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Environmental Impact Analysis of the Whole Life Cycle of Pure Electric Vehicles

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Environmental Impact Analysis of the Whole Life Cycle of Pure Electric Vehicles

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Abstract. Based on the method of life cycle assessment, this paper makes a comprehensive analysis of the environmental impact of pure electric vehicles in the three most important stages of automobile manufacturing, automobile use and vehicle scrap recovery. The environmental problems caused by pure electric vehicle and traditional fuel vehicle represented by Santara are compared. The results show that the total energy consumption of the pure electric vehicle is 60.8% of that of the fuel vehicle in the whole life cycle, and the energy consumption of the traditional fuel vehicle is 58.6% of that of the pure electric vehicle in the automobile manufacturing stage, but the emission of pollutants is higher. In the use stage of the vehicle, the energy consumption of the pure electric vehicle is that of the fuel vehicle. The energy consumption of pure electric vehicles is 52.2% of that of fuel vehicles, and the emissions of pollutants are still lower than those of fuel vehicles. Generally speaking, the energy consumption and pollutant emission of pure electric vehicles in the whole life cycle are lower than those of traditional fuel vehicles. Therefore, under the national policy of sustainable development, the state should vigorously advocate and subsidize the development of pure electric vehicles.

Keywords: full life cycle evaluation; pure electric vehicle; energy consumption; pollutant discharge.

1. Introduction

China has a large population base, so far it still has the largest car ownership in the world. A total of 3.2432 million passenger cars were sold from January to February 2019, and 1.2195 million passenger cars were sold in February, according to the China Automobile Industry Association. However, with the increasing number of cars, the environmental pollution of traditional fuel vehicles is becoming more and more serious. The transportation industry consumes 40% of the world's fossil fuel carbon emissions accounting for nearly 25% of the world's total and produces nearly 50% of CO,HC,NOx, and other compounds. Environmental problems are becoming more and more serious. Electric car owner It can be divided into three categories: pure electric vehicle, hybrid electric vehicle and fuel electric vehicle. The pure electric vehicle is the direct utilization of electric energy, and it is the technical basis of the other two types. Therefore, this paper mainly focuses on the pure electric vehicle as the research object. Compared with fuel vehicles, electric vehicles have attracted more and more attention from automakers and buyers because they are pollution-free and clean energy. Even so, the issue of environmental protection for electric vehicles is still controversial. Although electric vehicles do not produce pollution emissions that are harmful to the environment at the use stage, their electricity comes from the burning of coal and only moves pollution from the city to the suburbs. In that proces of manufacturing and scrap recovery, great environmental pollution is still caused. Therefore, it is necessary to comprehensively analyze and evaluate the energy consumption and emission pollution caused by the environment during the whole life cycle of production, use and scrap recovery of the pure electric vehicle. Under the concept of sustainable development, our government should vigorously promote the development and innovation of the electric automobile industry

2. Research methods and data

2.1. research methods

According to ISO14040:1999, the definition of Life Cycle Assessment (Life Cycle Assessment, LCA) refers to "the Life Cycle of a product system input, output, and its potential environmental impact of assembly and evaluation, including contact each other, constantly repeated four steps: the determination of the purpose and scope, inventory analysis, impact Assessment and interpretation results.

In this paper, life cycle assessment include car manufacturing, the use of the car, the car of the scrap recycling process, three at the same time, according to the < regulations of motor vehicle compulsory standards miles traveled 600000 km which meet rejection standard, therefore, in this paper, a car driving 600000 km as evaluation unit, to fuel cars and pure electric vehicles in the whole life cycle of all pollution emissions inventory analysis and environmental impact analysis to compare.

2.2. subjects

In China, the total car ownership of civil cars keeps rising. In 2017, the car ownership of civil cars was 108.76 million (national bureau of statistics 2017), and in 2018, it was 134.51 million (national bureau of statistics 2018). Therefore, this paper takes civil cars as the research object, and takes into account such factors as typicality and market share when selecting various representative models. Gao yubing took the 2007 jingchang santana as the representative of the traditional fuel car in the analysis and evaluation of the energy saving and emission reduction effect of the new energy car based on LCA. Santana was listed in China in 1985, with a long sales time and a large market share. In 2010, it ranked the sixth among all kinds of car brands in China with the sales volume of 211,000 cars. Therefore, the 2007 santana sedan is selected as the representative of the traditional fuel car. In the full life cycle evaluation of electric vehicles, liu kaihui took byd E6 pure electric vehicle as the research object. Domestic byd is the most representative in mainland China automobile brand leader in electric field and at the same time, the company in 2011 and released by the E6 all-electric vehicles once listed will evoke a strong repercussion among the pure electric vehicle industry, sales straight up. The model 2015 sales of byd new energy vehicles in 89. %, therefore this article selects the E6 is the representative of pure electric vehicles.

2.3. research data and materials

2.3.1. Environmental pollution in the automobile manufacturing stage. The mass of a vehicle generally includes the dry mass of the vehicle when it is empty plus the coolant and fuel (no less than 90% of the tank capacity) and the total mass of the vehicle accessories. In the process of automobile manufacturing, only the main components of the automobile are generally considered, and some factors that have weak influence on the quality of the automobile or little influence on the environment are ignored. After excluding the above neglected factors, the proportion of the main components of the automobile in the total mass is obtained.

According to the data calculation in table 1, the environmental pollution caused by automobiles in the manufacturing stage can be obtained, as shown in table 1.

Table 1. Energy consumption and environmental pollutant emissions during the automobile manufacturing phase

Car type	Energy consumption/KJ	Environmental pollutant emission coefficient/10^-3						
		CO_2	CO	SO_x	NO_x	dust	CH_4	VOC
conventional car	9.50×10^7	7.63×10^6	7.63×10^6	1.32×10^5	6.5×10^4	1.27×10^5	1.71×10^4	4.94×10^2
Pure electric vehicles	1.62×10^8	1.18×10^7	2.03×10^5	1.07×10^4	2.99×10^4	1.95×10^5	2.64×10^4	7.61×10^2

It can be seen from table 1 that compared with conventional fuel vehicles, pure electric vehicles generate more energy consumption and environmental pollutant emissions in the manufacturing stage. Therefore, in the field of automobile manufacturing, China should improve the technology and use updated materials to replace the car body, so as to reduce the quality of the car body and reduce energy consumption and environmental pollutant emissions.

2.3.2. Environmental pollution in the use stage of automobiles. At present, most of the civil traditional fuel cars on the market in China mainly use 93# gasoline, so this paper takes 93# gasoline as the fuel of the traditional fuel car as the research. According to the 2018-2019 national electricity supply and demand situation analysis and forecast report of China power union, the types of power generation in China are: 350 million kilowatts of hydropower, 1.14 billion kilowatts of coal power, 44.66 million kilowatts of nuclear power, 180 million kilowatts of wind power, and 170 million kilowatts of solar power, with the proportions of 18.42%, 60%, 2.35%, 9.48% and 8.95% respectively. It can be seen that China is still dominated by thermal power generation, while the power source of pure electric vehicles is mainly relying on thermal power generation. According to the mandatory scrapping standard for motor vehicles, when the driving distance reaches 600,000 km, the scrapping standard will be reached. Therefore, in this paper, 600,000 km is used as the scrapping standard for two types of vehicles, so as to obtain the data of energy consumption and environmental pollutant emission in the driving stage, as shown in table 2.

Table 2. Energy consumption and emission of environmental pollutants in the driving stage

car type	Energy consumption/KJ	Environmental pollutants discharge coefficient / 10^{-3}						
		CO_2	CO	SO_x	NO_x	dust	CH_4	VOC
conventional car	2.40×10^9	1.79×10^8	1.43×10^6	2.59×10^4	1.43×10^5	4.30×10^4	1.91×10^5	1.18×10^5
Pure electric vehicles	1.36×10^9	9.74×10^8	1.91×10^4	4.81×10^4	5.72×10^4	1.57×10^5	1.25×10^5	8.33×10^3

It can be seen from table 2 that compared with conventional fuel vehicles, pure electric vehicles generate more energy consumption and environmental pollutant emissions in the manufacturing stage. Therefore, in the field of automobile manufacturing, China should improve the technology and use updated materials to replace the car body, so as to reduce the quality of the car body and reduce energy consumption and environmental pollutant emissions.

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Table 3. Energy consumption and emission of environmental pollutants in the driving stage

car type	Energy consumption/KJ	Environmental pollutants discharge coefficient / 10^{-3}						
		CO_2	CO	SO_x	NO_x	dust	CH_4	VOC
conventional car	2.40×10^8	1.79×10^8	1.43×10^6	2.59×10^4	1.43×10^5	4.30×10^4	1.91×10^5	1.18×10^5
Pure electric vehicles	1.36×10^9	9.74×10^8	1.91×10^4	4.81×10^4	5.72×10^4	1.57×10^5	1.25×10^5	8.33×10^3

It can be seen from table 3 that there is not much difference between the two models in terms of environmental protection, and pure electric vehicles do not show strong environmental advantages.

2.3.4. Environmental pollution in the stage of automobile scrap recycling. After the car reaches 600,000 kilometers and reaches the scrapping standard, it will usually be sent to the scrapping factory for dismantling and recycling. However, China's automobile scrap recycling industry is still in its infancy, and the processes, operating procedures, and recycling technologies are not very standardized. Therefore, only some metal materials are considered for recycling. The specific waste recycling and consumption of pollutants and pollutants are shown in Table 4.

Table 4. Energy consumption and environmental pollutant emission at the stage of vehicle scrap recovery

car type	Environmental pollutants discharge coefficient / 10^{-3}						
	CO_2	CO	SO_x	NO_x	dust	CH_4	VOC
conventional car	1.71×10^5	2.73×10	6.65×10^2	2.59×10^2	1.31×10^2	6.03×10^2	1.52×10^1
Pure electric vehicles	4.68×10^7	7.60×10^2	1.82×10^4	7.10×10^3	3.57×10^3	1.65×10^4	4.09×10^2

3. Result analysis

3.1. Total energy consumption throughout the life cycle

The total energy consumption of the two similar vehicles in the manufacturing, use and scrap recycling stages is shown in Table 5.

Table 5. Energy consumption over the life cycle of an automobile

Full life cycle	Energy consumption/KJ	
	conventional car	Pure electric vehicles
Manufacturing stage	9.50×10^7	1.62×10^8
On stage	2.40×10^9	1.36×10^9
Scrap stage	1.99×10^6	5.14×10^8
Total	2.50×10^9	2.04×10^9

It can be seen from table 5 that in the whole life cycle, the total energy consumption caused by pure electric vehicles is 60.8% of that of fuel vehicles. In the automobile manufacturing stage, the energy consumption of traditional fuel vehicles is 58.6% of that of pure electric vehicles. In the use stage, the energy consumption of pure electric vehicles is 56.7% of that of fuel electric vehicles. In the car scrapping stage, the fuel car is 52.2% of the pure tram. The energy consumed in the driving stage

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accounts for the largest proportion of the total energy, among which the proportion of fuel cars is as high as 96%.

3.2. *emission of pollutants around the whole life*

The main environmental pollutants discharged in the three processes of automobile manufacturing, driving and scrapping and recycling are carbon dioxide, carbon monoxide, sulfide, nitrogen oxide, methane and dust, etc. It can be seen from table 6 that the carbon dioxide emitted by two similar cars is the highest, followed by carbon monoxide.

Table 6. The total pollutant emissions in the whole life cycle

car type	Environmental pollutants discharge coefficient / 10^{-3}						
	CO2	CO	SOx	NOx	dust	CH4	VOC
conventional car	1.89×10^8	1.55×10^6	9.58×10^2	1.64×10^5	1.67×10^5	2.10×10^5	1.19×10^5
Pure electric vehicles	1.14×10^8	2.19×10^5	2.24×10^5	9.27×10^4	3.78×10^5	1.57×10^5	1.02×10^4

4. Conclusion

This paper comprehensively adopts the method of full life cycle evaluation, and comprehensively evaluates the life cycle of traditional fuel vehicles and pure electric vehicles. The results show that in terms of energy consumption: both fuel-efficient vehicles and pure electric vehicles consume the most energy during the driving phase of the vehicle, accounting for 96% and 66.67% of the total energy consumption respectively; and in the manufacture of automobiles and In the scrap recycling phase, pure electric vehicles consume more energy than conventional fuel vehicles, but pure electric vehicles consume less energy than conventional fuel vehicles. As far as environmental pollution emissions are concerned: CO_2, CO, SO_x, NO_x, dust, etc., pure electric vehicle emissions are more environmentally friendly than conventional fuel vehicles.

References

[1] vegetable seed kun, guo qiaoying, vegetable xiang. Environmental protection of garbage power generation to promote the development of electric vehicles [J]. China new technology and new products, 2012, 22 (135): 24-26.
[2] wang liwei. Investigation and reflection on the response to energy and protection of electric vehicles instead of fuel vehicles [J]. Inner anal technology, 2018 (4): 138-139.
[3] China association of automobile manufacturers, world automobile organization.2011 oica China essays [M]. Shanghai: tongji university press, 2011.
[4] xue xiuyuan, xue yueyuan. Discussion on environmental protection of electric vehicles [J]. Shanxi chemical industry, 2017 (3): 145-148.
[5] liu kaihui. Full life cycle evaluation of byd E6 pure electric vehicle [D]. Fuzhou: fujian university of agriculture and forestry, 2016.
[6] Gao yubing, MAO xianqiang, Yang shuqian, et al. Analysis and evaluation of energy-saving and emission reduction effects of new energy vehicles based on LCA [J]. Journal of environmental science, 2013 (5): 1504-1512.
[7] wang qian, zhang xu, huang zhijia. Energy consumption and pollutant emission inventory analysis of building materials production based on LCA [J]. Environmental science research, 2007 (6): 149-53.
[8] wu juanni, wan hongyan, Chen weiqiang, et al. Energy consumption and greenhouse gas emission accounting of China's primary aluminum industry [J]. Journal of tsinghua university, 2010, 50 (3): 407-410.
[9] Jiang J l, dai J f, feng w J, et al. Life cycle evaluation of electrolytic copper production by fire and wet processes [J]. Journal of lanzhou university of technology, 2006 (1): 19-21. (in Chinese).

[10] Yan junhua, wang shuxiao, yuan haoran, et al. Energy consumption and gas emission analysis and environmental impact assessment of electric vehicles [J]. Journal of south China university of technology (natural science edition), 2018 (6): 137-144.
[11] EGEDE DETTMER T, might C, et al., Life cycle assessment of electric vehicles - a framework to consider influencing factors [J]. Procedia CIRP, 2015, 29: 233-238.