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Governance Challenges in Electric Vehicle Adoption: A Case Study of China

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Abstract:

The paper discusses the governance challenges of electric vehicle adoption in China, now a global leader in EV promotion, as part of its strategy to cut greenhouse gas emissions and achieve carbon neutrality by 2060. Three major governance challenges point out the use of non-renewable energy sources, an insufficient number of charging infrastructures, and environmental impact due to battery production. While EVs can have a positive impact on the reduction of emissions in the transportation sectors, much is left in the balance due to a high proportion of coal-based electricity in China's energy mix and environmental costs from producing and disposing of batteries. The analysis, therefore, puts forward some remedies for these challenges: better cross-sectoral policy integration between the energy and transport sectors, infrastructure development through public-private partnerships, and international cooperation on regulating battery supply chains. It concludes that EVs require a holistic approach that combines energy policy, infrastructure development, and global supply chain governance for maximum environmental benefit. The big picture of sustainable transport, such findings have offered insights and recommendations for other countries willing to overcome similar governance challenges in their efforts and processes of transitioning towards electric mobility.

Keywords: Electric Vehicles; Environmental Governance; Renewable Energy; Battery Production; Policy Integration

1. Introduction

1.1 Background of the Research

The environmental governance issue stands at the heart of increased global challenges arising from issues such as climate change, loss of biodiversity, and environmental pollution. Such urgency has called for a number of policy measures and technological innovations toward sustainable solutions.

Of all, EVs have emerged as a promising tool for mitigating greenhouse gas emissions from the trans-

port sector, accounting for about 24% of global CO2 emissions [1]. The number of vehicles on the roadways is expected to increase drastically with the continuation of urbanization and growth in population, hence aggravating the need for cleaner alternatives to conventional gasoline and diesel vehicles. As opponents indicate, electric vehicles present an opportunity for large environmental gains, including zero tailpipe emissions and cheaper operating costs [2]. However, the EV economy is, in practice, a multiscalar governance challenge. While it has already been witnessed that governments and industries in most countries of the world have pledged to support EVs, the broader environmental impacts- including the source of electricity powering EVs and the environmental production costs of batteries- will have to be kept under critical management.

Without proper governance, however, their environmental dividends are negated by dependence on fossil-fuel-powered electricity grids and the ecological destruction by raw material extraction for battery production. Thus, understanding and addressing these governance challenges is an important component in the successful integration of EVs within a sustainable transport framework. In fact, with China as the biggest automobile market worldwide, EV adoption forms a core part of its strategy for meeting carbon neutrality targets by 2060 [3]. The Chinese government has subsidized EVs through tax breaks and other benefits, reflecting a view that EVs are a key piece in solving problems of air pollution and carbon emissions. But these efforts have been largely undeterred by the significant barriers standing in the way, especially in the energy infrastructure the nation needs to provide with widespread use of EVs.

The integration of renewable energy sources, charging networks, and environmental impacts of battery manufacturing also pose serious governance challenges that must be met if EVs are to contribute to a sustainable future.

1.2 Literature Review

Several research works have been conducted to compare environmental opportunities and issues. A comparative LCA regarding the environmental impacts, Hawkins et al. concluded from their study that though EVs can reduce GHG emissions by an amount comparable to that produced by conventional vehicles, they increase human toxicity and freshwater eco-toxicity due to battery manufacturing [4,5]. It, therefore, means that EVs cannot be used as universal solutions to environmental problems, and their whole life cycle must therefore be well thought out if their benefits are anything to go by.

A study by Zhang & Fujimori analyzed transport electrification within the standard climate change mitigation scenarios globally [1]. The study revealed that electrification within the transport sector can easily lead to high emissions depending on the nature of the electricity used in the operations of the EVs. Additionally, research by Gan et al. examines the growth of electric vehicle markets in China, the United States, and the European Union, highlighting the role of policy incentives in driving adoption [6]. However, the study also notes that without improvements in electricity generation methods, the environmental advantages of EVs will remain limited [7].

The findings above indicate that to achieve a drastic decrease in carbon emissions, EV adoption needs to go hand in hand with the switching of energy to renewable forms. Their studies also emphasize the need for a strong governance framework that incorporates policies in the areas of energy, environment, and transport to achieve all the potential of EVs. The extraction of necessary rare earth metals from production processes in lithium-ion batteries is another key issue in the literature. Wang & Zhang, in this regard, discuss the environmental and social costs of battery production, citing that the extractive industries induce different ecological destructions or degradation, especially in some under-developed countries [8].

This raises questions of global environmental governance and the need for international cooperation in regulating the supply chain, with a view to reducing environmental impacts in battery production.

1.3 Research Gap

While evoking the sphere of EV-related research, it must be noticed that most studies highly focus on technological and environmental dimensions, thus creating a literature gap in terms of the need for governance frameworks necessary to address these challenges. This seamless integration of EVs within both national and global strategies for sustainable development is going to be highly dependent not only on technological innovation but also on policy coordination across energy, transport, and environmental regulation.

In particular, very few studies have looked at the governance mechanisms needed for managing the life cycle impacts of EVs from production to disposal. The paper tries to fill this lacuna by focusing on governance challenges related to the adoption of EVs and proffers solutions in the form of a greener transportation system.

1.4 Research Framework

The paper is organized as follows: after this introductory section, the next section now sets out in detail the strategy for the adoption of EVs in China, describing in depth the

major policies and challenges found in promoting electric vehicles. The third section examines, in regard to the case study, identified governance challenges with respect to energy reliance, infrastructure development, and battery generation. Chapter four provides policy recommendations for tackling those challenges, emphasizing the need for intersectoral and international cooperation. Finally, this paper concludes with its main findings and discusses the broader implications for environmental governance.

2. Case Description

2.1 China‘s Electric Vehicle Adoption Strategy

As the world’s largest automobile market, China has an indispensable position in the global transition to EVs. To address severe air pollution and reach a carbon-neutral target by 2060, the Chinese government has issued a series of ambitious policies to promote EVs [3]. This has helped the country rapidly expand its EV market, which in 2019 was more than half of the global EV sales, powered by government incentives, subsidies, and supportive infrastructure policies.

The “Dual Credit” policy has been part of the backbone surrounding China’s strategy since 2017. The policy marries corporate average fuel consumption standards with New Energy Vehicle Credits, making automobile manufacturers comply with targets not just on improving fuel efficiency but also on producing electric vehicles. This has created a dual approach to incentivizing the leading manufacturers to produce more EVs while simultaneously improving the fuel efficiency of traditional gasoline-powered vehicles.

The Chinese government has subsidized the purchase of EVs heavily, trying to entice consumers into buying them, but it plans for its gradual cancellation by 2022. Besides this, the country laid down ambitious targets for the installation of EV charging stations, which will ensure that the EV infrastructure at least keeps pace with the exponential demand for electric vehicles [6].

2.2 Challenges in Implementation

Although the EV market is growing very fast in China, there have remained a number of challenges that indicate some governance issues in transitioning towards low-carbon transportation. First, most of the country’s electricity generation plants are thermoelectric coal-fired. While it is true that electric vehicles reduce pollution from the tailpipe, the overall environmental benefit of electric vehicles is reduced when the feeding electricity is generated from high-emission sources like coal [4]. To resolve this predicament, China needs to expedite the integration of renewable energy into its grid. This process is presently lagging in comparison with the expansion of the EV market. The development of the charging infrastructure represents another big challenge. While China indeed made formidable progress in constructing places for charging, the number and distribution of existing facilities are still highly insufficient to satisfy market demand for EVs. This imbalance in the development of infrastructure may further hinder the diffusion of EVs, especially in less urbanized areas where access to charging points is highly insufficient.

Finally, there is an environmental concern in battery production. Most electric vehicles depend on lithium-ion batteries, whose extraction of rare earth metals- a process often destructive to the environment- depends on an appreciable amount of processing. In addition, recycling such batteries has raised other issues of governance, where China lacks a comprehensive mechanism for recovering used batteries in an environmentally friendly manner [5].

3. Analyze the Problem

3.1 Analysis of Problems in the Case

3.1.1 Over-reliance on non-renewable energy

One of the most critical issues facing the transition to electric vehicles in China is the dominance of its electrical generation mix through non-renewable sources, precisely coal-fired power plants. In theory, EVs seem to be a cleaner manifestation of internal combustion engine vehicles; however, their ecological advantages are weakened when the electricity they require for motion comes from coal, a high GHG emitter [1]. Indeed, studies have demonstrated that if charged with electricity from fossil fuel sources, EVs can give out a higher carbon footprint in the use phase compared with conventional gasoline vehicles. Thus, without an aggressive shift toward renewable energy sources like solar, wind, and hydro, the full potential of EVs in reducing carbon emissions cannot be realized. In some instances, the Chinese government’s initiatives to speed up EV growth have significantly outpaced the necessary matching investments in renewable energy supply [4]. This mismatch in the pace at which EVs are adopted and energy is transitioned points to a seam in governance whereby seams between the energy and transportation sectors must be more effectively integrated in order to maximize the environmental potential of EVs. Absent coherent policy efforts, the increasing demand for electricity in the country from EVs may further burden the use of coal and undermine efficient emissions reduction [6].

3.1.2 Inadequate charging infrastructure

Yet another critical challenge is the inadequacy of charging infrastructure with respect to the EV sector in China. In as much as the Chinese government has set ambitious targets in relation to installation numbers for public charging stations, current numbers cannot meet the needs of the growing EV population within the country.

Most especially, it can be noted that in less urbanized and rural areas, accessibility to charging stations is scarce, hence acting as a greater barrier to wider ranges of EV adoption [9]. In return, the charger distribution-to-large-urban-area skew reduces the convenience of using an EV for long-distance travel.

This has not only caused a lack of confidence among consumers to switch to EVs but also increased range anxiety, which is considered one of the main concerns for potential EV buyers who may consider purchasing an electric vehicle [9]. This again raises the issue that unless the charging network is proper and well-distributed, the transition to electric mobility cannot be smooth. Unless some revolutionary changes occur over the particular issue, the adoption of EVs may come to a conclusion, particularly in places where there are scattered infrastructure developments.

3.1.3 Environmental impact of the battery production

The most significant environmental concern is mostly lithium-ion. The manufacturing of such batteries requires rare earth metals, including lithium, cobalt, and nickel, mostly mined using sm TECH from countries with shaky environmental laws [7]. This extraction, at times, leads to serious environmental degradation, including deforestation, soil erosion, and water pollution.

Additionally, due to the way in which battery production is notably energy-intensive, telling against EVs is the overall carbon footprint that this engenders, illustrating a vehicle choice not as ‘green’ as perhaps initially thought [10].

Further challenges arise with the appropriate waste management and recycling of EV batteries. Currently, the lack of a comprehensive recycling network in China for handling spent batteries creates potential environmental contamination if not properly managed. With only a few recycling facilities for lithium-ion batteries in existence, vital material resources can often be lost, further adding to the environmental burden of battery production. In a future where the number of EVs on the road continues to grow, lifecycle environmental impact will be an increasingly important consideration for batteries.

3.2 Reasons for Analysis of Problem

3.2.1 Policy mismatch between energy and transport sectors

The policy disconnect between the energy and transport sectors is one of the major causes of governance gaps on EVs in China. While China has been adopting progressive policies on solar-powered electric vehicles, its energy policies have been lagging, with most of its electricity still harnessed from coal.

This is a policy mismatch that limits the environmental benefits of EVs since, in most cases, the electricity that is fed comes from non-renewable sources [6]. In fact, for EVs to be truly effective in reducing carbon emissions, energy policies must also be aligned with transport policies to ensure the decarbonization of the electricity grid runs parallel with the adoption of cleaner vehicles [6]. There has also been no long-term planning with respect to integrating renewable sources with the increasing electricity needs of the industry segment of EVs. In the absence of such a calibrated policy covering both energy generation and transportation, fully unleashing the potential of EVs for climate goals will not be possible.

3.2.2 . Economic constraints on infrastructure development

This, in part, can be attributed to the inability of charging infrastructure to catch up with the economic constraints of the growth of electric vehicles. While the Chinese government has invested huge amounts in EV subsidies and incentives, less attention has been paid to financing the building of a comprehensive charging network. A good charging infrastructure requires a great investment from the public and private sectors, especially in less profitable areas such as the countryside and remote areas [7]. It is also hard to attract private investment in the installation and maintenance of charging stations since the costs are relatively high in less densely populated areas. As a result, there is uneven development across the country.

This is an economic constraint that depicts the necessity for new financing mechanisms and public-private partnership initiatives to support the scaling up of the charging infrastructure. Unless these economic barriers are lifted, inadequate infrastructure will remain one of the major barriers to widescale EV adoption in China.

3.2.3 Lack of international cooperation regarding supply chain management

Since the chains of production are international, the environmental impact of battery production is not limited to but is an international problem. The mining of these rare earth metals used in EV batteries normally occurs

in developing countries lacking stringent environmental controls, bringing ecological degradation in its wake. Despite the existence of such deleterious consequences, international cooperation on the elaboration of governance frameworks that control environmentally and socially adverse impacts of the chain of supply is virtually nonexistent [9].

This is because, without global governance, the environmental cost of EV fabrication falls disproportionately on resource-rich, low-income countries, while the benefits flow to the richer countries consuming the final products. The question calls for increased international cooperation on standard setting for responsible mining, production, and recycling of materials for EV batteries. Without such measures, the rapid inroad of EVs may well result in environmental consequences that are a reaction to its auspicious goals of sustainability.

4. Suggestions

4.1 Improve Cross-Sectoral Policy Integration

EV adoption in China faces several challenges that could be better addressed with more integration between policy development. The incomplete integration of transportation and energy sectors occurs at the cost of fully realizing the environmental benefits of electric vehicles. Key recommendations underpin an appeal for strengthened cross-sectoral policy integration wherein transportation policies focusing on increasing the adoption of EVs are in line with energy policies that target decarbonization of the electricity grid. It would also be very helpful if the Chinese government formulated more challenging targets for renewable energy production together with its ambitions vis-à-vis expanding EVs. First, this will ensure that the electricity used to charge the EVs is from clean, renewable sources, which will go a long way in reducing the overall carbon footprint of the transportation sector [6]. Coordinated policies could also include incentives for industries related to renewable energy development and those on electric vehicle infrastructure, thus incentivizing synergy amongst these critically linked sectors. Such an integrated policy approach meets China's broader environmental goals while maximizing the concomitant benefits of EV adoption.

4.2 Improvement in Infrastructure Development Planning

The main obstacle to the large-scale adoption of EVs in China is the insufficient infrastructure for charging. In the face of such challenges, infrastructure development planning should be improved. A national strategy is needed, and it should be directed at increasing the number of charging stations along with the appropriate distribution between urban and rural areas. Public-private partnerships can altogether act as an accelerator in the development of charging infrastructure. For this, the government may partner with private companies to leverage private investment for building and maintaining charging stations in those areas where companies would not find it economically viable to invest without government support. Currently, with this, there is further clamor to raise technological advancements in the fast-charging stations a notch by reducing charging time and making EVs more convenient for long-distance travel [11]. Besides, the government can enact policies whereby the incorporation of EV charging infrastructure in the building processes of new commercial and residential buildings is made a requirement. In this case, there will be assurance that EV owners are closer to convenient charging options both at home and at work to enhance the use of electric vehicles [12].

4.3 Enhance International Governance of Battery Supply Chains

As identified from the analysis, the environmental and social impacts associated with battery production can be alarming. It is important in this regard that China and other countries involved take serious measures with respect to the improvement of international governance over the value chains of the batteries. Formulation of international standards and, when necessary, regulations with respect to mining, manufacturing, and recycling of battery materials should be evolved to ensure that the environmental benefits of EVs are not transformed by negative impacts from battery manufacturing [1,10]. One way to add more order is through the creation of a battery material global certification process, akin to the Kimberley Process for conflict diamonds. In this way, the raw materials would be responsibly sourced with only minimal environmental damage while strict criteria on labor and environmental issues are met. The result would be supply-chain transparency, enabling consumers to make informed choices about the environmental impacts of the products they use.

Besides this, China can also advocate for a circular economy for EV batteries. This is the way forward, and it has the potential to avoid digging and dumping by recovering and reusing these materials. Aggressively investing in advanced recycling technologies and infrastructure, this country will shrink the demand for virgin raw materials and reduce the environmental footprint of battery manufacturing. This would place it as a leader throughout the chain of sustainable EV manufacturing [9].

4.4 Encouraging Technological Innovations for Energy Efficiency

While most of the attention has centered around greater EV adoption and infrastructure, there is also a related need for facilitating technologies that continue to enhance the energy efficiency of the vehicles themselves. Examples of this are solid-state batteries, a new development in battery technology, which could raise the range of EVs while lowering their environmental impacts.

Additionally, there is the ability to decrease the overall demand for electricity by improving the energy efficiency of EVs, especially in regions where renewable energy is not yet part of the integrated grid system. It could finance R&D and provide related incentives for such research in those areas, both for the public and private sectors, to develop more efficient and sustainable EV technologies. In so doing, China prioritizes technological innovation to ensure its EV strategy is always a step ahead of the rest of the world in the decarbonization of transportation.

5. Conclusion

5.1 Summary of Key Findings

Governance challenges in EV adoption in China refer to three tiers: the dependence of the economy on non-renewable sources, underdeveloped charging infrastructure, and environmental impacts of battery production. While electric vehicles may come with considerable positive externalities via reducing GHG emissions in transport, their actual efficacy is hugely curtailed by China's continued reliance on coal-based electricity. Besides that, the lack of comprehensive charging infrastructure, especially in rural areas, and the environmental costs of battery production stand drastically opposed to a sustainable EV transition. The recommendations for several policies have been addressed in light of the problems mentioned. Cross-sector policy integration should be reinforced for enforcement into strategic energy and transport policy, allowing EVs to move abreast with the decarbonization of the electricity grid. Further, with better-charging infrastructure, consumer confidence can increase toward long-term EV growth. Finally, better governance of the supply chains related to batteries in an international context and the promotion of innovation in technology could potentially reduce any negative environmental impacts that battery production causes and further improve overall sustainability.

5.2 Significance of the Research

The need to adopt EVs, therefore, requires a holistic approach through the integration of energy policy, infrastructure development, and environmental governance. As the Chinese EV market continues to balloon, addressing these challenges would be important in ensuring that maximum benefits environmentally and societally are accrued from the transition. Moreover, the recommendations provided give a blueprint for other countries facing similar challenges in their efforts toward promoting sustainable transportation.

5.3 Implications, Limitations, and Future Research

Although this paper has done an in-depth analysis of the governance challenges associated with the adoption of EVs, limitations abound. The analysis is done mainly with secondary data, taking China as a case study. Future research should consider primary data collection, such as interviews with policymakers, industry experts, and consumers, to provide deeper insights into the local governance challenges. In this respect, one avenue for further research could be an investigation of the extent to which international agreements or cooperative frameworks will aid in confronting environmental liabilities along international battery supply chains.

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