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Development of Performance Dashboard Visualization Using Power BI: A Data-Driven Analysis of Global EV Charging Behavior

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ABSTRACT
In today's fast-paced and rapidly evolving world, access to the right information and effective decision-making is crucial for both individuals and organizations. Right decision-making by businesses not only helps them in problem solving, achieving goals, and strategic thinking, but also creates competitive advantage in the market. Business intelligence tools like Power BI are revolutionizing decision-making by empowering businesses to make real-time data-driven choices by simplifying large datasets into strategic insights. This study leverages Power BI to analyze Global EV charging station behavior, specifically charging efficiency and cost. The data-set has been taken from Gallup Pakistan website and includes variables such as charging duration, charging cost, temperature, energy deliverables, charging session outcomes, and station utilization rate across multiple countries. In Pakistan, a nation facing rising fuel import expenses, urban pollution, and energy instability, there is a need to shift on alternative energy sources such as hybrid electric vehicles. This paper will also offer data-driven insights to support stakeholders in the Pakistani automobile industry, in assessing the efficiency and economic benefits of EV battery technologies. One of the findings of the study showed variability in charging preferences based on station type, with DC Fast charging being the most efficient among all. Additionally, payment method preferences revealed regional distinctions in digital technology adoption, further emphasizing the importance of localized strategies. This paper contributes to explore the importance of Power BI in supporting decision-making by enhancing efficiency and strategic growth and it will serve as a practical guide for policymakers, infrastructure developers, and stakeholders aiming to foster a more sustainable and technologically advanced transportation ecosystem.

Keywords: *Power BI, Business intelligence, EV charging station, charging efficiency, station utilization, Decision-making, automobile industry, Pakistan, Charging Cost, Interactive Dashboards.*

1. Introduction

In today's world, businesses have access to vast amounts of data, and this significant increase in data accessibility requires more advanced, data-driven decision-making. Data-driven decision-making involves utilizing data to guide the decision-making process and to assess a chosen course of action before fully committing to it (Stobierski, 2019). This approach is vital in the modern landscape as it offers businesses real-time insights and forecasts, resulting in enhanced performance and more efficient strategies. Predictive analytics enable organizations to foresee trends and obstacles, allowing them to take proactive measures. Insights derived from data assist

in crafting realistic strategic plans and reducing personal biases. The cyclical approach to data-driven decision-making permits companies to fine-tune their strategies, helping them stay competitive in a swiftly evolving environment (Mucci, 2024).

Business Intelligence is essential for making informed decisions, as it equips organizations with the necessary data and analytics to understand their performance, recognize trends, and make choices based on data. Business intelligence, known as BI, is a process driven by technology that facilitates data analysis to empower decision-makers within an organization to make knowledgeable business choices. It helps businesses boost revenue, enhance operational efficiency, and secure competitive advantages over rivals. BI achieves this through a combination of analytical tools, data visualization, reporting instruments, and various techniques for data management and analysis (Stedman, 2024).

One of the most effective and user-friendly business intelligence tools frequently utilized by decision-makers is Power BI. Power BI, offered by Microsoft, is a technology-oriented business intelligence tool that analyzes and visualizes raw data to deliver actionable insights. It merges business analytics, data visualization, and best practices to aid organizations in making data-informed decisions. Power BI can handle large volumes of data from diverse sources. It enhances visual appeal and features a user-friendly drag-and-drop functionality, allowing users to replicate formatting across similar visualizations. Furthermore, it enables seamless integration of data from various sources, such as Excel, SQL Server, and cloud platforms like Azure and Salesforce, while also supporting real-time data processing, so users can access the most current information in their reports and dashboards (Biswal, 2025).

The widespread dependence on fossil fuels globally results in numerous environmental challenges. The increasing worry over these environmental issues has spurred the creation of eco-friendly products. As stated in the latest European Environment Agency (EEA) report, the EU is progressing toward climate neutrality, although reductions in greenhouse gas emissions from transportation remain relatively stagnant. According to a recent report from the United States Environmental Protection Agency, greenhouse gas (GHG) emissions from transportation make up approximately 28 percent of the total GHG emissions in the U.S. Electric Vehicles (EVs) are rapidly gaining traction because they can help lower CO2 emissions, as electricity can be generated from renewable energy sources. As the world shifts toward more sustainable and cost-effective options, the demand for EVs has surged. Electric Vehicle Batteries present a promising alternative to conventional fuel sources since they are more economical to operate than petrol and diesel (Higueras-Castillo, Guillén, Herrera, & Liébana-Cabanillas, 2020). Using EVs can save money and reduce carbon footprints. However, in certain regions, customers haven't been able to buy EVs because they don't comprehend the technology behind the production of EVs or the infrastructure that has to be in place to support them.

1.1. Research Objective

The major goal of this study is to find out how business intelligence technologies, especially Power BI, can be used to visualize and understand the information related to worldwide electric vehicle (EV) charging stations to support smart and effective decision making. This study aims to analyze the charging efficiency, how much it costs, and how people use it in different nations. Furthermore, this research also intends to give stakeholders and decision-makers in Pakistan's automotive sector, a data-driven information about the costs and effectiveness of EV charging stations. The findings of the study will be used to support the development of electric cars and

battery technologies because they are both environmentally friendly and economically feasible. This will encourage local production of EVs, which will minimize operating costs and dependency on fossil fuels.

1.2. Significance of the Study

This study is valuable in multiple dimensions. Using Power BI as a business intelligence tool backs up the idea that data analytics can change the way decisions are made in the electric vehicle (EV) charging infrastructure field. The research gives important information on charging patterns, cost-effectiveness, and the utilization rates of charging stations. This information may help improve the development and maintenance of EV charging networks throughout the world. The effects are especially substantial in Pakistan, as the country is facing multiple issues because of rising fuel import costs, urban air pollution, and power outages that happen all the time. Moving toward electric transportation is a strategic opportunity. The goal of this study is to help people in the Pakistani automotive sector to make better decisions on the cost-effectiveness and operational efficiency of electric vehicle charging infrastructure.

The results can be used to enhance the local production of electric cars that use cutting-edge battery technology to cut costs and dependency on fossil fuels. This study also shows how important data-driven insights are for strategic planning by making real-time, interactive dashboards, which give useful information that supports long-term industrial growth and sustainable transportation in Pakistan.

1.3. Literature Review

The already existing literature provides critical insights regarding Power BI as a powerful tool in decision making.

Sangeetha, Elantamalia, and Indrapandi (2025) used the training data-set of MRC Private Limited Company to gain the understanding of ETL process and its applications in analyzing complex data by the use of Microsoft Power BI. Their research findings show the effectiveness of Power BI in visualizing data to data-driven insights, enabling decision makers to identify trends and weaknesses, and to implement required strategies to drive organizational success.

Widjaja and Mauritsius (2019) explored the capabilities of Power BI using Vercelli's methodology to analyze its role in data-informed decision making. Using the Indomobil data, they found that the BI performance dashboard can be used as reference in decision making. They also analyzed that to produce correct information, the data cleaning process is a major step to be followed.

Goncalves, Goncalves, and Campante (2023) found that business intelligence tools, specifically Power BI, supports the integration and transformation of large datasets into easy-to-interpret visuals i.e. data-integrated dashboard visualization.

In the current era, business have access to the large quantity of data and this unprecedented increase in data availability needs more advance and user-friendly tools to help them in decision making. As business intelligence tools have now gained significant popularity, particularly Power BI, as a powerful decision-making tool. Marques and Moreira (2024) explored the role of Power BI in decision making using real case. They applied certain methodologies in their research including case study, action research, and questionnaire. Through this research they found that Power BI is a valuable decision-making tool which not only saves time but also provide accurate and precise results to use for business analysis.

Hafeez (2023) studied the impact of Power BI on modern business intelligence by taking the interviews from the industry experts. The transformation of Power BI is ultimately improving business outcomes by assisting in data driven decision making. He provided detailed and in-depth literature review, where his main focus was on features, advantages and impact of Microsoft Power BI in decision making. This study also includes implications and evidence-based recommendations including best implementation practices and major pitfalls that should be avoided. The paper concluded by providing the role of Power BI in the transformation of Business intelligence processes and a support system for business leaders and analysts in the right decision making.

Marques, Moura, and Teixeira (2020) in their study regarding decision support system for the industry 4.0 environment, emphasized that the emergence of this industry (4.0) has increased the competitiveness among the organizations, creating a need to identify tools that are efficient to support decision making. Their findings concluded that Power BI offers a significant advantage in simplifying data refresh processes which reduces the dependency on traditional methods, by improving speed and efficiency. Power Bi enable users to focus on core tasks & improve decision making through visual dashboard which provides real time insights.

Mishra (2020) in his study regarding role of data visualization tools in real-time reporting, compared three powerful business intelligence tools i.e.Power BI, Tableau, and Qlik Sense. According to Mishra, as data continues to accumulate over time, it has led to the development of distributed systems to handle large data. However, these systems are still not strong enough to assist in exploratory data analysis. To address this gap, Mishra used these power BI tools to analyze role of visualization in delivering actionable insights. The results of the study demonstrated that these visualization platforms play an important role in transforming raw data into meaningful insights.

Electric vehicles are securing notable spot in the global market, driven by factors such as sustainability and cost efficiency. Sanguesa, Sanz, Garrido, Martinez, and Barja (2021) in their study, analyzed the global electric vehicle (EV) market, highlighting both its challenges and strengths and presented a detailed review of battery technologies including standard available for electric vehicle charging techniques. One of the key findings revealed that graphene is expected to be a solution that allows higher amount of power storage by charging faster. The researchers further suggested that the continued development of high-capacity EV batteries will foster the use of powerful and efficient charging modes.

Hanan, Azidin, and Mohamed (2014) investigated various features and strategies related to hybrid electric vehicles (HEVs), focusing on aspects such as energy management systems (EMS), power conditioning, propulsion systems, and other associated components like DC machines and the overall vehicle configuration. The research highlighted numerous challenges linked to hybrid vehicles while stressing the promise of Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) as a sustainable transportation solution for the future. The EMS is vital in these vehicles, efficiently regulating current flow and synchronizing various power sources, thereby enhancing performance and aiding energy efficiency. The study concluded that ongoing technological progress is likely to propel the HEV market forward by decreasing costs and improving accessibility for future transport requirements.

Sun, Li, Wang, and Li (2021) provided a thorough overview of the technological advancements in electric vehicles (EVs) and prospective technologies for their future use. Their paper summarizes crucial technologies concerning batteries, charging technology, electric motors and control, as well as the charging infrastructure of EVs. Additionally, the paper addressed the technological hurdles and innovative solutions aimed at enhancing the efficiency, reliability, and safety of EVs in the forthcoming phases. Their research indicated that Nickel-metal hydride batteries, Zebra batteries, and lithium-ion batteries serve as the power sources for EVs, as they offer greater specific energy, superior power density, and are more eco-friendly. By 2021, the year of their publication, lithium-ion batteries were the most prevalent choice. EVs function not only as a means of transporting people and goods, similar to conventional vehicles, but also serve as a link connecting EVs with various smart devices.

2. Methodology

This study utilizes a data-driven visualization strategy, focusing on the development and examination of interactive dashboards. The approach is aimed at converting complex datasets into meaningful insights, with each element of the dashboard playing a crucial role in contributing to a deeper understanding of the research objective.

There are numerous types of visual elements on the dashboards, such as histograms, line graphs, bar charts, and geographic maps. These visuals were chosen because they highlight certain aspects of the data. These graphs and charts are more than just visuals; they are also analytical tools that help with exploratory data analysis, finding patterns, and testing hypotheses which makes the decision-making process more natural and effective by putting the facts into interactive visual forms. This section puts clarity, interactivity, and the contextual meaning of each visualization to ensure that the dashboards give both big-picture overviews and small-picture insights. This part explains how to design, build, and use these dashboards, which are the most important part of the study's analytical framework.

An interactive dashboard (Figure 1.1) was made as part of the methodological approach to provide different visual insights at the same time. This dashboard uses multiple types of visualizations to let you look at the data from different angles, which helps you understand how crucial variables are related to each other and what patterns they show.

The initial visual component of the dashboard is a histogram featuring manufacturers along the x-axis and four aggregated variables on the y-axis: total charging cost, total battery capacity, total charging duration, and total temperature. This info-graphic was made to compare the efficiency of manufacturers in five important areas. Looking at the histogram, it seems that Porsche has the best battery capacity and charging time, which means it lasts longer and charges for longer periods of time. On the other hand, BMW has the worst battery capacity and Chevrolet has the least charging time. Charging cost and temperature don't vary much between manufacturers, which suggests that these characteristics are very consistent among brands.

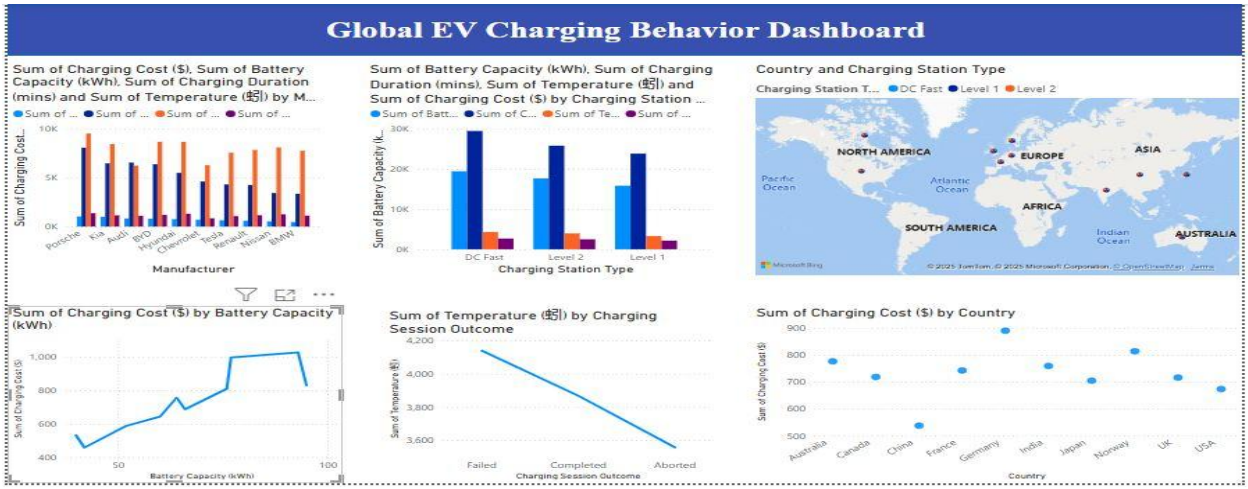

Figure 1.1

The second histogram analyzes that how the different charging station types affects the same four variables, with station types on the x-axis and the other variables on y-axis. The results show that DC Fast stations have the maximum battery capacity and charging time, which means they may be used for charging sessions that need more energy. On the other hand, Level 1 stations have the lowest values for all four variables, which suggests that they are not used as often or are less efficient. Charging costs and temperatures are still rather steady across all types of stations, with DC Fast stations having somewhat higher values.

There are also line charts on the dashboard for trends evaluation. The first line chart shows the relationship between battery capacity and total charging cost. The trend is generally upward. This means that charging prices are usually higher for batteries with bigger capacity. But there are times when the growth rate slows down, and at one point, the trend goes down a little, which means that costs go down for a short time even while battery capacity goes up. This is probably because of outside factors like pricing structures or improvements in energy efficiency. The second line chart shows the results of charging sessions compared to the overall temperature. It shows a definite declining trend. This means that when temperatures rise, the chances of a successful charge go down. This might be because the system loses thermal efficiency or because it can't handle high circumstances.

Also, a map was included to show how different types of charging stations are spread out throughout different nations. This geographical study focuses on regional preferences and the availability of infrastructure. It helps to figure out the demand of charging stations in terms of country.

Finally, a scatter plot shows the overall cost of charging by country, giving a comparative view of national energy economics. This graphic shows that Germany has the highest total charge costs and China has the lowest. This might be due to differences in energy prices, how people use energy, or government policies.

Here another dashboard (Figure 1.2) was created to deepen the analytical insights of the study by incorporating new visual formats and emphasizing metrics at the country level, as well as comparisons among different EV models. This dashboard features four visual components, each chosen to offer a unique perspective on the data.

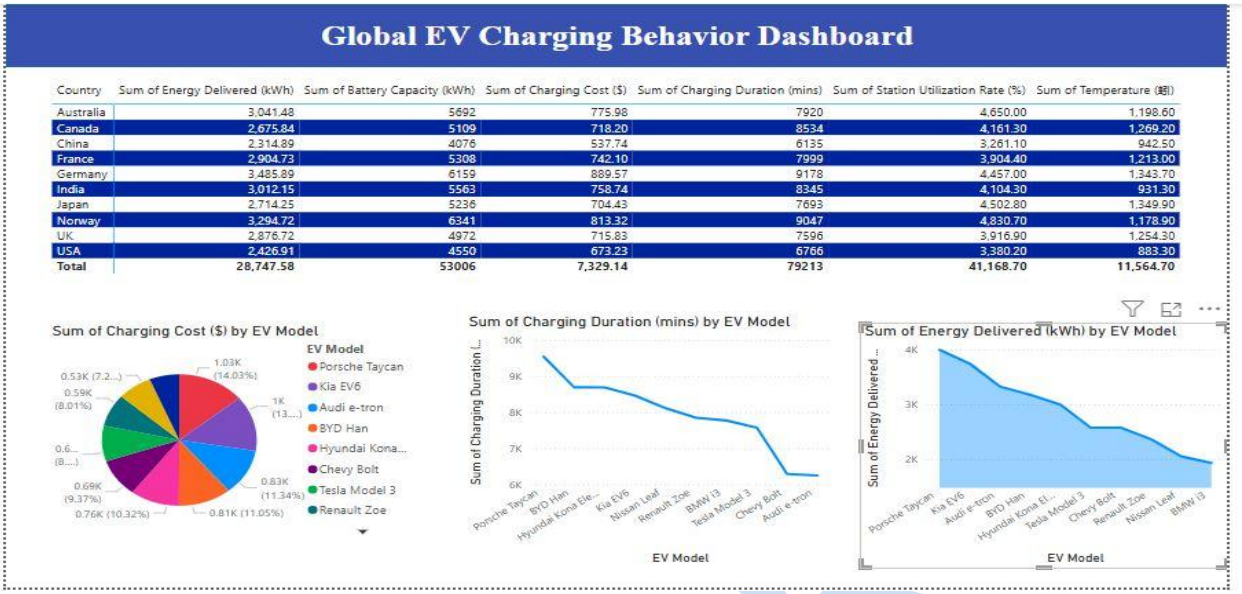

Figure 1.2

The first visualization is a heat map that shows the values for various important characteristics for each nation. These variables include total energy provided, total battery capacity, total charging expenses, total charging duration, total station usage rate, and total temperature. This chart was meant to highlight how these parameters vary by location. The heat map makes it easy to see which nations have high or low values by using a color gradient to show different levels. This makes it easier to find regional trends and outliers.

The second graphic is a pie chart that shows how much is the charging cost in terms of EV Model. This figure shows how charging costs are spread out among different car brands. The study found that Porsche cars had the highest charging expenses while BMW models have the lowest. This means that Porsche cars can use more energy or take longer to charge than other cars.

Three of the visuals on this dashboard are regarding electric vehicle models, which makes it easier to compare companies more deeply. Another figure, a line chart, shows how long it takes to charge each EV model. The line's trend goes down throughout the cars, with the Porsche showing the longest charging time and the Chevy Bolt and Audi e-tron showing the shortest. This pattern supports what we learned from the initial dashboard, which said that Porsche needs longer charging times.

An area chart that shows the total energy provided by each EV model is the fourth and last visualization on this dashboard. This graphic shows that Porsche delivers the highest energy overall, while BMW delivers the least.

This dashboard gives you a thorough look at performance information for both countries and models. The dashboard shows layered perspective on energy use, charging habits, and vehicle performance by using several sorts of charts, such as a heat map, pie chart, line chart, and area chart.

A third interactive dashboard was made (Figure 1.3) to provide more visual information from the data set. This dashboard's goal is to look at new elements of how people charge their electric vehicles by adding more variables and metrics for comparison. It builds on what was learned from

the previous dashboards and adds new ways to look at things to help people make better decisions.

One of the most important parts of this dashboard is the Q&A visual. This lets users write or pick from a list of pre-set questions and get the answers right away in a graphical manner. This feature lets people do rapid exploratory analysis without needing a lot of technical knowledge, which makes it easier for more people to understand the data.

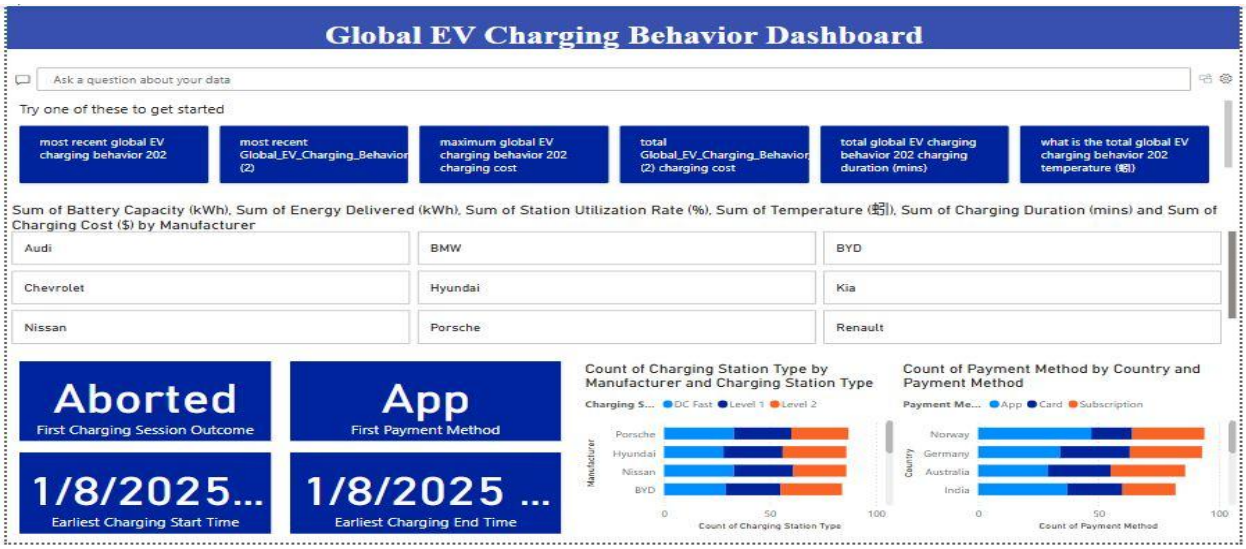

Figure 1.3

The dashboard also has four card visualizations that show important data items right away. These cards provide high-level parameters like the outcome of the charging session, the payment method, the start and end times of the charging session. They act as real-time indicators, giving fast look into trends in operations and patterns of use.

The interface also has two stacked bar charts that show more complicated interactions between categories. The first image looks at the relationship between Charging Session Type and Manufacturer. It shows which brands are more often associated with certain charging methods, such as DC Fast vs. Level 1. The second bar chart shows the number of payment methods per country. This shows how people in different parts of the world pay for EV batteries.

Together, these images give a full, multi-faceted view of how EV charging works. By combining interactive elements with categorical analytics, stakeholders in the EV and energy sectors may better understand both global and local trends, which helps them make better decisions.

3. Conclusion

This research effectively illustrates how Power BI, a contemporary business intelligence platform, can convert unprocessed electric vehicle (EV) charging station data into valuable insights that aid strategic and data-informed decision-making. By utilizing a collection of interactive dashboards, the study investigates global EV charging patterns through a visual analytics perspective, providing practical benefits for stakeholders, particularly in the context of Pakistan's shift towards electric mobility.

From the three dashboards created, several significant findings have been identified that DC Fast Charging Stations were consistently recognized as the most efficient and preferred charging option among manufacturers, indicating their increasing significance in high-capacity and rapid-

charging situations. Porsche emerged as a prominent brand in terms of overall charging duration, battery capacity, and energy output, suggesting that its vehicles are engineered for performance-focused, long-distance use, albeit with greater operating costs. The heat map visualization showcased considerable discrepancies in EV infrastructure metrics across different countries, revealing regional differences in energy output, station usage, and the impact of temperature. Data derived from line and area charts indicated a positive relationship between battery capacity and charging expenses, while higher temperatures were correlated with a decrease in successful charging instances, pointing to environmental efficiency challenges. The incorporation of interactive slicers and Q&A visuals greatly improved user interaction, enabling immediate exploration of variables by manufacturer and providing quick answers to frequently asked analytical inquiries. Regarding payment methods, a regional pattern was noted: nations like Norway, India, the UK, Germany, and China displayed a greater preference for app-based payments, while the US, France, and Japan favored card-based transactions. Although these insights were not the primary focus of the study, they highlight differing patterns of digital technology adoption across markets.

For Pakistan, a nation facing challenges such as urban pollution, energy instability, and high costs of fuel imports, these conclusions hold particular significance. The capacity to track and evaluate EV charging behaviors can bolster national initiatives aimed at embracing clean transportation alternatives. This research acts as a data-informed guide for policymakers and automotive industry stakeholders, directing investments in battery technologies, infrastructure enhancement, and consumer outreach.

In summary, this study not only showcases the analytical capabilities of Power BI but also reveals its transformative power in facilitating sustainable, economically viable, and strategically sound decision-making. As electric mobility accelerates globally, embedding business intelligence into national EV strategies will be crucial for countries like Pakistan to stay competitive, environmentally accountable, and prepared for the future.

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