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Assessing the Future Trajectory of the China's Electric Vehicle Industry：A Mini-Review of the Greenhouse Gas Emissions in Beijing and Shenzhen

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Abstract. Electric vehicles (EVs) have emerged as a promising solution to mitigate environmental degradation caused by transportation. The increased concerns over climate change and air pollution have accelerated the adoption of EVs globally. The use of renewable energy sources such as solar and wind power to charge EVs significantly reduces the emission of harmful gases, contributing to cleaner air and a healthier environment. The transition to EVs has the potential to create a significant positive impact on the environment, reducing the carbon footprint of the transportation sector. This study will explore the potential benefits of EVs for reducing greenhouse gas emissions, air pollution, and noise pollution. Furthermore, this research will consider the impact of EVs on the energy grid and investigate the feasibility of integrating renewable energy sources to power EVs. The study will also examine the economic and social implications of EV adoption and the potential for job creation in the EV industry. The findings of this research will contribute to a better understanding of the role that EVs play in mitigating the environmental impact of transportation. This research is especially relevant as the world moves towards a more sustainable and decarbonized future. Policymakers, industry leaders, and consumers can use the insights gained from this study to make informed decisions about the future of transportation and its impact on the environment. In conclusion, this study aims to provide a comprehensive assessment of the environmental impact of EVs and their potential to create a sustainable future for transportation.

1. Introduction

The utilization of electric vehicle has garnered increasing attention globally as a means to mitigate dependence on traditional fossil fuel-based transportation systems [1]. Recent research indicates that there has been a significant increase in the proportion of electric vehicle in the global vehicle fleet, with electric vehicles accounting for 4.1% of the total in 2021 [2], representing a significant increase from 2.5% in 2020 [2-3]. Given the pressing need to address these issues, the focus on electric vehicles as a means to reduce dependence on fossil fuels and mitigate emissions is of paramount importance [4]. Additionally, the finite nature of natural resources such as coal and petroleum further emphasizes the necessity to transition towards sustainable transportation solutions [5]. China, as one of the world's most populous countries, faces a particularly pressing need to address transportation-related issues stemming from its large population. The reliance on traditional transportation systems that consume fossil fuels has resulted in significant emissions of carbon dioxide and other greenhouse gases, which have a detrimental impact on the environment and contribute to global warming and climate change, as well as exacerbating respiratory illnesses in humans [6-7]. In recent years, the Chinese government has continued to prioritize the development of new energy vehicle (NEVs), with all provinces closely monitoring new policies and formulating implementation methods [8]. The success of these efforts varies due to differences in economic development levels and environmental factors. In this project, we aim to analyze the environmental impact of NEVs in China by focusing on the overall situation in the country and two representative cities, Beijing and Shenzhen, which have successfully implemented the policy of public vehicle electrification [9]. Additionally, to analyze the global trend of NEVs, activity data from the government database and scientific journals for the number of NEVs worldwide and one typical highly developed country, the UK, with significant scientific and technological influence are collected and analysed [10]. The data collected over the last 10 years includes the number of NEVs, the proportion of conventional vehicles and NEVs, energy consumption per 100km for Electric

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vehicles (EVs) and internal combustion engine vehicles (ICEVs), fuel production for various types of vehicles, charging station and facility data, and the total amount of greenhouse gas emissions for conventional and NEV vehicles [11]. The main objective is to generate a comprehensive analysis of the influence of the environment and energy consumption in China and forecast the future EV market by comparing conventional vehicles and NEVs using the collected data [12].

2. Methodology

The proposed analysis of the environmental impact of electric vehicles involves gathering data on environmental indicators from both new energy and traditional internal combustion engine vehicles [12]. To start, data is collected on the whole life cycle CO_2 emissions from various types of vehicles, including ICEVs, HEVs, PHEVs, and BEVs, in China, measured in gCO_2/km. The whole life cycle CO_2 emissions value is an important indicator of the vehicle's environmental impact and helps determine the extent to which Electric vehicle can reduce this impact. Other harmful gas emissions, such as volatile organic compounds, nitrogen oxides, PM2.5, and SO_2, are also collected for comparison [13]. After comparing the whole life cycle CO_2 emissions and harmful gas emissions in China as a whole, two representative cities, Shenzhen and Beijing, are selected for further analysis. The volume of emissions, including CO_2 and black carbon, from traditional and electric vehicle during manufacture and in operation are collected and compared to provide an intuitive view of the impact of Electric vehicle on the environment in China [14].

To understand the global trend in the future of Electric vehicle, annual sales and market shares over the past ten years are analysed, as well as the lifetime CO_2 emissions in the UK and the state of EV charging globally, including the number and speed of chargers. The environmental impact, charging conditions, sales, and market share data can be used to deduce the future global trend of electric vehicle [15]. However, in order to draw more accurate conclusions, a more comprehensive analysis of emissions data for both EVs and internal combustion engine vehicles is still required. Additionally, this study does not consider the potential advantages that internal combustion engine vehicles may have over EVs, which could impact the future marketing trend of the industry. Nevertheless, this research provides valuable insights into the future of the EV industry [16].

3. Results and Discussions

Two cities, Beijing and Shenzhen, were selected for analysis as they are typical examples of cities with high Electric vehicle (EV) usage in China (**Figure 1**) [9, 17]. The data for various gas emissions in these cities was collected and used to create the figures presented. The figures show that EVs do not emit volatile organic compounds (VOC) during fuel transport in either Beijing or Shenzhen, with only small amounts produced during fuel production. On the other hand, internal combustion engine vehicles (ICEVs) emit similar levels of VOC in both cities. In terms of nitrogen oxide (NOX) emissions, fuel transport for EVs in Beijing produces almost triple the amount compared to Shenzhen [18]. The average NOX emission produced by ICEV fuel production is slightly higher in Beijing compared to Shenzhen, while fuel production for EVs in both cities does not produce any NOX. The emission of sulfur dioxide (SO_2) from fuel transport for EVs in Beijing is larger than in Shenzhen, while the average SO_2 emission from ICEV fuel production is larger in both cities. Fuel production for EVs in both cities does not produce any carbon dioxide (CO_2), while ICEV fuel production results in significant CO_2 emissions. Black carbon (BC) emissions from conventional vehicles in both cities are similar, with EVs producing less BC than conventional vehicles [9]. Fuel transport for EVs results in higher PM2.5 emissions in Beijing compared to Shenzhen, while total PM2.5 emissions from ICEVs are similar in both cities. Overall, EVs have lower levels of various types of pollutants compared to ICEVs and provide an advantage in terms of environmental protection [19].

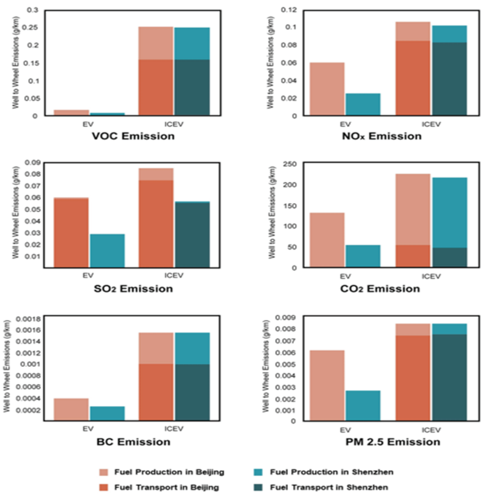

Fig. 1. Comparative analysis of fuel production and transport between Beijing and Shenzhen [9,17].

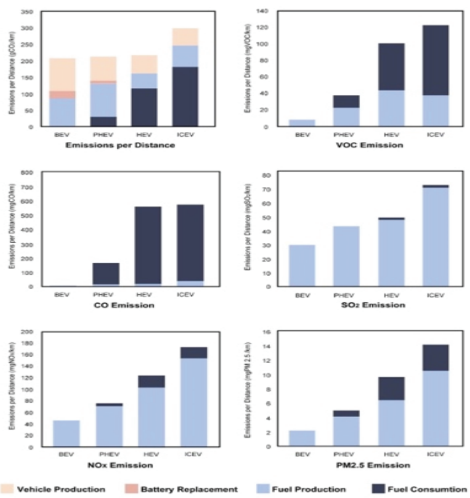

Fig. 2. Fuel consumption, fuel production, battery replacement, and vehicle production with a lifetime distance [20].

A study of data from two cities in China was carried out to shed light on the status of Electric vehicle. The graph depicts the evaluation of four vehicle categories with regards to fuel consumption, fuel production, battery replacement and vehicle production using a lifetime distance of 150,000 km in 2017 (**Figure 2**) [20]. The findings indicate that, in terms of total emissions per distance, BEVs exhibit the lowest emissions while ICEVs demonstrate the highest. In fuel consumption, ICEVs produced the greatest emissions (gCO_2/km), followed by HEVs, whereas BEVs don't have any fuel consumption as they are fully battery powered. As for fuel production, PHEVs had the largest CO_2 emissions, whereas HEVs had the smallest. Only PHEVs and BEVs had emissions related to battery replacement. BEVs had the highest emissions per distance in terms of vehicle production, while ICEVs had the lowest. In conclusion, BEVs appear to have the most significant potential for reducing CO_2 emissions among the four vehicle categories, while ICEVs produced the most CO_2 emissions per distance [21].

The use of Electric vehicles not only contributes to environmental protection, but also proves to be a cost-effective option. The data presented in the graph was gathered in the UK in 2019 and the cumulative lifetime emissions were based on a mileage of 150,000 km over a 12-year period (**Figure 3**). The blue bars represent the average conventional car, while the red bars depict new EVs. It demonstrates that EVs have a relatively stable and consistently low level of CO_2 emissions throughout their lifetime. In contrast, the average conventional car initially has lower CO_2 emissions during the first four years of its lifetime compared to EVs, but its emissions gradually increase over time. Overall, EVs possess a clear advantage in controlling CO_2 emissions, and their energy usage costs are comparatively lower than those of conventional cars.

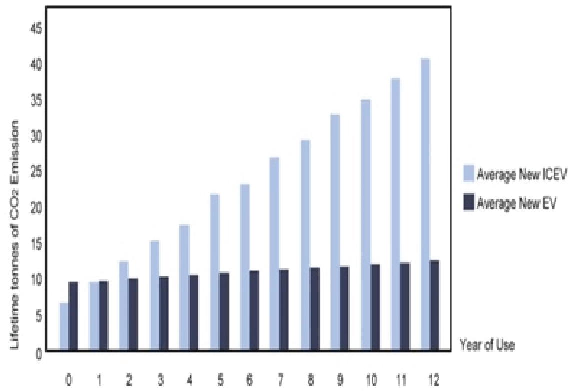

Fig. 3. Lifetime tonnes of CO_2 emission vs Year of use [21].

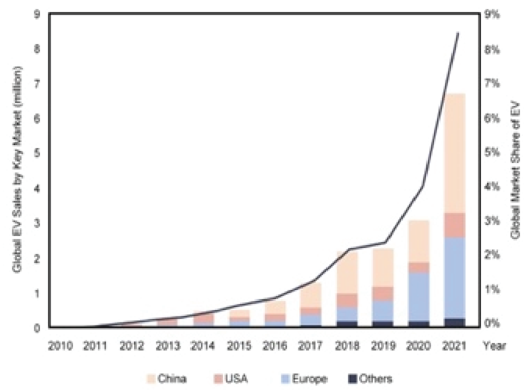

Fig. 4. Global EV sales by key market from 2010 to 2021 and global market share [22].

The benefits of environmental protection and energy efficiency are gaining increasing recognition worldwide, supported by growing empirical evidence. According to data from the International Energy Agency (IEA), the global sales of EVs have seen significant growth in recent years, with 6.4 million EVs sold in 2021, constituting 96% of worldwide EV sales, in the three regions of China, the US, and Europe [20]. China has played a significant role in EV sales, accounting for 51% of sales in 2021, followed by Europe at 34% and the US at 10%. The global market share of EVs has also increased dramatically, rising from nearly 0% (2010) to 8.57% (2020) (**Figure 4**) [22].

This change can largely be attributed to national emission reduction plans. For example, in China, the Communist Party of China Central Committee and the State Council issued guidance in 2021 to reach carbon peaking in 2030 and carbon neutrality in 2060, with a focus on developing a green, low-carbon, circular economy and reducing CO2 emissions [23]. The automotive industry transformation, including the growth in EV sales, was emphasized in these documents. Similarly, Europe and the US have implemented policies to promote EV sales, such as Europe's Passenger Vehicle Carbon Dioxide Regulation and Zero- and Low-Emission Vehicle Regulation. One data analysis has resulted in the creation the projected sales of Electric vehicles (EVs) in 2025 and 2030 [24-25]. The data predicts that EV sales will reach approximately 20 million in 2025 and over 45 million vehicles in 2030. Furthermore, the data indicates that China and Europe will account for more than half of the total number of electric vehicle by 2030, suggesting that EVs are becoming more widely accepted in these regions [26-27].

4. Conclusion

In conclusion, the evidence suggests that electric vehicle have a more favorable environmental impact compared to traditional internal combustion engine vehicles. Our analysis of the emissions data from China indicates that electric vehicle emit fewer hazardous and greenhouse gases over their entire lifecycle, from production to recycling. The trend of global new energy vehicle sales has seen exponential growth in recent years, particularly in China and Europe, and in the UK, for example, electric vehicle have been shown to have lower CO_2 emissions and operating costs than conventional vehicles after just four years of use. However, there are still barriers to widespread adoption of electric vehicle, such as cost and access to charging infrastructure. To overcome these obstacles, it may be necessary for new energy vehicle companies and governments to take steps such as lowering the cost of vehicles, increasing the availability of charging stations, and promoting the benefits of these vehicles through public education campaign.

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