Global EV Market Analysis

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INTRODUCTION

The global electric vehicle (EV) market is experiencing rapid growth driven by environmental concerns, government regulations, and continuous advancements in battery and charging technologies. As more manufacturers enter the market and consumers increasingly adopt EVs, large volumes of data are generated related to vehicle performance, sales, pricing, and technology features.

In real-world business settings, this data is often scattered across multiple sources and lacks a structured analytical framework. Without proper organization and visualization, it becomes difficult for stakeholders to compare manufacturers, evaluate technology choices, or identify meaningful market trends. This project represents a realistic scenario in which raw EV data must be transformed into a structured analytical solution that supports both high-level business decisions and detailed technical analysis.

By applying data warehousing concepts and business intelligence techniques, this project demonstrates how EV market data can be organized, analyzed, and presented in a clear and user-friendly manner using interactive dashboards.

PROBLEM STATEMENT

The primary problem addressed in this project is the lack of a unified, analytical view of the EV market that enables stakeholders to:

- Compare manufacturer performance
- Evaluate battery and charging technologies
- Analyze sales and revenue trends over time
- Identify efficiency, safety, and warranty differentiators
- Support strategic and data-driven decision-making

Raw datasets alone are insufficient for insight generation without proper modelling, cleaning, and visualization.

INTENDED AUDIENCE

The intended audience includes:

- Automotive manufacturers and EV strategists
- Business analysts and data analysts
- Investors and market researchers
- Sustainability and mobility planners
- Academic users studying EV adoption trends

DATA SOURCE

The dataset used in this project is an EV market dataset, designed to reflect real-world EV industry characteristics. It includes:

1. Manufacturer and model information
2. Production year
3. Battery type and capacity
4. Driving range
5. Charging methods and charging time
6. Pricing
7. Country of manufacture
8. Units sold
9. Revenue
10. Safety ratings
11. Warranty coverage
12. Autonomous driving levels
13. The data was provided as a cleaned CSV file and imported into Power BI for analysis.

The dataset is a **simulated EV market dataset** designed to approximate real-world industry characteristics for academic analysis.
Link to dataset: https://www.kaggle.com/datasets/pratyushpuri/ev-electrical-vehicles-dataset-3k-records-2025

CLIENT

Client Role:

The project was developed for a simulated client engagement, where the client role was represented by a classmate acting as a business stakeholder from an EV market research and analytics team.

Client Perspective:

From the client's perspective, the key requirements for the project included:

- A scalable and well-structured analytical data model
- Clearly defined KPIs and performance benchmarks
- Intuitive, executive-friendly dashboards for decision-making
- Regional comparisons and short-term market forecasting

The client reviewed the dashboards as a business user and decision-maker, focusing on how clearly insights were presented rather than on the technical implementation. The feedback highlighted the need to reduce visual clutter, improve overall interpretability, and include clear KPIs and executive-level summaries. Based on this input, the dashboards were refined to better emphasize high-impact metrics, simplify visual layouts, and provide summary indicators that support quick and informed decision making.

Client Details:

Name: ABCD
Email: abcd@gmail.com

PROJECT STEPS

Step 1: Data Preparation & ETL

- **Imported CSV data into Power BI:** Loaded the cleaned EV dataset into Power BI as the primary data source, ensuring successful ingestion and initial validation of the data structure.

- **Cleaned missing and inconsistent values:** Identified and addressed missing, duplicate, or inconsistent records to improve overall data quality and reliability for analysis.

- **Standardized data types:** Converted fields into appropriate numeric, categorical, and time-based data types to support accurate calculations, filtering, and visualizations.

- **Verified ranges, prices, and sales values:** Reviewed key numerical fields such as driving range, pricing, and units sold to confirm values were within reasonable and expected limits.

- **Removed nulls from dimension keys:** Eliminated null values from dimension key columns to ensure valid relationships and maintain data integrity within the star schema.

Step 2: Data Modelling (Datamart in Power BI)

A star schema data model was designed and implemented **directly within Power BI, not in SQL Server**. Although the project proposal mentioned loading data into a SQL database, during implementation the DataMart was created in Power BI using DAX and Power BI relationships as we encountered connectivity issues.

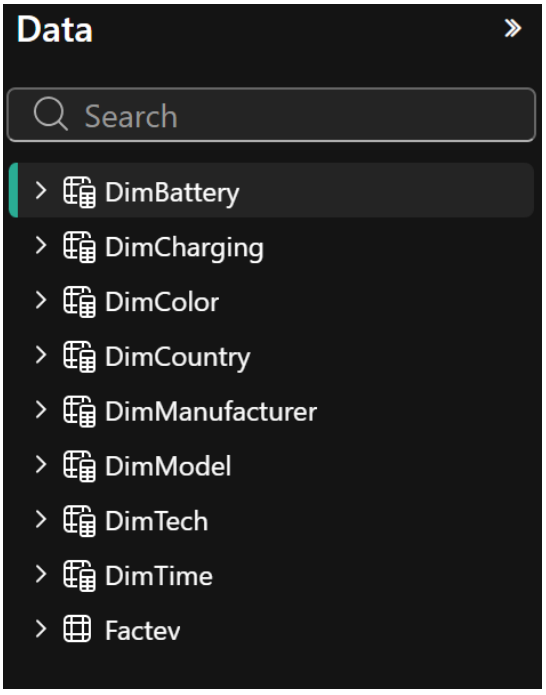
Fact Table:

- FactEV
- Measures: Total Units Sold, Revenue, Battery Capacity, Range, Charging Time, Average Price, Average Range, Average Range per kWh, Most Sold Battery Type, Total Revenue.

Dimension Tables:

- DimManufacturer
- DimModel
- DimBattery
- DimCharging
- DimCountry

- DimTime
- DimColor
- DimTech



Relationships:

• **All relationships are Many-to-One (*:1):** Each dimension table contains unique values that relate to multiple records in the FactEV table, ensuring accurate aggregations and filtering.

• **Dimensions → FactEV:** All relationships are directed from dimension tables to the central fact table, following standard star schema design principles.

• **Single-direction filtering:** Filtering flows in a single direction to prevent ambiguity and ensure predictable behavior across visuals and calculations.

• **No many-to-many relationships:** The data model avoids many-to-many relationships, reducing complexity and eliminating potential aggregation errors.

• **No bidirectional ambiguity:** Bidirectional filters were intentionally avoided to maintain model clarity, performance, and analytical consistency.

ANALYSIS PERFORMED

The analysis was divided into four dashboard sections:

Dashboard 1: Market Overview

This dashboard was developed to provide a **comprehensive market overview** by tracking crucial sales performance metrics and trends for manufactured units. It highlights key findings such as the fluctuating Total Units Sold by Year and the overall market value, **quantified by the 2.39T Total Revenue KPI**. Furthermore, it identifies top market performers by units sold, led by Ferrari, and visually represents the global reach of sales through the Units Sold by Country map. Finally, the dashboard offers detailed insights into shifting consumer preferences by charting Sales Trends by Battery Type across different model years, enabling strategic decision-making.

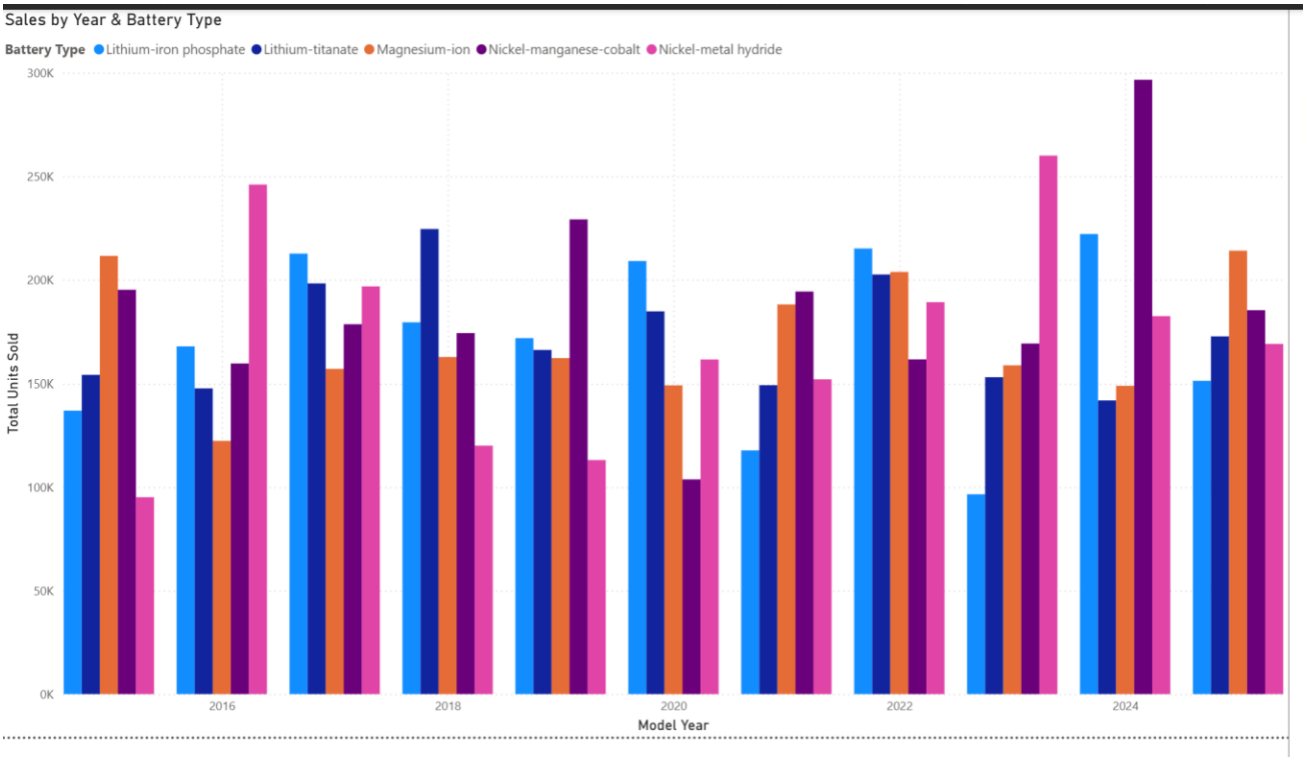


Figure 1: Sales by Year & Battery Type

The motivation for this **Sales by Year & Battery Type chart** (*Figure 1*) is to visualize and analyze the shifting preferences and market share among **different battery chemistries** over time, which is critical for forecasting and resource planning. The chart, which tracks **Total Units Sold from 2015 to 2024** by Model Year, reveals dynamic sales patterns. For example, Nickel-metal hydride (magenta) appears to have experienced the highest peak sales year-over-year, particularly around 2024, achieving close to 300K units sold. In contrast, the use of Magnesium-ion (orange) and Lithium-titanate (dark blue) shows more consistent, though typically lower, unit sales across the same period. This visual decomposition of **sales by battery type allows stakeholders to pinpoint dominant technologies** and **assess the market viability of each chemistry**.

Dashboard 2: Technology & Performance Analysis

This dashboard was created to analyze **key technical performance indicators** for electric vehicles, focusing specifically on **battery technology and charging efficiency**. The objective is to evaluate which battery types offer the **greatest Average Range and to assess the time-effectiveness** of various Charging Types. Furthermore, the inclusion of Range per kWh Efficiency by Manufacturer allows for a direct comparison of powertrain optimization among key market players. Finally, the Battery Capacity vs Driving Range scatter plot provides insight into the relationship between energy storage and vehicle performance, enabling data-driven decisions on component selection and product development.

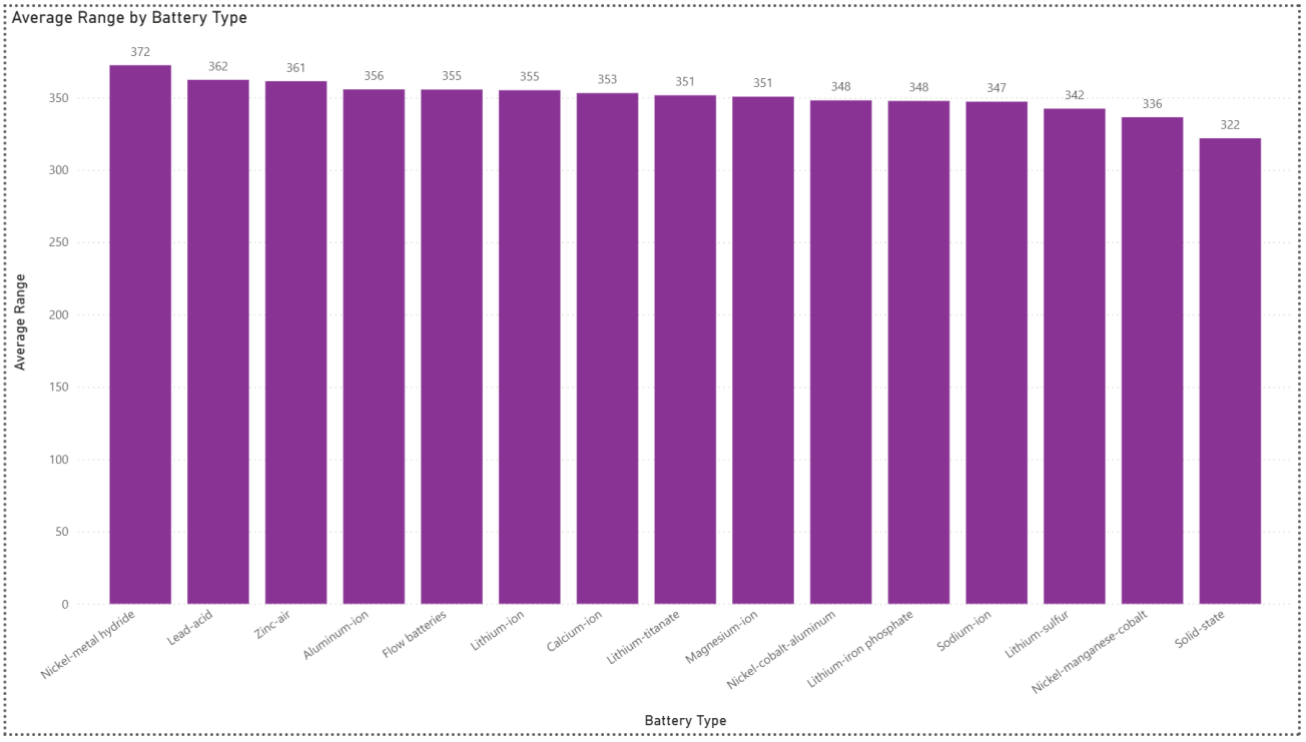


Figure 2: Average Range by Battery Type

The motivation for creating the **Average Range by Battery Type chart** (*Figure 2*) is to establish a clear **performance benchmark for different battery chemistries**, aiding in technology selection and product positioning. This visualization directly **addresses the question of which battery types offer the longest driving range.** The chart reveals that Nickel-metal hydride batteries provide the highest average range at 372 (units not specified, but likely kilometers or miles), followed closely by Lead-acid (362) and Zinc-air (361). Conversely, Solid-state batteries currently exhibit the lowest average range at 322. These findings are crucial for manufacturers deciding on the **optimal battery chemistry to balance cost, capacity, and performance requirements** in new vehicle models.

Dashboard 3: Market Forecast & Financial Insights

This dashboard was developed to provide a **focused, high-level financial and market share analysis** for strategic business planning. The key motivation was to establish the relationship between **sales volume and financial performance** through the Correlation between Units Sold and Revenue chart. It also includes an assessment of future performance by implementing a 3-Year Sales Forecast based on historical trends. Furthermore, the dashboard offers a detailed view of competitive standing by identifying the Top Manufacturers by Total Revenue, while simultaneously breaking down market value by Revenue Share by Battery Type to inform future product investment decisions.

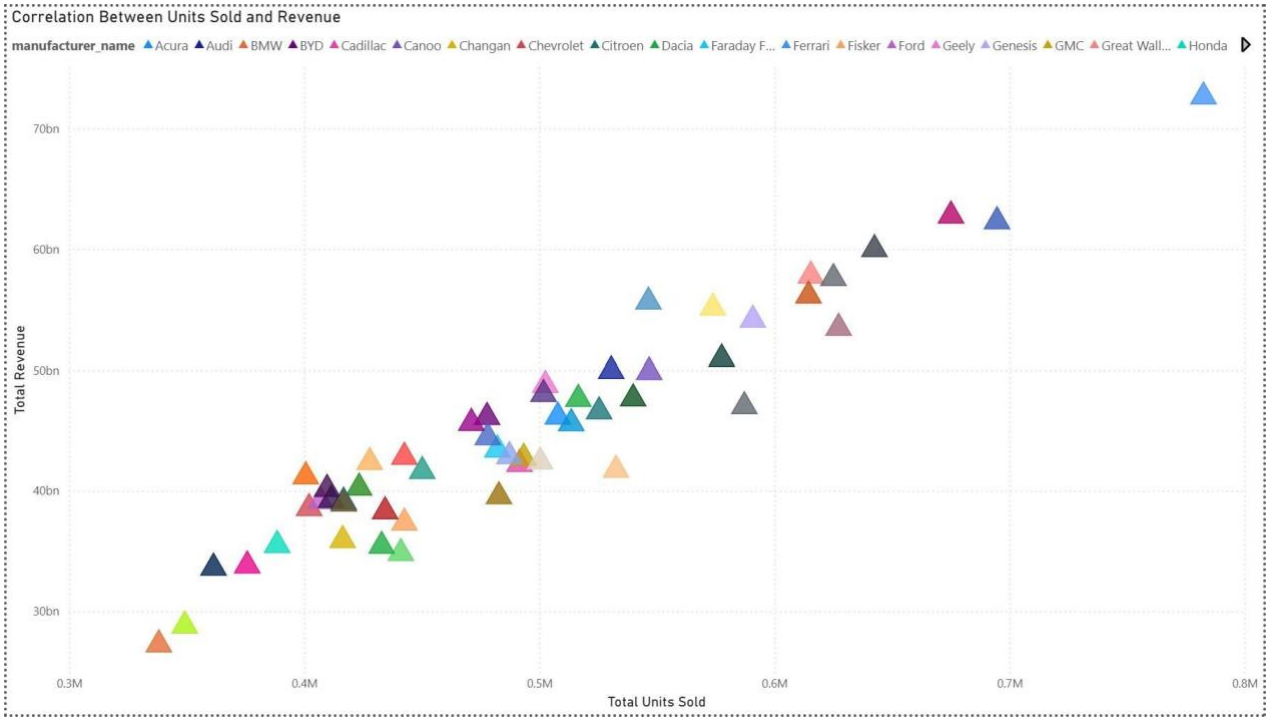


Figure 3: Correlation Between Units Sold and Revenue

The motivation for creating the **Correlation between Units Sold and Revenue chart** (*Figure 3*) is to understand the **fundamental relationship between sales volume and financial performance** across the market and individual manufacturers. This scatter plot directly addresses whether **higher unit sales consistently translate into higher revenue**, which is a key metric for evaluating business strategy effectiveness. The chart shows a generally positive correlation between the two variables: as Total Units Sold increase (moving right on the x-axis), Total Revenue also tends to increase (moving up on the y-axis). However, the scatter of points, especially the outliers, suggests that price and margin significantly differentiate manufacturers- some achieve high revenue with relatively lower unit sales (high price/margin), while others require massive volume to reach comparable revenue levels.

Dashboard 4: Consumer & Vehicle Insights

This dashboard was developed to provide a **comprehensive comparison of vehicle and manufacturer attributes** crucial for competitive analysis and consumer insights. A primary motivation was to **visually position different battery types by balancing cost and performance** using the Price vs Driving Range (Performance Positioning) scatter plot. The dashboard also **provides critical quality and trust** indicators by ranking Top Manufacturers by Safety Rating and displaying the Average Warranty Coverage by Manufacturer. Finally, the Vehicle Attribute **Comparison Matrix consolidates key metrics like price, range, and charging time into a single, comprehensive table for easy, multi-factor evaluation across all models**.

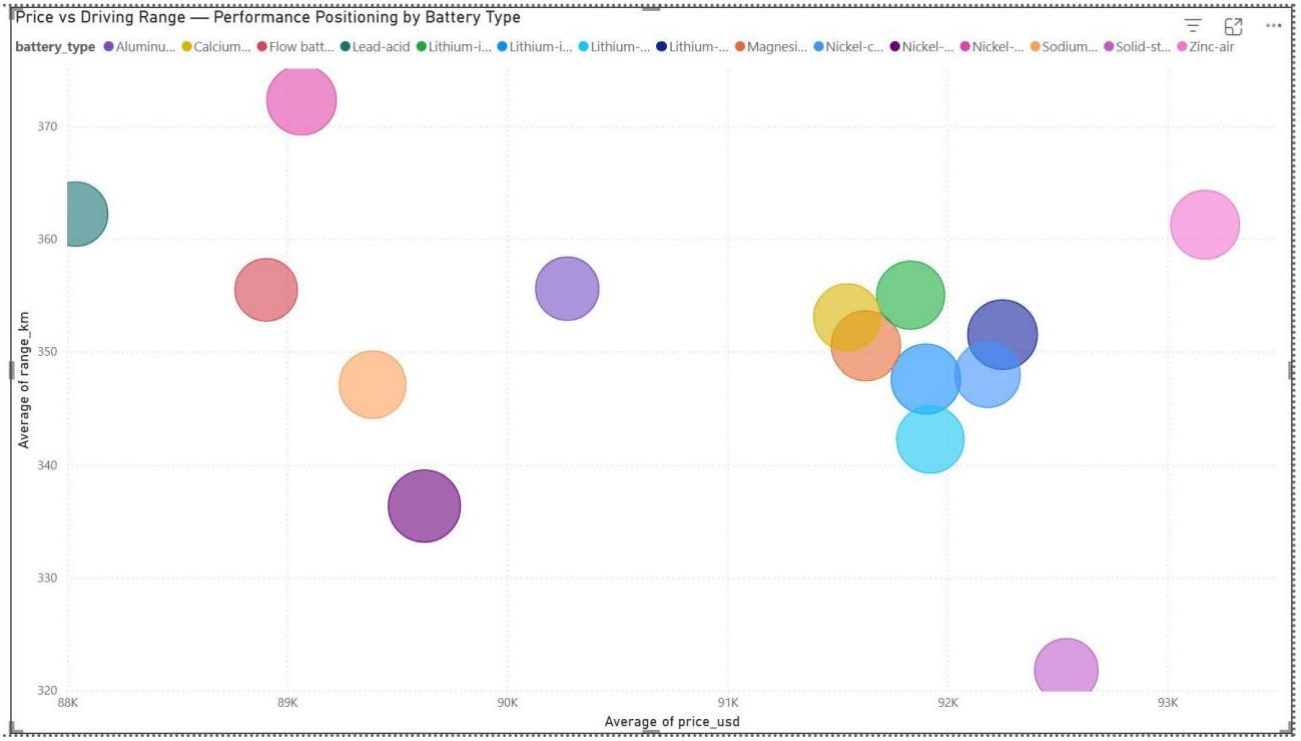


Figure 4: Price vs Driving Range with respect to Battery Type

The motivation for generating the **Price vs Driving Range (Performance Positioning) scatter plot** (*Figure 4*) is to analyze the trade-off between vehicle cost and performance as dictated by different battery technologies. This chart provides a **direct comparison of value proposition by mapping the Average Price (USD) against the Average of Range (km) for various battery types**. Key findings show a wide distribution, indicating that higher price does not universally guarantee a longer range, highlighting competitive gaps. For instance, Flow Batteries (pink/magenta) and Zinc-air (light purple) offer a high range (over 360 km) at a moderate price (around $89K and $93K, respectively). Conversely, Solid-state (dark purple) and Lithium-iron-phosphate (blue) are clustered in the lower range (320-350 km) bracket, showing a varying return on investment for different battery chemistries.

KEY DISCOVERIES AND INSIGHTS

- Based on dataset structure, Ferrari, Nissan, VinFast emerge as top performers.
- Lithium-based battery technologies dominate both revenue and sales share.
- Higher battery capacity generally correlates with increased driving range.
- Faster charging standards reduce charging time but are less widely adopted.
- Manufacturers offering longer warranties tend to have higher safety ratings.
- EV pricing shows stability with moderate growth aligned to revenue increases.
- Sales forecasts indicate continued market growth over the next three years.

CHALLENGES AND RESOLUTIONS

Challenges:

• **Many-to-many relationship conflicts:** Initial data modelling attempts resulted in many-to-many relationships, which caused ambiguous filtering and incorrect aggregations across visuals, requiring revisions to the data model.

• **NULL values in dimension keys:** Some dimension tables contained null values in key attributes, which prevented valid one-to-many relationships and required additional data cleaning steps in Power Query.

• **Overcrowded scatter plots:** Early scatter plots contained too many data points and overlapping markers, making patterns difficult to interpret and necessitating changes to aggregation methods and visual formatting.

• **KPI text formatting limitations in Power BI:** Power BI's native KPI and card visuals offered limited text formatting options, which required layout adjustments and alternative visual choices to maintain readability.

Resolutions:

• **Enforced strict star schema design:** Revised the data model to follow star schema best practices, ensuring all dimension tables maintained one-to-many relationships with the central fact table to eliminate ambiguity.

• **Removed NULL values from dimension tables:** Cleaned and validated dimension key columns in Power Query to ensure uniqueness and completeness, allowing relationships to function correctly.

• **Aggregated scatter plots using averages:** Updated aggregation methods for performance-related visuals to use average values, improving interpretability and preventing misleading comparisons.

• **Optimized KPI card titles and labels:** Adjusted KPI titles, labels, and layouts to improve readability and clearly communicate key metrics within Power BI's formatting constraints.

ADJUSTMENTS FROM ORIGINAL PLAN

- **Datamart built directly in Power BI:** Instead of implementing the data warehouse in SQL Server, the datamart was created within Power BI to support faster development, easier modelling, and seamless integration with dashboards.

- **DAX measures replaced SQL aggregations:** Analytical calculations were implemented using DAX measures, allowing dynamic filtering and interactive analysis without relying on external SQL queries.

- **ETL finalized within Power Query:** Data cleaning, transformation, and preparation were completed using Power Query, providing a centralized and efficient ETL workflow within Power BI.

- **Forecasting implemented using Power BI analytics features:** Sales and trend forecasts were generated using Power BI's built-in analytics tools to support forward-looking insights.

These changes improved agility and visualization performance

CLIENT FEEDBACK AND IMPROVEMENT

Client Feedback:

- **Reduce visual clutter:** Simplify dashboard layouts by limiting unnecessary visuals, avoiding excessive colors, and removing design elements that do not directly contribute to the analysis, allowing users to focus on key insights.

- **Improve interpretability:** Improve clarity by using descriptive chart titles, clear axis labels, and focused visualizations that communicate insights effectively and can be easily understood by non-technical users.

- **Add KPIs and executive summaries:** Introduce KPI cards and summary-level metrics that highlight overall performance and trends, enabling executives and decision-makers to quickly grasp important information before exploring detailed visuals.

Incorporation:

- **Simplified color themes:** Applied consistent and minimal color schemes across all dashboards to improve visual clarity and reduce distractions, ensuring that key data points stand out.

- **Added KPI cards:** Introduced KPI cards and executive summaries to highlight important metrics such as total sales, revenue, and top-performing categories for quick reference.

- **Improved sorting and labeling:** Refined chart sorting and enhanced titles, axis labels, and legends to make trends and comparisons easier to understand at a glance.

- **Refined dashboard layouts:** Reorganized visual placements and spacing to create a cleaner, more structured layout that supports both high-level review and detailed analysis.

CONCLUSION

Overall, this project demonstrates how organizing electric vehicle data using a star schema and analyzing it through Power BI dashboards can turn complex and scattered information into clear, meaningful insights. By combining proper data modelling, ETL processes, and interactive visualizations, the project highlights key trends in EV performance, technology, and market behaviour. The final dashboards make it easier for stakeholders to compare manufacturers, evaluate battery and charging technologies, and understand sales and revenue patterns. This approach shows the practical value of business intelligence tools in supporting data-driven decision making within the rapidly growing electric vehicle market.

FUTURE ENHANCEMENTS

In the future, this project could be enhanced by incorporating more recent and continuously updated EV datasets to reflect real-time market changes. Automating data refreshes would allow the dashboards to remain current without manual intervention. Additionally, more advanced forecasting or predictive modelling techniques could be explored to improve sales and revenue projections. The analysis could also be expanded by integrating external data sources such as charging infrastructure availability, government incentives, fuel prices, or regional policies to provide deeper context and more comprehensive insights into EV adoption trends.

APPENDIX

Dashboard 1: Market overview

Figure 5: Market overview

Dashboard 2: Technology & Performance Analysis

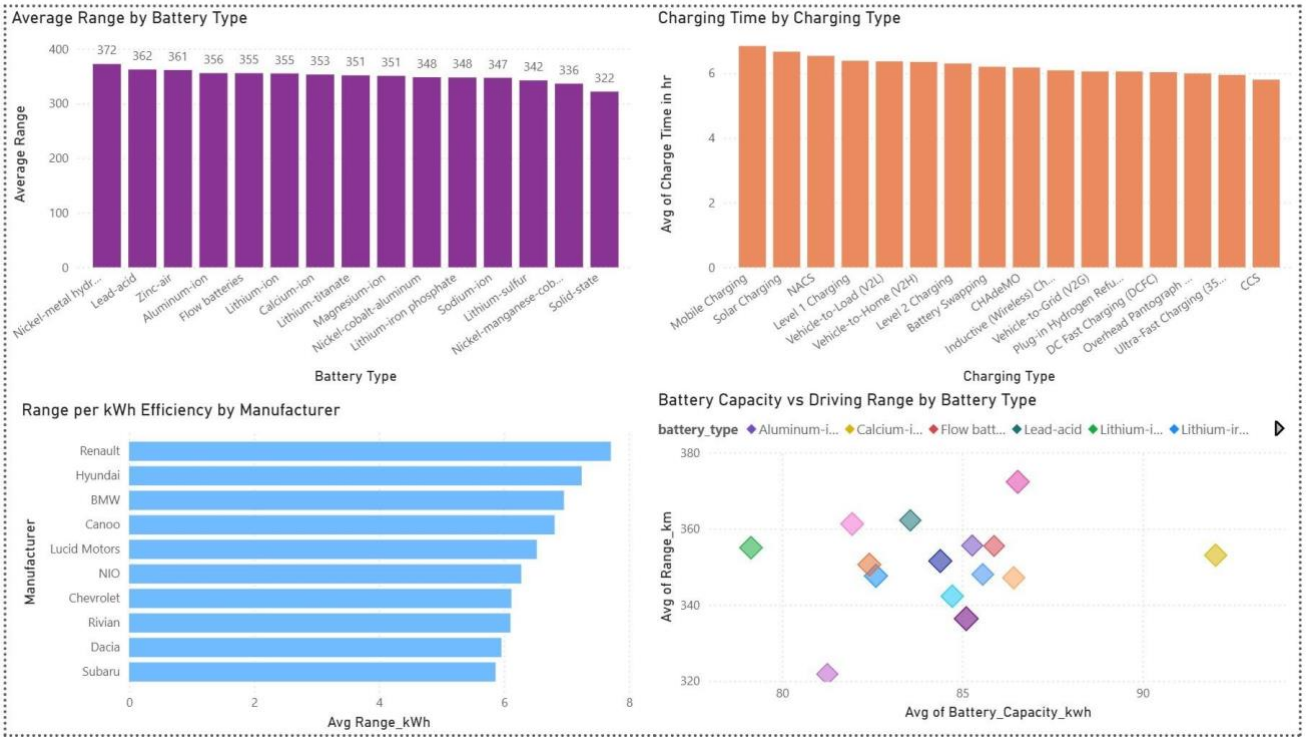


Figure 6: Technology & Performance Analysis

Dashboard 3: Market Forecast & Financial Insights

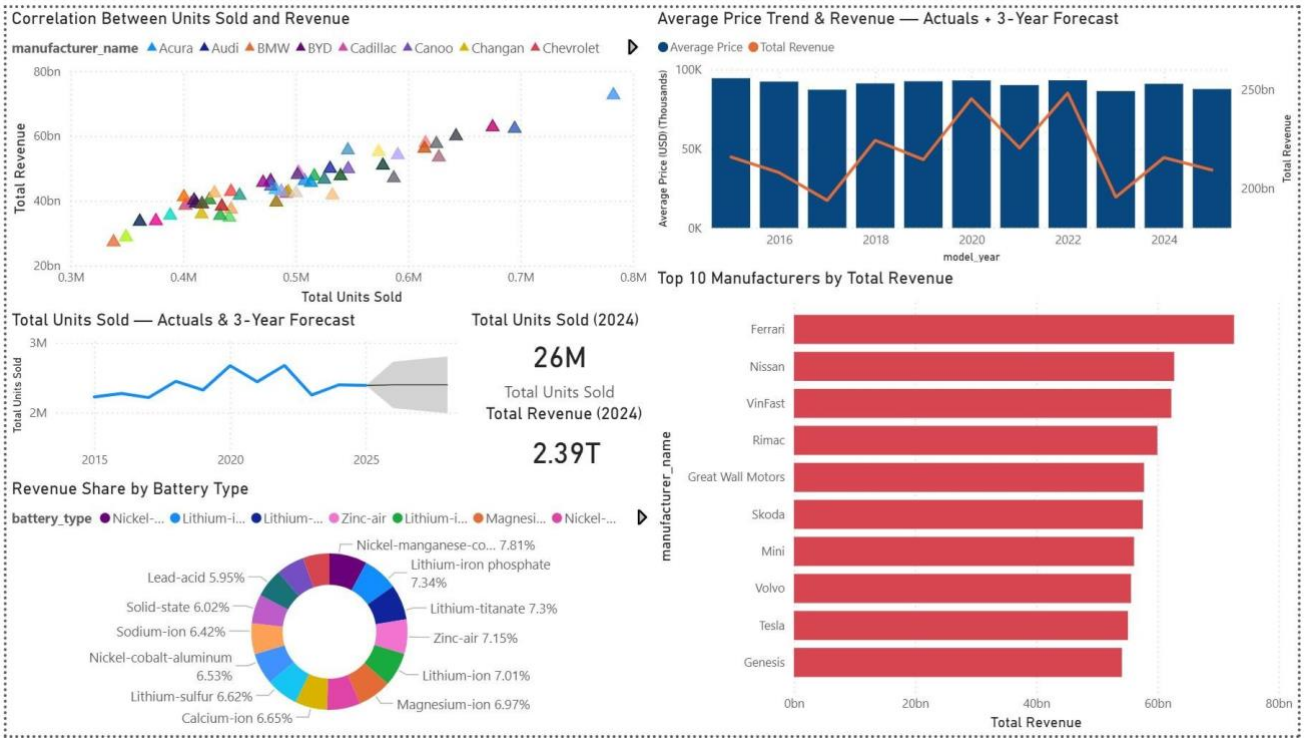
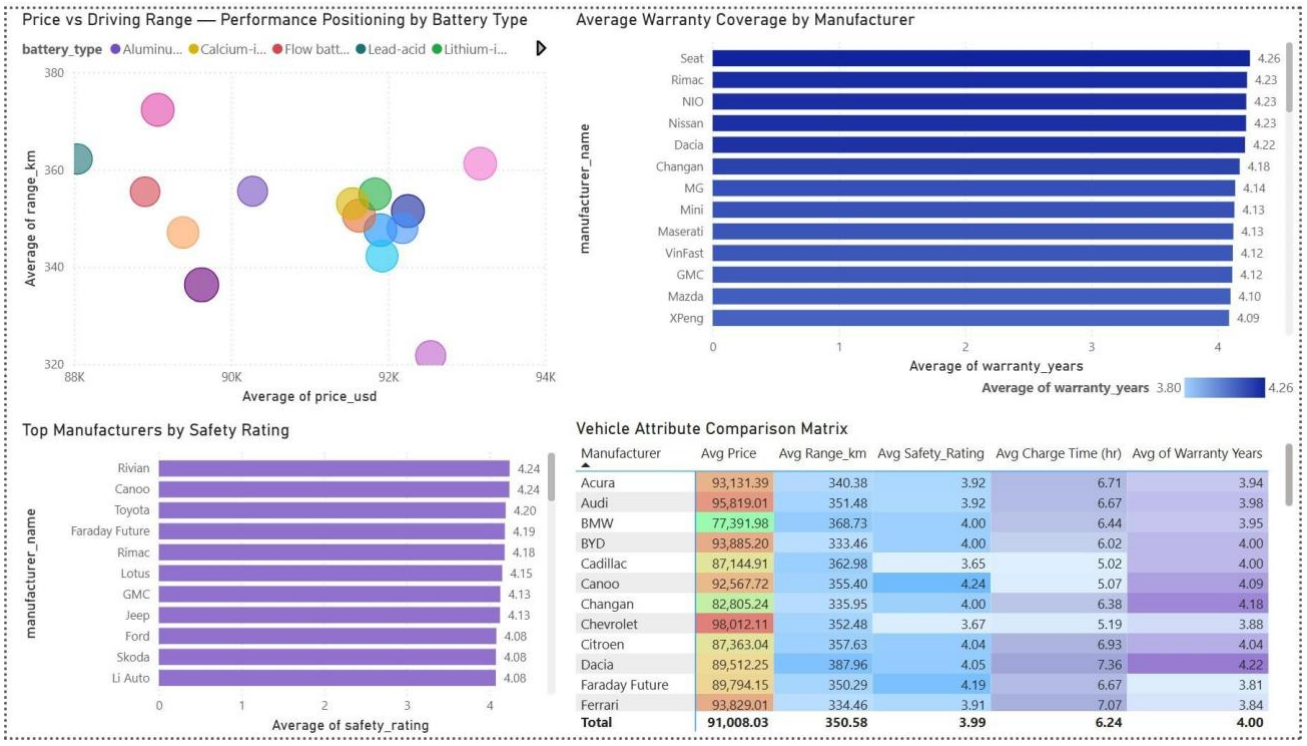


Figure 7: Market Forecast & Financial Insights

Dashboard 4: Consumer & Vehicle Attribute Insights



Manufacturer	Avg Price	Avg Range_km	Avg Safety_Rating	Avg Charge Time (hr)	Avg of Warranty Years
Acura	93,131.39	340.38	3.92	6.71	3.94
Audi	95,819.01	351.48	3.92	6.67	3.98
BMW	77,391.98	368.73	4.00	6.44	3.95
BYD	93,885.20	333.46	4.00	6.02	4.00
Cadillac	87,144.91	362.98	3.65	5.02	4.00
Canoo	92,567.72	355.40	4.24	5.07	4.09
Changan	82,805.24	335.95	4.00	6.38	4.18
Chevrolet	98,012.11	352.48	3.67	5.19	3.88
Citroen	87,363.04	357.63	4.04	6.93	4.04
Dacia	89,512.25	387.96	4.05	7.36	4.22
Faraday Future	89,794.15	350.29	4.19	6.67	3.81
Ferrari	93,829.01	334.46	3.91	7.07	3.84
Total	**91,008.03**	**350.58**	**3.99**	**6.24**	**4.00**

Figure 8: Consumer & Vehicle Attribute Insights