PACIFIC ENVIRONMENT

Battery Ships In The Yangtze River Basin

A Series of Reports On Sailing To Net-Zero

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Executive Summary

Since President Xi Jinping solemnly announced the "3060" carbon target at the general debate of the 75th United Nations General Assembly on September 22, 2020, the shipping industry in China has been moving towards the goal of creating low-carbon fuel supply, building a modern value chain, and achieving high-quality growth.

Changjiang River Administration of Navigational Affairs, which oversees the world's largest inland cargo shipping waterway, has been vigorously promoting the "Electrification of the Yangtze River" initiative. This initiative aims to reduce carbon emissions and mitigate pollution while also expanding the green transition and promoting economic growth. As a result, "Yangtze River Three Gorges No. 1", the world's largest pure electric cruise ship, made its maiden voyage in March 2022 and the world's first 700 TEU battery container ship "N997" docked in July 2023. These ships, together with the initiative, showcase not only the willingness of China's shipping industry to achieve net zero but also demonstrate their capabilities to do so.

Compared to fossil fuel vessels, battery-powered ships offer many climate, environmental, and economic benefits.

Climate

In terms of climate, battery-powered vessels could serve as an important tool for reducing carbon emissions in inland shipping. Its zero-carbon emission advantages will help the 14 provinces/cities in the Yangtze River Region better complete the "14th Five-Year Plan" carbon reduction goals, reach carbon peaks earlier, and achieve carbon neutrality faster.

Environment

As for the environment, battery-powered ships could become a key instrument in fighting air pollution. Its zero pollutant emission characteristics will accelerate the Yangtze River Region to achieve the targets of "By 2025, reducing PM2.5 and the nitrogen oxide emissions by 10% compared with 2020".

Economy

Regarding the economy, battery-powered vessels could support industry advancement and provide opportunities for high-quality growth of the shipping industry. In 2021, China's electric ship market size reached 9.48 billion RMB, and it is expected to grow to 16.87 billion RMB by 2025.

However, even though electric ships offer many climate, environmental, and economic benefits, the adoption rate for battery ships is far less than 1% in the country. After having conducted extensive primary and secondary research with our partners in China, Pacific Environment strongly believes the following factors inhibit the deployment of battery ships in the Yangtze River Region, many of which are intertwined.

First, the lack of financial feasibility is a significant hurdle to growing the battery ship industry. The capital cost of an electric vessel is much higher than a fossil fuel one, which makes the payback period unattractive. Second, the low battery energy density and limited charging infrastructure in place add another layer to the complexity of electric ship adoption. Lastly, insufficient support from the government, compounded with an unprofitable shipping sector, makes things even more challenging.

To tackle these issues, Pacific Environment recommends the following measures to accelerate the adoption of battery ships in the Yangtze River Region.

I. Send Long-Term Market Signals To Address Stakeholders' Uncertainty.

Carbon Tax

The International Monetary Fund has found that a carbon tax is more efficient than other carbon pricing mechanisms to deploy zero-emissions technology, like battery ships. Furthermore, a fuel tax has already been implemented by more than 160 countries/regions, one of the easiest of all taxes to collect.

Battery Ship Adoption Rate Target

Many of the provinces in the Yangtze River Region do not yet have a target for the battery ship adoption rate. Setting a goal in the 15th-year plan could enable long-term planning.

Direct Grants and Incentives

To improve the financial feasibility of battery ships at an early stage of the market, financial support from governments is needed. This will improve investors' Internal Rate of Return.

II. Support Technology Innovation To Accelerate Electric Ship Research, Development, And Deployment.

Financial Instruments

Loan guarantees, loan-loss reserves, and other mechanisms could help startups raise funds and speed up technology iteration.

Green Shipping Corridors

These partnerships are a key tool to catalyze testing, demonstration, and deployment needed to achieve net zero. Since the green corridor movement started at COP26 in November 2021, more than 20 international green corridor initiatives have been announced globally.

III. Establish Business Models To Unleash Market Potential.

The battery shipping industry could leverage experience from the electric vehicles industry. The battery swap model or the ship-to-grid model could be potential solutions to boost the market.

IV. Strengthen Knowledge Sharing And Industrial Cooperation To Reduce Stakeholders' Risks.

Establishing industry alliances and partnerships is not only conducive to forming industry consensus but also promotes knowledge transfer to solve the bottlenecks in the shipping sector.

Regularly holding industry webinars and forums, publishing best practices and case studies, and standardizing commercial terms can help the industry avoid unnecessary pitfalls.

Government-supported projects should disclose projects' cash flow and operational data for stakeholders to access risks of the technology, finance, and operation. By doing this, the shipping industry could more rapidly address bottlenecks and make any necessary changes.

Currently, there are significant challenges to scaling the battery ship industry. However, with the implementation of a set of measures, we believe it is possible to address these barriers.

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Background

On September 22, 2020, at the General Debate of the 75th Session of United Nations General Assembly, Chinese President Xi Jinping announced that “China will scale up its Intended Nationally Determined Contributions by adopting more vigorous policies and measures. We aim to have CO_2 emissions before 2030 and achieve carbon neutrality before 2060”.

These “dual carbon” goals reflect a significant strategic decision by the central government and represent China’s pledge to the global community. It underscores China’s dedication to high-quality and sustainable development. By pursuing these goals, China not only reaffirms its stance as a responsible major country but also seeks to lead and inspire green and low-carbon development globally.

Against the backdrop of achieving “Carbon Peak and Carbon Neutrality” targets, the waterway transport sector -- crucial for handling over 90% of China’s foreign trade[01] -- is intensifying its commitment to fighting against climate change. Early in 2022, the Chinese State Council released “Transportation Network Development in the 14th Five-Year Plan Period (2021-2025)”[02] . This plan emphasizes the transition to clean energy for inland vessels and aims to lower the energy consumption of transport vehicles.

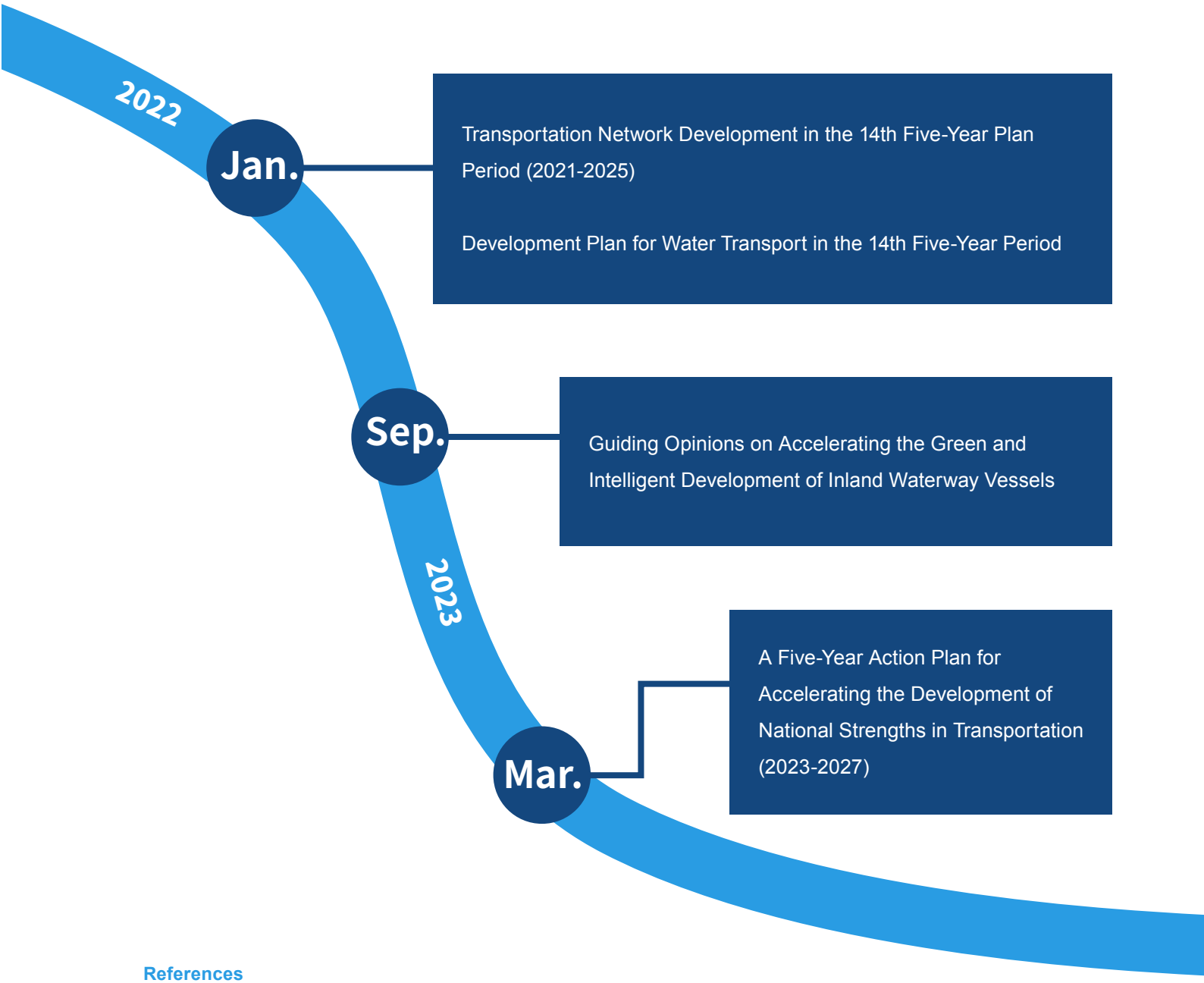
In January of the same year, aligning with key national strategies in comprehensive transportation development such as the Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China, the Outline for Building China’s Strengths in Transportation, and the Guidelines on Developing Comprehensive National Transport Network, the Ministry of Transport of the People’s Republic of China launched the Development Plan for Water Transport for the 14th Five-Year Period (hereinafter referred to as the “Water Transport Development Plan”). This plan seeks to increase waterway cargo turnover, encourage shifts from road to rail and water transport for port logistics, and specifically aims to reduce the reliance on highway transport for iron ore at ports--efforts that are critical for cutting carbon emissions in the sector. Additionally, the plan prioritizes the “development of a clean and low-carbon

energy system for port & ships", pushing for the adoption of shore power and the advancement of electric and other renewable energy vessels.

In September 2022, a collaborative directive from China's Ministry of Industry and Information Technology (MIIT), National Development and Reform Commission (NDRC), Ministry of Finance (MOF), Ministry of Ecology and Environment (MOE), and Ministry of Transportation (MOT) was released, titled "Guiding Opinions on Accelerating the Green and Intelligent Development of Inland Waterway Vessels"[03]. This guideline outlines an ambitious roadmap for the inland waterway sector: "By 2025, the shipping industry is expected witness significant advancements in key green power technologies, including liquefied natural gas (LNG), batteries, methanol, and hydrogen. Additionally, the intelligent technology used in ship equipment will see substantial improvements, and a basic framework for green and intelligent standards for inland waterway ships will emerge. By 2030, these green and intelligent technologies for inland waterway vessels will be widely adopted, enhancing support infrastructure, operation management, and business models. The industry will move towards standardization and serialization, with the mass production of green and intelligent vessels. The shift will notably improve the industrial and supply chain levels, laying the groundwork for a modernized inland shipping." This strategic approach underscores the shipping industry's commitment to carbon reduction through the high-quality development of green and intelligent inland waterway vessels.

In March 2023, a coalition of China's key transportation and regulatory bodies -- including the Ministry of Transportation, the National Railway Administration, the Civil Aviation Administration of China (CAAC), the State Post Bureau, and the China State Railway Group Co., Ltd. (China Railway) -- unveiled the Five-Year Action Plan for Accelerating the Development of National Strengths in Transportation (2023-2027)[04]. This plan emphasizes "the effective implementation of Regulations on Energy Consumption Data and Carbon Intensity of Ships" and aims to establish a robust framework for achieving carbon peak and carbon neutrality goals within the transportation sector.

Figure 1.1 Key National Policies for Carbon Reduction in China's Shipping Industry Since Adopting the "Dual-Carbon" Strategy



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02

Current Status of Shipping in the Yangtze River Basin

Despite the challenges posed by the energy crisis and COVID-19, China's waterway transport system proved it is resilient in 2022, offering robust support to the nation's journey toward building a modern country in all respects.

Infrastructure saw significant enhancements, with the addition of 456 new operational port berths and an increase in the share of navigation channels rated Grade III and higher to 11.6%, indicating continuous improvements in the water transport network. On the equipment front, the capacity for container shipping expanded by 102,900 TEU, and the average net tonnage of commercial vessels increased by 184 tons per ship, reflecting ongoing advancements in equipment specialization. Furthermore, the freight sector witnessed a 16.0% rise in the volume of combined rail-waterway container transport, signaling a further optimization of the transportation mix[01].

The Yangtze River, the world's largest natural water transport network, achieved remarkable transportation results in 2022. The provinces and cities within its basin handled a total of 6.17 billion tons of waterway freight, with the mainline ports managing 3.59 billion tons. This accounted for 80% of China's inland waterway freight volume, maintaining its global lead for the 18th consecutive year[02, 03].

With China's economic resurgence and the gradual revival of production and consumption activities, the Yangtze River's waterway transportation is poised for recovery growth. Furthermore, it is anticipated that mainline tourist passenger transport will return to pre-pandemic levels[03].

2.1 Inland Waterways

As of the end of 2022, China's inland waterways spanned a total of 128,000 kilometers, marking a 2.6% increase from 2021. This network includes 67,500 kilometers of graded navigable waterways and 60,500 kilometers of ungraded ones[01].

The Yangtze River mainline waterway, the core of this system, extends through major tributaries such as the Minjiang, Jialing, Xiangjiang, and Ganjiang rivers, covering a total of 64,818 kilometers. This represents approximately 56.6% of China's total inland waterway length[01].

Efforts to enhance and expand the Yangtze River's mainline waterway have been outlined in the "Plan for the Port Layout and the Protection and Utilization of Port Shorelines along the Yangtze River Mainline". This plan sets ambitious targets, allowing "vessels of up to 50,000 tons to reach Nanjing, 10,000-ton vessels to Wuhan, 5,000-ton vessels to Chongqing, and 3,000-ton vessels to Yibin". These developments indicate the Yangtze River's increasing role in China's waterborne transport future[04].

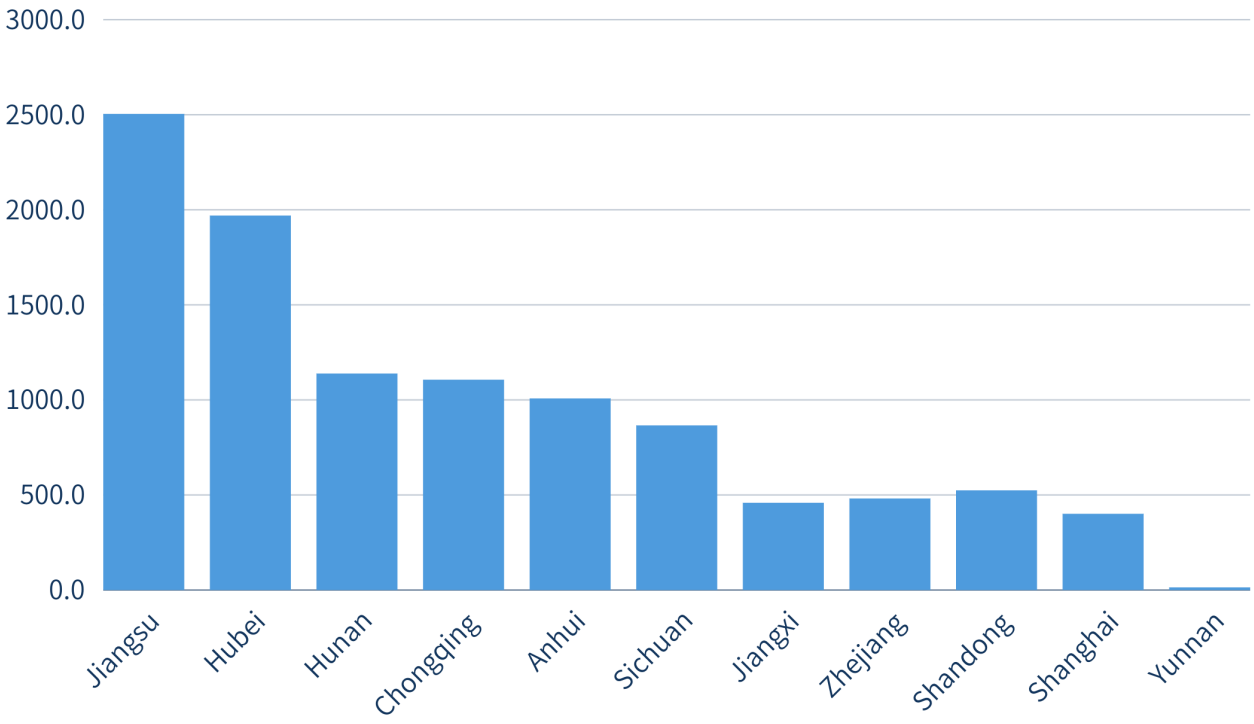

Figure 2.1 High-Graded Waterway Mileage within the Yangtze River System, 2021 (in kilometers)

2.2 Ports

As of the close of 2022, China's ports boasted a total of 21,323 operational berths, marking an addition of 456 berths since 2021. Specifically, the inland river ports accounted for 15,882 of these berths, witnessing an increase of 434 berths[01]. In terms of capacity, the distribution includes 9 berths capable of handling 100,000 tons or more, 132 berths for 50,000 to under 100,000 tons, 125 berths for

30,000 to under 50,000 tons, and 185 berths for vessels under 30,000 tons. Specialized berths* lead in quantity, with 1,468 berths accommodating over 10,000 tons, followed by 637 general bulk berths, and 434 berths for general cargo.

By the end of 2021, the Yangtze River's mainline featured 2,720 operational berths, including 443 berths with a capacity of over 10,000 tons. Within this allocation, Jiangsu Province comprises the majority with 426 berths, followed by Anhui with 16, and Chongqing with a single berth[05].

Table 2.1 Designed Capacity and Number of Operational Berths at Yangtze River Mainline Ports[05]

Location	Total Berths	Annual Volume of Freight by Design			
		Bulk and Break-Bulk Cargo (in 10,000 tons)	Container Cargo (in 10,000 TEUs)	Passenger Volume (in 10,000)	Roll-on/Roll-off Vehicle Capacity (in 10,000 CEUs)
Jiangsu	1,170	109,790	1,078	11	79.7
Anhui	359	35,426	63.6	290	14
Jiangxi	146	12,138	104	250	
Hubei	568	34,358	492	1,778	136
Hunan	53	3,281.2	85	5	10
Chong qing	362	11,429	400	3,493	162
Sichuan	59	2,485	150		30
Yunnan	3	30		50	
Total	**2,717**	**20,8937.2**	**2,372.6**	**5,877**	**431.7**

**According to the "Port Comprehensive Statistical Reporting System", berths are categorized by their primary function into specialized berths, general bulk cargo berths, general cargo berths, passenger and cargo berths, multi-purpose berths, and others. Specialized berths encompass a variety of types, including those for containers, coal, metal ores, crude oil, refined oil, liquid chemicals, liquefied natural gas (LNG), liquefied petroleum gas (LPG), bulk food, bulk cement, passengers, and roll-on/roll-off (ro-ro) vessels.*

The Yangtze River mainline ports, pivotal for the high-quality development of the Yangtze River Economic Belt, are committed to prioritizing the environment and embracing green development. The Plan for the Port Layout and the Protection and Utilization of Port Shorelines along the Yangtze River Mainline, sets a clear goal: by 2035, establish a modern, well-structured, functional, efficient, green, safe and smart Yangtze River mainline port system. This vision includes a hierarchical development model “featuring hub ports as leaders, major ports as the backbone, and the collaborative growth of other ports”. The strategy emphasizes the expansion of “intermodal rail-water freight and aims to broaden the range of cost-effective transportation channels along the river, enhance efficiency and service quality of the entire logistics process”, and “prioritize direct river-sea transport, especially for ports downstream from Anqing. Specifically, ports downstream from Nanjing will accommodate large sea vessels of over 50,000 tons for direct river entry after cargo unloading, while the Wuhan to Anqing segment will focus on direct and transit operations, with moderate development of river-sea transport within segment upstream from Wuhan”[04].

Table 2.2 Green Port Overview in the Yangtze River Basin (2021) [05]

Shanghai	Achieved full coverage of pollutant reception for inland vessels in the Huangpu River's downstream section; constructed 68 specialized shore power berths, achieving a 79% coverage rate.
Jiangsu	Installed 3,147 shore power setups and upgraded power receiving facilities on 945 river trade vessels.
Zhejiang	Implemented incentive and subsidy programs for port shore power expansion, installing 159 shore power units and upgrading power receiving facilities on 109 ships.
Anhui	Upgraded power receiving facilities on 1,984 vessels.
Jiangxi	Completed power facility upgrades for 391 vessels.
Shandong	Advanced the routine use of shore power across Bohai Bay's inter-provincial roll-on/roll-off routes.
Henan	Installed shore power at 47 berths in Zhoukou Port's central area and 10 berths at Xinyang Lyuhekou.
Hubei	Equipped 357 berths with shore power and upgraded power receiving facilities on 235 ships.
Hunan	Constructed 40 port and 50 anchorage shore power setups, including 64 low-voltage connectors.
Chongqing	Standardized shore power at 31 berths across 9 terminals, including Guoyuan Port and Fo'eryan Port in Main City Port Area, as well as Chonggang Port in Changshou District, and upgraded power receiving facilities on 1,120 cargo ships.
Sichuan	Established 84 shore power systems, ensuring all container and dry bulk terminals are equipped with shore power capability.
Guizhou	Accelerated shore power setups and upgrade at Lianyuxi Creek, Bajie, and Hongchun terminals.
Yunnan	Developed three electric propulsion passenger ships with a capacity of 150-200 guests by Dianchi shipping enterprise.
Shaanxi	Initiated a carbon peak and neutrality action plan for waterways and investigated the existing distribution of charging vessels.

2.3 Ships

As of the end of 2022, China's transportation fleet comprised 121,900 vessels with a collective net tonnage of 298 million tons. These ships have the capacity to carry 861,800 passengers and offer container space amounting to 2.9872 million TEUs. Notably, 109,500 of these vessels are designated for inland river transport, representing approximately 89.8% of the total transportation fleet[01].

Table 2.3 Overview of China' s Water Transport Fleet (2022)[01]

Key Metrics	Volume	YoY Growth Rate (%)
Overall Fleet		
Number of Ships (in 10,000)	12.19	-3.2
Net Tonnage (in 10,000 tons)	29,775.81	4.7
Passenger Capacity (in 10,000 pax)	86.18	0.5
Container Capacity (in 10,000 TEUs)	298.72	3.6
Inland Waterway Fleet		
Number of Ships (in 10,000)	10.95	-3.6
Net Tonnage (in 10,000 tons)	15,249.73	3.9
Passenger Capacity (in 10,000 pax)	57.27	-3.7
Container Capacity (in 10,000 TEUs)	55.16	14.1

Jiangsu and Anhui Provinces, leading with the highest numbers of inland river vessels, each boast over 20,000 ships, ranking first and second respectively. Zhejiang follows with 10,000 vessels, and Shandong comes in fourth with more than 9,000 ships.

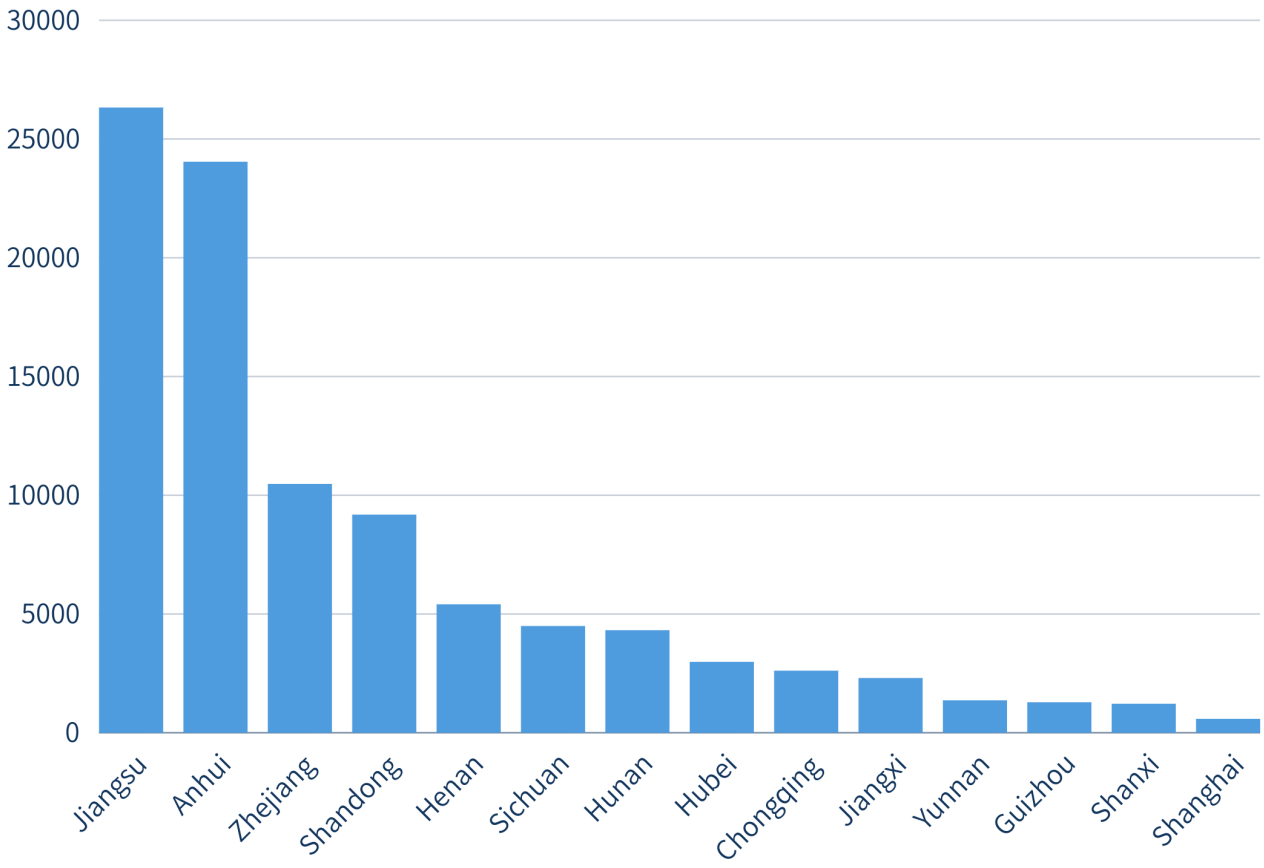

Figure 2.2 Inland Ship Distribution by Province and City[05]

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03

Battery-Powered Ships

Battery-powered ships exclusively utilize batteries for propulsion[01]. These vessels offer several advantages:

- Environmental Benefits: These vessels are characterized by low-carbon, minimal noise, and zero air pollution.
- Operational Efficiency: These ships demonstrate robust performance with the flexibility for easy speed adjustments.
- Cost Savings: Operating costs are lower compared to fossil fuel vessels, offering significant savings on fuel and maintenance.
- Automation and Intelligence: A high level of automation supports the advancement towards digital and intelligent ship operations.

The advent of battery-powered ships began overseas around 2007 to 2008, following advancements in lithium-ion battery technology. Countries like Norway and Germany were pioneers in the field of battery-powered ships. China's journey towards ship electrification commenced later but gained significant momentum after 2017, backed by supportive national policies and regulations[02]. As of July 2023, the global fleet is comprised of 769 electric vessels (including plug-in hybrids, hybrids and pure battery ships), with an additional 245 under construction. Norway leads globally, home to 34% of the world's electric ships, underscoring its dominant position in the electric maritime sector around the world[03].

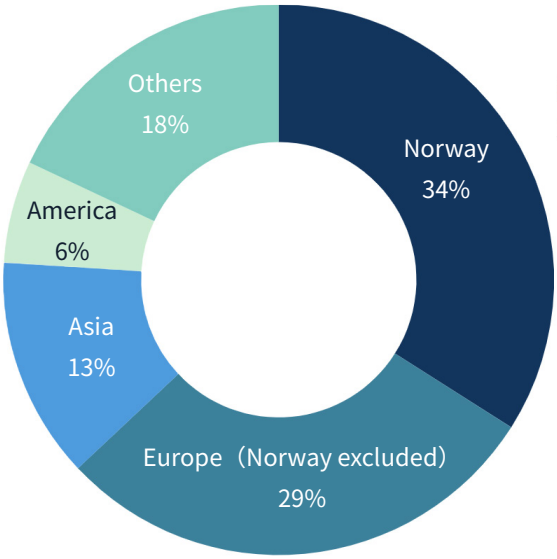

Figure 3.1 Global Distribution of Electric Ships

Figure 3.2 “Yangtze Three Gorges 1” Cruise Ship – The Electric Green Commercial Ship with the World’s Largest Electric Power Capacity

As the battery-powered ship industry progresses and expands, China’s fleet of such vessels now encompasses a wide range of waterways covering rivers, lakes and sea basins, as well as diversified vessel types, including inland river cargo ships, riverside cruise ships, and those operating in reservoirs and lakes. The country boasts over 20 large-scale battery-powered ships[02].

3.1 Power Battery for Ships

Batteries, the essential power source for pure electric ships, are critical in terms of their performance and cost. As of July 2023, onboard nickel-manganese-cobalt (NMC) batteries dominated the global market, comprising 86% of total battery-powered ships. NMC batteries significantly surpasses the share of lithium iron phosphate (LFP) batteries, which are popular in China, accounting for just 7%[03].

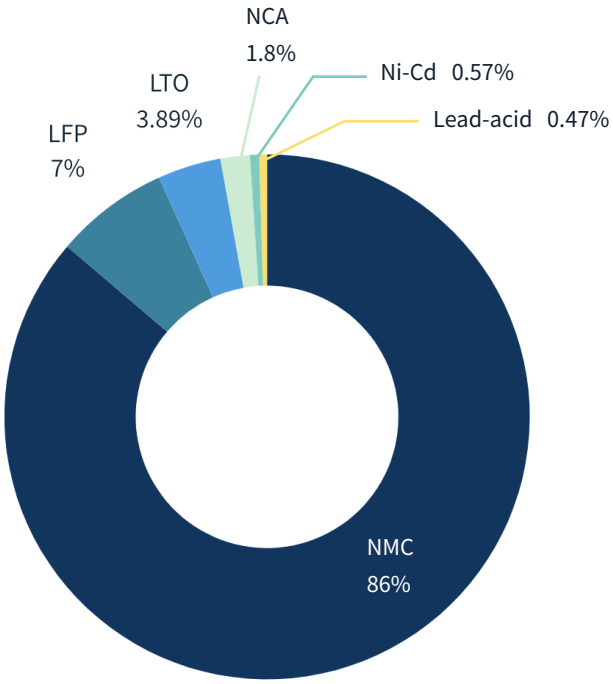

Figure 3.3 Global Distribution of Battery Types for Electric Ships

LFP batteries, known for their high safety, extended lifespan, cost-effectiveness, and balanced performance, currently dominate China’s market for ship batteries. As for July 2023, the China Classification Society’s certification statistics indicates that 36 companies have had their lithium-ion batteries certified, with 30 of these companies announcing the adoption of LFP batteries in their certifications. Notably, products from industry leaders CATL and EVE Energy are primarily based on LFP technology[04].

Table 3.1 China Classification Society's Certification of Power Battery for Ships

No.	Company	Product*	
		Lithium-ion Battery	LFP Battery
1	Contemporary Amperex Technology Co., Ltd. (CATL)		√
2	REPT BATTERO		√
3	Hubei EVE Power Co., Ltd.		√
4	Hunan Sanxun New Energy Technology Co., Ltd.		√
5	CORNEX New Energy Co., Ltd.		√
6	Hunan Meten New Energy Co., Ltd.		√
7	Branch of CSSC Fengfan Co., Ltd.		√
8	Shuangdeng Group Co., Ltd.		√
9	Qingdao Lishen New Energy Technology Co., Ltd.	√	
10	Shenzhen Racern Technology Co., Ltd.		√
11	BYD Lithium Battery Co., Ltd.		√
12	Changshu Guorui Technology Co., Ltd.		√
13	FinDreams Battery Co., Ltd.		√
14	Gree Titanium New Energy Co., Ltd.	√▲	
15	Shanghai Sonon Lithium Co., Ltd.		√
16	Zhuhai COSMX Co., Ltd.		√
17	China Aviation Lithium Battery (Luoyang) Co., Ltd		√
18	Fujian Super Power New Energy Co., Ltd.		√

** As listed under the product name in the China Classification Society's Marine Product Catalog.*

▲ Nano LTO batteries.

No.	Company	Product*	
		Lithium-ion Battery	LFP Battery
19	Zhejiang GBS Energy Co., Ltd.		√
20	Anhui Yijiatong Battery Co., Ltd.		√
21	Sunwoda Mobility Energy Technology Co., Ltd.		√
22	Ruipu Energy Co., Ltd.		√
23	Hefei Gotion High-tech Co., Ltd.		√
24	Tianjin Lishen Battery Joint-Stock Co., Ltd.		√
25	Sichuan Nan Guang New Energy Co., Ltd.		√
26	Chengdu Tecloman Energy Storage Technology Co., Ltd.	√	√
27	Ningbo Chiyang Electronic Technology Co., Ltd.	√	
28	Jiangxi Anchi New Energy Technology Co.,Ltd		√
29	GuangZhou Great Power Energy & Techology Co., Ltd.		√
30	Anhui Xinyi Power Source Co., Ltd.		√
31	Chengdu Jianzhong Lithium Battery Co., Ltd.	√	
32	Jiangxi Xingying Technology Co., Ltd.		√
33	Jiangsu Higee Energy Co., Ltd.		√
34	SGCC Smart Energy and Electric Transportation Technology Innovation Center (Suzhou) Co., Ltd.	√	
35	Henan Prospower Technology Co., Ltd.	√	
36	Sichuan Nan Guang New Energy Co., Ltd.	√	

3.2 Economic Analysis of Battery-Powered Ships

As of July 2023, alternative fuel represents only 0.56% of the global fleet, accounting for less than 1%[03]. In China, the count of electric ships did not exceed 100 in 2022[02]. A major factor behind the low adoption rate of electric ships is a lack of financial feasibility. Studies indicate that, currently, China's inland waterway electric passenger ships have a more favorable economic case compared to electric container ships and dry bulk carriers. However, as ship tonnage increases, the savings in operational costs do not offset the higher capital cost[05].

The table below contrasts the economic performance of electric passenger ships and container ships against their fuel-powered counterparts[06]. Generally, the larger a ship's tonnage, the less financially feasible it becomes.

Table 3.2 Financial Comparison of Electric and Fuel-Powered Vessels

	Fuel-powered Passenger Ships	Electric Passenger Ships	Fuel-powered Container Ships	Electric Container Ship (DWT 3,000 tons)
Capital Cost (in RMB 10,000)	130.0	586.8	180	962.4
Operating Cost (in RMB 10,000)	203.4	113.5	297.6	213.8
(1) Energy Cost (in RMB 10,000)	116.4	53.5	138.6	102.8
(2) Maintenance Cost (in RMB 10,000)	87.0	60.0	159	111
Payback Period for Electric Ships (years)		5.1		9.3

Note:
1. Passenger ships operate 80 kilometers daily, while container ships cover 100 kilometers, with both types operating 330 days annually.
2. Ships have a lifespan of 30 years, with battery warranties lasting 8 years*.
3. Fuel costs are 7.0 RMB per liter, and electricity is priced at 0.7 RMB per kWh.
4. Green box indicates a payback period shorter than the battery's warranty period, while red signifies a payback period exceeding the warranty duration of battery.

** The battery warranty period was established through industry interviews.*

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04

The Role of Battery-Powered Ships in the Context of "Dual Carbon" Goals

China's green water transport sector has seen rapid development in recent years, with the Yangtze River and coastal regions actively engaging in pilot projects. A significant number of clean energy vessels, including pure battery-powered ships, have been constructed and launched. Key policy documents, such as the "Guiding Opinions on Accelerating the Green and Intelligent Development of Inland Waterway Vessels" jointly introduced by five ministries including the MIIT, along with the "A Five-Year Action Plan for Accelerating the Development of National Strengths in Transportation (2023-2027)" from the Ministry of Transport, emphasize the push towards developing green, intelligent inland vessels. These initiatives aim to promote the high-quality advancement of the shipping industry.

In June 2023, representatives from 13 provinces and cities along the Yangtze River unveiled the "Electrification of the Yangtze River" initiative. This move is pivotal for achieving China's "dual carbon" goals, enhancing the high-quality growth of Yangtze River shipping, and supporting the "Yangtze River Conservation" strategy[01]. It signifies a new phase in the electrification of the Yangtze River Basin's shipping industry.

4.1 Impact on Carbon Emission Reduction

In 2018, global shipping emitted over 1 billion tons of greenhouse gases, with carbon dioxide making up 98% of these emissions[02]. In China, the transportation sector's carbon emissions contribute approximately 10% to the national total, with water transport emissions representing 6.5% of this sector[03]. Research from the China Waterborne Transport Research Institute under the Ministry of Transport indicates that in 2020, carbon emissions from China's inland waterway ships reached around 15 million tons, with an energy intensity of 9.32 g CO_2 /(t*km)[04].

Compared to their fuel-powered counterparts, pure battery-powered ships offer substantial benefits in carbon emission reduction. When powered by zero-carbon electricity, these vessels do not produce carbon dioxide or other greenhouse gases. As of the end of 2021, the Yangtze River system across 14 provinces and cities hosted 104,100 water transport ships[05], yet the electrification rate stood at less than 1%[06]. This underscores the significant potential for further reducing carbon emissions in Yangtze River shipping.

Table 4.1 Greenhouse Gas Emissions Comparison Across Energy Carriers Relative to Marine Light Diesel Oil[07]

Energy Carrier	Greenhouse Gas Emissions Proportion in the Whole Life Cycle Compared to Marine Light Diesel	
	Prepared by Fossil Fuel	Electricity-based Fuel from Renewable Energy
Liquid Ammonia	140%	6%
Liquid Hydrogen	166%	0%
Methanol	101%	1%
LNG	83-103%	2-12%
Lithium-ion Battery	Varies with the power grid's carbon emission intensity	

4.2 Contribution to the Industry's High-Quality Development

In July 2023, the International Maritime Organization's (IMO) Marine Environment Protection Committee during its 80th session (MEPC 80) revised the strategy to reduce greenhouse gas (GHG) emissions from international shipping[08]:

5%-10% *Uptake of zero/near-zero GHG emission technologies, fuels and/or energy sources to represent at least 5%, striving for 10%, of the energy used by international shipping by 2030.*

Net-Zero *To reach net-zero GHG emissions by or around, i.e. close to, 2050, from international shipping.*

Two “indicative checkpoints” have been established:

20%-30%	*To reduce the total annual GHG emissions from international shipping by at least 20%, striving for 30%, by 2030, compared to 2008; and*
70%-80%	*To reduce the total annual GHG emissions from international shipping by at least 70%, striving for 80%, by 2040, compared to 2008.*

The introduction of this revised IMO strategy signifies a push towards greener shipping, presenting China with a prime opportunity to lead in developing engines, core components, and power systems.

Although Chinese shipbuilding enterprises topped global new orders in 12 out of 18 major ship types in 2022 and maintained the largest international market share in shipbuilding for 13 consecutive years, solidifying its status as a major player in shipbuilding size[09], China is not yet considered a leading shipbuilding power. Embracing the technological shift towards green shipping is crucial for the high-quality evolution of China’s shipbuilding industry. This shift also serves as a vital step for China to transit from a major shipbuilding player merely in size to a leading shipbuilding power.

Globally, the average age of the current shipping fleet stands at 22.3 years. Clarksons Research estimates that between 2023 and 2035, approximately 24,500 vessels (each with a load capacity over 2,000 tons) will be due for dismantling[10]. Niels Rasmussen, chief shipping analyst at BIMCO, suggests that stricter greenhouse gas emission regulations could see up to 15,000 older ships being dismantled in the next decade[11]. From a Chinese viewpoint, the Huajing Industrial Research Institute notes that in 2021, the market for China’s electric ships reached RMB 9.48 billion, with projections indicating a growth to RMB 16.87 billion by 2025[12].

Thus, considering both the global and China’s domestic markets, the future of pure battery-powered ships looks promising. This trend is poised to advance China’s shipbuilding industry, contribute significantly to the development of national strength in transportation, and position the shipping industry as a frontrunner in the path toward Chinese modernization.

4.3 Significance for Environmental Protection

In 2021, emissions from Chinese ships included approximately 97,000 tons of hydrocarbons, 1.48 million tons of nitrogen oxides, and 60,000 tons of particulate matter[13]. Pure battery-powered ships offer significant environmental benefits over fuel-powered vessels in terms of water, air, noise, and waste pollution, particularly in controlling PM2.5 levels and reducing nitrogen oxide emissions. Adopting these cleaner ships will assist the Yangtze River Basin in meeting its 2025 environmental targets: reducing PM2.5 concentration in cities at the prefectural level and above by 10% relative to 2020 and cutting total nitrogen oxide emissions by over 10% compared to 2020.

Regarding sewage, fuel-powered ships generate power through diesel combustion, inevitably producing oily wastewater. If this contaminated water leaks or is directly discharged, it can pollute water sources, leading to diseases in humans and animals, create a surface oil film that depletes oxygen levels causing fish fatalities, and even impair soil metabolism, affecting crop growth. In contrast, pure battery-powered ships operate on electrical energy without fuel combustion, thus eliminating the discharge of oily wastewater. This approach reduces the risk of toxic exposure to aquatic life, safeguards aquatic ecosystems, and protects surrounding community waters from pollution.

In terms of air pollution, the combustion in fuel-powered vessels releases various pollutants like particulate matter, nitrogen oxides, hydrocarbons, and carbon monoxide, adversely affecting marine environments and human health. The World Health Organization (WHO) has highlighted that fossil fuel combustion not only pollutes the air but also contributes to ocean acidification through the atmospheric deposition of acidic gases like nitrogen oxides and sulfur dioxide, with contributions to ocean acidification in some coastal areas ranging from 10% to 50%[14]. Additionally, these air pollutants can induce sensory and physiological discomfort in humans, potentially leading to pathological changes, clinical symptoms, potential genetic impacts, and even acute or chronic poisoning, or death. Particulate matter, especially PM2.5 and PM10, poses significant health risks, as they can penetrate deep into the lungs, with PM2.5 also capable of entering the bloodstream, primarily affecting the cardiovascular and respiratory systems and possibly other organs. The WHO reports that air pollution causes up to 7 million deaths annually, with one-third of deaths from stroke, lung cancer, and heart disease attributable to air pollution[15]. In contrast, pure battery-powered vessels, which utilize electricity, produce negligible atmospheric pollutants, offering benefits for both environmental protection and human health.

Concerning noise pollution, fuel-powered ships generate significant noise that disrupts both aquatic life and coastal communities, and adversely affects the crew's hearing and sleep, potentially causing issues like neurasthenia, increased heart rate, and higher blood pressure. In contrast, battery-powered ships greatly minimize onboard vibration and noise. ABB, a global leading technology power

in electrification and automation based in Zurich, Switzerland, has shown that an onboard DC power grid can cut engine room noise in fuel-powered ships by 30%[16]. Moreover, the launch of China's first 1000-ton pure electric passenger ship, "Junlyu", achieved noise levels below 50 dB, quieter than many automobiles[17]. Thus, pure battery-powered ships not only offer a better working environment for their crew but also contribute to the protection of marine ecosystems and the enhancement of coastal communities' living conditions.

Regarding solid waste, the fuel combustion in conventional ships generates fuel residues and other waste, potentially containing toxic substances that adversely affect aquatic environments. Conversely, pure battery-powered ships, which operate without fuel, do not produce such solid waste, eliminating related water and shoreline pollution. This absence of waste mitigates potential health risks to humans.

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05

Challenges Faced by the Battery Ship Industry

Although battery-powered ships bring low operational cost, high environmental benefits, good operational performance, and more, their deployment may be hindered due to challenges in technology, financial feasibility, infrastructure, and supporting policy.

5.1 Low Battery Energy Density

Hampered by technical limitations, such as low battery energy density, charge and discharge rate, battery-powered vessels are mainly deployed with light deadweight and short sailing range. According to industry news, the lithium iron phosphate (LFP) batteries in mass production currently boast the highest energy density of 153 Wh/kg[01]. One of the limitations of low energy density can be found in the sailing range. Taking “JIANG YUAN BAI HE” as an example, its power system is connected to three battery containers with capacity up to 4,620 kWh, while the sailing range per charge is only 270 kilometers. However, it takes two and a half hours to charge each battery container [02].

There are 231 battery-powered ships worldwide, of which 169 are short distance ferries carrying cars/passengers, accounting for approximately 73.2% of the total number[03]. In China, according to estimation by the China Waterborne Transport Research Institute under the Ministry of Transport, the electrification ratio of ships with 500 DWT, 1,000 DWT and 2,000 DWT could be maximum at 80%, 60%, and 50%, respectively[04]. It indicates that under current technical limitations, the higher the DWT and the longer the range, the greater the challenge of electrification.

5.2 Lack of Financial Feasibility

In the commercialization of battery-powered vessels, its capital cost is much higher than that of traditional fossil fuel ships. For example, China's first 120 TEU inland battery container ship "JIANG YUAN BAI HE", which made its maiden voyage in Taicang, Jiangsu Province in October 2022, is equipped with three 4,620 kWh lithium battery containers. Each battery container costs 3.8 million yuan. The total investment merely in power battery far exceeds the total cost of a diesel-powered container ship of the same capacity[05]. Moreover, with generally about 8 years quality warranty for battery, and approximately 30 years' service life of the battery-powered ships, three to four times of battery replacement are necessary. This adds another layer to the complexity of the electric ship adoption.

According to the estimation by China Waterborne Transport Research Institute under the Ministry of Transport[04], the payback period of 1,000 DWT electric vessels is at least 15 years. Therefore, there is lack of financial feasibility currently. Given with priority and free charge when passing the lockage, the payback period of 800-1,000 DWT electric ships can fall into 8 years range, which is slightly shorter than the service life of batteries, but it's still not cost-effective.

5.3 Limited Charging Infrastructure in Place

At present, during the process of the shipping electrification in the Yangtze River Region, the infrastructure retrofit mainly concentrates on increasing shore power systems and installing more power receiving facilities. In the first half of 2023, 11 provinces and cities along the Yangtze River Economic Belt witnessed about 430,000 berthing vessels/time using shore power, approximately 50 million kWh electricity, with a year-on-year increase of up to 40% and 63% respectively[06]. The higher utilization rate of shore power, to some extent, has effectively reduced ship pollutant emissions and carbon emissions.

However, even if the shore power was utilized 100%, it could only reduce carbon emissions of vessels when they were staying or berthing at ports. As estimated by China Waterborne Transport Research Institute under the Ministry of Transport, the use of shore power by ships in berthing only contributes to 5% reduction in the total carbon emissions during the entire sailing range[04]. It' s clear that the shore power cannot serve as a pivot for achieving carbon neutrality in the shipping sector.

Although battery-powered ships are an important tool for reducing carbon emissions in the shipping industry, there are few charging facilities specifically for large capacity electric ships in China. Meanwhile, the existing shore power system fails to meet the charging needs of electric ships. It's understandable that many industry experts have expressed that the planning and construction of charging and swapping infrastructure lags far behind the development of electric vessels. At present, the absence of charging infrastructure is one of the obstacles to the carbon emissions reduction and rapid development of the shipping industry.

5.4 Insufficient Policy Support and Standards

Presently, the market for electric ships is still emerging, and relevant policies, regulations, norms, and standards are not yet in place, which to some extent hinders the development of electric vessels.

As of June 2023, although local governments issued policies to promote battery ships, few offer subsidies. Only Jiangsu and Hubei provinces are taking the lead. Jiangsu Province proposed explicitly to pilot "pure electric inland container ships" as a breakthrough, and quantified target for deploying battery ships. Hubei Province fully supports "pure battery-powered cruise ships" and provides financial incentive to "build an industry cluster of green and intelligent inland ships".

Table 5.1 Policies on Electric Ships Issued by Provinces and Municipalities along the Yangtze River Mainline[07]

Province & Municipality	Document Name	Issued	Relevant Content
Shanghai Municipality	Implementation Plan of Shanghai Municipality for Carbon Peak in Transportation Sector	**Jan 2023**	Promote the construction and retrofit of inland hybrid power vessels, pure electric ships, and LNG-powered vessels; Encourage the adoption of electricity or LNG by inland vessels, such as sanitation ships, ferries, Huangpu River cruise ships, and public service ships; Explore the mandatory phasing-out system for coastal and inland ships, guiding the obsoleted, high pollution and energy intensive ships to accelerate their withdrawal from the market.
Jiangsu Province	Plan for Water Transport Development of Jiangsu Province for the 14th Five Year Plan	**Aug 2021**	Take the initiative to promote the pilot of pure electric vessels in Suzhou; Encourage the shift to clean energy; Promote the deployment of ships powered by LNG and battery.
	Opinions of the Provincial Government on Accelerating the Construction of a More Distinctive "Water Transport Jiangsu"	**Apr 2023**	Promote the adoption of battery power technology by inland ships; Guide the construction and retrofit of inland electric vessels; Push forward the construction of charging and swapping stations in inland ports, water service areas, and more, striving for large-scale deployment of inland electric vessels by 2025.

Province & Municipality	Document Name	Issued	Relevant Content
Jiangsu Province	Implementation Plan for Pilot Deployment of Inland Electric Container Ships in Jiangsu Province	**Oct 2022**	By 2023, establish a pilot deployment advance mechanism for inland electric container ships, and construct supporting charging and swapping facilities, ensuring the sound operation of pilot shipping line from the southern operation area of Suzhou Inland Port Industrial Park to the Fu Qiao operation area of Suzhou Port; By 2025, achieve the initial commercialization of pure electric inland container ships in Jiangsu Province; make breakthroughs in standardization and key technologies for pure electric ships; take the lead in inland electric vessels development scale and deployment effectiveness. Achieve the goal of deploying 17 inland pure electric ships and expand the application scenarios to the entire Jiangsu section of the Beijing-Hangzhou Canal during the14th Five Year Plan period.
Anhui Province	Implementation Plan of Anhui Province for Carbon Peak	**Dec 2022**	Accelerate the retrofit of obsoleted ships; Develop electric and LNG powered ones.
Jiangxi Province	Plan for Highway and Waterway Transportation Development of Jiangxi Province for the 14th Five Year Plan	**Jun 2022**	Promote ship governance and retrofit, pushing forward the deployment of LNG powered ships, speeding up the deployment of pure electric tourist ships according to local conditions.

Province & Municipality	Document Name	Issued	Relevant Content
Jiangxi Province	Implementation Plan of Jiangxi Province for Carbon Peak	**Jul 2022**	Accelerate the retrofit of obsoleted vessels; Develop electric and LNG powered vessels; Promote the usage of shore power by ships in berthing, and advance the deployment of hydrogen powered ships in Poyang Lake.
Hubei Province	Plan for Waterway Transport Development of Hubei Province for the 14th Five Year Plan	**January 2022**	Promote the deployment of LNG powered energy-saving and environmental-friendly ships; Explore the development path for vessels powered by battery and fuel cells; Support the development and construction of fully battery powered cruise ships suitable for Wuhan's "Two Rivers and Four Banks" tourism and Yichang's "Two Dams and One Gorge" characteristic tourism routes in Wuhan and Yichang; Carry out pilot deployment of clean energy vessels in building public service ships.
	Several Measures to Support the Pilot Demonstration of Green and Intelligent Ship Industry Development in Hubei Province	**March 2023**	Foster a green and intelligent industry cluster of inland waterway vessels, promoting the concentrated development of upstream and downstream supporting sectors such as power batteries, motors, box type power supplies, battery management systems, and charging and swapping facilities. For the main units that have been approved as national new industrialization demonstration bases for the first time, a one-off reward of 5 million yuan will be given.

Province & Municipality	Document Name	Issued	Relevant Content
Hubei Province	Several Measures to Support the Pilot Demonstration of Green and Intelligent Ship Industry Development in Hubei Province	**March 2023**	Support the building of characteristic industrial clusters for green and intelligent shipbuilding industry, with a focus on developing green and intelligent shipbuilding industry demonstration bases in Wuhan, Xiangyang, Yichang, Huanggang, Jingmen and other places, and provide appropriate rewards based on the assessment results. Support the intelligent upgrading, cluster development, service-oriented extension, green transformation, and safety control of shipbuilding enterprises. Encourage the participation of technical innovation investment projects with a total amount over 20 million yuan and provide subsidies of 8% of the production equipment investment amount for qualified projects. The subsidy for a single project shall not be less than 1 million yuan and not exceed 10 million yuan. Encourage universities, research institutes, and enterprises and institutions within the province to focus on the green and intelligent shipbuilding industry chain, tackling and addressing a series of “bottleneck” technical challenges. Key projects topped the provincial ranking will be granted one-off subsidy of 10% of the project investment, with a maximum of 10 million yuan per project.

Province & Municipality	Document Name	Issued	Relevant Content
Hunan Province	Implementation Plan for Ship Pollution Control in the Yangtze River Economic Belt of Hunan Province in the 14th Five Year Plan Period	May 2022	Deploy electric ships and other clean energy vessels in the market of public service ships and short-distance cruise ships in 2024, developing a batch of shipping lines for clean energy vessels.
	Implementation Plan of Hunan Province for Carbon Peak	November 2022	Accelerate the exit of inefficient and energy-intensive old ships, develop container ships and large-scale bulk multi-purpose vessels, and carry out pilot of green and intelligent ships such as LNG powered ships and electric vessels.
Chongqing Municipality	Plan for Comprehensive Transportation Development of Chongqing Municipality for the 14th Five Year Plan	October 2021	Strengthen the capability in independent design of large and medium-sized cruise ships, intelligent ships, clean energy ships, etc., integrate the shipbuilding industry, cruise ship parts manufacturing, ship maintenance and supply industries, and promote the development of the entire industry chain.
Sichuan Province	Plan for Comprehensive Transportation Development of Sichuan Province for the 14th Five Year Plan	October 2022	Intensify efforts to promote the deployment of clean energy vehicles and ships.
	"Electric Sichuan" Action Plan (2022-2025)	March 2022	Carry out pilot for clean energy ships; Renovate the power receiving facilities of existing qualified cargo ships; Support the building of demonstration projects for electric ship charging and swapping wharfs.

Documents issued concerning rules and standards mainly concentrate on ships, shedding no light on standard system for charging (swapping) of battery powered ships, safety and quality technical standards for key facilities of green and intelligent vessels.

Table 5.2 Relevant Standards and Rules of Electric Vessels[08]

No.	Norms, Guidelines, Rules, etc.
1	Rules for Ships Applying Battery as a Power (2023)
2	Rules for Inland Green Ships (2023)
3	Guidelines for the Inspection of Ships Using DC Integrated Power System (2023)
4	Rules for the Inspection of Domestic Ocean-Going Ships (revised and released in 2022)
5	Technical Rules for Public Service Ships (2020)
6	Technical Rules for Statutory Inspection of Inland Waterway Vessels (2019)
7	Technical Rules for Statutory Inspection of Inland Waterway Small Vessels (revised and released in 2016 and 2019)

5.5 Fragmented Industry with Poor Profitability [09]

As of the end of 2021, there were 3,727 transportation enterprises and 9,858 individually owned inland shipping companies in the Yangtze River system, among which, more than 700 enterprises are registered in Jiangsu and Anhui provinces, and over 6,000 individually owned inland shipping companies are in Zhejiang province. Undoubtedly, the fragmented industry increases the difficulty of deploying battery powered ships.

In addition, according to sampling survey conducted by Changjiang River Administration of Navigational Affairs, only transportation enterprises of dry bulk and liquid dangerous goods achieved profitability increase, that of container transportation enterprises decreased, while most passenger transportation enterprises were losing money. The reality of underperformance of transportation enterprises makes the deployment of electric ships more challenging.

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06

Recommendation

At present, the electrification rate of ships is less than 1%, and the market of electric vessels is still emerging. Therefore, various measures and approaches should be applied to accelerate the healthy development of electric vessels, ensuring they can serve as a key tool for carbon emission reduction in China's shipping industry. This will not only help to develop national strength in transportation, but also contribute to high-quality development of the shipping sector.

6.1 Send Long-term Market Signals to Address Stakeholders' Uncertainty

Sending long-term market signals is one of the effective means to promote business investment. For example, with the CFD (Contract for Difference) mechanism, the UK grid successfully added low-carbon power generation facilities of 27GW within 10 years, with offshore wind power costs cut by 70%[01]. The IRA (Inflation Reduction Act of 2022) introduced by the United States last year successfully attracted $500 billion investment in the United States [02].

Table 6.1 Newly-added Investment, Facilities and Jobs in the United States[03]

Industry	Investment (USD 100 million)	New/expanded facilities (set)	Newly added jobs (person)
Battery	**>1,000**	**>190**	**>75,000**
EV	**>300**	**>80**	**>40,000**
PV	**~100**	**69**	>10,000
Offshore wind power	**~35**	**12**	>1,000

In China, the electric vehicle industry has been supported by the government since 2009. By the end of 2022, the market share of new car sales has exceeded 25%. The goal to “Ensure that the total sales of clean energy vehicles taking up 20% of the total new car sales by 2025” proposed in New Energy Vehicle Industry Development Plan (2021-2035) was realized three years ahead of schedule[04]. It has already been worthy of a new trillion-yuan industry and is moving towards a 10-trillion level business.

Although electric vessels are one of the important pathways for pursuing high-quality development of the shipping sector, a long-term market signal is still missing. For example, carbon taxes not collected yet, no targets for ship electrification, and related subsidy policies remain unavailable. With these long-term market signals, market uncertainties can be addressed, helping to boost the market, and giving confidence to private investment.

6.1.1 Carbon Tax

As a core element of strategy mitigating climate change, carbon pricing is helpful for countries to achieve net zero emissions quickly. Carbon tax, as one of the methods for carbon pricing, mainly promotes carbon emission reduction through industrial upgrading and transformation, and delivers significant environmental and economic benefits.

The International Monetary Fund published a report on the role of carbon tax in July 2022. They have found that with features such as easy managing and operating, investment promoting, income increasing and broader coverage, a carbon tax not only accelerates carbon emission reduction, but also helps the research, development, and deployment of cutting-edge zero-emissions technology, especially the equipment and facilities with high capital investment and long service life, such as ships. Furthermore, a fuel tax has already been introduced by more than 160 countries/regions as one of the easiest of all taxes to collect [05].

Table 6.1 Country/Region Collecting Carbon Tax[05]

No.	Country/ Region	Since	No.	Country/ Region	Since
1	Argentina	2018	15	Mexico	2014
2	Colombia	2017	16	Japan	2010
3	Chile	2017	17	Latvia	2004
4	Indonesia	2022	18	Liechtenstein	2005
5	Singapore	2019	19	Luxembourg	2005
6	Ukraine	2011	20	Netherlands	2005
7	Uruguay	2022	21	Norway	1991
8	Canada	2019	22	Poland	1990
9	Denmark	1992	23	Portugal	2005
10	Estonia	2000	24	Slovenia	1996
11	Finland	1992	25	Spain	2005
12	France	2005	26	Sweden	1991
13	Iceland	2005	27	Britain	2013
14	Ireland	2005	28	Switzerland	2008

6.1.2 Electric Ship Adoption Targets

As one of the long-term market signals, electric ship adoption targets also help to accelerate market development. According to research, in the United States, states with mandatory energy efficiency targets achieved electrification more than four times higher than states without ones[06].

Internationally, Singapore has set a goal of achieving net zero emissions for harbor crafts by 2050 and stipulates that starting from 2030, new harbor crafts must be fully electric or powered by zero emission fuel7. In China, although provinces and municipalities in the Yangtze River Basin have set a reduction rate of CO_2 per unit of transportation volume of ships during the 14th Five Year Plan period, most provinces and municipalities have not yet set electric ship adoption targets. Only Jiangsu Province proposed the goal of “Achieving the large-scale deployment of 17 inland electric ships”, but it is not powerful enough to promote the high-quality development

of the shipping sector and the realization of emission reduction goals. Thus, relevant policy documents should be introduced as soon as possible to set the adoption targets of the electric ship industry, helping the industry make long-term strategic planning, guiding the healthy development, and boosting industry confidence.

Table 6.2 Indicators on Carbon Emission Reduction Released by Provinces and Municipalities along the Yangtze River Mainline[08]

Province/ municipality	Document name	Issued on	Ship relevant content
Shanghai municipality	Implementation Plan of Shanghai Municipality for Carbon Peak in Transportation Sector	**Jan 2023**	Converted turnover carbon intensity of operating vehicles is about 5% lower than in 2020.
Jiangsu Province	Plan for Water Transport Development of Jiangsu Province for the 14th Five Year Plan	**Aug 2021**	CO2 emissions per unit throughput decreased by 3% (binding targets)
Anhui Province	Plan for Transportation Development of Anhui Province for the 14th Five Year Plan	**Dec 2021**	Carbon intensity per unit of transportation volume of ships declined by 3.5% (anticipated targets)
Jiangxi Province	Plan for Highway and Waterway Transportation Development of Jiangxi Province for the 14th Five Year Plan	**Jun 2022**	CO2 emission per unit of transportation volume of operating ships is 3.5% lower than in 2020 (anticipated targets)

Province/ municipality	Document name	Issued on	Ship relevant content
Hubei Province	Plan for Waterway Transportation Development of Hubei Province for the 14th Five Year Plan	**Jan 2022**	Water transport carbon intensity decreased by 5%
Hunan Province	Plan for Transportation Development (Highway/ Waterway) of Hunan Province for the 14th Five Year Plan	**Aug 2021**	CO2 emission per unit of transportation volume of ships declined by 2.8% (anticipated targets)
Chong qing	Plan for Comprehensive Transportation Development of Chongqing Municipality for the 14th Five Year Plan	**Oct 2021**	CO2 emission per unit of transportation volume of operating vehicles and ships declined by 4% (anticipated targets)
Sichuan Province	Plan for Comprehensive Transportation Development of Sichuan Province for the 14th Five Year Plan	**Oct 2022**	Transportation carbon intensity decreased by 3% (binding targets)

6.1.3 Financial Subsidies

Due to the lack of financial feasibility, subsidy policies like those introduced for electric vehicles are needed now to deploy electric vessels in large scale. With subsidies available, the capital cost and the operation cost of electric vessels can be reduced, the Internal Rate of Return increased, and payback period shortened.

In terms of subsidy policies, no big moves have been observed in provinces and cities in the Yangtze River Basin. While the coastal province Fujian stays one step ahead. In the Implementation Plan for Pilot Demonstration of Electric Ship Industry Development of Fujian Province 2022 and the Implementation Opinions on Comprehensively Promoting the Development

of "Electric Fujian"(2023-2025), it's clearly stated that subsidies ranging from 20% to 60% of the total price will be given to those included in the provincial electric ship demonstration projects (including new construction and retrofit) based on battery power propulsion systems. Pilot areas or units will receive a subsidy of no more than 10 million yuan (including 60% for the first batch of provincial demonstration projects, with a maximum subsidy of 15 million yuan per ship). One-off equipment purchase subsidy of no more than 500,000 yuan will be given for power battery charging facilities, and an annual subsidy of no more than 30 million yuan will be granted to enterprises engaged in electric ship power battery leasing business. These subsidy policies are designed to create a business environment conducive to the development of electric vessels, comprehensively promote the development of the industry chain, and explore a "Fujian model" for the adoption of electrification[09,10].

6.2 Support Technology Innovation to Accelerate Electric Ship Research, Development, and Deployment

Hampered by low battery energy density, charge and discharge rate, and financial feasibility, electric vessels are mainly deployed for light load, medium- and short-distance shipping. For example, "ZHONG TIAN DIAN YUN 001", the first thousand-ton level electric cargo ship in the Yangtze River Basin, made its trial voyage successfully in Changzhou on May 8, 2020. Its sailing range per charge (2.5 hours) through shore power setups is 50km[11]. Moreover, "Yangtze River Three Gorges No. 1", the world's largest pure electric cruise ship, made its maiden voyage in March 2022, with a sailing range per charge (6 hours needed to be fully charged) of only 100km[12]. Furthermore, the world's first 700 TEU battery container ship can sail less than 400km per charge[13].

In the "Several Measures to Support the Pilot Demonstration of Green and Intelligent Ship Industry Development in Hubei Province", the provincial government announced a one-off subsidy of 10% of the total project investment. To some extent, it serves as support for developing breakthrough technologies of pure electric ships. Apart from one-off grants, other financial instruments like loan guarantees, loan-loss reserves, guarantee of return, low interest loans, and green bonds, should be applied to support technology innovation, help startups raise funds and speed up technology iteration.

In addition, a green shipping corridor developed in the Yangtze River Basin will contribute to the demonstration and deployment of pure battery-powered ships. These partnerships are a key tool to catalyze testing, demonstration, and deployment needed to achieve net zero. Since the green corridor movement started at COP26 in November 2021, more than 20 international green corridor initiatives have been announced globally. In China, the first Trans-Pacific green corridor was designed from Shanghai to Los Angeles[14].

Finally, the introduction and acceleration of systematic phasing-out of obsoleted ships and the market entry of new ships, and other policies, as well as the improvement of standards and regulations, are supportive of technology iteration and cost reduction, especially the reduction of battery costs.

6.3 Establish Business Models to Unleash Market Potential

There are two barriers in the commercialization of battery-powered vessels: higher capital cost compared to traditional fossil fuel ships; three to four times of battery replacement in about 30 years' service life of the battery-powered ships. To address these challenges, battery swapping mode popular in EV industry can be adopted. By introducing "Battery Bank", ships can rent batteries from the bank at the time of charging or replacing, without having the burden of owning batteries. This business model of separating the ownerships of batteries and ships, which enables the sharing of fixed assets investment, is undoubtedly a solution to high capital cost. In addition, the battery swapping mode also helps to reduce the charging time, so it's an important approach relieving anxiety over the sailing range per charge.

The battery shipping industry could leverage experience from Vehicle to Grid (V2G) in electric vehicles industry, to develop its Ship to Grid (S2G). By arbitraging the peak and off-peak rate difference and providing auxiliary services to the power grid, the financial feasibility can be further improved, and the deployment threshold can be lowered.

Many banks and venture capitals are actively seeking companies with mature business models as investment targets. However, at present, the profit model of pure battery powered ships has not been established. Issues such as the reasonable business mode for swapping and charging remain to be figured out during the pilot/demonstration process. Meanwhile, factors such as revenue (e.g. electric rate, power battery rental fees) and cost (e.g. the cost curve formed according to the first and the Nth generation products) should be identified, so that the investment institutions can assess their cash flow more clearly, reducing uncertainty and risk, attracting more low-cost funds, and accelerating the development of the industry.

6.4 Strengthen Knowledge Sharing and Industrial Cooperation to Reduce Stakeholders' Risks

Establishing industry alliances and partnerships is not only conducive to forming industry consensus such as standardization of skill requirements and talent training, but also promotes knowledge sharing to solve the bottlenecks in the shipping sector. In February 2023, the China Electric Ship Innovation Alliance was established in Shanghai. The alliance includes “manufacturer, university, research, engineering, and finance” and covers green power supply, power batteries, ship design and building, port terminals, shore-based charging and swapping, passenger and cargo ship transportation, research institutes, and industrial chain investment and financing. By serving as a bridge between various fields, the alliance promotes cooperation among upstream, midstream, and downstream enterprises in the industrial value chain, to jointly build the ecosystem of battery powered ships, and contribute to healthy development of the industry[15].

Government-supported pilot and demonstration projects should disclose projects’ cash flow, operational time and operating range, and etc. The data transparency helps investors to access risks of the technology, projects, and market. By doing this, the electric ship industry could speed up technology iteration, identify key development routes and address bottlenecks, and provide more specific support.

Regularly holding industry webinars and forums, publishing best practices and case studies, and standardizing commercial terms can help the industry avoid unnecessary pitfalls, and sustain rapid development.

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Conclusion

With the revision of IMO GHG Strategy, the carbon emission reduction in the global shipping industry is bound to be accelerated. As a result, China’s shipping sector will not only bear enormous pressure of carbon emission reduction, but also be impacted by industrial upgrading of shipbuilding powers such as Norway, Finland, South Korea, and Japan.

Electric vessels are not only an important tool for reducing carbon emission in China's inland waterway, but also a vital approach to develop national strength in transportation, and sustain high-quality development of the shipping industry. Despite challenges in the field, such as short sailing range per charge, lack of financial feasibility, insufficient supporting facilities, and few policies and regulations in place, a set of measures can be implemented to address all these barriers.

The central and local governments can send long-term market signals, support technology innovation, establish business models, and strengthen knowledge sharing and industrial cooperation to promote the sound and sustainable development of the battery powered ship industry. This will not only make it a new trillion-yuan industry like electric vehicles, contributing to developing the Yangtze River Economic Belt and the building of a country with strengths in manufacturing, shipbuilding and transportation but also achieve the goals of “dual carbon”, reducing air pollution and carbon emissions.

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