

# Transport Electrification: Opportunities and Future Challenges

Xianzhi Bi<sup>1, †</sup>, Wenqing Li<sup>2, †, \*</sup>, Hengjie Zhang<sup>3, †</sup>

<sup>1</sup> Beijing Royal School, Beijing, 102209, China

<sup>2</sup> China (Hong Kong) English School, Guangdong, 528402, China

<sup>3</sup> No.1 Middle School of Linyi, Shandong, 276002, China

\* Corresponding Author Email: 20148227@stu.sicau.edu.cn

†These authors contributed equally.

**Abstract.** In 2016, transport emissions (mainly involving roads, railways, aviation and maritime transport) accounted for more than 24% of global carbon dioxide emissions. It is also expected to grow faster than any other sector, which poses a major challenge to efforts to reduce emissions in accordance with the Paris Agreement and other global goals. Each year there is a remarkable growth in vehicles that emit massive amounts of greenhouse gases, which highly contribute to climate change. So, it is essential to reduce carbon emissions by changing transport. Electric cars, trucks, and buses produce no tailpipe emissions and thus help reduce local air pollution. Moreover, buses typically run on diesel fuel or compressed natural gas, emitting nitrogen oxides and sulfur dioxide that reduce air quality and are eliminated by electrification. The theme of this paper is to study the fundamental reasons and limitations of the electrification of transport. The research methods of this paper are as follows: Firstly, search relevant documents and obtain information that can use. Secondly, sort out information and then conclude. Research shows that the need for electrification of transport is because it is environmentally friendly, has lower costs for customers compared to conventional vehicles, and gives benefits to the power grid. However, several limitations that are inevitable and hard to be solved in a short period are brakes to the development of electric vehicles (EVs). Although the ultimate shift from internal combustion vehicles (ICEs) to EVs is inevitable, the market structure is fragmented, complex and emergent.

**Keywords:** Electrification; transportation; electric vehicle; power grid.

## 1. Introduction

Under certain scenarios of transforming transportation, the word electrification meant replacing traditional fuel cars with electric vehicles (EVs) [1, 2]. EVs have low maintenance, which is especially attractive to fleet operators. Commercial power rates for fleets are lower than residential; fleets offer access to more financial instruments to finance the initial high costs for EVs; EVs in fleets can help meet corporate greening goals [3]. From the perspective of EV owners, the electrification of transport is beneficial for its lower maintenance cost, power cost and initial cost due to local policies. On the other hand, governments are happy to see that EVs can help reduce pollution. Apart from driving around in EVs. The electrification of transportation also meant the infrastructure used to power fuel cars is going through a stage of transition to serving EVs.

### 1.1. The market for electrification

The electrification of transportation has a century-old history. According to the article "Courting and sparking: wooing consumer's interest in the EV market", from 1801 to 1900, EVs entered the marketplace, and from 1901 to 1950, EV production inks. Then, from 1951 to 1999, EVs renewed interest due to the high oil price. Then, since 2000, there has been increased interest in EVs. Clearly, the electrification of transport always has a share of the market and is gaining interest over time. The interest in EVs has directly affected the sales of these vehicles. In the same passage, in 2011, the Asia Pacific region only had less than 100,000 EVs sold. However, in the year 2017, there were more than 600,000 EVs sold in the same region [4]. According to Inflationdata.com, the historical oil price between the years 2011 to 2017 are experiencing significant fluctuation. The balanced oil price

between 2011 to 2014 was 114.65\$ to 107.08 (balanced for inflation). However, there was a significant drop in 2015, when the oil price fell to 52.31\$ (balanced). Even after the drop in fuel prices, the sales of EVs still increased at a steady rate [5]. There is no major correlation between total EV sales and oil prices. However, the price of the power source is still a major factor for people when considering a car.

## 1.2. Actions from the government

For the effort needed to electrify traffic, individual efforts are insufficient, and the process involves government support. A passage named "Charging infrastructure experiences in Norway – the world's most advanced EV market" mentioned policies of the Norwegian government over zero emission cars. These policies, such as "no purchase taxes, exemption from reading toll, or free access on state ferries," are especially desirable for individual car owners. This method of policy is not alone in the world. In China, where the number of plate numbers is planned, EVs have an advantage over getting a plate number than traditional fuel-powered cars. The government's power does not only include incentives for people to purchase such cars but also building charging stations and battery swapping stations to aid these cars [6]. Governments are particularly capable of breaking the "chicken or egg" problem for EVs as the government builds and maintains charging stations. In the same passage, the fast-charging infrastructure increased from more than 200 in 2014 to more than 1400 in 2017 [6]. Also mentioned in the passage "Vehicle Electrification: Status and Issues", Denmark will spend 100 million dollars on EV infrastructures like charging stations or battery swapping stations [3]. The support of the government may be crucial for the electrification of transportation. It is a benefit to the power grid (PG) and the development of the PG, which can support the huge number of EVs in the future. Furthermore, bringing cars closer to the grid, and promoting the combination of electrification and digital technology, will make a big difference. Trading patterns for PGs and EVs will also become complicated. It will also impact the grid in a short period because of the high load. There will be some challenges in the future, such as battery energy density and vehicle design. Nevertheless, there are ways around this.

## 2. Higher demand

### 2.1. Reduction in CO<sub>2</sub>

EVs that are purely electric can reduce air pollution while operating because their energy sources are from the battery packs but not fuel. One of the most common types of battery used in EVs is lithium-ion batteries, which can be recharged and reused. The current situation with charging stations that serves such vehicle is their power. More specifically, some charging stations are still powered with coal-generated electricity. In certain countries that rely mostly on fossil fuels for generating electricity, charging an EV in these countries means a larger carbon footprint. However, even though the electricity may be fossil fuel powered, EVs still benefit the climate. China and other coal-dependent countries have reduced their greenhouse gas emissions from using EVs by 20%. For countries that rely less on fossil fuels, clean energy makes EVs more environmentally friendly. Although EVs will not cause too much impact on air pollution on the road, they may be harmful if electric vehicle batteries are not manufactured responsibly. Almost all electric vehicle emissions are the wheel emissions generated in the battery production process. Certain production methods or processes may lead to a larger Co<sub>2</sub> emission amount for Electric vehicles. However, that has begun to change. The carbon footprint of electric vehicle batteries today is two to three times lower than two years ago, becoming cleaner and cleaner. With new requirement from the car industry and contractors, the manufacturing process are transforming into a more environmentally friendly stage. Some brands require their factories to run on renewable energy such as solar, wind, or tidal. With the transformation under its way, it is expected that the carbon footprint per vehicle in the future will shrink.

One of the main obstacles electric vehicle manufacturer's faces is the production of functional, light vehicles. Traditional materials are hard to achieve a large range and smaller footprint, which

lighter EVs have. Nevertheless, comparisons can be made between recycled, organic materials and traditional materials. They are lighter, better for environments and with stronger durability. Recycled materials are used in small parts by many conventional manufacturers. However, currently, these materials do not participate in manufacturing vehicle structures. In order to create vehicles with lighter weight and higher efficiency, they are improving environmental-friendly materials. The only advantage of using recycled, organic materials is weight loss which is also better for the environment. New materials, for example, metals and plastics, are unsustainable and polluting. The environmental impacts are minimized during and after EV production using natural or recycled materials [7].

## 2.2. Lower maintenance cost

EVs require less maintenance since manufacturers design them with considerations of maintenance and safety, and also, they publish guidelines. All EVs generally require less maintenance than traditional vehicles because there are fewer fluids and moving parts to maintain in EVs than in fuel cars. Also, fewer fluids and reduced wear to breaks lead to the result. Unfortunately, due to the material property of batteries, they have a lifespan of a certain amount of recharge-discharge cycle. As the number of cycles affects the battery, the capacity of the battery will decrease during the process. Some automotive battery systems use liquid coolant to maintain a safe operating temperature. Such systems will only function properly as the vehicle is maintained and inspected regularly to ensure reliability of such systems.

Batteries in EVs are usually designed to last the expected life of the vehicle. Like traditional car engines, advanced EV batteries are designed to extend their life but eventually wear out. Although comprehensive data on EV battery failures are unavailable, some manufacturers provide an 8-year/100000-mile warranty on their EV batteries. As manufacturers will not stop people from replacing their batteries by price, changing an overused battery is expected to be a huge cost. Also, some cars with certain designs fixed their batteries to the chassis and are hard to replace. However, battery prices are expected to decline as technology advances and production increases [8]. Another possibility to lower battery prices is recycling used-up batteries and remaking new ones. This may be the future of EVs, as the elements for making batteries are limited in the earth's crust, and recycling costs less than mining and extracting raw materials.

## 3. The PG

The electrification of transportation has a profound impact on the PG. The power network is called the whole substation and transmission and distribution lines of various voltages in the power system. It contains three units of transformation, transmission and distribution. The task of a power network is to transmit and distribute electrical energy and change the voltage [9]. Two parts are concentrated here: advantages and disadvantages.

On the plus side, electric-vehicle-to-grid technology will help stabilize the PG and meet the growing demand for EVs while also facilitating the development of the grid because the development of transportation electrification and the development of the grid are inextricably linked to each other, just like a fish cannot leave the water. It has a certain impact on PG planning, which can reduce the peak-valley difference of the PG, smooth the PG's load and frequency fluctuation, reduce the PG's demand for standby power generation capacity, and significantly change the operation mode of the PG. Smart power management can charge EVs when electricity demand is low, such as late at night or early morning, and send power back to the grid when demand is high [10]. Moreover, it can be evenly distributed throughout the day in terms of daily power consumption, which is often very different between peaks and troughs. It could even store renewable energy in a car battery when needed. This greatly reduces the load pressure of the PG in different periods and makes the whole technology more flexible and convenient. At the same time, the electrification of transport will be combined with digital technology, which will make a huge difference. Moreover, power companies are in a key position to develop this, helping to build a stronger infrastructure of charging stations

and ensuring that EVs are well integrated into the grid, as well as studying the potential problems of the future of transportation electrification.

From the disadvantages, the urban rail transit with high power and high-speed load is connected to the urban PG on a large scale, which brings a strong impact force. Influence of temporary fast charging on PG load. Due to the increase in battery capacity and power demand after the large-scale application of EVs in the future, the charging power and battery capacity of a single electric vehicle will be unimaginable. EVs will account for 30% of all vehicle sales by 2030 and a half or more of all vehicles by 2040, and the large number of EVs will cause a huge load on the undeveloped PG. At the same time, it also has an impact on power quality. Electric vehicle charging is a variable current operation mode, so it is necessary to strictly control the harmonic and other technical indicators of electric vehicle charging equipment. The grid and electric vehicle trading model will change from simple to complex, which requires the support of more advanced electricity markets. These shortcomings also represent deficiencies and opportunities for development. When perfected, it will be a different situation.

#### **4. Limitations**

When electrification was moving very fast, there were some limitations. This is why the electrification of transport has not yet been fully achieved. At the same time, these limitations are unavoidable when a new concept is introduced to people, such as consumer awareness, familiarity, and the ability to accept new things [11]. In other aspects, many problems cannot be avoided. For example, the high production cost is also a big problem in the early stage. At the same time, it also needs to mention the PG. As mentioned above, transportation electrification will cause a certain load and impact the PG, reflecting a problem: the lack of available charging infrastructure. Limited by battery technology, battery energy density is insufficient to provide ideal driving power [11]. The only way to increase the battery pack is to improve the vehicle's driving range. Electrification has not yet been completed, and the availability of models is limited.

Regarding vehicle design, all self-owned and joint venture brands sold off the spot are directly using traditional fuel cars or slightly modified, with no characteristics of chassis and body structure. At the same time, engineers will face some obstacles, such as control software, electric motors and other problems. These are not small issues, which will be part of the importance of electrification of transportation. There are some problems to be solved in the future. To address these issues, some groups have also developed effective plans: raising awareness about EVs, investing in infrastructure such as PGs and charging stations, ensuring that EVs can be charged when they are cheapest, and trying to design different models using different materials [11]. If these restrictions are improved, the road to transportation electrification will be smoother and faster.

#### **5. Conclusion**

Through investigation, it is clear that the electrification of transportation results from climate change and market behaviors. As electrification provides governments with less air pollution and greenhouse gases, governments are happy to provide subsidies for people moving to EVs. Governments also encourage electrification by providing infrastructures such as charging stations or battery swapping stations, giving people incentives to shift from fuel cars to EVs. Apart from government support, the concept of being environmentally friendly is getting more widespread among consumers, who believe their behavior would help protect the world. Another advantage of such vehicles is lower cost. Whether from power sources or daily maintenance, EVs cost less to own and operate.

However, there are inevitably obstacles faced for transformations, one of the most common things people encounter in life. For the aspect of vehicles themselves, the demand for solutions is increasing the power of the car and the motors. These required advances in more novel materials and better

technologies. On the other hand, more infrastructures are needed, such as charging stations or battery swapping stations. The development of transportation electrification will bring the load to the PG, but it also greatly promotes the development of the PG. The relationship between cars and the PG is increasingly close, which will make consumers get more welfare and significantly improve their quality of life. At the same time, there will be some challenges along the way, battery energy density, consumer awareness and the ability to accept new things. There is also the design model of the car and the control software, and the motor also needs a more advanced model.

## References

- [1] Wang, S., Ge, M., "Everything you need to know about the fastest-growing source of global emissions: Transport," World Resources Institute, 16 October 2019, <<https://www.wri.org/insights/everything-you-need-know-about-fastest-growing-source-global-emissions-transport>> (4 October 2022).
- [2] Dewing, C., "The electrification of transport," Future Agenda, 6 August 2019, <https://www.futureagenda.org/the-electrification-of-transport/> (4 October 2022).
- [3] Boulanger, A. G., Chu, A. C., Maxx, S., Waltz, D. L., "Vehicle electrification: Status and issues," Proceedings of the IEEE 99(6), 1116–1138 (2011).
- [4] Kar, N. C., Iyer, K. L. V., Labak, A., Lu, X., Lai, C., Balamurali, A., Esteban, B., Sid-Ahmed, M., "Courting and sparking: Wooing consumer' s interest in the EV market," IEEE Electrification Magazine 1(1), 21–31 (2013).
- [5] McMahon, T., "Historical crude oil prices (table)," InflationData.com, 10 August 2022, <<https://inflationdata.com/articles/inflation-adjusted-prices/historical-crude-oil-prices-table/>> (4 October 2022).
- [6] Lorentzen, E., Haugneland, P., Bu, C., Hauge, E., "Charging infrastructure experiences in Norway-the world's most advanced EV market," EVS30 Symposium, 1-11 (2017).
- [7] "How are electric vehicles better for the environment?" samsara, <<https://www.samsara.com/guides/how-are-electric-vehicles-better-for-the-environment/>> (4 October 2022).
- [8] "Maintenance and safety of electric vehicles," Alternative Fuels Data Center: Maintenance and Safety of Electric Vehicles, <[https://afdc.energy.gov/vehicles/electric\\_maintenance.html](https://afdc.energy.gov/vehicles/electric_maintenance.html)> (4 October 2022).
- [9] "Grid. Baidu Baike," <https://baike.baidu.com/item/%E7%94%B5%E7%BD%91/1250763?fr=al> (4 October 2022).
- [10] Team, D., "What is electrification of Transportation?" Driivz, 24 July 2022, <<https://driivz.com/glossary/transportation-electrification/>> (4 October 2022).
- [11] "Transportation electrification." Western Resource Advocates, 30 March 2021, <<https://westernresourceadvocates.org/clean-energy-and-climate/revitalizing-the-economy/transportation-electrification>> (4 October 2022).