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Impact of Electric Vehicle on Energy and Environment

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***Abstract*— China's current energy is made up of a large amount of coal, a small amount of oil and lack of gas., so since 2005, the National Development and Reform Commission has proposed to develop clean vehicles such as hybrid vehicles, gas vehicles and so on. After that, the Chinese government gave a series of supportive policies to vigorously promote the development of electric vehicles, but there are still some objections to whether electric vehicles are conducive to energy conservation and emission reduction. This article analyzed energy and emission impact of electric vehicles from the whole process of life cycle of electric vehicles. Results show that all conventional atmospheric pollutants for electric vehicles will be lower than conventional gasoline vehicles in 2050, while NOx, PM, and SO2 emissions increased in the near future. Through the above methods, it provides a theoretical basis for the future development of electric vehicles in China.**

***Index Terms*— Electric vehicle; Emission; Energy; Life cycle assessment;**

I. INTRODUCTION

With the rapidly development of China's economy and vehicle, the energy consumption of the transportation has grown rapidly from 35 million tons of coal in 1980 to 424 million tons of coal in 2013 [1]. In addition, oil consumption in 2015 reached 543 million tons [2], of which the transportation accounted for about 35% in China [3]. The rapidly increasing and widespread use of vehicles has intensified energy consumption and environmental pollution, as a result, import rate of oil increase repeatedly, and environment get worse in China.

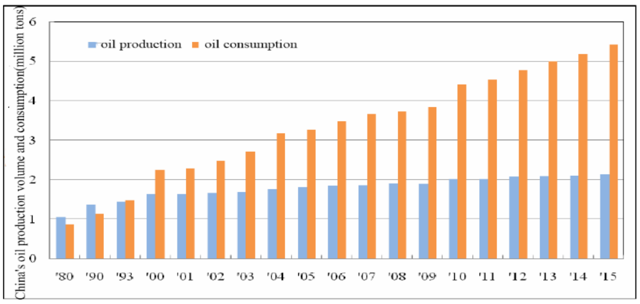

Fig.1 production and consumption of oil in 1980-2015 in China

According to data from the Ministry of Environmental Protection, NO_x emission increased up 6.278 million tons, accounting for 30.2% of the country's total emissions in 2014 [4]. So, it is very necessary to advocate clean travel in the future. As an efficient way, electric vehicle gain more and more attention around China, however, the power of electric vehicles is electricity which is a secondary energy, the common interest of our government and people is whether electric vehicle can achieve real-energy saving and emission reduction benefits in China.

II. THE METHODS

This part uses the full life cycle assessment（LCA）of EVs to calculate the energy consumption and emission of electric vehicles. The LCA includes fuel cycle, vehicle cycle and basic supporting facilities cycle. Where the fuel cycle refers to the power from raw materials (raw coal, oil, natural gas) to consumption during vehicle travel. And vehicle cycle refers to the batteries from raw material to end-of-life, and basic supporting facilities cycle refers to charging stations, battery replacement stations [5], etc.

A. The impact on energy.

We record total energy consumption for the entire life cycle of a product as E_{wtp}, showed in Eq.(1) and Eq.(2), Energy consumption calculation as shown in Eq.(3):

$$E_{wt} = \sum_{i=1}^{4} E_{wt,i} \qquad (1)$$

$$E_{wt,i} = E_i(1) + E_i(2) + \cdots E_i(n) \qquad (2)$$

$$E_{total}(t) = \sum_{i=1}^{4} Q_i(t) \times L_i(t) \times E_{wt,i}(t) \qquad (3)$$

Where i refer to different types of primary energy consumption, (i=*1.2.3.4*=coal, oil, gas and non-fossil energy), $E_{wtp,i}$ is the energy consumption intensity, and E_i(n) represents the total energy consumption intensity during a cycle, $Q_i(t)$ is the amount of vehicle powered by i, $L_i(t)$ is average annual mileage, and $E_{total}(t)$ is total energy consumption for the entire life cycle of the vehicle.

B. The impact on emission.

Today, a few amount of electric vehicle ownership has a little influence on environment, but we do not know what effect on emission caused by the development under the benchmark scenario power structure, the article try to clearly understand this by calculating. The expression is:

$$P_{s,total}(t) = \sum_{i=1}^{3} Q_i(t) \times L_i(t) \times P_{s,wti,j}(t) \quad (4)$$

Where t represent the year, $Q_i(t)$ is the amount of vehicle, $L_i(t)$ is average annual mileage, $P_{s,total}(t)$ refer to the total emission, s is different pollutant (CO, HC, NO_x, SO_2, VOCS)

$$P_{s,wti,j} = \sum_{j=1}^{6} \sum_{n=1}^{\infty} \sum_{k=1}^{4} P_{s,wti,k,j}(n) \quad (5)$$

Where $P_{s,wtp,j}$ refer to emission from different cycle (n) or different stage (k).

III. RESULTS AND DISCUSSION

According Eq.(1)- Eq.(3), we can calculate the fact that under the benchmark scenario power structure, coal electricity still accounts for 55% of the total electricity in 2050, which means this is also mainly electricity power, and obtain Fig.2:

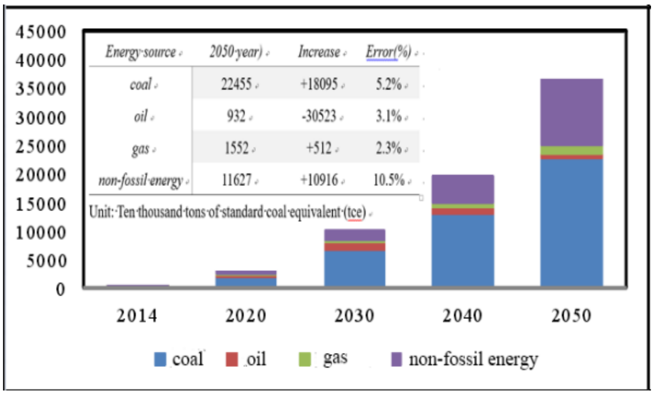

Fig.2 The impact of electric vehicle on energy

As seen from Fig.2, there are different influence on different energy sources. All in all, the amount of oil is 932tce in 2050, decreased about 30523tce, which means the development of electric vehicle can reduce oil effectively, while the amount of coal, gas and non-fossil energy is 22455tce, 1552tce and 11627tce respectively, all of those increase about 18095tce, 512tce and 10916tce respectively, which means when the large-scale development of electric vehicle under the benchmark scenario power structure in the case of a significant replacement of oil consumption, still need to increase a large number of coal and certain gas consumption, which caused by the way of generating electricity from coal. At the same time, there are an increase in growth rate of coal and non-fossil energy, however, the growth rate of gas is decrease gradually.

By Eq.(4) and Eq.(5), article gain the pollutants emission intensity and life cycle total pollutant emissions of EVs, the result show in Table. I and Table.II. As we can see from Table.1, only emission intensity of VOCs and CO in GICEV is higher than PEV and PHEV, and which is average about 1.5 times. However, other emission intensity in GICEV of the NO_x, HC, SO_2, PM is smaller compared to PEV and PHEV, which is average around between 30%-70%.

Table.I The calculation results of vehicle LCA pollutants emission intensity (Gram/km)

	VOCs	CO	HC	NO_x	SO_2	PM
PEV	0.03	0.5	0.91	1.38	1.36	0.75
PHEV	0.31	0.61	0.89	1.02	0.99	0.61
GICEV	0.72	0.83	0.7	0.42	0.48	0.4

PEV: Pure electric vehicle

PHEV: Plug-in hybrid electric vehicle

GICEV: Gasoline internal combustion engine vehicle

Table. II The life cycle total pollutant emissions of EVs in baseline scenario (0.01 million tons)

	VOCs	CO	HC	NO_x	SO_2	PM
EVs	14.3	92.36	250.02	207.09	18.9	26.09
GICEV	199.47	218.43	277.22	63.43	6.53	5.04

EVs: Electric vehicle

By pollutants emission intensity, the article gain the total emission and complete the analysis in 2050, the result show in Table.II. By which we can conclude that the life cycle total pollutant emissions include VOCs, CO, and HC under baseline scenario are less than total emission caused by GICEV, and decrease amount about 185.17, 126.07 and 27.2 respectively. On the contrary, the total pollutant emissions of NO_x, SO_2 and PM caused by EVs are more than GICEV's, the increase amount is 143.66, 12.37 and 21.05 respectively.

Above all, which indicate that since current electric vehicle power is mainly derived from coal power generation in China, which is benefit at fossil energy saving and oil substitution during LCA, but the increase in coal demand during the whole life cycle will lead to the emission of pollutants such as NO_x, PM and SO_2 has increased significantly, which is against with national development strategy of tackling climate change and reducing air pollution. So it is necessary to develop the clean energy, such as nuclear power, hydropower and so on.

Based on the results, for the next step of electric vehicle in China, there are three suggestions. Firstly, the development of electric vehicle should be closely adapted to the national power development trend. Secondly, promoting the development of electric vehicles should focus on the combination of new energy and smart traffic network. On the other hand, no matter enterprises and governments should improve the scrap recycling program for driving batteries as soon as possible to optimize the final disposal process. In one word, the development of electric vehicles in China is still in the exploratory stage, and it is necessary to balance the influencing factors to achieve the concept of sustainable development.

IV. CONCLUSION

Based on the result of the life cycle total pollutant emissions and energy of EVs, the following conclusions can be drawn:

1) Compared to GICEV, electric vehicle can reduce the amount of oil used in transportation and help solve the problem in oil in China.
2) Due to electric power come from coal, so until 2050, the development of electric vehicle decrease pollutant emission VOCs, CO, and HC, but increase pollutant emission of NO_x, PM and SO_2.
3) In order to achieve the goal of reducing emissions and saving oil, the development of electric vehicles is an inevitable trend, but the Chinese government needs to make efforts to improve electric vehicle technology and formulate sound development strategies.

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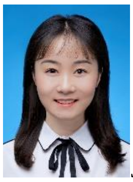
AUTHOR PROFILE

**Juan Wang**, She was born on September 1993 in Gansu Province, China. She is a graduate student at the Shandong University of Technology, and major in Transportation Engineering. Her research direction is the Vehicle Emissions.

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