

Energy Saving and Low-carbon Transformation Path of Guizhou Province Transportation

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Abstract. To help the transportation sector achieve the goal of the energy saving and low-carbon transformation, including highway, waterborne, urban transportation and ports. This paper sets four development scenarios to predict the carbon emission of the transportation sector in Guizhou province. Results indicate that in business-as-usual scenario, the carbon emissions show an overall upward trend; in high speed development scenario, the transportation in Guizhou province will reach a carbon peak in 2030, with a peak value of 8.76 million tons. China should actively take measures for energy saving and carbon reduction. By 2060, optimization of the energy structure contributes more carbon reduction than the optimization of transportation structure. We will promote the energy-saving and green development of China's transportation carbon emissions.

1. Introduction

As the world's largest emitter of greenhouse gases, China is under tremendous international pressure to reduce emissions. On September 22, 2020, President Xi Jinping made an important speech at the general debate of the 75th session of the United Nations General Assembly (UNGA), proposing that China will increase the intensity of its intended nationally determined contributions, adopt more effective policies and measures, strive to peak carbon dioxide emissions prior to 2030, and endeavor to achieve carbon neutrality before 2060. China's commitment to the "3060 Goals" of carbon peak and carbon neutrality demonstrates its responsibility as a major power, as well as opens a new journey for all industries to promote energy conservation and carbon reduction. Meanwhile, by adopting clean and low-carbon primary energy and high electrification as the main path, China will boost carbon peak and carbon neutrality. From the perspective of the national energy utilization structure, industrial engineering, construction and transportation are three major terminal energy utilization sectors. With the continuous advancement of China's industrialization and urbanization, the energy demand of the transportation sector has a sustained growth, and thus the transportation sector faces great challenges in achieving carbon peak and carbon neutrality. This paper conducts strategic research on the carbon peak and carbon neutrality path for transportation in Guizhou Province, expecting to provide an integrated program and action guidance for promoting the low-carbon development of transportation in Guizhou Province.

In recent years, the assessment of the carbon emissions of urban traffic has received more and more attention from many scholars. Zhang et al.^[1] used the travel data of residents to estimate the total carbon emission of urban transportation, and tried to discuss the carbon emission factors of different modes of transportation. Wang et al.^[2] estimated the public transport system carbon emission, based on Slack Based Model to evaluate the efficiency of public transport carbon emissions. Liu et al.^[3] establishes the LSTM carbon emission model based on the extended STIRPAT model to forecast carbon emissions in the transportation sector.

In order to analyze and predict the changes of carbon emissions of transportation in the coming years, scholars constructed Long-range Energy Alternatives Planning System (LEAP) model for scenario analysis. Zhao et al.^[4] constructed carbon-reduction policy scenarios, and analyzed the effect of the policies of vehicle and fuel improvement on the carbon emission reduction of passenger transportation in Beijing. Based on the LEAP model, Yang et al.^[5] simulated the future energy consumption and the emission trend of major air pollutants, and analyzed the energy saving and air pollutant emission control strategies in transportation sector in Guangzhou. Lu Ru^[6] uses the LEAP model to construct four different scenarios to predict the energy demand and carbon emissions in each period under different schemes. Bao et al.^[7] analyzed the carbon peak characteristics of urban traffic system from a global perspective and analyzed the carbon peak years of urban traffic in Shanghai based on the LEAP model.

In the study of measures for green development in the field of transportation, Huang^[8] and others proposed to formulate strategies from the new energy of transportation

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vehicles, the optimization of transportation structure, and the transformation of residents' travel mode. Combined with the low-carbon transportation planning practice of Songjiang New City, Lv et al.^[9] put forward low-carbon travel optimization strategies and suggestions in the new city from various aspects. Tan et al.^[10] systematically sorted out the current situation of six relevant policies on low-carbon transportation equipment and transportation structure optimization in Inner Mongolia Autonomous Region, and put forward policy suggestions from the aspects of statistical accounting, assessment and financial subsidies.

2. Method

There are two common methods of carbon emission scenario analysis: bottom-up and top-down. The bottom-up method has high calculation accuracy, but relying on comprehensive and detailed basic data, the calculation process is complicated and complex. The top-down method has low requirements on basic data and is easy to calculate, which is more suitable for macro-level carbon emission scenario analysis. Due to the detail of statistical data, the top-down method was used for scenario analysis. The calculation formula is as follows:

$$C = \sum_{i=1}^n C_i = \sum_{i=1}^n E_i \times F_i \quad (1)$$

Where:

C is carbon emissions; i is the i^{th} energy; C_i is the carbon emissions from the i^{th} energy consumption; E_i is energy consumption of the i^{th} energy; F_i is the carbon emission factor of the i^{th} energy.

3. Scenario analysis

3.1.Scenario setting

Based on the existing policy, technology and economic development situation, four scenarios are set:

- High-speed development scenario(HSD): in this scenario, the economy maintains rapid development,

the energy terminal has been promoted to clean transformation on a large scale, and the energy structure has been optimized significantly.

- Medium-speed development scenario(MSD): Under this scenario, it is assumed that the policy, technology and economy develop steadily according to the existing situation, the throughput and turnover grow gently, and the clean transformation rate of energy terminals is stable.
- Low-speed development scenario(LSD): economic development is blocked, the growth rate of throughput and turnover slows down, and the clean transformation of energy terminals is promoted slowly.
- Business-as-usual scenario(BAU): Under this scenario, the policy, technology and economy develop steadily according to the existing situation, the throughput and turnover grow gently, and the existing foundation remains unchanged with the clean energy terminal.

Due to the uncertainty of scenario analysis and the lack of current basic data and policy planning, the following basic assumptions need to be proposed in the calculation process of scenario analysis:

- The energy use terminal does not change the drive type, and the energy consumption per unit transportation volume remains unchanged;
- The emission factors of future fossil energy (diesel, gasoline, compressed natural gas, liquefied natural gas) do not change;
- The carbon emission factor of China Southern Power Grid decreases in the same proportion as the average carbon emission factor of the national power grid. The forecast trend of the carbon emission factor of the national power grid is shown in Figure 1.

In the analysis of carbon emissions of freight and passenger transport, the contribution of two measures to carbon reduction is considered, namely, transport structure adjustment and energy structure adjustment. In the analysis of port carbon emissions, only the contribution of energy structure adjustment to carbon reduction is considered.

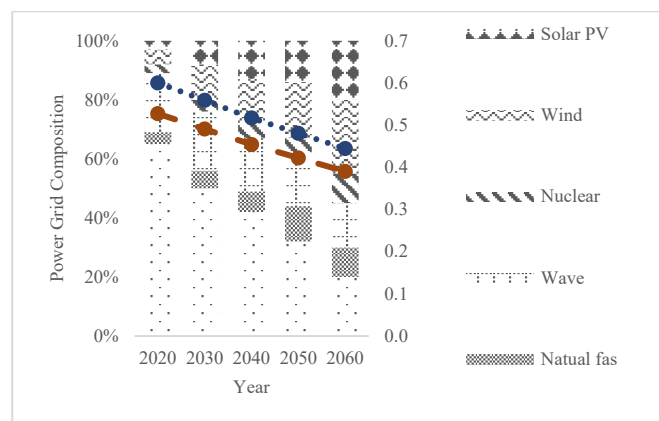


Figure 1 Change trend of the average emission factor of the national power grid from 2020 to 2060

3.2.Result

Based on the above scenario analysis of highway freight transport, highway passenger transport, waterway freight transport, waterway passenger transport, urban transport and port carbon emission in Guizhou province, and adopting two energy saving measures: transportation structure optimization and energy structure optimization,

the transportation in Guizhou province can reach the carbon peak in 2030. As can be seen from Figure 2, under the scenario of high speed development, the transportation in Guizhou province will reach a carbon peak in 2030, with a peak value of 8.76 million tons of CO₂; In the medium-speed and low-speed development scenarios, the carbon peak will occur in 2035, peak 8.69 million tons and 8.7 million tons of CO₂, respectively.

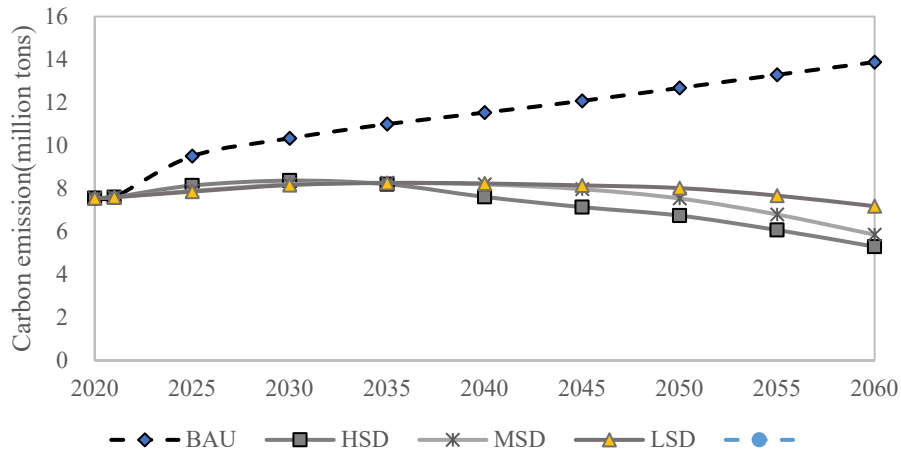
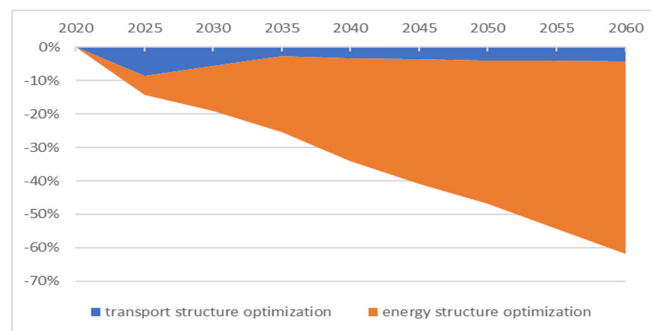


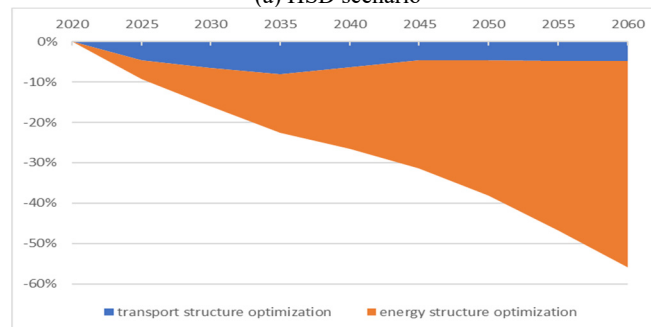
Figure 2 Trend of carbon emission in transportation of Guizhou Province

Figures 3 show the emission reduction contribution values of transport structure optimization and energy structure optimization under different development scenarios. Relatively speaking, the optimization of the energy structure contributes more carbon reduction. By 2060, optimization of the energy structure contributes more carbon reduction than the optimization of transportation structure, 57% in HSD scenario, 52% in

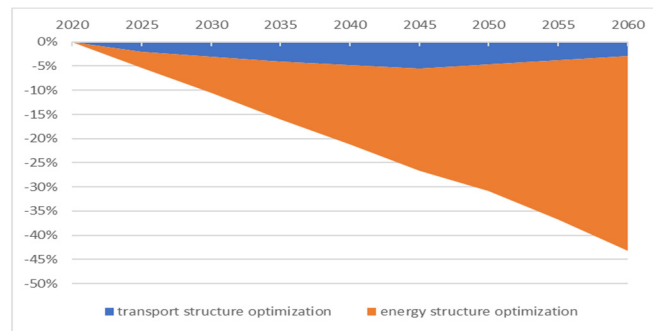
MSD scenario and 41% in LSD scenario, respectively. While, the contribution of carbon reduction brought about by the optimization of the transport structure is roughly 10% in 2060. Therefore, the future planning should focus on improving the electrification rate of transportation vehicles and increasing the proportion of new energy and clean energy.



(a) HSD scenario



(b) MSD scenario



(c) LSD scenario

Figure 3 The emission reduction contribution value of energy-saving measures

4. Research on the path to carbon peak and carbon neutrality

4.1. Construction of green and low-carbon transportation infrastructure

- Construction of an interconnected transport network: A high-quality and efficient highway network is expected to be built. Meanwhile, there's a need to coordinate highways, railways, civil aviation, water transport, pipelines and other modes of transportation. Besides, it's hopeful to build efficient urban rail transit networks. It's planned to build a "five-river linkage" network connecting trunk and branch regional waterways and forming intercommunication of river systems.
- Construction of green and low-carbon transportation infrastructure: The concept of ecology first and green and low-carbon is promising to run throughout the whole process of planning, construction, operation and maintenance of transportation infrastructure. The construction of green highways will be promoted. In addition, near-zero carbon ports, near-zero carbon service areas, near-zero carbon stations and ecological waterways will be implemented.

4.2. Acceleration of the popularization and application of new energy and clean energy transportation equipment

- Advancement of low-carbon transformation of road transport equipment: The use of new and clean energy such as electric power, natural gas, hydrogen energy, and advanced biology liquid fuels will be actively expanded in the transportation field. By 2030, the proportion of new energy and clean energy buses is estimated to reach 100%.
- Development of clean and efficient inland water transport equipment: Old ships will be eliminated, and new and clean energy powered ships will be popularized. Pure electric cruise ships and pure electric boats will be promoted in lake reservoir areas and tourist attractions. In addition, the large-scale, specialized and standardized development of transport ships will be comprehensively promoted. The standardization rate of lockage vessels is

- expected to reach 100% by 2035.
- Increase of cleaning ratio of port operating machinery, vehicles and ships: The newly added and renewed port operating machinery, vehicles and tugboats in ports and vehicles in freight hubs (logistics parks) are encouraged to give priority to new and clean energy. Meanwhile, it's recommended to promote the application of lightweight, high-efficiency, electric driven, and frequency converting controlled ports handling machines.
- Construction of the new and clean energy infrastructure: The construction of charging (battery swap) facilities in highway service areas, port areas, passenger terminals, logistics parks, bus stations and other areas will be promoted. Photovoltaic and wind power generation facilities are advocated in service areas, along highways, in port areas and in other infrastructure facilities according to local conditions.

4.3. Continuous optimization of transportation structure and organization pattern

- Promotion of "highway-to-railway" and "highway-to-waterway": "highway-to-railway" and "highway-to-waterway" for medium- and long-distance large bulk cargoes will be promoted. Besides, the water transport capacity will be improved, and the construction of inland ports will be accelerated.
- Improvement of port collection and distribution system: The planning and construction of railways, highways and trunk waterways and ports is expected to be comprehensively coordinated, the port collection and distribution system to be improved. The construction of infrastructure such as special lines and connection lines for railways entering the ports will be strengthened.
- Vigorous development of multi-modal transport: The railway-water combined transport will be vigorously developed; direct or transfer lines to the Beibu Gulf port in the south, as well as to Chongqing in the north, will be opened up, so as to achieve effective connection with China-Europe trains. Meanwhile, the containerized transportation of goods suitable for container will be promoted, and it's aimed to promote direct trunk-branch transportation, river-sea combined transport and water-water transfer.
- Construction of urban green freight distribution demonstration projects: The development of intensive

distribution modes such as uniform distribution, centralized distribution, joint distribution, and night distribution is encouraged.

4.4. Acceleration of the construction of a green travel system

- The priority development strategy of public transport will be deeply implemented. Besides, the construction of the slow traffic system will be further improved, and the public will be guided to take the initiative to choose green and low-carbon transportation modes. By 2030, the average share ratio of motorized public transport in central cities is expected to increase to above 50%. Moreover, the new bus travel service of mobility as a service (MaaS) will be explored.

4.5. Coordinated governance of pollution reduction and carbon drop

- Accelerated formation of system and mechanism coordination: An institutional system for integrated planning, promotion and assessment of pollution reduction and carbon drop will be constructed; the system for statistical investigation, accounting, verification and supervision of greenhouse gas and air pollutant emission sources will be improved; and integrated supervision and law enforcement will be explored.
- Promotion of green and low-carbon transformation of energy: Wind energy, solar energy, biomass energy, and geothermal energy will be vigorously developed; and water and electricity will be developed according to local conditions. Meanwhile, the integrated development of transportation energy is promising to be carried forward. It's advocated to promote the construction of pilot projects for the integration of power supply, grid, load, energy storage.
- Pollution prevention in operating vehicles, ports and ships: China VI vehicle emission standards and China IV emission standards for non-road mobile diesel machinery will be fully implemented. Meanwhile, priority will be given to the use of new and clean energy vehicles, operating machines, and ships. Besides, the construction of shore power and the transformation of ship power receiving facilities will be implemented.
- Enhancement of carbon sequestration and purification functions of ecosystem: It's expected to rationally plan the greening construction of traffic projects, and to reasonably expand three-dimensional green space to improve the carbon sequestration capacity of vegetation.

4.6. Reinforcement of innovation-oriented green and low-carbon technology

- Great efforts will be devoted to make technological breakthrough in key technologies such as high-efficiency photovoltaic, hydrogen production by low-cost renewable energy, and transportation energy

integration. Efforts to promote the application of advanced and mature green and low-carbon technologies will be increased. The research and development of new equipment and facilities for smart highways, intelligent shipping, automation hubs, intelligent warehousing, and sorting systems will be reinforced.

4.7. Governance system and ability enhancement

- To build a carbon emission statistical measurement system for competent authorities of industry and key enterprises. Meanwhile, transportation digitization projects will be implemented. The construction of green transportation cloud service platform will be explored, aiming to achieve full coverage and acquisition of key data such as transportation infrastructure, transportation equipment, transportation services, energy consumption, resource occupation, and environmental monitoring.

5. Conclusion

This paper sets four development scenarios to predict the carbon emission of the transportation sector in Guizhou province. Conclusion can be drawn as below:

- (1) In business-as-usual scenario, the carbon emissions show an overall upward trend;
- (2) In high speed development scenario, the transportation in Guizhou province will reach a carbon peak in 2030;
- (3) Optimization of the energy structure contributes more carbon reduction than the optimization of transportation structure.

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