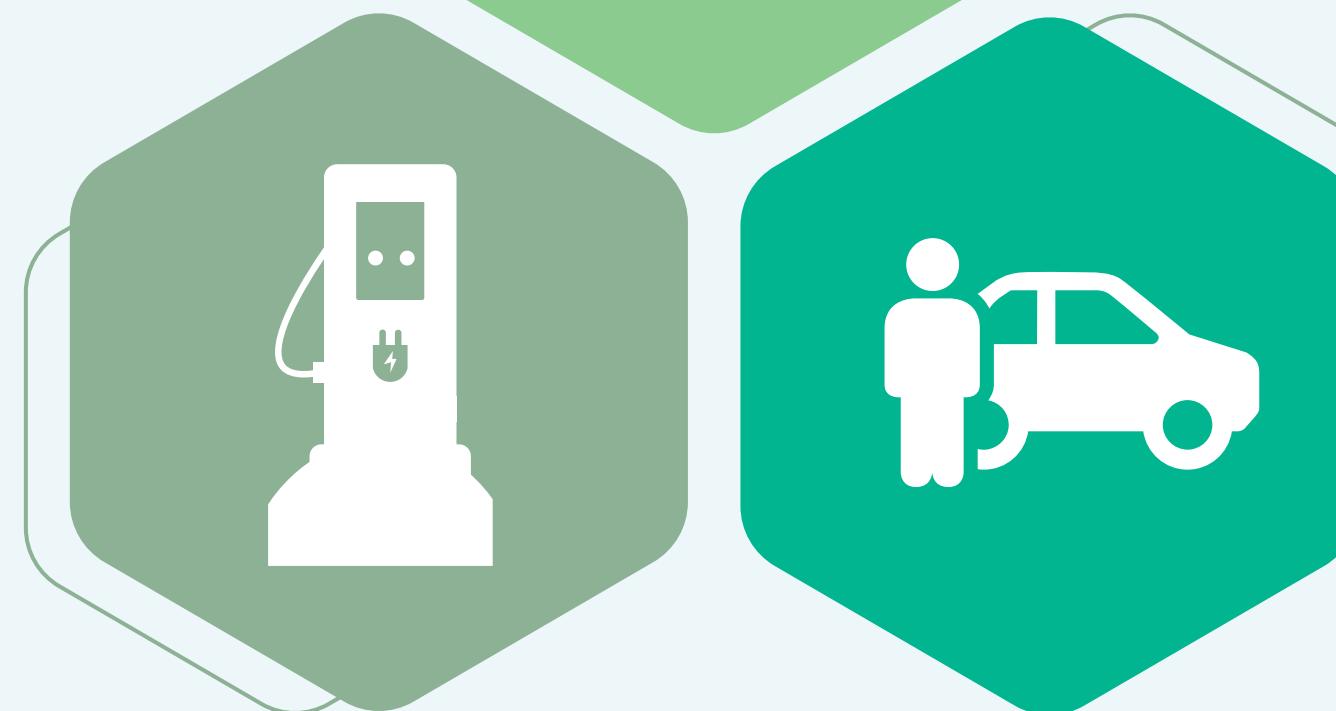
# TARGET USER GROUPS



**Policy Makers  
& Regulators**



**Electric Utilities &  
Charging  
Operators**



**OEMs &  
Dealerships**



# PROJECT OBJECTIVE

## GOALS

### 1 Monitor Adoption Trends:

- Track growth over time and identify acceleration points.

### 2 Evaluate BEV vs PHEV Share:

- Assess consumer preference shifts toward full EV adoption.

### 3 Identify Market Leaders:

- Benchmark brands and models dominating the market.

### 4 Map Hotspots:

- Analyze adoption by City, County, and ZIP to inform infrastructure planning.

### 5 Assess CAFV Effectiveness:

- Compare eligible vs non-eligible vehicles to measure policy impact.

### 6 Analyze Utility Demand:

- Estimate charging demand by utility providers.

### 7 Explore Pricing and Range Relationships

- Analyze the relationship between Base MSRP and Electric Range..

- To analyze EV adoption patterns in Washington State using
  - Alteryx (data preparation)
  - Power BI (dashboards).



**Research Questions:** For example, which counties or cities adopt the most EVs?

# DATA DESCRIPTION

## “2025 Electric and Hybrid Cars in” Washington, USA

kaggle

by the Washington State Department of Licensing (DOL)



| Column               | Description                                                                  | Example            | Data Type |
|----------------------|------------------------------------------------------------------------------|--------------------|-----------|
| VIN                  | Vehicle Identification Number (masked)                                       | 5YJSA1E26HF...     | String    |
| Make                 | Vehicle brand                                                                | Tesla              | String    |
| Model                | Model name                                                                   | Model Y            | String    |
| Model Year           | Year of manufacture / registration                                           | 2023               | Integer   |
| EV Type              | BEV / PHEV                                                                   | BEV                | String    |
| Electric Range       | Electric-only driving Range in miles (BEVs are coded as 0 miles)             | 42 (for PHEV)      | Integer   |
| Base MSRP            | Manufacturer Suggested Retail Price (USD)                                    | 52,000             | Float     |
| City                 | City of registration                                                         | Seattle            | String    |
| County               | County of registration                                                       | King               | String    |
| ZIP Code             | Registration ZIP                                                             | 98109              | Integer   |
| Legislative District | Washington State legislative district                                        | 36                 | Integer   |
| Electric Utility     | Utility provider for the registered location                                 | Seattle City Light | String    |
| CAFV Eligibility     | Whether the vehicle qualifies for the Clean Alternative Fuel Vehicle program | Eligible           | String    |
| DOL Vehicle ID       | Unique identifier from the Department of Licensing                           | 1234567            | Integer   |

Source Link: [2025 Electric and Hybrid Cars in Washington, USA](#)

## Dataset Overview



- Contains detailed registration records of **battery electric vehicles (BEVs)** and **plug-in hybrid electric vehicles (PHEVs)** currently registered in Washington State.

**Size:** Over **200,000 records**, each representing one registered EV or PHEV.

**Columns:** **17 attributes** describing vehicle characteristics, location, and eligibility

## Data Characteristics



**Coverage:** Vehicle registrations across **all cities and counties** in Washington State.

**Scope:** Covers **BEV and PHEV** registrations from early models up to **2025**

**Policy Field:** Indicates whether a vehicle qualifies for the **Clean Alternative Fuel Vehicle** program,

- useful for evaluating policy effectiveness.

**Utility Field:** Connects each registration with its **electricity provider**, supporting analysis of EV use relative to grid infrastructure.

**Geographic Field:** Contains **City, County and ZIP Code** allowing spatial visualization and regional comparisons.

# Data Quality Notes



## Electric range for BEVs recorded as “0”

- For BEVs, the field is recorded as 0 (not actual range), so it requires special handling in analysis.

## Inconsistent naming in categorical fields (e.g., utilities, cities)

- City and Utility names may have spelling variations (e.g., “Seattle City Light” vs “City of Seattle – SCL”), so requiring standardization.

## Duplicated Records

- VIN duplicates may exist and must be removed during cleansing.

# Washington CAFV POLICY?

*Washington's Clean Alternative Fuel Vehicle*

A Clean Alternative Fuel Vehicle (CAFV) runs on **clean energy like electricity or hydrogen**.

- To qualify for state tax incentives, Plug-in Hybrid Electric Vehicles (PHEVs) must have an all-electric range of at least 30 miles (48 km).

## Eligibility Status Categories



| Status                  | Clean Alternative Fuel Vehicle Eligible                                                                                                                               | Not Eligible Due to Low Battery Range                                                                                                    | Eligibility Unknown                                                                                                                            |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>What it means:</b>   | The vehicle meets all state criteria.                                                                                                                                 | The vehicle does not meet the minimum electric range requirement.                                                                        | There is insufficient data to determine eligibility.                                                                                           |
| <b>Who is included:</b> | <ul style="list-style-type: none"> <li>Battery Electric Vehicles (BEVs).</li> <li>Plug-in Hybrid Electric Vehicles (PHEVs) with a 30+ mile electric range.</li> </ul> | <ul style="list-style-type: none"> <li>Plug-in Hybrid Electric Vehicles (PHEVs) with an electric range of less than 30 miles.</li> </ul> | <ul style="list-style-type: none"> <li>Typically new models where the electric range has not been officially verified by the state.</li> </ul> |
| <b>Outcome:</b>         | Qualifies for state incentives and tax exemptions.                                                                                                                    | Does not qualify for state incentives.                                                                                                   | Status is pending until data is available and verified.                                                                                        |

**Purpose:** To transparently administer tax incentives and promote vehicles that significantly contribute to Washington's environmental goals.

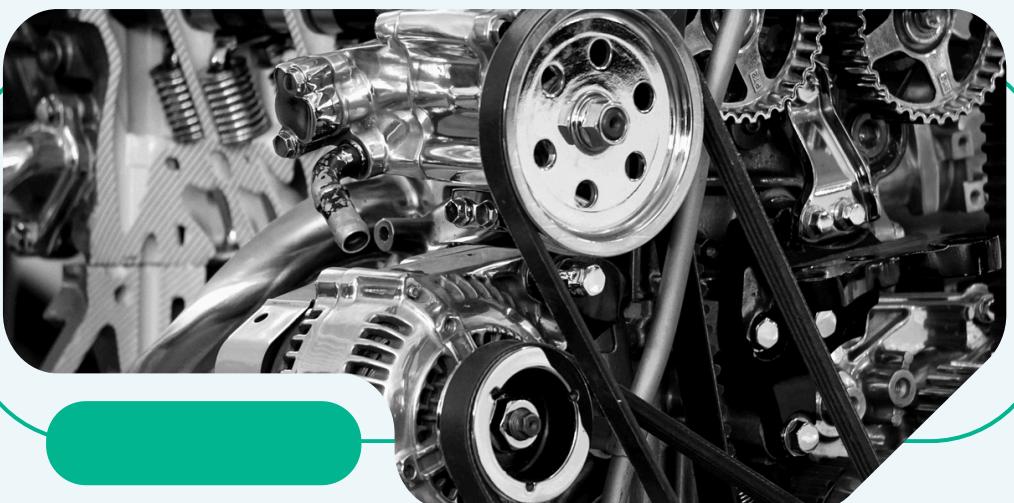


# DATA PREPARATION



## THE OBJECTIVE OF DATA PREPARATION

This stage is to transform the raw Washington State EV dataset from Kaggle into a clean, consistent, and analysis-ready format for use in Power BI. The process involves data cleansing, deduplication, handling missing values, feature engineering, and the addition of geographic coordinates.



## WORKFLOW OVERVIEW



### Initial Data Ingestion and Profiling

#### Tool: Input Data

- Loaded Electric\_Vehicle\_Population\_Data.csv into Alteryx
- Initial data review showed missing values, inconsistent formatting, and unnecessary fields
- Formed the basis for subsequent cleaning and transformation steps

#### Tool: Auto Field

- Automatically optimized data types for all columns
- Converted fields to the most efficient types (e.g., string → integer)
- Ensured data integrity and improved workflow performance for later calculations

## Data Cleansing and Standardization

# DATA PREPARATION



## WORKFLOW OVERVIEW



### Data Cleansing and Standardization

#### Tool: Data Cleansing

- Handled Null Values:
  - Replaced string nulls with empty strings ""
  - Replaced numeric nulls with 0 as a baseline
- Removed extra spaces: Trimmed leading/trailing whitespaces to ensure consistent joins, filters, and logic (e.g., "TESLA " → "TESLA")

#### Tool: Select

- Removed Irrelevant Columns:
  - VIN: Anonymized, not useful for unique identification
  - 2020 Census Tract: Outside the scope of analysis

#### Tool: Text to Columns

- Input the vehicle Location field in the format "POINT (Longitude Latitude)". Then, Split the string using a space delimiter to separate Longitude and Latitude

#### Tool: Formula

- Categorical Simplification: Extracted short form (BEV/PHEV) from EV\_Type using Regex → EV\_Type\_short
- Data Quality Fix: Replaced invalid BEV Range\_Miles = 0 → Null() to prevent skewed averages
- New Feature – Vehicle Age: Created Vehicle\_Age = 2025 – ModelYear for time-based analysis
- Binary Flags: Added BEV\_Flag, PHEV\_Flag, CAFV\_Flag for efficient filtering and aggregation
- MSRP Imputation: Assigned estimated Base\_MSRP by vehicle model using verified price sources
- Coordinate Cleanup: Removed parentheses in Latitude & Longitude → ensured numeric values
- Utility Name Standardization: Grouped variants under unified company names for accurate aggregation

## Final Scoping and Output

# DATA PREPARATION



## WORKFLOW OVERVIEW



## Final Scoping and Output

- **Tool: Filter**
  - Model Year Range: Included vehicles from 2008–2024 (excluded 2025 due to incomplete data)
  - Vehicle Type: Kept only Battery Electric (BEV) and Plug-in Hybrid (PHEV) vehicles

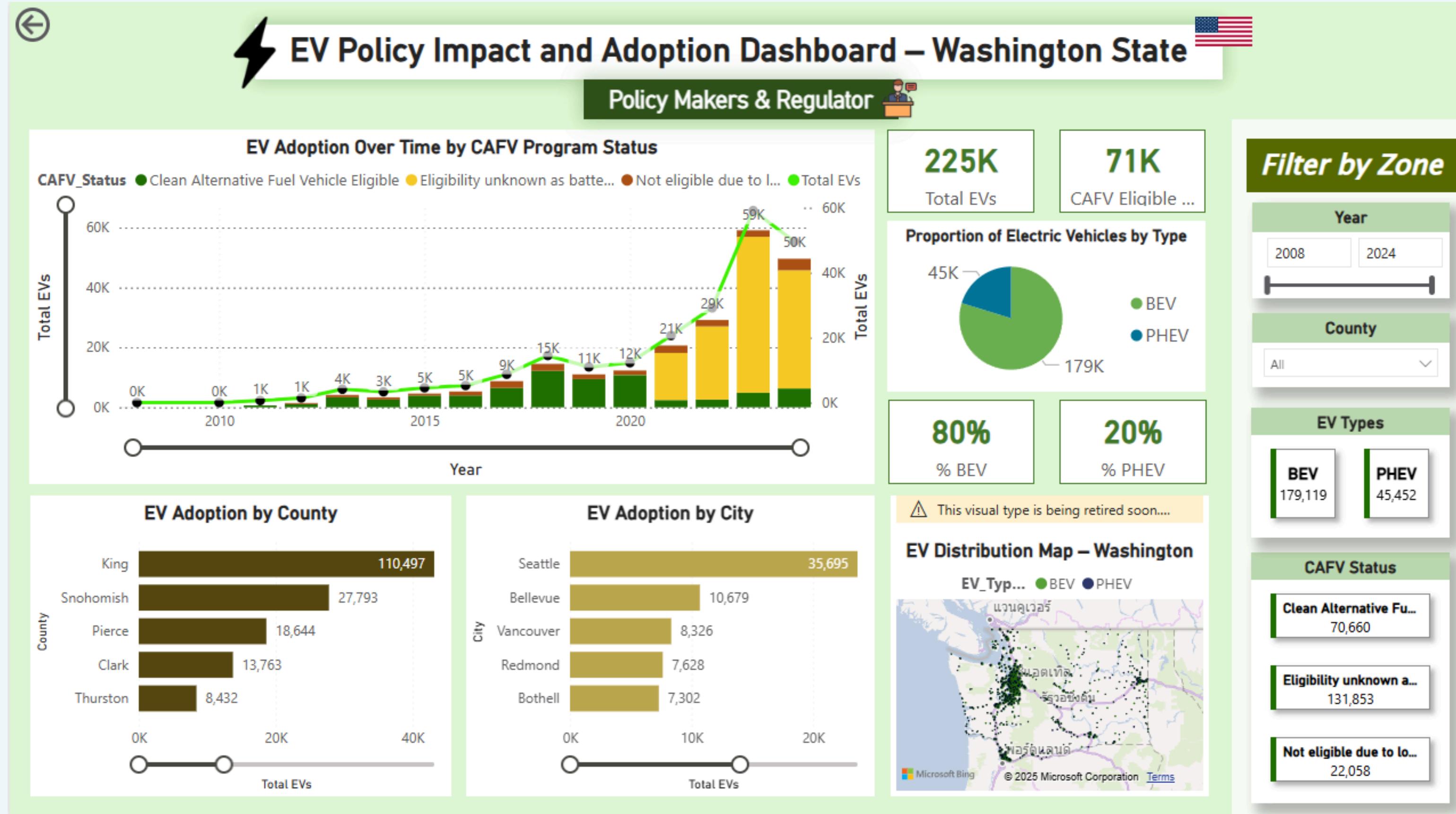


## DATA QUALITY RESULTS

- Row Count: ~200,000 valid and relevant records retained
- Column Count: 20 key attributes (2 removed, 6 new engineered features added)
- Duplicate Removal: All duplicates eliminated using DOL\_ID as a unique key
- Standardization:
  - Unified City/County formatting
  - Standardized Electric Utility names into Company\_Name
- Missing Value Treatment:
  - Imputed Base\_MSRP intelligently
  - Corrected invalid BEV Range (0 → Null)



# DASHBOARD 1



# DASHBOARD 1 INSIGHT/ANALYSIS

Policy Makers  
& Regulators

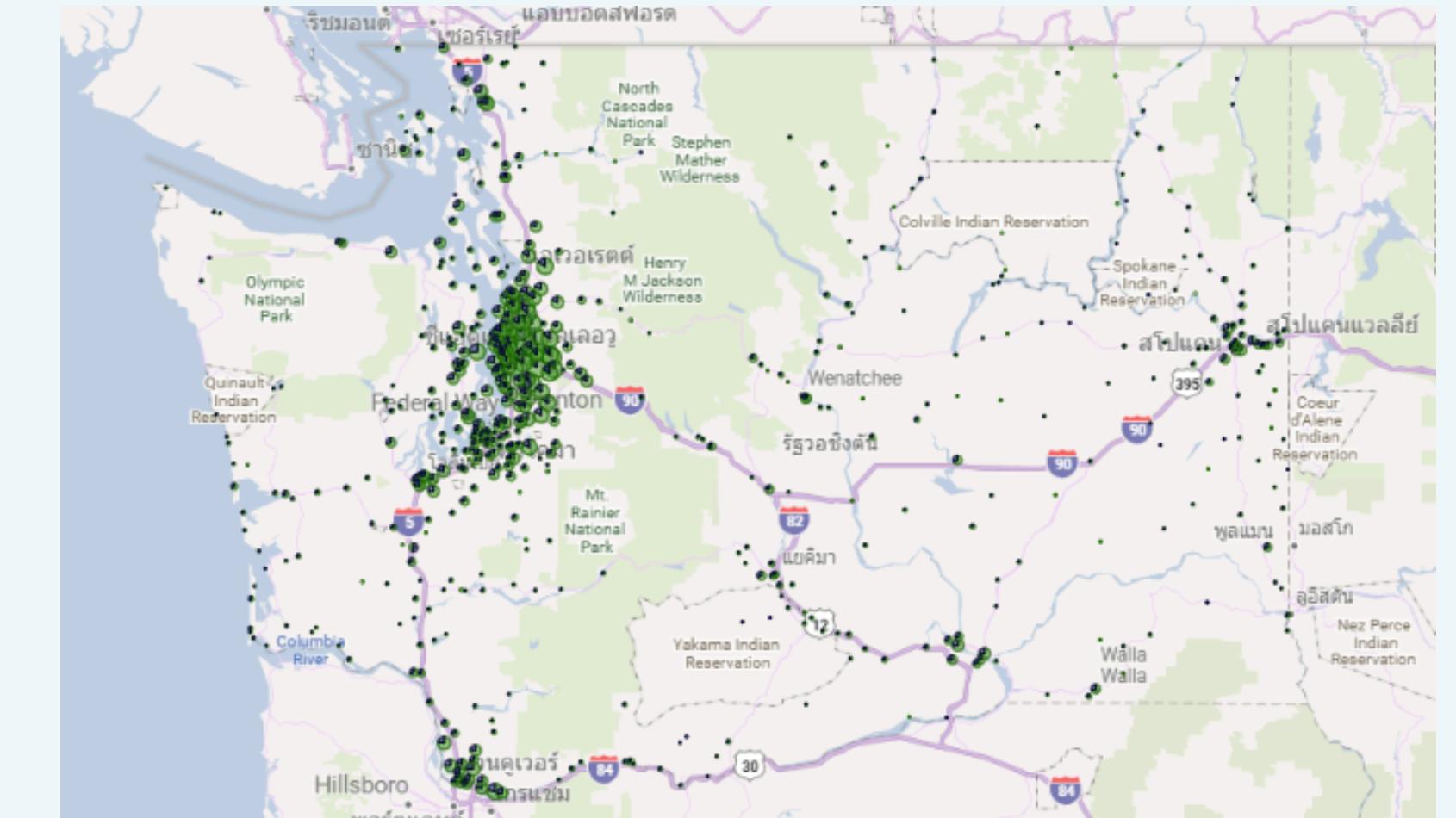
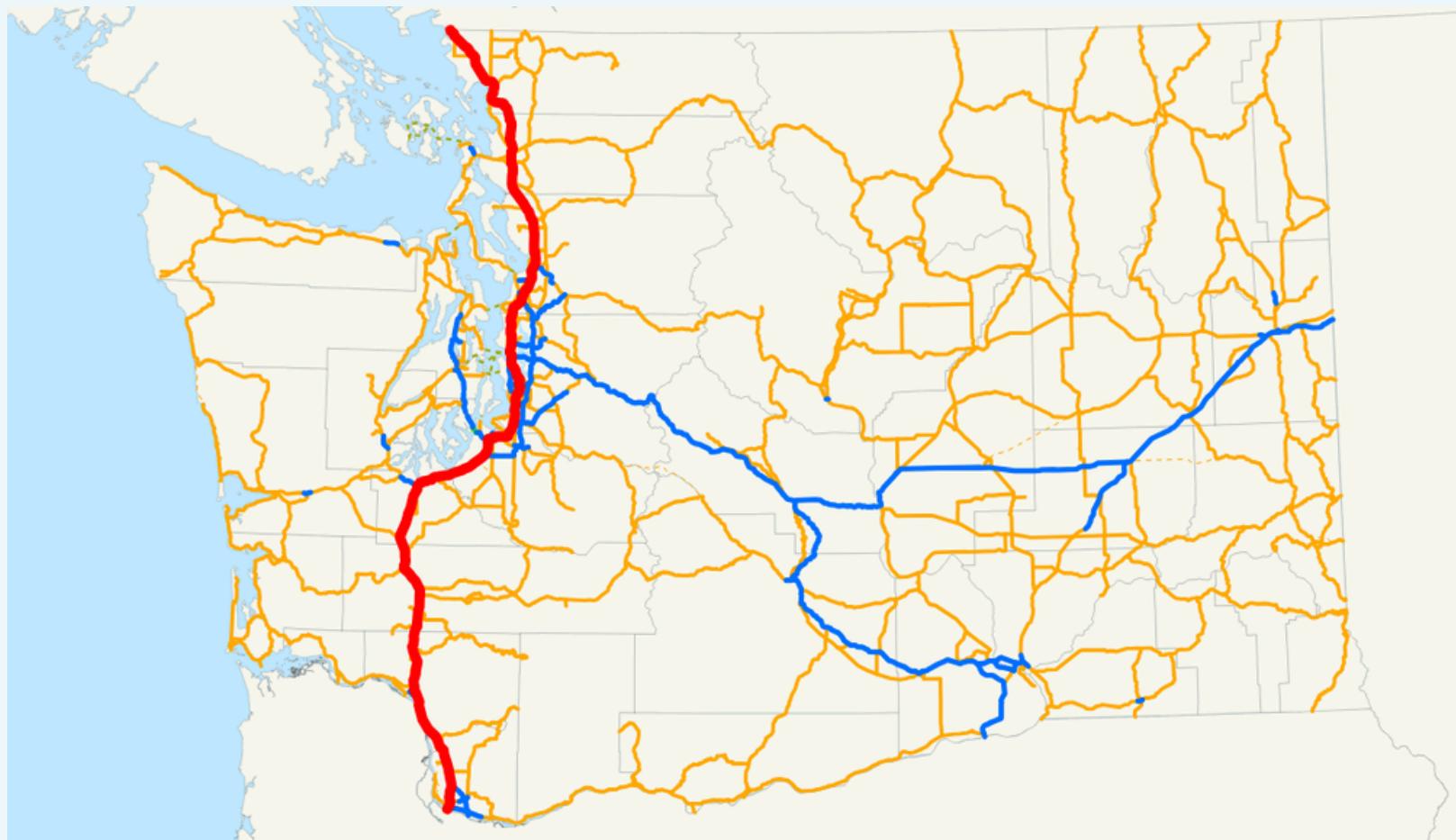


## Dashboard 1 – EV Policy Impact & Adoption in Washington State

### Key Insights:

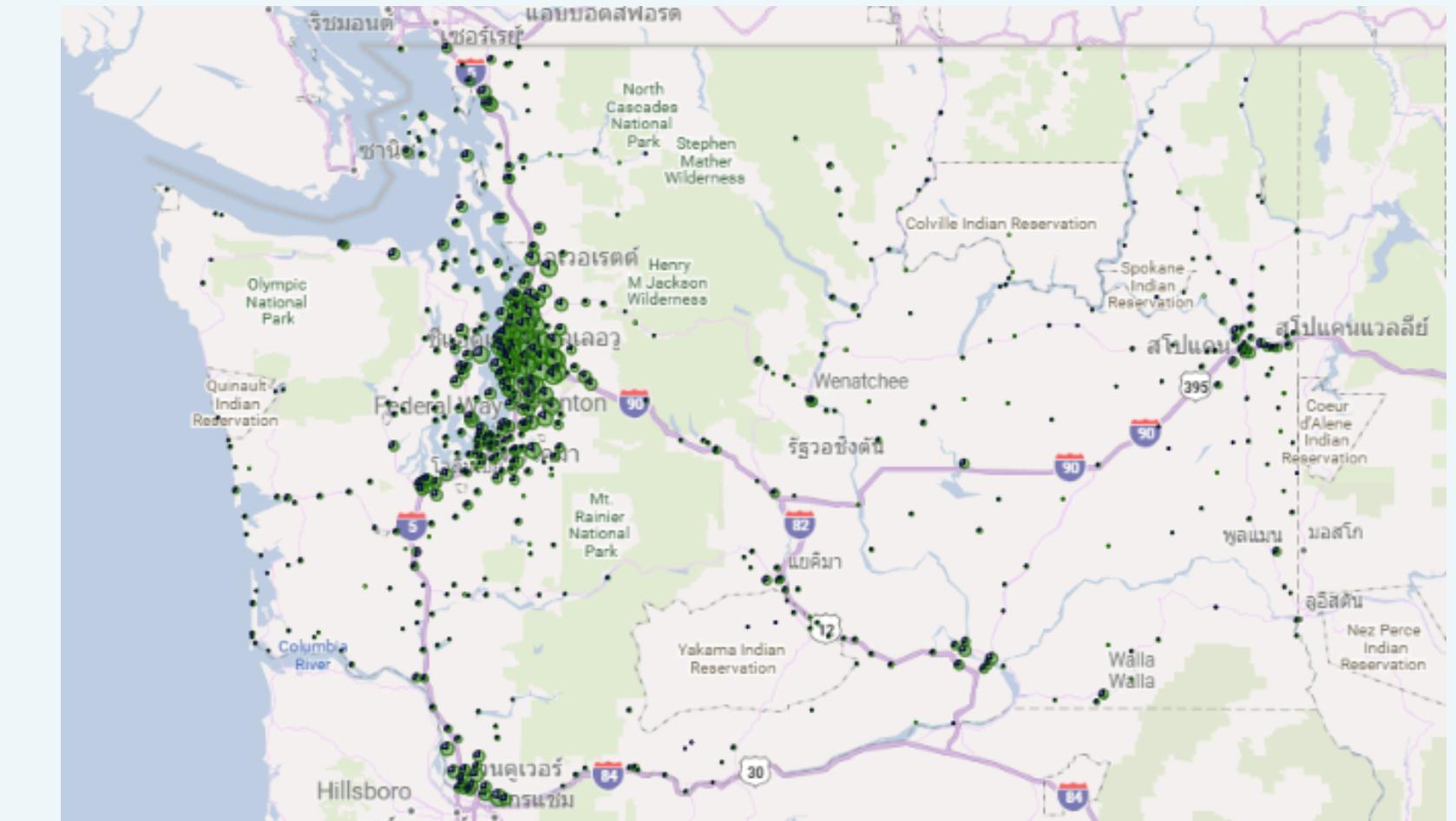
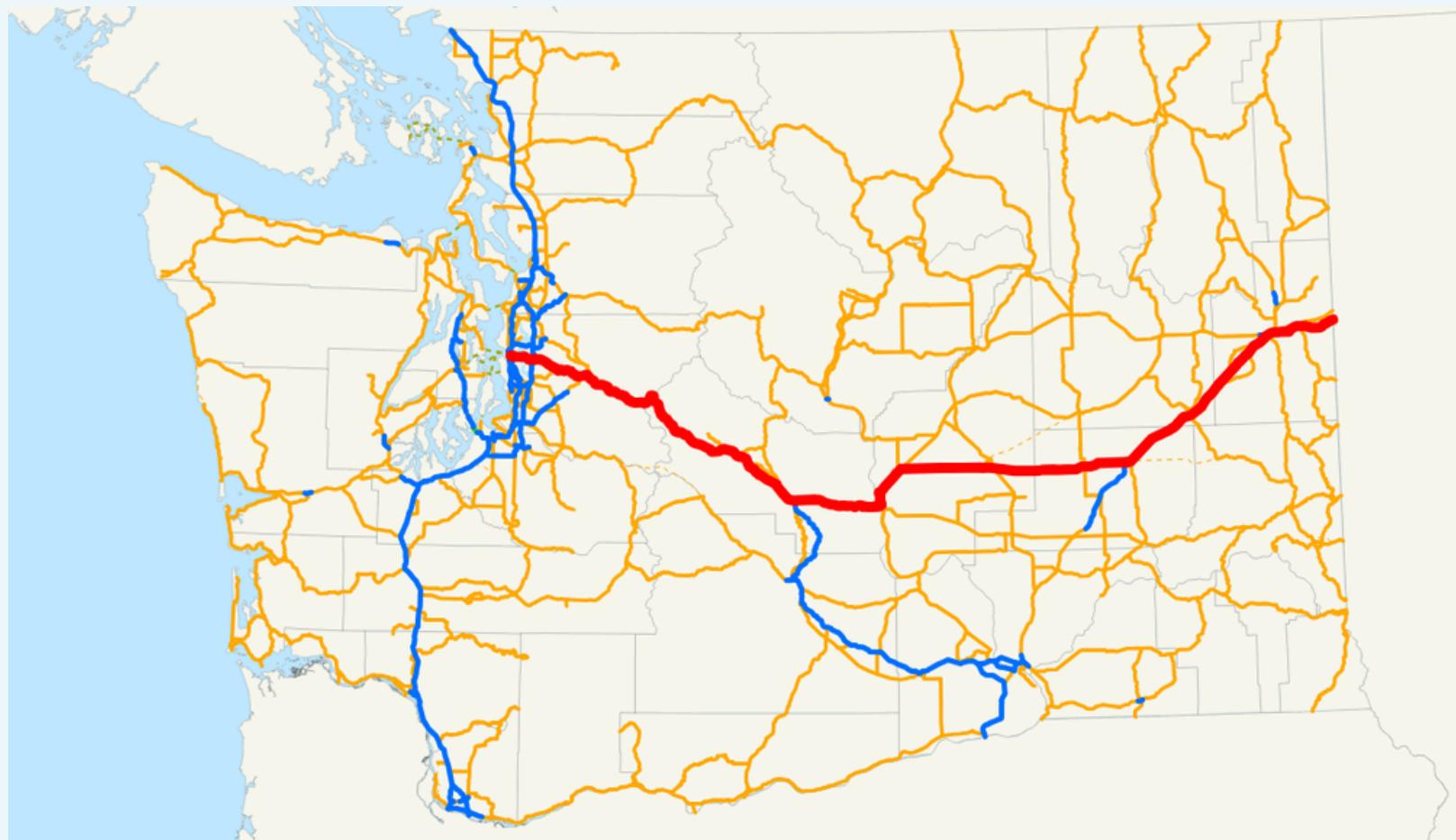
- Growth was gradual in the early 2010s, but began to accelerate significantly after 2018, reaching a total of over 225,000 registered vehicles by 2024. This shows sustained growth momentum across the state.
- Approximately 71,000 of these vehicles, which are about 31% of the total, are Clean Alternative Fuel Vehicle (CAFV) eligible. This strong representation suggests that financial incentives and state programs have played a crucial role in influencing consumer decisions and promoting cleaner transportation.
- The major counties that are the center of EV adoption are King County with 110,000 EVs, Snohomish with 28,000 EVs, and Pierce with 19,000. Finally, if we go even deeper to the city level, Seattle is top of the list with over 35,000 EVs, followed by Bellevue with around 11,000, and Vancouver at 8,000.
- The following counties and cities alone represent the vast majority of EVs in the state. The map shows dense EV clusters along major transportation arteries like Interstate 5 and Interstate 90.

# I-5 Highway



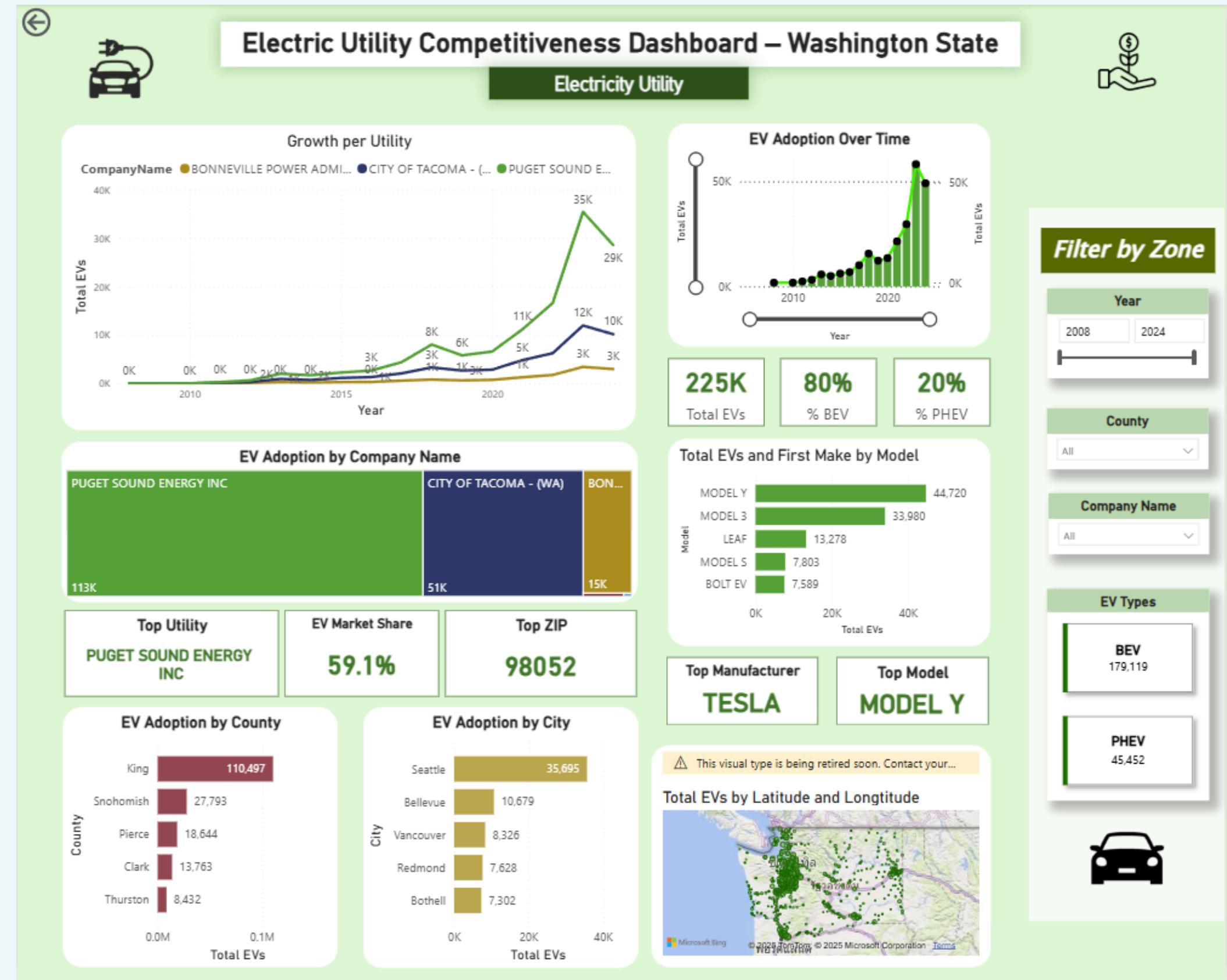
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# I-90 Highway



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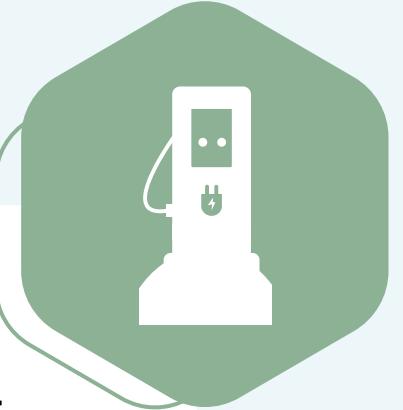
# DASHBOARD 2



# DASHBOARD 2

## INSIGHT/ANALYSIS

Electric Utilities &  
Charging  
Operators



### Uneven EV Distribution Across Utilities

- EV adoption in Washington State is highly concentrated within the territories of a few major electric utilities.
- Puget Sound Energy (PSE) collectively serve over 59% of all registered EVs.

### Geographic Concentration in the Puget Sound Corridor

- Within PSE's territory, approximately 60,000 EVs are registered in King County, 25,000 in Snohomish, and 19,000 in Pierce.

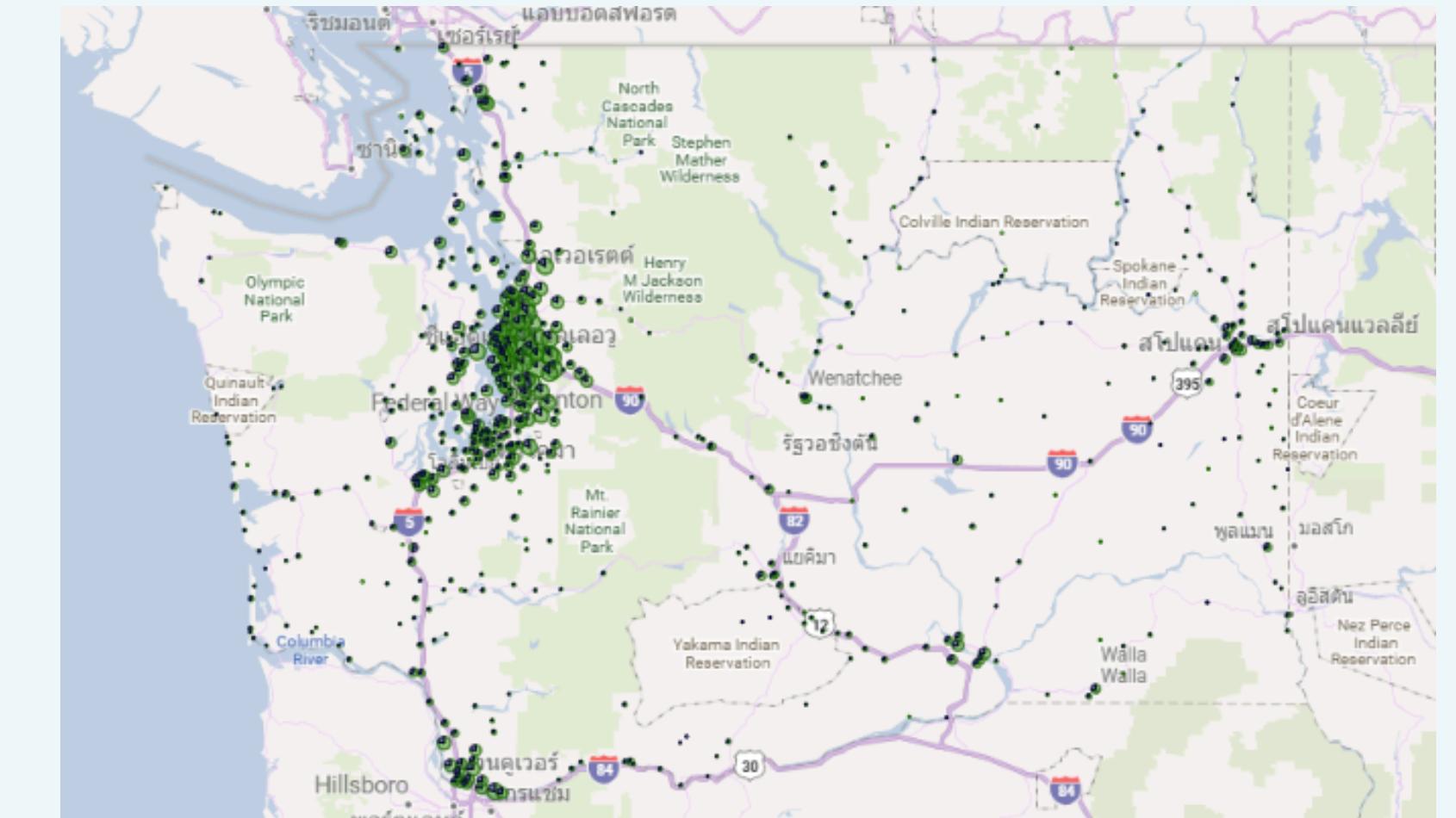
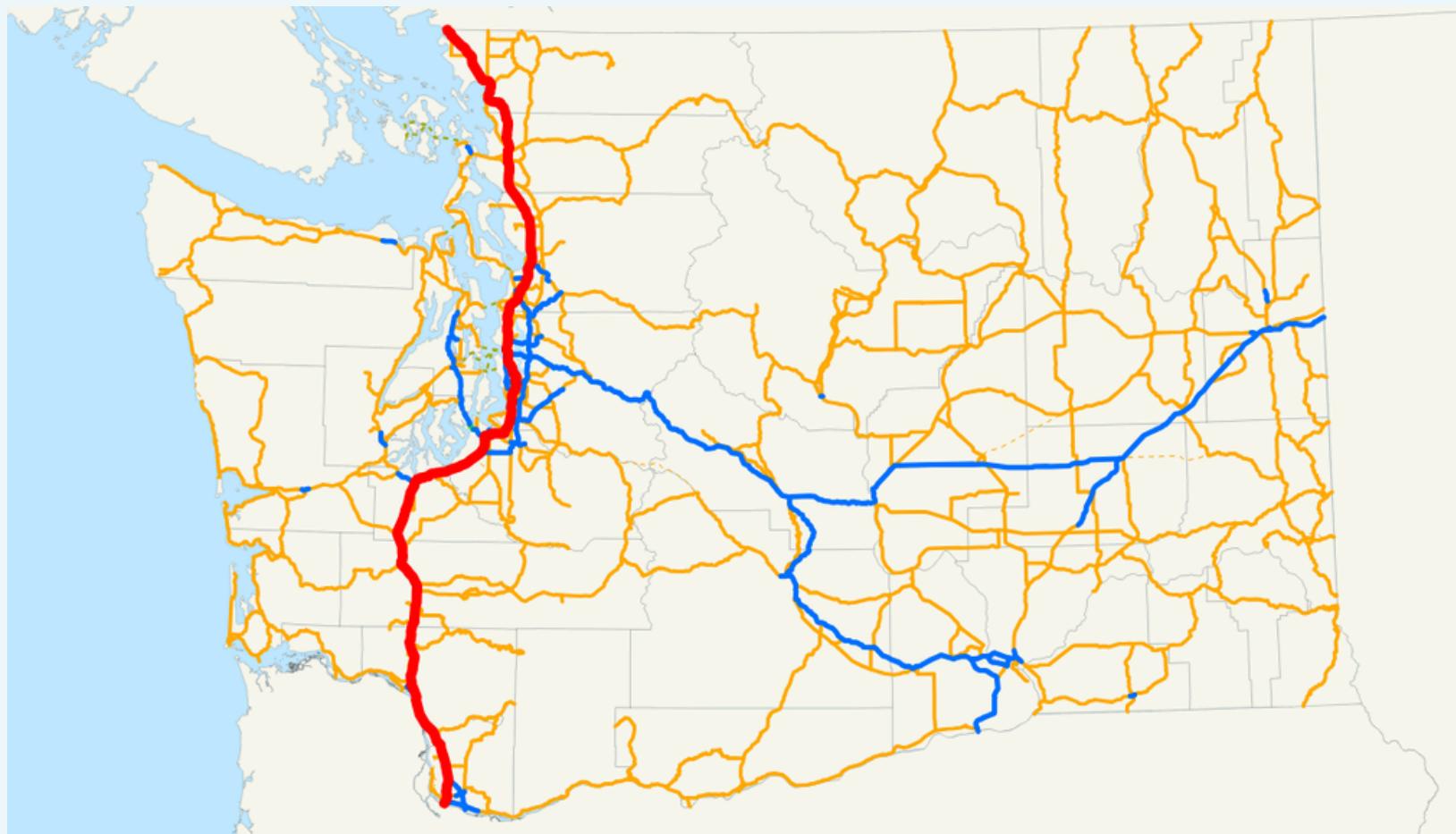
### Strategic Link Between EV Density and Transportation Corridors

- High EV adoption areas align closely with major highway systems—notably Interstate 5 (I-5) and Interstate 90 (I-90).

### Guidance for Charging Infrastructure Deployment

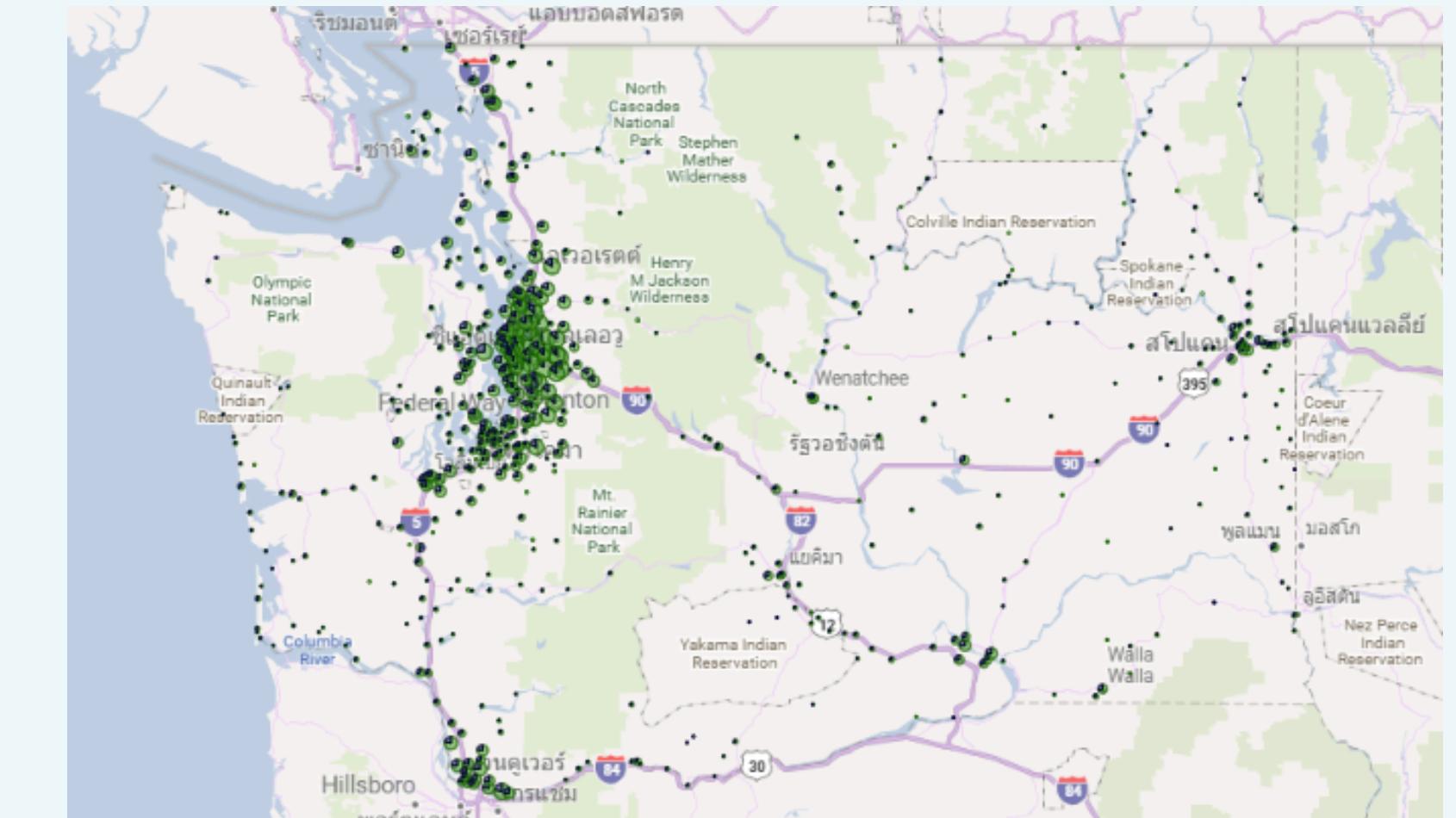
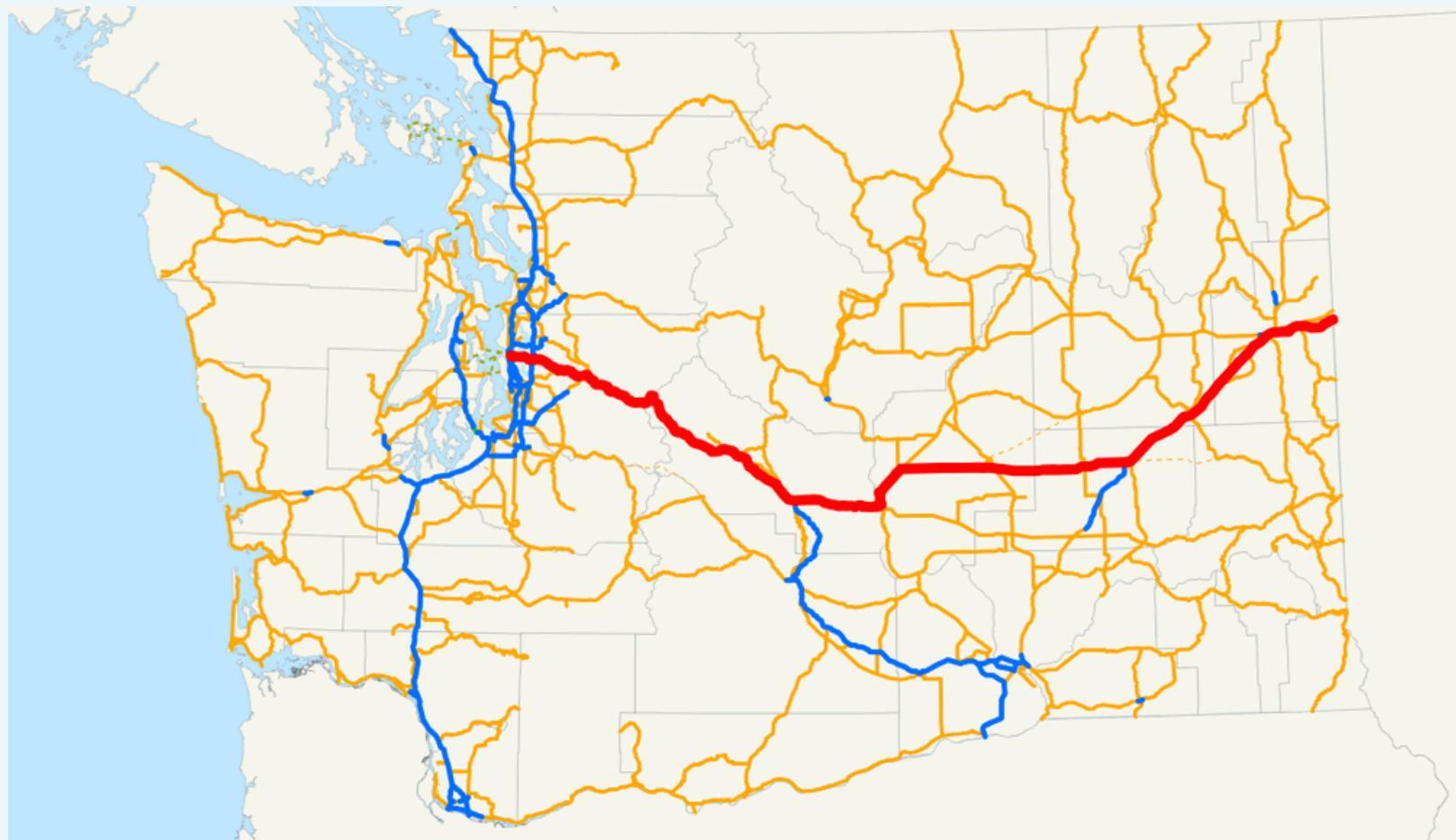
- Charging network operators can use this data to identify high-demand zones and optimize DC Fast Charging (DCFC) station locations.
- Aligning charging infrastructure with traffic flow and EV density improves utilization rates, customer accessibility, and return on investment.

# I-5 Highway



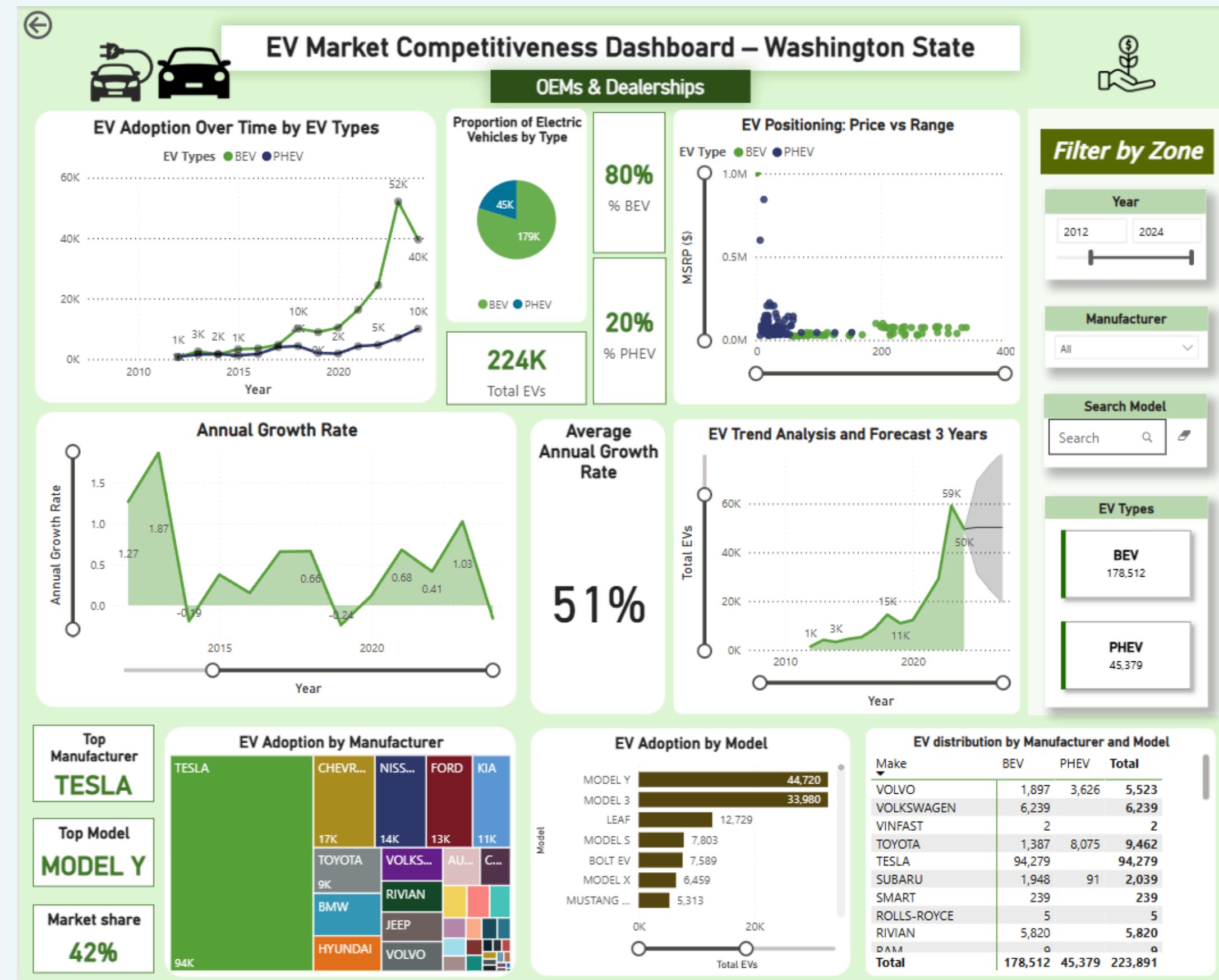
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# I-90 Highway



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# DASHBOARD 3



OEMs &  
Dealerships

# DASHBOARD 3

## INSIGHT/ANALYSIS

### Key Insights:

- Over 225K EVs registered by 2024, showing strong post-2018 growth momentum.
- BEVs lead with 80% share, PHEVs 20% – marking a clear consumer shift to full electrification.
- Average annual growth rate (230%) from 2008-2024 indicates steady, long-term expansion.

### Market & Brand Performance:

- Tesla dominates with ~94K units ( $\approx$ 42% share), led by Model Y and Model 3.
- Chevrolet, Nissan, Ford, and Kia show stable competition across mid-price tiers.
- Toyota remains key in the PHEV segment, reflecting its hybrid-to-EV transition.

### Product & Pricing Trends:

- BEVs span \$30K–\$80K with ranges of 250–350 miles, appealing to mainstream consumers.
- PHEVs occupy lower-price, shorter-range segments – signaling gradual decline.
- Range and zero-emission capability are now primary purchase drivers.

### Emerging Competitors:

- Chevy Bolt, Nissan Leaf, Ford Mach-E show rising adoption and growth potential.
- Rivian gains traction in premium adventure EVs; Hyundai and Kia expand diversification.

### Strategic Implications:

- OEMs should focus on BEV innovation and refine pricing strategy to stay competitive.
- Invest in infrastructure partnerships to accelerate adoption.
- Align product portfolios with Washington's consumer trends toward sustainable mobility.

:: GROUP 1 (B.E.A.N.S TEAM)

**THANK  
YOU FOR  
YOUR  
ATTENTION**