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Policy Requirements for Infrastructure Planning and Construction of Large Cities in the Development of New Energy Vehicles—A Case Study of the Sustainable Transport Policy of Large Cities in China

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Abstract

The auto industry is moving forward in reducing the reliance on fossil fuels and increasing renewable energy usage, as new energy vehicles are considered the key strategy to strengthen the country's energy security, protect the environment, and enhance sustainable development. To cope with the pressure caused by the rapid increase in the number of cars, the Chinese government has implemented incentives in terms of markets, digital information networks, and infrastructure. This report focuses on the policies implemented by the Chinese government to enhance the application of new energy vehicles, and analyses the basic principles of urban transportation planning in China. By assessing the benefits and weaknesses of new energy vehicle policies, this study critically evaluates China's project to promote new energy vehicles. The findings show that China's alternative fuel industry has reached a turning point of rapid growth and is expected to become the mainstream of automobile consumption in the coming years. As the largest developing country, China's development of new energy vehicles can provide valuable experiences to address both the opportunities and challenges of their cities moving to sustainable transport.

Keywords: new energy vehicles, public policy, China, urban environment, sustainable transportation

1. Introduction to Background and Policy Issues

Over the past half century, the development of automobiles has gradually improved the way people travel. With the acceleration of urbanisation, the urban population is gradually increasing, and people's demand for transportation is increasing, leading to an increasing number of urban transportation means. As shown in Figure 1, private car ownership of China's urban population grew steadily from 2009 to 2019, reaching 250.9 million in 2019, which is equivalent to 43 cars per 100 urban families (Wong, 2020b). However, carbon emissions from conventional energy contribute to greenhouse gas emissions and air pollution. In recent years, the urbanisation process has been accelerated in China, resulting in traffic congestion, automobile emissions, and industrial pollution, with a consequent severe decline in environment quality (Yang et al., 2018). Motor vehicles are one of the main sources of air pollution in China, which brings huge environmental costs and challenges to traffic management. To effectively deal with traffic congestion and urban pollution, some cities in China are focusing on exploring more sustainable transportation in terms of social, environmental, and climate impacts (Shaokun & Lievano, 2018).

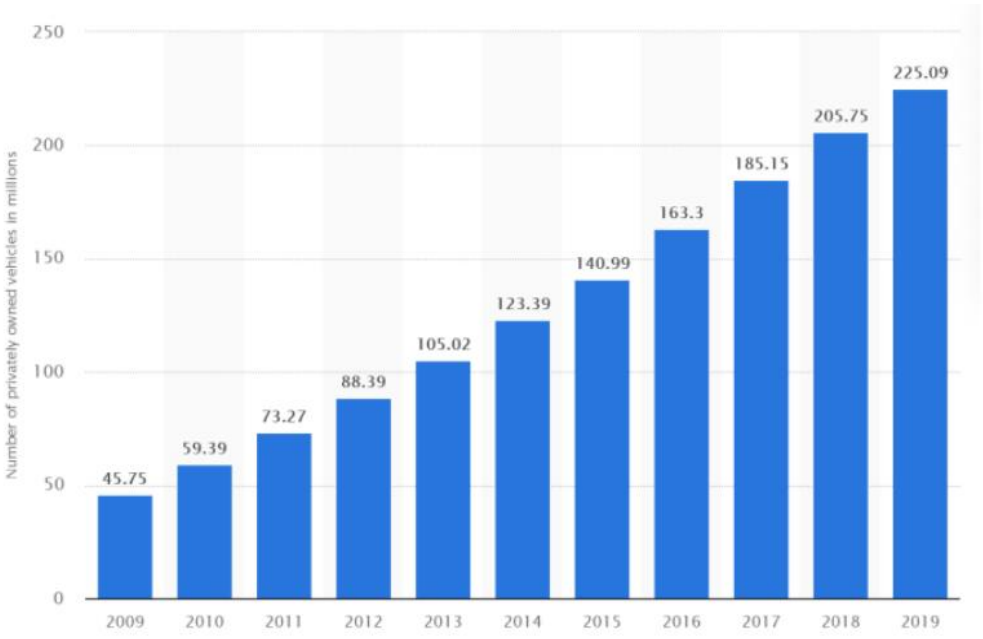


Figure 1. Private-owned vehicles number in China 2009–2019 (Wong, 2020, b)

The current rise of new energy has brought an opportunity for the urban transportation mode to change. The relationship between sustainable transportation and urban development is getting closer. The application of renewable energy in the automobile industry has gradually improved residents' demands. Recently, faced with increasing energy demand and environmental problems, the sustainable energy vehicle market has become one of the fastest-growing markets in China. Current new energy vehicle types include pure electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV), and fuel cell vehicles (FCV). According to Wong (2020), a total of 232,000 plug-in hybrid cars and 972,000 EVs were sold in China in 2019 (see Figure 2). Unlike conventional fossil energy vehicles, new energy vehicles are driven by renewable energy and have become one of the most significant methods for reducing transportation emissions. Since 2009, China's central and local governments have adopted a series of policies to promote the use of new energy vehicles (Tan et al., 2019).

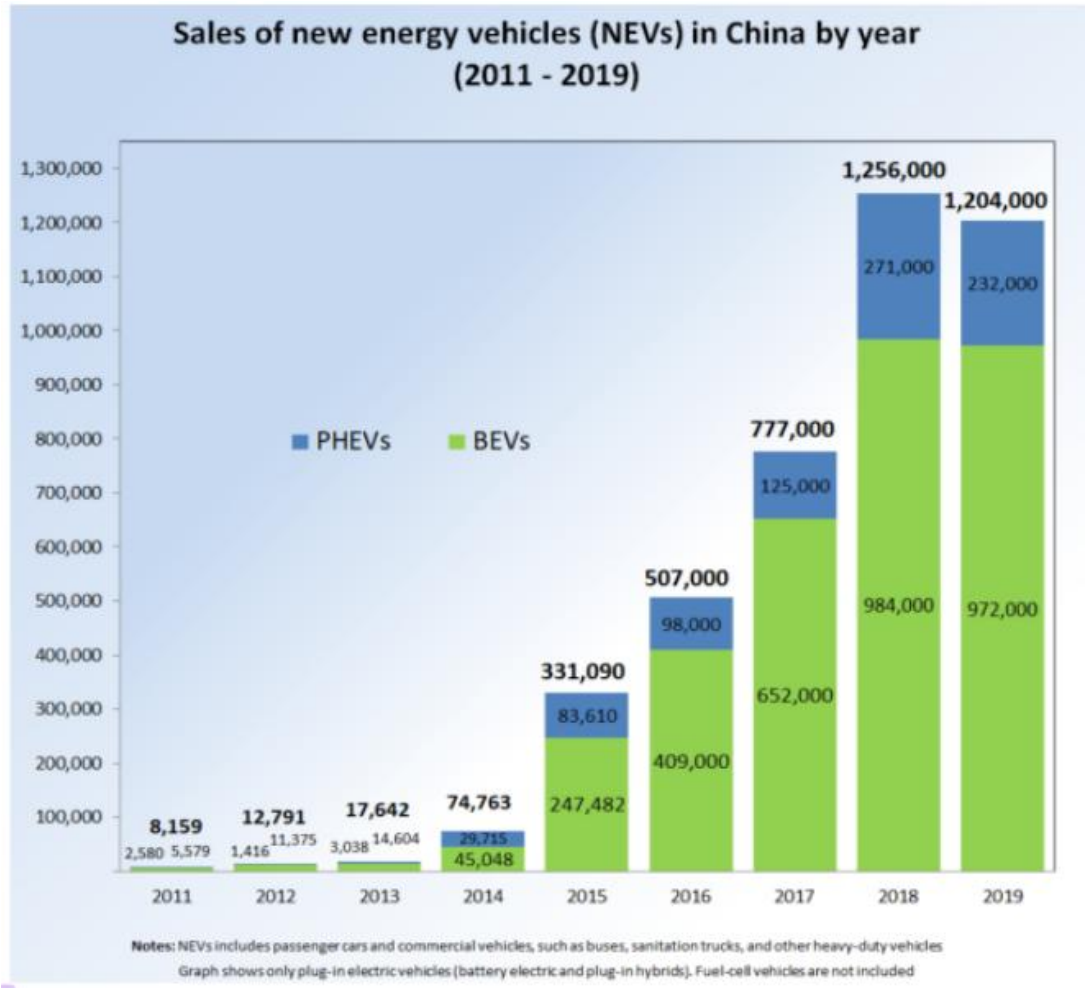


Figure 2. Sales of new energy vehicles in China by year (Wong, 2020c)

Figure 2 shows that, with the growth of urban population and the improvement of residents' demands, the development of intelligent cities has gradually become a part of urban development and planning, and indicates the need for residents to switch from traditional cars to sustainable transportation. Due to fast car energy security and urban air pollution problems caused by population growth, the Chinese government has launched a series of measures to ensure that new energy automobile industry development policy, including financial subsidies, such as growth in support of new energy vehicle infrastructure construction, promotes new energy vehicle business value (Zhang & Liu, 2016). This change also poses a challenge to the city's infrastructure capacity. To apply cutting-edge science and technology to urban development, it is necessary to improve by enhancing the planning of infrastructure and the implementation of policies and increasing urban traffic capacity to meet the transportation challenge in the future.

2. Current Policies and Their Effects in China

China's urbanisation development has steadily improved in recent years. According to the National New Urban Planning (2014–2020) (2013), 16 cities are projected to have a population of over 10 million in 2019. In some large cities, the contradiction between the size of the population and the ability to control air pollution is increasing, which puts higher demands on the comprehensive carrying capacity of the city and makes it urgent to strengthen the improvement of public facilities. To cope with the pressure caused by the rapid growth in the number of cars, the Chinese government has carried out a series of incentives in terms of markets, digital information networks, and infrastructure.

2.1 Production and Consumption Policy

For the purpose of improving the layout of the vehicle industry and promoting the new energy vehicle project, the Chinese government has launched the *Ten Cities, Thousands of NVEs Programme* (Xu & Wang, 2019) since 2009 to accelerate and develop the commercialisation of urban sustainable energy transportation and encourage enterprises to increase investment in the production and R&D of new energy vehicles. The policy indicates that the change in vehicle kinetic energy sources is driving the transformation of production operation mode and

consumption mode, and emphasises that the new policy should adopt the multi-field participation mode of automobile, transportation, and information communication, and build a delivery network supporting sustainable energy vehicles.

Further, to increase consumers' purchasing power, the government has implemented subsidies for new energy vehicles. The chart below shows the Chinese government's policy improvements on new energy vehicles since 2009. In 2012, the Chinese government laid out a plan to develop the new energy vehicle market, aiming to sell 500,000 new energy vehicles by 2015. Driven by incentives for purchase, the production of new energy vehicles shows a variety of growth trends available. Due to the impact of COVID-19 in 2020, the Chinese government has again announced that it will extend the subsidy period from the end of 2020 to 2022 to stimulate the automotive market, which has been affected by the COVID-19 epidemic and the global automotive industry downturn since 2019 (Cui & He, 2020).

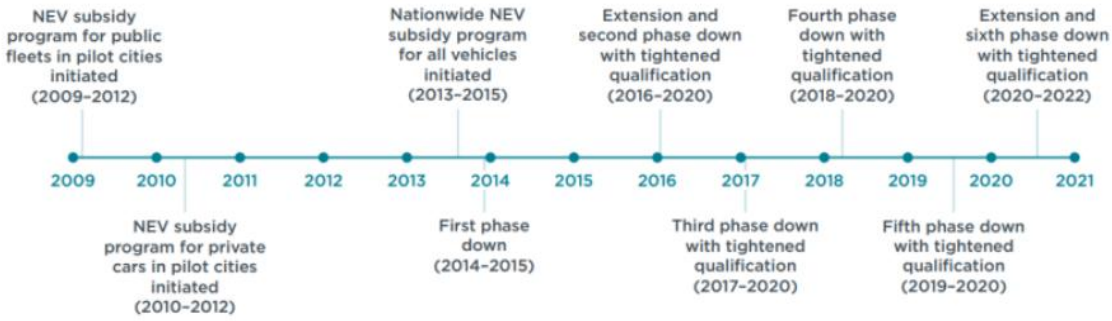


Figure 3. Timeline of China's national subsidy programme for new energy vehicles (Cui & He, 2020)

2.2 Digital Network Infrastructure

The Energy Saving and New Energy Vehicle Industry Development Plan (2012–2020) (2012) released by the State Council pointed out that China's new energy vehicle development is still facing the problem of backward infrastructure construction. To improve the integration of new energy vehicles and information communication, and promote data sharing, the government has begun to implement and develop smart cities. The State Council of China has formulated a policy of "developing integrated smart travel services", applying new energy technologies to public transportation, and using a new intelligent traffic control system with cloud collaborative control (Zhang & Liu, 2016). The policy aims to use the Internet of Things technology to build a data processing platform for urban and traffic information so that buses can be connected to the Internet, and unified deployment and management can be carried out through backstage devices. This demonstrates the determination of the Chinese government to strengthen the application of sustainable transport strategies in public transport and to optimise the environment for using new energy vehicles in public services.

2.3 Urban and Energy Infrastructure

According to the New Energy Vehicle Industry Development Plan (2021–2035) (2020), the current new energy vehicles on the market mainly depend on urban charging devices. To ensure that this new smart device is connected to the city's energy infrastructure, the Chinese government has taken the following steps:

(1) Accelerate the construction of charging infrastructure. The scientific layout of charging infrastructure is the focus of this programme. The design of the charging pile should be reasonable enough, and it is necessary to strengthen the planning of power grid construction and community management. Given the limited power supply in cities, the simultaneous access of a large number of rechargeable vehicles may lead to an overload of regional power grids (Goncalves, 2018). In Shanghai and other major cities, the management mode of orderly slow charging is the main one, and emergency quick charging is the auxiliary one, which not only saves energy but also effectively meets the charging needs of new household energy vehicles.

(2) Improve the service level of charging infrastructure. The urban development of new energy vehicles needs to consider whether the number of charging devices can meet the needs of consumers. The layout and planning of the charging pile should be convenient and fast. In response, parking lots in some big cities have begun to install charging facilities, connect charging piles to city electric boxes, and set rules for the use of public charging devices.

(3) Encourage business model innovation. Due to the condition limitations, at present, Shanghai, Beijing, and other big cities in part of the old community, installing charging devices is difficult. Further, some consumers do not have a private garage. Therefore, the government encourages qualified residential areas to share the same charging pile with multiple vehicles, nearby parking spaces to share the charging pile, and commercial places to cooperate with enterprises to build integrated service facilities for parking lots. This will not only improve the capacity of charging services in public places but will also meet the minimum demand.

3. Discussion of Key Policy Outputs and Benefits

3.1 Urban Environment and Green Spaces

It has been proven that the clean energy used in the new energy vehicle project can improve air quality in cities. Tan et al. (2018) pointed out that the Ten Cities, *Ten Thousand NEVs Programme* can reduce harmful gases in urban air and the influence of harmful substances on the environment and people's health. As the chart shows, the concentration of nitrogen oxide decreased significantly during the policy period. The reduction was between 0.07% and 0.08% over the whole period of implementation, and increased over time.

	Dependent variable: nitrogen dioxide concentration in air			
	(1)	(2)	(3)	(4)
Promotion period (2009–2012)	−0.0862**		−0.0734*	
	(−2.16)		(−1.95)	
2009		0.00711		0.00730
		(0.06)		(0.06)
2010		−0.0156		−0.00892
		(−0.23)		(−0.13)
2011		−0.0715		−0.0656
		(−1.21)		(−1.13)
2012		−0.0774		−0.0706
		(−1.30)		(−1.21)
Other control variable	Yes	Yes	No	No
Observation	720	720	720	720
R-square	0.04	0.04	0.03	0.03

Figure 4. The effect of the 'Ten Cities, Ten Thousand new energy vehicles project' (Tan et al., 2018)

The pollution of traditional fuel cars often comes from the excessive consumption of fossil energy. New energy vehicles can use not only electricity but also solar energy or other clean fuels. They are cheap and affordable, and improve urban greening.

3.2 Economics Benefits

The development of a new energy industry can promote the improvement of the industrial structure. It can drive the development of a new industrial chain, provide enough jobs, and promote the development and transformation of the automobile industry (Gong et al., 2012). The economic feasibility of electric vehicle to grid (V2G) technology in various markets can reduce energy costs. Juul and Meibom (2011) indicated that the intelligent charging system can reduce system costs, with annual profits ranging from $100 to $300. If smart charging methods are used, new energy vehicles will improve the efficiency of the grid's base load and have a beneficial impact on the grid. Charging during off-peak times also reduces the cost of the grid (Andwari et al., 2017).

4. Discussions of Key Challenges and Problems

4.1 Negative Environmental Flow

Some analysts suggest that the effect of new energy vehicles on reducing harmful gases, such as nitrogen dioxide, is not significant. The Ten Cities, Ten Thousand NEVs programme did not achieve the expected purpose; instead, the effect decreased over time (Tan et al., 2018). According to the survey, many of the cities in the plan did not achieve the targets set, with only four cities achieving 30% of the target by 2017 (Tan, 2018). More importantly, although the emissions of new energy vehicles are small, the consumption of electricity and the emission of carbon dioxide in the production process cannot be underestimated (Goncalves, 2018). As shown in Figure 5, most of China's electricity sources are fossil fuels, which are also very polluting to the environment. According to a survey, the carbon dioxide produced by China's EV battery manufacturers during the manufacturing process is 60% higher than that produced by the internal combustion engine vehicle (ICEV) engine (Ellsmoor, 2021). Further, pure electric vehicles are mainly driven by batteries, and lithium batteries abandoned in nature will do great harm to the soil (Goncalves, 2018).

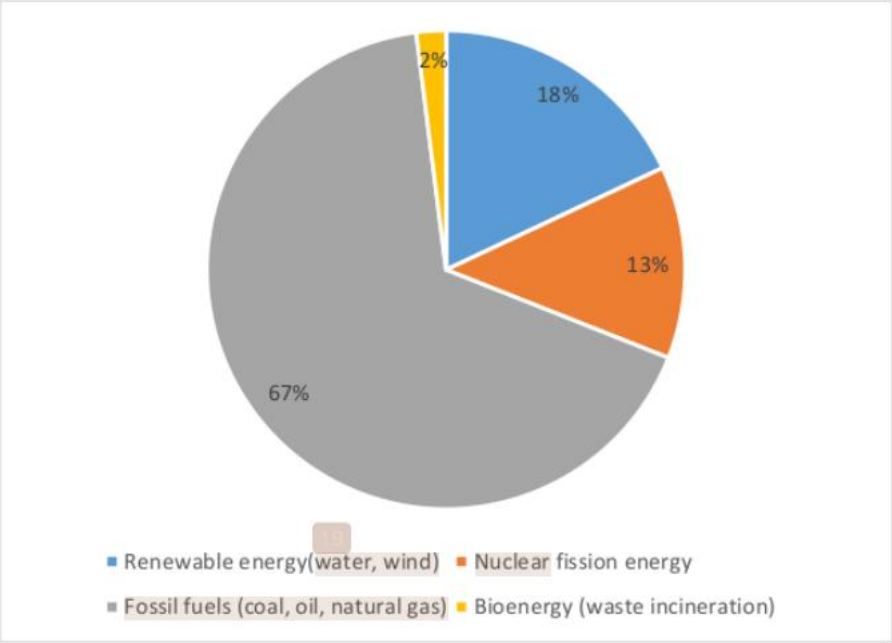


Figure 5. Proportion of energy generated in China (Goncalves, 2018)

4.2 Affordable New Energy

Achieving and implementing sustainable energy is not easy. Wind energy and solar energy have developed rapidly in recent years, and competition is fierce. However, the acquisition of these unconventional energy sources is accompanied by higher technology and labour costs (Department of Transport, 2019). If the energy to power new energy vehicles is not from solar panels, wind turbines, or other powers, such as nuclear or hydroelectric, then their carbon dioxide emissions will be greater (Goncalves, 2018). Therefore, a major challenge for new energy vehicles in the future is how to obtain cleaner energy, make more renewable energy into the grid, and reduce harm to the environment, such as battery pollution.

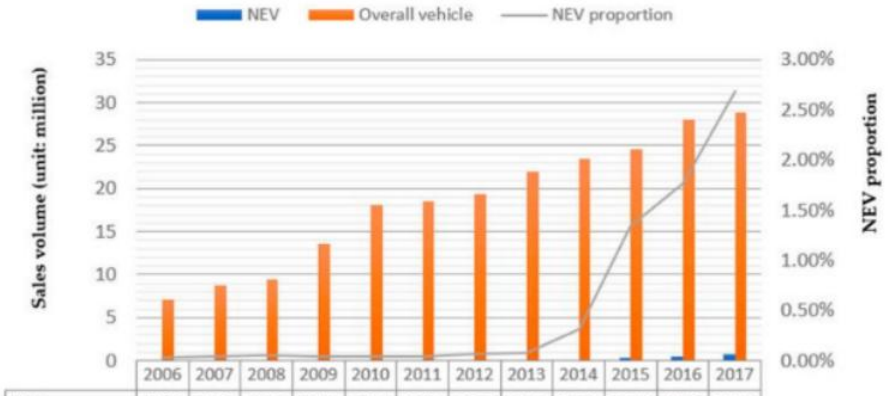
4.3 Charging Station Infrastructure

One of the difficulties in promoting new energy vehicles is that not everyone has access to them. In some areas where plug-in cars are not yet common, owners who want to charge their cars have to buy their own independent garages and install charging piles in their cars. However, in some big cities with high housing prices (e.g., Shanghai), some people do not have this condition. The lack of charging facilities also puts higher demands on the range of electric vehicles. There are also questions as to whether the high cost of electricity will be affordable. Furthermore, the price of new energy vehicles is quite cheaper than that of traditional energy, but the urban class division makes the purchasing power of residents of different classes significantly different. Opponents say that the increase of new energy vehicles not only brings a burden to urban infrastructure but may also exacerbate the inequality between urban classes (Tan et al., 2018).

5. Policy Actors and Stakeholders

Due to China's political background, the central government wields a lot of control. Therefore, after the central

government issued instructions for new energy development, local governments responded positively. Some provincial governments, such as Shanghai and Shenzhen, have become important advocates for electric vehicle innovation. They implement similar subsidy policies for new energy vehicles in various places to support the development of the automobile industry (Howell et al., 2015). As shown in Figure 6, with the active efforts of local governments, sales of new energy vehicles in China have begun to increase gradually.



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
NEV	2358	3245	4368	5324	6234	8159	12,79	17,64	74,76	331,0	493,8	777,0
Overall vehicle	7,116	8,791	9,380	13,64	18,06	18,50	19,30	21,98	23,49	24,59	28,02	28,87
NEV proportion	0.03%	0.04%	0.05%	0.04%	0.04%	0.04%	0.07%	0.08%	0.31%	1.34%	1.76%	2.69%

Figure 6. New energy vehicle sales trends from 2006 to 2017 (Yu et al., 2019)

6. Major Findings of the Research

(1) Decisions on infrastructure construction may be influenced by institutional arrangements. The success of new energy cars in China cannot be separated from its unique policy background. Under the political status and institutional background of China's construction of a "beautiful countryside" and "ecological civilisation", the new energy vehicle industry has specific advantages. China's development of new energy vehicles is also related to its historical background. China's great achievements in economic development have been made at the expense of the environment. Today, China faces the huge challenge of balancing economic growth with environmental sustainability, and the growth of the automotive sector may affect China's goal of achieving a peak in carbon dioxide emissions by 2030 (Heller, 2017). To meet the emissions target, the government is adopting a number of policies to reduce vehicle emissions. These measures include the comprehensive promotion of sustainable new energy vehicles.

(2) The effectiveness of new energy vehicles to protect the environment is controversial. Although sustainable energy can replace traditional polluting energy sources, the energy consumption of electric vehicles during the entire manufacturing process is far greater than the exhaust emissions of ordinary vehicles. Thus, new energy vehicles can reduce exhaust emissions, but only a small part of all the electricity in the manufacturing plant comes from renewable energy; thus, environmental costs are still being generated.

(3) The effect of consumption power and productivity on the application and real-time performance of sustainable energy is unclear. In Ten Cities, Thousands of NVEs, the reduction in nitrogen emissions from new energy vehicles throughout the rollout period was limited, partly because of the low number of new energy vehicles in use in cities. In Beijing and Shenzhen, for instance, the proportion of new energy buses in the city's bus chain is only 6 percent, higher than in Shanghai. Until November 2012, only 425 new energy vehicles were qualified for use in Xiamen (Tan et al., 2018). This hinders new energy vehicles from changing air quality in the early stages of the policy. As the policy continues, the impact on the concentration of harmful gases is only beginning to emerge.

(4) The Chinese government's general policy tools for stimulating new energy innovation fall into two categories. The first is technology-driven policies, which mainly promote research and development and production through regulations, such as technology, tax incentives, financial support, and infrastructure. Such tools include the government's continuing subsidies for new energy projects. Second, demand-driven policies include all kinds of policies to stimulate demand. For example, government subsidies and purchase targets are mainly used to stimulate market formation and product consumption.

(5) The role of stakeholders in policy decision making is important. Some local governments have played an

important role in the innovative development of sustainable energy, thus supporting the implementation of the policy. The initiative of these local governments determines the success of the project.

7. Suggestions and a New Policy Approach

Overall, China's success in developing sustainable transportation has been impressive. Here are some suggestions for consideration. First, the government should continue to strengthen the public to cultivate awareness of energy conservation, increase the publicity of new energy vehicles, and encourage people to buy renewable energy vehicles. Second, the quality and safety guarantee of charging infrastructure should be strengthened. There is a need to strengthen the construction of charging infrastructure equipment, starting with improving the intelligence and energy savings of charging devices, as well as creating an intelligent and orderly charging mode. Moreover, an argument often raised in contrast to the positive side of electric cars is the pollution associated with battery manufacturing. Infrastructure and effective manufacturing tools are the key to reducing emissions from the production process, according to an ICTT report. It is suggested that China could adopt US or European manufacturing technologies, which could reduce emissions from its production by around 66% (Ellsmoor, 2021). As electric cars become more common, batteries should be recycled more efficiently. In addition, there is a reduction in the need to explore new materials, thus reducing dependency on the production of new batteries.

8. Conclusion

Research suggests that the future of electric cars will improve as countries shift their goals to clean energy. Faced with the problems of urban air pollution, global warming, and other urban issues, China has chosen to develop and invest in new energy vehicles as one of its policies. The development of new energy has become an important performance criterion for urban planning and management in China. However, it is still controversial whether new energy electric vehicles can solve the environmental problems faced by cities. Overall, electric cars are less polluting than internal combustion engines, and they offer a way to significantly reduce greenhouse gas emissions. With the development of technology and economies of scale, cities will provide better energy infrastructure and more efficient production techniques, making electric vehicles increasingly sustainable and efficient.

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