

Case Study: Collaborative Solutions to Air Pollution in China through Electric Vehicle Promotion

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Abstract: China is facing environmental issues which might urge the sustainability development of China. Due to globalisation, rapid growth of urbanisation and industrialization have brought environmental issues such as disaster, air pollution, water pollution and others. This has brought tremendous impact on the environment, people's health and wealth. In this research, air pollution will be the main problem of the study and discussing how the government, corporations and society make joint effort towards electric vehicles. The transformation from gasoline vehicles towards electric cars will be the main focus on solving the air pollution of this research. The Chinese government has implemented lots of policies, subsidies and regulations on promoting electric cars. Besides, the government provides subsidies and tax breaks for both car manufacturers and the public to increase the production and adoption of electric cars. Furthermore, the government also invests heavily on the infrastructure of the charging station to develop the sustainability of the electric car industry. Chinese companies also respond to the government policies to promote local electric vehicles. The government policy has created lots of car manufacturers such as BYD, Nio and Xpeng which produce high quality and affordable electric cars to the public. Furthermore, Chinese companies also invested in batteries of EVs which are the main components of EVs. The two largest battery manufacturers are also from China which are BYD and CATL that become the largest supplier of the battery in the world. For CATL, it also has the most advanced technology on recycling batteries, which provides sustainability of the EVs market and reusing batteries that minimise the impact of the environment. Moreover, Chinese society is interested in replacing their gasoline vehicles with electric vehicles thanks to the policy of the government. As the society benefits on tax breaks and subsidies when purchasing electric vehicles. Besides, the society has become more aware of the environmental issues in which the public purchase electric cars to decrease their carbon emission from the traditional gasoline car. The joint effort among government, corporation and society has brought significant results on the adoption of electric cars. In manufacturing, China is now the largest supplier of electric vehicles and batteries in the world. Besides, China has also become the world largest market share of electric cars which accounted for about half of the global electric cars sales. This has significantly reduced the carbon emission of the country, providing a sustainable development of the country and improvement of the public health and environment. However, there are still some issues on the impact of electric cars such as the performance of EVs in extreme weather, used batteries from EVs and coal for electricity. Furthermore, there are some recommendations on promoting EVs such as solving the limited charging station and auction system and lottery system for EVs. To conclude, with the joint efforts of the Chinese government, corporation and the society, there is a significant result on the adoption of electric cars. Electric cars not only reduce the environmental issues of the country, but also benefit the public's health, employment and the growth of the economy. Therefore, the success of China can be a representative of promoting electric cars in order to build a sustainable economy and environment.

Keywords: air pollution, China, electric vehicles, sustainable development.

I. INTRODUCTION

Due to globalisation, urbanisation and industrialization, China has become the second largest of the GDP in the world. However, this has brought environmental issues to the country such as air pollution, water pollution, disaster and others. Among these environmental issues, the air pollution caused by transportation will be focused in this research paper. Besides, this paper will also discuss how the Chinese government, companies and the Chinese society put efforts on promoting and

adopting electric vehicles to solve the air pollution. Furthermore, electric vehicles could be a model for the sustainability of the environment in the transportation sector using the three pillars of sustainability. The Chinese government sees an opportunity in promoting EVs to replace gasoline vehicles that could reduce the carbon emission and also reduce the reliance on the crude oil from the Middle East. The government promotes EVs by setting rules and regulations and also subsidies for the manufacturers and the Chinese society. For example, the provincial government restricts gasoline cars on the road in some of the areas. Furthermore, the government provides subsidies and tax breaks for the manufacturers and consumers to encourage the production and the adoption towards EVs. Furthermore, the government also invested heavily in the infrastructure of charging stations to meet the rapid growth of EVs on the road. Nevertheless, with the support and policy of the Chinese government, it has developed lots of excellent EVs manufacturers and battery manufacturers. For example, BYD, NIO and Xpeng have become the standard of EVs in the industry and provide high end EVs in the world. Furthermore, Chinese corporations also invest in the batteries of EVs which BYD and CATL becomes the major supplier of EVs' batteries in the world. Furthermore, CATL also invests in the technologies of recycling waste batteries that would minimise the pollution due to the disposal of batteries. Besides, it also could increase the efficiency of the usage of the used batteries and the raw materials. In addition, the Chinese society has more awareness on the environment and their living standard. Besides, the government provides subsidies and tax breaks for the public which increase the adoption of EVs market in China. The joint efforts of the government, companies and society towards promoting electric vehicles has significantly increased the adoption of EVs in China which China is now the largest market of EVs and supplier of EVs and batteries in the world. Furthermore, it also significantly reduce the air pollution that caused by the transportation, which develop a sustainable environment to the society. However, there are some challenges and things to improve on promoting EVs that will be discussed in this research.

II. LITERATURE REVIEWS

Environmental issues are the major concern of social issues in China. It has not only affected people's health, it also costs billions of dollars to face the consequences of destroying the environment such as floods, smog, landslides and others. With the rapid growth in foreign investment and urbanisation, it indeed brings tremendous achievement in people's employment, wealth, advanced technology and others. Nowadays, China has achieved the second largest GDP in the world and the largest importer and exporter in the world. According to Textor (2022), the estimation of China's GDP will rise from 17 trillion to 28 trillion in the year of 2021 to 2027. Due to the rapid growth of urbanisation and climate change, disasters have occurred more recently in China. For example, in July 2021, Henan, China has experienced the most severe floods in history which has caused hundreds of deaths and loss of 120 billion yuan (CCTV News, 2022). Besides, in 2022, the Environmental Performance Index (EPI) of China was ranked 160th among 180 countries in the world (Environmental Performance Index, 2022). Therefore, the China policy makers started paying attention to environmental sustainability while not influencing the growth of the economy.

As a government role, the Chinese government implemented the environmental policies and it encouraged the provincial government, businesses and society to comply with the regulations on environmental protection. The major move of the Chinese government is promoting support for new energy vehicles including battery electric, plug-in electric and fuel cell vehicles. In 2020, China has the largest market share of electric vehicles in the world with about 4.92 million of electric cars sold in China and it accounted for about 1.75% of the total vehicles in China (He & Jin, 2021). The central government has been investing heavily on green technology such as electric vehicles to promote a sustainable economy and society. The government provides incentives and tax breaks for those companies who adopt the policy. With the full support from the central government and provincial government, China has now become the world largest manufacturer of new energy vehicles in the world. Therefore, the green transition policy not only provides sustainability development, but also provides opportunities of technology transformation to China. The research showed that the environmental policies did not have direct impact on the GDP but it brought positive effects in the long term (Shuyang, Mingjie, Cynthia & Songk, 2021). Besides, the GDP of China increased from 59 trillion yuan to 90 trillion. The increase of GDP does not have additional environmental cost but even has a decrease in air pollution. Moreover, the policy on promoting new energy vehicles has achieved job opportunities in manufacturing, reduced urban air pollution, reduced vehicle carbon emissions and the most important one is on the political side which is reducing the reliance on oil from the Middle east. China's dependence on

foreign crude oil has risen dramatically from 53% to 70% between 2010 to 2018 which has become a major concern as it will threaten the development and national security of China (China Petroleum Institute of Economics and Technology, 2019).

Furthermore, infrastructure is also complementary to developing electric vehicles. The booming growth of electric vehicles in recent years is due to the Chinese government has been building electric vehicle stations since 2013. The charging station in China has 50% market share of the world but the per capita charging station is still below the average of the world (Jin, et al., 2021). Xinhua (2023) stated that the charging station has doubled in 2022 which it has reached about 5.21 million charging stations by the end of 2022. With the growth of infrastructure, society starts to adopt the new technology transition from gas-powered vehicles to electric vehicles. In 2022, China sold about 6.9 million of NEVs which accounted for 93% of growth compared to the previous year and the NEVs market share also increased to 25.6 percent of China's auto market. The study found that the policy of China indeed has significantly influenced the consumers' behaviour towards consuming EVs rather than gas-powered vehicles (Xing, Li, & Liao, 2022).

III. DISCUSSIONS

Limited charging station

This research indicates that the electric vehicle is only suitable in developed cities such as Shanghai, Beijing, Shenzhen and other developed cities. The insufficient charging station cannot meet the high growth demand for electric vehicles. The infrastructure is important and necessary for the transition of EVs (Endo Tsuboyama & Hara, 2016). Therefore, electric vehicle owners may experience longer charging times which will result in changing their driving plans and having bad experiences driving electric vehicles. The users might be concerned about the reliability and availability of the charging station when considering buying an electric vehicle which would urge the growth of EV in China. Especially in rural areas, the charging station is limited and does not have the usage of it. Therefore, this can be an issue for people who drive electric vehicles for long distances and it may be not practical for some consumers. As a result, it is a challenge to develop electric vehicles in rural areas. The installation of charging stations is a challenging issue for governments and companies as from a business perspective, the development of the network of charging stations is costly and has a longer-term return on equity compared to cities. Since 2015, the subsidies and tax breaks have been implemented for 13 years for electric vehicles manufacturers and tax exemption for consumers. However, the subsidies and tax breaks ended at the end of 2022. To solve the shortage of charging stations, the government should focus on the subsidies policy towards charging stations and extend the policy until the market is nearly mature. Besides, the local government should implement a more strict subsidies policy on the charging station to solve the problem. As there were many cases that were reported that lots of auto manufacturers cheated on the subsidies and resulted in the subsidies not going to the right person (Wang, Sperling, Tal. & Fang, 2017). The provincial government could implement subsidies on the personal charging station in the condominium to encourage EV users to charge in their residency rather than queuing in the charging station. From the research, the availability of home-based charge stations will have a positive impact on the consumers' behaviour towards purchasing an electric vehicle (Qian, Grisolia & Soopramanien, 2019). By providing subsidies it can reduce the cost of charging that creates the sustainability of society as it reduces the cost of charging that benefits the people.

Auction system and lottery system for electric cars

In real case studies of Beijing and Shanghai, these cities promote vehicle restriction to control the number of vehicles in the cities. People have to go through the auction system and lottery system to get the vehicle number plate. The research suggests that the local government could increase the percentage share of number plates on electric cars in the auction system and lottery system. This would significantly increase the number of EVs in the road while decreasing the gas-powered vehicles. Furthermore, these systems could be applied at other cities and even among the country. Some of the local provincial governments also responded to the central government's policy by providing restrictions on gasoline vehicles driving on the certain local traffic (Moore & Scott, 2020). Furthermore, for those provinces that still do not have much penetration of electric cars, the local government could implement free licensing policy until it reached the average market share. According to Qian, Grisolia & Soopramanien (2019), the result found that people are more attracted to the free licence policy of electric vehicles rather than the lottery licence policy for gas-powered vehicles.

Charging performance and range performance of electric car

Furthermore, this study researches that the new energy vehicles are limited to the atmosphere and the location in China. As northern China is mostly in low temperature, especially below freezing in winter. The freezing temperature will affect the efficiency of the battery and the driving range of electric vehicles. Therefore, this is a major concern for the public as they are worried that the vehicles are out of power on the road in the extreme weather. Furthermore, the freezing weather will also affect the charging performance of the vehicles which the fast charging takes about 1 hour to fully charge but it may triple the time when in freezing weather. The research found that the colder the weather, the more time for the battery to charge as the vehicle's software reduces its power to avoid stress on the battery (Motoaki, Yi. & Salisbury, 2018). To solve the problem, this research suggests that companies should increase the research and development on the efficiency of the battery to minimise the impact caused by extreme weather. Other than that, corporations could invent EVs that do not require recharging the battery but only take five minutes to change their used battery to a fully charged battery which is just as convenient as adding gasoline. Nio Inc. is an electric car manufacturer in China which is the only one who provides battery swap services in the world. This would solve the problem of charging performance in extreme weather and the problem of limited charging stations and the long charging time. However, there are only about 1300 battery swap stations across China. Besides, Nio has only delivered about 120,000 vehicles in 2021 which is low compared to other car manufacturers such as BYD and Tesla. Besides, the unit price per vehicle is valued at a high value which a Nio car could cost about 400,000 Yuan. Therefore, it is hard for consumers in northern China to adopt electric vehicles.

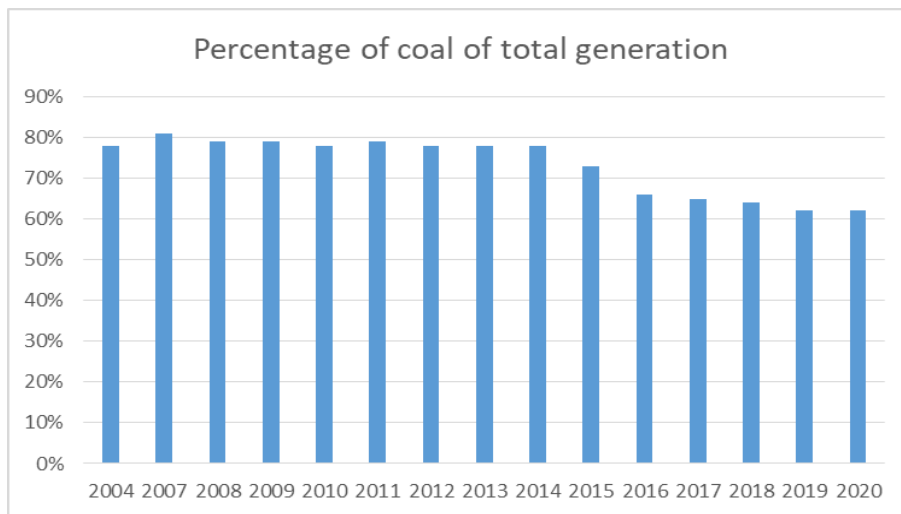
Coal for electricity

This research claims that although electric cars do have a positive impact on the air pollution and creating a better environment in urban areas, it still has some drawbacks on harming the environment. Firstly, the electric vehicle does not pollute the environment when using it, but the electricity that is used for charging EVs has an impact on the environment. In 2022, about 60% of the generation of electricity is from coal and China is still the largest coal consumer in the world. Furthermore, China still has lots of coal powered plants that are old and less efficient. These plants would release the poisonous air that is harmful for human health and the environment. Therefore, using coal for electric generation is a major issue for carbon emission and air pollution. Using electric cars might not have a significant impact on reducing carbon emission and may not have benefits on the environment as the public expected.

However, China has been transforming their ways of electric generation from coal to renewable energy. They have been putting efforts towards using cleaner energy for generating electricity such as solar power and wind. Renewable energy could reduce the reliance on coal and carbon emission (Guang, 2020). Besides, it also aligns with the objective of China's policies and strategies towards clean energy (Lin & Zhu, 2020). This would significantly reduce the environmental impact of electric vehicles. From the figure 1 below, China policy is working, in which the share of coal for total generation of electricity has decreased dramatically from the highest of about 80% to about 62% between the years of 2004 to 2020 (BP., 2021). Furthermore, figure 2 also shows that the percentage of renewable energy generation has a total of about 27% which includes hydro, wind, solar and biomass (BP. 2021).

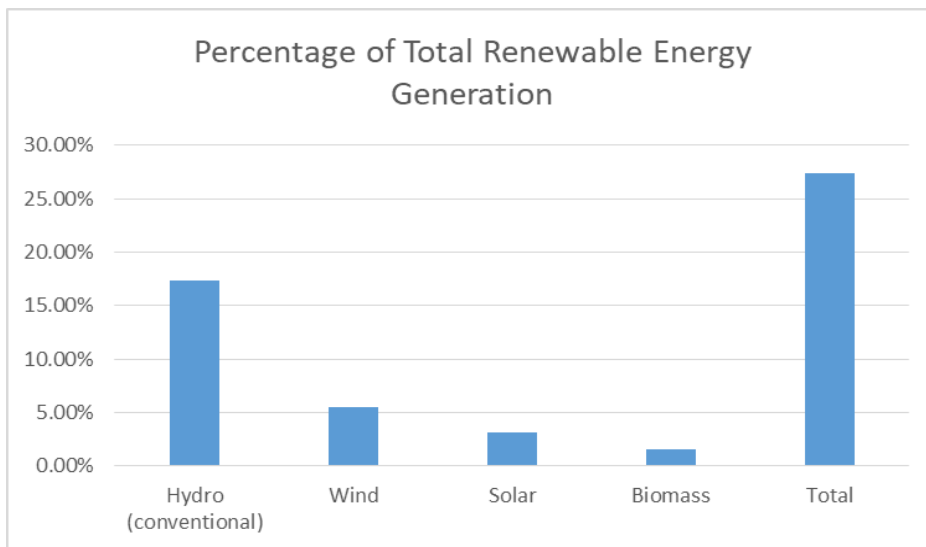
Despite China moving towards renewable energy, coal is still the major source of electricity generation. It is expected that China will have to rely on coal for generating electricity in the future. However, with the effort and the policies of the government, the research believes that China will achieve a greater share of renewable energy and a more diversified source of electric generation in the near future. Moreover, as a business role, corporations could adopt the policy by using renewable energy for their charging stations. Furthermore, corporations could remind the consumer to charge their EVs when their storage of electricity is at full capacity which will increase the efficiency of the usage of electricity. They can encourage people to charge their EVs by promoting discounts as when the battery is at full capacity, the more electricity comes in will harm the battery's life. Therefore, this is a win-win situation for both corporations and the consumer. Nevertheless, for society, people could support the policies by choosing the charging stations that are verified as green energy generation which ensure that the electricity is generated from green energy sources. Environmental sustainability under the three pillars of sustainability could be addressed as the electric vehicles that are charged by using renewable energy such as solar power and wind could further reduce the carbon emission from coal. Furthermore, it also creates economic sustainability that increases local development. As the local renewable energy can create job opportunities for the local people such as installation of renewable energy and research and development on it.

Figure 1. Percentage of coal of total generation in China



Source from: (BP., 2021).

Figure 2. Percentage of total generation by renewable energy, 2021



Source from: (BP., 2021).

Used battery of electric vehicle

Now the world is facing the massive amounts of used batteries from electric vehicles. According to Mitch (2019), the improper ways of disposing and recycling batteries will have a serious impact on the environment and only 5% of the batteries were recycled. The batteries contain metals and chemicals that will have a severe impact on the environment and human health if the batteries were not recycled properly. The batteries that are disposed of in the landfill will end up releasing toxic chemicals and metals which result in pollution in soil and water. Moreover, this research claims that EVs indeed reduce the carbon emission but the production of the EVs’ batteries still have an impact on the environment. It is because the production of batteries requires lots of energy and water and also carbon emission during extracting raw materials, processing and manufacturing the batteries. Besides, the extraction of materials would also impact soil pollution, water pollution and deforestation. The improper ways of processing the waste from manufacturing will also be a problem for the environment and human health. Furthermore, China is the world largest producer of lithium batteries which accounted for about 70% of the production in the world. Furthermore, about 45% of the lithium batteries are used for electric vehicles. Besides, recycling batteries could help in reducing the environmental impact. The recycled materials from the

batteries such as metals could be reused which reduces the use of new materials. Therefore, this not only reduces the environmental impact but also reallocation on the resources which will create an environmental sustainability of China. However, this research claims that the recycle battery for electric cars indeed decreases the negative impact on the environment but the public are concerned about the reliability of the recycled battery on EVs and the fact of the environmental impact. There is some evidence that the quality of reused lithium is not as good as the new lithium which will affect the performance and durability of the batteries (Zhang. et al., 2018; Sun et al., 2019). Due to the concern, the Chinese government promotes a standard system and regulations on reuse and recycling batteries and encourages corporations to develop new technologies on recycling batteries. Furthermore, for businesses, the recycled battery could reduce the cost of EVs batteries and increase the supply on the EVs batteries. This will create economic sustainability and social sustainability as it will decrease the overall cost of electric vehicles which make electric vehicles more accessible to the public. With the rapid growth of the EVs industry, the recycled batteries could ease down the shortage of the batteries which ensure the sustainable growth in EVs. To ensure the sustainable development of the EVs industry, the Chinese government implemented policies and investment on recycling batteries. With the support of the Chinese government, there are several Chinese companies that recycle batteries as a business opportunity such as CATL and GEM.

As Contemporary Amperex Technology Co. Limited (CATL), it is the world's largest manufacturer of lithium batteries, which are mostly for the electric vehicles. Furthermore, with policies of the Chinese government, CATL has become the lead in the industry and over 1000 patents of recycling batteries technology. With the booming growth of the EVs, it brings tremendous demand for the lithium batteries and this has brought challenges for the environment due to the waste and release of toxic materials. To overcome this problem, CATL has set up a subsidy called Guangdong Brunp Recycling Technology Co. Ltd. which the core business of it is recycling batteries of waste digital and EVs' batteries. (CATL, 2023). The company has a standardised system on recycling the valuable materials from the used batteries. According to CATL (2023), the first step of recycling batteries is to categorise them by age and other characteristics, and disassemble them into different components. After that, they use chemicals and their own technologies to separate the batteries into different components such as lithium, metals and others, which the materials could be used to produce new batteries or other products. Furthermore, during the process of recycling, Brunp has strict rules and regulations on the air filter, water measures and others to minimise the impact on the environment (Brunp Recycling, 2023). Besides, the company also dispose of the waste and dangerous materials in an environmentally friendly way which would minimise the harm on the environment. Nevertheless, the company also emphasises on the research and development of recycling batteries to increase the efficiency and sustainability. They are also researching the recycling materials to use on other batteries rather than lithium batteries only. The company now has already disposed of 120,000 tons of waste batteries, 99.3% of metal recovery rate and about 50% of recycling rate in China (CATL, 2023). To conclude, reuse and recycle the used EV batteries might have environmental impact but the Chinese government and corporation are trying their efforts to minimise the impact on the environment and create a sustainable development of the electric vehicle industry.

Three pillars of sustainability on electric vehicles.

Electric vehicles could achieve the three pillars of sustainability which are environmental sustainability, economic sustainability and social sustainability. Firstly, electric vehicles could reduce the carbon emission and air pollution compare to the traditional gasoline car, which create the sustainability on environment. Furthermore, it can also provide social sustainability by creating a health environment and society, create employment for the local people in renewable energy sector and battery recycle industry. Besides, it also create a more affordable and accessible of electric vehicles to the public. Nevertheless. Electric vehicles also create economic sustainability as it reduce the reliance on the crude oil from the Middle East and promote the local economic development.

Environmental sustainability

In China, transportation is the major contribution of the air pollution and carbon emission that affect the environment and the public health. The rise of electric vehicles has significantly reduce the carbon emission when comparing with the traditional gasoline vehicles. Besides, the electricity that for charging electric vehicles could powered by the renewable energy such as solar power and wind. Furthermore, the manufacture of electric vehicles could reduce the impact on the environment as it do not require much raw materials as traditional gasoline cars do. Furthermore, Chinese corporations also invest heavily on the recycle and reused of the waste batteries which further reduce the mining of raw materials and increase the efficiency of allocation of the raw materials.

Social sustainability

An affordable and accessible of transportation can create a more sustainability of social. Electric vehicles can provide a more affordable and low cost of transportation to the public. For example, the owner do not have to pay the high cost on the petrol and lower maintenance fees compare to gasoline cars. Furthermore, another side of social sustainability of social sustainability is that it create job opportunities and development of economic to China. The rapid growth on the demand of electric vehicles has create lots of local electric vehicles auto manufacturers and in renewable energy industry. These will create job opportunities for the local people such as technicians, manufacturing of electric vehicles, installation of solar power and wind power, maintenance and others.

Economic sustainability

Electric vehicles can also provide economic sustainability to China by reducing the import and reliance of crude oil from foreign countries and develop the economics of China. Electric vehicles could be charged by using the renewable energy such as wind and solar and therefore reduce the reliance of imported oil. The electric vehicles manufacturer and battery makers are the main supplier of the world such as BYD, Nio and CATL that will develop the economics of China and the related provinces.

In conclusion, electric vehicles could achieve the three pillar of sustainability in environmental, social and economics. Electric vehicles can reduce the carbon emissions, more affordable of transportation mode, create job opportunities for local people, reduce the dependency of imported crude oil and brings prosperity to the local economics.

IV. CONCLUSION

To conclude, air pollution is a critical environmental issue for China and is vital for the actions and joint efforts of the Chinese government, corporation and the society to solve the problem. The transformation from gasoline cars to electric cars has played an important role in developing the electric car industry. The adoption of electric cars changes the transportation mode of the public which is a solution on reducing the carbon emissions of gasoline cars and a major step on creating a sustainable environment. With the policies and regulations of the Chinese government on promoting electric vehicles, Chinese corporations have become the major supplier of electric vehicles and batteries in the world. Besides, they also have advanced technologies in recycling waste batteries. In addition, the public is also interested in changing their vehicles to electric cars due to the awareness of the environment and the policies of the government. The efforts do have a significant impact on the adoption of electric vehicles. However, there are concerns of the negative impact of electric vehicles on the environment, which are the range performance and charging performance of EVs in extreme weather, coal for electricity and the disposal of used EVs' batteries. Furthermore, the solution of the limited charging station and the policies on auction system and lottery system on the EVs will significantly increase the adoption towards EVs. The joint efforts of the government, corporations and the society in promoting electric vehicles are essential for China in developing a sustainable environment and society. This paper demonstrates how the three parties approach environmental challenges, adoption of electric vehicles and the drawbacks of electric vehicles on the environment, and the potential actions that the government, corporations and the society to improve in order to create a sustainable environment for their next generation. Therefore, promoting electric vehicles is an essential action for China as it achieves growth in economy, gaining advanced technology and creating a healthier environment for the society.

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