Research on the development and improvement strategies of green transformation in the field of transportation

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Abstract: *Under the "dual carbon" vision, the concept of green transportation has become a key factor to promote the sustainable development of the transportation economy, especially in the field of railway transportation. This paper explores how new green transportation technologies can drive the innovation path of safety management and sustainable economic development of railway transportation. This paper analyzes the sustainable development path of railway transportation under the concept of green transportation, identifies the challenges that may be faced in the process of realizing green railway transportation, and proposes a series of coping strategies such as strengthening the research and development and application of energy-saving and emission reduction technologies, accelerating the pace of infrastructure renovation, and improving the level of informatization and intelligence. At the same time, this paper also pays attention to the basic position of railway transportation safety management, and emphasizes the importance of railway safety to the personal and property safety of the public. Under the guidance of the "dual carbon" goal, this paper aims to provide valuable reference for policymakers, industry practitioners and the public, provide theoretical support and practical guidance for promoting the green, safe and efficient development of railway transportation, and look forward to the future development direction.*

Keyword: *Carbon peaking, carbon neutrality, green transportation concept, transportation economy, sustainable development, railway transportation, safety management*

1. Introduction

Under the severe challenges of environmental degradation and resource depletion in the world, the concept of green development has become a key strategy to achieve sustainable development. This concept emphasizes that while promoting economic growth, we must pay attention to environmental protection and the efficient use of resources to achieve shared economic, social and environmental development. As the core engine of economic growth, the transportation industry has become increasingly prominent in terms of energy consumption and environmental pollution, and it is particularly important to promote its green transformation. In 2024, the State Council issued the Notice on Printing and Distributing the Action Plan for Promoting Large-scale Equipment Renewal and Trade-in of Consumer Goods, which further emphasizes that the renewal of energy-saving and carbon-reduction equipment and the need to meet energy-saving and carbon-reduction standards in the process of updating and renewing must meet energy-saving and

carbon-reduction standards, which highlights the country's emphasis on the "dual carbon" goal. As one of the main areas of energy consumption and carbon emissions, the transportation industry is of great significance to achieve the "dual carbon" goal by integrating the concept of green and low-carbon. In this context, the concept of green transportation came into being. This philosophy emphasizes a series of environmentally friendly measures during transportation to reduce the negative impact on the environment and promote sustainable development. Railway transportation has become an important part of supporting the sustainable development of China's transportation industry due to its significant advantages such as strong carrying capacity, large capacity and economic benefits, and it is also an important way to ensure the stability of social production and life. However, with the rapid development of the economy and the acceleration of urbanization, the safety management of railway transportation is facing many challenges. Integrating the concept of green transportation into the safety management of railway transportation has become an important measure to cope with the current challenges and promote the sustainable development of railway transportation. Through in-depth research on the application of new green transportation technologies in railway transportation, it is increasingly important to provide theoretical support and practical guidance for the green transformation of railway transportation.

2. Overview of the "Green Transition".

2.1 Definition and 3D structural modeling

Green transformation refers to the transformation of the development model to sustainable development with the construction of ecological civilization as the leading, the circular economy as the foundation, and the green management as the guarantee, so as to achieve resource conservation, environmental friendliness, ecological balance, and harmonious development of people, nature and society. Its core content is the transformation from the traditional development model to the scientific development model, that is, the transformation from the development form of separation between man and nature and the separation of economy, society and ecology to the harmonious coexistence of man and nature and the coordinated development of economy, society and ecology

The three-dimensional structural model of green transformation makes the connotation of green transformation more intuitive and clear, and promotes the process of ecological civilization construction, which includes the cause dimension, the method dimension, and the effect dimension, and the three dimensions are interrelated and inseparable.

(1) Cause dimension

The essence of the Reason Dimension is to answer the question of "why to carry out green transformation", which is composed of four aspects, namely economic development, social harmony, resource conservation, and environmental friendliness, and analyzes the necessity and internal motivation of green transformation. The traditional development model has always adopted "high input, high consumption and high pollution" in order to pursue sustained and rapid economic and social development, but this undoubtedly pollutes the environment and depletes resources. In order to solve the contradiction between development needs and environmental resources, "green transformation" has become the best solution.

(2) Method dimension

The methodological dimension, or "how to carry out the green transition", is achieved by the joint efforts of the three parties. Enterprises are the micro main body of green transformation and the foundation of the operation and development of the market economy. Industry is the main body of green transformation and the pillar of the economy, and the green reconstruction of the industry is the core of the development of the green economy. The government is the macro main body of green transformation and the leading force in promoting scientific development and the transformation of growth mode, and should consciously assume

the responsibility of "green transformation" and carry out green supervision for the harmony between man and nature, and the coordination between ecology and economy.

(3) Effect dimension

The effect dimension explains "what is the goal of green transformation", which is composed of the cause dimension and the effect dimension, and makes a systematic evaluation of the target effect that should be achieved by the green transition. The four major factors and the three main bodies play a comprehensive role in jointly creating the green transformation of resource-based cities, so it has become the top priority to pay attention to the development of each factor and coordinate the relationship between the factors and the subjects.

2.2 Development Background and Trends

(1) The low-carbon transition is accelerating

With the proposal of the "dual carbon" goal, the railway transportation industry has a deep understanding of the urgency and importance of low-carbon transformation. More and more railway enterprises and institutions have begun to actively explore and practice low-carbon transportation development models to promote the low-carbon transformation of railway transportation. This includes promoting low-carbon transportation modes such as new energy vehicles and clean energy vehicles, and actively adopting clean energy such as solar and wind energy in the construction of transportation infrastructure to reduce dependence on traditional fossil fuels.

(2) The concept of green travel is gradually popularized

In the context of the "dual carbon" strategy, the concept of green travel has gradually become popular in China. The public is beginning to pay attention to the environmental impact of their personal mobility and recognize the importance of choosing green mobility options. New green travel modes such as shared bicycles and shared electric vehicles are gradually emerging, effectively reducing carbon emissions. Enterprises and social organizations are also actively involved in the promotion of green travel methods, and guide citizens to develop green travel habits by launching low-carbon travel apps and organizing green travel activities.

(3) The level of intelligence and informatization has been significantly improved

With the continuous development of artificial intelligence, big data, cloud computing and other technologies, intelligence has become an important trend in the development of railway transportation. Intelligent transportation systems can collect and analyze traffic data in real time, accurately predict traffic flow and congestion, provide decision-making support for railway managers, and optimize transportation layout and travel routes. At the same time, the level of informatization has been significantly improved, and passengers can query train schedules, fares and other information in real time through the mobile APP, and reasonably arrange travel time; Railway transport enterprises can monitor the operation status of trains in real time through the information platform, dispatch and manage trains in a timely manner, and improve transportation efficiency.

3. Current situation and challenges under the "green transition".
3.1 It is difficult to control carbon emissions

On the one hand, the continuous growth of transportation demand has brought unprecedented challenges to the control of carbon emissions. With the continuous vigorous development of China's economy and the continuous improvement of people's living standards, people's demand for railway transportation is showing

an increasingly strong trend. Whether it is passenger or freight, the continuous increase in transportation has directly led to the continuous rise in carbon emissions. This not only exacerbates environmental pressures, but also poses a major challenge to achieving the goal of carbon neutrality. Although rail transport has a lower carbon emission intensity than road and air transport, its total carbon emissions cannot be ignored in the face of huge transportation demand.

On the other hand, technical bottlenecks and cost issues have become the key factors restricting carbon emission control. Although a certain degree of progress has been made in the field of energy-saving and emission reduction technologies and green transportation, there are still many technical bottlenecks that need to be broken through. For example, the research and development of high-efficiency and energy-saving EMUs still faces many technical problems, and there is still a lot of room for improvement in energy efficiency. At the same time, the implementation of energy-saving and emission reduction technologies and the promotion of new energy sources are not easy, and they are often accompanied by high initial investment and maintenance costs. The purchase cost of new energy vehicles is high, and the construction and operation of charging facilities also require a large amount of capital investment. All of this has put forward stricter requirements for the financial situation of rail transport companies, making them face greater economic pressure when promoting green transport technologies.

3.2 The green infrastructure system still needs to be improved

At present, although cities have made positive progress in the construction of green infrastructure, the green infrastructure system as a whole is still imperfect and difficult to meet the growing demand for green travel. On the one hand, the lack of unified and clear green infrastructure construction standards and planning guidance has led to differences and uncertainties in the construction of green infrastructure in various regions, and the construction quality is uneven, making it difficult to form an efficient and coordinated green transportation network. On the other hand, the construction progress of green infrastructure does not match the growth of green travel demand, and green infrastructure lags behind the actual demand in some areas, which affects the popularization and development of green transportation.

3.3 The adjustment of the transportation structure is facing bottlenecks

Although new modes of transportation such as electric vehicles and hydrogen vehicles have achieved a certain degree of development in the field of rail transportation and show great potential, there are still many challenges in terms of technology maturity, market acceptance, and infrastructure construction. These new modes of transportation still need further breakthroughs at the technical level, such as the improvement of battery life and the extensive layout of hydrogen refueling stations, in order to truly realize their wide application in railway transportation. At the same time, the market's awareness and acceptance of these new modes of transportation also need to be improved, which requires the joint efforts of the government, enterprises and the media to promote and popularize. In addition, multimodal operation is an important means to optimize the transportation structure, improve transportation efficiency and reduce carbon emissions, and the development level in China still needs to be improved. At present, the connection between various modes of transport is still not smooth enough, and the information sharing and coordination mechanism is not perfect, resulting in the actual operation of multimodal transport is not smooth, which seriously affects the transport efficiency. This inaccessible mode of transportation not only causes a lot of waste of energy, but also increases carbon emissions, which is contrary to the development goal of green transportation.

3.4 It is difficult to apply and promote informatization and intelligent technology

Informatization and intelligent technology undoubtedly has great potential and broad application

prospects in improving the efficiency of railway transportation and ensuring driving safety. However, in the process of practical application and promotion, these technologies face many difficulties and challenges.

First, the lack of technology maturity is a key factor restricting the wide application of informatization and intelligent technology. Although some progress has been made in these technologies, some of them are still in the R&D or experimental stage, and have not yet reached the level of stable, reliable, and commercial application. This leads to technical failures or instabilities in practical applications, which affect the normal operation of rail transport.

Second, limited application scenarios and high maintenance costs are also important factors restricting the development of informatization and intelligent technology. At present, the application scenarios of these technologies in the field of railway transportation are relatively limited, mainly focusing on some key links and specific scenarios. At the same time, because these technologies involve complex hardware and software systems, the maintenance costs are relatively high, which puts an additional economic burden on rail transport enterprises.

Third, the scarcity of interdisciplinary and compound talents is also one of the bottlenecks restricting the development of intelligence. The development of informatization and intelligent technology requires interdisciplinary talents who understand both railway transportation and information technology. However, such talents are relatively scarce in the field of rail transportation, and their training and introduction require investment of time and resources. This leads to a lack of sufficient professionals to support the development and application of technology in practical applications.

4. Development strategies of the times under the green transition

Driven by the new technological revolution of green transportation, intelligent technology has penetrated into various fields, providing strong support for green transformation. Through the application of intelligent technology, the optimal allocation and efficient utilization of resources can be realized, the development and utilization of green energy can be promoted, and the pollution and damage to the environment can be reduced. In the future, with the continuous development and improvement of intelligent technology, it is believed that it will play a more important role in the green transformation and make greater contributions to the realization of sustainable development and ecological civilization construction.

4.1 The integration and application of clean energy and intelligent monitoring technology

The integration and application of clean energy and intelligent monitoring technology is becoming an important force to promote green transformation. This integration not only improves the efficiency of clean energy use, but also reduces its environmental impact, supporting the achievement of the Sustainable Development Goals.

The promotion of clean energy plays a vital role in railway transportation, and its advantage is that the production process does not produce harmful substances, which can effectively reduce greenhouse gas emissions, fight global climate change, and protect the atmospheric environment. Compared with traditional fossil energy, the use of clean energy can significantly reduce environmental pollution in the process of energy extraction and consumption, and reduce the damage to water resources, soil and ecology. New energy technologies, such as solar and wind energy, as well as hydrogen fuel cells, are key to reducing carbon emissions and achieving green development. It is necessary to increase R&D investment in key technology fields such as high-efficiency and energy-saving EMUs and new energy vehicles, break through technical bottlenecks, and improve energy efficiency.

By collecting and analyzing operational data from clean energy systems in real time, smart monitoring

technology can accurately predict energy production, optimize equipment parameters, and identify potential failures in advance. For example, in the field of solar energy, intelligent monitoring systems can combine weather forecasts and solar panel performance data to predict solar power generation and optimize the angle and inclination of solar panels, thereby improving solar energy efficiency. In the field of wind energy, the intelligent monitoring system can analyze historical meteorological data and real-time meteorological data, predict wind speed and direction, optimize the operating parameters of wind turbines, and improve wind energy utilization efficiency.

The integrated application of clean energy and intelligent monitoring technology not only improves energy efficiency, but also reduces railway operation and maintenance costs. Through the real-time monitoring and early warning function of the intelligent monitoring system, enterprises can detect and deal with equipment failures in time to avoid downtime losses. In addition, the intelligent monitoring system can also provide energy management suggestions for enterprises, help enterprises optimize energy use strategies, and achieve energy conservation and emission reduction goals. The integrated application of clean energy and intelligent monitoring technology provides strong support for green transformation and promotes the innovation and development of clean energy technology.

4.2 Intelligent construction of green infrastructure

Improving the green infrastructure system will help improve the operational efficiency of railway infrastructure, strengthen the ecological and environmental protection construction along the railway, and promote the use of environmentally friendly materials and design solutions. Through the application of cutting-edge technologies such as big data, cloud computing, Internet of Things and artificial intelligence, green infrastructure can achieve intelligent management and maintenance, real-time monitoring and regulation of operating status, timely response and handling of abnormal situations, so as to ensure the stable and efficient operation of infrastructure. In addition, intelligent construction helps to reduce operating costs. Through the intelligent management system, the accurate measurement and optimal allocation of energy, water resources and other resources can be realized, waste and loss can be reduced, and operating costs can be reduced, so as to improve energy efficiency, reduce carbon emissions, and promote sustainable development.

Formulate unified standards and planning guidelines for green infrastructure construction, and clarify construction goals, requirements and timelines. Strengthen communication and coordination between localities to ensure the coordination and consistency of green infrastructure construction. Increase investment in the construction of green infrastructure, and speed up the progress of construction and transformation. Priority should be given to supporting the construction of green infrastructure in key areas and key nodes, and forming a demonstration effect. Strengthen the daily maintenance and upkeep of green infrastructure to ensure its normal operation and functioning. Strengthen the publicity and promotion of green infrastructure, and improve the public's awareness and acceptance of green travel.

4.3 Improvement of the level of informatization and intelligence

The improvement of informatization and intelligence has far-reaching and positive significance for green transformation. Through the deep integration of the railway transportation information system and the construction of a comprehensive and unified platform, a high degree of data sharing and efficient utilization will be realized. This initiative will break the information island, so that the data originally scattered in various subsystems can be gathered, forming a complete and accurate data chain, and providing a solid foundation for the intelligent management of railway transportation.

On this basis, cloud computing and big data technology are introduced to support the processing and

analysis of massive data with powerful computing power. The elastic scalability of cloud computing ensures the efficiency and stability of data processing, while big data technology can dig deep into the value of data, reveal the potential laws of train operation, energy consumption, emissions, etc., and provide a scientific basis for optimal decision-making.

Furthermore, artificial intelligence technology is used to build an intelligent scheduling system. The system receives and analyzes data from a unified platform in real time, and dynamically adjusts and optimizes train operations through advanced algorithmic models. It can not only intelligently adjust the train departure interval and travel speed according to real-time road conditions and passenger flow conditions, but also predict and respond to potential congestion and delays to ensure the punctuality and safety of train operation. Use intelligent technical means to optimize the train timetable and improve the efficiency of train operation to reduce unnecessary carbon emissions. Strengthen the management of transportation demand, reasonably guide transportation demand, and avoid excessive transportation and ineffective transportation.

Through the application of intelligent dispatching system, energy consumption and emissions can be effectively reduced while ensuring transportation efficiency. The optimization of train operation will reduce unnecessary acceleration and braking, thereby reducing energy consumption; The reduction of emissions will help improve air quality and protect the ecological environment. This initiative not only promotes the green transformation of rail transport, but also contributes to the achievement of the Sustainable Development Goals.

4.4 Guidelines for Green Policies

The government plays a vital role in promoting the development of green transportation, and in order to encourage logistics companies to actively adopt green freight tools and technologies, the government has formulated a series of powerful policy measures.

The development of strict environmental protection standards has put forward clear requirements for the emission and energy efficiency of freight vehicles. These standards not only encourage logistics companies to upgrade their equipment and adopt more environmentally friendly means of transportation, but also promote the green transformation of the entire industry; The introduction of the car purchase subsidy policy has reduced the cost of logistics enterprises to purchase green freight tools and accelerated their market popularization; Tax relief is an important means for the government to encourage green freight. By giving tax incentives to logistics companies that adopt green technologies, the government has further stimulated the enthusiasm of enterprises and promoted the widespread application of green freight technologies. Strengthening international cooperation and agreements is an important step to promote the coordination of technical standards and policies on a global scale, and accelerate the international exchange and cooperation of green transportation technologies. This will not only help improve the level of China's green transportation technology, but also promote the common development of global green transportation. These initiatives not only promote the green transformation of the logistics industry, but also make a positive contribution to the development of global green transportation.

4.5 Green regulation of social economy

Diversified financing methods, such as green bonds and green funds, are gradually becoming an important source of funds to promote the development of green transportation projects. These financial instruments not only provide the necessary financial support for green transportation projects, but also guide the flow of social capital to environmental protection and low-carbon fields through their unique investment philosophy and return mechanism, and promote the rapid development of the green transportation industry. As one of them, green bonds are usually issued by enterprises or government agencies committed to green

development, and the funds raised are mainly used to support green transportation projects, such as the research and development and promotion of new energy vehicles, the construction and renovation of public transportation facilities, etc. The green fund invests funds in a number of green transportation projects through collective investment, diversifying risks and improving the efficiency of capital utilization.

At the same time, market mechanisms also play an important role in promoting the development of green transportation. The ETS allows companies to buy and sell carbon credits in the market, thus creating an economic constraint on carbon emissions. This has prompted logistics companies to pay more attention to energy conservation and emission reduction, and actively adopt green freight tools and technologies to reduce carbon emissions and reduce operating costs. The environmental tax policy guides enterprises to reduce pollutant emissions by levying taxes and fees related to environmental protection, and further promotes the effective allocation of resources and environmental protection.

5. Conclusion

Under the guidance of the "dual carbon" future vision, the new technological revolution of green transportation is profoundly changing the face of railway transportation safety management and sustainable economic development with unprecedented speed and intensity. Through the discussion and analysis of this paper, it is not difficult to find that as an important part of the transportation system, railway transportation has made progress in green transformation and technological innovation, which is not only of great significance for reducing carbon emissions and protecting the environment, but also plays an irreplaceable role in improving transportation efficiency and ensuring the safety of people's lives and property. With the continuous progress of science and technology and the improvement of environmental protection regulations, the new technological revolution of green transportation is leading railway transportation into a new stage of development. In this stage, intelligence, informatization and low-carbon have become the key words for the development of railway transportation. By strengthening the R&D and application of energy-saving and emission-reduction technologies, accelerating the pace of infrastructure renovation, and improving the level of informatization and intelligence, railway transport enterprises are constantly promoting safety management in a more efficient, green and intelligent direction. These efforts will not only help reduce losses in the process of railway transportation and ensure smooth traffic, but also provide a more solid guarantee for the safety of people's lives and property. At the same time, we should also see that the sustainable development of the railway transport economy is showing significant market prospects and potential, driven by the new technological revolution of green transportation. In the future, with the further application of clean energy technology and intelligent transportation system, as well as the improvement of policies and regulations and the optimization of economic incentive mechanisms, railway transportation will be able to achieve sustainable economic growth while reducing carbon emissions. This will not only help to complete a higher level of environmental protection tasks, but also bring more extensive economic and social benefits to the society. However, we should also be soberly aware that there are still many challenges in the green transformation and technological innovation of railway transport. Problems such as the difficulty of carbon emission control, the lack of popularization of the concept of green travel, the need to improve the green infrastructure system, and the bottleneck of transportation structure adjustment all require us to take further targeted measures to solve them. Only by continuously deepening the concept of green and low-carbon development, strengthening technological innovation and management innovation, and rapidly transforming and applying new technologies and new energy to the transportation field, can we promote the rapid, healthy and sustainable development of railway transportation under the "double carbon" goal.

To sum up, the safety management and sustainable economic development of railway transportation

under the guidance of the new revolution of green transportation is a topic full of challenges and opportunities. In the future, we need to continue to strengthen research and practice, and continue to explore new technologies and methods to promote the development of railway transportation in a more efficient, green and intelligent way. At the same time, we also need to strengthen international cooperation and exchanges to jointly address the challenges brought about by global climate change and contribute to building a better future where man and nature coexist in harmony.

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