Project Report: Electric Vehicle (EV) Market Insights & Population Analysis

1. Executive Summary

This report provides a comprehensive analysis of the Electric Vehicle (EV) landscape in Washington State, utilizing a dataset of over **268,000 registered vehicles**. The primary objective was to uncover market trends, manufacturer performance, and geographic adoption patterns. Key findings reveal a significant market dominance by **Battery Electric Vehicles (BEVs)** over Plug-in Hybrids (PHEVs), with **Tesla** leading as the top manufacturer. Geographic analysis highlights **King County** as the primary hub for EV adoption, while SQL-based market segmentation identifies a growing shift toward "Long Range" vehicle categories.

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2. Data Cleaning & Preprocessing (Python)

Before analysis, the raw dataset underwent a rigorous cleaning process using Python (Pandas and NumPy) to ensure data integrity:

- **Initial Assessment**: Loaded the data and inspected its structure using `.info()` and `.head()` to identify data types and missing values.
- **Handling Missing Values**: Columns like `county`, `city`, and `postal_code` were checked for nulls.
- **Deduplication**: Identified and removed exact duplicate records to prevent skewed volume-based insights.
- **Data Transformation**: Standardized column names and ensured numeric fields like `electric_range` and `base_msrp` were correctly formatted for calculation.

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3. Exploratory Data Analysis (EDA) & Visualizations

Visual insights generated through Python (Matplotlib/Seaborn) provided a high-level view of the EV population:

- **Vehicle Type Distribution**: A clear majority of the population consists of **Battery Electric Vehicles (BEVs)** compared to Plug-in Hybrid Electric Vehicles (PHEVs).
- **Manufacturer Performance**: **Tesla** is the runaway leader in market share, followed by brands like Chevrolet, Nissan, and Ford.
- **Geographic Hotspots**: Adoption is heavily concentrated in urban centers, with **King County** representing the highest number of registrations.

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4. Advanced SQL Analytics & Business Insights

Structured Query Language (SQL) was used to perform deep-dive analysis on specific business questions:

A. Market Overview

- **Share of BEVs vs. PHEVs**: Calculated the exact percentage of each vehicle type to understand consumer preference for pure electric vs. hybrid options.
- **Adoption by Year**: Analyzed the volume of vehicles by `model_year` to track growth trends over time.

B. Performance & Technology

- **Battery Tech Leaders**: Identified the top 3 manufacturers with the highest average electric range, highlighting brands with superior battery technology.
- **Market Segmentation**: Segmented vehicles based on range into three categories:
    - **Short Range**: <100 miles
    - **Mid Range**: 100–250 miles
    - **Long Range**: >250 miles

C. Geographic & Sales Insights

- **City Performance**: Identified the top 5 cities with the highest adoption of pure BEVs and the cities with the best average electric range for vehicles (filtered for cities with >100 vehicles).
- **Brand Deep-Dives**: Used Common Table Expressions (CTEs) to rank the most popular models within each manufacturer's lineup.

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5. Key Findings & Conclusions

1. **Dominance of BEVs**: BEVs not only hold a higher market share but also show stronger alignment with **Clean Alternative Fuel Vehicle (CAFV)** eligibility due to their superior electric range.
2. **Market Concentration**: A few manufacturers (Tesla, Chevrolet) and specific geographic regions (King County) drive the majority of the state's EV growth.
3. **Technological Evolution**: There is a clear trend toward **Long Range** vehicles as manufacturers improve battery density, addressing "range anxiety" for consumers.