

Environmental Benefits of New Energy Vehicles: Co2 Emissions of Electric and Hybrid Vehicles

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Abstract. New energy vehicles (NEV) are considered vital to deal with environmental issues. NEVs use clean energy such as electricity and hydrogen as their fuel, allowing them to accomplish carbon-free emission during driving conditions. This paper analyses two major types of NEVs, electric vehicles and hybrid vehicles' carbon footprint through their lifecycle, including manufacturing, usage and end-of-life recycling. The results shows that NEVs have a significant advantage over ICEVs with respect to environmental benefits which they can bring. Although NEVs have a higher CO₂ emission in the manufacturing stage and the electricity largely comes from burning fossil fuels, the combined drawback is completely overshadowed by NEVs' high energy utilization rate and their green drivetrain.

Keywords: New energy vehicles; carbon footprint; co₂ emissions; environmental benefits.

1. Introduction

Since the industrial revolution, there has been a sudden surge in greenhouse gas emissions and pollutants into the atmosphere. These greenhouse gases and pollutants have exceeded the self-cleaning capacity of the atmosphere, and a series of environmental problems have arisen. With more and more natural disasters and extreme weather occurring, people have now realized the importance of environmental protection. Solutions are being implemented to solve the environmental problems, including the greenhouse effect. Among them, the automobile industry, as an important component of carbon emissions, is particularly important to reduce carbon emissions from the automobile industry. NEVs have become the focus of the automotive industry. NEV specifically refers to vehicles which use non-conventional automotive fuel as a power source. These vehicles not only integrate advanced technology in drivetrains and central control systems resulting to more efficient power output, but also fabricate with new structures so that their safety is enhanced [1]. In today's market, full-electric vehicles, hybrid vehicles hold the largest proportion of new energy vehicles. But these two kinds of cars, even if they are driven by green energy, they cannot achieve zero carbon emissions. Because in the two processes of vehicle manufacturing and end-of-life recycling, the battery packs will cause much more carbon emissions to be produced than the traditional internal combustion engine vehicles. As a matter of fact, hybrid cars also produce carbon emissions due to their internal combustion engine part during the driving phase of the vehicle. The electricity charged in a full-electric vehicle also contributes to carbon emissions from the electricity production process. Even so, during the driving phase, the environmental benefits of new energy vehicles such as electric vehicles and hybrid vehicles are much higher than those of gasoline-burning internal combustion engines. This study analyzes the carbon emissions of new energy vehicles and internal combustion engine vehicles in these three phases, finds that new energy vehicles can effectively reduce carbon emissions throughout their lifecycle. Moreover, the environmental benefits of the new energy vehicle industry will gradually increase as the industry matures.

2. The structure of hybrid and electric vehicles

This study chose to focus on two major types of vehicles, hybrid and full-electric vehicles. As hydrogen energy vehicles the rest types of NEV only take up a very small prestige of the entire NEV market. There are two kinds of hybrid modes. The first is the hybrid electric vehicle (HEV), and the

second is the plug-in hybrid electric vehicle (PHEV). Both of them share the same components: a battery, converter, electric generator, electric traction motor, and power electronic controller. PHEV is almost identical to HEV except for two components: the charge port and the onboard charger. These two parts give PHEV the ability to charge electricity through external power sources instead of just using the electric generator. Electric vehicles are powered by batteries and use an electric traction motor to drive the vehicle's wheels. The basic components of an electric vehicle are very similar to those of a hybrid vehicle, as both vehicles' powertrains are powered by batteries.

3. Carbon footprint of NEVs

3.1. NEVs have a larger carbon footprint than ICEVs in the manufacturing stage

Regardless of which types of power systems, electric vehicles and hybrid vehicles all use batteries. Typically, the manufacturing of these batteries requires a number of complicated procedures. From the mining and smelting of raw metals to the batching of positive and negative electrodes in the factory and the baking of the cells, these steps produce large amounts of carbon emissions. In these procedures, the mining of these raw materials is more polluting to the environment than the mining of common ores. Take the lithium batteries as an example, the GHG emissions of the production of batteries had the median values of 64 kg CO₂-eq kWh⁻¹ in 2021[2]. Based on this status quo, the global carbon footprint of the lithium-ion battery industry is expected to be very high over the next decade. Adding up each manufacturing step in the industry, the carbon footprint would amount to 1.0 gigatons of CO₂ equivalent per year. However, with conventional cars, their drive systems are manufactured by simply taking into account the processing of the raw metal. No additional chemical steps are required. For a standard medium-sized gasoline ICEV the embedded carbon in the production process is about 5.6 tons of CO₂ equivalent, of which about three-quarters is the steel in the vehicle's coasting unit [3]. But in terms of hybrid vehicle, plug-in hybrid vehicle and battery electric vehicle, each can produce 6.5, 6.7, 6.8t CO₂ in production [4]. It is difficult to specifically analyze the carbon footprint of each of the materials used to produce batteries based on the available literatures. But with the overall data it is easy to see that those three types of NEVs will produce more carbon emissions during production stage than present internal combustion engine vehicles.

3.2. The carbon emissions reduced in the driving stage

Many people would think that the carbon emissions produced by new energy vehicles in the process of using them are much smaller than those of internal combustion engine vehicles. After all, the former relies on electricity and does not produce any pollutants. But this conclusion does not take into account the fact that the process of generating electricity requires the combustion of large amounts of fossil fuels. Thermal power is still the dominant way to generate electricity, especially in developing countries. Burning fossil fuels, such as coal, and burning gasoline in automobiles both produce high levels of carbon emissions. Based on the available data on electricity generation, electric vehicles are likely to have greater emissions than vehicles powered by internal combustion engines. Compared to oil, coal produces about 1.22 times the amount of CO₂ emissions for every 1 Wh of energy generated. In addition, coal power plants are less efficient compared to compression-ignition engines which have the ratio of 1:1.8, while compared to thermal power plants using oil/diesel at a ratio of 1:1.4 [5]. It is clear that even though NEV may have a lean way of driving the car, their energy is still produced in the old and unclean way. However, the average energy consumption between the electric cars and standard gasoline cars tells a different story. Based on available data from literature, the average ICEV with petrol as fuel does 0.144 kg/km of CO₂, meanwhile ICEV with diesel has the emissions of only 0.109 kg/km of CO₂ [4] on the road. On the other hand, the average energy consumption per kilometer of electricity car is 0.182 kWh. Yet generate 1 kWh of electricity will emit 0.275 kg of CO₂ in The United Kingdom [5], 0.597 kg of CO₂ in Germany and 0.7212 kg of CO₂ in China [6]. Which demonstrates the result of less CO₂ emissions per kilometer for electric cars

than ICEV. Even in the developing country like China, the average CO₂ emissions per kilometer for electric cars is 0.1313 kg, which is still less than the figure of 0.144 kg/km for ICEV.

3.3. Comparison of carbon emissions with full recycling at end-of-Life

Most of the batteries in an ordinary full-electric car or a hybrid car are about 10 years of life. With the first batch of NEVs' batteries have reached the end of their service life, how to deal with these end-of-life batteries is a critical issue. Besides recycling can effectively solve the problem of the extra energy consumption and carbon emissions in the manufacturing process. The carbon emissions from the dismantling of end-of-life automobiles and the recycling of various parts and components account for about 4.5% of the total life-cycle carbon emissions. However, reusing recycled materials in production can effectively reduce carbon emissions in the production process. For instance, China, the biggest Electric Vehicle Market, recycling can bring a 5.1t of CO₂ reduction compared to the electric vehicle which not go through recycling [7], implying a 34% decrease of CO₂ emissions in production. It can be seen that by recycling electric and hybrid vehicles, the carbon emissions from their production process can be effectively reduced. This also mitigates the disadvantage that electric and hybrid vehicles emit far more carbon than internal combustion engine vehicles during the whole vehicle manufacturing stage. Making the environmental benefits they bring even more obvious. In Europe in 2021, BEVs already have more than 66% lower life cycle emissions than ICEVs. In China its 37% to 45%, 60% to 68% in the US, and 19% to 34% in India. Studies have also found that 20% of lifecycle GHG emissions can be lessened by using HEVs compared to conventional gasoline vehicles [2]. There is significant variation between regions, with today's mid-size PHEVs emitting 42%-46% less life cycle GHGs compared to gasoline vehicles in the U.S. and 25%-27% less in Europe. In the developing regions like China, the figure can be 6%-12% less, mainly due to the development of the electricity mix [2].

4. Future Developments of Electric and Hybrid Vehicles

In the foreseeable future, NEV will continue to be a hot topic in research fields. Some new innovations have emerged in recent years, including silicon anode batteries, lithium-sulfur batteries and recycling and second-use batteries. These batteries are aimed to elevate sustainability and energy storage capacity. Same development also occurs in the hybrid industry where energy management system has been improved. This system manages the current flows in the vehicle and coordinates multiple power sources efficiently. With the help of this system, the electricity can be organized and used more directly and without additional waste. Other studies on the energy efficiency of hybrid vehicles involve kinetic energy recovery systems [8]. For example, regenerative braking saves energy through braking choppers and multi-level inverters, thereby using inertia to recover some of the kinetic energy to charge the battery during normal driving to save energy. All these developments will inevitably make NEVs more efficient, sustainable and convenient to use. Therefore, NEVs will bring more and more environmental benefits in the future.

5. Summary

This paper discusses the CO₂ emissions of NEVs in their life-cycle. By dividing the life-cycle in to three main phases: manufacturing, usage, end-of-life recycling and summarizing the CO₂ emissions in each phase, the conclusion is that NEVs have a significant advantage over ICEVs with respect to environmental benefits which they can bring. Although NEVs have higher CO₂ emissions in the manufacturing stage and the electricity largely comes from burning fossil fuels, the combined drawback is completely overshadowed by NEVs' high energy utilization rate and their green drivetrain. To achieve further breakthroughs in environmental benefits brought by NEVs, energy restructuring is therefore fundamental. As the electricity production chain and energy intensity are key to reducing emissions from pure electric vehicles. The cleanliness of the future energy mix is

closely linked to emissions from the road transportation sector. Moreover, promoting energy conservation and emission reduction in relevant industrial fields, such as metal smelting, chemical industry, painting, rubber, battery manufacturing, etc., will be of great significance in enhancing the life cycle emission reduction effect of vehicles.

Reference

- [1] Wei, Y., & Huang, M. (2023). The Technology and Development of New Energy Vehicles. *Highlights in Science, Engineering and Technology*, 29, 93-104.
- [2] Bieker, G. (2021). A global comparison of the life-cycle greenhouse gas emissions of combustion engine and electric passenger cars. *Communications*, 49(30), 847129-102.
- [3] Kallitsis, E., Lindsay, J. J., Chordia, M., Wu, B., Offer, G. J., & Edge, J. S. (2024). Think global act local: The dependency of global lithium-ion battery emissions on production location and material sources. *Journal of Cleaner Production*, 449, 141725
- [4] Towoju, O. A., & Ishola, F. A. (2020). A case for the internal combustion engine powered vehicle. *Energy Reports*, 6, 315-321.
- [5] Loughran, J. (2017). Carbon emissions associated with UK's electricity generation have halved since 2012. *Eng Technol*. Retrieved May, 1, 2019.
- [6] Gu, B., Tan, X., Zeng, Y., & Mu, Z. (2015). CO₂ emission reduction potential in China's electricity sector: scenario analysis based on LMDI decomposition. *Energy Procedia*, 75, 2436-2447
- [7] Hao, H., Qiao, Q., Liu, Z., & Zhao, F. (2017). Impact of recycling on energy consumption and greenhouse gas emissions from electric vehicle production: The China 2025 case. *Resources, Conservation and recycling*, 122, 114-125.
- [8] Hannan, M. A., Azidin, F. A., & Mohamed, A. (2014). Hybrid electric vehicles and their challenges: A review. *Renewable and Sustainable Energy Reviews*, 29, 135-150.