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| seminar report |
| Analysis of carbon emission reduction contribution during usage phase of new energy vehicles based on big data |
| A case study of Tianjin |
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| **REETAM DAS**  **B.E PRODUCTION ENGINEERING**  **3RD YEAR 2ND SEMESTER**  **ROLL - 002111701101** |
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| Countries around the world are paying increasing attention to greenhouse gas emissions reduction. Under the guidance of "dual carbon" strategy in China, the development of the new energy vehicle industry as an important means of carbon emission reduction in the transportation sector has become a trend. At the same time, the Tianjin New Energy Vehicle Monitoring Platform has recorded real-time big data on the operation of new-energy vehicles since 2017, covering vehicle ownership and mileage data, which can support the calculation of carbon emission reduction contributions during usage stage of new energy vehicles. Based on the big data of the platform, this article calculates the carbon emission reduction contribution of new energy vehicles in Tianjin during usage stage, and analyzes the carbon emission reduction contributions under different technology types, vehicle types, vehicle classes, and usage scenarios. Moreover, an analysis was conducted on the top ten enterprises in Tianjin that contribute to carbon emission reduction. The reasons for the carbon emission reduction contributions of different enterprises are slightly different, mainly due to high ownership or actual driving mileage. |

**ABSTRACT**

1. **Introduction**

With the increasing attention paid by countries around the world to environmental protection, the Chinese government has also proposed a "dual carbon" strategy based on China's national conditions. Currently, the "dual carbon" goal has become a consensus in the development of various industries. As the country with the world's largest total carbon emissions, China's transportation sector accounts for about 11% of the country's carbon emissions[1,2], while road transportation accounts for about 86% of the total carbon emissions. Therefore, carbon reduction in the automotive industry has become an important component of China's transportation sector to achieve the dual carbon goals[3]. Accelerating the process of low-carbon and decarbonization throughout the entire industry chain and achieving full lifecycle carbon reduction is imperative. New energy vehicles(NEV) are driven by electricity and emit almost no exhaust gases or greenhouse gases, resulting in significant energy-saving and emission reduction effects. Therefore, developing the new energy vehicle industry has become an important means of carbon reduction in China's transportation sector[4]. In order to implement the requirements of the Ministry of Industry and Information Technology's "Notice on Further Improving the Safety Supervision of the Promotion and Application of NEV" on monitoring and managing the safety status of key systems such as the vehicle and power battery, Tianjin Industry and Information Techology Institute has built the Tianjin NEV safety monitoring platform. This platform implements functions such as basic data collection for NEV, real-time monitoring of vehicle geographic location and operational status. This platform records actual driving data of NEV, which can be used to calculate the carbon emission reduction contribution of NEV during usage phase. Based on the big data of NEV monitoring in Tianjin, we calculated the carbon emission reduction contribution of NEV during usage phase in Tianjin, and analyzed the impact of ownership structure and usage characteristics on carbon emission reduction contribution.

1. **LITERATURE REVIEW**

**Fang K, Li C, Tang Y, et al. (2022)** China’s pathways to peak carbon emission insights from various industrial sectors. Applied Energy, 2022, 306: 118039, analyzed the new energy vehicle industry has become an important means of carbon reduction in China's transportation sector.

**IEA. (2021) An Energy Sector Roadmap to Carbon Neutrality in China. Paris: IEA,** analyzed With increasing global attention on reducing greenhouse gas emissions, China's "dual carbon" strategy emphasizes the development of the new energy vehicle (NEV) industry to reduce carbon emissions in the transportation sector.

**China Automotive Technology and Research Center Co.Ltd.. (2021) Annual Report on Energy-saving and New Energy Vehicle in China. Posts and Telecommunications Press,** analyzed the transportation sector is a significant contributor to global carbon emissions, with road transportation accounting for a substantial portion of these emissions. In the context of China's "dual carbon" strategy aimed at achieving peak carbon and carbon neutrality, new energy vehicles (NEVs) are viewed as a critical component in reducing transportation-related carbon emissions.

**Wang Z., Zhan W., Sun F., et al. (2023) Review of Carbon Emission Reduction Potential Analysis on New Energy Vehicles. Transactions of Beijing Institute of Technology, 1-12. DOI:** [**https://doi.org/10.15918/j.tbit1001-0645.2023.128**](https://doi.org/10.15918/j.tbit1001-0645.2023.128)**,** analyzed the significant potential of NEVs in reducing carbon emissions within the transportation sector. Methodologies involving baseline and project emissions provide a robust framework for quantifying these reductions.

**Ren H., Li B., Xia L., et al. (2022) Status and Application of Carbon Assets for NEV Travel in China. Green Petroleum & Petrochemicals, 7(06): 1- 6,** analyzed NEV use electricity to replace traditional fossil fuel engines. Compared to internal combustion engine vehicles(ICEV), NEV almost do not directly generate carbon emissions during usage phase, thus having great potential for carbon reduction.

**Asamer J, Graser A, Heilmann B, et al. (2016) Sensitivity analysis for energy demand estimation of electric vehicles. Transportation Research Part D: Transport and Environment, 46: 182−199. DOI: 10.1016/j.trd.2016.03.017**, analyzed more than 60% of GAC A ion vehicle models in Tianjin are online car-hailing vehicles, with a high average annual mileage, ranking first in Tianjin. And GAC A ion is among the top active vehicles in Tianjin.

**Xia L., Chen C., Li B., et al. (2023) Calculation modeling and analysis of carbon emission reduction of battery electric passenger vehicles in use phase. Proc. SPIE., 12642: 126420M-1–126420M-7. DOI: 10.1117/12.2674604,** analyzed comprehensive lifecycle assessments (LCA) of NEVs, which include the manufacturing, usage, and disposal phases, are essential for understanding the total carbon footprint. The transition to a low-carbon transportation sector requires policies that support the entire lifecycle of NEVs, from production to end-of-life management.

**Ran C., Ren H., Liu H., et al. (2022) Research on the Calculation Method of Carbon Emission Reduction of Battery Electric Passenger Vehicles in Use Phase. China Auto, 08: 24-29,** analyzed as the adoption of NEVs continues to grow, future research should focus on comprehensive lifecycle assessments and the integration of NEVs into local and national carbon markets to sustain and enhance their environmental benefits.

**Fiori C, Arcidiacono V, Fontaras G, et al. (2019) The effect of electrified mobility on the relationship between traffic conditions and energy consumption. Transportation Research Part D: Transport and Environment, 67:275−290. DOI: 10.1016/j.trd.2018.11.018,** analyzed the difference in carbon emissions between NEV and ICEV under the same usage conditions, which is the carbon emission reduction contribution of NEV during usage phase.

**Hou L., Wang Y., Zheng Y. Zhang, A., et al. (2022) The Impact of Vehicle Ownership on Carbon Emissions in the Transportation Sector. Sustainability, 14, 12657. DOI:** [**https://doi.org/10.3390/su141912657**](https://doi.org/10.3390/su141912657)**,** analyzed the development of local carbon markets that include NEVs can further enhance their role in carbon emission reduction. By integrating NEVs into carbon trading systems, economic incentives can be provided to encourage greater adoption and usage. This approach not only promotes the use of NEVs but also supports the broader goal of carbon neutrality.

**Field F, Kirchain R, Clark J. (2000) Life‐cycle assessment and temporal distributions of emissions: Developing a fleet based analysis. Journal of Industrial Ecology, 4(2):71−91. DOI: 10.1162/108819800569816,** analyzed a significant case study is the Tianjin NEV Monitoring Platform, which provides real-time data on NEV operation since 2017. This platform has been instrumental in calculating the carbon emission reduction contributions of NEVs in Tianjin during their usage phase. In 2022, the carbon emission reduction contribution of NEVs in Tianjin was calculated to be 171,400 tons, with an average annual reduction of about 0.721 tons per vehicle.

**CDM AMS-III.C. Emission reductions by electric and hybrid vehicles,** analyzed the contributions to carbon emission reduction vary significantly across different types of NEVs. Battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) have been studied extensively. In Tianjin, BEVs accounted for 73% of the carbon emission reductions in 2022, achieving a reduction of 126,000 tons, compared to 45,500 tons for PHEVs.

1. **OBJECTIVE**

The primary objective of the paper is to analyze and quantify the carbon emission reduction contributions during the usage phase of new energy vehicles (NEVs) in Tianjin, China. With the increasing global focus on reducing greenhouse gas emissions and China's commitment to the "dual carbon" strategy, this study aims to provide a detailed assessment of how NEVs contribute to carbon reduction. This is particularly pertinent given the significant role of the transportation sector in carbon emissions, with road transportation accounting for a substantial portion.

The study leverages the comprehensive big data collected by the Tianjin New Energy Vehicle Monitoring Platform. This platform, operational since 2017, provides real-time data on vehicle ownership, configuration parameters, and actual driving mileage of NEVs in Tianjin. By utilizing this data, the paper aims to offer a precise calculation of carbon emission reductions achieved through the use of NEVs.To achieve its objectives, the paper adopts a robust methodology. It begins by extracting relevant data from the monitoring platform, including vehicle parameters such as electricity consumption, curb weight, vehicle type, and level. This data is crucial for establishing baseline emissions, which represent the carbon emissions of conventional internal combustion engine vehicles (ICEVs) that NEVs are replacing. By comparing these baseline emissions with project emissions (the actual emissions from NEVs), the study calculates the carbon emission reduction contributions.

The study is structured to provide insights into several key aspects. Firstly, it evaluates the overall carbon emission reduction contribution of NEVs in Tianjin for the year 2022. This involves detailed calculations that reveal the total reduction in carbon emissions and the average annual reduction per vehicle. Secondly, it delves into the contributions of different types of NEVs, specifically battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). The analysis highlights the significant role of BEVs, which account for a major share of the total carbon reduction due to their high ownership and superior carbon reduction performance per vehicle.Furthermore, the paper explores the carbon emission reduction contributions across various vehicle types, including cars, sport-utility vehicles (SUVs), multi-purpose vehicles (MPVs), and minibuses. This segmentation provides a granular view of how different vehicle categories contribute to overall carbon reduction, with cars leading due to their higher market penetration.

The study also extends its analysis to different vehicle classes and usage scenarios, offering a comprehensive understanding of how vehicle characteristics and usage patterns impact carbon emission reduction. Additionally, it identifies the top ten enterprises in Tianjin that contribute significantly to carbon reduction, attributing their success to factors such as high ownership rates and actual driving mileage.

1. **METHODOLOGY**

NEV use electricity to replace traditional fossil fuel engines. Compared to internal combustion engine vehicles(ICEV), NEV almost do not directly generate carbon emissions during usage phase, thus having great potential for carbon reduction[5]. This article selects ICEV as the base-line vehicles and calculates the difference in carbon emissions between NEV and ICEV under the same usage conditions, which is the carbon emission reduction contribution of NEV during usage phase[6-11]. Considering that NEV are driven by electricity, we have included the carbon emissions from the power grid in the carbon emission considerations for of NEV during usage phase[12]. Therefore, the carbon emission reduction contribution of NEV during usage phase over a period of time can be expressed as

ER= BE-PE … (1)

where ER is the carbon emission reduction contribution of NEV during usage phase, BE is the baseline emission representing the carbon emissions of ICEV, and PE is the project emission representing the carbon emissions of NEV.

* 1. **Baseline emission**

Baseline emissions refer to the estimated amount of greenhouse gases (GHGs) or pollutants that would have been released into the atmosphere if a specific mitigation project or intervention had not been implemented. This concept is fundamental in environmental studies, particularly in the contexts of climate change, carbon trading, and sustainability assessments. The baseline serves as a reference point against which the effectiveness of carbon reduction projects and other environmental interventions can be measured.

**Importance in Climate Change Mitigation**

In the realm of climate change mitigation, baseline emissions are crucial for evaluating the impact of various strategies aimed at reducing GHG emissions. These strategies include the adoption of renewable energy, energy efficiency improvements, reforestation projects, and the deployment of clean technologies like electric vehicles (EVs). By establishing a baseline, policymakers and stakeholders can determine the actual reductions in emissions achieved by these interventions.

**Calculation of Baseline Emissions**

The calculation of baseline emissions involves several steps:

**Identification of the Project Scope and Boundaries**: This includes defining the geographical, temporal, and technological boundaries within which the project will operate. For instance, in assessing the impact of electric vehicles on carbon emissions, the scope may include a specific city or region, a defined time period, and particular types of vehicles.

**Selection of Baseline Scenario**: This scenario represents the business-as-usual (BAU) case, where no intervention or project is implemented. It is crucial to select a realistic and representative scenario that accurately reflects the conditions without the mitigation project.

**Data Collection**: Gathering historical and current data on emissions from relevant sources is essential. This data could include fuel consumption records, vehicle mileage, energy usage statistics, and industrial activity logs.

**Emission Factors**: These are coefficients that quantify the emissions produced per unit of activity, such as kilograms of CO2 per liter of gasoline burned or per kilowatt-hour of electricity consumed. Emission factors vary depending on the type of fuel, technology, and efficiency of the processes involved.

**Baseline Emission Calculation**: Using the collected data and emission factors, baseline emissions can be estimated. This involves multiplying the activity data (e.g., fuel consumption) by the corresponding emission factors.

The baseline emission is related to the fuel consumption, vehicle miles traveled(VMT), and fuel type used by ICEV, which can be expressed as



where i is serial number of ICEV model, j is serial number of vehicle, FCi is the fuel consumption of the i th ICEV model, VMTi, j is vehicle miles traveled of the j th ICEV in the i th ICEV model, ECgasoline is the carbon dioxide emission coefficient of gasoline.

**Types of Baseline Emissions**

Baseline emissions can be categorized into several types based on the nature of the projects and the methodologies used:

**Historical Baseline**: This is based on historical data and trends of emissions from the past. It assumes that past emission patterns will continue into the future if no intervention occurs. Historical baselines are often used in projects where historical data is reliable and representative of future trends.

**Projected Baseline**: This involves forecasting future emissions based on current trends, technological developments, and anticipated economic growth. Projected baselines are useful in dynamic environments where historical trends may not accurately predict future emissions.

**Hybrid Baseline**: This approach combines elements of both historical and projected baselines to create a more robust and realistic estimate of baseline emissions. It may adjust historical data with future projections to account for expected changes in technology, policy, or behavior.

**Applications in Different Sectors**

**Energy Sector**: In renewable energy projects, baseline emissions are calculated to determine the emissions that would have been generated by conventional energy sources (e.g., coal, natural gas) in the absence of renewable energy installations. This helps quantify the carbon offset achieved by renewable projects.

**Transportation Sector**: For initiatives like the adoption of electric vehicles, baseline emissions are derived from the emissions of internal combustion engine vehicles that the EVs are replacing. This involves considering factors like average fuel efficiency, mileage, and the types of fuels used.

**Industrial Sector**: In energy efficiency projects within industries, baseline emissions are estimated based on the historical energy consumption and emissions associated with standard industrial practices. The reduction achieved through efficiency improvements can then be measured against this baseline.

**Forestry and Land Use**: In reforestation and afforestation projects, baseline emissions include the carbon emissions from deforestation and land degradation activities that would have continued in the absence of the project. The sequestration potential of the new forest cover is then measured against these baseline emissions.

**Challenges and Considerations**

**Accuracy and Uncertainty**: One of the main challenges in establishing baseline emissions is ensuring accuracy and minimizing uncertainties. Variations in data quality, emission factors, and assumptions about future trends can introduce significant uncertainties in baseline estimates.

**Dynamic Baselines**: In rapidly changing environments, static baselines may become outdated. Dynamic baselines that can be periodically updated to reflect new data and changing conditions are often more accurate and reliable.

**Policy and Regulation Compliance**: Baseline emissions must comply with national and international standards and methodologies, such as those set by the Intergovernmental Panel on Climate Change (IPCC) or the United Nations Framework Convention on Climate Change (UNFCCC). Adhering to these standards ensures consistency and comparability across different projects and regions.

**Stakeholder Engagement**: Developing baselines often involves multiple stakeholders, including government agencies, industry representatives, and community groups. Effective stakeholder engagement is crucial to ensure that the baseline is realistic, acceptable, and aligned with the interests of all parties involved.

Baseline emissions serve as a fundamental benchmark for measuring the effectiveness of environmental interventions and mitigation projects. By providing a reference point, they enable accurate assessment of emission reductions, guide policy decisions, and support the development of carbon markets and trading schemes. As the world continues to tackle the challenge of climate change, the role of baseline emissions in tracking progress and ensuring accountability becomes increasingly important. Accurate and robust baseline calculations are essential for achieving global sustainability goals and fostering a transition to a low-carbon econom

* 1. **PROJECT EMISSION**

Project emissions refer to the greenhouse gas (GHG) emissions produced as a direct result of a specific project or activity. This concept is integral to the evaluation of environmental impacts and the effectiveness of mitigation strategies, particularly in sectors such as energy, transportation, industry, and land use. Understanding project emissions is essential for assessing the environmental footprint of new initiatives and for implementing effective measures to reduce or offset these emissions.

#### Importance in Environmental Impact Assessments

In environmental impact assessments (EIAs), project emissions are a critical component. They provide a quantifiable measure of the additional GHG emissions that result from the implementation of a project compared to a scenario where the project is not implemented. This comparison is fundamental in determining the net environmental impact of a project and is used to evaluate whether the project contributes positively or negatively to climate change mitigation efforts.

#### Calculation of Project Emissions

Calculating project emissions involves several key steps:

**Defining the Project Scope**: The first step is to clearly define the boundaries of the project. This includes the geographical area, the technologies involved, the timeline, and the specific activities that will generate emissions.

**Identifying Emission Sources**: All sources of GHG emissions related to the project must be identified. This can include direct emissions from on-site activities (e.g., fuel combustion, industrial processes), indirect emissions from electricity consumption, and emissions from associated activities such as transportation of materials.

**Data Collection**: Accurate data must be gathered on all relevant activities. This data might include fuel usage records, electricity consumption, production outputs, and transportation logs. High-quality data is crucial for precise emission calculations.

**Applying Emission Factors**: Emission factors are used to convert activity data into GHG emissions. These factors represent the average emissions associated with a specific activity, such as the amount of CO2 produced per unit of fuel burned or per kilowatt-hour of electricity consumed.

**Calculating Total Emissions**: The final step involves multiplying the activity data by the relevant emission factors to estimate the total GHG emissions generated by the project. This calculation provides a comprehensive picture of the project's environmental impact.

The project emission is related to the electricity consumption and vehicle miles traveled(VMT) of NEV, and the grid emission factor, which can be expressed as



where i is serial number of NEV model, j is serial number of project vehicle, ECi is the electricity consumption of the I th NEV model, VMTi , j is vehicle miles traveled of the j th NEV in the i th NEV model, EF grid is the grid emission factor.

**Types of Project Emissions**

Project emissions can be categorized based on their sources and the nature of the projects:

**Direct Emissions**: These are emissions directly generated by the project's activities. For instance, emissions from the combustion of fossil fuels in a power plant or the exhaust from construction machinery.

**Indirect Emissions**: These emissions occur as a result of the project but are produced by external sources. An example would be the emissions from electricity used by the project, which is generated off-site.

**Upstream and Downstream Emissions**: Upstream emissions refer to those generated during the production and transportation of materials and fuels used in the project. Downstream emissions occur after the project's completion, such as emissions from the use of a manufactured product.

**Applications in Different Sectors**

**Energy Sector**: In renewable energy projects, such as wind farms or solar installations, project emissions might include the emissions from the manufacturing and transportation of equipment, as well as any emissions from construction activities. These are typically lower compared to conventional energy projects but are still important to quantify.

**Transportation Sector**: For transportation projects, emissions could come from the construction of infrastructure (roads, bridges), the production of vehicles, and the emissions from the operation of these vehicles. Calculating these emissions helps in assessing the benefits of transitioning to electric vehicles or improving public transportation.

**Industrial Sector**: In industrial projects, emissions can arise from manufacturing processes, energy use, and the transportation of raw materials. Assessing these emissions is essential for implementing cleaner production techniques and improving energy efficiency.

**Land Use and Forestry**: In projects involving reforestation or afforestation, project emissions would include those from the preparation of land, planting, and maintenance activities. While these projects generally aim to sequester carbon, understanding the emissions from their implementation is crucial for a complete assessment.

**Challenges and Considerations**

**Accuracy and Uncertainty**: One of the main challenges in calculating project emissions is ensuring accuracy and minimizing uncertainties. Variations in data quality, emission factors, and assumptions about future activities can introduce significant uncertainties in emission estimates.

**Dynamic and Evolving Projects**: Projects that evolve over time or have phases can complicate emission calculations. It is important to periodically update emission estimates to reflect changes in project scope, technology, and operational practices.

**Regulatory Compliance**: Projects must comply with national and international environmental standards and methodologies. Adherence to frameworks such as those provided by the Intergovernmental Panel on Climate Change (IPCC) ensures consistency and comparability.

**Stakeholder Engagement**: Accurate emission calculations often require input from various stakeholders, including project developers, government agencies, and local communities. Effective engagement ensures that all relevant sources of emissions are considered and that the data used is comprehensive and reliable.

**Mitigation and Offset Strategies**

Understanding project emissions is the first step in developing strategies to mitigate or offset these emissions. This can involve:

**Adopting Cleaner Technologies**: Using more efficient and less polluting technologies can significantly reduce project emissions. For example, switching from fossil fuel-based energy to renewable sources.

**Improving Energy Efficiency**: Enhancing the energy efficiency of project activities can reduce the amount of fuel and electricity consumed, thereby lowering emissions.

**Carbon Offsetting**: Projects can invest in carbon offset initiatives, such as reforestation or renewable energy projects elsewhere, to compensate for their own emissions. This approach helps balance out the emissions generated by the project.

**Monitoring and Reporting**: Continuous monitoring of emissions and transparent reporting are crucial for managing and reducing project emissions. This allows for the identification of trends and areas for improvement.

1. **ANALYSIS AND RESULTS**

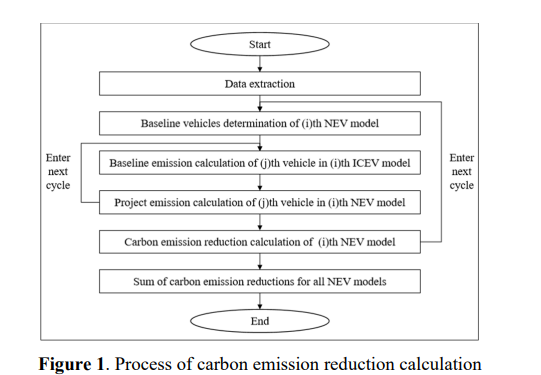
In the context of the global effort to reduce greenhouse gas emissions, the city of Tianjin, China, has made significant strides with its fleet of new energy vehicles (NEVs). Using comprehensive data from the NEV monitoring platform in Tianjin for the year 2022, we have calculated the carbon emission reduction contributions of NEVs during their usage phase. According to the China Automotive Technology and Research Center (CATARC) vehicle ownership database, by the end of 2022, Tianjin had a total of 324,000 new energy passenger vehicles (NEPVs). This fleet includes 234,200 battery electric vehicles (BEVs), which represent a substantial 72.3% of the total NEPV population, and 89,800 plug-in hybrid vehicles (PHEVs), making up the remaining 27.7%. However, it's important to note that not all these vehicles were actively contributing to the data collected in 2022. This discrepancy is primarily due to two significant factors. Firstly, vehicles that were produced and sold before 2017 were not integrated into the Tianjin NEV safety monitoring platform. Secondly, some companies that had previously provided data had since gone out of business and ceased uploading their vehicle information. Consequently, only a subset of the total NEPVs in Tianjin were active in the data set for 2022. Specifically, the active NEPV count stood at 237,900, covering approximately 73.4% of the total NEPV fleet.

Among the active NEPVs, there were 166,200 BEVs, accounting for 69.9% of the active fleet, and 71,700 PHEVs, comprising 30.1%. This active data subset is crucial for accurately assessing the carbon emission reduction contributions of NEVs because it represents the vehicles that were in regular use and monitored throughout the year. The high percentage of active BEVs indicates a strong reliance on fully electric vehicles within the city's NEV strategy, underscoring their significant role in reducing urban carbon emissions.The extensive use of BEVs in Tianjin can be attributed to several factors. BEVs are generally seen as more environmentally friendly compared to PHEVs because they do not rely on gasoline or diesel engines at all. This pure reliance on electric power translates to zero tailpipe emissions, making BEVs an ideal choice for reducing air pollution and mitigating climate change. Additionally, the infrastructure to support BEVs, such as charging stations, has seen considerable growth, making it more convenient for users to adopt and maintain BEVs.

On the other hand, PHEVs, while still contributing to carbon emission reductions, do so to a lesser extent compared to BEVs. PHEVs can operate on both electric power and traditional fuel, providing a flexible alternative for users who may have concerns about the range limitations of BEVs. However, this dual capability means that PHEVs still produce some emissions when operating on fuel, thus offering a lower overall reduction in carbon emissions compared to BEVs. The presence of 71,700 active PHEVs in Tianjin reflects a transitional phase where both fully electric and hybrid technologies coexist to cater to different user needs and preferences. Analyzing the data further, it becomes evident that the usage patterns of these vehicles play a critical role in their carbon emission reduction potential. BEVs, with their higher adoption rate, contribute significantly to emission reductions due to their extensive usage and the absence of fossil fuel consumption during operation. The active BEV fleet, comprising 166,200 vehicles, demonstrates the city's commitment to fostering an environment where electric mobility can thrive.

Moreover, the implementation of supportive policies and incentives has likely influenced the high adoption rates of BEVs. Government subsidies, tax rebates, and the provision of charging infrastructure are some of the measures that have encouraged residents to switch from traditional ICEVs to NEVs. These policies not only make BEVs more affordable but also more practical, thus accelerating their adoption and usage.

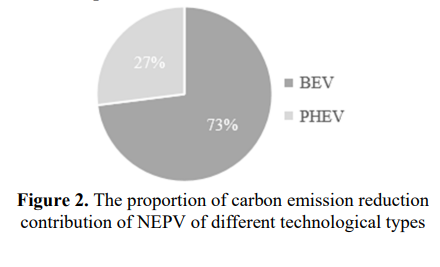
The active monitoring and data collection from the NEV platform provide a wealth of information that can be used to optimize future strategies for carbon emission reduction. For instance, by analyzing the driving patterns, energy consumption, and maintenance needs of NEVs, policymakers can identify areas where further improvements can be made. This could involve enhancing the efficiency of charging networks, introducing more stringent emission standards for PHEVs, or incentivizing the use of renewable energy sources for electricity generation to further reduce the carbon footprint of BEVs.Furthermore the data from Tianjin's NEV monitoring platform for 2022 highlights the substantial contribution of NEVs, particularly BEVs, in reducing carbon emissions during their usage phase. The active NEPV fleet, which represents a significant portion of the total NEPV population, underscores the effectiveness of NEVs in achieving environmental goals. By continuing to support the adoption and optimal use of NEVs through robust policies and infrastructure development, Tianjin can further enhance its efforts to combat climate change and promote sustainable urban mobility. The insights gained from this data are invaluable for shaping future initiatives and ensuring that NEVs remain a cornerstone of the city's strategy to reduce carbon emissions and improve air quality.



To calculate the carbon emission reduction contribution of NEV during usage phase, it is necessary to first extract data from the Tianjin NEV safety monitoring platform, including the configuration parameters of the NEV models, such as electricity consumption, curb weight, vehicle type and level, as well as the actual driving mileage data of the vehicles. Based on the vehicle configuration parameters of different NEV models, baseline vehicles can be determined, which should have the same transportation service capacity as the NEV models. According to Equation (2) and Equation (3), the baseline emissions and project emissions of different vehicles can be calculated, and then the carbon emission reduction contribution can be calculated using Equation (1). The overall process of carbon emission reduction contribution calculation based on NEV monitoring big data is shown in Figure 1. According to calculations, the carbon emission reduction contribution of NEPV during usage phase in Tianjin in 2022 is 171400 tons, with an average annual carbon emission reduction contribution of about 0.721 tons per vehicle.

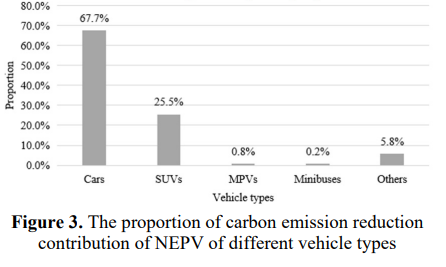
**Carbon emission reduction contribution of NEPV in different technological types**

In 2022, the Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) contributed significantly to the carbon emission reduction in Tianjin. According to the data, BEVs and PHEVs accounted for 73% and 27% of the total carbon emission reduction, respectively. Specifically, BEVs achieved a reduction of 126,000 tons of carbon emissions, while PHEVs achieved a reduction of 45,500 tons. The advantage of BEVs in carbon emission reduction is primarily due to their higher ownership numbers and superior performance in reducing emissions on a per-vehicle basis. This indicates that the widespread adoption of BEVs plays a crucial role in enhancing environmental sustainability in urban areas like Tianjin.



**Carbon emission reduction contribution of NEPV in different vehicle types**

The carbon emission reduction contribution of NEPV of different vehicle types is shown in Figure 3. As shown in Figure 3, among the carbon emission reduction contribution of NEPV in Tianjin, 2022, cars made the largest contribution, at 116000 tons, accounting for 67.7%. The carbon emission reduction contribution of sport-utility vehicles(SUVs) is 43700 tons, accounting for 25.5%, ranking second. The multi-purpose vehicles(MPVs) and minibuses have lower carbon emission reduction contribution, with a 1400 tons and 400 tons respectively, accounting for 0.8% and 0.2%, respectively. In addition, 5.8% of carbon emission reduction cannot be determined as belonging to a specific vehicle type due to missing data fields. The high penetration rate of NEV in the car market is the main reason for the significant contribution of cars to carbon emission reduction during during usage phase.



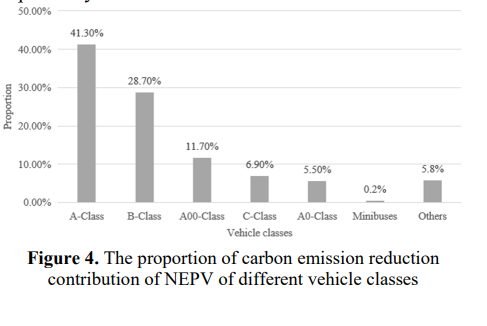
**Carbon emission reduction contribution of NEPV in different vehicle classes**

In 2022, the new energy passenger vehicles (NEPVs) in Tianjin made significant contributions to carbon emission reduction across various vehicle classes, as illustrated by the data on their respective contributions. A-class vehicles led the way, achieving the largest carbon emission reduction of 70,800 tons, which represented 41.3% of the total reduction. This class's dominant contribution underscores the high usage and efficiency of A-class NEPVs in cutting emissions.

Following A-class vehicles, B-class vehicles were the next significant contributors, with a carbon emission reduction of 49,200 tons, accounting for 28.7% of the total reduction. This substantial share highlights the effective role of B-class vehicles in reducing the city's carbon footprint, likely due to their favorable balance between size, efficiency, and market penetration. The A00-class, C-class, and A0-class vehicles also contributed to carbon emission reductions, although to a lesser extent compared to A and B classes. A00-class vehicles achieved a reduction of 20,000 tons, which accounted for 11.7% of the total reduction. This suggests that smaller, more compact NEPVs, while fewer in number, still play a meaningful role in emission reduction due to their high efficiency and frequent use in urban settings.

C-class vehicles, which are typically larger and more luxurious, contributed 11,900 tons to the reduction, making up 6.9% of the total. Despite their higher energy consumption, the adoption of NEV technology in this class shows a positive impact on reducing emissions, highlighting the potential for luxury and larger vehicles to contribute to environmental sustainability when equipped with efficient, clean energy technologies. Finally, A0-class vehicles accounted for a reduction of 9,300 tons, or 5.5% of the total. This class, which often includes smaller family cars, demonstrates that a diverse range of vehicle sizes and types can effectively contribute to overall emission reductions.

Overall, the data from 2022 clearly shows that while A and B-class vehicles are the primary contributors to carbon emission reduction among NEPVs in Tianjin, all vehicle classes collectively play a role in this critical environmental effort. The substantial contributions from each class underscore the importance of promoting NEV adoption across a broad spectrum of vehicle types to maximize the overall impact on reducing urban carbon emissions. By continuing to support the deployment of NEVs in various classes, Tianjin can further enhance its carbon reduction achievements and move closer to its sustainability goals.

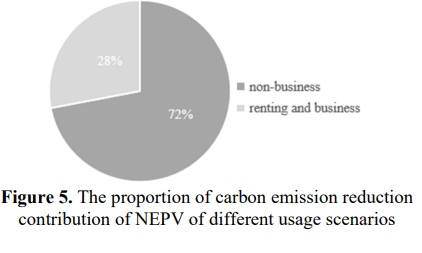


**Carbon emission reduction contribution of NEPV in different usage scenarios**

In 2022, the carbon emission reduction contributions of new energy passenger vehicles (NEPVs) in Tianjin varied significantly across different usage scenarios. According to the data, non-business NEPVs led the way with a substantial reduction of 123,900 tons of carbon emissions, accounting for a remarkable 72% of the total reduction. In contrast, NEPVs used for renting and business purposes contributed to a combined reduction of 47,500 tons, representing 28% of the total reduction. This significant difference can be attributed to the dominance of private cars in the overall NEPV population in Tianjin. Private cars constitute approximately 80.2% of the total NEPVs, which is a major factor behind the higher carbon emission reduction contribution from non-business NEPVs. The extensive use of private NEPVs for daily commuting and personal travel ensures that they cover more mileage compared to their business and rental counterparts. This higher usage directly translates into greater opportunities for reducing carbon emissions, as these vehicles replace a significant amount of conventional fuel-driven vehicle activity with cleaner, electric alternatives. Private NEPVs typically operate under conditions that maximize the efficiency and benefits of electric vehicle technology. They are often used for regular, predictable routes such as commuting to work, school runs, and other daily errands. These usage patterns are well-suited to the strengths of electric vehicles, which excel in urban driving conditions with frequent stops and starts, and benefit from regenerative braking systems that further enhance their efficiency.

On the other hand, rental and business NEPVs, although making a notable contribution to emission reductions, do not match the scale of private NEPVs. Rental vehicles often have varied and unpredictable usage patterns, which can sometimes be less efficient than the regular patterns of private vehicles. Additionally, business NEPVs might include larger vehicles that, while still more efficient than their internal combustion engine counterparts, may not achieve the same level of emission reductions as smaller private NEPVs due to their size and operational requirements. The significant carbon emission reduction achieved by non-business NEPVs underscores the critical role that private ownership of electric vehicles can play in urban sustainability efforts. It highlights the importance of encouraging more individuals to switch from conventional vehicles to electric ones. To sustain and amplify these benefits, policies and incentives that promote private NEV ownership are essential. These could include subsidies for vehicle purchase, tax incentives, investment in charging infrastructure, and public awareness campaigns highlighting the environmental and economic benefits of electric vehicles. Moreover, the data suggests that there is still substantial room for growth in the business and rental NEPV sectors. Enhancing the efficiency and appeal of electric vehicles for these purposes could further boost their contribution to overall carbon emission reductions. For instance, businesses could be incentivized to electrify their fleets, and rental companies could be encouraged to expand their electric vehicle offerings through targeted subsidies or tax breaks.

In conclusion, the analysis of NEPV usage scenarios in Tianjin for 2022 clearly indicates that non-business NEPVs are the predominant contributors to carbon emission reduction, driven by the high proportion of private electric vehicles in the city. The substantial carbon reduction achievements of private NEPVs highlight the effectiveness of electric vehicles in everyday use and the critical impact of private ownership on environmental sustainability. Moving forward, enhancing the adoption of NEVs in all sectors, supported by robust policies and infrastructure, will be key to maximizing their potential for carbon emission reductions and contributing to broader environmental goals.

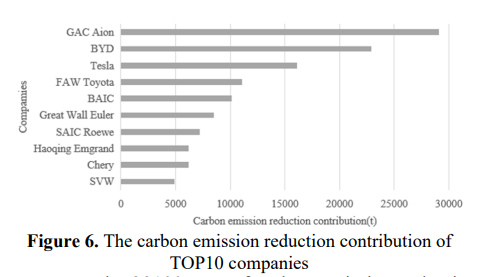


**Carbon emission reduction contribution of TOP10 companies**

Figure 6 shows the carbon emission reduction contribution of TOP10 companies. In 2022, GAC Aion, BYD, and Tesla made significant carbon emission reduction contributions of NEPV during usage phase in Tianjin, with carbon emission reductions of 29100 tons, 22900 tons, and 16100 tons respectively, accounting for 17.0%, 13.4%, and 9.4%. More than 60% of GAC A ion vehicle models in Tianjin are online car-hailing vehicles, with a high average annual mileage, ranking first in Tianjin. And GAC A ion is among the top active vehicles in Tianjin.

Therefore, GAC A ion has made a significant contribution to carbon emission reduction. The significant contribution to carbon emissions reduction of BYD is due to the fact that the number of active vehicles ranks first in Tianjin. In addition, Tesla, FAW Toyota, BAIC, Great Wall Euler, SAIC Roewe, and Chery are also among the top ten contributors to carbon emission reduction in Tianjin due to their high number of active vehicles. Haoqing Emgrand is similar to GAC A ion, with a majority of online car-hailing vehicles and an average annual mileage ranking among the top ten in Tianjin. Therefore, its contribution to carbon emission reduction is among the top ten in Tianjin. This also indirectly confirms that the contribution of carbon emission reduction is mainly determined by two factors: the number of active vehicles and the average annual mileage traveled.

Among the 29100 tons of carbon emission reduction contribution generated by GAC A ion, the contribution of GAC A ion S is particularly prominent, accounting for 84.5%. Next is GAC A ion Y, which contributes 10.7% to carbon emission reduction contribution of GAC A ion. Guangqi A ion S and Guangqi A ion Y are currently the main models in the online car-hailing market, especially A ion S, which is known for its high cost-effectiveness and is the darling of the online car-hailing market. A ion S has two important advantages: a large number of active vehicles and high annual driving mileage, making it the main force contributing to the carbon emission reduction contribution of GAC A ion.



1. **Conclusions**

Based on the above analysis and results, we can draw the following conclusion:

(1)The vehicle ownership and actual mileage are the main factors affecting the carbon emission reduction during usage phase of NEV. Both of the factors have a positive impact on carbon emission reduction contributions.

(2)The carbon emission reduction contribution of BEV far exceeds that of PHEV. On the one hand, PHEV have lower electric driving range and lower emission reduction potential per vehicle compared to BEV. On the other hand, the ownership of PHEV is also much lower than that of BEV.

(3)The carbon emission reduction contribution in Tianjin is mainly from GAC A ion and BYD. The main reason that GAC A ion has made the greatest carbon emission reduction contribution is the high travel frequency of online car-hailing vehicles.

The significant contribution to carbon emission reduction of BYD is due to the far leading ownership. At present, several auto companies have released comprehensive electrification strategies. With the continuous expansion of the ownership of NEV, the travel frequency of NEV will also be further increased, and the potential for carbon emission reduction will increase year by year.

At present, Tianjin has initiated research and exploration work on local carbon inclusive mechanisms. In the future, if the local carbon inclusive system in Tianjin includes NEV usage in the incentive scenario, the carbon emission reduction contribution during usage of NEV can be promoted to the local carbon market for trading. By utilizing the benefits of carbon trading, users can be further encouraged to use NEV for transportation, thereby promoting the development of the new energy vehicle industry.

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