

Electric Cars: The Green Transportation of the Future

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ABSTRACT: The paper studies the advantages and disadvantages of electric cars over fossil fuel cars in the context of climate change and increasingly serious environmental pollution. The paper points out that electric cars can reduce greenhouse gas emissions and air pollutants, save operating and maintenance costs, and are suitable for urban transportation. The paper also addresses challenges and solutions for developing electric cars, such as improving charging infrastructure, recycling batteries, and using renewable energy sources to produce electricity. The paper concludes that electric cars are an irreversible trend in the transportation sector and have great potential to become the green transport of the future

Keywords: environmental pollution, emissions, greenhouse effect, electric cars.

I. INTRODUCTION

Cars are one of the most popular means of transport in the world, but also one of the main causes of climate change and environmental pollution. According to the Organisation for Economic Co-operation and Development (OECD), the transport sector accounted for about 23 % of global CO₂-Emissions in 2018, of which 74 % came from fossil-fuel-cars [1]. In addition, cars also emit air pollutants such as NO_x, CO, HC, PM, SO₂, O₃, and heavy metals, affecting the health of humans and living organisms. [2] In this context, electric cars are considered an effective solution to minimize the negative impact of the transport sector on the environment and the climate. An electric car is an automobile that uses one or mehr electric motors to convert electrical energy in mechanical energy to operate the vehicle. [3] Electric cars come in different types, such as battery-electric-vehicles (BEVs), hybrid-electric-vehicles (HEV), plug-in-hybrid-electric-vehicles (PHEVs) and fuel-electric-vehicles (FCEVs) [4]. Electric cars have many advantages over fossil fuel cars, such as zero direct emissions, savings in

operating and maintenance costs, and suitability for urban transportation.

However, electric cars also face some challenges and limitations, such as improving charging infrastructure, recycling batteries, and using renewable energy sources to produce electricity. Dienes article will study the advantages and disadvantages of electric cars versus fossil-fuel-cars in the context of climate change and increasingly serious environmental pollution.

II. ADVANTAGES OF ELECTRIC CARS

2.1 Reduce greenhouse gas emissions

Greenhouse gases are gases capable of absorbing and reflecting infrared radiation from the Sun, increasing the Earth's surface temperature [5]. Greenhouse gas emissions mainly include CO₂, CH₄, N₂O, O₃ and fluorocarbons. Greenhouse-gas-Emissions are of natural or man-made origin, of which the transport sector is one of the largest sources of emissions.



Fig. 1. Earth at risk of 1.5 degrees Celsius warming as CO₂ emissions rise

According to the World Meteorological Organization's (WMO) Annual Report on Climate in 2020, the amount of CO₂ in the air reached a record high of 410 ppm in 2019, an increase of 148% compared to pre-industrial-era-levels [6]. The amount of CO₂ in the air tends to increase each year, due to human activity, especially the burning of fossil fuels. CO₂ is the longest-lived

greenhouse gas in the air, lasting hundreds of years. According to the Intergovernmental Panel on Climate Change (IPCC) Special Report on Climate Change (IPCC) in 2019, to keep global temperatures below 1,5°C above pre-industrial-era-levels, CO₂-Emissions must be reduced by about 45 % by 2030 and reach equilibrium by 2050 [7].

To achieve this goal, the transition from fossil-fuel-cars to electric-cars is one of the important measures. According to a study by the US National Institute of Transportation Studies (NREL) in 2018, electric cars could reduce CO₂-Emissions from the transportation sector by about 1,5 billion tons by 2050, equivalent to 32 % compared to the absence of electric cars [8]. Diese ist based on the Assumption, that electric-car-ownership will increase from 1,5% in 2018 to 58 % in 2050, and dass electric-energy-sources will gradually shift to renewable-types. In addition, electric cars can also reduce CH₄ and N₂O emissions due to fossil fuel production and consumption [9]. According to a study by France's National Institute for Energy and Environment (IFPEN) in 2019, electric cars can reduce CH₄ and N₂O emissions from the transport sector by about 80 % compared to fossil fuel cars. Diese ist based on the Assumption, that electric-car-ownership will increase from 2 % in 2015 to 80 % in 2050, and dass electric-energy-sources gradually shift to renewable-types.

2.2 Minimize air pollutants



Fig. 2. FSchool-friendly electric cars reduce pollution

Air pollutants are substances that are harmful to human and living organisms when inhaled or exposed [10]. Air pollutants mainly include NO_x, CO, HC, PM, SO₂, O₃ and heavy metals. Air pollutants are of natural or man-made origin, of which the transport sector is one of the largest sources of emissions. According to the World Health Organization (WHO), air pollution is one of the leading causes of respiratory, cardiovascular, cancer and death diseases in the world[11]. According to the WHO, about 4.2

million people die each year from outdoor air pollution, of which about 29% are due to cardiovascular disease, 27% to chronic obstructive pulmonary disease, 22% to lung cancer, and 14% to pneumonia. According to WHO, about 91 % of the world's population lives in areas with air quality that does not meet WHO-standards. To minimize the amount of air pollutants from the transportation sector, switching from fossil-fuel-cars to electric-cars is one of the effective measures. Electric cars do not emit air pollutants directly when operating, thus minimizing human and living organism exposure to these substances [12]. According to a study by the US National Institute of Transportation Studies (NREL) in 2018, electric cars could reduce the amount of air pollutants from the transportation sector by about 50 % by 2050, compared to the case without electric cars [8]. Diese ist based on the Assumption, that electric-car-ownership will increase from 1,5% in 2018 to 58 % in 2050, and dass electric-energy-sources will gradually shift to renewable-types. In addition, electric cars can also reduce the amount of indirect air pollutants when using electricity produced from renewable energy sources such as solar, wind, hydropower, biomass and biogas [13]. According to a study by France's National Institute for Energy and Environment (IFPEN), in 2019, electric cars can reduce the amount of air pollutants from the transport sector by about 90 % compared to fossil fuel cars, if electricity is produced from renewable energy sources [9] – This is based on the assumption that the percentage of electric-car-ownership will increase from 2 % in 2015 to 80 % in 2050, and electric-energy-sources will gradually switch to renewable types [9].

2.3 Save operating and maintenance costs

The operating and maintenance costs of cars are among the important factors influencing consumers' decision to buy a car[14]. The operation and maintenance costs of the automobile include fuel costs, maintenance costs, repair costs, and tax costs. The operation and maintenance costs of electric cars are generally lower than fossil-fuel-cars, due to a number of reasons:

1. Electric motors are more efficient than internal combustion engines, thus consuming less energy to operate the vehicle. [15] According to a study by the US National Institute of Transportation Research (NEL) in 2018, the efficiency of electric motors is about 77 %, while the efficiency of internal combustion engines is about 22 % [8]. Diese means, dass electric cars only need about a quarter of the energy of fossil-fuel-cars to travel the same distance.

2. The price of electricity is usually cheaper than the price of gasoline, so the fuel cost of electric cars is usually lower than that of fossil-fuel-cars [16]. According to a report by the National Electric Vehicle Association (EDTA) in 2020, the fuel cost of electric cars is about \$0.03 per mile, while the fuel cost of gasoline cars is about \$0.13 per mile. This means that electric cars only need about a quarter of the cost of gasoline cars to travel the same distance.

3. Electric motors have fewer moving parts than internal combustion engines, so they are less prone to wear and failure and also require less maintenance and repair. [17] According to a report by the Organization for Economic Co-operation and Development (OECD) in 2019, the maintenance and repair costs of electric cars are about 35 % of those of gasoline-cars. This means that electric cars only need about 1/3 of the cost of gasoline cars to stay running.

However, the operation and maintenance costs of electric cars can also fluctuate according to factors such as electricity prices, battery prices, vehicle prices, and national and local tax and fee policies. According to a study by the US National Institute of Transportation Studies (NREL) in 2018, the operation and maintenance costs of electric cars can be higher or lower than gasoline cars, depending on different scenarios [8]. For example, if electricity prices are high, battery prices are high, car prices are high, and there are no preferential policies for electric cars, then the operation and maintenance costs of electric cars can be 50 % higher than those of gasoline cars. Conversely, if electricity prices are low, battery prices are low, car prices are low, and there are preferential policies for electric cars, the operation and maintenance costs of electric cars can be 50 % lower than gasoline cars.

2.4 Suitable for urban traffic

Urban transport is the type of traffic that takes place in a densely populated area, has many different types of transport, has many intersections and high traffic pressure [17]. Urban transport has such characteristics as: short distances, low speeds, frequent stops and starts, and a lot of noise and smog. Urban transport causes many environmental and health problems, such as: increasing greenhouse-gas-emissions and air pollutants, consuming more energy and fossil fuels, causing traffic jams and accidents, and reducing people's quality of life. To solve these problems, the use of electric cars is one of the effective solutions. Electric cars are suitable for urban transport for the following reasons:

1. Electric cars do not emit air pollutants directly when operating, thus helping to improve the air quality and the attractiveness of people in urban areas [12].

2. Electric cars are more efficient than fossil-fuel-cars, thus saving a lot of energy and operating costs when moving in urban areas [16]. According to a study by the US National Institute of Transportation Studies (NREL) in 2017, electric cars have an average efficiency of about 60 %, while gasoline cars only have an average efficiency of about 20 % [15]. This means that electric cars only need to use about 1/3 of the energy compared to gasoline cars to travel the same distance.

3. Electric cars have the ability to regenerate energy when braking or decelerating, thus increasing the life of the battery and minimizing the amount of energy consumed when traveling in urban areas [17]. According to a study by the US National Institute of Transportation Studies (NREL) in 2017, electric cars can regenerate about 10 % of the energy consumed when traveling in urban areas [15]. This means that electric cars can save about 10 % of energy compared to gasoline cars when traveling the same distance.

4. Electric cars have a lower noise level than fossil-fuel-cars, thus helping to reduce noise and improve the quality of life of people in urban areas [18]. According to a study by the US National Institute of Transportation Studies (NREL) in 2017, electric cars have an average noise level of about 55 dB, while gasoline cars have an average noise level of about 75 dB [15]. This means that electric cars make about 20 dB less noise than gasoline-powered cars, which is equivalent to the difference between a hairdryer and a jet.

5. Electric cars are more compact in size than fossil-fuel-cars, thus saving parking space and moving in urban areas [19]. According to a study by the US National Institute of Transportation Studies (NREL) in 2017, electric cars have an average size of about 4.2 m, while gasoline cars have an average size of about 4.6 m [15]. This means that electric cars take up about 0.4 m less space than petrol cars, which is equivalent to the difference between a motorcycle and a bicycle [20].

III. DISADVANTAGES OF ELECTRIC CARS

3.1 Limitations of charging infrastructure

The charging infrastructure system is one of the important factors affecting the popularity and development of electric cars. Charging infrastructure includes equipment and facilities to

provide electricity to electric cars, such as public charging stations, home charging, wireless charging, and fast charging. The charging infrastructure system needs to meet the quantity, distribution, capacity, safety and convenience needs of electric-car-users. However, at present, the charging infrastructure system of electric cars still faces some limitations and challenges, such as:

The number and distribution of public charging stations are inadequate and uneven across regions and countries [21]. According to a report by the National Electric Vehicle Association (EDTA) in 2020, there are about 7.3 million public charging stations in the world, of which 6 % are concentrated in China [22]. According to a report by the Organization for Economic Co-operation and Development (OECD) in 2019, the average ratio between the number of electric cars and the number of public charging stations is about 7:1 but can range from 2:1 to 40:1 depending on the country [23]. The Shortage and Unevenness of public charging stations cause many difficulties for electric-car-users to travel long distances or to different areas.

The capacity and duration of charging stations are low and long compared to petrol-filling-stations. According to a report by the National Electric Vehicle Association (EDTA) in 2020, the average power of public charging stations is about 50 kW, while the average power of petrol-filling stations is about 300 kW [22]. According to a report by the Organization for Economic Co-operation and Development (OECD) in 2019, the average time to fully charge the battery of an electric car is about 30 minutes, while the average time to fill up the petrol of a fossil-fuel-car is about 5 minutes [23]. The slowness and loss of time of charging stations causes many inconveniences and annoyances for electric-car-users when it comes to recharging vehicles.

1. The safety and convenience of charging stations are lacking and heterogeneous across regions and countries. According to a report by the Organization for Economic Co-operation and Development (OECD) in 2019, charging stations need to ensure the safety of users and vehicles when charging, such as avoiding the risks of fire, electric shock, battery damage and theft. In addition, charging stations also need to be convenient for users when charging, such as: have enough parking space, can pay in many forms, can be used with many different vehicles and batteries, and can be connected to smart applications. However, at present, standards and regulations on the safety and convenience of charging stations vary from region to region and country, causing

many troubles and difficulties for electric-car-users when using charging stations.

3.2. Battery limitations

The life of the battery is short compared to the life of the car. According to a report by the Organization for Economic Co-operation and Development (OECD) in 2019, the average battery life of electric cars is about 8 years, while the average life of vehicles is about 15 years. This means that electric-car-users may have to replace batteries at least once during vehicle-use, causing costs and annoyances for users. In addition, replacing batteries also causes problems with the Disposal and Recycling of old batteries, as old batteries can contain toxic substances and pose environmental and health hazards [25].

Battery safety is lacking and heterogeneous between different types of batteries. According to a report by the Organization for Economic Co-operation and Development (OECD) in 2019, the battery of electric cars needs to ensure the safety of users and vehicles when charging, operating, collision, or explosion [23]. However, battery safety standards and regulations vary between different types of batteries: lithium-ion batteries, lithium-polymer batteries, lithium-sulfur batteries, lithium-air batteries and metal-hydrogen batteries. The differences and heterogeneities of battery safety standards and regulations pose many risks and difficulties for electric-car-users when using different types of batteries.

The cost of the battery is high, compared to the cost of the car. According to a report by the Organization for Economic Co-operation and Development (OECD) in 2019, the average cost of batteries of electric cars is about 200/kWh, while the average cost of vehicles is about 30,000 \$. This means, that the cost of batteries accounts for about 40 % of the cost of the vehicle, which increases the cost of electric cars compared to fossil-fuel-cars. According to a study by the US National Institute of Transportation Studies (NREL) in 2018, the average cost of electric cars is about 35,000 USD, while the average cost of gasoline cars is about 25,000 USD [8]. The premium and non-competitive cost of electric cars reduces the attractiveness and accessibility of electric-car-users.

IV. CONCLUSIONS

Electric cars are among the effective solutions to minimize the negative impact of the transport sector on the environment and the climate. Electric cars have many advantages over fossil fuel cars, such as: reducing greenhouse-gas-

emissions and air pollutants, saving operating and maintenance costs, and being suitable for urban transportation. However, electric cars also face some challenges and limitations, such as Limitations in charging infrastructure, Limitations on batteries, and Limitations on electrical energy sources. To develop electric cars, it requires the cooperation and consensus of stakeholders, such as governments, businesses, scientists and consumers. Policies and regulations are needed to encourage and support the Production, Purchase, Sale, Use, and Recycling of electric cars. Research and innovation are needed to improve the performance, safety, and cost of electric cars. There is a need for campaigns and activities to raise people's awareness and attitudes about electric cars. Electric cars are an irreversible trend in the transportation sector and have great potential to become the Green Transport of the Future.

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