Arizona State University
Ira A. Fulton School of Engineering - The Polytechnic School

Technological Entrepreneurship & Management Department
Master's Management of Technology

OMT 520: Strategic Management of Technology

Strategy Examination of the Electric Vehicle Industry

Team 6:
Pruthviraj Jadhav
Sameer Mundle
Shubham Raut
Chetan Jonnalagadda

Professor Advisor: Dr. Andrea Cherman, Ph.D.

Fall 2025

INTRODUCTION

The first electric vehicle (EV) was made in Scotland by Robert Anderson between 1832 and 1839, powered by non-rechargeable galvanic cells. Another Scot, Robert Davidson of Aberdeen, built a prototype electric locomotive in 1837 and later demonstrated an improved version in 1841 that could tow six tons over 1.5 miles at four miles per hour before needing new batteries. Batteries that could be recharged came along in 1859, making the electric-car idea more viable. Around 1884, inventor Thomas Parker helped deploy electric-powered trams and built prototype electric cars in England. These early experiments laid the groundwork for today's EV industry, which continues to evolve with greater range, speed, and efficiency as a sustainable alternative to gas powered vehicles (U.S. Department of Energy, 2014).

In 2024, global electric vehicle (EV) sales crossed 17 million for the first time, which is equivalent to almost 21% of all new car sales, compared to 18% in 2023 (International Energy Agency [IEA], 2024). This milestone represents one of the most significant transformations in the history of the automobile industry. Climate change, strict emissions regulations, and the successful improvements in battery technology and charging infrastructure are the key forces driving this influential shift. EVs have shifted from being a secondary choice to being the primary one. They are now directly influencing and playing an important role in governments' energy policies, the private sector's plans and investing strategies, and in customer purchasing options.

Electric vehicles are reshaping the global automotive landscape. EV subsidies are now being offered by governments to motivate the public toward EV purchases and eliminate carbon emissions. Consumers are becoming more aware of the green aspect as well as total cost of ownership and convenience (McKinsey & Company, 2024). Yet, consumers continue to face formidable barriers, including limited charging infrastructure in most areas, worsening bottlenecks in the supply chains and the scarcity of key materials such as lithium, nickel and cobalt (BloombergNEF, 2024). These barriers, when combined with high vehicle costs and

unequal access to resources create challenges for both consumers and manufacturers (BloombergNEF, 2024).

Although EVs have existed for decades, their adoption has accelerated only in recent years due to stricter regulations, environmental concerns, and also the advancements in battery technology. However, this transition has exposed major challenges that are there in the infrastructure expansion, and the supply of critical minerals that complicate the path towards sustainable growth.

The objective of this paper is to conduct a Strategy Examination of the Electric Vehicle (EV) Industry, analyzing how firms adapt to changing conditions, manage disruptions,and compete for advantage in a rapidly evolving global market. It also helps understand the policies used by the newcomers as well as the experienced firms. This study explains that competitive advantage can be achieved in an industry that is undergoing fast evolution and growth.

This paper is organized to examine the evolution, technology, and strategic dynamics of the global EV industry. The Literature Review discusses the evolution of the EV sector and the strategic theories that guide the analysis. The Industry Case provides an overview of the market conditions, growth trends and leading players. The Strategy Analysis applies the frameworks in depth to selected firms, evaluating their resources, capabilities, and competitive positions. Finally, the Results and Conclusion synthesize these insights, highlighting the industry's strategic direction and identifying approaches most likely to support long-term competitive advantage.

LITERATURE REVIEW

Evolution of the Technology and Industry

Electric vehicles (EVs) have a history that goes back to the late nineteenth century, when they competed with the steam and gasoline models. By 1900, EVs accounted for a full third of all cars on American roads. EVs were valued for their quiet operation and ease of use back then (U.S. Department of Energy, 2014). However, the landscape has changed with the release of Henry Ford's mass-produced Model T in 1908. Suddenly, gasoline cars have become affordable for the average American, combined with the new discoveries of cheap oil, which made the internal combustion engine the default option for the twentieth century.

In the early 1900s, electric vehicles outsold gasoline vehicles, but their popularity declined when Internal Combustion Engine (ICE) vehicles were less expensive, lighter, and also refueling the gas powered vehicles will take very much less time and it is easier. For several decades of the twenty first century electric vehicles innovation was halted as gas powered vehicles dominated the global markets. However, a new interest began in the 1990's due to increasing gas prices , and the rising environmental concerns, and increasing government regulations like California's Zero-Emission Vehicle (ZEV) mandate (California Governor's Office of Business & Economic Development, n.d.).

The Revival of EVs began in the 1990s, which can be traced to the Zero-Emission Vehicle (ZEV) mandate, which made manufacturers explore the technology. Because of that period, it yielded pioneering models like EV from General Motors. Even though these early

models were discontinued due to their high costs and the limited range that they have, they provided valuable lessons and great insights for the industry (California Governor's Office of Business & Economic Development, n.d.). The breakthrough came with the maturation of the lithium-ion battery technology in the early 2000s, which offered the energy density that is needed for a longer range. Tesla, founded in 2003, disrupted the automobile industry with the Tesla Roadster EV, proving that EVs can compete with the internal combustion engine on performance and desirability, which drew global attention to EVs (Tesla, 2008).

Since then, the key milestones have accelerated the shift from internal combustion engine (ICE) to EVs. The prices for batteries have fallen 90% from 2010 to 2024, reaching about $115/kWh (Bloomberg NEF, 2024). Governments have started giving strong policy signals, subsidies, tax credits, and bans on new ICE sales, such as the European Union's 2035 target (European Parliament, 2022). At the same time, charging networks have expanded, with the Tesla supercharger network setting early standards and later opening to the other automakers(IEA, 2024).

Technology in the Electric Vehicle Industry

Figure 1: Volume-weighted average lithium-ion battery pack and cell price split, 2013-2023

Source: BloombergNEF. Historical prices have been updated to reflect real 2023 dollars. Weighted average survey value includes 303 data points from passenger cars, buses, commercial vehicles, and stationary storage.

Figure 1, Volume-weighted average lithium-ion battery pack and cell-price split, 2013-2023.

Source: BloombergNEF (2024).

Today, the auto industry is in the middle of a structural transition, carefully moving away from its century-old foundation. Legacy automakers such as General Motors and Volkswagen have committed to phasing out ICE vehicles by the 2030s, while the Chinese firms like BYD are dominating the mass production, and the new entrants, such as Rivian and Lucid, focus on niche

markets. The evolution of the EV industry from its initial experiments to its current state of large-scale adoption heavily demonstrates how technology, policy, and market forces interact to shape the global competition. This historical trajectory sets the foundation for examining the current technological capabilities and strategic capabilities in the next section.

Current Technology and Uses

Electric Vehicles, including Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Fuel Cell Electric Vehicle (FCEV), are becoming dominant in the transportation sector in recent times. As the present and past trend shows that EV are more likely to replace the traditional Internal Combustion Engines (ICE) in future. The present power plant system could face huge disruption and be short for providing electricity as Electric Vehicles will use more energy for repeated charging of vehicles. The power sector is going through a changing phase where renewable sources are gaining momentum. The next generation power grid, called 'smart grid' is also being developed. EVs are being considered a major contributor to this new power system comprised of renewable generating facilities and advanced grid systems (Fuad Un-Noor, 2017)

The power sector is going through a changing phase where renewable sources are gaining momentum. The next generation power grid, called 'smart grid' is also being developed. EVs are being considered a major contributor to this new power system consisting of renewable generating facilities and advanced grid systems. As a vehicle, an EV is quiet, easy to operate, and does not have the fuel costs associated with conventional vehicles. As an urban transport mode, it is highly useful. It does not use any stored energy or cause any emission while idling, is capable of frequent start-stop driving, provides the total torque from the startup, and does not require trips to the gas station. It does not contribute either to any of the smog making the city air highly polluted. The instant torque makes it highly preferable for motor sports. The quietness and low infrared signature makes it useful in military use as well. The power sector is going through a changing phase where renewable sources are gaining momentum. The next generation power grid, called 'smart grid' is also being developed. EVs are being considered a major contributor to this new power system consisting of renewable generating facilities and advanced grid systems. (Camacho, O.M.F.; Nørgård, P.B.; Rao, N.; Mihet-Popa, L. Electrical Vehicle Batteries Testing in a Distribution Network using Sustainable Energy. *IEEE Trans. Smart Grid* **2014**, *5*, 1033–1042).

Competitive Analysis & Resource-Based View

An industry's structure and competitive forces are evaluated using the Porter 5 forces model first introduced in 1980 by Michael Porter. There are five forces that determine the attractiveness of an industry as a whole: the potential name new entrants and suppliers bargaining, buyers' bargaining power, availability of threat substitutes or offer products and services and extent competition among firms already in the industry (Porter, 1980). The model offers a structured way of thinking about the factors that contribute to competition and profitability. This analysis allows companies to focus on the most significant pressure impacting industry dynamics and strategies, ensuring that they are an economic leader, not a follower.

Whether competitive analysis is oriented towards elements influencing a firm's performance, the Resource-Based View (RBV) concentrates on internal resources and capabilities that allow firms to reach and maintain competitive superiority. According to Barney

(1991): The RBV takes that firms have resources which are heterogeneous in nature and not all resources can add value to the firm, on contrary to this some of the resource contributes competitive advantages when they are valuable, rare, inimitable and non-substitutable (VRIN). This is followed by the VRIO model which builds on this idea, highlighting that firms also need to be well-structured for them to fully utilize these resources (Barney & Hesterly, 2015).

The Five Forces and RBV/VRIO frameworks have a complementary view on strategy. The descriptor that the five forces allow us to understand external context and competition pressure, but also that the RBV and VRIO allow us for firms to use their strengths in a way that creates and manages competitive advantage. Simultaneous use permits a more complete understanding of how external conditions interact with internal capabilities on firm strategy and performance in dynamic industries.

Core Competencies: The Secret Sauce.

Each of the EV companies is doing better than the others at certain things. Here are their "core competencies:Innovation involves development of new products like those that have longer life. Self-driving Systems, Smart Software, and Manufacturing Scale. Much of automobiles being quickly and inexpensively manufactured in efficient factories.Brand - These strengths open the door on how people perceive the firm; trust, excitement or loyalty. for their larger strategies. Business Strategies: How They Play Companies tend to choose between one of two choices: Cost Leadership - Be the cheapest, offer cars at lower prices through differentiation involves reduction of costs and construction on a greater scale. different and not cheap. Present something unique, like luxuriousness, adventure, or high performance, so that customers would pay additional. Corporate. and collaborative policies: working together or doing it all. Alliances / Joint Ventures - Like group undertakings. Companies exchange technology and resources. Tesla, Ford, and Vertical integration involves GM working together to develop charging plugs (Reuters, 2023) making more parts in-house, including batteries, semiconductors, and. even chairs. This gives control and maintains the costs.

Case Studies: BYD, the Low-cost Leader with a Secret Weapon.

Core competencies: Batteries and Technology- BYD started as a battery. manufacturer and it is currently recognized by its so-called Blade Battery, which is safe and at the same time. durable (ResearchGate, 2023).Cost Control - Generates realistically all the parts in. house, price reduction.Innovation Rates: The new autos can be introduced within approximately 18. months (FT, 2024).Strategies:Cost Leadership - Sells cheap EVs, Vertical integration involves the manufacture of batteries, processors, especially in China. and in-sourcing motors, shortening supply chain lead times.Weaknesses and threats are that we in source motors, which minimizes the supply chain lead times. high dependence on Chinese market and trade barriers and politics. antipathy towards global growth (Elsevier, 2016).

Rivian The Adventure Differentiator.

Core competencies:Target Audience - Manufactures outdoor vehicles and SUV. lovers.Exclusive Design and Brand name Rugged look, environmentally friendly brand. In-house Technology - Updates and develops hardware and software on a regular basis. Strategies:Differentiation: Not cheap, but special (gear tunnel, Adventure Network charging).Cooperative Moves - Invents its own Rivian. Young and quite new company concept

to be represented by Adventure Network. Weaknesses and risks include complicated expansion of manufacturing, high capital incineration, and few customer bases (Bloomberg, 2024).

Lucid Motors The Luxury Differentiator.

Core competencies:Luxury and Performance - Longest range EVs (more than 500). miles), very quick, and highly tech (InsideEVs, 2025).Proprietary. Technology - an ultra-fast charging device, called "Wunderbox" and many Patents. In-house Manufacturing - Built a sustainable plant in the US. Strategies: Differentiation (High-End) - Does not compete with Mercedes and Porsche. BYD or Tesla. Cooperative - Shares technology (as with Aston Martin) and partners with mineral manufacturers to acquire US battery materials (Lucid Press). Release, 2025).Weaknesses/Risks: Expensive products subject it to a small market; poor ability to scale. manufacturing; and sometimes compelled to fight with discounts (AInvest, 2025).

Due to a lack of information, most research does not fully address this topic.

The majority of evaluations only focus on what these firms can achieve most of the time. But to obtain the whole picture we must also have: Risks and weaknesses include scaling up, high price, low demand and reliance on subsidies outside some of the forces are policies and trade barriers and availability of raw materials, which can render. Sustainability and Supply Chains involve ethical mining, recycling of batteries, and emission lessening. Financial Reality - It takes billions of dollars to run electric vehicle companies, profitability is low and unpredictable. Consumer Behavior - The degree of range anxiety, charging availability and price sensitivity are relevant still.The research proves its relevance by integrating advantages and disadvantages how promising, yet at same time so delicate is the EV race.

INDUSTRY CASE

The transport sector is increasingly solidifying its place as one of the most significant sectors in terms of energy use. Despite being influenced by multiple variables such as the COVID-19 pandemic and the energy crisis, its proportion of energy utilization reached 25% of the overall final consumption (TFC) in 2023, with fossil fuels serving as the primary energy source. Transportation is responsible for 32% of direct CO_2 emissions from burning fuel. Specifically, road vehicles such as cars, buses, and two and three wheelers are accountable for nearly three quarters of these emissions. Consequently, there has been a continuous and increasing endeavor worldwide to promote the advancement of electric transportation as a viable solution to reduce the rise in carbon emissions and greenhouse gases, while also decreasing reliance on fossil fuels.

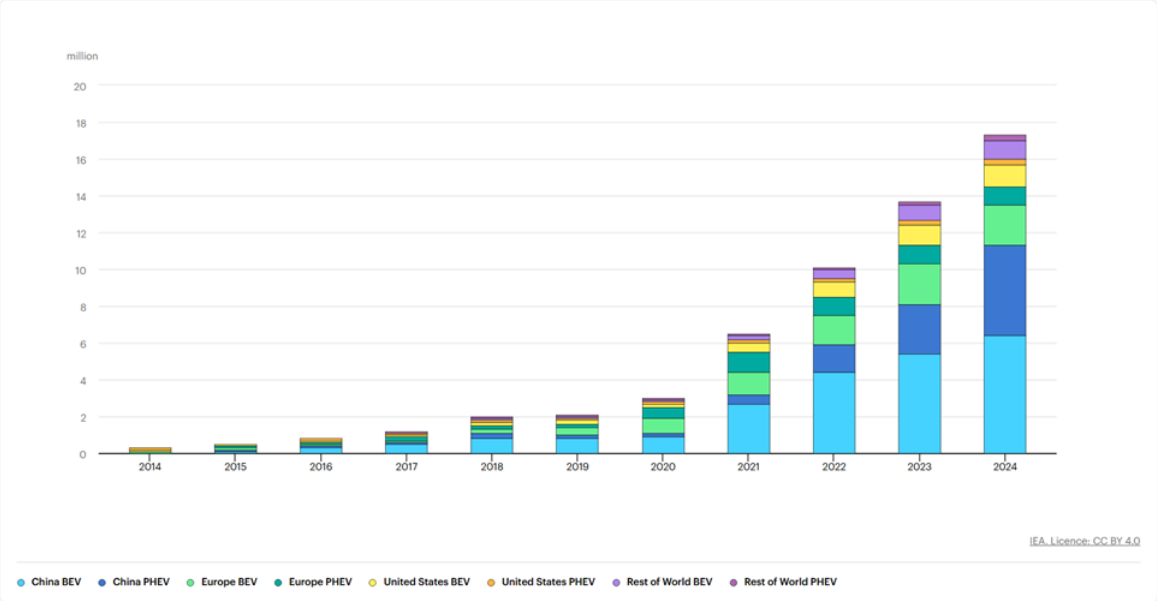

Figure 2, Global Electric Car sales, 2014 - 2024

Source : IEA (2025), Global electric car sales, 2014-2024, IEA, Paris https://www.iea.org/data-and-statistics/charts/global-electric-car-sales-2014-2024, Licence: CC BY 4.0

The Global electric car sales exceeded 17 million worldwide in 2024. China had sold most EVs with sales exceeding 11 million. Sales in Europe were slightly tempered as the subsidies were phased out or reduced in several major markets. The rapid growth in electric car had reached almost 58 million, about 4% of the total passenger car fleet. The stock of electric cars is not spread evenly – In China around one in ten cars is electric. Whereas in Europe, the ratio is close to one in twenty. Electric car sales increased by almost 40% in 2024. In 2024, about one in every five cars sold in Europe was electric. Countries like Germany and Netherlands are leading the charge with the significant market shares.

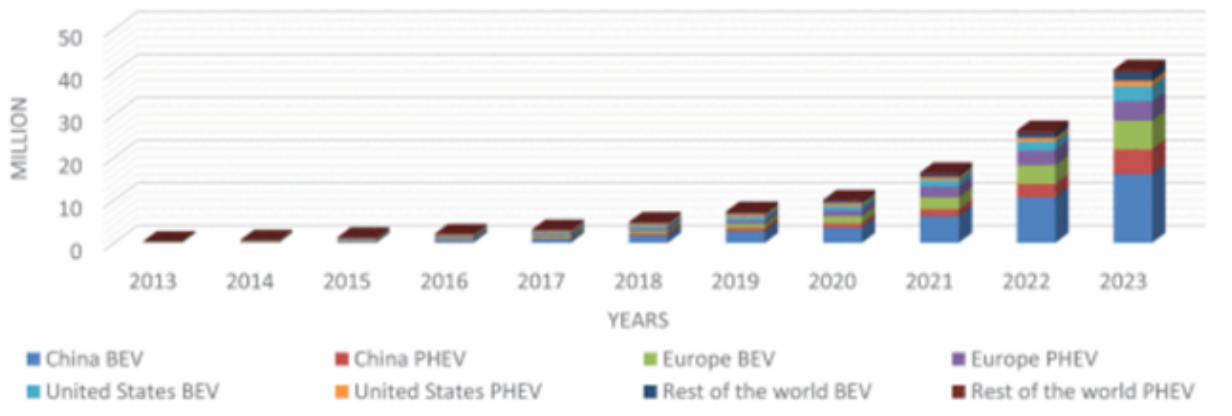

Figure 3, Worldwide Inventory of Electric Vehicles, 2013 - 2023

Source: IEEE Xplore, Electric Vehicles: A Comprehensive Review of Technologies, Integration, Adoption, and Optimization

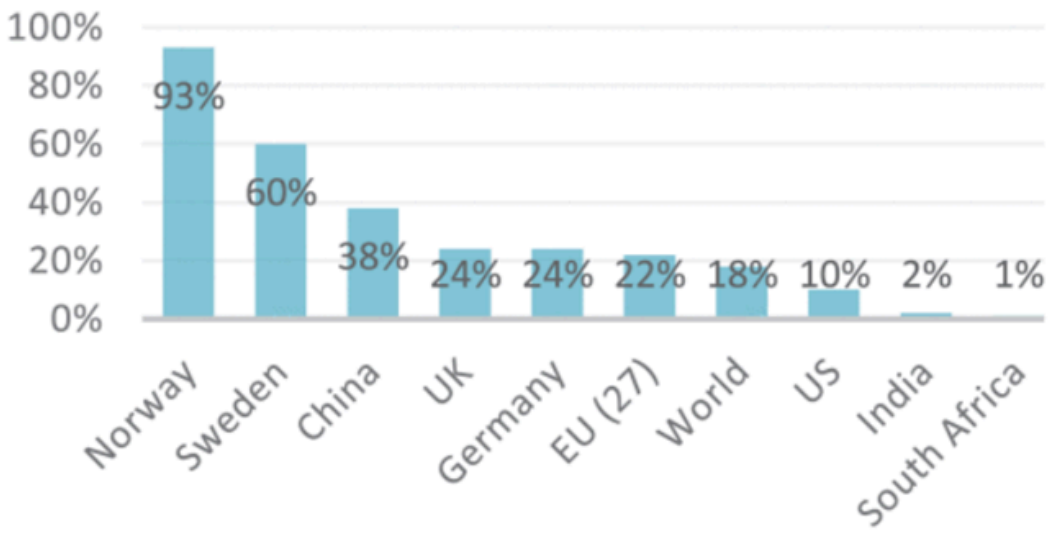

Figure 4, Global Electric Vehicle market share in 2023

Source: IEEE Xplore, Electric Vehicles: A Comprehensive Review of Technologies, Integration, Adoption, and Optimization

The data in figure not only reflects a substantial increase in consumer adoption rates but also it indicates the wider changes in the automobile industry and government policies favoring eco-friendly alternatives. Some factors contributing to the Electric Vehicle Industry can be summarized as follows:

Technological Advancements: Improvements in the battery technology have played a crucial role in it's growth. The development of Lithium-ion batteries with higher energy densities and lower costs has extended the range of Electric Vehicles while reducing the price, making the average cost of lithium-ion batteries per kilowatt hour has decreased significantly over the past decade, co-relating with the Electric Vehicle adaption.

Consumer Awareness and Preferences: The growing awareness about environmental issues among consumers have raised the demand for sustainable alternatives. As consumers look to reduce the carbon footprint, they are increasingly considering Electric Vehicles as their primary or secondary vehicles, considering both environmental and long term ownership costs.

Expansion of Charging Infrastructure: The expansion of charging infrastructure has supported the growth of the Electric Vehicle market. Public and private investments in charging stations have reduced range anxiety, making Electric Vehicles a more practical choice for everyday use. The ACEA, i.e. European Automobile Manufacturers Association, represents European car manufacturers. Electric Vehicles, Plug in hybrid vehicles make up 21.6% of new

passenger cars in EU. Whereas, Hybrids account for 22.6% of total car sales for 2018-2022 timeline.

China now globally dominates the Global Electric Vehicle Supply Equipment (EVSE), boasting over 85% of the world's fast chargers and over 60% of slow chargers. China has already exceeded its goal for electric car sales, with a market share of over 35%, surpassing its objective for 2025. Now, China is shifting its attention to developing charging infrastructure. The aim is to have complete coverage of charging stations in cities and highways by 2030 and expand coverage in rural areas.

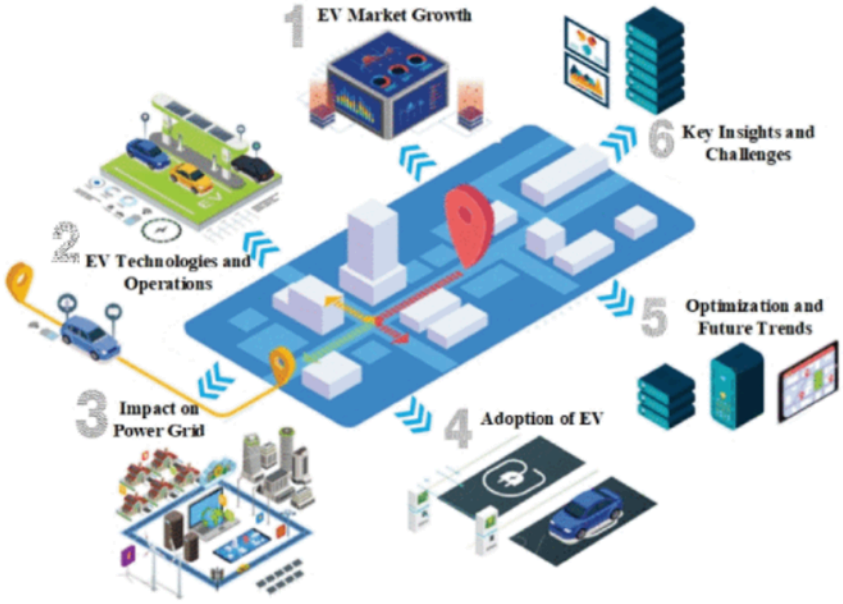

Figure 5, Structural representation of Electric Market growth

Source: IEEE Xplore, Electric Vehicles: A Comprehensive Review of Technologies, Integration, Adoption, and Optimization

This diagram outlines the main sections of EV market growth to the technological, operational, and grid-related challenges, and finally to the optimization strategies and future trends in the EV domain.

EV Market Growth:

This block highlights the rapid expansion of the global EV market, driven by technological advancements and supportive government policies. EV market growth already is discussed in the Introduction Section. This growth serves as the foundation for the rest of the paper.

EV Technologies and Operations:

This section delves into the various types of EVs, the infrastructure required to support them, and the mechanisms by which EVs interact with the power grid. It covers essential aspects such as charging modes, standards, and smart charging strategies like V1G and V2G.

Impact on Power Grid:

As EV adoption increases, their integration into power systems presents challenges, including load profile alterations, power quality issues like harmonics and voltage imbalances, and stress on grid assets. These topics are discussed in detail, with a focus on how they affect grid stability and reliability.

Adoption of EV:

This section examines the factors that influence the widespread adoption of EVs, focusing on both the drivers and barriers that affect consumer decisions and market dynamics. It explores the role of governmental incentives, public awareness, infrastructure availability, and technological advancements in accelerating EV adoption.

Optimization and Future Trends:

The final section of the diagram addresses the strategies for optimizing EV integration, including load management and grid modernization efforts. It also explores future trends and innovations that could shape the future of EVs and their role in energy systems.

Key Insights and Challenges:

The conclusion summarizes the key insights gained from this comprehensive review and highlights the challenges that remain for the successful and widespread adoption of EVs.

Market Characteristics and Segmentation

There are several technology and product segments in the EV market broadly. Battery Electric Vehicles (BEVs) dominate international sales of EVs and claim more than 70% of total volume in 2024, followed by plug-in hybrid electric vehicles (PHEV) and hybrids (Global Growth Insights, 2025). Fuel-cell electric vehicles (FCEVs) have a niche market because of expensive and insufficient hydrogen stations. In the field of passenger transport, sport-utility vehicles (SUV) is the fastest-growing sector, and commercial EVs are gradually growing in logistics and urban transportation.

Regional Segmentation Asia-Pacific, primarily driven by China, holds more than 60% share of the total global EV market. Europe comes in second, due to tightening emissions rules and government subsidies. North America comes in 3rd place, with government incentive policies like the U.S. Inflation Reduction Act on its side. Latin America and Africa are fledgling markets, with relatively low levels of uptake to date, but uptake is projected to increase rapidly as technology costs drop and local assembly programmes take hold (IEA, 2024).

Main Players

The world electric vehicles (EV) industry comprises a variety of firms which compete in terms of innovation, scale and differentiation. BYD, Rivian and Lucid Motors are the largest players influencing the competitive scenario. There have been three companies with rather different strategic positions in the EV value chain that will be taken as objects of further consideration through the remaining sections.

These companies were chosen because they represent three different but synergistic strategic archetypes in the EV ecosystem. Chinese market leader BYD shows how vertical integration and cost leadership can lead to mass production and global expansion. Rivian is an American premium adventure vehicle company, having partnerships and niche differentiation. Also based in the U.S. Lucid Motors portrays technology leadership and high-end positioning by specializing in high-performance, long range EVs.

Together, these companies represent the various strategic positions of stakeholders in the EV space ranging from traditional mass manufacturers to new disruptive innovators and niche luxury technology specialists. Their distinctive business models and market positions offer rich information on how organizations maintain their competitive edge in a fast-changing business environment.

Characteristics of the Main Players

BYD (Build Your Dreams) officially started operations in 1995 and LINK was founded in Shenzhen, China, and BYD entered the automotive space twelve years later with its iconic F3 sedan. Today, it is the largest manufacturer of EV by volume in the world with a reported sale of more than 3 million vehicles in 2023 combined (battery-electric and plug-in hybrid) category (CarNewsChina, 2024). What distinguishes BYD is its deep vertical integration — it makes and designs batteries, semiconductors and electric powertrains itself, avoiding supplier ties to boost cost efficiency. The company also profits from a strong support of domestic policies along with increasing exports to Europe, Latin America, and Southeast Asia to solidify its ranking as the EV global leader (IEA, 2024).

Rivian Founded in 2009 in Irvine, California, Rivian Automotive specializes in electric adventure vehicles like the R1T pickup and the R1S SUV. Its strategy is focused on a unique lifestyle brand appealing to consumers in search of performance, sustainability and outdoor functionality. An important competitive advantage is due to Rivian's strategic alliance with Amazon whose order of 100,000 electric delivery vans was revealed in 2019 (IEA, 2024). But Mark and the business are still dealing with production issues, as well as the burden of heavy capital costs. Rivian's focus on vertically integrated software and design is an example of how differentiation can lead a top line growth strategy in the highly competitive premium space.

Lucid Motors Founded in 2007, Lucid Motors is based in Newark, California, and competes in the luxury electric vehicle space with its model, Lucid Air. In 2021, Lucid Air Dream Edition became an EV with production – vehicle range holding the record of 520-miles certified from the U.S. Environmental Protection Agency (Lucid Motors, 2021). Lucid's approach focuses on engineering and driving performance as well as next-generation battery technology. Despite relatively small volumes – around 8,400 vehicles in 2023 (AInvest, 2025) , Lucid's value proposition is high-end design, fast charging and a premium brand competing with

manufacturers such as Tesla and MercedesBenz.

All three companies represent different scales, innovation and differentiation in the EV space. BYD embodies cost leadership at mass scale, Rivian is design led differentiation and partnership innovation, and Lucid is tech-driven luxury performance. Their introduction would provide a more holistic strategic consideration of how firms seek to achieve sustainable competitive advantage in the dynamic EV markets worldwide.

General Environment Affecting the Industry

Regulations and Policy

Regulatory policies are the main reason behind the electric-vehicle (EV) adoption globally. In the European Union, the updated CO_2 performance standards regulation imposes a 100 percent fleet average reduction for new cars and vans in CO_2 emissions by 2035, effectively banning sales of new internal combustion engine (ICE) cars and vans sold after 2035. 2030 interim targets are also tightened, requiring a 55 percent cars reduction and 50 percent vans reduction relative to 2021 levels (European Commission, 2023).

The Inflation Reduction Act of 2022 in the United States introduced the clean vehicle credit (Internal Revenue Code 30D) of $7,500 or less per qualifying light duty Ev. The credit is divided into two requirements: 50 percent for critical minerals sourcing requirements and 50 percent for battery component content. The eligibility also depends on final assembly in North America, manufacturers suggested retail price (MSRP) limits, tax payer income and new Foreign Entity of Concern and point of sale credit transfer requirements finalized by U.S. treasury and IRS in 2024 (Internal Revenue Service [IRS], 2024; U.S. Department of the Treasury & IRS, 2024).

In China, national incentives remain the center of market growth. The State Taxation Administration, the Ministry of Finance , and the Ministry of Industry and Information Technology continued the exemption of the purchase tax on new-energy-vehicle (NEV) until 2025, up to ¥30,000 per vehicle, then a 50 percent reduced purchase tax for 2026-2027, at a fixed amount of ¥ 15,000 (Ministry of Finance of the People's Republic of China [MOF PRC] et al., 2023).

Together these policies define global investment geography. EU caps dictate full electrification strategies for legacy automakers; U.S. content decisions dictate localization of battery supply chains; and China's tax relief preserves cost competitiveness. Regulatory design therefore prescribes where automakers invest in plants, how they source materials, and which EV segments they prioritized.

Supply Chain and Critical Minerals

After a sharp increase cycle, battery-metal markets fell into surplus for 2023-2024. As the International Energy Agents (IEA) confirms, supply of lithium exceeded demand by over 10 percent in 2023. While nickel and cobalt surpluses reached 8 percent and 6 percent, respectively. Prices fell correspondingly - lithium - 75 percent, cobalt and nickel -30-45 percent year on year - cutting average battery pack prices (IEA, 2024a).

At the same time policy limitations add further complexity to qualify for the full U.S. Clean Vehicle Credit . An increasing share of critical-mineral content needs to be mined or processed inside the United States or in free-trade-agreement partner countries, and battery components have to be manufactured or assembled inside North America. From 2025, cars from Foreign Entities of Concern (primarily China and Russia) will make them ineligible (IRS, 2024)

These opposing forces - price relief versus sourcing restrictions are reshaping the industry strategy. Automakers are seeking vertical integration, locally based battery-cell manufacturing , long term offtake agreements, and recycling programs to stabilize supply, cover compliance risk, and maintain access to incentives.

Charging Infrastructure

Availability of charging infrastructure, as well as reliability, remains top drivers of EV adoption. Public charging points grew over 40 percent in 2023 according to the IEA Global EV Outlook 2024, reaching 4 million globally, while DC fast chargers exceeded 55 percent, headed mainly by China, which accounts for over 60 percent of public chargers worldwide. United States and EU investments are gaining momentum with publicly funded programs such as the National Electric Vehicle Infrastructure [NEVI] program and the Alternative Fuels Infrastructure Regulation, but network density and grid interconnection remains behind urban demand (IEA, 2024b).

The world public charging points are projected to increase to over 15 million up to 2030, which will require more investments on grid infrastructure and renewable integration (IEA, 2024b).

Grid charging infrastructure directly influences total cost of ownership[and user experience. Appropriate corridor DC fast charging and high-density urban AC accessibility will determine fleet EV conversion rates and customer confidence, driving local market growth.

Examination of Important Developments in the Electric Vehicle Sector

The electric vehicle (EV) is at the heart of the worldwide revolution that is transforming the automotive industry. The sector is simultaneously growing and changing in a number of strategic and technological dimensions. With the help of current statistics and case studies from industry leaders, this study examines four key themes influencing the direction of electric mobility.

EV Adoption's Unstoppable Growth

Moving past early adopters, switching to electric mobility is now a widely accepted worldwide trend. Over 17 million EVs were sold worldwide in 2024, a 25% increase over 2023. Globally, over one out of every five new automobiles sold was an electric car (International Energy Agency [IEA], 2025).

Nevertheless, this growth varies by region. With more than 11 million EVs sold in 2024 a 40% increase in sales compared to just two years prior China remains the market leader in EVs worldwide (Rho Motion, 2025). Strong government incentives and the quick release of creative, reasonably priced domestic models are the main drivers of this expansion.

In contrast, sales in Europe slightly decreased, mostly as a result of the phase-out of purchase subsidies in important markets like Germany. Thanks to U.S. tax credits and growing consumer interest in electric trucks and SUVs, North America experienced moderate growth of about 9% (Rho Motion, 2025). As competitively priced Chinese EVs make their way into emerging markets in Asia and Latin America, adoption is rising in these regions (BloombergNEF, 2025). Example: By combining strong domestic sales with aggressive expansion into Europe, Southeast Asia, and Latin America, Chinese automaker BYD has become a global leader.

The Strategic Drive for Battery Dominance and Vertical Integration

As the EV market develops, businesses come to understand that resilience and cost competitiveness depend on supply chain control, particularly in the production of batteries. This has led to a significant trend toward vertical integration, in which automakers assume control of several production phases, from sourcing raw materials to producing batteries and other components internally.

Through its Gigafactories, which produce batteries like the 4680 cell and have long-term agreements with mining companies to stabilize the supply of raw materials, Tesla led the way in this strategy (Eightception, 2024). Likewise, BYD is perhaps the world's most vertically integrated EV company. Having started out as a battery manufacturer, BYD now manufactures its own electric motors, batteries (including the Blade Battery), and semiconductors, which leads to remarkable cost effectiveness and innovation speed (Energy Central, 2025). To further support

its long-term electrification objectives, Volkswagen has also committed billions to build internal battery facilities and ensure raw material access throughout Europe.

The Revolution in Intelligence: AI and Self-Driving Cars

Electric cars are becoming smart, connected computing platforms on wheels, which makes them perfect for integrating autonomous systems and artificial intelligence (AI). AI is used for much more than just self-driving cars; it also maximizes maintenance, safety, and energy efficiency.To improve range efficiency, AI systems now examine weather, traffic, and driving habits. Advanced driver-assistance systems (ADAS) use AI to prevent collisions and control lanes, and predictive maintenance algorithms identify component wear before failures happen.

For instance, AI-driven perception and decision-making are used by Tesla's Autopilot and Full Self-Driving (FSD) systems to traverse a variety of terrains. With its Ultium battery platform, General Motors uses AI to optimize charging cycles and track cell health, extending battery life (Appinventiv, 2025).Automakers such as BYD, Rivian, and Xiaomi have embraced Nvidia's DRIVE platform, which serves as the foundation for AI computing in EVs and powers infotainment and autonomous driving systems (Nasdaq, 2025).

The Great Divide: Premiumization vs. Affordability

China's and the West's approaches to the EV market have shown a startling difference. Whereas Western automakers prioritize high-end features and performance, Chinese manufacturers prioritize affordability and accessibility. Due to fierce competition and vertical integration, internal combustion vehicle prices have been matched in China. Nearly two-thirds of EVs are less expensive than traditional models, and by 2024, the median price of a battery electric vehicle in China was lower than that of a comparable gasoline car (IEA, 2025). Mass adoption of EVs has accelerated due to their democratization.

On the other hand, larger, luxury-focused EVs that are still pricey in comparison to gasoline-powered vehicles dominate the U.S. and European markets. In 2023, the average EV price in these regions was more than twice that of China, despite the emergence of more affordable models, like the Chevrolet Equinox EV (JATO Dynamics, 2023).

For instance, consumers in China can buy useful EVs for less than USD 25,000, while Western buyers have far fewer affordable options. Automakers' production, marketing, and policy strategies are being shaped by the ensuing global split.

REFERENCES

A Comprehensive Study of Key Electric Vehicle (EV) Components, Technologies, Challenges, Impacts, and Future Direction of Development. (Camacho, O.M.F.; Nørgård, P.B.; Rao, N.; Mihet-Popa, L. Electrical Vehicle Batteries Testing in a Distribution Network using Sustainable Energy. *IEEE Trans. Smart Grid* 2014, *5*, 1033–1042).

AInvest. (2025).Lucid Motors Press Release (2025): Lucid and critical form a partnership. mineral producers. Premium EV strategy, Lucid 2025 manufacturing goals

Appinventiv. (2025, September). How AI in electric vehicles is driving innovation.

Best-Selling Cars. (2024). 2023 (Full Year) Global: BYD worldwide sales and car production. https://www.best-selling-cars.com/brands/2023-full-year-global-byd-worldwide-sales-and-car-production

Best-Selling Cars. (2024). 2023 (Full Year) Global: BYD worldwide sales and car production.

BloombergNEF. (2024). *Electric vehicle outlook 2024*. Bloomberg New Energy Finance. https://about.bnef.com/electric-vehicle-outlook/

BloombergNEF. (2024). *Electric vehicle outlook 2024*. Bloomberg New Energy Finance.

BloombergNEF. (2025, June). Global electric vehicle sales set for record-breaking year.

Boston Consulting Group (BCG). (2025, February). What China's EV market can teach U.S. and EU automakers.

California Governor's Office of Business & Economic Development. (n.d.). *ZEV timeline*. https://business.ca.gov/industries/zero-emission-vehicles/zev-timeline/

CarNewsChina. (2024, January 1). BYD sold 3.02 million vehicles in 2023, up 61.9%. CarNewsChina.https://carnewschina.com/2024/01/01/byd-sold-3-02-million-vehicles-in-2023

Charger S.A. (2025, September). Autonomous driving, artificial intelligence and integrated technologies in electric vehicles.

Eightception. (2024, December). Why vertical integration worked for Tesla.

Elsevier (2016), BYD Strategies and Government: Electric Vehicles in China. Support.

Energy Central. (2025, April). Case study addendum: Why BYD leads in EV battery manufacturing.

European Commission. (2023, March 28). *CO_2 emission performance standards for cars and vans: Regulation (EU) 2023/851 amending Regulations (EU) 2019/631 and (EU) 2019/1242.* Directorate-General for Climate Action**.** https://climate.ec.europa.eu/index_en

European Parliament. (2022, November 3). *EU ban on sale of new petrol and diesel cars from 2035—explained*. https://www.europarl.europa.eu/topics/en/article/20221019STO44572

General Motors. (2021, January 28). *GM plans to be carbon neutral by 2040; aspires to eliminate tailpipe emissions from new light-duty vehicles by 2035* [Press release].https://investor.gm.com/news-releases/news-release-details/general-motors-largest-us-automaker-plans-be-carbon-neutral-2040

https://about.bnef.com/electric-vehicle-outlook/

https://business.ca.gov/industries/zero-emission-vehicles/zev-timeline/

https://carnewschina.com/2024/01/01/byd-sold-3-02-million-vehicles-in-2023

https://english.www.gov.cn/news/202306/21/content_WS64929394c6d0868f4e8dd11c.html

https://www.best-selling-cars.com/brands/2023-full-year-global-byd-worldwide-sales-and-car-production

https://www.europarl.europa.eu/topics/en/article/20221019STO44572

https://www.federalregister.gov/documents/2024/05/08/2024-09970/initiation-of-antidumping-and-countervailing-duty-administrative-reviews

https://www.iea.org/reports/global-critical-minerals-outlook-2024

https://www.irs.gov/pub/taxpros/fs-2024-26.pdf

https://www.mckinsey.com/industries/automotive-and-assembly/our-insights

IEA (2025), Global EV Outlook 2025, IEA, Paris https://www.iea.org/reports/global-ev-outlook-2025, Licence: CC BY 4.0

IEA (2025), Global EV Outlook 2025, IEA,Parishttps://www.iea.org/reports/global-ev-outlook-2025, Licence: CC BY 4.0

Internal Revenue Service. (2024, July 26). *FS-2024-26: Clean Vehicle Credit — critical-mineral and battery-component requirements (updated guidance)*. U.S. Department of the Treasury.https://www.irs.gov/pub/taxpros/fs-2024-26.pdf

International Energy Agency (IEA). (2025). Global EV outlook 2025.

International Energy Agency (IEA). (2025). Trends in electric car affordability – Global EV outlook 2025.

International Energy Agency. (2024). Global EV outlook 2024. IEA.https://www.iea.org/reports/global-ev-outlook-2024

International Energy Agency. (2024). *Global EV outlook 2024: Driving ambition into reality*. IEA Publications. https://www.iea.org/reports/global-ev-ou

International Energy Agency. (2024a). *Global Critical Minerals Outlook 2024.* IEA Publications.https://www.iea.org/reports/global-critical-minerals-outlook-2024

JATO Dynamics. (2023, October). JATO EV price gap: A divide in the global automotive industry.

McKinsey & Company. (2024). *The global electric-vehicle market is accelerating into the next phase of growth*. McKinsey & Company.https://www.mckinsey.com/industries/automotive-and-assembly/our-insights

McKinsey (2024). Electric vehicle transition: Raw materials and global critical hazards.

Methodology.net, A Brief Overview of the Business Strategy of BYD.

Ministry of Finance of the People's Republic of China (MOF PRC); State Taxation Administration (STA); & Ministry of Industry and Information Technology (MIIT). (2023, June 21). *Notice on continuing and optimizing the vehicle purchase-tax exemption policy for new-energy vehicles (2024–2027).* The State Council of the People's Republic of China.https://english.www.gov.cn/news/202306/21/content_WS64929394c6d0868f4e8dd11c.html

Nasdaq. (2025, October). Prediction: This artificial intelligence (AI) stock could power the next generation of EVs.

Rho Motion. (2025, January). Over 17 million EVs sold in 2024 – Record year.

Tesla, Inc. (2008, March 16). *Tesla Motors begins regular production of 2008 Tesla Roadster* https://ir.tesla.com/press-release/tesla-motors-begins-regular-production-2008-tesla-roadster

The article by Financial Times (2024) addresses the e-platform and battery integration of BYD. Tesla, Ford and GM have reached a consensus on charging plugs.

The blueprint of EV empire. EVBoosters.com. ResearchGate (2023).

The Disruptive Innovation: BYD business Case Study. Model Canvas.U. Fesli and M. B. Ozdemir, "Electric Vehicles: A Comprehensive Review of Technologies, Integration, Adoption, and Optimization," in IEEE Access, vol. 12, pp. 140908-140931, 2024, doi: 10.1109/ACCESS.2024.3469054.

U. Fesli and M. B. Ozdemir, "Electric Vehicles: A Comprehensive Review of Technologies, Integration, Adoption, and Optimization," in IEEE Access, vol. 12, pp. 140908-140931, 2024, doi: 10.1109/ACCESS.2024.3469054.

U.S. Department of Energy. (2014, September 15). *The history of the electric car*.https://www.energy.gov/articles/history-electric-car

U.S. Department of the Treasury & Internal Revenue Service. (2024, May 6). *Clean Vehicle Credits under §§ 25E and 30D — transfer of credits; critical-minerals and battery-component requirements (final guidance)*. Federal Register / Treasury Decision 10045.https://www.federalregister.gov/documents/2024/05/08/2024-09970/initiation-of-antidumping-and-countervailing-duty-administrative-reviews