



Green and Intelligent Transformation of China's Ferry Transportation under the Strategy of Building a Strong Transportation Country: Current Situation, Effectiveness, and Optimization Path

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Abstract

Under the dual strategic guidance of the “dual carbon” goal and the construction of a strong transportation country, ferry transportation, as a key component of the comprehensive transportation system, is facing an urgent need for structural optimization and high-quality development. This article is based on the statistical data of the national ferry industry from 2021 to 2024, systematically analyzing the scale characteristics, regional differences, and technological upgrading status of ferry transportation in China, with a focus on exploring the transformation path of green power substitution and intelligent operation empowerment. Combining the promotion of new energy ferries with the practice of smart ferry platforms, using data comparison methods to verify the effectiveness of transformation, and analyzing the current problems such as regional development imbalance, insufficient technology application, inadequate policy support, and shortage of talent and funds. Finally, targeted optimization suggestions are proposed from four dimensions: coordinating regional development, deepening technological integration, improving policy systems, and strengthening talent and financial support, providing theoretical support and practical reference for the green, intelligent, and high-quality development of China's ferry transportation industry.

Subject Areas

Transportation Engineering

Keywords

Ferry Transportation, Green Transformation, Smart Upgrade, A Country with Great Transportation Strength, Regional Coordination

1. Introduction

1.1. Research Background

Ferry transportation, with its unique advantage of cross water connectivity, plays an irreplaceable role in coastal commuting, inland waterway transportation, island connections, and tourism connections, and is an important link in building a comprehensive three-dimensional transportation network. With the formation of a global consensus on low-carbon development and the deepening of China's transportation power strategy, the development bottleneck of traditional ferries relying on fossil fuels, low operational efficiency, and single service models is becoming increasingly prominent.

At the policy level, the "14th Five Year Plan for the Development of Water Transport" clearly proposes to build more than 15 smart ferry demonstration projects, promote the deep integration of intelligent ferry terminals, ship informationization, and digital dispatching; The 14th Five Year Plan for the Development of Green Transportation focuses on the green replacement of ship power and accelerating the phasing out and upgrading of old high emission ferries. At the market level, the total annual passenger volume of ferries in China reached 3.26 billion in 2024, a year-on-year increase of 6.8%. The highest daily passenger flow during peak holidays exceeded 12 million, and the public's demand for low-carbon, convenient, and safe ferry services continues to upgrade. In this context, promoting the coordinated transformation of greening and intelligence has become an inevitable choice for the ferry transportation industry to break through development difficulties and enhance core competitiveness [1] [2].

1.2. Research Significance

1.2.1. Theoretical Significance

Constructing an analytical framework for the green and intelligent transformation of ferry transportation, combining real industry data to reveal the inherent laws of transformation, enriching the theoretical system of green, low-carbon and digital integration development in the transportation field, and providing a new perspective for research on the transformation of cross water transportation modes.

1.2.2. Practical Significance

By quantitatively analyzing the effectiveness of transformation and existing problems, proposing feasible optimization paths, providing reference for ferry operation enterprises to formulate transformation strategies, and providing decision-making basis for government departments to improve industry supervision and

policy support, it helps to achieve results in the construction of a strong transportation country.

1.3. Current Research Status at Home and Abroad

Foreign research started earlier and focused on two main directions: first, the research and development of green power technology. Many European countries have achieved commercial operation of lithium battery and hydrogen fuel cell ferries, with new energy ferries accounting for over 30% in countries such as Norway and Sweden; The second is the construction of a smart shipping system, relying on 5G private network and IoT technology to achieve functions such as autonomous collision avoidance and remote control of ferries.

Domestic research has grown rapidly in recent years, mainly focusing on three dimensions: first, analyzing the current situation and characteristics of industry development, and sorting out the number, capacity, and regional distribution patterns of ferries through statistical data; The second is the research on green transformation technology, focusing on the optimization of new energy ferry power systems and the application of clean energy; The third is the exploration of intelligent applications, involving the construction of platforms such as intelligent scheduling and security monitoring. However, existing research mostly focuses on a single dimension or local region, lacking systematic data support for the national level green and smart transformation, and insufficient attention to regional development differences. A transformation path optimization plan covering the entire industry has not yet been formed.

1.4. Research Content and Methods

1.4.1. Research Content

Based on statistical data of the national ferry industry, analyze the industry scale, regional distribution, and transformation status; Elaborate on the core path and practical cases of green and intelligent transformation; Verify the effectiveness of transformation through data comparison; Analyze existing problems and propose optimization suggestions.

1.4.2. Research Method

Using literature review to sort out policy documents and academic achievements; Using data analysis methods, based on real data from the Ministry of Transport and industry monitoring reports, quantitatively analyze the development characteristics and transformation effects of the industry; Through case study method, select typical demonstration projects to summarize practical experience.

2. The Development Status and Characteristics of China's Ferry Transport Industry

(1) Steady expansion of industry scale and continuous optimization of structure

As of the end of 2024, the total number of various types of ferries in operation nationwide reached 8732, an increase of 18.7% compared to 2020, with an average

annual compound growth rate of 4.3%. It is expected that the market size will exceed 26 billion yuan by 2025. From the perspective of transportation capacity structure, the total number of ferry seats in China will reach 1.428 million in 2024, a year-on-year increase of 2.1%; The total carrying capacity is about 988000 tons, a year-on-year increase of 0.9%. The increase in transportation capacity is mainly due to the upgrading of large passenger and roll on/roll off ships on key coastal routes.

The ship structure shows a clear trend of optimization, with steel ferries accounting for 76.8% (6707 ships), becoming the main force in the market; Fiber-glass material ferries account for 18.3% (1594 ships), and the proportion of light-weight and environmentally friendly ship types continues to increase. The transformation of new energy has achieved significant results. In 2024, the proportion of new energy ferries (electric, LNG powered) reached 12.4%, an increase of nearly 4 percentage points compared to 2023. It is expected that more than 300 new energy ferries will be put into pilot routes in the next two years.

(2) Uneven regional distribution and differentiated development characteristics

In terms of regional distribution, the number of ferries in Jiangsu, Zhejiang, Guangdong, Hubei and Sichuan provinces ranks first in the country, accounting for 58.3% of the national total, mainly relying on the dense waterway network of the Yangtze River, the Pearl River and other water systems and the demand for tourist attractions. Jiangsu Province ranks first in the country with 968 ferries, accounting for 11.1% of the total. In 2024, the passenger volume reached 370 million, ranking first in the country for five consecutive years.

The regional differences in urban passenger ferry services are more significant. From January to August 2025, the total number of urban passenger ferry services in China was 51.63 million, a year-on-year decrease of 2.8%. The East China region accounts for 74.91%, while the South China region accounts for 12.84%. Shanghai, Fujian, and Guangdong rank among the top three provinces, with 18.23 million, 18.07 million, and 6.63 million people respectively; In terms of growth rate, Jiangsu increased by 26.8% year-on-year, while Guangdong decreased by 21.3% year-on-year, highlighting the problem of regional development imbalance (see **Table 1**) [3] [4].

Table 1. Statistics of urban ferry passenger transport volume in China from January to August 2025. (Unit: 10,000 people)

Region	Accumulated from January to August	Year on year growth rate (%)
Total	5163	-2.8
Shanghai	1823	4.1
Fujain	1807	-2.2
Guangdong	663	-21.3
Hubei	403	-5.3
Jiangsu	237	26.8
Chongqing	117	-2.0
Heilongjiang	112	-17.8

The operational characteristics of key water areas are distinct. As a key channel connecting Hainan Island and the mainland, the Qiongzhou Strait had a passenger flow of 1.688 million people entering and leaving the island in August 2025, a year-on-year increase of 3.8%; The traffic volume was 433,000 units, a year-on-year increase of 5.5%; We conducted 6113 actual flights with a carrying capacity of 7.3 million tons, a year-on-year increase of 3.5%, demonstrating the characteristics of large-scale operation that balances passenger and cargo. The Yangtze River Delta region focuses on the construction of integrated ferry transportation. The average daily passenger flow of Shanghai Huangpu River water buses will exceed 50000 in 2024, a year-on-year increase of 21%, becoming an important component of the urban slow traffic system.

(3) Technological upgrades are accelerating, and the level of intelligence is gradually improving

The configuration of intelligent equipment continues to improve. By the end of 2024, more than 40% of large ferry companies will be connected to the provincial water traffic supervision platform, achieving real-time data upload for ship positioning, passenger monitoring, safety warning and other functions. The construction of intelligent scheduling and passenger real name management platform is progressing in an orderly manner, and some key routes have achieved digital services such as flight dynamic query and online ticket booking.

The iteration of ship manufacturing technology has been accelerated. Leading enterprises such as China Shipbuilding Group and China Merchants Industry Group have launched a number of pure electric ferries with a continuous voyage of more than 200 nautical miles to achieve commercial operation in closed waters such as Qiandao Lake and the Taihu Lake. The ferry service model is constantly innovating. In addition to traditional commuting functions, new application scenarios such as water buses, mobile cultural spaces, and emergency rescue platforms are gradually expanding, and the industry's functional attributes continue to enrich [5].

3. The Core Path and Practical Achievements of Green and Intelligent Transformation of China's Ferry Transportation

(1) Core Transformation Path

Green power alternative path: Promote new energy ferries such as lithium batteries and LNG power, prioritize the use of pure electric ships for short distance inland and scenic routes, and explore hybrid power modes for medium to long distance coastal routes. From 2023 to 2024, the central and local governments have cumulatively invested over 1.8 billion yuan in special funds to promote the upgrading and replacement of over 800 old ferries that do not meet emission and safety standards.

Intelligent operation empowerment path: Build an integrated intelligent supervision system of "ship port shore", use AI algorithms to optimize route planning

and capacity allocation, and achieve equipment failure warning and real-time energy consumption monitoring through IoT devices. Build a digital service platform that integrates functions such as flight inquiry, ticket booking, and information consultation to enhance service convenience [6].

Regional collaborative development path: Based on regional integration strategies such as the Yangtze River Delta and the Guangdong Hong Kong Macao Greater Bay Area, we will promote the networking of ferry routes, standardization, and resource sharing. Strengthen the complementary advantages of coastal and inland waterway transportation, optimize the layout of ferry crossings and route networks, and enhance the collaborative efficiency of cross regional ferry transportation.

(2) Typical Practice Cases

Case study of large-scale promotion of new energy ferries: The Qingjiang Gallery Scenic Area in Hubei Province has invested in 12 pure electric ferries, with a single passenger capacity of 200 people, achieving zero emission operation and reducing carbon emissions by over 300 tons annually. During the 14th Five Year Plan period, Zhoushan City, Zhejiang Province, has invested a total of 1.2 billion yuan in ferry upgrades. The average passenger capacity of operating ferries in the area has increased from 85 in 2019 to 137 in 2024, an increase of 61.2%. At the same time, the proportion of new energy ferries has increased to 18%.

Case study of smart ferry platform construction: Wuhan city promotes the digital transformation of public ferries, builds an intelligent dispatch center, integrates real-time passenger flow data, channel environment, ship status and other information, and uses AI algorithms to dynamically allocate transportation capacity. The on-time rate of flights has been improved to 96%, and the average waiting time of passengers has been reduced by 35%. The Huangpu River water bus in Shanghai has been connected to the urban transportation one card system, achieving seamless transfer between water and land transportation. By 2024, the proportion of online ticket bookings will reach 72% [7].

Regional ferry integration case: Qiongzhou Strait optimized the cross sea transportation system, invested in 18 new large passenger roll on/roll off ships, with a maximum capacity of 1200 passengers and 120 standard vehicles per ship. In August 2025, the traffic volume entering and leaving the island increased by 5.5% year-on-year, and the carrying capacity increased by 3.5% year-on-year, significantly improving transportation efficiency. The Yangtze River Delta region is promoting the interconnection of ferry routes, realizing the networked operation of water public transportation in cities such as Shanghai, Hangzhou, and Suzhou, with an annual cross regional passenger volume exceeding 80 million.

(3) Quantitative analysis of transformation effectiveness

Green transformation achievements: By 2024, the proportion of new energy ferries will reach 12.4%, an increase of 8.7 percentage points from 2021. Calculated based on a reduction of 150 tons in annual carbon emissions per ship, the annual emission reduction of new energy ferries in China will exceed 160,000 tons. The ferry transportation environment in key scenic spots has significantly improved. After the introduction of new energy ferries in areas such as Xiandao Lake and

Qiandao Lake, the air quality rate in the water area has increased to over 98%.

The effectiveness of smart transformation: Enterprises that connect to intelligent supervision platforms have an average increase in operational efficiency of 22%, a 30% decrease in equipment failure rates, and an 18% reduction in maintenance costs. The satisfaction rate of passengers in the coverage area of digital services has reached 92%, and the average penetration rate of online services exceeds 65%. Cities such as Shanghai and Wuhan have achieved “one-stop” ferry services.

Improvement of industry development quality: From 2021 to 2024, the utilization rate of national ferry production capacity will increase from 81.7% to 84.2%. In 2024, the domestic demand for ferries will reach 980,000 deadweight tons, accounting for 26.4% of global ferry production. The frequency of safety production accidents in the industry has decreased by 27% year-on-year, and the ability to ensure safety in key water areas has significantly increased [8].

4. The Problems Faced by China's Green and Intelligent Transformation of Ferry Transportation

(1) The problem of imbalanced regional development is prominent

According to passenger volume data, from January to August 2025, the proportion of urban passenger ferries in East China reached 74.91%, while some provinces in central and western China accounted for less than 1%, indicating a significant regional development gap. From January to August 2025, the passenger volume in Jiangsu Province increased by 26.8% year-on-year, while in Guangdong Province it decreased by 21.3% year-on-year and in Heilongjiang Province it decreased by 17.8%, indicating significant regional growth differentiation. The ferry infrastructure in the central and western regions is weak, and the promotion of new energy ferries is slow. Some remote water areas still use old high emission ships, and the transformation process is lagging behind.

(2) Insufficient depth of technology integration application

New energy ferries face core technological bottlenecks, with limited range of pure electric ferries and restricted application on medium to long haul routes; Hydrogen fuel cell technology has high costs, insufficient durability, and difficulty in commercial promotion. The adaptability between smart technology and operational scenarios is insufficient, and some intelligent scheduling systems have inaccurate data collection and delayed decision response; The data barriers between different enterprises and regions have not been broken down, making it difficult to achieve cross regional and cross platform collaborative operations. Key components rely on imports, and the localization rate of core power components and intelligent control systems for new energy ferries is less than 40%, highlighting supply chain security risks.

(3) The policy guarantee system is not yet perfect

Insufficient policy support for regional differentiation, lack of special subsidies for remote areas in the central and western regions, and high cost pressure on the purchase and construction of new energy ferries and supporting facilities. The

technical standards are not unified, and there is a lack of unified specifications for the power system, charging interface, data format, etc. of new energy ferries, making it difficult for products from different enterprises to be compatible. The regulatory system is not adapted to the needs of transformation, and regulatory rules for new issues such as autonomous navigation and data security of intelligent ferries have not yet been established. In some areas, the regulatory capacity of maritime departments is insufficient, making it difficult to meet the development needs of intelligent ferry transportation.

(4) Insufficient talent and financial support

The shortage of composite talents is prominent, with insufficient reserves of professional talents who not only master ship engineering and shipping management knowledge, but also are familiar with new energy technology and information technology. There is a structural gap in capital investment, limited financing channels for small and medium-sized enterprises, and a large initial investment and long return cycle (usually 5 - 8 years) for green and smart transformation, which affects the investment enthusiasm of enterprises. The construction of supporting facilities is lagging behind, and the coverage of new energy supply facilities such as charging piles and hydrogen refueling stations is less than 30%. Some ferry crossings have weak information infrastructure, which restricts the implementation and application of smart technology [9].

5. Optimization Path for Promoting Green and Intelligent Transformation of Ferry Transportation

(1) Coordinate regional development and narrow the development gap

Optimize the regional layout: prepare the overall plan for the national ferry network, focus on supporting the upgrading of ferry infrastructure in the central and western regions, and add smart ferry demonstration projects in the middle and upper reaches of the Yangtze River, the Pearl River basin and other regions. Establish a paired assistance mechanism between the eastern and central western regions, and promote advanced transformation experience.

Differentiated policy tilt: Provide a special subsidy of up to 50% for the purchase of new energy ferries in remote areas of central and western China, and reduce related taxes and fees; Establish a special fund for regional ferry development to support the construction of supporting facilities such as charging stations and information technology.

Strengthen resource sharing: Build a national ferry resource sharing platform, promote the transfer of advanced technology and management experience from the eastern region to the central and western regions, and achieve cross regional route networking, capacity allocation, and data exchange.

(2) Deepen technological integration and break through core bottlenecks

Increase investment in technology research and development: Establish a special research and development fund for green and intelligent transformation of ferries to support joint efforts between enterprises and research institutions to im-

prove the range of lithium batteries, reduce the cost of hydrogen fuel cells, optimize the adaptability of intelligent systems, and other key technologies.

Promote the large-scale application of technology: Expand the pilot scope of new energy ferries and promote hybrid electric ferries on medium and long haul routes such as the Qiongzhou Strait and Bohai Bay; Accelerate the nationwide networking of smart ferry platforms, unify data interface standards, and break down information barriers.

Building an independent industrial chain: supporting local enterprises to develop and produce core components and intelligent equipment for new energy ferries, and improving localization rates; Cultivate a group of specialized technical service enterprises to provide integrated installation, maintenance, and upgrading services.

(3) Improve the policy system and strengthen the guarantee and support

Establish sound standards and regulations: Led by the Ministry of Transport, develop technical standards for new energy ferry power systems, charging facilities, intelligent devices, etc., unify data formats and safety standards, and achieve orderly development of the industry.

Innovative regulatory model: Establish a dynamic regulatory system that adapts to the development of smart transportation, and use technologies such as big data and artificial intelligence to enhance regulatory efficiency; Develop safety management measures for intelligent ferries, clarify responsibility allocation and risk prevention and control measures.

Expand financing channels: Encourage financial institutions to launch specialized financial products such as green loans and leasing to reduce financing costs for enterprises; Support social capital to participate in the construction and operation of ferry infrastructure, and establish a diversified funding mechanism.

(4) Strengthen talent cultivation and solidify intellectual foundation

Optimize the talent cultivation system: Universities adjust their major settings, offer majors such as ship new energy technology and intelligent shipping management, establish a school enterprise cooperation mechanism for education, and target the cultivation of composite talents.

Strengthen talent training: carry out industry skills training, organize existing employees to learn new energy technology, intelligent equipment operation and other knowledge, and enhance their ability to adapt to transformation; Invite experts and scholars to give special lectures and update the knowledge structure of industry talents [10].

Improve talent incentive mechanism: formulate preferential policies to attract high-end talents at home and abroad, provide good salary and development space for talents; Establish an industry talent evaluation system and reward technological innovation achievements.

6. Conclusions and Prospect

6.1. Research Conclusion

The scale of China's ferry transportation industry is steadily expanding. By 2024,

the total number of ferries will reach 8732, with a passenger volume of 3.26 billion. The green and smart transformation has achieved phased results, and the proportion of new energy ferries has increased to 12.4%. More than 40% of large enterprises will be connected to intelligent supervision platforms. Through green power substitution, intelligent operation empowerment, and regional coordinated development, the industry's operational efficiency, environmental protection level, and service quality have significantly improved. However, it still faces problems such as regional development imbalance, insufficient technology application, inadequate policy guarantees, and shortage of talent and funds. To promote the high-quality development of ferry transportation, it is necessary to coordinate regional efforts, deepen technological integration, improve policy systems, and strengthen talent cultivation, in order to achieve deep synergy between greening and intelligence.

6.2. Future Prospects

With the deepening of the strategy of building a strong transportation country and continuous technological progress, China's ferry transportation industry will present three major development trends: first, the level of greenization will continue to improve, and the proportion of new energy ferries is expected to exceed 30% by 2030, achieving zero emission operation in key water areas; Secondly, the level of intelligence continues to deepen, and functions such as autonomous navigation and unmanned operation and maintenance on all routes will gradually be implemented; Thirdly, regional development will be more balanced, and the infrastructure and service quality of ferry transportation in the central and western regions will be significantly improved.

Future research can further focus on the differentiated transformation paths of different types of ferries (coastal ferries, inland ferries, and tourist ferries), deeply analyze the integration and innovation mechanism of new energy technology and smart technology, and provide more targeted theoretical support for the high-quality development of the industry.

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Conflicts of Interest

The authors declare no conflicts of interest.

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