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Analysis of the Electric Vehicle Space

## 1. Introduction, Trends, and Outlook

Every year, the global transportation of goods and people uses about 25% of the total delivered energy consumption (EIA 2016).[1] Yet, renewable energy only makes up a small fraction of energy usage in this sector. While the increasing usage and development of biofuels is a promising path, I believe that electric vehicles play a larger, key role in the clean energy transition. Numerous governments and companies around the world plan to electrify their vehicle fleet within the coming decades.[2] The main goal of this paper is to analyze the electric vehicle market's characteristics and trends and contextualize its impact on $CO_2$ emissions. I will also look at Tesla as a case study of some economic and strategic challenges a firm in the EV market can face. Finally, this paper will conclude with discussing some barriers and promoters of EV adoption.

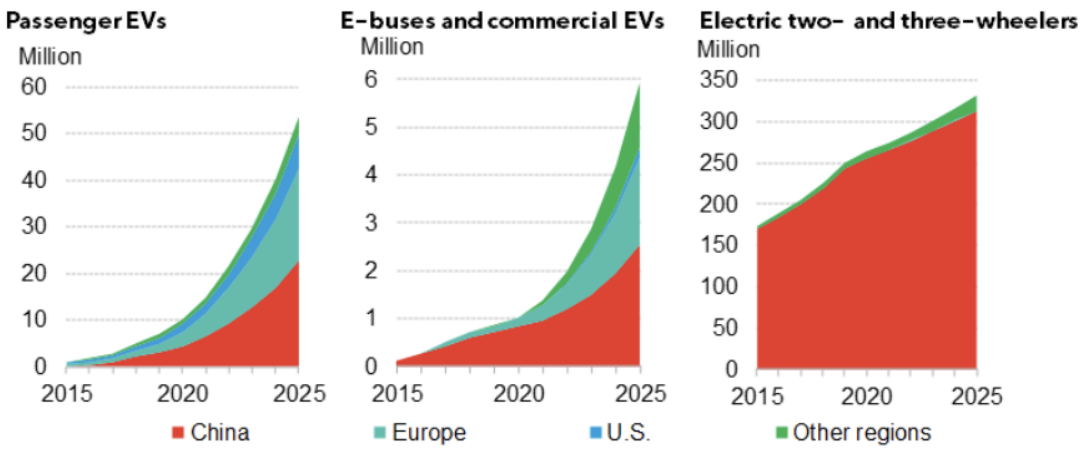
Currently, there are three major EV markets: North America, Europe, and China. The automobile industry as a whole has been shifting towards electric vehicles, with numerous companies like Chevrolet, Audi, and Mercedes-Benz all pledging to go all-electric within the next decade.[3] Figure 1 below shows the electric vehicle stock over time, region, and segment.[4] This chart shows that China and Europe lead in total stock with the U.S. and other regions

[1] https://www.eia.gov/outlooks/ieo/pdf/transportation.pdf
[2] https://www.weforum.org/agenda/2020/09/heres-how-electric-vehicles-can-keep-us-on-the-road-to-paris/
[3] https://www.gearpatrol.com/cars/g38986745/car-brands-going-electric/?slide=5
[4] https://bnef.turtl.co/story/evo-2021/page/3/2?teaser=yes

trailing them. These numbers are projected to increase dramatically by 2025 for passenger and commercial electric vehicles.

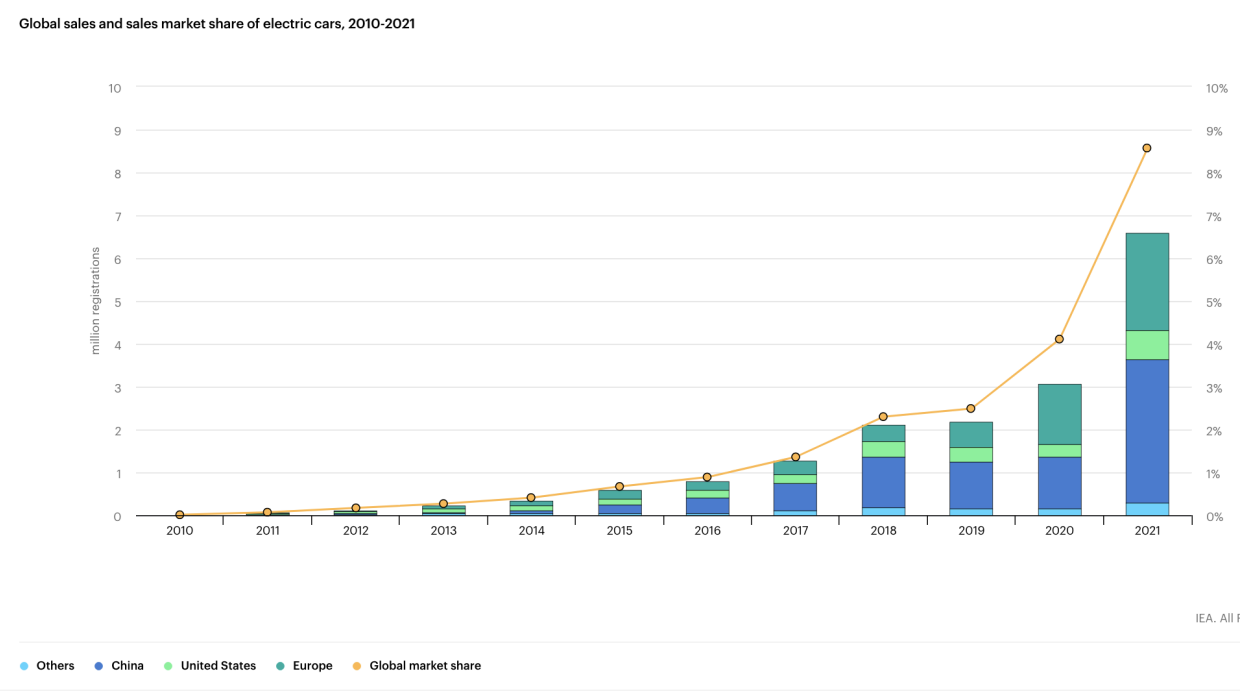
**Figure 1**

**Global EV fleet by segment and market**




*Source: BNEF. Note: Two-wheelers includes mopeds, scooters and motorcycles, excludes e-bikes.*

Figure 2



Interestingly to note, electric two and three wheelers see the greatest adoption in China by a large margin over other regions. This is likely due to policies promoting electrification of small format EVs. In figure 2, electric vehicles represented over 7% of global vehicle sales in 2021, doubling from the previous year.[5] These charts highlight the increasing prominence and development of electric vehicles in recent years.

The top EV manufacturers by market share and sales in 2022 include Tesla (leading by a large margin) with a market cap of $893 billion, SAIC (the largest in China by sales) with a market cap of $34 billion, and Volkswagen with a share of $98.34 billion.[6]

| World's largest electric car companies | 2021 EV sales | Market cap in March 2022 |
|---|---|---|
| Tesla | 936,172 | USD 893 billion |
| SAIC Motor | 732,646 (including PHEVs) | USD 34 billion |
| Volkswagen Group | 452,900 | USD 98.34 billion |
| BYD | 320,810 | USD 104.72 billion |
| Hyundai Motor Group | 184,660 (approximation) | USD 33.73 billion (Hyundai Motor Company |

## 2. Impact on $CO_2$ Emissions and the Clean Energy Transition

Although electric vehicles are widely seen as a driver of the clean energy transition, there is more to this perspective than meets the eye. According to the MIT Energy Initiative, electric vehicles on average emit about 200 grams of $CO_2$ per mile compared to hybrid vehicles that emit 275 grams of $CO_2$.[7] ICE vehicles on the other hand emit around 400 grams of $CO_2$ per mile. EVs

[5] https://www.iea.org/data-and-statistics/charts/global-sales-and-sales-market-share-of-electric-cars-2010-2021
[6] https://topelectricsuv.com/featured/worlds-largest-electric-car-companies/
[7] https://www.cnbc.com/2021/07/26/lifetime-emissions-of-evs-are-lower-than-gasoline-cars-experts-say.html

do not emit tailpipe emissions but create 30% to 40% more carbon emissions from the production of its batteries in the factory than the production of gas fueled cars. Another point to consider is the source of the electricity charging EVs, whether it is fossil fuel or renewable in origin. MIT projects that EVs will emit 50 grams of $CO_2$ per mile by 2050 as the electric grid becomes more green. All in all, they conclude that EVs emit less lifetime emissions than petrol vehicles but the total difference considering production emissions means that EVs by themselves are currently not a huge mitigator of climate change.

## 3. Background Overview on the Electric Vehicle Market

Although electric vehicles were first introduced in the 19th century, the modern day segment truly took off during the 1990s. During this time, California's regulatory policies on pollution led to widespread interest for many automobile manufacturers such as Ford, Toyota, and Nissan, to produce EVs (Fisk 2018). Famously, General Motors (GM) also debuted the first ever mass-produced electric vehicle with the EV1, which garnered positive reviews and a cult-like following. The car was brought to market on a lease-only program, meaning the company could repossess them once the leases came to a close. Despite the popularity of the car, GM eventually discontinued production and recalled all EV1s to be crushed. The company cited low profitability on account of high production costs and a niche market (Brown 2016). Although they were indeed expensive and limited in many aspects (such as range) in comparison to their gasoline counterparts, the EV1s proved that there was demand in the market for electric vehicles.

Tesla Motors was founded in 2003 by Martin Eberhard and Marc Tarpenning, who were inspired to create the company after the death of the EV1. The company's first model, the Roadster, was notable for being the first highway viable serial production all-electric car. Due to

the company's technological advancements with its lithium ion battery, the Roadster was able to travel up to 250 miles on a single charge and provide the acceleration needed for faster roads (Reed 2019). Over the next decade, the company would proceed to achieve many different milestones such as releasing three more models with various new features, going public, and briefly being the world's most valued car company (Greiner et al, 2019). With the popularity of the brand and its vehicles, Tesla has spurred global attention to the electric vehicle space, both on the side of consumers and manufacturers (Romm 2018).

The ability for new entrants to penetrate the market is a point of contention among existing academic sources. Perkins and Murmann argue, "...a well funded company could develop a new electric vehicle (EV) from scratch and move it to production within 3-5 years...the Tesla example demonstrates that new entry into the industry has become feasible." (2018, pg. 1) However, MacDuffie instead asserts, "...Tesla's story teaches us something quite different — that a new automotive entrant must master the same integral product architecture, production and supply chain capabilities, and system integrator role as incumbent OEMs." (2018, pg. 1) If Perkins and Murmann are correct, the electric vehicle market may become flooded with completely new companies if profits are being realized in this space, not just existing manufacturers. If MacDuffie is correct, Tesla is an outlier that has established themselves in the electric vehicle market but will face stiff pressure from industry veterans who have mastered those processes described. Either way, these sources suggest that the EV market is particularly competitive. The implications of these scenarios are important because they outline the future of the market and the level of competitive pressure on Tesla.

## 4. Strategic Advantages and Challenges in the EV Market (Tesla)

One powerful asset of Tesla is their brand value. Mangram (2012, pg. 306) notes, “Much like Apple Computer, Tesla represents a premium brand…” The Roadster was an integral piece in building this image, both through its technological innovations as previously mentioned, and its targeting of the high end sports car market. The flashy car debuted at a star-studded launch party and attracted much media attention through spreads in major articles like The Washington Post, The New York Times, and Fortune (Fisk 2018). Tesla’s reputation of producing attractive, high-tech, and environmentally-friendly vehicles is in stark contrast to the predominantly existing industry business model of mass-producing cheaper models (Mangram, 2012). The cool factor of the company has thus allowed it to stand out amongst the crowd and garner massive amounts of media coverage. In addition, AutoTrader named Tesla as the most-loved auto brand in 2019 based on a survey of 60,000 vehicle owners, serving as a testament to the amount of loyalty and praise that car owners give to the company over all others (Matousek, 2019). With this brand image, Tesla has given themselves a strategic advantage in allowing major room for error without negative consequences. For example, its investors have been very patient, giving the company a $900B valuation despite a long history of not being profitable prior to recent years. The loyalty and support that their consumers and investors have given is a considerable advantage in the competitive landscape, especially as new companies enter the space and threaten to convert consumers from existing contenders. In terms of safety, the Tesla brand accumulated perfect 5 star ratings from the National Highway Traffic Safety Administration for all of its production vehicles (Ferris, 2018). This is another edge over competitors as it signals to consumers that the company has a consistent history of producing safe electric vehicles, something that new entrants both in the domestic and global sectors cannot attest to. These are the reasons why Tesla’s brand image is a crucial driver of success in the electric vehicle market.

Research and development on battery technology is a central area of focus for current industry contenders, including Tesla. Currently, the costs of manufacturing batteries for EVs remain the single highest factor impeding profitability on vehicle margins (Baik et al, 2019). By developing more technologically advanced batteries, vehicles will also perform better, serving to increase the demand for electric vehicles as well. As Teece remarks, "Incumbents will need to adapt, but the problem is to know which technology combinations are worth developing." (2018, pg. 508) Firms are trying to innovate in this field, but two different research paths have developed to pursue the advancement of either the lithium-ion battery or the solid-state battery. In recent years, Tesla announced a breakthrough in their R&D efforts with a lithium-ion battery that is capable of lasting a million miles over its lifespan, more than double what the current expectations are (Oberhaus, 2019). Although they have yet to implement this technology in their cars, this may be a significant future competitive advantage. In contrast, other major competitors like Ford, Toyota, and Daimler have decided to invest millions of dollars into the development of solid-state batteries which are lighter, nonflammable, and can significantly increase the range of EVs (O'Dell, 2019). However, no breakthroughs have been made so far in this avenue either. Toyota in particular has been developing this technology for years, and it is not expected to be ready for widespread commercialization until 2026 (O'Dell, 2019). However, Tesla's new "4860" battery (unveiled in 2020) holds promise, as it will have 5 to 6 times the energy and power capacity of previous generations, while significantly decreasing the cost.[8] Considering this outlook, the firm will likely maintain a healthy advantage in this space.

Tesla has historically had many hurdles to overcome with manufacturing, most famously in hitting its goal of producing 5,000 Model 3 cars per week (Sherman 2018). In comparison, the incumbents in the automobile industry have had decades to perfect their mass production

[8] https://electrek.co/2022/02/18/tesla-produced-1-million-next-gen-4680-battery-cell/

process. The Gigafactory is the proposed solution to both source the batteries needed to hit production goals and reduce costs through economies of scale. These massive, highly automated factories are located around the globe, with the largest factories in Nevada, Fremont, and China. Two more gigafactories in Berlin and Texas are also currently being built. The location and specialization of factories allow for versatility and ease of distribution in the supply chain operation. With reduced battery and manufacturing costs over time, Tesla's gigafactories are highly valuable assets as the reduction of costs and utilization of economies of scale are crucial for mass production and expansion.

A current challenge for EV manufacturers is the global supply chain shortage of battery ingredients. A number of different factors have led to this shortage, like increased demand for batteries and the Russia-Ukraine conflict, which has caused prices in the global commodity market to soar.[9] Nickel, cobalt, lithium, and graphite are some of the battery metals that have been affected by these price shocks. Observing the supply chain, China is the top refiner of raw materials in lithium-ion battery production as well as the top producer of graphite. Although the price shocks will likely subside, it is important to note the dependency on imported metals that the U.S. and Europe have on battery producing and metal refining countries.[10] Managing relationships with these producers and refiners will be key for the success of manufacturers and political supporters of EVs.

There are two limiting aspects of my analysis for Tesla. First, industry secrecy makes it difficult to understand any firm's true position with respect to its competitors. Second, due to the fast rate of new developments and news, my research may cease to be accurate after a short

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9 https://insideclimatenews.org/news/28032022/russias-war-in-ukraine-reveals-a-risk-for-the-ev-future-price-shocks-in-precious-metals/

10 https://elements.visualcapitalist.com/ranked-top-25-nations-for-battery-metals/

period of time. Future work may build on mine by analyzing more recent developments and data as well as the impact of newer models released in the market.

## 5. Barriers and Promoters of EV Adoption

Electric vehicle adoption is increasing at a rapid pace, yet there are still barriers to overcome for consumer adoption. One barrier is range anxiety, which refers to the fear of running out of electricity while driving. Consumers want a dependable car that can last many miles on a single charge. However, this is not as much of an issue today as it was in the past as many current EV models have ranges of 200-500 miles, comparable to the range of gas fueled cars.[11] However, it is important to note that higher range models are generally more expensive. Besides range, charging infrastructure and cost are two of the most important barriers. In 2019, IEA reported there to be about 7.3 million chargers globally, of which 6.5 million were private residential chargers, with the remainder being public.[12] Public charging stations increased by 60% in that year, with 31% of new development being fast charging stations. As time passes, charging infrastructure should increase greatly as governments pass bills supporting infrastructure. Electric vehicles are also typically more expensive than ICE cars upfront (average of $10,000 higher than the industry average transaction price) but with lower operational costs over its lifetime of usage.[13]

To address these barriers, policy plays a key role in supporting adoption of EVs. In the U.S, the Biden administration recently announced a plan to build 500,000 charging stations by 2030 by giving states $5 billion in funding over 5 years through the Bipartisan Infrastructure

[11] https://insideevs.com/news/566954/bev-epa-range-comparison-february2022/
[12] https://electrek.co/2020/06/15/electric-car-charge-points-data/
[13] https://www.cnbc.com/2021/12/29/electric-vehicles-are-becoming-more-affordable-amid-spiking-gas-prices.html

Law.[14] This law also provides about $7 billion to support the U.S. battery supply chain, and $10 billion for electric transit and school buses. Other types of policy, like tax rebate and credit programs, are important in decreasing consumer costs of owning an electric vehicle. These policies help to further incentivize people to go electric. Policies banning the sale of ICE vehicles may also be in effect in the near future as countries around the world like France, the UK, Norway, Sweden, and many others seek to phase out conventional cars within the next two decades.[15]

## 6. Conclusion

The rapidly growing and dynamic EV market will dramatically change transportation in the future. We are still in the early stages of this transition but it is exciting to imagine how the market will continue to develop as costs of production decrease and charging infrastructure expands. In any case, governmental policy will greatly contribute to EV adoption as countries seek to decarbonize. Competitively, EV companies will likely face more pressure from new entrants as automobile companies shift further and further towards electric. To keep an edge in the market, factors like brand value, manufacturing economics, and battery technology will all play a role in differentiating brands and maintaining competitive advantages.

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14 https://highways.dot.gov/newsroom/president-biden-usdot-and-usdoe-announce-5-billion-over-five-years-national-ev-charging

15 https://www.transportenvironment.org/discover/end-fossil-fuel-car-eu-agenda

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