

Analysis of Economic Instruments for Energy Transition Transformation and Their Effects: The Development Process of Electric Vehicles in China

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Abstract: In recent years, the escalating environmental problems posed by climate change have prompted countries to expedite their energy transition. Headed by the Paris Agreement, which sets temperature control targets for the world, countries have taken a variety of measures to promote the development of low-carbon energy. Among them, electric vehicles have played an indelible role in China's energy transition. In terms of energy structure, electric vehicles can assist in reducing reliance on traditional fossil fuels, lowering greenhouse gas emissions, and providing an effective route to achieving the “dual-carbon” objective. In terms of environmental benefits, electric vehicles can effectively reduce urban air pollution and improve the quality of life of residents. This research analyses government economic instruments, such as carbon pricing, carbon taxes and infrastructure development. Understanding the impacts of policies on consumers, businesses and identifying current shortcomings provides recommendations for a sustainable future with enhanced life-cycle use and a circular economy. This paper is designed to encourage further research, standardisation work, public communication, and future progress.

Keywords: Electric vehicles, carbon pricing, carbon tax, lithium battery life cycle, circular economy.

1. Introduction

As the problems of global climate change and resource depletion intensify, energy transition has goal of carbon peak and carbon neutrality, the electric vehicle industry is regarded as one of the important areas to promote the energy transition. Therefore, strategies and methods of China's energy transition can be drawn by analysing the development process of electric vehicles,. With the increasing share of renewable energy in power generation, replacing conventional fuel vehicles with electric vehicles could reduce greenhouse gas emissions by at least 22.32% in all regions of China by 2050 [1]. China has abundant lithium reserves providing a relatively stable supply chain for lithium batteries. The government promotes the new thing of electric vehicles into people's daily life through carbon pricing policy. But the emergence of new products still faces challenges such as funding, policy continuity and infrastructure adaptation. To further analyse this argument, the body of this paper will be divided into three parts. The first part will outline the inevitability of the rise of electric vehicles. The second part will analyse the economic instruments used by the Chinese government.

The third part will explain and suggest a sustainable future. The research significance of this paper lies in its in-depth analysis of the role of economic instruments in the process of China's energy transition, with a particular focus on the pivotal influence of government incentive policies on the advancement of a low-carbon economy and green development.

2. The inevitability of carbon pricing policies and the rise of electric vehicles

In recent years, China has relied heavily on fossil fuels in the course of its development. The extraction, transport and use of fossil fuels (coal, oil and natural gas) have caused damage to the ecosystem in many ways. As a result of this, the country has introduced a series of policies such as carbon pricing and taxes to curb the use of fossil fuels, while at the same time searching for new energy sources to replace them. With the discovery of lithium batteries, China's energy transition has begun.

2.1. Carbon Pricing Policies

By raising taxes or restricting the use of high carbon emitting energy sources, like fuel oil and diesel, through the carbon emissions trading market (ETS) and carbon taxes, carbon pricing policies automatically internalise the effects of global warming by businesses and consumers, leading to a rise in the cost of fossil fuel use [2]. This means that industries with carbon-intensive fuels will face higher input costs, which will require customers to increase the price of their output. In this scenario, consumers and businesses are more inclined to look for more economical alternatives, and electric vehicles become the ideal choice. Companies such as Tesla, for example, saw the business opportunity in electric vehicles and started working on battery systems. Many cities have even introduced low- and zero-emission zones, further driving up the cost of fuel cars and boosting demand for electric vehicles. And China's multi-trillion-dollar Belt and Road Initiative includes a wide range of infrastructure development. By strengthening cooperation with countries along the route, it will help electric vehicle companies to expand overseas markets [3].

Theoretically, investing carbon pricing revenues in the construction of charging infrastructure is an effective way to promote the development of electric vehicles (EVs), but the effectiveness of its implementation will be affected by the efficiency of policy formulation and implementation.

2.2. Advantages and challenges of Natural Resources - Lithium Battery Storage

In the process of China's electric vehicle development, lithium battery storage capacity occupies a crucial position. According to the latest data from the U.S. Geological Survey (USGS) in 2023, China has 3 million tonnes of lithium storage, ranking it fourth globally [4]. As a key material for manufacturing batteries, lithium reserves affect the cost, production and sustainability of electric vehicles. However, the availability and management of lithium reserves significantly influence this development. The severe challenges facing the supply chain are not once and for all driving the development of China's electric vehicle industry.

Firstly, the limited nature and exploitation of lithium resources limit the production capacity of batteries. Although China has a certain advantage in the global cost of lithium resource allocation, it still faces problems such as uneven resource distribution and difficulty in exploration. In addition, The extraction and refinement of lithium are water-intensive processes that contribute to pollution, raising environmental concerns. According to a survey by the National Institute of Health, lithium batteries contain potentially toxic substances, including metals such as copper, nickel and lead, and organic chemicals that may pose a threat to the environment and human health [5]. Therefore, the promotion of lithium resources for electric vehicles is limited and moderating.

Second, reliance on lithium resources makes the EV industry vulnerable to supply chain fluctuations and geopolitical factors. For example, the concentrated distribution of lithium resources globally puts some countries in a monopoly position, such as the “lithium triangle” of Chile, Argentina, and Bolivia, where political stability, mining policies, and attitudes toward foreign investment can affect the global supply of lithium and lead to price volatility.

In summary, China's energy transition benefits from robust policies and substantial lithium resources. The government promotes initiatives like carbon pricing and taxes while leveraging its renewable energy potential. Even so, the government faces some problems in policy implementation and resource utilisation affecting the environment. However, in the context of global cooperation on the energy transition, China's active promotion of green development along the Belt and Road has laid a solid foundation for a sustainable energy transition and aided in the global response to climate action change.

3. Economic instruments

In the context of addressing climate change and promoting green development, economic instruments have become an important driving force of China's energy transition. Government reinvestment and subsidies in the electric vehicle industry can effectively guide resource allocation and encourage low-carbon technological innovation through the adoption of policies and market regulation. Under the government's leadership, the impact of economic instruments is mainly reflected in two aspects. Firstly, through policies like carbon tax and green subsidies, consumers' energy consumption habits are changed and low-carbon lifestyles are made more popular. Secondly, through the carbon trading market, Dual-Credit Policy and other means, enterprises are encouraged to improve their production processes, reduce carbon emissions, and enhance their competitiveness in the green economy.

3.1. Government incentives

3.1.1. For consumers: reduction in purchase and use costs

China's electric vehicles were supported by the government in the early stage of development. In April 2020, the Chinese government announced that vehicle purchase tax exemptions for new energy vehicles would take effect January 2021 [4]. In addition to this, there are vehicle purchase subsidies, tax incentives and local policy support. These policies are indeed effective in driving market demand at the early stage of EV development, but long-term reliance may lead to market dependence on the policies [6]. A challenge arises with the sustainability of subsidy policies. As the market expands, the government gradually cuts the subsidy, creating uncertainty for consumers about the future price of EVs. In addition, while the preferential licence plate policy offered by local governments is attractive to purchase-restricted cities, it has limited influence on non-restricted areas and small cities [7]. Therefore, the government should gradually guide the market towards autonomous demand, reduce reliance on subsidies, and explore ways to maintain competitiveness through technological upgrades and cost reductions. Consumer incentives can be made more sustainable through long-term measures such as increasing infrastructure support and upgrading battery technology.

3.1.2. For enterprises: Promotion of Industry Chain Innovation and Expansion

The government's support for the EV industry chain has been very effective in promoting EV technological innovation in China, including Research and development (R&D) subsidies, low-interest loans, and the Dual-Credit Policy. According to research, the Dual-Credit Policy does promote the growth of new energy vehicles, but it imposes a certain economic burden on traditional fuel vehicle enterprises, especially small and medium-sized enterprises that are unable to transform

quickly [8]. The widespread application of subsidies and incentives may lead to enterprises relying too much on policy support and neglecting market competitiveness and their own innovation ability. These policies would be more useful if the government considers gradually transitioning to a market-oriented incentive model that motivates firms to reduce costs through innovation and efficiency improvements, rather than relying solely on policy subsidies. Peng and Li also suggest that policy design should be in line with the stage of industrial development, and that more emphasis needs to be placed on research and application of charging and switching technologies in the future [9].

3.2. Reinvestment of Government Revenues: Promoting of EV Infrastructure Development

Additional revenues from carbon pricing policies become an important source of funding to support clean energy projects. The government can invest revenues from carbon taxes and carbon emissions trading into clean transport infrastructure, such as EV charging piles and fast charging stations, to address the plight of insufficient EV infrastructure. In this way, the policy not only promotes market demand, but also provides the necessary supporting facilities to support the development of the industry.

However, this action does not completely solve the problem. While the Chinese government's subsidies did promote the construction of charging stations and charging piles, they only focused on the construction of facilities, and the vast majority of regions did not consider the issue of facility utilisation. In some areas, the construction of charging piles is excessive or the layout is irrational, leading to a waste of resources [10]. Therefore, the government should give more consideration to the data-driven approach in charging network planning, and reasonably distribute charging facilities according to the actual demand, rather than simply increasing the number. In addition, the establishment of a battery recycling system has a positive environmental significance, but the industry chain still faces technical and economic challenges due to the immature technology and low battery recycling rate and reuse rate.

4. Future development

4.1. Promotion of the battery life cycle and realisation of circular economy

The main purpose of the energy transition of electric vehicles is to save energy and reduce emissions, the battery before the end of its life is to make a certain contribution to the protection of the environment, but the energy consumption and waste of the battery after the end of its life should also be calculated. According to UK data, the health of electric vehicle battery life is not optimistic, and the second life business of batteries is attracting attention[11]. This article on automotive energy conversion in China provides a valuable perspective on the green treatment of batteries after disposal. China is in the process of establishing a total life cycle management system for batteries to minimise resource consumption and pollution during battery production and end-of-life by regulating battery manufacturing, recycling and reuse to form a closed-loop circular economy model. Liu et al. study suggests that the government encourages battery manufacturers to lead recycling initiatives, consumers and battery manufacturers to check for risk sensitivities, and Original equipment manufacturers (OEMs) to prefer separate recycling of batteries [12]. In recent years, the government has increased its investment in research and development of recycling technologies and has enacted regulations to promote co-operation between battery producers and recycling companies. This study would be more relevant to explore if China's treatment of waste batteries was more extensive and recycling of resources was realised.

4.2. Diversification of ecological transport construction

The popularisation of electric vehicles plays an important role in ecological transport construction. For example, the promotion of electric buses and metro systems can effectively reduce the use of fuel vehicles, slow down urban air pollution, and reduce traffic congestion at the same time. In addition, the addition of bicycle paths and walking areas allows residents to choose healthier, low-cost travelling options, thus improving the overall quality of life in the city. In these ways, eco-mobility diversification not only meets the Goal 12 of sustainability to ensure sustainable consumption and production patterns, but also improves the quality of life and travelling experience of urban residents.

Despite the obvious advantages of eco-mobility diversification, its implementation faces the dual challenges of funding and infrastructure. Firstly, the construction of transport infrastructure like diversification requires a large amount of funding. It will take a long time if all the construction is invested by the government, and at the same time, it is difficult to attract corporate investment for such a project that involves a lot of investment and little return. Secondly, for the relatively poor and backward rural areas of China, new transport systems are difficult to carry out.

In the future, the diversification of eco-mobility needs to overcome these challenges through multi-party collaboration, balancing resource investment with social benefits. The government needs to invest more in eco-mobility and develop long-term and stable support policies to ensure the sustainability of eco-mobility projects. The study points out that various transport sectors can achieve efficient high-speed surface transport through the design process of an integrated superhigh-speed rail system and the resulting technological concepts, which can effectively promote the popularisation of a green transport culture [13].

5. Conclusion

In conclusion, this paper argues that the government's carbon tax, Belt and Road and carbon pricing policies are helpful for the initial development of electric vehicles. Firstly, this paper describes the advantages of China's EV development in terms of both global form and resources. Then it describes the actions from consumers, enterprises to the government with the economic instruments used in government incentive policies. Finally, it strengthens the improvement of the whole industrial chain of electric vehicles, realises the circular economy of reusing waste batteries, and develops the use of electric buses and subways to achieve a sustainable future.

Although facing limited resources, the implementation of the national policy has different effects in different regions with different levels of economic development, and the electric vehicle infrastructure is not fully covered. It is believed that in the future the Chinese government will improve the system to ensure that electric vehicles are used in a sustainable way. Additionally, the government is anticipated to address the shortcomings by tailoring improvements to different regions while actively developing diversified eco-mobility.

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