BOCCONI STUDENTS FOR
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ELECTRIFIED TRANSPORTATION: SHAPING THE FUTURE OF SUSTAINABLE MOBILITY

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The transportation sector contributes about one-fifth of total global carbon dioxide emissions. Electrified transportation is rapidly becoming the driving force of the shift towards a cleaner alternative to the traditional fuel-powered transportation means. While shared mobility, vehicle connectivity, and autonomous driving are some candidates to reshape the transportation sector, electric vehicles (EVs) are leading this change.

In 2023, investments in electrified transportation surged past renewable energy to become the top green spending category, reaching $634 billion – a 36% year-on-year increase. This surge is fueled by different factors, including the urgency of drastically reducing emissions and technological advancements in the supply chain, making EVs increasingly appealing in developing markets. However, the industry is currently facing emerging challenges. Falling battery prices are diminishing the margins for manufacturers, potentially discouraging new entrants in the industry. Additionally, geopolitical tensions and pressures to reduce reliance on China's supply chain are encouraging the U.S., Europe, and India to prioritize domestic production and innovation. Also, issues including the combined semiconductor shortage and the limited access to essential materials, like nickel and lithium affect the ability of manufacturers to meet demand. Furthermore, the gradual phasing out of subsidies and incentives in key markets like Europe has reduced financial support for both buyers and producers. The pace of adoption of EVs is hence various across countries. Developed markets have recently experienced a slowdown in EV sales. Despite this, projections suggest that EVs will account for 100% of new passenger vehicles sales globally by 2034, with the entire on-road fleet expected to go electric by 2046.

The goal of this article is to provide an extensive analysis of the current progress and growth potential of electrification in markets around the world. It begins by examining the urgent need for a sustainable transition in the automotive industry and presents the current state of investments driving this shift. Then, the report will also explore the challenges facing the industry and expose future trends that could shape or slow down the path toward widespread electrification.

Fueling the Green Transition Through Electrified Transportation:

Traditional transport systems significantly threaten the environment, driving many countries to prioritize the transition to electrified transportation. The transport sector alone contributes 21% of total emissions, with road transport accounting for 15%. The remaining 6% comes from marine (2.5%), aviation (2.5%), and rail (less than 1%) transportation. As a result, growing interest in Environmental, Social, and Governance (ESG) factors have become powerful drivers of growth in the electrified transportation sector. Indeed, investors are increasingly directing capital toward industries that align with these sustainable goals. Major funds, including BlackRock and Vanguard, have highlighted EV

manufacturers as key players in the transition to a low-carbon economy. Companies with strong ESG credentials, such as Tesla and Rivian, are attracting significant interest due to their role in driving sustainability. Additionally, many funds now consider supply chain practices and renewable energy integration when evaluating EV companies, pushing firms to adopt even more environmentally friendly production methods.

As we will investigate in the following section, capitalizing on these environmental goals will require governments to use financial support and regulatory mechanisms to encourage R&D and capital spending in electrified transportation. In China, for example, a global leader in overall energy transition investment ($676 billion in 2023), incentives for EV production include tax breaks, subsidies, cheap land, loans, and grants. Overall, global spending on electrified transport needs to significantly increase, as the road transport sector is not yet on a trajectory aligned with limiting warming to 2 degrees Celsius.

A Growth Driven by Government Support:

In recent years, the interest from investors in electrified transportation has been steadily increasing. This growth in investments has been accelerated by several factors, regulatory support being the most important force.

The EV market is growing exponentially with each year passing by. Electric car sales in 2023 have increased by 3.5 million compared to 2022. This is more than six times higher than just 5 years earlier in 2018. In 2023 electric cars made up nearly 18% of all cars sold, which again reflects significant market growth compared to 14% in 2022 and just 2% in 2018. These statistics demonstrate that growth remains resilient - demand and adoption of EVs are increasing, as the electrified transportation market advances. Looking into the future, the market is expected to expand at a steady compound annual growth rate (CAGR) of 6.63% from 2024-2029. This growth will lead to a projected market volume of $1,084bn by 2029, double the market volume of $500.48 bn in 2023. As the market will continue its steady expansion, investors within the market or the ones looking to enter it could see increased opportunities.

The main driver behind the increasing interest in electrified transportation is regulatory support. Governments worldwide keep pushing the transition to EVs by implementing stricter regulations to phase out internal combustion engines (ICE) vehicles. Policies in markets like the EU, the US, and China are attracting investment in EV development by creating strong incentives for automakers, battery producers, and infrastructure providers. An example is the European Union's ban on new ICE sales by 2035, which states that after 2035, no new ICE vehicles will be allowed to be sold in EU countries. This

policy pushes all new vehicle sales toward zero-emission options such as electric and hydrogen fuel cell vehicles, leaving no alternative but the complete electrification of the automotive fleet. Not only by introducing a ban, but the EU is also supporting the transition by investing in the construction of millions of EV charging points across member states. This regulatory push has led to massive transformation among automakers in Europe. Volkswagen for example has promised to become a fully electric brand in Europe by 2033 through investing heavily in new EV models and battery production facilities. Furthermore, governments also push on the demand side, helping consumers to afford the high cost of electric vehicles. Again, Europe is leading in these stimuli, with member states incentivizing the widespread adoption these vehicles. For instance, the EU has launched several programs including the "Fit for 55" initiative that targets a 55% decrease in GHG by 2030, and "Horizon 2020," which invest in sustainable mobility innovation (budget of nearly €80 billion). Another example is the Netherlands' "Ecodrive Programme," that successfully reduced CO2 emissions through eco-driving education, tax incentives for fuel-saving devices, and public awareness campaigns. This initiative alone cut emissions by up to 222 kilotons between 2000 and 2004, demonstrating the tangible benefits of targeted policies. Similarly, in the United States, the Inflation Reduction Act represents a significant push for electrification, allocating substantial funding to EV adoption, charging infrastructure, and clean energy. The U.S. federal government also called for zero-emission vehicles to comprise half of all new passenger car and light-truck sales by 2030.

Together, such efforts on both sides of the Atlantic show the role of comprehensive policy frameworks in accelerating the transition to sustainable transportation systems. This makes the EV industry attractive to investors as the introduced policies create more predictable, long-term growth opportunities.

Investment Opportunities in Electrified Transportation: Key Areas

The electrified transportation sector consists of multiple interconnected investment areas, each critical to enhancing the EV industry.

Vehicles:

Vehicles account for the majority of electrified transportation investments. This category includes electric passenger cars, commercial EVs and two-wheelers. The global market for passenger EVs is dominated by companies like Tesla, BYD, Ford and GM. However, electrification is advancing beyond passenger vehicles into trucks, buses and delivery fleets. Examples of companies leading the market are Volvo and Daimer Trucks, producing heavy-duty EV trucks, or Rivian, which partners with Amazon to provide electric delivery vans. The last main subcategory of vehicles are the electric two-

wheelers, represented by electric scooters or motorcycles. These are highly demanded in markets like India and Southeast Asia, where urban mobility and affordability are key factors. Gogoro, a business based in Taiwan, has changed the game by introducing battery-swapping stations for scooters, creating a sustainable ecosystem. Investments in the vehicles category focus on creating affordable EV models to enter mass markets, on improving vehicle efficiency through software and hardware innovation and on building gigafactories for EVs and batteries.

Charging infrastructure:

Accessible charging networks are required for the successful adoption of EVs. Companies like ChargePoint, EVgo, and Tesla's Supercharger network invest in building vast infrastructure globally. The main investments include public charging stations, home charging solutions and fast-charging technology. The aim of giants such as ChargePoint is increasing the density of chargers in urban and highway areas. Governments also work on achieving this goal. Examples are the US Bipartisan Infrastructure Law and EU's Alternative Fuels Infrastructure Regulation, both focusing on increasing the number of public EV chargers. Another key investment area is the expanding charging options for homes and workplaces. Last but not least, investors are also interested in fast-charging technologies. Companies like ABB and Tritium develop high-speed chargers (350 kW+) that reduce charging time to under 15 minutes. In Europe, Ionity - a group of companies including BMW, Mercedes-Benz, and Ford, is expanding ultra-fast charging stations across the continent. In the US, Electrify America has established one of the most comprehensive fast-charging networks.

Batteries:

The most critical investment area in the electrified transportation industry are batteries, as their performance determines the EV's range and sustainability. This category can be divided into two subcategories - battery production facilities (gigafactories) and battery chemistry innovation. Investments in gigafactories have been increasingly growing so as to ensure that the battery demand is met. For example, Tesla operates multiple gigafactories like Gigafactory Nevada and Gigafactory Berlin, to produce massive amounts of EV batteries. When it comes to the chemical composition of the battery, companies like QuantumSpace are developing solid-state batteries with faster charging time and higher energy density. Investments are also growing in battery recycling, where Redwood Materials has taken the lead.

Supply chains for critical minerals

Batteries are heavily dependent on materials like lithium, cobalt, nickel, and rare earth elements. Therefore, ensuring a strong supply chain is of huge importance for the EV industry. A lot is invested into mining companies to ensure that the demand for critical minerals is met. Examples include Albemarle and Glencore that partner with EV manufacturers to secure an efficient supply. Also, countries rich in resources such as Australia, Chile, and Indonesia, are experiencing significant foreign direct investment (FDI).

The Key Players Driving Investment in ET

The increased opportunities in the electrified transportation sector attract a large variety of investors - from institutional investors and private equity (PE) firms to corporate players like automakers and technology giants.

Key investors: Institutional investors and PE firms

Recognizing the long-term growth opportunities within the industry, institutional investors such as pension funds, sovereign wealth funds and insurance companies target electrified transportation projects. In this way, they do not only focus on scalable investments, but also align their portfolios with ESG goals and the global shift towards sustainability. One of the world's largest sovereign wealth funds, namely Norway's Government Pension Fund, invests heavily in companies developing EV technology and clean, renewable energy solutions like Iberdrola and Ørsted A/S. Another example includes Singapore's GIC and Canada Pension Plan Investment Board (CPP Investments), which both have invested in ChargePoint, as part of its $240 million fundraising campaign.

Also, private equity firms increasingly invest in promising startups and innovative companies, providing them with the capital necessary to expand production. Perfect example is TPG Rise Climate - a fund "created to address the challenges of global climate change as well as the opportunities to scale innovative businesses that can enable quantifiable carbon aversion", that has invested in EV and battery technology ventures like Redwood Materials (specializing in battery recycling).

Asset managers follow this trend as well. Taking into consideration the growth potential of the EV sector, major asset management firms allocate substantial funds to companies that are leading the electrification of transportation. The world's largest asset manager and one of the biggest investors in clean energy - BlackRock, holds significant positions in both EV manufacturers like Tesla and battery giants such as CATL. Vanguard, on the other hand, has invested across the entire EV supply chain - from mining companies and firms developing chips for EV, to automakers.

Corporate players

Corporations across industries are also leading investment and innovation in electrified transportation to keep up with the speed of the rapidly growing sector. Traditional automakers are investing billions into the transition from ICE vehicles to electric ones. By investing heavily in EV platforms and battery gigafactories, Volkswagen aims to make 70% of its European sales electric by 2030 through its “Accelerate” program. Another example is Ford, investing in battery and vehicle production facilities and developing its EV portfolio with models like Ford Mustang Mach-E and electric F-150 Lightning. Tech companies have also become important players in the electrified transportation sector, leveraging their expertise in software, hardware and data systems. Not only do they develop cutting-edge EVs, but also invest in developing innovations such as autonomous driving. Apple, for instance, is rumored to be developing its own electric and autonomous vehicle - the “Apple Car”.

An Example of Successful Investment: Tesla's Gigafactories

Tesla's gigafactories are a successful example of how strategic investments in large-scale infrastructure can revolutionize industries. In line with its mission to "accelerate the world's transition to sustainable energy", Tesla's Gigafactory journey began in 2014 in Nevada, USA. The construction of the Nevada Gigafactory was funded through a combination of private investment from Tesla, public-private partnerships, and substantial state incentives. For example, Nevada provided Tesla with a $1.25 billion tax incentive package. And so, since its final completion, the Nevada Gigafactory has become one of the world's largest battery manufacturing plants. This massive production scale allowed Tesla to meet the growing demand for EVs while reducing unit costs through economies of scale. Observing the massive success of the first gigafactory, Tesla continued investing in gigafactories leading to the construction of 7 such factories across the world. These infrastructural giants enabled Tesla to lead global EV sales, producing 1.8 million EVs in 2023. Tesla has officially published that: "All in, since 2014 a total of $17.1 billion in economic output has been generated as a result of the Gigafactory". This massive success inspired other players in the industry to make similar investments – yet not all efforts have been equally profitable. For instance, aiming to replicate Tesla's approach, Northvolt's gigafactory in Sweden has been focusing on scaling battery production. However, Europe's leading battery maker recently filed for bankruptcy after struggling to scale production in response to a slower than expected shift to electric vehicles.

Not only did Tesla benefit from the Gigafactories through lowering production costs and enhancing profitability, but society and the environment were also positively impacted. Thousands of jobs were created - not just at Tesla, but also in the local economy. Growth of skilled labor in fields like engineering and manufacturing, was observed, which further boosted the regional economy in Nevada and other locations. The Gigafactory has also significantly contributed to reducing global transportation emissions. By producing more affordable EVs and lowering the cost of batteries, Tesla has driven forward the shift towards cleaner energy solutions. For all these reasons, Tesla's Gigafactories can be presented as an example for a successful investment in the electrified transportation sector.

The Challenges and Foreseeable Future

In recent years, the sector has faced a range of challenges resulting from supply chain disruptions to market variability, and technical challenges.

Supply chain disruptions have been one of the key areas in which the EV sector has been struck. Indeed, as mentioned earlier, EV batteries contain several metals that are crucial to their operation, namely lithium, cobalt, and nickel. One of the main concerns has been the rarity of cobalt, but also the limited availability of other materials, leading to increased price volatility, directly impacting supply chains. Moreover, mining has been at the center of many considerations due to the dependence on resource-rich but politically unstable regions, such as the Democratic Republic of Congo. The country has more reserves than the rest of the world combined but is characterized by an employment structure that renders miners “freelance”, subjecting them to highly dangerous work for only a few dollars a day. These conditions are illegal, but despite outcries from human rights organizations, they continue to exist in the shadows. Finally, these operations have been subject to further scrutiny due to the Chinese ownership of roughly 70-80% of the refined cobalt market. Due to a combination of these factors, there has been increasing pressure on EV companies to innovate and reduce dependency on cobalt. However, it is clear that due to it being an essential component that is so rare, it will be difficult for companies to adapt.

Manufacturing bottlenecks have posed another significant challenge for the EV sector, slowing down production and making it harder to meet growing demand. One of the main issues is the shortage of semiconductors, which are vital components in EVs, powering systems like batteries and advanced features such as driver assistance. Unlike traditional vehicles, EVs need more semiconductors, so when a global shortage hit - largely caused by the COVID-19 pandemic - automakers had to delay production or focus on producing fewer models.

On top of this, battery production has also faced obstacles. EVs require a significant number of batteries, but building the factories to make them takes a lot of time and money. Even major players like Tesla or Volkswagen have struggled to ramp up battery production fast enough, as they also depend on the availability of raw materials and trained workers.

Increased production costs due to supply chain disruptions, such as the semiconductor shortage and battery constraints, have delayed profitability for many companies. For example, Rivian has experienced major setbacks, reporting a 34.6% drop in quarterly revenue as it struggles with component shortages.

To navigate these challenges, companies are increasingly turning to vertical integration. Tesla, for instance, has expanded its in-house battery production to reduce dependence on external suppliers. This approach helps control costs and ensures a stable supply of critical components, providing a more predictable investment outlook. Investors should also pay attention to companies diversifying their supply chains. Firms establishing local manufacturing facilities, like BYD in Thailand and Brazil, are reducing reliance on single suppliers and protecting against geopolitical risks. Diversification strategies can create more resilient production lines, which may translate into more stable returns.

Market variability is an ever-growing challenge for the EV sector, as regional dynamics and external pressures shape the growth trajectory differently across regional markets.

In Europe, the EV market is experiencing a slowdown. Early adopting countries such as Norway and the Netherlands are approaching saturation, where EVs have already captured a significant share of the market. At the same time, some governments have scaled back subsidies and tax incentives. For example, Germany, one of Europe's largest EV markets, has reduced its subsidy program for electric vehicles, causing a noticeable 69% dip in car deliveries in August. These policy changes, coupled with rising inflation and economic uncertainties, have made EVs less attractive for middle-income buyers, posing a challenge to further growth.

China on the other hand, the world's largest EV market, is in a completely different dynamic. Domestic players such as BYD and NIO dominate the market. China's near monopoly on battery production gives its manufacturers a significant cost advantage. Foreign automakers, including Tesla and Volkswagen, face stiff competition not only in price but also innovation, as Chinese manufacturers continue to lead in areas like battery technology and smart vehicle software. For international investors, this intensifying competition makes China an interesting investing opportunity.

In the United States, political uncertainty looms as a critical factor. A return to a Trump administration could deprioritize federal EV incentives and weaken regulatory support for green energy. Programs like the Inflation Reduction Act, which offers tax credits of up to $7,500 per vehicle for consumers and provides substantial funding for EV manufacturing and infrastructure development, could be scaled back or eliminated, affecting consumer demand and profitability for U.S. manufacturers. This political variability makes it difficult to predict long-term growth trends in the U.S., creating additional risk for investors.

Technological challenges are at the core of the EV industry's struggles, as companies strive to enhance performance, reduce costs, and address infrastructure gaps.

One of the most pressing issues is the race for battery innovation. Companies are investing heavily in research and development to tackle these challenges, with solid-state batteries emerging as a potential game-changer. These batteries promise higher energy efficiency, faster charging, and longer lifespans compared to current lithium-ion technology, but they remain costly and are not yet ready for mass production. Firms like Toyota and QuantumScape are at the forefront of this innovation, but commercialization may still be years away.

Another critical challenge for a widespread adoption is the lack of widespread charging infrastructure. While urban centers are seeing rapid growth in charging networks, rural and emerging regions remain underserved, making EV adoption difficult in those areas. This disparity is particularly evident in countries with vast geographical areas like the United States, Canada, and Australia, where long-distance travel requires a robust charging network.

Conclusion:

As this article has explored, the EV sector is undergoing a period of rapid evolution. While it presents unparalleled opportunities, its expansion faces various obstacles, such as supply chain disruptions, market variability, and technological challenges. To overcome these, continued investment in R&D and supportive government policies are essential.

The future of mobility is increasingly electric, promising a cleaner and more sustainable environment. Strategic investments in key areas like vehicle innovation, charging infrastructure, and battery technology are changing the automotive landscape, as exemplified by Tesla's Gigafactories. In particular, the development of advanced battery technologies, such as solid-state batteries, holds the potential to significantly improve the performance and range of electric vehicles. Additionally, the rise of autonomous vehicles and the integration of renewable energy are reshaping the industry.

As investors increasingly recognize this sector's long-term potential, collaborative efforts among governments, businesses, and consumers are vital to unlock electrified transportation's full potential.

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