GLOBAL OFFSHORE WIND SUPPLY CHAIN REPORT 2025

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GLOBAL OFFSHORE WIND SUPPLY CHAIN REPORT 2025

Against this backdrop, the Wind Energy Professional Committee of the China Renewable Energy Society (CWEA) and the Global Wind Energy Council (GWEC) have jointly prepared this report. Based on a global perspective and focusing on the core segments of the industrial chain, the report systematically evaluates the current development status, bottlenecks, and trends of global offshore wind power. It provides forward-looking insights and action references for policymakers, industry players, and investors.

The report is divided into two parts:

- **The first part** emphasizes the development of the offshore wind power market and industrial chain globally and in the Latin American region. The world's largest assembly centers for wind turbines and production hubs for key components are located in the Asia-Pacific region, with capacity primarily distributed in China and India. However, excluding China, other countries will face varying degrees of bottlenecks in some key segments of the industrial chain before 2030. Although the Latin American region possesses some foundation in the onshore wind power industrial chain, it is expected that the entire industrial chain will encounter constraints by 2029, and the offshore wind power industrial chain bottlenecks will persist until 2045.
- **The second part** focuses on the development of China's offshore wind power market and industrial chain. Leveraging advantages in cost, technology, capital, and services, Chinese wind power enterprises are providing comprehensive solutions globally and playing an increasingly important leading role.

Looking ahead, only by establishing an open, cooperative, and mutually beneficial industrial ecosystem can we promote the accelerated and high-quality development of the global offshore wind power industry, in which China can play a pivotal role. Let us move forward hand in hand, using offshore wind power as a strategic fulcrum to trigger a surging wave of global green energy transformation and jointly compose a new chapter of sustainable development.

Secretary General, Wind Energy Professional Committee of the China Renewable Energy Society

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1. **Global**
    - Market Development Overview
    - Overall Industrial Chain Development Overview
    - Industrial Chain Development in the Latin American Region
    - Future Outlook

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Market Development Overview

As a form of clean energy, offshore wind power possesses immense development potential and is gradually becoming a focus of attention and development for various nations. Starting in Europe in the early 1990s, offshore wind power has undergone over thirty years of development. Beyond the European market, the Asia-Pacific region and other emerging markets are also gradually growing and expanding. Although the global newly installed capacity of offshore wind power slowed down briefly in 2024 due to supply chain and policy adjustments, the industry still demonstrated strong long-term growth resilience. The cumulative installed capacity for the year increased by 12% year-on-year, continuing to lead the renewable energy expansion track. Europe and China continue to maintain leading positions, while Asia-Pacific countries such as Japan, South Korea, Australia, Vietnam, and the Philippines are accelerating their layouts. Notably, the Philippines completed its first offshore wind power auction, and Japan passed the Exclusive Economic Zone (EEZ) bill, paving the way for the development of floating wind power, marking the rise of emerging markets.

According to statistics from the Global Wind Energy Council (GWEC), the global newly installed capacity of offshore wind power in 2024 was 8 GW, a 26% decrease compared to 2023, falling short of expectations. In 2024, a total of 8 countries added new offshore wind power capacity. Although China's installations did not meet expectations, it still remained at the top of the list, with newly connected capacity of approximately 4 GW, accounting for half of the global newly connected capacity. The United Kingdom ranked second in newly installed capacity with 1.2 GW, accounting for 15% of the global newly installed offshore wind capacity. Other major countries with newly installed capacity include Germany (730 MW, 9%), France (658 MW, 8%), while the Netherlands and the United States both stood at 132 MW, and Japan and South Korea at 100 MW each.

By the end of 2024, the global cumulative connected capacity of offshore wind power reached 83.2 GW, an increase of approximately 10.6% compared to 2023, accounting for 7.3% of the global total wind power installed capacity. China maintained the world's first rank for the fourth consecutive year, with cumulative installed capacity accounting for more than half of the global total. The United Kingdom maintained the second rank, though its global share declined to 19.2% of the global cumulative connected capacity, followed by Germany, the Netherlands, and others.

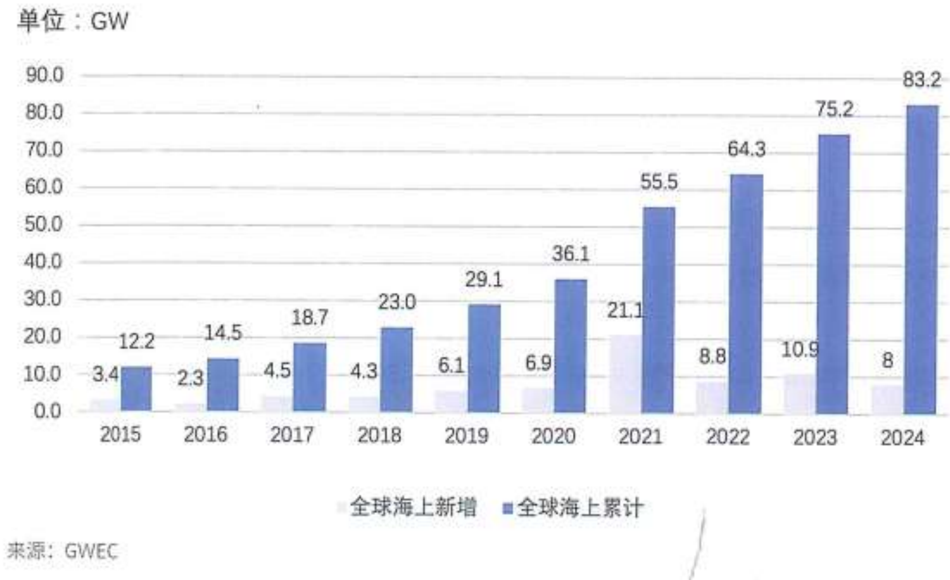

图 1-1
2015-2024 年全球海上风电新增和累计并网装机容量

Figure 1-1: Global Newly Added and Cumulative Grid-Connected Offshore Wind Installed Capacity (2015-2024)

Source: GWEC

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图 1-2
2015-2024 年全球主要国家海上风电新增装机占比

(Graph: Figure 1-2 Share of Newly Installed Offshore Wind Capacity by Major Global Countries 2015-2024)

Key Categories: China, UK, Germany, Netherlands, Other Europe, Other Asia, USA.

Offshore wind power development is currently still dominated by fixed-bottom structures, while floating offshore wind power is in the demonstration and application stage. In 2023, the last four SGRE SG-8.6-167 floating wind turbines totaling 35 MW were installed in Norway's Hywind Tampen project (94.6 MW). Other installations included 13 MW of floating wind turbines, with 2 MW in Spain and China's "CNOOC Guanlan" Mingyang Smart floating offshore wind equipment (7.25 MW) as well as the "Guoneng Shared" Electric Wind Power 4 MW floating equipment. In 2024, new additions included China's "Mingyang Tiancheng" (16.6 MW) and France's 25 MW. By the end of 2024, the global floating offshore wind installed capacity was 278 MW across 7 countries. Norway ranks first in the world with an installed capacity of 101 MW, followed by the UK (78 MW), China (40 MW), France (27 MW), Portugal (25 MW), Japan (5 MW), and Spain (2 MW). Floating technology is receiving increasing attention, and large-scale development is expected to truly materialize after 2030.

With the continuous improvement of offshore wind power technology, the unit capacity of offshore wind turbines is increasing. In 2024, the average unit capacity of global newly added offshore wind turbines was 9.8 MW, an increase of approximately 0.2 MW compared to 2023 (specifically, it reached 10.1 MW in Europe, up about 0.3 MW from 2023, and 9.6 MW in the Asia-Pacific region, up about 0.1 MW). With technological progress and the expansion of installation scale, the Levelized Cost of Energy (LCOE) for global offshore wind power has dropped by more than 60% over the past decade. According to data from the International Renewable Energy Agency (IRENA), the LCOE of global offshore wind power projects dropped from $0.208/kWh in 2010 to $0.079/kWh in 2024, a cumulative decrease of 62%. However, market performance in 2024 differed from 2023. Benefiting from continuous cost reduction in Chinese offshore wind power, the LCOE for Asian offshore wind dropped to $0.078/kWh in 2024, a 1.3% decrease from 2023 ($0.079/kWh) and a 61% decrease from 2010 ($0.201/kWh). China's LCOE in 2024 was $0.056/kWh, a 22% decrease from 2023 ($0.072/kWh) and a 72% decrease from 2010 ($0.200/kWh). In contrast, the LCOE for European offshore wind power grew significantly in 2024, rising about 16% year-on-year from $0.069/kWh to $0.080/kWh.

1. Data Source: International Renewable Energy Agency (IRENA) "Renewable Power Generation Costs in 2024"

Supply Chain Overview

(Image provided by Mingyang Smart)

GLOBAL OFFSHORE WIND SUPPLY CHAIN REPORT 2025

(1) Current Status

- **Initial formation of global offshore wind supply chain synergy:** The industry is evolving from simple equipment manufacturing toward an integrated "Development—Manufacturing—Construction—O&M" system. A supply chain network centered on turbines, towers, foundation structures, subsea cables, and installation vessels has been formed, yet the whole still faces regional imbalances and capacity mismatches.
- **Capacity expansion on the supply side lags behind demand growth:** Despite the continuous upward adjustment of installation targets, the manufacturing capacity and delivery cycles for key segments (such as high-power wind turbines, high-end subsea cables, and professional installation vessels) struggle to match the rapidly growing project demands. Supply chain bottlenecks are prominent, especially with "stranglehold" risks in high-end equipment manufacturing and professional construction equipment.
- **Long-term strong demand vs. short-term delivery pressure:** Many countries view offshore wind power as a core pathway to achieving carbon neutrality and energy independence, driving the intensive release of long-term procurement plans. For instance, the EU's "REPowerEU" plan and China's renewable energy planning have set clear targets. However, the 26% year-on-year decrease in newly installed capacity in 2024 reflects delays at the project execution level and a periodic disconnect between supply and demand.
- **Obvious regional supply-demand imbalance:** Asia (especially China) undertakes the primary role of equipment supply, while Europe and North America possess advantages in R&D and high-end services but face supply chain challenges. Rising demand in emerging markets (such as Southeast Asia) is coupled with weak localized manufacturing capacity and high dependence on imports, exacerbating global supply chain pressures.

(2) Challenges

- **Macroeconomics and Financing Difficulties:** Rising interest rates and increased capital costs have led to a decline in project economics and greater financing difficulty, forcing some projects to be delayed or canceled. Particularly, the work-stop order issued in the United States due to sudden policy changes has severely affected investor confidence.
- **Policy Uncertainty and Slow Approval:** Offshore wind projects in many countries face lengthy environmental impact assessments and sea area use right approval processes, which have become major obstacles to project advancement. Policy fluctuations (such as subsidy phase-outs and frequent adjustments to tender rules) also increase investment risks for enterprises.
- **Highlighting Supply Chain Vulnerability:** The globalized supply chain is increasingly affected by geopolitics, leading to unstable supplies of critical raw materials (such as rare earths and copper) and core components. Simultaneously, the shortage of

professional vessels (such as installation vessels) severely restricts construction progress, posing risks of delivery delays for projects under construction.

- **Technical Iteration and Talent Gap:** As wind turbines become larger, move further offshore, and floating technologies develop, the industrial chain must rapidly adapt to new technical requirements. However, there is currently an insufficient reserve of high-end talent, particularly in marine engineering, electrical integration, and intelligent O&M, which restricts industrial upgrades.

(3) Supply and Demand Analysis and Forecast

Most suppliers in the wind power industrial chain are still located in the Asia-Pacific, European, and American regions, though new suppliers have emerged in the Middle East and North Africa. Regionally, the Asia-Pacific is the world's largest center for wind turbine assembly and key component production. Onshore capacity is mainly distributed in China and India. By 2030, countries other than China will face supply bottlenecks. For offshore capacity, markets outside China will all face bottlenecks by 2030. Europe is the world's second-largest wind turbine assembly and production base, but its current capacity after 2030 will be insufficient to support future demand. While the Latin American region has a certain foundation in the onshore industrial chain, it will face bottlenecks across the entire chain after 2029. The offshore wind industrial chain there is currently almost a blank and will face bottlenecks until 2045.

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Figure 1-3: Global Offshore Wind Supply Capacity (Excluding China) in 2025

- Total: 14,490 MW
- Regional Distribution: North America, Asia-Pacific (excluding China), Europe.

Figure 1-4: Planned New Offshore Wind Supply Capacity (Up to 2030)

- Total: 2,040 MW
- Main contributors: Japan (planned), South Korea (planned).

Table 1-1: Global Offshore Wind Turbine Supply and Demand Forecast 2024-2030 (Unit: MW)

表1-1 2024—2030年全球海上风电机组供需预测

单位：MW

区域市场	2024	2025e	2026e	2027e	2028e	2029e	2030e
中国	4038	8000	10000	15000	15000	15000	20000
欧洲	2698	4170	8736	7610	5998	8965	11780
拉丁美洲	0	0	0	0	22	0	0
北美	132	806	3244	924	810	0	0
亚太（不包括中国）	1133	1319	1461	1785	3090	4045	4595
总计	8001	14295	23441	25319	24920	28010	36375

图例说明： 无瓶颈 潜在瓶颈 瓶颈

来源：GWEC

Regional Market	**2024**	**2025e**	**2026e**	**2027e**	**2028e**	**2029e**	**2030e**
China	4,038	8,000	10,000	15,000	15,000	15,000	20,000
Europe	2,698	4,170	8,736	7,610	5,998	8,965	11,780
Latin America	0	0	0	0	22	0	0
North America	132	806	3,244	924	810	0	0

Asia-Pacific (excl. China)	1,133	1,319	1,461	1,785	3,090	4,045	4,595
Total	**8,001**	**14,295**	**23,441**	**25,319**	**24,920**	**28,010**	**36,375**

Legend: Green = No Bottleneck; Yellow = Potential Bottleneck; Red = Bottleneck.

Source: GWEC

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Figure 1-5: Supply and Demand Analysis of Asia-Pacific Onshore Wind Industrial Chain to 2030

图 1-5
到 2030 年亚太地区陆上风电
产业链供需分析

来源：GWEC Market Intelligence, ERM, October 2024

(Includes countries like China, India, Vietnam, Japan, Indonesia, Philippines, Australia, South Korea. Covers Turbine Assembly, Blades, Gearboxes, Generators, Key Components, and Raw Materials.)

Figure 1-6: Supply and Demand Analysis of Asia-Pacific Offshore Wind Industrial Chain to 2030

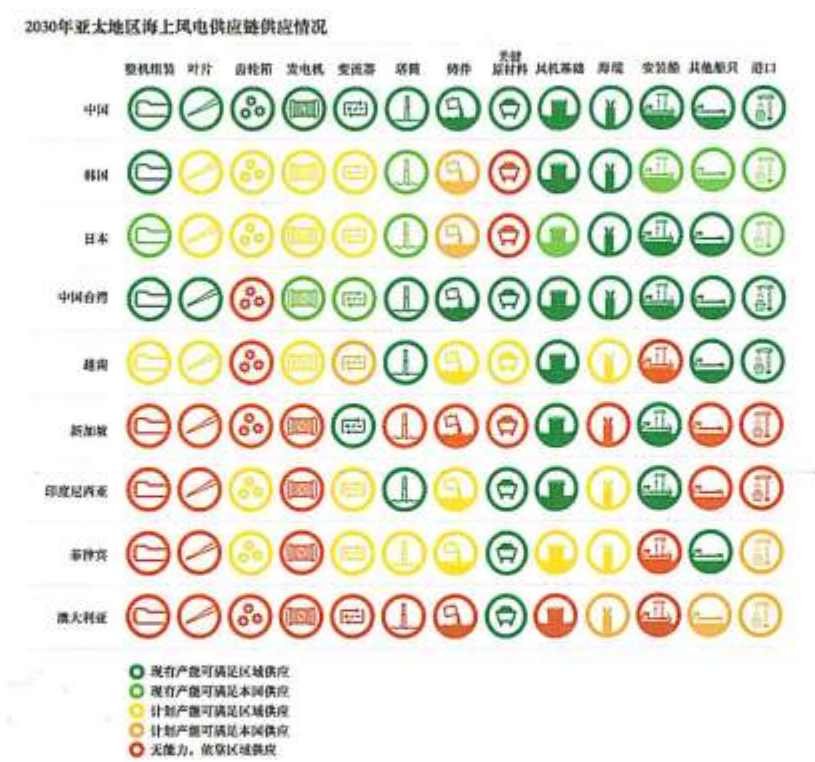

图 1-6
到 2030 年亚太地区海上风电产应链供需分析

(Covers Turbine Assembly, Gearboxes, Generators, Converters, Towers, Castings, Installation Vessels, Ports.)

Figure 1-7: Supply and Demand Situation of Latin American Onshore Wind Industrial Chain to 2035

图 1-7

到 2035 年拉美地区陆上风电
产业链供需分析

来源：GWEC Market Intelligence, ERM, October 2025

(Includes Argentina, Brazil, Chile, Colombia, Mexico.)

Figure 1-8: Supply and Demand Situation of Latin American Offshore Wind Industrial Chain to 2045

图 1-8
到 2045 年拉美地区海上风电
产业链供需分析

Legend for Figures 1-5 to 1-8:

- ● Existing capacity can meet regional supply.
- ● Existing capacity can meet domestic supply.
- ● Planned capacity can meet regional supply.
- ● Planned capacity can meet domestic supply.
- ● No capability, dependent on regional/external supply.

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GLOBAL

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2 CHINA

- Market Development Overview
- Industrial Chain Development Status
- Future Outlook

3 CONCLUSION

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1 市场发展概况 Market Overview

摄影：杨铭轩

1 Market Overview

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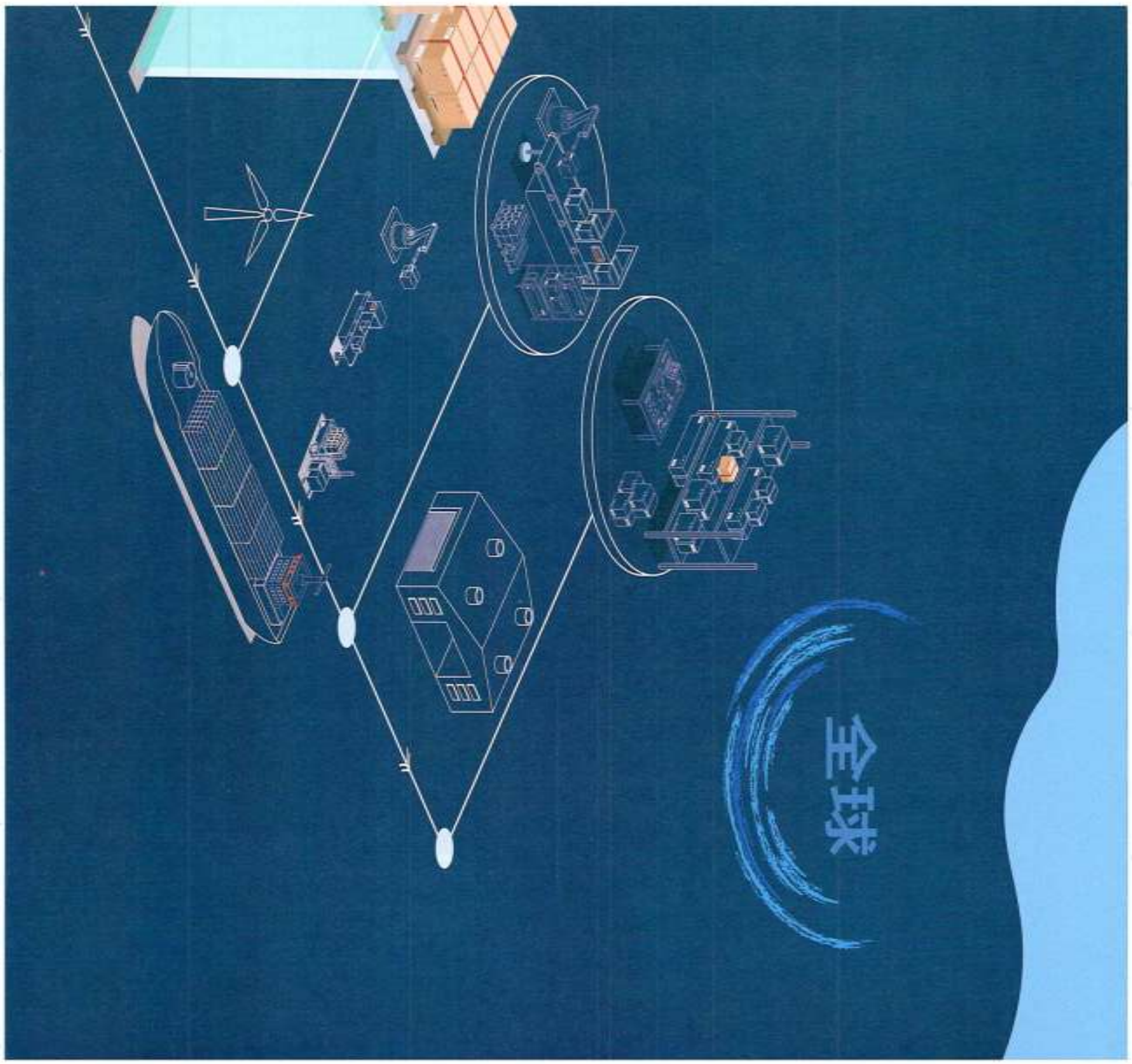

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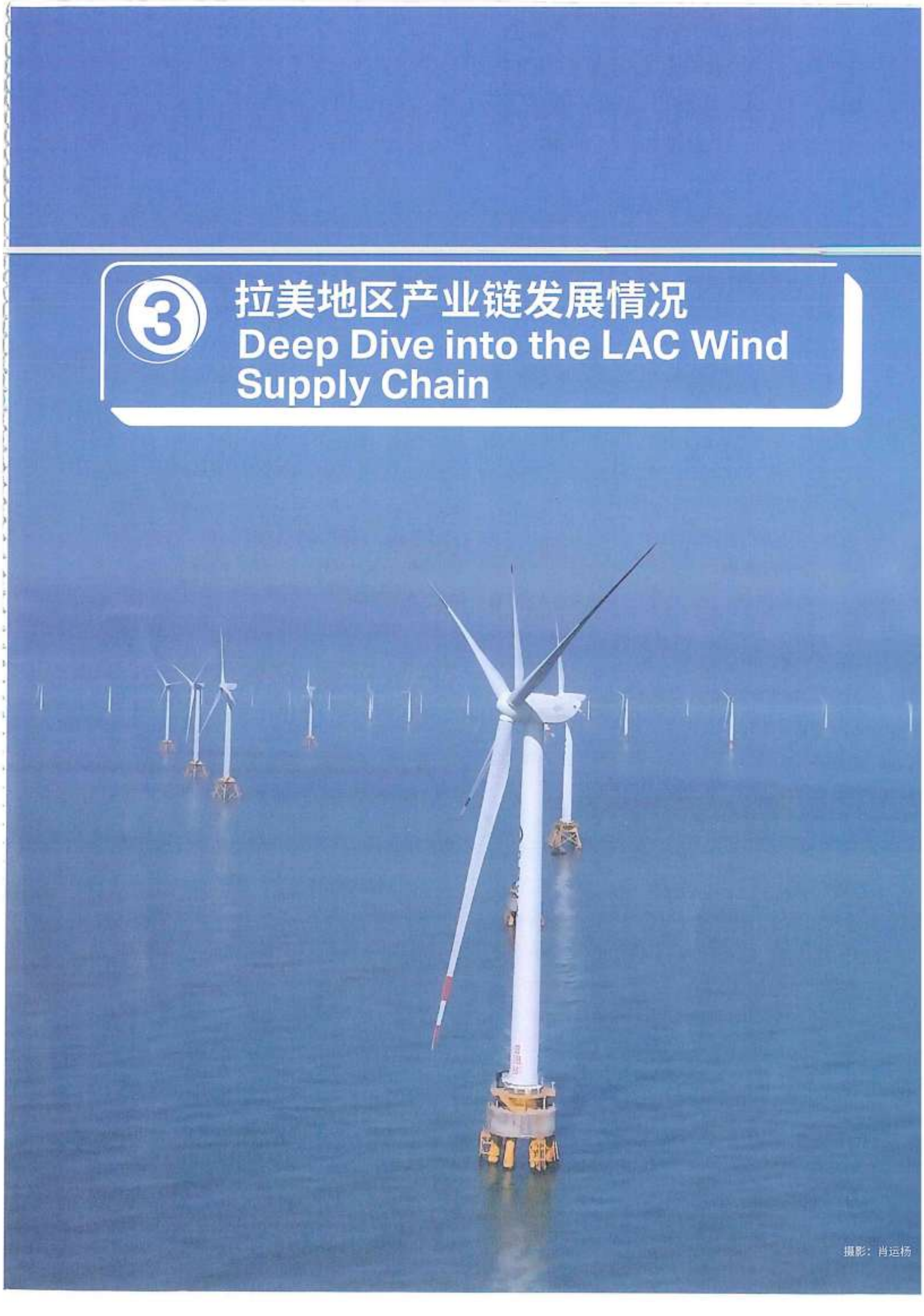
Deep Dive into the LAC Wind Supply Chain

③ 拉美地区产业链发展情况
Deep Dive into the LAC Wind Supply Chain



摄影：肖运杨

GLOBAL OFFSHORE WIND SUPPLY CHAIN REPORT 2025

The Latin America and Caribbean (LAC) region possesses abundant wind energy resources. Countries such as Brazil, Colombia, and Chile, in particular, have excellent wind speed conditions and immense potential for wind power development. However, despite this superior resource endowment, the region's wind power industry is generally in its early stages of expansion, facing multiple constraints such as policy gaps, infrastructure deficiencies, and insufficient local manufacturing capacity. To achieve the COP28 goal of "tripling global renewable energy capacity by 2030," the LAC region must significantly accelerate its wind energy deployment and build an autonomous, resilient, and sustainable localized supply chain system. Currently, the wind power industrial chain has some foundation in the onshore sector, but it is almost at the starting point in the offshore sector.

(1) Onshore Wind Power

As of the release of this report, the cumulative installed onshore wind power capacity in the LAC region is approximately 25 GW. Brazil holds a dominant position with over 20 GW of installations, making it the largest market in the region. Mexico, Chile, Argentina, and Colombia together contribute the remaining approximately 5 GW, forming a multi-point development pattern. Several countries have set clear renewable energy targets: for instance, Chile plans to achieve 70% of its electricity from renewable sources by 2030, and Brazil aims to increase the share of wind power to 23% by 2030.

Currently, the LAC onshore wind power industrial chain is highly dependent on imports. Key core components such as gearboxes, generators, converters, and main bearings are essentially imported from Europe and China. Blades and towers are partially produced locally, mainly concentrated in Brazil and Mexico; however, their technical level and production scale are limited, making it difficult to meet the needs of future large-scale expansion. Regarding original equipment manufacturers (OEMs), the market was dominated by international manufacturers such as VESTAS, Nordex, and Siemens Gamesa through the end of 2024. Currently, WEG is the only local turbine manufacturer, and it has not yet formed a complete system, still relying on imports for some components.

(2) Offshore Wind Power

There are currently no operational offshore wind projects in the LAC region; the sector is generally in the stages of policy exploration and preliminary planning. Colombia, Brazil, and Chile are conducting offshore wind resource assessments and have identified sea areas with development potential, particularly along the northern coast of Chile and the southeastern continental shelf of Brazil. Some areas of the Gulf of Mexico are also considered to have prospects for deep-water offshore wind development, but substantive project bidding or construction has not yet commenced.

The offshore wind supply chain is almost entirely missing in the LAC region. There are no local offshore wind turbine manufacturers, no professional installation fleets, and no high-voltage subsea cable production bases. If offshore wind projects were to start before 2030, all critical equipment (including floating foundations, dynamic cables, and substations) would need to be fully imported, resulting in high costs and long delivery cycles. Marine engineering service capabilities are almost non-existent, with a lack of experience in offshore construction, monitoring, and operations and maintenance (O&M).

Offshore wind power in the LAC region is expected to grow steadily starting from the mid-2030s and exceed 40 GW by 2045. The region requires significant upfront investment to expand manufacturing capacity and support infrastructure to accommodate the offshore demand expected from 2031 onwards. Chile has incorporated offshore wind into its national green hydrogen strategy, exploring integrated "wind power + green hydrogen" projects, with the first batch of demonstration projects expected to start before 2030. Brazil is revising its marine spatial planning regulations and intends to establish an offshore wind concession system to attract international investment. Regional cooperation mechanisms, such as the Latin American Energy Organization (OLADE), are promoting cross-border grid interconnection and standard unification, laying the foundation for future regional offshore wind consumption.

Industrial Chain Development in the LAC Region

(3) Challenges and Trends

Based on the report's data analysis, in terms of onshore wind power, local suppliers can basically meet the various market demands for regional onshore wind turbines, towers, and castings before 2035. Although in the short term, the local supply chain for wind turbine assembly, generators, and blades is currently facing overcapacity, bottlenecks are expected to emerge for these components and converters starting from 2029 due to accelerated demand growth. Additionally, the lack of local gearboxes provides a clear window of opportunity for strategic investment in local manufacturing capabilities. Regarding offshore wind power, the region currently lacks an industrial base to support turbine assembly, major components, and other equipment; current supply is negligible.

The core bottlenecks and trends in the current development of the wind power industrial chain in the LAC region are as follows:

Five Key Bottlenecks:

1. **Weak Local Manufacturing Capacity:** The localization rate of core components (gearboxes, generators, converters) is generally below 30%, resulting in a passive situation where "turbines rely on imports and O&M relies on external support."
2. **Severely Inadequate Infrastructure:** A lack of roads, railways, and specialized wind power ports capable of transporting large-scale wind turbines restricts project

implementation efficiency. For example, only a few ports in Brazil can handle ultra-long blades.

3. **Policy and Regulatory Uncertainty:** Frequent electricity market reforms in several countries (such as Mexico) and approval processes lasting 2–5 years cause developers to delay investment decisions.
4. **Limited Financing Channels:** High capital costs, exchange rate fluctuations, and low credit ratings make international financing difficult. Risk guarantees and low-cost funding from multilateral financial institutions (such as IDB and World Bank) are urgently needed.
5. **Technology and Talent Gap:** A shortage of high-end talent in wind power design, marine engineering, and intelligent O&M, combined with an unestablished vocational education system, restricts industrial upgrades.

Future Trends:

1. **Strengthened Regional Synergy:** Platforms like UNASUR and OLADE will promote standard unification, grid interconnection, and joint procurement to lower the development threshold for individual countries.
2. **Accelerated Layout of Local Manufacturing:** Countries like Brazil and Chile are encouraging foreign investment in local factories, offering tax incentives and land support, particularly in blades, towers, and converters.
3. **Innovation in Green Finance:** Promoting the "sovereign guarantee + project finance" model to attract private capital for wind power infrastructure.
4. **Coupled Resource Development:** Chile and Brazil are exploring "wind power + lithium mining/green hydrogen" integrated projects, leveraging local resource advantages to create a new industrial chain ecosystem.

Overall, onshore wind power in the LAC region has an established industrial foundation but suffers from poor supply chain autonomy and lagging infrastructure. Offshore wind power starts from zero and requires policy guidance and international collaboration to begin. To achieve the goal of doubling wind power installations by 2030, the region must break through the four major bottlenecks—local manufacturing, grids, ports, and talent—and transition from a "resource-exporting" model to a "supply-chain-driven" model. Priority should be given to building regional wind power equipment manufacturing centers in leading countries like Brazil and Chile, sharing technology, standards, and financing tools through regional cooperation to build a more resilient and inclusive LAC wind power industrial chain system.

Table 1-2: Supply and Demand Forecast for the Onshore Wind Industrial Chain in the LAC Region (2025–2035)

Onshore Wind Turbines & Key Components	**Unit**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Turbine Assembly	MW	3730	3515	3950	5875	7330	7300	7050	7150	7200	7300	7400
Gearboxes	MW	3730	3515	3950	5875	7330	7300	7050	7180	7200	7300	7400
Generators	MW	3730	3515	3950	5875	7330	7300	7050	7150	7200	7300	7400
Blades	MW	3730	3515	3950	5875	7330	7300	7050	7150	7200	7300	7400
Converters	MW	3730	3515	3950	5875	7330	7300	7050	7150	7200	7300	7400
Towers	Units	746	586	658	979	7330	1217	881	894	900	913	925

Castings	Tons	45506	42883	48190	71675	7330	89060	86010	87230	87840	89060	90280

Legend: Green = Overcapacity (>10%); Yellow = Balanced; Orange = Slight Bottleneck (<10%); Red = Severe Bottleneck (>10%).

Source: GWEC Market Intelligence, ERM, October 2025

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Table 1-3: Supply and Demand Forecast for the Offshore Wind Industrial Chain in the LAC Region (2025–2045)

Offshore Wind Turbine Components & Segments	Unit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Turbine Assembly	MW	0	0	0	25	0	0	500	500	1500	1550	2050
Gearboxes	MW	0	0	0	25	0	0	500	500	1500	1550	2050
Generators	MW	0	0	0	25	0	0	500	500	1500	1550	2050

Blades	MW	0	0	0	25	0	0	500	500	1500	1550	2050
Converters	MW	0	0	0	25	0	0	500	500	1500	1550	2050
Towers	Units	0	0	0	2	0	0	33	33	100	103	137
Castings	Tons	0	0	0	434	0	0	8850	8850	26550	27435	36285
Subsea Cables	km	0	0	0	2	0	0	33	33	100	103	137
Fixed Foundations	Units	0	0	0	2	0	0	33	33	100	103	137
Floating Foundations	Units	0	0	0	9	0	0	178	178	533	551	729
WTIVs	MW	0	0	0	25	0	0	500	500	1500	1550	2050

(Continued)	Unit	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Turbine Assembly	MW	2000	2500	2000	3500	3525	4000	4200	4000	4200	5000
Gearboxes	MW	2000	2500	2000	3500	3525	4000	4200	4000	4200	5000
Generators	MW	2000	2500	2000	3500	3525	4000	4200	4000	4200	5000
Blades / Converters	MW	2000	2500	2000	3500	3525	4000	4200	4000	4200	5000
Towers	Units	133	167	133	233	235	200	210	200	210	250
Castings	Tons	35400	44250	35400	61950	62393	70800	74340	70800	74340	88500
Subsea Cables	km	133	167	133	233	235	200	210	200	210	250

Fixed Foundations	Units	133	167	133	233	235	200	210	200	210	250
Floating Foundations	Units	711	889	711	1244	1253	1422	1493	1422	1493	1777
WTIVs	MW	2000	2500	2000	3500	3525	4000	4200	4000	4200	5000

Legend: Green = Overcapacity (>10%); Yellow = Balanced; Orange = Slight Bottleneck (<10%); Red = Severe Bottleneck (>10%).

Source: GWEC Market Intelligence, ERM, October 2025

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Table 1-4: LAC Industrial Chain Development Potential and Drivers

Market	**Turbine Assembly**	**Key Components**	**Key Materials**	**Foundation Platforms**	**Offshore Wind Drivers**	**Other Drivers**	**Transition/Related Industries**
Argentina	Onshore	Towers, Castings, Converters	Copper, Steel, Rare Earths	—	Ongoing port expansion, technical potential, active intl.	—	Ports, mining (lithium), metallurgy

					participation		
Brazil / Chile / Colombia	Onshore	Towers, Blades, Generators, Castings; Towers	Rare Earths, Steel, Copper; Copper, Steel, Rare Earths; Copper	Floating foundations, leverage marine & oil/gas industries	Strategic ports, shipbuilding; Ports, shipbuilding, road/rail networks; Strategic ports, shipyards	Sector integration exp., regional wind manufacturing; RE project exp., PPPs; Intl. tech transfer & financing	Oil/gas, ports, mining, metallurgy, auto, steel & heavy industry, electrical/electronics; Ports, mining, metallurgy; Oil/gas, ports, mining, steel
Mexico	—	Towers, Blades	Copper, Steel	Technical potential, integrated logistics	—	Onshore supply chain 52% localized, structure exports, global integration	Oil/gas, mining, metallurgy, auto, electrical/electronics

1.3.1 Wind Turbines

(1) Onshore

Brazil leads the turbine assembly sector in Latin America, with current production capacity accounting for approximately 91% of the region's total, roughly 6 GW. Major manufacturers include Vestas, Goldwind, Nordex, Siemens Gamesa, and WEG. Although some facilities are currently facing operational disruptions due to market instability, a recovery is expected starting in 2028, aligning with projected demand growth.

Argentina has the second-largest development potential in the region. Before the COVID-19 outbreak, European turbine OEMs Vestas and Nordex had already established turbine assembly facilities locally.

In contrast, Chile, Colombia, and Mexico lack turbine assembly capabilities and rely entirely on imports. Given future demand growth, turbine supply chain bottlenecks are expected to persist at least until 2035.

The further expansion of the region's turbine assembly capacity will depend on several key factors: industrial investment levels, predictable regulatory frameworks, flexible supply chain localization requirements, and precise incentives for domestic manufacturing.

Manufacturing precision incentive measures.

In evaluating the ability of various LAC markets to meet their own onshore wind turbine demand between 2025 and 2035, currently only Brazil and Argentina possess autonomous supply capabilities. Other countries in the region, due to insufficient local turbine assembly infrastructure, must rely on imports to meet demand, primarily from global manufacturing hubs like Brazil or China, to avoid supply chain bottlenecks. Without these external supply channels, the region will face significant supply risks before 2035.

Figure 1-9: LAC Onshore Wind Turbine Capacity Distribution in 2025 (Total: 6,600 MW)

- Brazil: 91%
- Argentina: 9%
  Source: GWEC Market Intelligence, ERM, October 2025

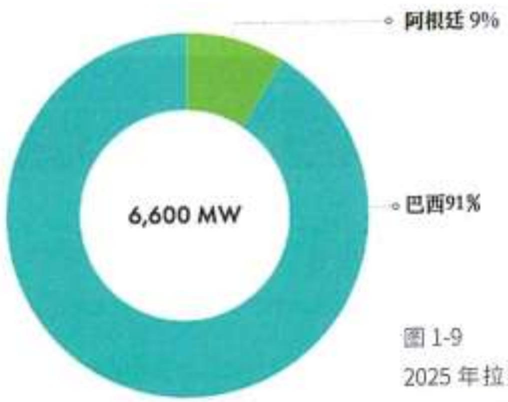

图 1-9
2025 年拉美地区陆上
风电机组产能分布

来源：GWEC Market Intelligence, ERM, October 2025

Table 1-5: LAC Onshore Wind Turbine Supply and Demand Analysis Forecast 2025–2035 (Unit: MW)

Market	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Argentina	200	400	400	450	350	400	350	400	400	400	450
Brazil	1645	1500	1500	3000	4500	4500	4000	4000	4000	4000	4000
Chile	1000	750	750	600	600	600	700	700	700	700	700
Colombia	300	0	0	500	500	500	350	350	350	400	400

Mexico	450	500	1000	1000	1000	1000	1000	1000	1000	1000	1000
Others	135	365	300	325	380	300	650	700	750	800	850
Total	**3730**	**3515**	**3950**	**5875**	**7330**	**7300**	**7050**	**7150**	**7200**	**7300**	**7400**
Total (excl. Brazil)	**2085**	**2015**	**2450**	**2875**	**2830**	**2800**	**3050**	**3150**	**3200**	**3300**	**3400**

Legend: Green = Overcapacity (>10%); Yellow = Balanced; Orange = Slight Bottleneck (<10%); Red = Severe Bottleneck (>10%).

Source: GWEC Market Intelligence, ERM, October 2025

Industrial Chain Development in the LAC Region

(2) Offshore

The development of offshore wind turbine production capacity in Latin America is relatively lagging, with no domestic production capacity identified in any of the five key country markets. This structural defect poses potential risks to regional industrial development, especially considering the significant growth in offshore wind demand expected from 2031 onwards.

Currently, the Latin American market has not established offshore wind turbine assembly capacity, and there are no plans for new construction in the short term. However, once market conditions mature, investment is expected to enter. Brazil has formulated ambitious wind energy development goals, including the vigorous development of offshore wind projects. With abundant wind resources, ample land space, a skilled technical workforce, and continuously growing energy demand, Brazil is well-positioned to lead such investments.

However, the region still faces major structural constraints. Regulatory hurdles are one of the main challenges, particularly regarding environmental permits and the legal and regulatory framework for offshore wind energy development. In addition, capital constraints and insufficient market demand also seriously hinder the industry's development. To enhance the feasibility and attractiveness of offshore wind projects, infrastructure gaps must be addressed, especially port facilities and logistics systems. Without coordinated efforts to improve regulation, financing, demand, and infrastructure, investing in the offshore wind market in Latin America will be difficult to realize.

Notably, Brazil's SENAI 2025 pilot project is expected to obtain installation permits within the next 12 to 18 months, becoming the country's first approved offshore wind project, with plans to become operational within 36 months. This project marks a major transformation in the prospects of Brazil's offshore wind industry in the coming years.

1.3.2 Blades

(1) Onshore

Brazil is an important production base for wind turbine blades in the LAC region, with Aeris Energy being the country's largest blade manufacturer, whose products meet domestic demand and are exported globally. Additionally, the Brazilian blade manufacturing industry includes local company Tecsis and international manufacturers such as LM and CNBM Blades. Currently, Brazil's annual production capacity for wind turbine blades has reached 5,540 MW, accounting for 84% of the total blade capacity in the LAC region, holding an absolute leading position.

Mexico, as another important blade production center in the LAC region, serves as a strategic hub for exports to the global market due to its superior geographical location.

Figure 1-10: LAC Onshore Wind Blade Capacity Distribution in 2025 (Total: 6,620 MW)

- Brazil: 84%
- Mexico: 16%

  Source: GWEC Market Intelligence, ERM, October 2025

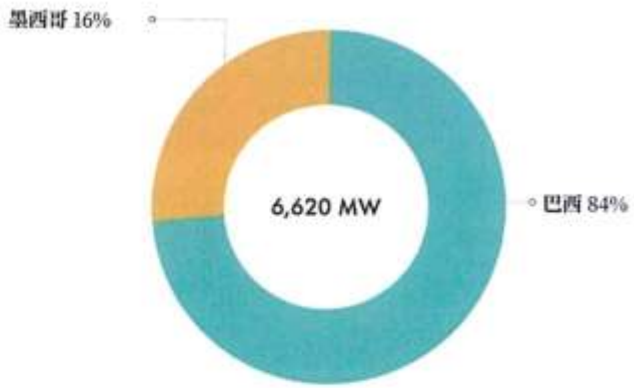

图 1-10
2025 年拉美地区陆上
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来源：GWEC Market Intelligence, ERM, October 2025

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Looking ahead to 2025–2035, Brazil and Mexico are expected to fully meet their domestic wind equipment needs without facing supply shortages. However, despite Brazil's dominant position in the region, it may face supply-demand balance challenges in the coming years; significant uncertainty exists in short-term market demand, and some factories may continue to face adjustments like idle capacity and layoffs.

In other major LAC countries such as Argentina, Chile, and Colombia, no blade manufacturing capacity has been established yet, and their demand for wind blades will continue to rely on imports.

Table 1-6: LAC Onshore Wind Blade Supply and Demand Analysis Forecast 2025–2035 (Unit: MW)

Market	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Argentina	200	400	400	450	350	400	350	400	400	400	450

Brazil	1645	1500	1500	3000	4500	4500	4000	4000	4000	4000	4000
Chile	1000	750	750	600	600	600	700	700	700	700	700
Colombia	300	0	0	500	500	500	350	350	350	400	400
Mexico	450	500	1000	1000	1000	1000	1000	1000	1000	1000	1000
Others	135	365	300	325	360	300	650	700	750	800	850
Total	**3730**	**3515**	**3950**	**5875**	**7330**	**7300**	**7050**	**7150**	**7200**	**7300**	**7400**
Total (excl. Brazil)	**2085**	**2015**	**2450**	**2875**	**2830**	**2800**	**3050**	**3150**	**3200**	**3300**	**3400**

Legend: Green = Overcapacity (>10%); Yellow = Balanced; Orange = Slight Bottleneck (<10%); Red = Severe Bottleneck (>10%).

Source: GWEC Market Intelligence, ERM, October 2025

(2) Offshore

The LAC region lacks local manufacturing facilities for producing the large, long blades required for offshore wind turbines. Currently, there is no offshore wind blade production capacity in the entire LAC region, and no blade suppliers have announced relevant investment plans. Unless massive investments are made, the region will rely long-term on expensive and logistically complex imports.

This predicament is further exacerbated by the slow development of the offshore wind market, inadequate infrastructure, and an unstable regulatory environment. Existing ports and transmission networks cannot support the large-scale deployment of offshore wind projects, and delays in Brazil's specialized offshore wind legislation, along with the lack of a specialized legal framework in countries like Colombia, further increase uncertainty for investors.

Offshore wind blade supply chain bottlenecks in Brazil are expected to emerge from 2028 when demonstration projects begin, creating opportunities for international suppliers with offshore blade production experience (such as CNBM Blades) to establish local operations.

Countries like Mexico, which already possess blade production technology, face a significant strategic opportunity to upgrade existing facilities through new investment to adapt to offshore wind demand. This industrial upgrade is expected to alleviate supply constraints and enhance regional technical self-sufficiency in the future. In contrast, countries like Colombia, Chile, and Argentina will continue to rely primarily on imports to meet demand for the foreseeable future due to the lack of professional offshore wind blade manufacturing facilities.

Industrial Chain Development in the LAC Region

(2) Offshore

The LAC region lacks local manufacturing facilities for producing the long blades required for large-scale offshore wind turbines. Currently, there is no offshore wind turbine blade production capacity in the entire LAC region, and no blade suppliers have announced relevant investment plans. Unless massive investments are made, the region will remain long-term dependent on expensive and logistically complex imports.

This predicament is further exacerbated by the slow development of the offshore wind market, inadequate infrastructure, and an unstable regulatory environment. Existing ports and transmission networks cannot support the large-scale deployment of offshore wind projects, while the delay in Brazil's specialized offshore wind legislation and the lack of a dedicated legal framework in countries like Colombia further increase uncertainty for investors.

Offshore wind blade supply chain bottlenecks in Brazil are expected to emerge starting in 2028 as demonstration projects begin. This creates an opportunity for international suppliers with offshore blade production experience (such as CNBM Blades) to establish local operations.

Countries like Mexico, which already possess blade production technology, face a significant strategic opportunity to upgrade existing facilities through new investment to adapt to offshore wind demand. This industrial upgrade is expected to alleviate supply constraints and enhance regional technical self-sufficiency in the future. In contrast, countries like Colombia, Chile, and Argentina will continue to rely primarily on imports to meet demand for the foreseeable future due to the lack of specialized offshore wind blade manufacturing facilities.

1.3.3 Gearboxes

(1) Onshore

The LAC region currently lacks domestic manufacturing enterprises for onshore wind turbine gearboxes, although some large European gearbox manufacturers, such as ZF and Winergy, have established partnerships in the region to serve the aftermarket. The main reasons for this situation include limited industrial scale and a lack of market competitive advantage. This dependence on external supply makes the region vulnerable to cost fluctuations, supply disruptions, and logistical constraints, while also restricting the cultivation and development of a local industrial base.

Analysis results indicate that between 2025 and 2035, all Latin American countries will face shortages in wind turbine gearbox supply. This finding highlights the urgency of formulating industrial development policies to address the supply gap through measures such as promoting local manufacturing, incentivizing technological innovation, and driving regional integration. These initiatives are of great significance for reducing supply chain vulnerability, enhancing industrial competitiveness, and strengthening the overall resilience of the Latin American wind energy sector.

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Table 1-7: LAC Onshore Wind Gearbox Supply and Demand Analysis Forecast 2025–2035 (Unit: MW)

Market	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Argentina	200	400	400	450	350	400	350	400	400	400	450
Brazil	1645	1500	1500	3000	4500	4500	4000	4000	4000	4000	4000
Chile	1000	750	750	600	600	600	700	700	700	700	700
Colombia	300	0	0	500	500	500	350	350	350	400	400
Mexico	450	500	1000	1000	1000	1000	1000	1000	1000	1000	1000
Others	135	365	300	325	380	300	650	700	750	800	850

Total	**3730**	**3515**	**3950**	**5875**	**7330**	**7300**	**7050**	**7150**	**7200**	**7300**	**7400**
Total (excl. Brazil)	**2085**	**2015**	**2450**	**2875**	**2830**	**2800**	**3050**	**3150**	**3200**	**3300**	**3400**

Legend: Green = Overcapacity (>10%); Yellow = Balanced; Orange = Slight Bottleneck (<10%); Red = Severe Bottleneck (>10%).

Source: GWEC Market Intelligence, ERM, October 2025

(2) Offshore

The Latin American market currently lacks production capacity for offshore wind turbine gearboxes, and there are no investment plans from any gearbox manufacturers in the short term. Supply and demand data analysis suggests that the gearbox supply chain may face significant bottlenecks through 2045. The lack of local manufacturing capacity and relevant investment plans exposes extensive structural defects in the supply chain, indicating that the entire supply chain system is far from mature or stable.

Due to high technical complexity, coupled with the region's lack of a necessary industrial foundation, skilled technical workers, financing channels, and logistical infrastructure capable of meeting offshore wind project requirements, Latin America remains heavily dependent on imported components. This further exacerbates its vulnerability to global supply chain disruptions and cost fluctuations.

Addressing these challenges requires the formulation of long-term industrial development plans, targeted infrastructure investments, and the establishment of a policy framework that supports the Latin American offshore wind supply chain in enhancing its competitiveness and resilience.

1.3.4 Generators

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Industrial Chain Development in the LAC Region

(1) Onshore

Brazil accounts for 70% of the onshore generator production capacity in the Latin American and Caribbean region, followed by Mexico; other markets have no local generator production capacity. Driven by the company WEG, Brazil's wind turbine generator manufacturing capacity is expected to reach approximately 4,200 MW in 2025 and may increase to 5,500 MW by 2030. By 2035, Mexico's wind turbine generator manufacturing capacity will be approximately 1,800 MW per year. Both countries face overcapacity issues for onshore wind generators; in Mexico, the supply is at least 10% higher than the demand. WEG holds a strategic position in Brazil, serving both local production and exporting onshore wind turbine generators to international markets.

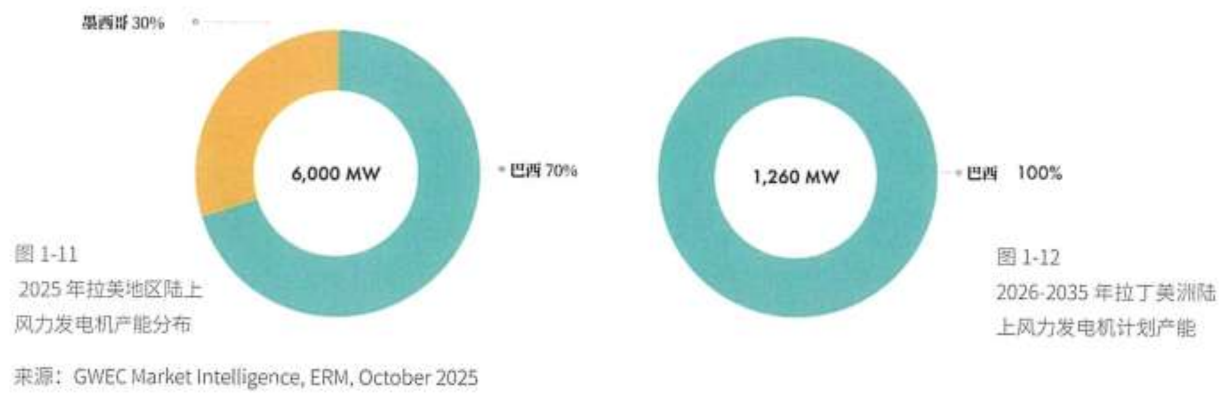

Figure 1-11: LAC Onshore Wind Generator Capacity Distribution in 2025 (Total: 6,000 MW)

- Brazil: 70% (4,200 MW)
- Mexico: 30% (1,800 MW)
  Source: GWEC Market Intelligence, ERM, October 2025

Figure 1-12: LAC Planned Onshore Wind Generator Capacity 2026–2035

- Brazil: 100%
  Source: GWEC Market Intelligence, ERM, October 2025

Table 1-8: LAC Onshore Wind Generator Supply and Demand Analysis Forecast 2025–2035 (Unit: MW)

Market	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Argentina	200	400	400	450	350	400	350	400	400	400	450

Brazil	1645	1500	1500	3000	4500	4500	4000	4000	4000	4000	4000
Chile	1000	750	750	600	600	600	700	700	700	700	700
Colombia	300	0	0	500	500	500	350	350	350	400	400
Mexico	450	500	1000	1000	1000	1000	1000	1000	1000	1000	1000
Others	135	365	300	325	380	300	650	700	750	800	850
Total	**3730**	**3515**	**3950**	**5875**	**7330**	**7300**	**7050**	**7150**	**7200**	**7300**	**7400**
Total (excl. Brazil)	**2085**	**2015**	**2450**	**2875**	**2830**	**2800**	**3050**	**3150**	**3200**	**3300**	**3400**

Legend: Green = Overcapacity (>10%); Yellow = Balanced; Orange = Slight Bottleneck (<10%); Red = Severe Bottleneck (>10%).

Source: GWEC Market Intelligence, ERM, October 2025

(2) Offshore

Currently, the LAC region has no production or manufacturing capacity for offshore wind generators, and no generator suppliers have announced investment plans. This represents a strategic opportunity for the region to invest in local production and strengthen its position in the global clean energy supply chain.

1.3.5 Power Converters

(1) Onshore

The wind power industry in the LAC region is primarily concentrated in Brazil and Argentina, each accounting for 50% of the regional total capacity. Brazil possesses power converter production facilities from two companies: WEG and Ingeteam. Although WEG has domestic production capability, it currently outsources converter production to China's Hopewind. While Ingeteam has a plant in Brazil, its existing facilities are mainly used for service support rather than large-scale production. Argentina's converter capacity is provided by two companies, Fohama and Tadeo Czerweny, making it one of the few countries with independent manufacturing capability. Mexican manufacturers have not yet established complete converter production capacity and can only manufacture certain subsystems, primarily focusing on electrical components such as power switchgear.

The LAC onshore wind converter supply chain is expected to face structural bottlenecks; only Argentina has no significant risk of supply constraints during the forecast period. Although Brazil currently has sufficient capacity to meet demand in the short term, a supply gap may emerge starting in 2028, and the risk of shortage will continue to intensify throughout the forecast period. Chile, Colombia, and Mexico lack mature local manufacturing capabilities and will remain long-term dependent on imports to bridge the supply-demand gap.

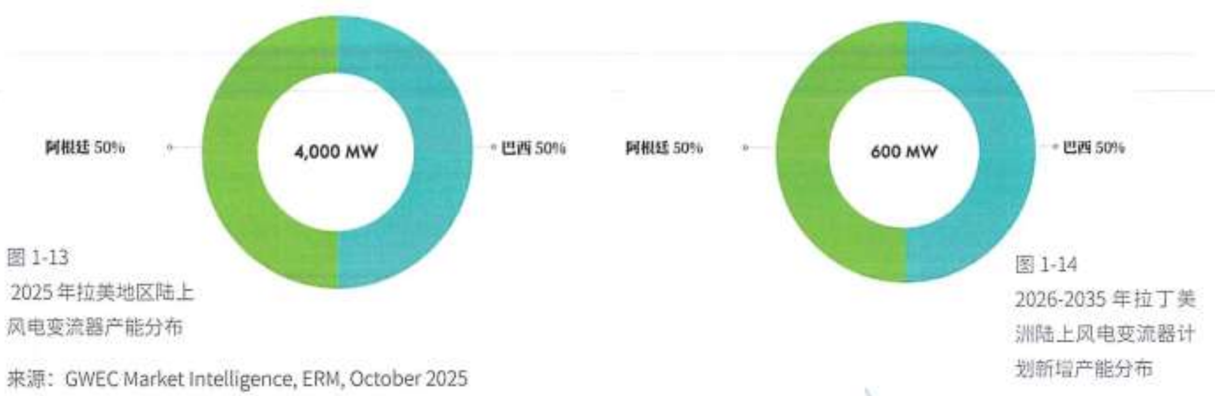

Figure 1-13: LAC Onshore Wind Converter Capacity Distribution in 2025 (Total: 4,000 MW)

- Argentina: 50%
- Brazil: 50%

  Source: GWEC Market Intelligence, ERM, October 2025

Figure 1-14: LAC Planned New Onshore Wind Converter Capacity 2026–2035 (Total: 600 MW)

- Argentina: 50%
- Brazil: 50%
  Source: GWEC Market Intelligence, ERM, October 2025

Industrial Chain Development in the LAC Region

Table 1-9: LAC Onshore Wind Converter Supply and Demand Analysis Forecast 2025–2035 (Unit: MW)

Market	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Argentina	200	400	400	450	350	400	350	400	400	400	450
Brazil	1645	1500	1500	3000	4500	4500	4000	4000	4000	4000	4000
Chile	1000	750	750	600	600	600	700	700	700	700	700
Colombia	300	0	0	500	500	500	350	350	350	400	400
Mexico	450	500	1000	1000	1000	1000	1000	1000	1000	1000	1000

Others	135	365	300	325	380	300	650	700	750	800	850
Total	**3730**	**3515**	**3950**	**5875**	**7330**	**7300**	**7050**	**7150**	**7200**	**7300**	**7400**
Total (excl. Brazil)	**2085**	**2015**	**2450**	**2875**	**2830**	**2800**	**3050**	**3150**	**3200**	**3300**	**3400**

Legend: Green = Overcapacity (>10%); Yellow = Balanced; Orange = Slight Bottleneck (<10%); Red = Severe Bottleneck (>10%).

Source: GWEC Market Intelligence, ERM, October 2025

(2) Offshore

Currently, the LAC region lacks offshore wind converter production capacity. Due to the lack of sufficient market predictability and maturity, there are no plans for new capacity additions. Brazil, as the largest offshore wind market in the LAC region, is expected to face supply chain bottleneck issues during the forecast period, and Colombia and Chile are likely to encounter similar challenges. Without new investment injections, both Brazil and Mexico will struggle to achieve their relevant development goals. However, countries like Brazil and Argentina can leverage their extensive experience in the onshore wind converter sector to seize development opportunities in the offshore wind field.

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1.3.6 Towers

(1) Onshore

Tower manufacturing is primarily concentrated in Brazil, Argentina, and Mexico, which possess specialized production facilities. While Chile and Colombia have no manufacturing plants, they remain active market participants. In terms of capacity distribution, Brazil holds an absolute leading position with 69% of the region's total production capacity, followed by Mexico (17%) and Argentina (14%).

Major suppliers in Brazil include Nordex Acciona Windpower, GRI Tower Brazil, and Windar. Argentina's main participant is GRI Calviño Towers. The Mexican market is dominated by Windar Renewables and Nordex-Acciona Windpower. Brazil's leading advantage stems from its mature industrial base and effective local content policies; in particular, the financing requirements of the Brazilian Development Bank (BNDES) have strongly promoted the development of the domestic manufacturing industry.

Despite the strength of the Brazilian market, industry demand remains uncertain. In 2024, at least one specialized Brazilian company manufacturing metal towers for onshore wind turbines ceased operations due to the industry slowdown. At the national level, Argentina, Brazil, and Mexico possess sufficient onshore tower production capacity to meet expected demand during the forecast period. However, Chile and Colombia are expected to face supply chain challenges between 2025 and 2035.

From a regional perspective, assuming the onshore wind turbine supply chain remains free-flowing, no bottleneck issues are expected during the forecast period, even if Brazil's impact is excluded. The region's growing industrial base and integrated supply chain provide a strong guarantee for overall supply stability.

Figure 1-15: LAC Onshore Wind Tower Capacity Distribution in 2025 (Total: 1,400 Units)

- Brazil: 69%
- Mexico: 17%
- Argentina: 14%

Source: GWEC Market Intelligence, ERM, October 2025

图 1-15
2025 年拉美地区陆上
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Table 1-10: LAC Onshore Wind Tower Supply and Demand Analysis Forecast 2025–2035 (Unit: Units/Sets)

Market	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Argentina	40	67	67	75	58	67	44	50	50	50	56
Brazil	329	250	250	500	750	750	500	500	500	500	500
Chile	200	125	125	100	100	100	88	88	88	88	88
Colombia	60	0	0	83	83	83	44	44	44	50	50

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Industrial Chain Development in the LAC Region

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Market	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Mexico	90	83	167	167	167	167	125	125	125	125	125
Others	27	61	50	54	63	50	81	88	94	100	106

Total	**746**	**586**	**658**	**979**	**1222**	**1217**	**881**	**894**	**900**	**913**	**925**
Total (excl. Brazil)	**417**	**336**	**408**	**479**	**472**	**467**	**381**	**394**	**400**	**413**	**425**

Legend: Green = Overcapacity (>10%); Yellow = Balanced; Orange = Slight Bottleneck (<10%); Red = Severe Bottleneck (>10%).

Source: GWEC Market Intelligence, ERM, October 2025

(2) Offshore

In the offshore wind field, the Latin American supply chain landscape is still in its infancy. Currently, only Mexico possesses operational offshore wind turbine tower manufacturing facilities, operated by Windar Renewables with an annual capacity of 50 units, primarily exporting to the United States. Although Brazil, Colombia, and Chile are widely recognized for their immense offshore wind potential, countries are still seeking effective ways to activate and expand their offshore supply chains.

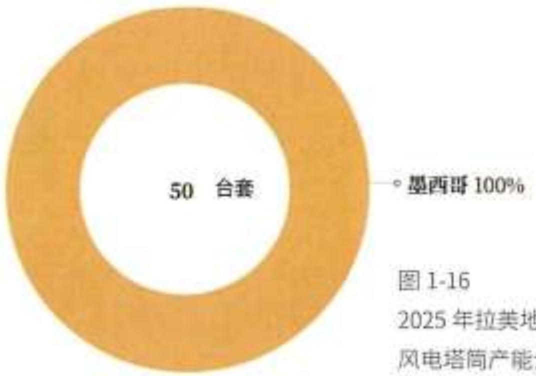
Supply chain expansion in Brazil and Colombia is expected to be driven by regulatory progress, international cooperation, growing investor interest, and government-led investment actions. However, the region still faces many challenges, including regulatory bottlenecks, a lack of local offshore wind turbine manufacturing capacity, and the need for massive investments in port and grid infrastructure.

Demand and supply benchmark analysis shows significant differences in development levels. Mexico is currently the only country in Latin America with the capacity to produce offshore wind towers to meet expected growth. Brazil is expected to face severe supply shortages starting in 2031, highlighting the urgency of industrial expansion. Supply chain bottlenecks in Colombia and Chile are expected to emerge from 2032 and 2033, respectively.

Notably, European tower manufacturers with facilities in Latin America are expected to transfer overseas expertise to the region once market conditions mature. To achieve this transition, it is crucial to formulate effective public policies and incentives to attract investment, while strengthening technology transfer and local talent development. These are essential for ensuring the sustained growth of the industry and achieving the economic and technical feasibility of offshore wind projects.

Figure 1-16: LAC Offshore Wind Tower Capacity Distribution in 2025 (Total: 50 Units)

- Mexico: 100%
  Source: GWEC Market Intelligence, ERM, October 2025



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来源：GWEC Market Intelligence, ERM, October 2025

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Table 1-11: LAC Offshore Wind Tower Supply and Demand Forecast 2025–2045 (Unit: Units/Sets)

Market	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Argentina	0	0	0	0	0	0	0	0	0	0	0
Brazil	0	0	0	2	0	0	33	33	67	67	67
Chile	0	0	0	0	0	0	0	0	0	3	33

Colombia	0	0	0	0	0	0	0	0	33	33	33
Mexico	0	0	0	0	0	0	0	0	0	0	3
Others	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**2**	**0**	**0**	**33**	**33**	**100**	**103**	**137**
Total (excl. Brazil)	**0**	**0**	**0**	**2**	**0**	**0**	**33**	**33**	**100**	**103**	**133**

Market	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
Argentina	0	0	0	0	0	0	0	0	0	0
Brazil	67	67	67	100	100	100	100	100	100	150
Chile	33	33	33	33	33	25	25	25	25	25

Colombia	33	33	33	67	67	50	50	50	50	50
Mexico	0	33	0	33	33	25	25	25	25	25
Others	0	0	0	0	2	0	10	0	10	0
Total	**133**	**167**	**133**	**233**	**235**	**200**	**210**	**200**	**210**	**250**
Total (excl. Brazil)	**133**	**133**	**133**	**200**	**202**	**175**	**185**	**175**	**185**	**225**

Legend: Green = Overcapacity (>10%); Yellow = Balanced; Orange = Slight Bottleneck (<10%); Red = Severe Bottleneck (>10%).

Source: GWEC Market Intelligence, ERM, October 2025

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Industrial Chain Development in the LAC Region

1.3.7 Castings

(1) Onshore

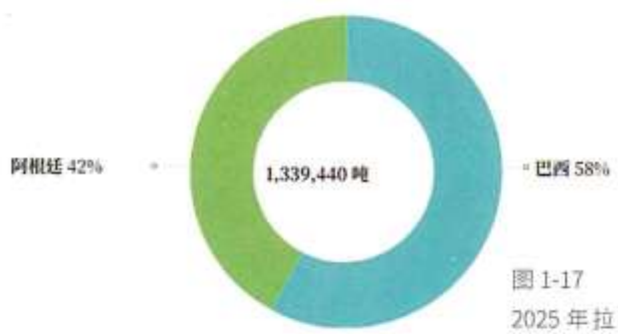
Latin America still faces significant challenges in building a competitive local wind power casting supply chain, although the region already possesses a certain casting foundation. Currently, onshore wind casting capacity is mainly concentrated in Brazil (approx. 58%) and Argentina. Major casting enterprises in Brazil include ICEC, Industrias ROMI, and BR Matozinhos Fundições Ltda, while Argentina's main suppliers are Fundición San Cayetano S.A. and Milicic S.A.

However, compared to the Asia-Pacific region, casting production costs in the LAC region are significantly higher. Combined with limited specialization and production scale, this leads to wind turbine manufacturers in the region being heavily dependent on imported castings, especially from China—which accounts for over 85% of the global wind turbine casting market and possesses significant price advantages. Brazil, as the core of the region's casting supply chain, largely supports the entire region's demand, with casting enterprises mainly distributed in the southeastern region. Regarding supply security, currently only Brazil and Argentina face no bottlenecks in casting component supply, while Chile, Colombia, and Mexico face severe constraints, primarily relying on Brazilian domestic capacity or imports from external markets like China.

Figure 1-17: LAC Onshore Wind Casting Capacity Distribution in 2025 (Total: 1,339,440 Tons)

- Brazil: 58%
- Argentina: 42%

Source: GWEC Market Intelligence, ERM, October 2025



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来源：GWEC Market Intelligence, ERM, October 2025

Table 1-12: LAC Onshore Wind Casting Supply and Demand Analysis Forecast 2025–2035 (Unit: Tons)

Market	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Argentina	2440	4880	4880	5490	4270	4880	4270	4880	4880	4880	5490

Brazil	20069	18300	18300	36600	54900	54900	48800	48800	48800	48800	48800
Chile	12200	9150	9150	7320	7320	7320	8540	8540	8540	8540	8540
Colombia	3560	0	0	5100	6100	6100	4270	4270	4270	4880	4880
Mexico	5490	6100	12200	12200	12200	12200	12200	17200	12200	12200	12200
Others	1647	4453	3660	3965	4636	3660	7930	8540	9150	9760	40370
Total	**45506**	**42883**	**48190**	**71675**	**89426**	**89060**	**86010**	**87230**	**87840**	**89060**	**90280**
Total (excl. Brazil)	**25437**	**24583**	**29890**	**35075**	**34526**	**34160**	**37210**	**38430**	**39040**	**40260**	**41480**

Legend: Green = Overcapacity (>10%); Yellow = Balanced; Red = Severe Bottleneck (>10%).

Source: GWEC Market Intelligence, ERM, October 2025

GLOBAL OFFSHORE WIND SUPPLY CHAIN REPORT 2025

(2) Offshore

Offshore wind casting capacity in the Latin American and Caribbean region is in its infancy, with only one company in Brazil, Tupy, considering expansion. Since offshore wind technology is more demanding—requiring larger diameters and the use of corrosion-resistant steel, as well as advanced manufacturing processes and specialized infrastructure—the region will face a structural supply gap if it does not increase investment to expand and upgrade local capacity to meet the quality and quantity requirements of offshore wind development.

1.3.8 Foundations

(1) Fixed Foundations

According to World Bank reports, Latin America has demonstrated immense technical development potential for fixed-bottom offshore wind since 2024 but faces significant challenges in supply chain construction.

Brazil, as a regional leader, possesses a technical potential of 480 GW and has the highest number of proposed projects. However, it requires substantial investment in port infrastructure, steel manufacturing, and grid integration, and must effectively translate mature offshore oil and gas industry experience into wind power development capabilities. Mexico, with its advanced oil and gas industry foundation, is well-positioned to transition to offshore wind. While Argentina has abundant wind resources and suitable sea areas, it has obvious weaknesses in manufacturing and installation capacity. Colombia has made major breakthroughs in policy regulation, launching the region's first seabed lease auction, with the Guajira region identified as a high-potential development zone.

However, the entire LAC region currently lacks manufacturing capacity for fixed-bottom offshore wind foundations, and there are no plans for new capacity construction. Demand is expected to grow significantly between 2035 and 2045. If relevant investments are not made promptly, all Latin American countries will face severe supply constraints.

(2) Floating Foundations

According to World Bank forecasts, commercialized floating offshore wind projects are unlikely to appear in the LAC region before 2030. Although Brazil has a technical development potential of up to 748 GW, the country only plans to build one demonstration project by the end of this decade.

- **Progress of Brazil's Demonstration Project:** Portos RS is advancing the first floating wind project in Rio Grande do Sul, located in the southern port city of Rio Grande. The project has successfully signed a tripartite cooperation agreement between Portos RS, Sindienergia-RS, and Mingyang Smart, marking a major milestone in the country's port construction and energy innovation.

- **Chile's Development Status:** The country's largest shipyard is expected to transform into a manufacturing base for wind turbine foundation components, but currently still relies on imported key equipment. Chile urgently needs to establish effective incentive mechanisms and conduct competitive bidding to cultivate and develop domestic capacity.

Various countries are actively exploring deep-water floating platform technology to expand the scope of offshore wind development, but they face common bottleneck constraints: a lack of specialized ports capable of handling large floating structures, the absence of local manufacturing plants...

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Industrial Chain Development in the LAC Region

Missing specialized installation and maintenance vessels, as well as the high upfront investment costs required for anchoring systems. Currently, the entire LAC region lacks floating foundation manufacturing capacity, and there are no relevant investment or construction plans. Without increased investment and strengthened regional coordination and cooperation, all Latin American countries will face severe supply challenges and may miss important development opportunities to establish local supply chains and reduce external dependence.

1.3.9 Subsea Cables

The subsea cable supply chain in the Latin American region is currently in its early stages of development, lacking large-scale local manufacturing capacity for medium-voltage subsea cables, with only Argentina maintaining relevant production operations. With the rapid expansion of offshore wind projects and the widespread application of High Voltage Direct Current (HVDC) transmission systems, the region urgently needs investment to build regional manufacturing, logistics, and installation capabilities; otherwise, it will remain long-term dependent on foreign supply chains that are already under immense pressure due to surging global demand.

Although Brazil has several cable manufacturing enterprises, most focus on onshore applications. Their products cannot meet the special technical requirements for offshore systems, such as voltage levels, durability, and adaptation to the marine environment. While existing onshore cable producers and overseas subsea cable companies are strategically preparing for the future Latin American offshore wind market, those with existing investments in LAC prefer to utilize their global manufacturing networks to meet local needs rather than investing in the construction of costly new production facilities before the market is fully mature.

In terms of key cable suppliers, overseas companies already operating in the region include Nexans and Prysmian Group, as well as Mexican local producers such as Viakable and Condumex. However, to date, no manufacturers have been found actively transitioning their business into subsea cable production.

Due to the lack of subsea cable manufacturing capacity and no new investment plans, all Latin American countries are expected to face supply constraints, posing risks of project delays and cost overruns. Particularly in the context of rapidly growing demand for HVDC cables for deep-water floating wind farms, the region's deficiency in professional manufacturing and installation capabilities will further restrict the development of the offshore wind industry.

1.3.10 Installation Vessels

The LAC region has obvious shortcomings in offshore wind infrastructure, especially the absence of professional Wind Turbine Installation Vessels (WTIVs), which has significantly impacted project feasibility. This issue is particularly prominent as wind turbine sizes and project scales continue to increase.

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1.3.10 Continued

For WTIVs, suitability depends on two core indicators: lifting capacity and hook height. Taking a 15 MW wind turbine as an example, the total weight of the nacelle can reach 800 tons, pre-assembled towers exceed 2,000 tons, and XXL foundations also weigh over 1,000 tons. Simultaneously, hub heights may exceed 150 meters, placing higher demands on the crane's lifting capacity. Because the number of vessels globally with the corresponding weight and lifting height capabilities is extremely limited, the scarcity of resources in this field is further exacerbated.

Currently, the LAC region has neither operational installation vessels nor relevant construction capabilities, which not only significantly increases project construction costs but also makes logistical arrangements more complex. Brazil is expected to be the first to encounter an installation vessel shortage in 2028, followed by Colombia (2033), Chile, and Mexico (2035). Additionally, factors such as inadequate heavy manufacturing capacity, backward port facilities, and regulatory system uncertainty pose multiple obstacles to industrial development.

Nevertheless, the region's accumulated experience and technical reserves in offshore oil and gas, shipbuilding, and maritime transport provide a good foundation for developing offshore wind installation capabilities. For example, Brazil's extensive experience with Floating Production Storage and Offloading (FPSO) units and Colombia's growing offshore exploration capabilities can be converted into advantages for developing customized installation vessels. Although the region does not yet possess large shipyards to build brand-new full-scale installation vessels, small and medium-sized shipyards can participate through modular manufacturing, component assembly, or the conversion of old vessels.

At the same time, countries like Mexico and Argentina, with their pool of marine engineering talent and coastal location advantages, have significant development potential in niche markets such as Commissioning Service Operation Vessels (CSOV), Crew Transfer Vessels (CTV), cable-laying support vessels, and maintenance platforms.

Other Latin American countries are also accelerating the development of offshore wind installation vessels. Peru and Venezuela have rich experience in offshore operations, while Ecuador shows potential based on the existing foundation of its oil and gas industry and preliminary shipbuilding capabilities. Panama, though lacking a strong domestic shipbuilding industry, possesses a world-class shipping route—the Panama Canal—along with advanced port facilities and a specialized logistics service system. If these can be integrated and optimized through international cooperation and capital investment, Panama could follow Vietnam's success model to build an installation fleet dedicated to offshore wind development.

Fully leveraging the synergistic effects of the region's mature oil and gas industry in shipbuilding and marine engineering is a key pathway to accelerating local capacity building and reducing external dependence. By introducing international vessel operators early, implementing policy incentives, and upgrading port infrastructure, the LAC region is expected to gradually grow into an important link in the global offshore wind supply chain and effectively alleviate future installation bottlenecks.

In contrast, the Asia-Pacific region, including China, South Korea, and Singapore, possesses numerous modern large shipyards with strong equipment manufacturing capabilities. The LAC region currently has no operational or under-construction offshore installation vessels and has not established a regional shipbuilding base for this purpose. This structural deficiency has become one of the core bottlenecks restricting the large-scale development of local offshore wind, especially as wind turbines become larger and installation processes more complex.

Notably, the region currently lacks regulations restricting foreign vessels from engaging in coastal transport (cabotage), allowing a short-term reliance on international fleets to meet some demand. However, as global demand for WTIVs grows, these international resources may struggle to guarantee a stable supply, triggering supply chain security risks. Therefore, promoting strategic WTIV investment for the LAC region and strengthening regional coordination mechanisms will be important measures to support future offshore wind development and safeguard energy transition security.

Industrial Chain Development in the LAC Region

1.3.11 Ports

Ports serve as critical infrastructure for offshore wind development, playing an indispensable role throughout the entire industrial chain—from early-stage site surveys to component manufacturing, construction, operations and maintenance, and finally decommissioning. In the offshore wind supply chain, ports undertake several strategic functions:

- **Manufacturing Ports:** Responsible for producing core components such as foundation structures, towers, and blades. These ports typically require large land areas to meet the needs of large-scale manufacturing and logistics.
- **Construction Ports:** Primarily used for receiving, processing, and assembling components delivered in batches, temporarily storing them before transferring them to installation vessels or offshore construction support vessels. Such ports must have sufficient storage capacity for foundations, transition pieces, towers, nacelles, blades, and other Balance of Plant (BoP) components.

- **Marshalling and Integration (M&I) Ports:** For floating wind projects, these ports have special significance. They enable the storage and preparation of floating foundations in a floating state, while using heavy lifting equipment to assemble the entire wind turbine, including tower sections and nacelles. Additionally, some systems can undergo preliminary commissioning at this stage, effectively shortening the actual installation cycle offshore.

To reduce project operational risks, ideal M&I ports should be as close as possible to the wind farm site to minimize towing distances and associated costs, which is especially important given limited and unpredictable weather windows. This requires ports to have sufficient "wet" storage berth resources; however, due to high throughput and space constraints, this capability often becomes a bottleneck.

Beyond these functions, ports are widely used in daily operations and maintenance (O&M) activities. Although the functional requirements for O&M ports are relatively simple compared to manufacturing or construction ports, whether the location is near the project site remains a major factor in determining practicality and efficiency. Proximity facilitates more cost-effective maintenance strategies.

Challenges

Despite the region's abundant offshore wind potential, LAC port infrastructure still faces many shortcomings, which may become a major obstacle to rapid industrial expansion in the coming years. Unlike Europe, where port facilities can be shared between neighboring countries, Latin American nations are currently in the initial stages of building their own port capacity and require significant capital investment to create a comprehensive port network capable of fully supporting the entire lifecycle of offshore wind operations.

As of now, there are approximately 44 ports across the LAC region, 28 of which are located near sea areas with high wind energy development value. Some regions have already initiated adaptation planning. Most countries' ports either have conditions for expansion or are formulating corresponding long-term development strategies. However, the situation in Chile is not optimistic: out of its 21 national ports, as many as 15 have not yet issued specific development plans for offshore wind-related facilities, exposing a serious lack of infrastructure readiness in the region.

Brazil:

Brazil currently holds a dominant position in LAC offshore wind development, with planned installations reaching hundreds of gigawatts. The main supporting ports include Suape, Itaqui/Pecém, Rio Grande, and Açu, which have begun upgrading dedicated handling and storage facilities for large-scale wind equipment.

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To achieve truly large-scale deployment, coordinated progress in grid expansion and environmental regulations is also necessary. This provides a valuable opportunity to revitalize the local shipbuilding industry, modernize ports, and cultivate an emerging technical workforce. It is predicted that this field could attract billions of dollars in investment and create hundreds of thousands of jobs over the next decade.

Port of Açu:

Located in northern Rio de Janeiro state, the Port of Açu is considered an ideal candidate to become a regional offshore wind supply chain hub due to its proximity (only 20 km) to potential offshore wind farms. Existing infrastructure includes functional areas designed specifically for offshore operations, a dredged channel with a depth of 14.5 meters, and professional docks capable of handling ultra-large wind turbine components. Therefore, it is highly suitable for industrial parks dedicated to assembling nacelles, blades, cables, and towers, serving both the domestic and international markets. With its superior location, direct dock access, and potential for coastal shipping, Port of Açu demonstrates a significant competitive advantage in implementing large-scale, complex engineering projects.

Colombia:

Colombia is also considered to have substantial offshore wind development potential. However, to support future large-scale project construction, capital investment in port infrastructure must be increased. Developing specialized ports is seen as a key step toward enhancing the competitiveness of the clean energy industry and gradually moving away from heavy dependence on hydropower.

Cartagena, Barranquilla, and Santa Marta possess mature offshore commercial experience and oil/gas industry backgrounds, providing good foundational conditions for expanding coastal port clusters. These ports have the capacity to handle marshalling, manufacturing, construction, and handling for both fixed and floating projects.

According to the World Bank's *2025 Report*, Colombia is poised to become a major global exporter of green hydrogen. The northern Caribbean coast, in particular, has competitive potential matching or exceeding the best wind bases in the Southern Cone. Meanwhile, the Colombian government is actively promoting policy frameworks, such as the "Green Hydrogen Roadmap," the "Offshore Wind Development Blueprint," and CONPES 4118/2023 "Sustainable Port Development Strategy," creating a favorable policy atmosphere to attract external capital and accelerate port facility modernization.

Core Issues and Solutions

The core difficulties facing port development in the LAC region include: the urgent need for hardware upgrades to meet the transport and lifting requirements of increasingly large wind turbine components; the lack of effective linkage mechanisms with local shipbuilding, leading to a shortage of specialized vessels; and the lack of unified coordination between relevant departments, where planning and regulatory systems have not yet formed a synergy.

In this regard, strengthening international cooperation is particularly crucial. For example, cooperation models between LAC countries and the UK can help promote advanced technology transfer, professional talent training, and the implementation of advanced management models.

Overall, the booming offshore wind industry urgently requires robust infrastructure guarantees, including assembly ports, staging areas, high-tonnage cranes, and deep-water channels. Early planning for port hubs can avoid future logistical congestion, attract more manufacturers, drive the formation of localized production chains, and stimulate technical innovation.

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Port Names:

1. Enseada Port, 2. Altamira Port, 3. Veracruz Port, 4. Lázaro Cárdenas Port, 5. Manzanillo Port, 6. Puerto Bolivar Port, 7. Santa Marta Port, 8. Barranquilla Port, 9. Cartagena Port, 10. Buenaventura Port, 11. Pecem Port, 12. Suape Port, 13. Açu Port, 14. São Sebastiao Port, 15. Santos Port, 16. Itajai Port, 17. Rio Grande Port, 18. Puerto Montt Port, 19. Talcahuano/San Vicente Port, 20. San Antonio Port, 21. Valparaiso Port, 22. Antofagasta Port, 23. Bahía Blanca Port, 24. Puerto Rosales Port, 25. Puerto Madryn Port, 26. La Plata Port, 27. Buenos Aires Port, 28. Quequén Port.

Figure 1-18: Potential LAC Ports Planned to Support Wind Power Development

Source: GWEC Market Intelligence, ERM, October 2025

1.3.12 Critical Materials

Rare Earths:

The LAC region possesses immense potential in Rare Earth Element (REE) reserves. Brazil, as a major country in the region, holds over 20% of the world's lithium reserves. Brazil also has the world's second-largest REE reserves, estimated at approximately 21 million tons of Rare Earth Oxides (REO), accounting for about 23% of the global total. However, despite being resource-rich, Brazil's rare earth production is still in its infancy. In 2024, the country's rare earth output was only 20 tons, accounting for less than 1% of the global total of 390,000 tons.

In terms of market size, the LAC rare earth market generated $21.5 million in revenue in 2024, representing only 0.5% of the global market. However, the regional market is expected to maintain a CAGR of 7.4%, with the market size reaching $32.1 million by 2030. This growth prospect is primarily driven by the rising global demand for critical minerals required for the clean energy transition, such as electric vehicles and wind energy.

Rare Earths Continued

Currently, Latin America lacks a complete industrial system for rare earth processing. Apart from some basic concentrate or oxide production, the region is essentially limited to the extraction and export of raw materials. These primary products are mostly exported to regions like Asia for subsequent refining, separation, and conversion into metals, alloys, and high-value-added components. Currently, all advanced rare earth processing activities are concentrated outside the region, with China dominating the market, holding over 85% of global refining capacity.

Carbon Fiber:

In the wind energy sector, carbon fiber is primarily used in structural composites, typically combined with epoxy resins, to create materials that are both lightweight and extremely durable. These materials can effectively withstand the various dynamic and environmental stresses faced by wind turbine blades. The application of carbon fiber enables the manufacturing of longer, more aerodynamically efficient blades, significantly increasing the power generation capacity of a single turbine. However, due to the high technical threshold and production costs of primary carbon fiber production (involving complex processes such as thermal stabilization and carbonization of polymer precursors), this industry is currently concentrated in technologically advanced countries such as Japan, China, the United States, and Germany.

The LAC region currently lacks the industrial production capacity for primary carbon fiber and is therefore entirely dependent on imports of raw fibers, technical fabrics, and prepregs. Nonetheless, some limited secondary processing capabilities have begun to emerge. For example, in Brazil and Mexico, some specialized companies engage in cutting, forming, and converting imported carbon fiber fabrics, primarily serving defense, industrial prototyping, lightweight transportation equipment, and scientific research. While these activities support some high-value applications, they have not yet formed a complete industrial chain and cannot meet large-scale industrial demand, especially for the wind energy industry.

In 2024, the carbon fiber market size in the LAC region reached 8,110 tons and is expected to maintain an annual growth rate of 9.5% through 2034, reaching 18,360 tons. This growth is driven by three major trends: first, the rapid development of the automotive industry, particularly in Brazil and Mexico; second, increased investment in aerospace manufacturing; and third, the sustained growth in demand for large wind turbines that utilize carbon fiber to enhance blade rigidity, reduce weight, and improve aerodynamic efficiency.

The region, particularly Brazil and Mexico, has already established wind blade manufacturing bases, providing an important industrial foundation for the application of advanced materials. In this context, China has become a potential important partner, having significantly expanded its production capacity for mid-performance carbon fiber over the past decade, becoming a cost-competitive supplier for emerging markets.

Despite broad market prospects, the development of the carbon fiber industry still faces many challenges. High production costs remain a major obstacle, primarily due to the complexity of the manufacturing process and massive energy consumption. The LAC region is currently a net importer of carbon fiber. However, the rapid growth in demand for lightweight high-performance materials, especially in wind energy, combined with the presence of advanced industrial centers in Brazil and Mexico, creates favorable conditions for developing regional secondary value chains focused on material processing, integration, and maintenance services.

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Industrial Chain Development in the LAC Region

Steel:

The wind energy industry is one of the main drivers for the growth in demand for steel plates. According to the International Energy Agency (IEA), rising energy costs and intensified global market competition have led to a decline in the market share of LAC producers, resulting in greater dependence on imported products. This situation poses a severe challenge to the competitiveness of local steel production and may affect the supply and cost control of critical raw materials required for the offshore wind industry, including steel plates, steel towers, and steel foundation structures.

Brazil holds a strategic position in the global steel industrial chain, especially as a leading producer in Latin America. In June 2025, the country's steel output reached 2.8 million tons, securing its place as the world's 9th largest steel producer. Although this was a slight decrease of 0.5% compared to the same period in 2024, Brazil's total steel output in the first half of 2025 achieved a 0.5% growth, totaling 16.5 million tons.

Brazil is also a major exporter of iron ore, the core raw material for blast furnace steelmaking. In 2023, Brazil's iron ore output reached 417.958 million tons, with exports reaching 407.970 million tons. According to World Steel Association statistics, this export volume accounts for about one-third of the global total, making Brazil second only to Australia. This unique control over high-quality iron ore provides Brazil with a significant competitive advantage in the production of various rolled steel products, including plates.

Despite its rich iron ore resources, Brazil is heavily dependent on imported metallurgical coal for producing blast furnace coke. This creates a structural vulnerability. According to industry data, producing 1,000 kg of pig iron using the integrated steelmaking process (Blast Furnace/Basic Oxygen Furnace) requires about 780 kg of metallurgical coal, making import dependence a major factor affecting production costs and competitiveness.

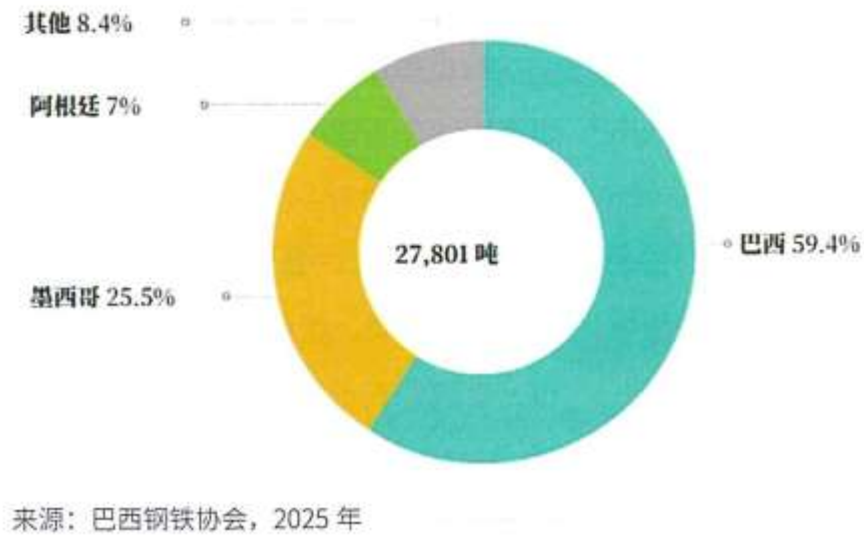
According to data from the Mexican Steel Association (CANACERO), the Mexican steel industry also plays an important role in the global market. In 2023, the country was the world's 14th largest steel producer, with 2024 production estimated at 18.2 million tons. The industry provides approximately 683,000 direct and indirect jobs. However, it faces the major challenge of high import dependence. CANACERO predicts that Mexico's finished steel imports will reach 12.6 million tons in 2024. This dependence is especially prominent in the flat steel sector; in 2023, U.S. flat steel exports to Mexico grew by 14% compared to 2022. By late 2024, the steel trade deficit between Mexico and the U.S. reached 2.3 million tons, in favor of the United States.

Theoretically, if the supply chain remains free-flowing, the LAC wind energy industry should not face steel supply shortages. However, two key factors may impact the supply chain. First, wind energy equipment has high material size requirements; in some extreme cases, required plate thickness can reach 150 mm. This significantly narrows the range of steel suppliers capable of meeting such technical specifications, as most standard plates range from 10 mm to 60 mm. Second, renewable energy projects focus on decarbonization goals, leading to increasing demand for low-carbon steel. However, most global steel is still produced via unabated blast furnace processes. Many developers may struggle to obtain low-carbon steel for a considerable time, as scaling up production is expected to take years. Meanwhile, while Brazil's steel industry has a foundation, it faces structural development challenges requiring large-scale expansion and upgrades.

Figure 1-19: Distribution of Total Crude Steel Production in the LAC Region in 2025

- Brazil: 59.4%
- Mexico: 25.5%
- Argentina: 7%
- Others: 8.4%

- Total: 27,801 tons



Source: Brazilian Steel Association, 2025

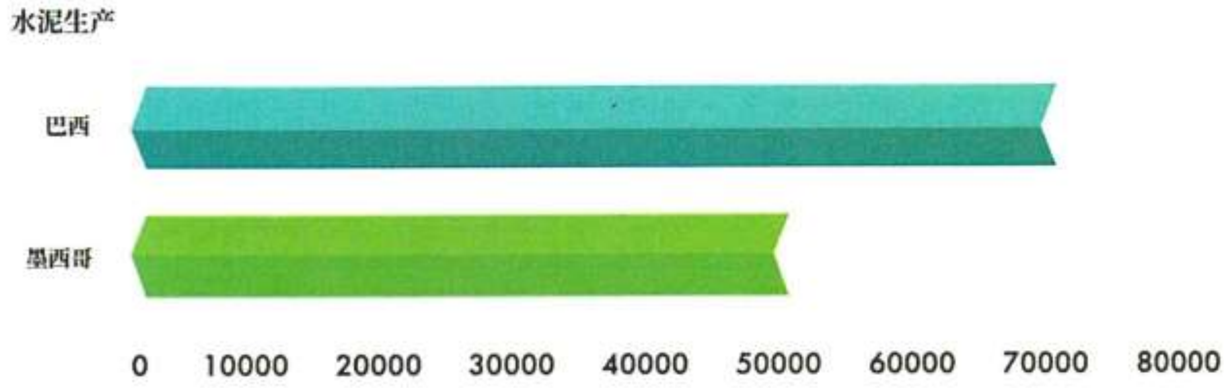
Concrete:

The risk of the LAC concrete supply chain facing bottlenecks is relatively low, primarily due to the wide distribution of concrete production across major countries in the region. Concrete production relies on locally available raw materials, including cement, aggregates, and water. This localized characteristic provides the supply chain with excellent flexibility, enabling it to respond quickly to market demand changes, including fluctuations from emerging growth sectors like wind energy.

The resilience of this logistics and production system explains why mature construction markets in the region—especially major economies like Brazil and Mexico—can maintain a stable and reliable concrete supply while vigorously advancing new energy infrastructure projects. Local geographical distribution and ease of access to raw materials provide a strong guarantee for handling the surge in demand brought by large-scale infrastructure investment.

Figure 1-20: Cement Production Capacity in the LAC Region

- Major Producers: Brazil, Mexico.
- Unit: 1,000 tons.
  Source: USGS, 2025



备注：数据以千吨为单位。
来源：美国地质调查局，2025 年

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Industrial Chain Development in the LAC Region

Copper:

The LAC region holds a strategically important position in the global copper supply chain, with its mine output accounting for approximately 40% of the global total, led by Chile and Peru. Based on 2024 historical data, the region possesses two of the world's three largest copper mines. Chile contributes 24% of global mine supply, and Peru accounts for 11%. These two countries, with mature infrastructure and strong capacity for expansion, jointly maintain Latin America's leadership in global copper mining.

In 2024, the market value of critical mineral production in the region reached approximately $100 billion for mining and $19 billion for refining. By 2040, these figures are expected to grow to $1300 billion and $24 billion, respectively. This growth momentum stems primarily from mining activities in Chile and Peru, and refining business development in Chile, Argentina, and Brazil. This is of particular significance for the wind energy industry, as copper is a critical material for core components such as electrical systems, cables, and generators, directly affecting the operational efficiency and performance of wind facilities.

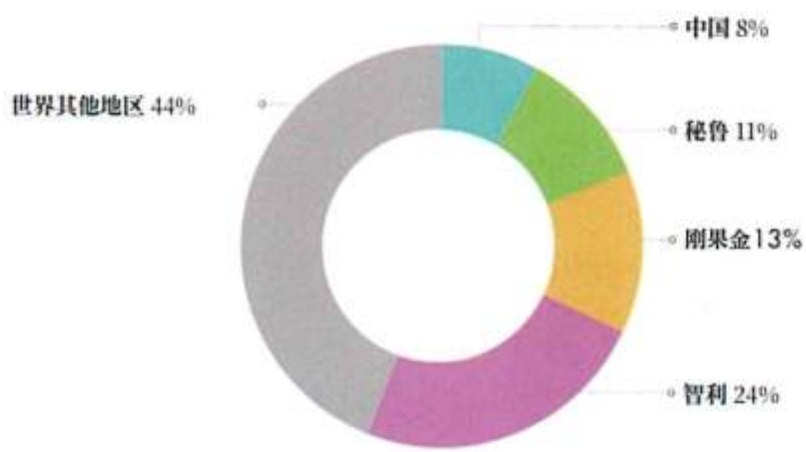
Globally, copper demand is on a continuous growth trend. According to the IEA's Stated Policies Scenario (STEPS), global copper demand will grow from 26.7 million tons in 2024 to 34.1 million tons by 2040. Approximately 12.1 million tons will be dedicated to clean energy technologies, including grids, EVs, and renewable systems. With its rich resources and existing capacity, the LAC region is fully capable of meeting this growing market demand. The region contributes about 7% of the global refined material market value, performing especially well in copper and lithium refining.

Despite the region's importance, the primary mining industry still faces structural challenges, including declining ore grades, aging infrastructure, permitting delays, and operational restrictions, which constrain production growth and drive up costs. While these challenges may not significantly impact supply in the short term, they require sufficient attention to ensure long-term sustainability.

The main logistical challenges in the region are concentrated in transport infrastructure: roads, railways, and ports are often inadequate for the growing demand for copper concentrate transport, especially in remote areas. However, refined copper projects announced by Chile, Brazil, and Argentina show a positive development trend, indicating that development in copper and lithium refining will drive regional growth.

Figure 1-21: Global Copper Mine Production Distribution by Country in 2024

- Chile: 24%
- DR Congo: 13%
- Peru: 11%
- China: 8%
- Rest of the World: 44%
  Source: EIA, "Global Critical Minerals Outlook 2025"



来源：美国能源信息署，《2025 年全球关键矿产展望》

4 前景展望 Outlook

摄影：刘行

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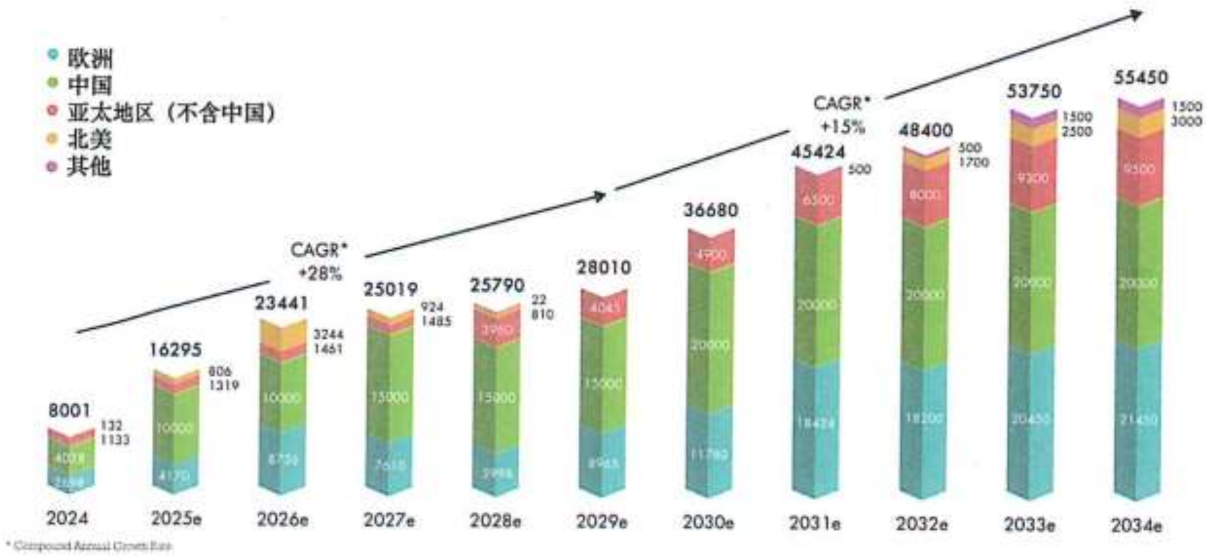
Outlook

- **Strong Global Demand Growth Expectations:** According to GWEC forecasts, the compound annual growth rate (CAGR) of global newly added offshore wind capacity will reach between 15% and 28% (range forecast). By 2030, annual new installations are expected to exceed 30 GW, and by 2033, cumulative installations are projected to surpass 50 GW, marking the industry's entry into a high-speed expansion phase.
- **Challenges in 2024:** In 2024, the global offshore wind industry faced multiple challenges, including macroeconomic fluctuations, geopolitical conflicts, and policy adjustments. Similar to other capital-intensive industries, this sector faced inflation, increased capital costs, and supply chain constraints. Simultaneously, the industry contended with geopolitical tensions and aggressive U.S. renewable energy and trade policies. Instability in government policies, permitting bottlenecks, and a lack of clarity regarding complex auction criteria failed to provide the necessary predictability and transparency, hindering forward-looking investments in the supply chain and offshore wind support sectors (including vessels, port infrastructure, and grid transmission). The offshore wind industry also faces risk assessments regarding future energy demand and prices. These factors will impact the sustainable development of global offshore wind to varying degrees.
- **Updated Forecasts:** GWEC's forecast for newly added global offshore wind capacity for 2025–2030 has been revised downward by 2.1% (approximately 3.3 GW) compared to the Q1 2025 estimate. However, most governments and developers remain committed to offshore wind development. The mid-term outlook for the global offshore wind market remains positive, with 152 GW of new capacity expected to be added during the forecast period. Growth will primarily come from the Asia-Pacific region (especially China) and Europe, with significant opportunities in the latter half of the forecast period. Installations are expected to triple by 2027 compared to 2024, rising from 8 GW to 24 GW. By 2034, annual additions are expected to reach 55 GW, increasing offshore wind's share of total wind power additions from the current 7% to approximately 25%. The CAGR is projected at 20.6% for 2025–2030 and 15% through 2034. Annual global offshore wind additions will pass the 30 GW milestone in 2030 and 50 GW in 2033. Overall, growth is expected to persist in the mid-to-long term (2025–2034), with over 350 GW of new installations, bringing cumulative global capacity to 441 GW by the end of 2034.
- **Floating Wind Technology:** The commercialization process for floating wind technology has been postponed until after 2030. It is estimated that 2.6 GW of floating wind projects will be completed by 2030, which is 69% lower than the 2024 forecast. From 2031 onwards, global floating wind will achieve leapfrog development, with a total of 19 GW installed by the end of 2034. Over the next decade (2025–2034), the market shares for Europe, Asia-Pacific, and North America are expected to be 57%, 42%, and 1%, respectively. Currently, Norway, the UK, China, France, and Portugal are the top five countries for cumulative floating wind capacity. By the end of 2034, China, the UK, South Korea, Norway, and Portugal are expected to emerge as the new top five leading nations in the floating offshore wind market.

(Graph: Figure 1-22 Forecast of Newly Added Offshore Wind Capacity by Global Region 2025–2034)

- Europe, China, Asia-Pacific (excl. China), North America, Others.
- CAGR (2024-2030): +28%
- CAGR (2030-2034): +15%
- Source: GWEC "Global Offshore Wind Report 2025"



来源：GWEC《全球海上风电发展报告 2025》

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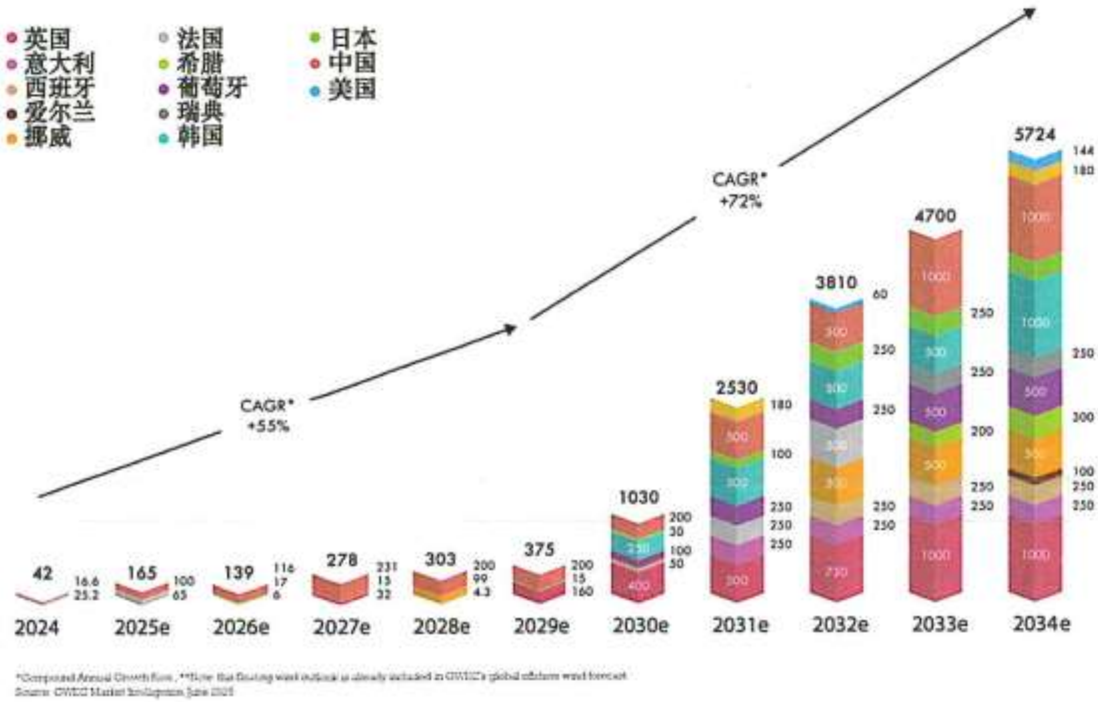
(Graph: Figure 1-23 Forecast of Newly Added Floating Offshore Wind Capacity by Country/Region 2025–2034)

- Key Countries: UK, France, Japan, Greece, China, Portugal, USA, Sweden, South Korea.
- CAGR (2024-2030): +55%
- CAGR (2030-2034): +72%
- Source: GWEC "Global Offshore Wind Report 2025"

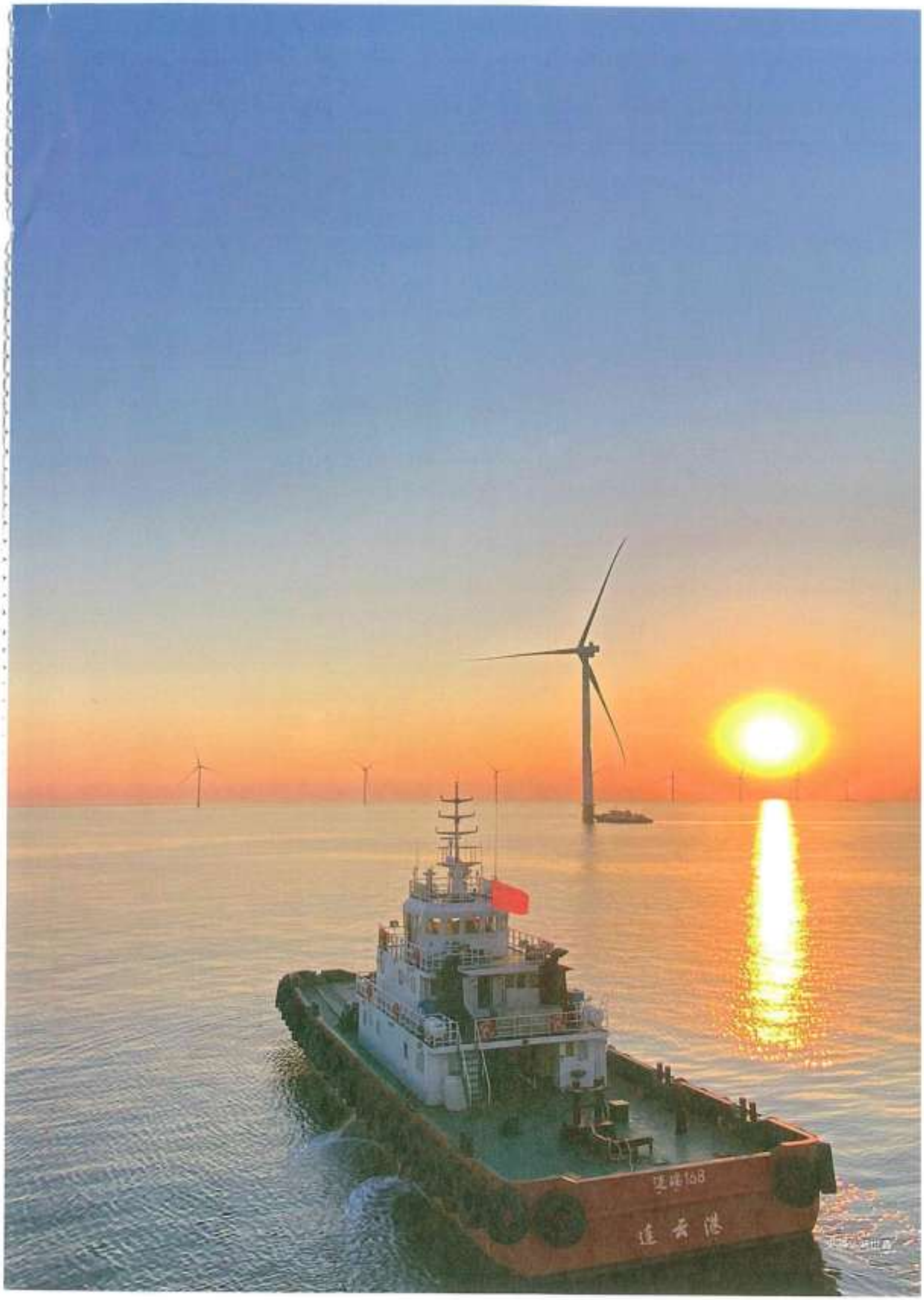


来源：GWEC《全球海上风电发展报告 2025》

To address robust future market demand, efforts must be strengthened in the following areas:

1. **Strengthening Supply Chain Localization and Regional Collaboration:** To enhance energy security and supply chain resilience, countries are promoting localized manufacturing. For example, Europe emphasizes "Green Local Industry," and the United States promotes domestic supply chain construction under the "Inflation Reduction Act." Simultaneously, transnational cooperation (such as China-EU technical cooperation and Asia-Pacific regional grid interconnection) will facilitate synergistic development of the industrial chain.
2. **Establishing Institutional Optimization and Risk-Sharing Mechanisms:** Some countries need to reform existing auction mechanisms and introduce risk-sharing models between governments and developers to reduce early-stage development risks for enterprises. Additionally, forward-looking grid planning must be strengthened to avoid grid connection bottlenecks where "power is generated but cannot be transmitted."
3. **Accelerating Technological Innovation to Drive Industrial Upgrades:** New technologies such as deep-water offshore wind, floating platforms, digital O&M, and green hydrogen coupling will become new growth points for the industrial chain. Japan's EEZ Act provides a legal foundation for floating wind, signaling a significant expansion of future technology application scenarios.

4. **Establishing Multi-party Synergy Mechanisms to Ensure Sustainable Development:** Achieving the aforementioned goals requires the concerted efforts of governments, enterprises, financial institutions, and research organizations. Priorities include: accelerating approval processes, stabilizing policy expectations, strengthening supply chain collaboration, increasing investment in talent cultivation, and building a resilient, efficient, and sustainable global offshore wind industrial chain system.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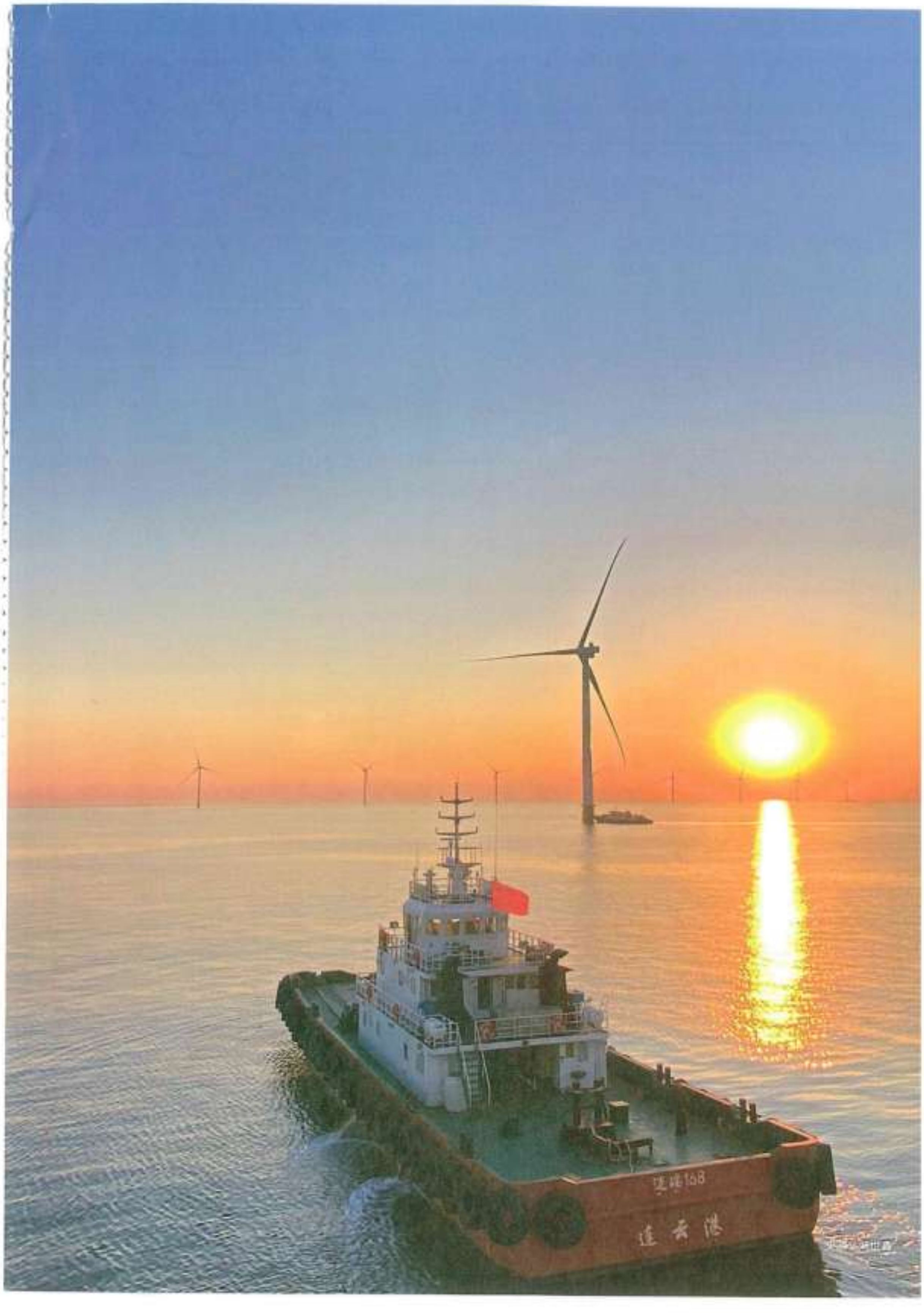
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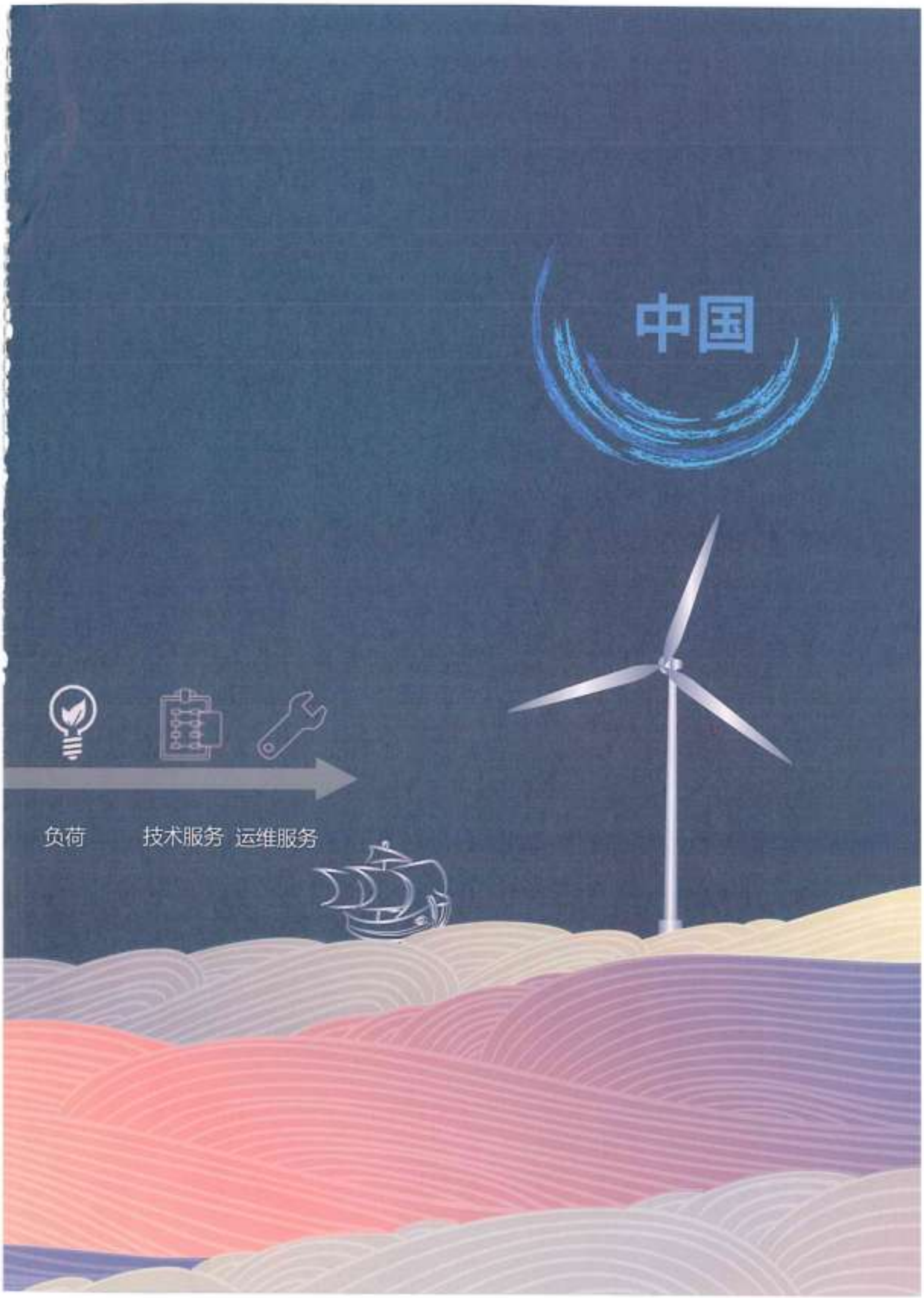
After more than a decade of development, China's offshore wind power has ranked first in the world in terms of installation scale for five consecutive years. Large-capacity wind turbines lead the world, domestic substitution technologies continue to achieve new breakthroughs, and floating offshore wind has entered the experimental demonstration stage. Offshore wind development is progressing from nearshore to deep-water areas, driving continuous industrial upgrades and becoming a vital direction for energy structure transformation in China and globally, with vast prospects for future development.

Industrial Chain Flow Chart:

- Raw Materials -> Key Components -> Foundation Platforms / Turbines -> Transport -> Construction & Installation -> Power Transmission & Transformation -> Load.
- Supported by: Technical Services & O&M Services.


中国
负荷
技术服务
运维服务

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1 市场发展概况

Market Overview

Market Development Overview

Immense Development Potential for China's Offshore Wind Resources

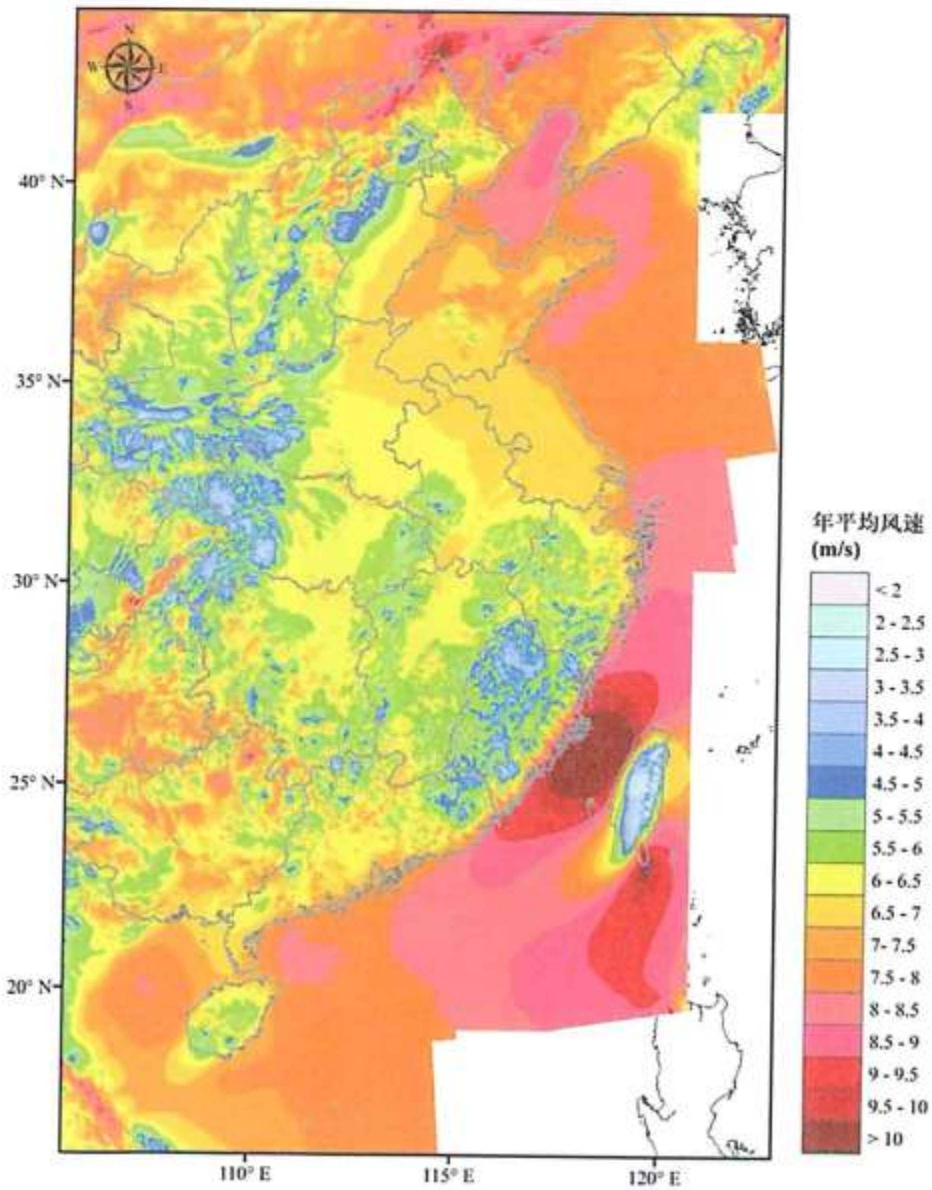
According to the latest assessment results from the National Climate Center, at a height of 150 meters and within 300 km of the coast—excluding sea areas for port shipping, industrial/urban use, mineral/energy zones, nature reserves, ecological red lines, major fairways, and offshore oil drilling platforms—the technical exploitable capacity of China's offshore wind energy resources is approximately **3,080 GW**.

- **Nearshore areas** (water depth 30–50 meters): Exploitable capacity is approximately 1,040 GW.
- **Deep-water areas** (water depth >50 meters): Exploitable capacity is approximately 2,040 GW.

By the end of 2024, the cumulative installed capacity of offshore wind exceeded 40 GW. Current development primarily focuses on nearshore resources, representing only about 4% of the nearshore technical exploitable capacity. Future expansion into deep-water areas offers immense potential.

(Map: Figure 2-1 Distribution Map of China's Offshore Wind Energy Resources at 150m Height)

Source: National Climate Center



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GLOBAL OFFSHORE WIND SUPPLY CHAIN REPORT 2025

Orderly Development of the Offshore Wind Industry

According to CWEA statistics:

- **In 2024:** China added 593 newly installed offshore wind turbines with a capacity of 5.9 GW, a year-on-year decrease of 17.9%, accounting for 6.8% of the country's total new wind power installations.

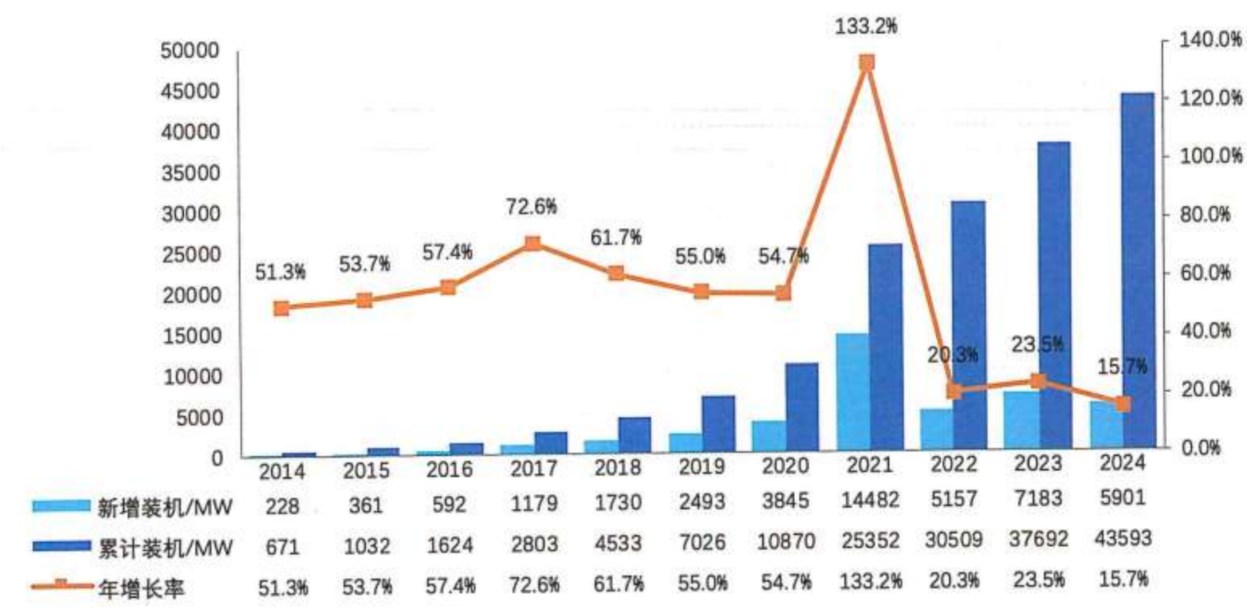
- **By the end of 2024:** There were over 150 offshore wind farms (excluding prototype testing projects), with a total of 7,273 turbines and a cumulative installed capacity of 43.59 GW, a year-on-year increase of 15.7%, accounting for 7.8% of China's total cumulative wind power installed capacity.

As of late September 2024, China's cumulative grid-connected offshore wind capacity reached 44.61 GW, up 14% year-on-year, representing approximately 7.7% of the national total grid-connected wind capacity. This is distributed across 11 coastal provinces (districts/cities):

- **Guangdong and Jiangsu:** Both exceed 12 GW, together accounting for 55% of the national total.
- **Shandong, Zhejiang, and Fujian:** Together exceed 14 GW, accounting for approximately 32.5%.
- **Hainan and Liaoning:** Total 3.3 GW, accounting for 7.4%.
- **Shanghai, Guangxi, Hebei, and Tianjin:** Total 2.27 GW, accounting for 5.1%.

(Graph: Figure 2-2 China's Offshore Wind Installed Capacity 2014–2024)

- Includes Newly Added Capacity (MW), Cumulative Capacity (MW), and Annual Growth Rate (%).
- *Data Source: CWEA*



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Market Development Overview

Table 2-1: Offshore Wind Installed Capacity by Type (End of 2024)

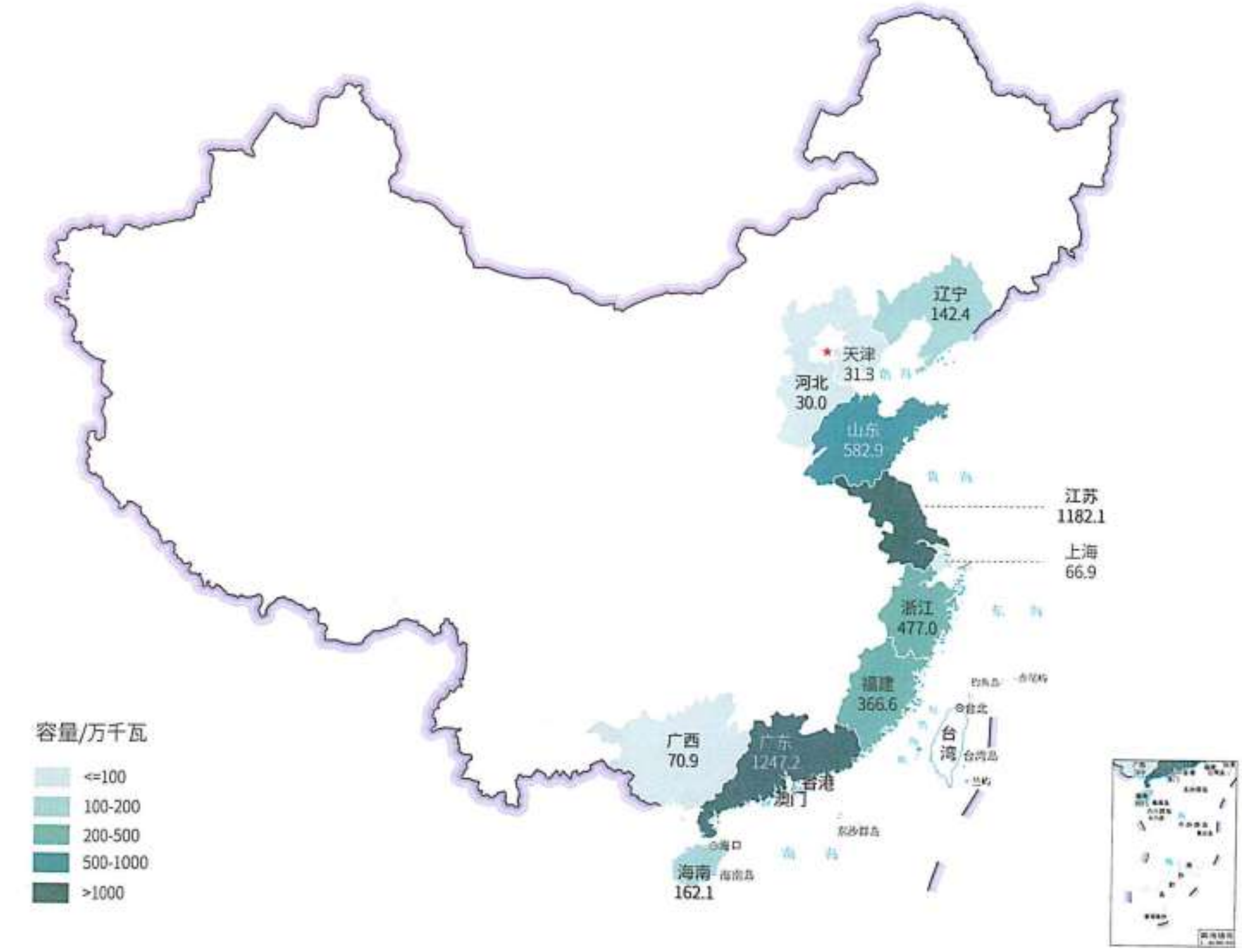
Type	Units (2024 New)	2024 New Installed Capacity (MW)	Units (Cumulative)	Cumulative Installed Capacity (MW)
Fixed-bottom	591	5884.3	7267	43553.4
Floating	2	16.6	6	39.6
Total	**593**	**5900.9**	**7273**	**43593.0**

Source: CWEA

(Map: Figure 2-3 Cumulative Offshore Wind Installed Capacity by Coastal Province/City (End of 2024))

- Liaoning: 1,424 MW
- Tianjin: 31.3 MW
- Hebei: 30.0 MW
- Guangxi: 70.9 MW
- Hainan: 162.1 MW
- Guangdong: 12,472 MW
- Fujian: 582.9 MW
- Jiangsu: 1,182.1 MW (*Note: Cumulative values reflect regional growth*)
- Shanghai: 66.9 MW
- Zhejiang: 4,770 MW
- Taiwan: 366.6 MW

  Source: CWEA



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GLOBAL OFFSHORE WIND SUPPLY CHAIN REPORT 2025

As China's offshore wind power gradually moves from nearshore to deep-water areas, floating offshore wind has entered the experimental demonstration stage. As of September 2025, five floating wind demonstration projects have been completed:

1. **"Leading" (Sanxia Group, 2021):** 5.5 MW.
2. **"Fuyao" (CSIC Haizhuang, 2022):** 6.2 MW.
3. **"CNOOC Guanlan" (CNOOC/Mingyang, 2023):** 7.25 MW.
4. **"Guoneng Shared" (Longyuan/Electric Wind, 2023):** 4 MW.
   Cumulative installed capacity reached 22.95 MW.

In June 2024, **"Mingyang Tiancheng"** was installed, equipped with two 8.3 MW offshore wind turbines, totaling 16.6 MW. On August 11, it began operations at the Mingyang Qingzhou IV offshore wind farm in Yangjiang, Guangdong. In January 2025, **"CRRC Qihang"** (unit capacity 20 MW) completed installation in Dongying for prototype testing. In July, a 17 MW direct-drive floating offshore wind turbine jointly developed by China Huaneng and Dongfang Electric was rolled out. In September, **"Sanxia Linghang"** was launched at Tieshan Port in Beihai, Guangxi. This project serves as the foundation for the Sanxia Yangjiang 16 MW floating turbine and is China's first large-capacity floating wind power scientific research demonstration project.

The development of the **17 MW-class floating wind prototype** is a special project under the "14th Five-Year Plan" National Key R&D Program "Renewable Energy Technology," led by the Huaneng Clean Energy Research Institute. The prototype is located at the Huaneng Yangjiang Shanshandao offshore wind farm. Technical specifications include:

- Wind resistance meeting IEC Class I; wave resistance for significant wave heights not less than 13 meters.
- Under operating conditions, the maximum tilt angle of the floating foundation is ≤5°, with maximum acceleration ≤0.3g.
- Under extreme conditions, the maximum tilt angle is ≤10°.

The project achieved breakthroughs in multi-body/multi-field coupling characteristics, global stability active-passive coordinated control, integrated simulation, lightweight optimization, and high-fidelity physical model testing. The foundation weight per megawatt is less than 340 tons. The prototype is scheduled for construction completion, commissioning, and sea testing by mid-2026.

The **Sanxia 16 MW Floating Offshore Wind System Demonstration Project** is located near Shapa Town, Yangxi County, Guangdong. The site is approximately 75 km offshore with water depths not less than 50m. The **Goldwind GWH252-16-F** turbine used is an upgrade of the commercialized GWH252-16 MW platform, utilizing core component reuse to reduce costs while significant performance optimization (over 10,000 load evaluation cases) ensures high reliability.

(Photo: Figure 2-4 China Huaneng 17 MW Direct-Drive Floating Wind Turbine Prototype)

图 2-5
“三峡领航号” 在广西北海铁山港下水

(Photo: Figure 2-5 "Sanxia Linghang" launching at Tieshan Port, Beihai, Guangxi)

2

产业链发展情况 Supply Chain Deep Dive

中国海上风电产业链愈发成熟，具备大规模发展基础。同时，海上风电产业已成为拉动区域经济的重要引擎。

来源：金风科技

بصفتي "مترجمًا أكاديميًا وعلميًا محترفًا"، أستكمل معك ترجمة الصفحات من 51 إلى 70 من "تقرير سلسلة توريد طاقة الرياح البحرية العالمية لعام 2025" إلى اللغة الإنجليزية الرسمية الأكاديمية:

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Figure 2-5: "Sanxia Linghang" launching at Tieshan Port, Beihai, Guangxi

Market Development Overview

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2 Supply Chain Development Status (Deep Dive)

China's offshore wind power industrial chain is becoming increasingly mature, possessing the foundation for large-scale development. Simultaneously, the offshore wind power industry has become a significant engine for driving regional economies.

(Source: Goldwind)

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2.2.1 Supply Landscape

(1) Wind Turbines

Current Status and Trends China has achieved global leadership in large-scale offshore wind turbine technology. In 2024, the average unit capacity of newly installed offshore wind turbines in China was 9.95 MW, which is higher than the global average (recorded as 9.8 MW by GWEC). Wind turbines with a unit capacity of 10 MW and above grew significantly; their share of newly added capacity rose from 12.1% in 2022 to 46.4% in 2023, and reached 55.8% in 2024—an increase of 9.4 percentage points over the previous year and 43.7 percentage points compared to 2022. The 16 MW unit capacity has reached mass application, while some prototypes in the 18–20 MW range have completed testing.

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In February 2025, Shanghai Electric Wind Power Group's EW14.0-270 unit was installed at the Offshore Wind Power Trial Base in Shantou, Guangdong. Within the year, it completed various product verification tests, including type testing, high/low voltage ride-through (HVRT/LVRT) capability testing, and grid adaptability testing, making it ready for mass delivery. Meanwhile, the EW18-20-260 unit, installed in August 2024 as the world's first 18–20 MW-class integrated wind-grid-load-storage offshore wind turbine, completed all pre-delivery verifications in the first half of 2025 and is operating stably.

Figure 2-6: Shanghai Electric Wind Power Group's EW14.0-270 Wind Turbine

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In October 2025, the world's largest 26 MW-class offshore wind turbine, developed by Dongfang Electric Corporation (DEC) with fully independent intellectual property rights, was successfully connected to the grid at the Dongying Wind Power Equipment Test and Certification Innovation Base. This set new global records for both single-unit capacity and rotor diameter of installed turbines. Comprehensive breakthroughs in key technologies such as gearboxes, generators, and electronic control systems highlight China's strong independent innovation capability in wind power equipment manufacturing and its determination to seize the global technological high ground, injecting powerful momentum into "new quality productive forces".

Figure 2-7: Dongfang Electric (DEC) 26 MW Large-scale Offshore Wind Turbine

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Supply Chain Development Status

In recent years, the transmission chain format for offshore wind turbines has been dominated by the semi-direct drive technical route. Medium-speed permanent magnet technology avoids the use of multi-stage gearboxes, which reduces failure rates while also reducing the volume and weight of the generator, thereby controlling costs. The proportion of units adopting the medium-speed permanent magnet technical route has grown annually. According to statistics from CWEA, in the newly added offshore wind turbine installations of 2024, the share of medium-speed semi-direct drive technology exceeded 90%, an increase of approximately 28 percentage points compared to 2023. Current original equipment manufacturers (OEMs) with semi-direct drive routes include Mingyang Smart, Goldwind, Dongfang Electric, Shanghai Electric Wind Power, CSSC Haizhuang, and CRRC.

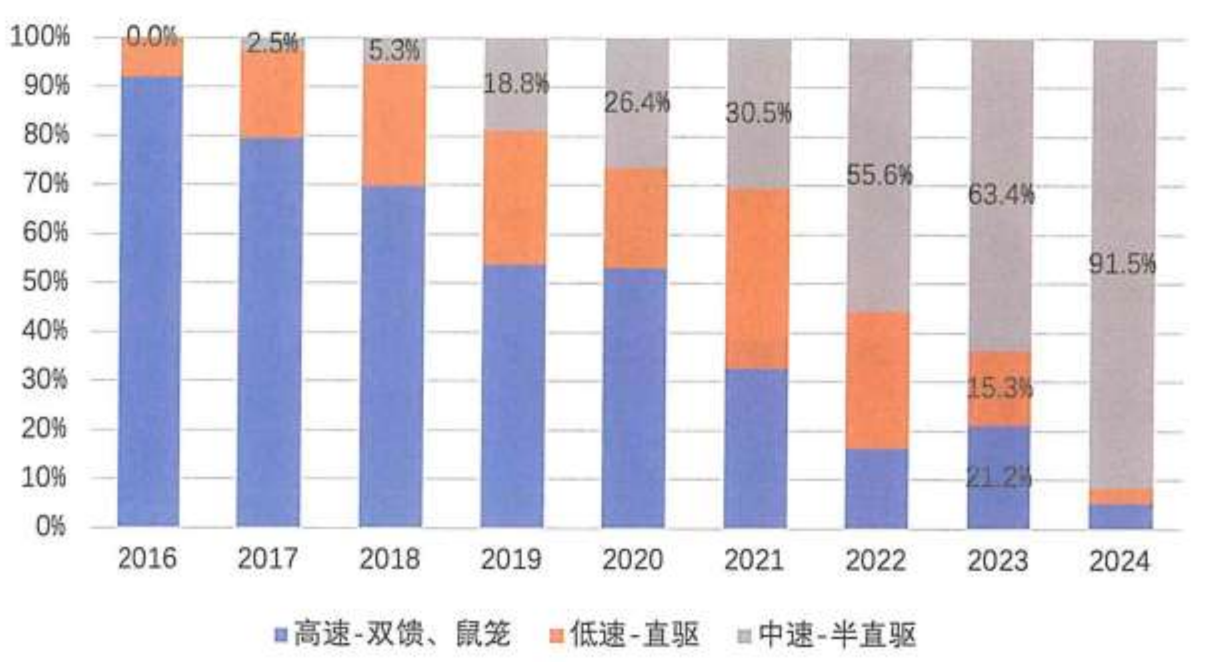

Figure 2-8: Market Share of Offshore Wind Turbines by Different Technical Routes (2016–2024)

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- (High-speed Doubly-fed/Squirrel Cage; Low-speed Direct Drive; Medium-speed Semi-direct Drive) *(Source: CWEA)*

Figure 2-9: Schematic Diagrams of Different Technical Routes

- (Doubly-fed [Four-point support], Direct Drive, Semi-direct Drive, Semi-direct Drive [Integrated])

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GLOBAL OFFSHORE WIND SUPPLY CHAIN REPORT 2025

Competitive Landscape Among the global Top 10 offshore wind turbine manufacturing enterprises in 2024, seven are Chinese. In 2024, a total of 13 wind turbine manufacturers globally installed 1,065 offshore wind turbines, with a scale approaching 10.5 GW. Four out of the top five companies are Chinese, with a combined market share of approximately 44.8%; seven out of the top ten are Chinese, with a total market share of approximately 54.5%. By the end of 2024, the global cumulative installed capacity of offshore wind reached 86.5 GW. Three out of the top five companies are Chinese, with a combined market share of approximately 34.4%; six out of the top ten are Chinese, with a total market share of approximately 49%.

Figure 2-10: Global Offshore Wind Turbine OEM Ranking by Newly Added Capacity in 2024

- (Siemens Gamesa: 32.5%; Mingyang Smart: 16.8%; Goldwind: 10.6%; Dongfang Electric: 9.3%; Shanghai Electric Wind Power: 8.1%; Vestas: 7.6%; CSSC Haizhuang: 5.9%; GE Vernova: 3.0%; CRRC: 2.2%; Envision Energy: 1.7%; Others: 2.5%)

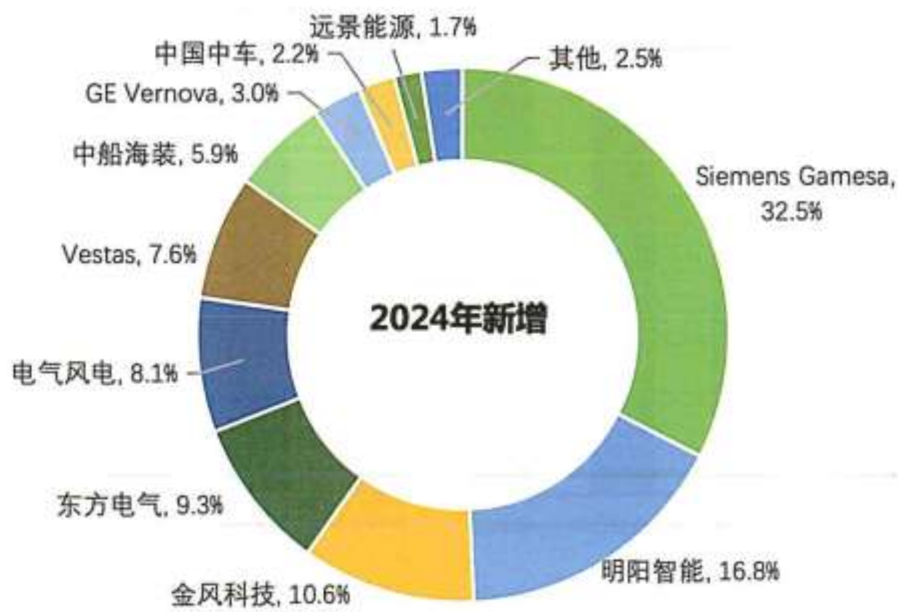
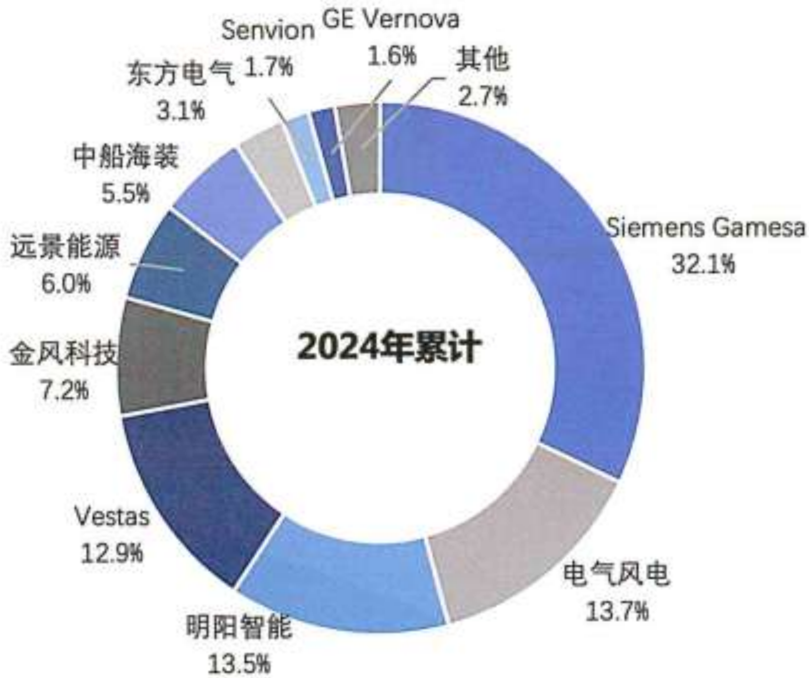


Figure 2-11: Global Offshore Wind Turbine OEM Ranking by Cumulative Installed Capacity (End of 2024)

- (Siemens Gamesa: 32.1%; Shanghai Electric Wind Power: 13.7%; Mingyang Smart: 13.5%; Vestas: 12.9%; GE Vernova: 7.2%; Goldwind: 6.0%; Envision Energy: 5.5%; CSSC Haizhuang: 3.1%; Dongfang Electric: 1.7%; Senvion: 1.6%; Others: 2.7%) *(Source: GWEC)*



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Supply Chain Development Status

The number of offshore wind turbine enterprises remains at approximately eight. As large-scale equipment, the manufacturing of offshore wind turbines has high technical barriers, and the number of enterprises has remained stable. In 2024, eight OEMs added new offshore wind installations, consistent with 2023. By the end of 2024, there were 15 offshore wind turbine OEMs in total. OEMs with installed capacity exceeding 1 million kW include Shanghai Electric Wind Power, Mingyang Smart, Goldwind, Envision Energy, CSSC Haizhuang, and Dongfang Electric. The cumulative installed capacity of these six enterprises totaled 42.042 million kW, accounting for 96.4% of the cumulative offshore installed capacity.

Figure 2-12: Number of Offshore Wind Turbine OEMs in China over the Years *(Source: CWEA)*

Table 2-2: Share of Newly Added Installed Capacity by China's Offshore Wind Turbine OEMs (2020–2024) |

No.	Company Name	2020	2021	2022	2023	2024
1	**Mingyang Smart Energy**	25.05%	26.11%	26.77%	40.94%	29.77%
2	**Goldwind**	8.13%	16.50%	5.70%	7.75%	18.68%
3	**Dongfang Electric**	1.56%	6.97%	2.91%	5.94%	16.45%

4	**Shanghai Electric Wind Power**	36.45%	29.03%	27.98%	15.61%	14.71%
5	**CSSC Haizhuang Windpower**	8.58%	13.79%	20.19%	6.77%	10.73%
6	**CRRC Corporation**	0.00%	0.00%	0.19%	0.00%	3.89%
7	**Envision Energy**	17.83%	6.74%	16.26%	15.84%	3.19%
8	**Windey**	0.00%	0.00%	0.00%	7.02%	2.59%
9	**Taiyuan Heavy Industry**	0.00%	0.00%	0.00%	0.14%	0.00%
10	**Xinglan Wind Power**	2.39%	0.86%	0.00%	0.00%	0.00%

+1

Figure 2-13: Cumulative Offshore Installed Capacity and Percentage of China's Wind Power Manufacturers (End of 2024)

- (Unit: 10,000 kW)

- Shanghai Electric Wind Power: 1194.7 (27.4%); Mingyang Smart: 1142.5 (26.2%); Goldwind: 603.4 (13.8%); Envision Energy: 522.4 (12.0%); CSSC Haizhuang: 478.2 (11.0%); Dongfang Electric: 263.1 (6.0%); Windey: 65.7 (1.5%); Sinovel: 28.7 (0.7%); CRRC: 24.0 (0.5%); Sinovel Wind: 17.0 (0.4%); Siemens Gamesa: 9.0 (0.2%); United Power: 6.6 (0.15%); Taiyuan Heavy Industry: 2.0 (0.05%); GE: 1.8 (0.04%); Sany Renewable Energy: 0.4 (0.01%) *(Source: CWEA)*

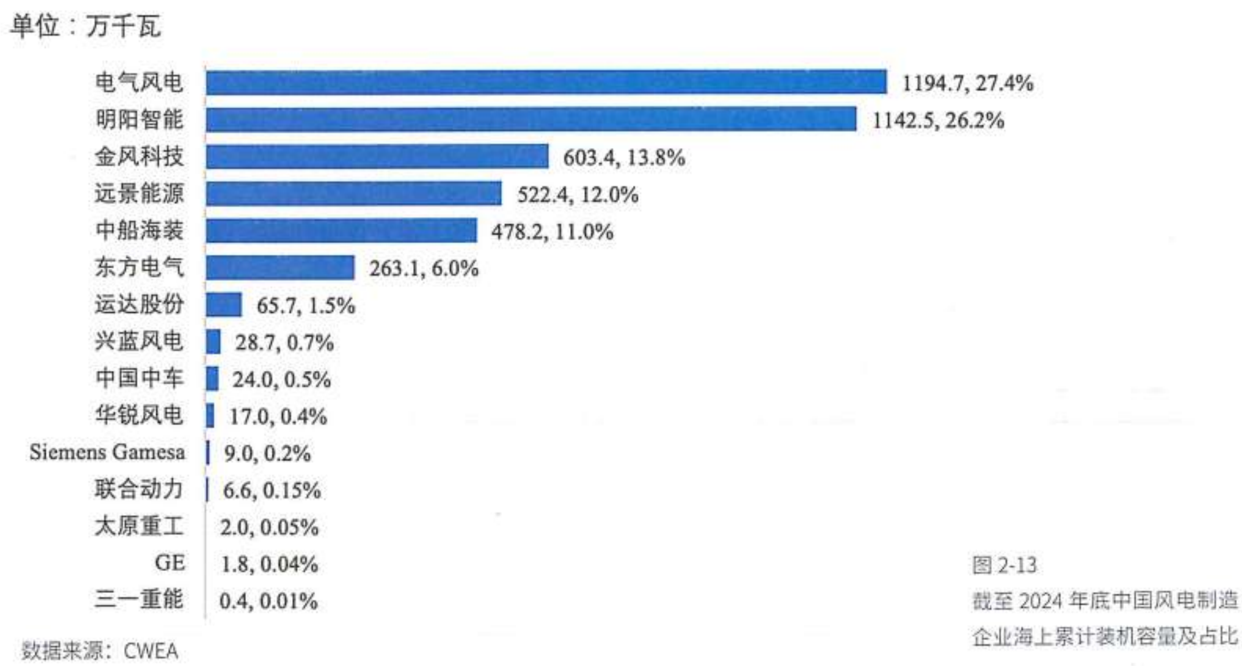

图 2-13
截至 2024 年底中国风电制造企业海上累计装机容量及占比

At the 2025 Beijing International Wind Energy Conference and Exhibition (CWP2025), multiple OEMs released a new generation of offshore wind turbines, demonstrating comprehensive breakthroughs in high power, deep-water adaptability, intelligence, and floating technology. Enterprises generally use new-generation product platforms for serialized development, achieving technology reuse and rapid customization. The new-generation offshore units are not just power generation equipment but intelligent energy systems integrating storage, AI control, and grid-friendliness. Faced with harsh marine environments like typhoons and high salt spray, the new models show significant improvements in structural strength and design life. For deep-water development, multiple floating units or units adapted for deep-water areas were showcased, pushing offshore wind further into deeper sea regions.

Table 2-3: Summary of New Models, Products, and Solutions Released by OEMs at CWP 2025

OEM	Name	Unit Capacity (MW)	Rotor Diameter (m)	Category
Goldwind	New Generation Ultra Series (GWH204-10MW)	10.5-11.1	204	All-scenario
	GWH266-14MW model for far-shore low wind speed	14	266	Offshore
	World's first Galileo AI Wind-Storage Integrated Unit	16.7	272	Land/Sea platform
Envision Energy	New Gen Onshore Model T Pro Platform EN-220/6.25~10+	6.25~10+	220	Onshore
	New Gen Onshore Model T Pro Platform EN-206/8.35~10+	8.35~10+	206	Onshore
	Offshore Model Y Pro EN-272/12.5	12.5	272	Offshore

	Model Z Pro EN-252/16.7 Series Intelligent Turbine	16.7	252	Offshore

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Supply Chain Development Status

(Continued from previous page)

OEM	Name	Unit Capacity (MW)	Rotor Diameter (m)	Category
Mingyang Smart	New Gen Medium-speed Compact Semi-direct Drive (MCD)	—	—	Land/Sea platform
	Ocean X Platform 50 MW Ultra-large Floating Unit	2x25	Dual Rotor	Offshore
	16-18 MW Floating "Sea Eagle" Unit (Model Display)	16-18	—	Offshore
Windey	New Gen 10 MW-class High-performance Onshore Unit	10-15	—	Onshore

	Wind Power O&M AI Agent, Green Fuel, etc. (6 segments)	—	—	Layout
Sany Renewable	Onshore All-scenario Model SI-242 Series	5.6-12.5	242	Onshore
	New Gen 17 MW-class Direct-drive Floating Offshore Unit	17	—	Offshore
Dongfang Electric	Onshore Platform adaptable to 6.X-10 MW	6.X-10	—	Onshore
	Offshore Platform adaptable to 12-18 MW	12-18	—	Offshore
	"Dongfang Xiaoxin" AI Agent, "Horn" monitoring system	—	—	Solution
	"Wind-Solar-Storage-Hydrogen" Green Tech, AI+Wind	—	—	Solution

CRRC	CRRC H4 Platform Serialized Offshore Wind Turbines	—	—	Offshore
	35kV High-voltage Doubly-fed, 12.9 MW PMSG	—	—	Generator
	Tubular Structure Floating Body Design (CRRC Qihang)	—	—	Floating Structure
Shanghai Electric	EW18.0-300 Far-shore Unit	18	300	Offshore
	W4000-130-Float Floating Unit	4.0	130	Offshore
	EW6.25-200 Overseas Customized Turbine	6.25	200	Onshore
	Poseidon Platform 8.5 MW Unit (Overseas, Certified)	8.5	230	Offshore

	EffiSync X Storage Platform (Overseas, Certified)	—	—	Storage
CSSC Haizhuang	H305-20 MW Offshore Wind Turbine	20	305	Offshore
	H220 Platform Onshore Wind Turbine 5 MW	5	220	Onshore
	H220 Platform Onshore Wind Turbine 7.7 MW	7.7	220	Onshore
	H220 Platform Onshore Wind Turbine 10 MW	10	220	Onshore
	Global Highest 200m Steel-concrete Tower HZ-200mHH+	5.X-15.X	—	Tower
Sinovel	SL6250/230	6.25	230	Onshore

OEM	Name	Unit Capacity (MW)	Rotor Diameter (m)	Category
Sinovel Wind	"One Base, Dual Turbines" 30 MW+ Floating Solution	2x15+	—	Offshore
	Efficient Green Hydrogen Synergetic Ecology Solution	—	—	Solution
	Intelligent O&M Solution	—	—	Solution
(Source: CWEA, compiled from public information)				

(2) Blades

Current Status and Trends Blades are core components of wind turbines. Their design, manufacturing process, and operating status determine power generation efficiency and economic benefits, while having a profound impact on long-term O&M costs. Offshore wind blades are specifically designed for marine environments and require higher corrosion resistance, fatigue resistance, and structural strength. Current blades are moving towards being larger, lighter, and more intelligent. Blade lengths are continuously increasing, from tens of meters to over 100 meters. Material technology innovation continues, with an increasing share of high-performance materials like carbon fiber. Intelligent manufacturing and digital technology are gradually integrating into the entire lifecycle. Blade recycling has become a new point of focus.

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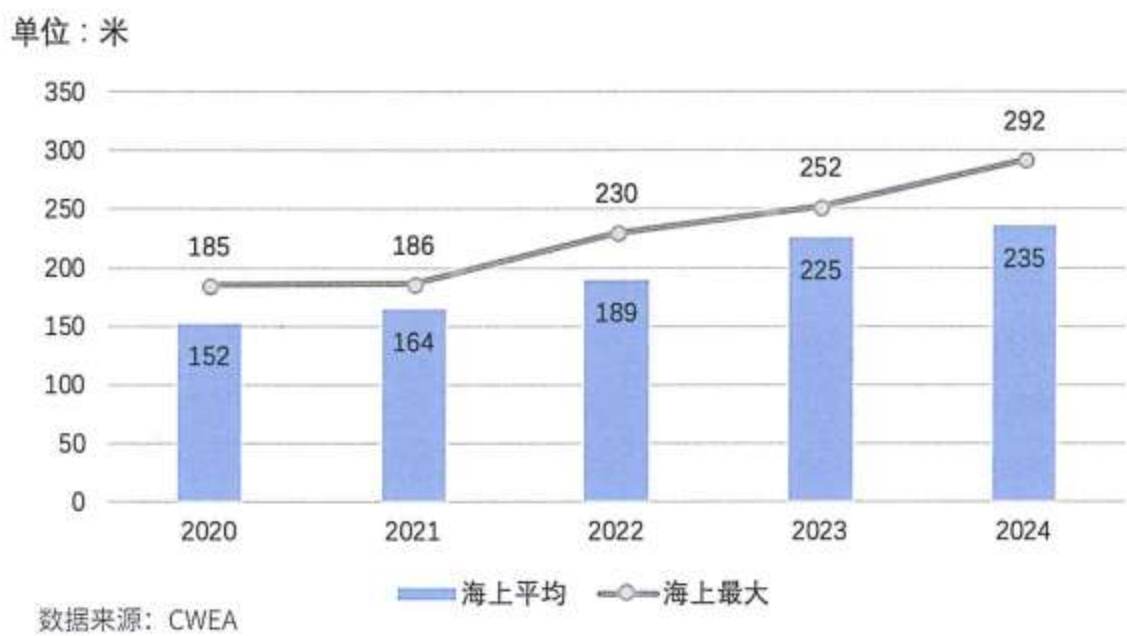
With the development of larger turbines, blade lengths have entered the 100-meter era. In the past five years, the average rotor diameter has grown by 83 meters. In 2024, the average rotor diameter reached 235 meters, an increase of 10 meters compared to 2023 and 83 meters compared to 2020. The maximum rotor diameter was 292 meters, an increase of 40 meters from 2023 and 107 meters from 2020. China's long blades are globally leading; 10 MW-class offshore unit blades have exceeded 110 meters.

Figure 2-14: Average and Maximum Rotor Diameter of New Offshore Wind Turbines in China (2020–2024)

- (Unit: Meters)
- 2020: Avg 152, Max 185; 2021: Avg 164, Max 186; 2022: Avg 189, Max 230; 2023: Avg 225, Max 252; 2024: Avg 235, Max 292 *(Source: CWEA)*



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Supply Chain Development Status

As units upscale, blade lengths reached 126 meters in 2023 (18 MW), a 147-meter blade rolled off the line in 2024, and a 153-meter blade for a 26 MW prototype is operational in 2025.

As blades grow longer, requirements for material performance continue to escalate. Carbon fiber, characterized by light weight, high strength, and high modulus, is the preferred material. It is applied in skins, leading edges, and trailing edges, but primarily in the main spar cap. 10 MW+ blades essentially use carbon fiber in spar caps. Major domestic producers include Jilin Chemical Fiber, Zhongfu Shenying, New Choice Carbon Fiber, and Baofeng Carbon Fiber. With 20 MW turbines and 150m+ blades, demand will further increase.

Enterprises are jointly tackling recyclable blade technology. In July 2025, the first domestic turbine with 220m+ recyclable blades, jointly developed by Swancor, Goldwind, and Sinoma Blade, was installed. It uses Swancor's "EzCiclo" recyclable resin, reducing the carbon footprint by at least 100 tons of CO_2e over its full lifecycle. EzCiclo resin decomposes into fibers and oligomers via mild acid after decommissioning, achieving a composite recovery rate of ≥95% without exhaust gas pollution. Additionally, Siemens Gamesa deployed 108m blades using third-gen EzCiclo resin at the Sofia project in the UK; Time New Material (TMT) also rolled off its TMT86A blade using EzCiclo resin. Recycling is in a transition stage between technical breakthroughs and large-scale application, with pyrolysis and cement kiln co-processing being relatively mature paths.

Competitive Landscape Technical barriers result in relatively high market concentration. Suppliers include independent suppliers and internal OEM factories: Sinoma Blade, Time New Material (TMT), Mingyang, Envision, Haizhuang, DEC, Shanghai Electric, and Shuangrui. Market leaders are Sinoma Blade (approx. 30%, ranking first), and TMT (approx. 22%, ranking second). After acquiring Zhongfu Lianzhong, Sinoma Technology further consolidated its advantage, holding nearly half of the offshore market.

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Sinoma Blade Sinoma Blade prioritizes technical innovation and possesses independent design and R&D capabilities. Products cover mainstream 1 MW–20 MW turbine platforms. Global cumulative sales and installations have exceeded 177 GW (64,600 sets), operating in 46 countries.

In 2023, it completed industrial integration with Zhongfu Lianzhong, becoming the unified wind blade business platform for CNBM Group. The company has ranked first in domestic market share for 14 consecutive years and first globally for 3 consecutive years.

Sinoma Blade possesses 16 production bases (including Gansu, Jilin, Jiangsu, Inner Mongolia, Hebei, Xinjiang, Shaanxi, Guangdong, Yunnan, and Bahia, Brazil) with a design capacity of 34 GW per year.

Led by systematic innovation, it possesses core technologies in aerodynamic and structural design, achieving full independent design and establishing verification routes from materials to full-scale blades. Mechanization and automation levels lead the industry. Over 200 product models cover 6 MW–20 MW+ platforms for various environments. It has achieved 100% localization and mass use of core raw materials.

Figure 2-15: Sinoma Blade 147-meter Blade

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Supply Chain Development Status

Time New Material (TMT) Time New Material is engaged in R&D, production, sales, and O&M services of wind turbine blades. It operates nine major blade production bases (including Zhuzhou, Tianjin, Sheyang, Mengxi, Jilin, Bin County, Baise, and Hami), radiating across five domestic regions. It possesses a manufacturing capacity of over 4,000 sets per year, with cumulative global installation exceeding 62 GW across Northern Europe, Central Asia, Southeast Asia, the Americas, and China.

TMT possesses a complete independent R&D system, with over 100 models across the 1.5 MW–18 MW range. Its offshore blades focus on the 11x and 12x series, with maximum application for 18 MW platforms.

The **TMT126BA floating wind blade** is a large-scale offshore ultra-long flexible blade with a carbon fiber spar cap, fully independently designed by TMT. It achieved an optimal balance between performance, weight, and cost for complex wind-wave-current coupling conditions. It uses a customized leading-edge protection film for deep-sea environments and a new high-efficiency lightning protection system.

Figure 2-16: Time New Material (TMT) TMT126BA

(3) Gearboxes

Current Status and Trends The primary function of a wind turbine gearbox is to transmit low-speed wind energy to the generator through a speed-increasing system. Design priorities include load-bearing capacity, reliability, lubrication, and corrosion resistance.

Offshore wind gearboxes are accelerating toward large-scale and intelligent development. Mainstream power ratings have risen from 3–5 MW to 10–15 MW, with 20–25 MW units under development. Upscaling demands higher load-bearing capacity and reliability. Lightweight design effectively reduces weight and costs, making the semi-direct drive technical route the absolute dominant position in the offshore market. Intelligent technology allows real-time monitoring and fault early-warning.

Facing special marine challenges, manufacturers continuously improve lubrication and cooling systems as well as sealing protection, extending service life. Modular and standardized design concepts improve versatility and reduce lifecycle costs.

Gearbox demand is increasing. The share of technical routes incorporating gearboxes is increasing annually; since 2021, almost all current offshore wind turbine OEMs require gearboxes.

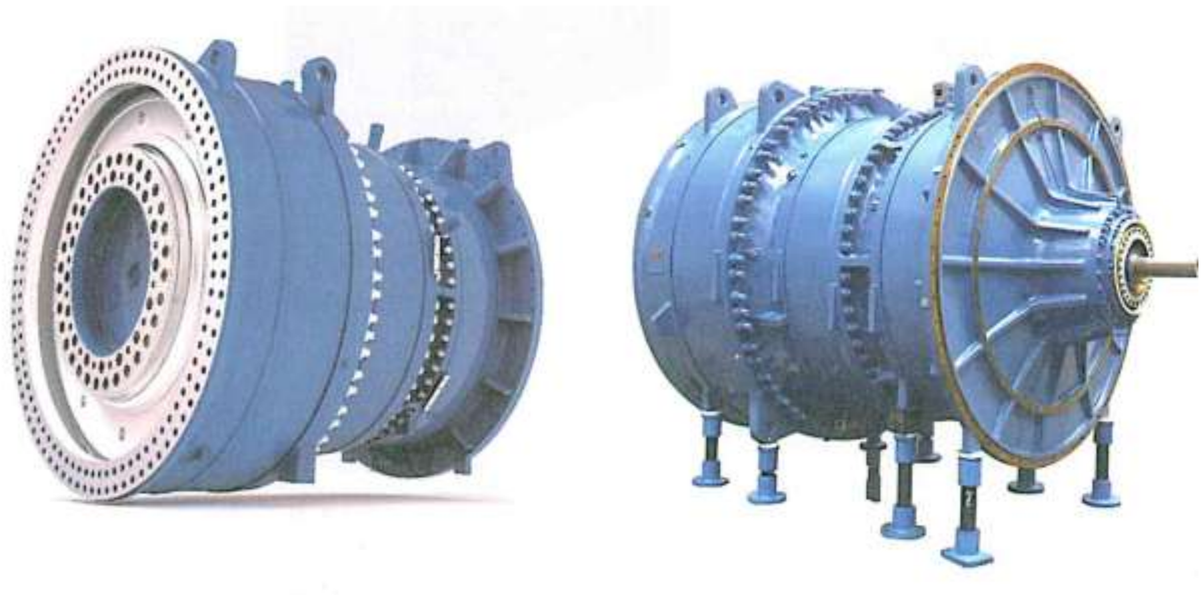
Competitive Landscape Market concentration is high. **NGC (Nanjing High Accurate Drive)** remains firms ranked first in the world, with a domestic market share near 60% and a global share exceeding one-third. **Dajia** was listed in November 2025; Shantou Dajia Transmission has an annual capacity project for 800 large offshore wind gearboxes. Major domestic suppliers include NGC, Dajia, Winergy, ZF, Southern Aerospace, Chongqing Wangjiang, Zhongchi, and Dalian Heavy Industry.

NGC NGC has been deeply involved in the industry for over 20 years. It was the first in China to develop the (6-20+) MW-class "three-in-one" integrated drive chain gearbox, achieving torque density of 270+ Nm/kg, already delivered in batches. It was the earliest in China to master sliding bearing gearbox technologies, with over 7,000 sets delivered globally. NGC has delivered (8.5-20) MW offshore gearboxes and is developing 25+ MW gearboxes for floating applications.

+1

20-22 MW Fully Integrated Medium-speed Drive Chain Gearbox: Focusing on floating wind, this won the **WIND POWER MONTHLY Global Best Turbine Drive Chain Gold Medal** for 2024! Product innovations: integrated connections at the low-speed end and between gearbox/generator; new lightweight design; and sealing structure and maintainability designs.

Figure 2-17: NGC 20-22 MW Fully Integrated Medium-speed Drive Chain Gearbox



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Supply Chain Development Status

(4) Generators

Current Status and Trends Wind power generators have achieved breakthroughs in insulation system design, structural design, ventilation, and cooling, providing support for turbine upscaling. Large capacity, ultra-high voltage, low cost, light weight, and intelligence are technical trends. Product types include doubly-fed, squirrel-cage, low-speed PM, medium-speed PM, and high-speed PM.

Doubly-fed turbines have low costs and high maintainability. Voltage levels are primarily 1140 V, though some have developed 10.5 kV high-voltage wind generators. 10.X MW direct-cooled doubly-fed generators are in mass production, and 15 MW-class prototypes have been developed.

Permanent magnet semi-direct drive units utilize medium-speed transmission, eliminating slip rings. Advantages are more prominent offshore. Maximum power has reached 26 MW. For the H260-18 MW model, power density reaches 350 W/kg, and torque density is not less than 12 kNm/t.

Competitive Landscape Domestic manufacturers include Yongji Electric, Jiangsu CRRC Zhuzhou Electric, Xiangtan Electric, CSSC Fenxi, Wuxi Zhongdian, Huayong, Flender, Shanghai Electric, and DEC. Industry concentration is high. **CRRC** has secured an absolute dominant position. In 2024, **Yongji Electric** ranked first with a market share of approximately 37% (offshore share 35%+). **Jiangsu CRRC** ranked second with a market share of about 31% (offshore share over 40%). Together they account for over 75% of offshore generators.

Figure 2-18: Jiangsu CRRC Zhuzhou Electric 12.9 MW High-speed Permanent Magnet Wind Generator

CRRC Yongji Yongji Electric focus on independent innovation and 6-10 MW high-power high/low-voltage direct-cooled doubly-fed generators. Its **26 MW-class offshore semi-direct drive PM synchronous generator** is the world's largest power rating generator, featuring integrated designs to reduce weight. The **16 MW-class high-voltage direct-cooled doubly-fed generator** utilizes stator 10.5 kV high-voltage insulation and efficient open-type cooling.

In 2026, it will complete development of the **10.X MW-class 35 kV ultra-high voltage doubly-fed generator**, overcoming key bottlenecks to lead wind power into the "ultra-high voltage" era for direct wind-to-grid connection.

Figure 2-19: CRRC Yongji 10-15 MW Direct-cooled Doubly-fed Wind Generator

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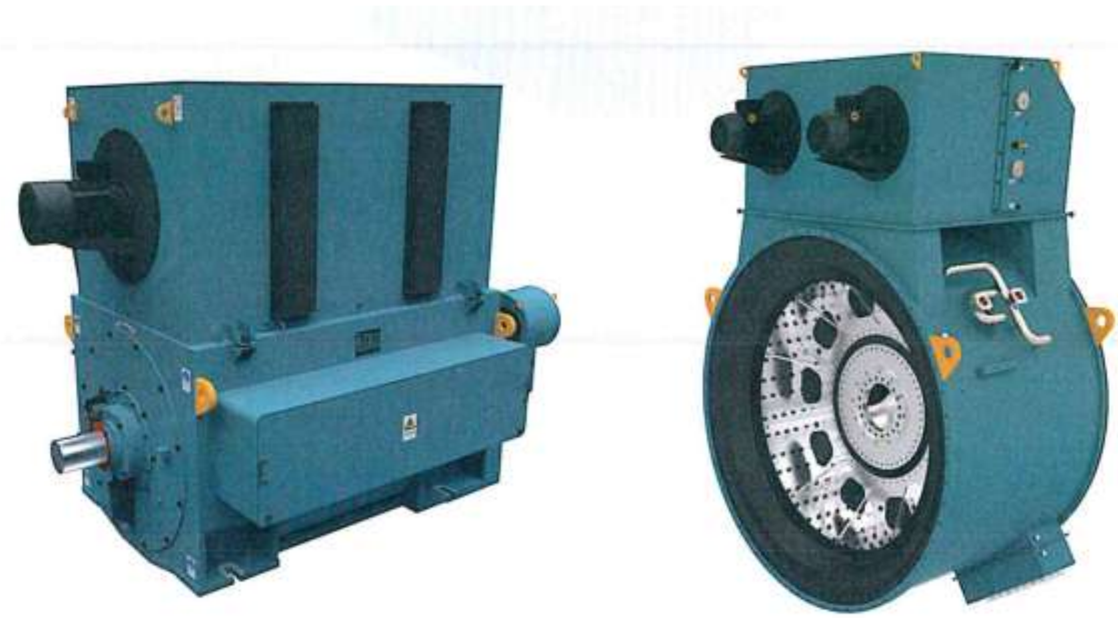
Supply Chain Development Status

Jiangsu CRRC Zhuzhou Electric (Jiangsu CRRC Motor) In 2025, it achieved breakthroughs in core technology and product development. It established platforms for 10-13 MW high-power doubly-fed, 19-22 MW high-power offshore medium-speed PM, and 11-12 MW high-speed PM generators. It successfully developed 13 MW-class land/sea doubly-fed generators and completed R&D of the National Key project 21 MW medium-speed PM generator. Expected 2025 completions include the 16 MW offshore high-voltage doubly-fed and 12.9 MW high-speed PM generators.

+1

Focusing on "**System+**", it overcame technical hurdles in medium-speed PM generators and reactive power coordination for doubly-fed systems. Focusing on "**Intelligence+**", it conducted research on generator fault diagnosis and developed 3D design platforms. Focusing on "**In-depth Research on Basic Technologies**", it researched high-efficiency cooling, high-reliability doubly-fed rotor technology, and rotation transport for high-power generators.

Figure 2-20: 16 MW Offshore High-voltage Doubly-fed Wind Generator and 19 MW Medium-speed Permanent Magnet Wind Generator



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(5) Power Converters

Current Status and Trends The electrical energy output by the generator must pass through a converter before grid connection. The converter converts unstable voltage, frequency, and amplitude into stable electrical energy that meets grid requirements. Every new wind turbine must be equipped with one set of converters.

+1

Converters are divided into doubly-fed and full-power types, covering voltage levels from 690 V to 3300 V. Ultra-large power converters represent future development directions. The substitution of localized IGBT modules has accelerated. CRRC Times Electric has built China's first professional 8-inch IGBT production line, forming an annual capacity of 1 million chips and modules. IGBT products from StarPower, Sijin, and Hongwei are also applied or in validation.

Competitive Landscape Offshore wind converters have higher power ratings and more stringent reliability requirements. Total capacity exceeds 7,000 sets. Major suppliers are **Sungrow** and **Hopewind**; NARI, Tianjin Ruineng, Rifeng, Times Electric, and Vertiv also provide supply. Sungrow's production volume leads significantly with a global market share of 37%.

+1

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Supply Chain Development Status

Sungrow From 2024 to 2025, Sungrow Wind Power Division deepened innovation. It launched 1800 V ultra-large power converters and achieved batch shipments for 18 MW offshore units. The 26 MW prototype successfully rolled off the line. It developed the world's first ultra-large power grid-forming conversion equipment—the **25 MW grid-forming wind power converter**. In pitch systems, it launched a four-quadrant pitch driver with energy feedback.

The company's 1-100+ MVA full-grid-condition large-capacity grid simulator has been applied in batches. Based on technical accumulation, it expanded high-power drive frequency converter business for large drive chain testing, with individual project scales reaching the 100 MW level.

Figure 2-21: Sungrow 1800 V Ultra-large Power Wind Power Converter assisting the first turbine grid connection.

Figure 2-22: World's first 25 MW Grid-forming Wind Power Converter successfully rolled off the line.

(6) Bearings

Current Status and Trends Wind power bearings include yaw, pitch, main shaft, and gearbox bearings. Yaw and pitch bearings have achieved 100% localization. Main shaft bearings achieved major breakthroughs in recent years. In 2022, **LYC (Luoyang LYC Bearing)** researched 16 MW offshore main shaft bearings, and in 2024, it researched 20+ MW-class offshore bearings, breaking the foreign monopoly. In the same year, **Luoyang Bearing Science & Technology (ZYS)** collaborated on main shaft and gearbox bearings for the world's largest 26 MW-class offshore turbine. In 2024, the localization share of main shaft bearings exceeded 70%, with LYC's domestic share reaching 40%.

Competitive Landscape Bearing upscaling forms high technical barriers. Domestic enterprises like LYC, Wafangdian Bearing (ZWZ), ZYS, Tianma, New Strong Lian, and Dalian Metallurgy already possess certain manufacturing capabilities.

Manufacturers represented by LYC collaborated with upstream domestic special steel companies (Daye, Fushun, Northeast, Xingcheng) to develop dedicated wind power bearing steel, driving key indicators to international standards. In the midstream, technical specifications were issued to drive process upgrades and form a "localized bearing - matching components" collaborative system, reducing dependence on imported matching parts.

Figure 2-23: LYC providing matching main shaft bearings for Goldwind's 20+ MW Turbine.

As an "Expert Scientific Translator," I am providing the formal English translation for **Pages 71 to 80** of the "Global Offshore Wind Supply Chain Report 2025." This translation adheres strictly to academic standards, maintains the original formatting, and includes no summarization.

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Supply Chain Development Status

(5) Power Converters

Current Status and Trends

The electrical energy output by the generator must pass through a converter before being transmitted to the grid or directly supplied to loads. The converter is a core component within the offshore wind turbine control system, responsible for converting the unstable voltage, frequency, and amplitude of the generator's output into stable electrical energy that meets grid requirements. Wind power converters play a critical role in turbine grid connection and the safe, stable operation of the power grid; every newly installed wind turbine must be equipped with a set of converters.

Wind power converters are categorized into doubly-fed converters and full-power converters (including direct-drive PM, semi-direct drive PM, squirrel-cage induction, and separate excitation), with voltage levels covering 690V, 900V, 950V, 1140V, 1800V, and 3300V. Doubly-fed converters are currently primarily used in onshore doubly-fed turbines and have been applied offshore in batches. Full-power converters are used both onshore and offshore, while 3300V-class medium-voltage full-power converters are gradually being applied in offshore turbines and pumped storage units.

Ultra-high-power wind converters are essential for the subsequent development of wind power. Parallel connection of ultra-high-power converters, intelligent redundancy control, and efficiency improvements represent the future directions for development. IGBT (Insulated Gate Bipolar Transistor) is a vital core component of these converters. Converter control systems are moving toward master controller integration and sub-system modularization, requiring high-end control chips with higher clock frequencies and rich peripherals. The domestic substitution of IGBT modules has accelerated, with increased investment in technology to address capacity constraints. Since 2020, CRRC Times Electric began domestic IGBT applications, achieving small-batch use in 2021 and large-scale application starting in 2022. They have built the world's second and China's first professional 8-inch IGBT production line, forming an annual capacity of 1 million IGBT chips and modules with a voltage range from 650V to 6500V. Additionally, StarPower Semiconductor's IGBT products are used in batches, and Sijin and Hongwei Semiconductor have begun factory validation.

Competitive Landscape

Offshore wind converters require higher power ratings and more stringent reliability and environmental adaptability than onshore products. The total domestic production capacity for offshore wind converters exceeds 7,000 sets. Major suppliers include **Sungrow** and **Hopewind**; others include NARI, Tianjin Ruineng, Rifeng, Times Electric, and Vertiv. Sungrow's production volume of offshore products leads significantly, holding a 37% global market share.

Sungrow

From 2024 to 2025, Sungrow's Wind Power Division deepened technical innovation and business upgrades. It took the lead in launching 1800V ultra-high-power wind power conversion products and solutions, achieving batch shipments and the first grid-connected power generation for the turbine, providing reliable support for turbine upscaling. Furthermore, 18MW offshore wind converters were shipped in batches, and the 26MW prototype successfully rolled off the line. In the field of grid-forming technology, Sungrow continues to advance key conversion techniques, developing the world's first ultra-high-power **25MW grid-forming wind power converter**, which ensures the efficiency and stability of grid connection. In the pitch system field, it launched a four-quadrant pitch driver that improves system efficiency through energy feedback.

The company's 1-100+ MVA full-grid-condition large-capacity grid simulators have been applied in batches, supporting the R&D and testing of grid performance for wind, PV, and energy storage. Based on its high-power expertise, Sungrow Wind also expanded into high-power drive frequency converters for large drive chain testing, with individual project scales reaching the 100MW level.

Figure 2-21: Sungrow 1800V Ultra-high-power Wind Power Converter assisting the first turbine grid connection.

Figure 2-22: World's first 25MW Grid-forming Wind Power Converter successfully rolled off the line.

Supply Chain Development Status

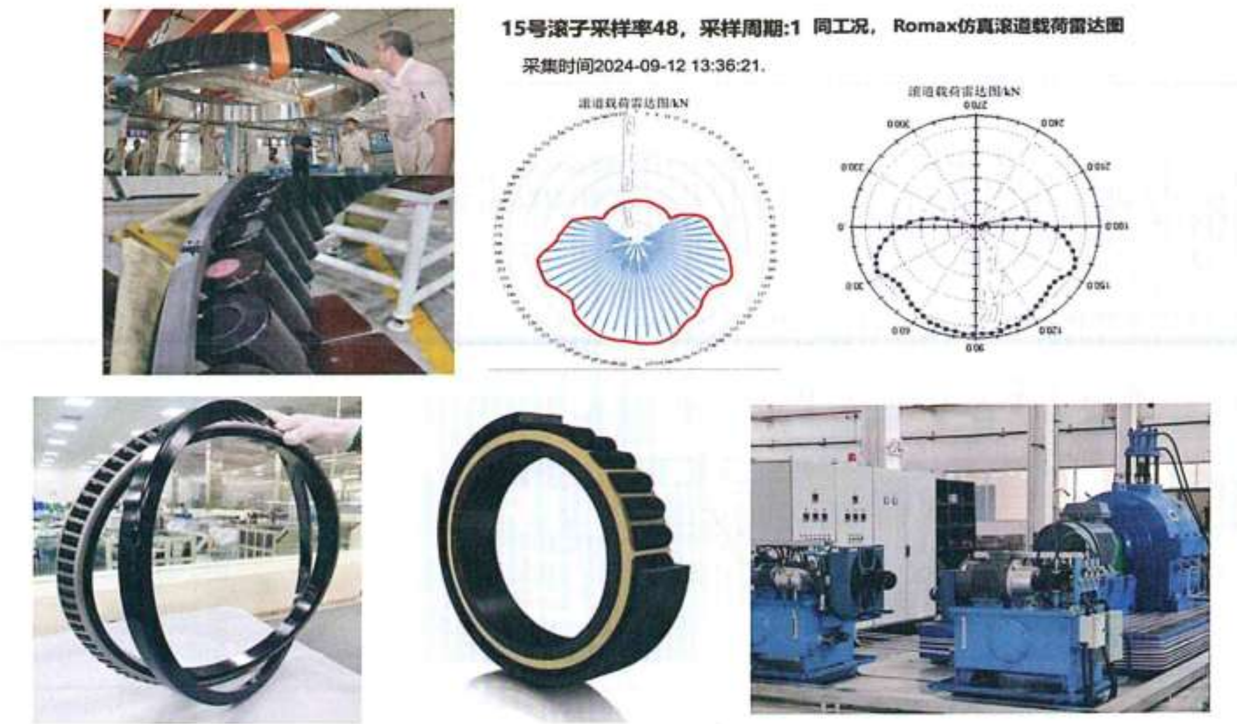
(6) Bearings

Current Status and Trends

Bearings are among the critical components of wind turbines, including yaw bearings, pitch bearings, main shaft bearings, and gearbox bearings. Currently, yaw and pitch bearings have achieved full domestic coverage with technical levels equivalent to those abroad, reaching 100% localization. Wind power main shaft bearings have achieved major breakthroughs recently, overcoming key core technologies. In 2022, **LYC (Luoyang LYC Bearing)** took the international lead in researching 16MW offshore main shaft bearings, and in 2024, it researched 20+ MW-class offshore bearings, breaking the long-term foreign monopoly in large-megawatt shaft bearings. In the same year, **Luoyang Bearing Science & Technology (ZYS)** collaborated with Dongfang Wind Power to develop bearings that assisted the successful roll-off of the world's largest 26MW offshore turbine. In 2024, the localization share of main shaft bearings exceeded 70%, with LYC's domestic market share reaching 40% for two consecutive years.

Competitive Landscape

Turbine upscaling increases bearing size and requirements for processing and R&D, forming high technical barriers. China is the world's largest wind bearing market. Domestic enterprises like LYC, Wafangdian Bearing (ZWZ), ZYS, Tianma, New Strong Lian, and Dalian Metallurgy possess significant manufacturing capabilities.



Bearing manufacturers like LYC have collaborated with upstream special steel companies (Daye, Fushun, Northeast, and Xingcheng Special Steel) to develop dedicated wind bearing steel. This has pushed purity and uniformity indicators to international standards, leading upstream firms to add 36,000 tons of annual capacity and increase R&D investment by 15%. In the midstream, technical specifications such as "Oxidation Blackening Sample Production Specification for Wind Power Bearings" were issued to drive collaborative manufacturing. This reduces dependence on imported matching parts and enhances the cost-effectiveness of the localized industrial chain.

Figure 2-23: LYC providing matching main shaft bearings for Goldwind's 20+ MW Turbine.

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LYC Bearing

Since developing the first domestic wind power bearing in 1997, LYC has adhered to the integrated "industry-university-research-application" philosophy. In 2022, it developed the world's largest 16MW turbine main shaft bearing, refreshing world records. In 2023, this technology was appraised as international leading, marking a leap from "following" to "leading".

In 2024, LYC successfully developed the world's largest 20+ MW offshore ultra-large main shaft bearing with an outer diameter of 3.6 meters. That same year, mass supply of 18MW offshore yaw and pitch bearings began, representing the first batch installation for such high-capacity models globally. In smart bearing development, LYC and Goldwind completed the first domestic intelligent bearing rack tests in 2024, showing close alignment between monitored loads and theoretical simulations. In 2025, LYC supplied mid-and-high-speed bearings for Envision Energy's gearboxes, successfully conquering the last stronghold of domestic substitution for wind gearbox bearings.

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Supply Chain Development Status

ZYS (Luoyang Bearing Science & Technology)

ZYS is committed to leading technological progress in wind power bearings. Recently, it developed the first domestic 8MW full-series gearbox bearings, and the first 7MW, 10MW, and

18MW TRB (Tapered Roller Bearing) main shaft bearings. 10MW-class bearings are already in mass application. ZYS currently has an annual capacity of 3,000 sets for main shaft bearings and 2,500 sets for gearbox bearings. It continues to focus on digitalization and intelligence to serve national needs and achieve high-level technological self-reliance.

Figure 2-24: ZYS 26MW Main Shaft Bearing and Gearbox Bearings.

(7) Offshore Wind Power Towers

Current Status and Trends

The tower serves as the connection between the turbine and the foundation (or pile/jacket), transmitting hundreds of tons of weight and housing maintenance and power transmission functions. Quality control is critical for safety and durability. Offshore towers are transitioning from "single steel structures" to "lightweight, intelligent, and integrated" models. Technical breakthroughs and policy support will accelerate iteration, though material, logistics, and cost balance remain challenges.

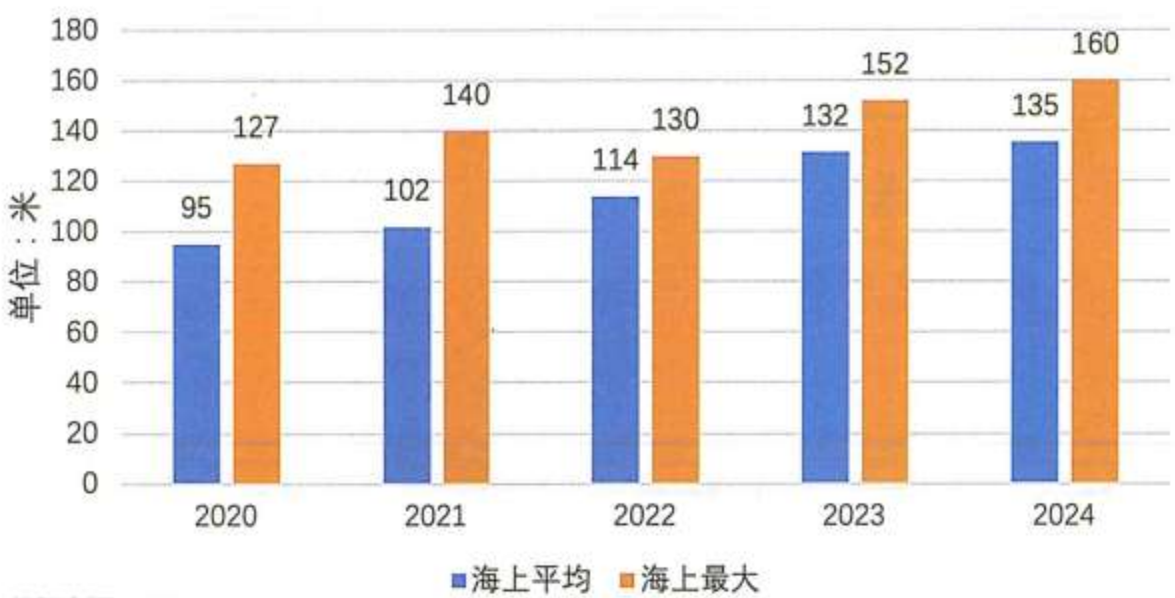
As turbine power increases, hub heights continue to grow, averaging a 40-meter increase over five years. In 2024, the average offshore hub height was 135 meters (up 40m from 2020), with a maximum of 160 meters. Steel demand per unit is relatively stable at approximately 70,000 tons per GW, but total consumption increases with tower height.

Competitive Landscape

Tower production is relatively simple with lower technical barriers and many competitors. Total market capacity is approximately 30,000 sets (8 million tons). Major manufacturers include Tianshun, Dajia Heavy Industry, Taisheng, Haili, Tianneng, and CRRC Lanzhou. Due to transport costs, economic plant radius has shrunk from 500km to within 200km, while offshore towers rely heavily on port resources. Larger turbines and deeper waters require greater yard space, port conditions, and equipment capacity. There are approximately 26 enterprises in coastal areas producing offshore towers, with self-owned and leased berths split equally.

Figure 2-25: Average and Maximum Hub Height of Domestic Offshore Turbines 2020–2024.

(Unit: Meters. 2020 Average: 95, Max: 127; 2024 Average: 135, Max: 160)



Dajia Heavy Industry

Founded in 2000 and listed in 2010, Dajia is a global leader in wind equipment manufacturing. It provides "construction + transport + delivery" one-stop solutions for global developers. It is the first Chinese enterprise to export offshore towers (14.7MW) to Europe and the first in Asia to export ultra-large single piles (14.7MW) to Europe.

Dajia operates export bases in Penglai, Tangshan, Panjin, and Yangjiang, with planned global capacity exceeding 3 million tons. In August 2025, its Panjin shipyard received its first overseas order. In October, its 40,000-ton deck carrier **KING ONE** was launched, specifically designed for ultra-large wind equipment transport. Dajia also established a professional SPMT (Self-Propelled Modular Transporter) team and completed the first independent roll-on/roll-off shipment of ultra-large piles. In November, its Caofeidian base began production, pushing the industry from "project customization" to "productization and serialization". Dajia holds an EcoVadis Silver Medal, ranking in the top 15% globally for ESG.

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Supply Chain Development Status

Figure 2-26: Dajia Heavy Industry delivering ultra-large wind power piles to Europe.

Figure 2-27: Dajia's SPMT team completing roll-on/roll-off loading for export.

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(8) Foundations and Jackets

Current Status and Trends

Offshore foundations are divided into fixed (jackets, large monopiles) and floating types. The foundation supports the tower and turbine, with the lower end driven into the seabed. Pile foundations account for approximately 14% of offshore wind construction costs. Monopile weights are currently around 2,000 tons, and steel demand per megawatt for deep-water platforms is expected to rise slightly. While upscaling thins unit demand, deeper water increases it. For 10MW+ units, steel usage is ~140,000 tons/GW at 20m depth, rising to ~220,000 tons/GW at 35m. Floating foundation steel usage ranges from 500,000 to 800,000 tons per GW.

The industry faces opportunities in upscaling, deep-water application, and modularization, with unit weights potentially exceeding 5,000 tons. Market trends include large-scale, standardized, and international services. Challenges include intensified competition and material price volatility. For floating structures, future research should focus on complex loads (typhoons, ice, earthquakes), high-performance steel/FRP, and integrated "tower-foundation-mooring" design.

Competitive Landscape

The market is maturing with clear leadership. The first tier includes Haily Wind Power, Dajia Heavy Industry, and Tianshun Wind Power. The second tier includes Taisheng, Zhenjiang, and Tongyu. Many SMEs focus on matching and niche markets.

Supply Chain Development Status

Haily Wind Power

Jiangsu Haily Wind Power Equipment Technology Co., Ltd. is a leading monopile enterprise, constructing three business segments: equipment manufacturing, new energy development, and O&M. Products include towers, piles, jackets, and substations for 12MW+ domestic and international projects. It is also expanding into deep-water jackets, marine ranching, and floating foundations.

Its "Two Seas" (Offshore and Overseas) strategy drove a breakthrough in 2024 with batch exports to South Africa. With bases in Jiangsu and Zhejiang, its capacity exceeds 1 million tons, and it is establishing export bases in Qidong and Zhanjiang to capture future global opportunities.

Figure 2-28: Haily Jacket.

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GLOBAL OFFSHORE WIND SUPPLY CHAIN REPORT 2025

(9) Subsea Cables

Current Status and Trends

Subsea cables are critical infrastructure connecting offshore turbines to the onshore grid. Historically restricted by Cross-Linked Polyethylene (XLPE) technology (temperature and cleanliness issues), China used oil-filled or paper-insulated cables. Ongoing optimization of XLPE formulas and processes has made XLPE-insulated cables the mainstream choice domestically, now evolving toward ultra-high and extra-high voltage.

AC cable technology continues to improve, and DC cables are rapidly closing the gap with international standards. Since 2013, China has localized high-voltage AC cables and now possesses full design, manufacturing, and O&M capabilities. DC cables, previously lagging due to insulation material import dependence, advanced from ±160kV to ±400kV within five years after export restrictions were lifted in 2013. ±400kV cables are already in use, transmitting up to 1.1GW. In September 2025, ±525kV aluminum core DC technology was achieved, though a gap remains in operating temperature (70°C vs. 80°C for global leaders like Prysmian and Nexans).

Floating wind is creating a new track for dynamic cables. These require higher flexibility and dynamic adaptability. While Europe started earlier (up to 66kV), China has made progress. ZTT (Zhongtian) built the dynamic cable for the "Guoneng Shared" integrated project, and the

"Mingyang Tiancheng" project utilized cables for the world's largest dual-rotor floating unit. China has mature 35kV capability and has developed 66kV dynamic cables for demonstration.

To meet deep-water needs, AC cables will move toward larger sections and longer lengths. Future focus includes ±640kV/±800kV ratings, higher-temperature insulation, and transmission capacities exceeding 3GW, alongside full-chain localization for extra-high-voltage DC cables.

Competitive Landscape

ZTT, Orient Cable, and Qingdao Hanlan were early entrants around 2000, followed by Hengtong Optic-Electric and Baosheng. Multiple companies now have track records for 220kV+ export cables. The top three—ZTT, Orient Cable, and Hengtong—all have 500kV delivery records. Bid requirements for track records have created market barriers.

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Supply Chain Development Status

Current market participants include ZTT, Orient Cable, Hengtong Optic-Electric, Hanlan, Baosheng, Wanda, Qifan, and Taiyang Cable, all of whom possess supply track records for 220kV and above export subsea cables. Among them, the top three leading manufacturers are **ZTT** (with bases in Nantong, Shanwei, Dafeng, and under-construction sites in Rushan and Wenzhou), **Orient Cable** (Beilun bases and new base in Yangjiang), and **Hengtong Submarine Cable** (Changshu and Sheyang bases). All three have successfully delivered 500kV high-voltage subsea cables. Given that most offshore wind subsea cable tenders require specific performance track records, these top-tier manufacturers have established significant market barriers, securing a dominant position in the competition for future high-voltage products. In terms of technical expertise and project experience, ZTT and Orient Cable hold distinct advantages in ultra-high voltage AC/DC subsea cables. Manufacturers like Baosheng and Qifan have also been actively expanding their subsea cable business and production capacity in recent years. Meanwhile, other new entrants such as Wanda, Jien, Tongguang, LS Hongqi, Far East Cable, Baoan, and Taiyang are mostly in the capacity expansion phase with limited technical accumulation and supply records, thus holding smaller market shares and lower industrialization capabilities.

Figure 2-29: Jiangsu Hengtong subsea cable construction site – SDIC Guangdong Zhanjiang Xuwen 300MW Expansion Project.

Zhongtian Technology (ZTT) ZTT's main products include 500kV and below AC subsea cables, ±525kV and below DC subsea cables, umbilical cables, dynamic cables, and bundled cables. The company provides integrated system solutions for offshore oil and gas, offshore wind power, offshore PV, and island interconnections.

In the field of AC subsea cables, ZTT has successfully developed a series of ultra-high voltage, low-loss, lightweight three-core AC subsea cables for 500kV and below. Single-circuit transmission capacity has exceeded 750MW, and the maximum applicable water depth has reached 1000 meters. These products effectively reduce cable weight while increasing transmission capacity, forming a low-cost, high-reliability product line. Leveraging continuous technical innovation, ZTT was the first in China to complete the R&D and full-performance certification of 66kV, 110kV, 220kV, 330kV, and 500kV three-core AC subsea cables, achieving large-scale engineering applications. To date, its cumulative track record for 220kV and above three-core AC subsea cables exceeds 4000 kilometers, demonstrating its technical strength and market recognition.

In the field of DC subsea cables, ZTT has supplied cables for all existing flexible DC transmission projects in China, achieving a "five-step leap" in flexible DC subsea cable systems from ±160kV, ±200kV, ±320kV, ±400kV to ±525kV. In November 2024, ZTT independently developed the world's first ±550kV 90°C DC subsea cable system, which passed full-performance type tests in one go, with an operating temperature of 90°C and a design transmission capacity exceeding 3GW. In September 2025, ZTT again successfully developed a ±525kV 80°C DC subsea cable system. This project marked the world's first R&D of 5000mm² aluminum core DC subsea cables, gas-insulated terminations for 5000mm² HVDC subsea cables, and unequal-diameter repair joints (2500mm²–5000mm²) for HVDC subsea cables, with a design transmission capacity exceeding 2.5GW.

Figure 2-30: Zhongtian Technology (ZTT) Products.

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Supply Chain Development Status

Jiangsu Hengtong Focusing on green, environmental, low-cost, and thin-insulation requirements, Hengtong has innovated key materials and structures, overcoming R&D hurdles for 66kV and 220kV aluminum core subsea cables. These have been appraised by the China Electricity Council (CEC) as "internationally leading," with the 66kV aluminum core cable winning a tender for a project in Iceland. The company has mastered the R&D and manufacturing of polypropylene (PP) insulated environmentally friendly cables, developing 110kV PP-insulated power cables that passed system type tests and were applied in the Shenzhen Power Supply Bureau's 110kV project. Additionally, 66kV PP subsea cables achieved China's first demonstration application of recyclable eco-friendly subsea cables. Driven by national key R&D projects and floating wind demand, Hengtong successfully developed 35kV and 66kV dynamic cables, enhancing its design, R&D, production, and testing capabilities for 66kV and below dynamic cables. The 35kV dynamic cable was successfully installed in China's first deep-sea floating wind demonstration project, "Fuyao," and was awarded the Third Prize of the Jiangsu Provincial Science and Technology Progress Award.

To meet the demand for high-voltage, large-capacity transmission, Hengtong successfully developed 330kV and 500kV high-voltage onshore cables and secured domestic and international orders. It completed type tests for ±400kV DC subsea cables and a self-developed ±320kV DC subsea cable system, as well as type tests for 500kV large-section three-core subsea cables. Supporting its overseas strategy, the company developed a full range of smooth aluminum sheathed cables for 220kV and below, securing multiple international orders. It also completed type tests for 500kV smooth aluminum cables, type tests and KEMA certification for 66kV and 220kV ultra-lightweight eco-friendly array cables, and type tests and multi-national qualifications for 150kV thin-insulation onshore and subsea cables. These cover AC to DC and conventional to thin insulation types, comprehensively enhancing product competitiveness. In the new field of oil and gas, Hengtong successfully completed the full process witnessing of umbilical cables—from design finalization and component configuration to sample production and testing—securing its first order and officially opening a new chapter in its oil and gas business.

Figure 2-31: Jiangsu Hengtong 2024 110kV Meimei Line Cable Replacement Emergency Project.

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(10) Castings

Current Status and Trends Wind power castings are specialized components for wind turbines, primarily including gearbox housings, torque arms, hubs, bedplates, planetary carriers, main frames, fixed/rotating shafts, and main shaft sleeves. The wind power casting industrial chain is relatively straightforward. Upstream consists of raw materials like coke, pig iron, scrap steel, and resins, along with production equipment. Due to the complexity of precision machining and varying processing methods, production equipment types are diverse. Currently, raw material costs in China account for approximately 60%–70% of total production costs. Midstream consists of casting manufacturers, primarily domestic, with **Riyue Heavy Industries** holding the leading position. Wind power casting involves processes such as melting, pouring, heat treatment, and machining. Raw material requirements are stringent; the commonly used ferritic ductile iron (equivalent to EN-GJS-400-18U-LT or DIN EN 1563 in European standards) must possess excellent tensile strength, elongation, stiffness, and high impact strength at low temperatures.

In the offshore wind sector, requirements for corrosion resistance and fatigue strength are even higher. Simultaneously, large-scale castings face significant manufacturing and transport barriers. Market demand for high-quality, large-size, and high-tech wind castings will further intensify, requiring breakthroughs in high-end casting segments. The industry is actively exploring the application of lightweight, high-strength, and corrosion-resistant new materials, as well as more precise and efficient casting processes, to meet the wind energy industry's needs for cost reduction, efficiency improvement, and extended service life.

Competitive Landscape Currently, China's overall casting capacity is sufficient. **Riyue Heavy Industries** and **Longma Heavy Industries** lead the industry with capacities of 600,000 tons and 500,000 tons, respectively. Companies like Huarui Casting, Jinlei, and Tongyu Heavy Industries also have capacities exceeding 150,000 tons and perform strongly in customer recognition. The competitive landscape is relatively fragmented and can be categorized into three segments:

1. **Traditional Onshore Components:** Primarily includes main shafts, bearing housings, hubs, and bedplates for onshore turbines. This segment has low technical barriers and high competition.
2. **Integrated High-Precision Shaft Systems:** Covers integrated designs of main shafts and combined bearing housings. These require higher material performance and machining precision, raising technical barriers.
3. **Large Offshore Castings:** Includes large-scale components like main shafts, fixed shafts, combined bearing housings, hubs, and bedplates for offshore turbines. These have high technical and process thresholds. As product structures upgrade toward high precision and large scale, the competitive landscape is being reshaped.

Supply Chain Development Status

(11) Mooring Systems

Mooring chains are primarily used for the positioning of offshore floating structures, commonly found in offshore drilling rigs, oil and gas production platforms, buoys, and marine ranches. They are a critical component of floating wind mooring systems. In a narrow sense, mooring chains refer to steel circular link chains; in a broad sense, they include all components connecting the floating body to the anchoring device, such as shackles, universal joints, tensioners, tension regulators, and clump weights.

Due to characteristics like environmental embrittlement, mooring chains require high standards for materials, processes, manufacturing equipment, and quality control, necessitating long-term verification in specific projects. Currently, only **Asiacon (Asxing)** from China and **Vicinay** from Spain possess full-size, full-grade mooring chain classification society certificates, with their products fully verified in the marine engineering industry for over twenty years.

Competitive Landscape Mooring chains are the primary component of mooring systems, fixing floating bodies by transmitting tensile stress between the body and the anchor. Based on material strength, they are graded as R3, R3S, R4, R4S, R5, and R6, with diameters typically ranging from 60mm to 220mm. R4S, R5, and R6 are considered high-grade mooring chains, while those with diameters above 142mm are large-specification chains. Unlike anchor chains, mooring chains often require a service life exceeding 20 years. Due to long service life, harsh environments, and high safety requirements, they must possess high strength, deformation resistance, fatigue resistance, and environmental resistance.

The main global mooring chain manufacturers are **Jiangsu Asxing Anchor Chain** and **Vicinay**, together accounting for 95% of the global market. Asxing provides mooring chains for all domestic floating wind demonstration projects and some international ones, while Vicinay supplies most international projects. For mooring chains with diameters above 100mm, China's current capacity is approximately 100,000 tons per year, compared to 50,000 tons per year abroad.

Asxing Anchor Chain Jiangsu Asxing Anchor Chain Co., Ltd. is a leading global supplier of mooring components for offshore facilities and is recognized by the Ministry of Industry and Information Technology (MIIT) as a "Single Champion Enterprise" in mooring chains. It possesses a national-level enterprise technology center and has won the 2014 State Science and Technology Progress Award (Special Prize). Its R5-grade chains were used in CNOOC's 6th-generation semi-submersible platform "Ocean Oil 981". In 2020, its R6-grade chains were first applied globally to the "Deep Blue Explorer" rig.

Figure 2-32: Asxing Anchor Chain.

 

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(12) Ports

Ports provide the essential infrastructure support for the offshore wind industry, including lifting equipment, berths, and storage facilities, which are vital for equipment transport, installation, and maintenance. Specialized offshore wind ports facilitate resource integration, cost reduction, and industrial cluster development, driving regional economies. In the future, they will also support green energy projects like hydrogen production, enhancing China's competitiveness in the global wind power industrial chain by building "World-Class Offshore Wind Mother Ports".

With the growth of unit capacity, requirements for heavy lifting capacity and transport at ports have increased. Port upgrades and expansions are necessary to accommodate these large-scale components. Large-megawatt towers and pile foundations, with increased weights and diameters, must rely on specialized port terminals for transport. According to public information, more than ten offshore wind mother ports have been clearly planned in China, located in Yantai and Dongying (Shandong); Nantong and Yancheng (Jiangsu); Fuqing and Zhangzhou (Fujian); and Yangjiang, Jieyang, and Shantou (Guangdong). Beyond the Bohai Rim, Yangtze River Delta, and Fujian-Guangdong regions, construction is also accelerating in the Beibu Gulf. As offshore wind trends toward larger equipment, deeper waters, specialized O&M, and industrial clustering, focusing on key ports to build global-leading mother ports will bolster China's competitive voice in the industrial chain.

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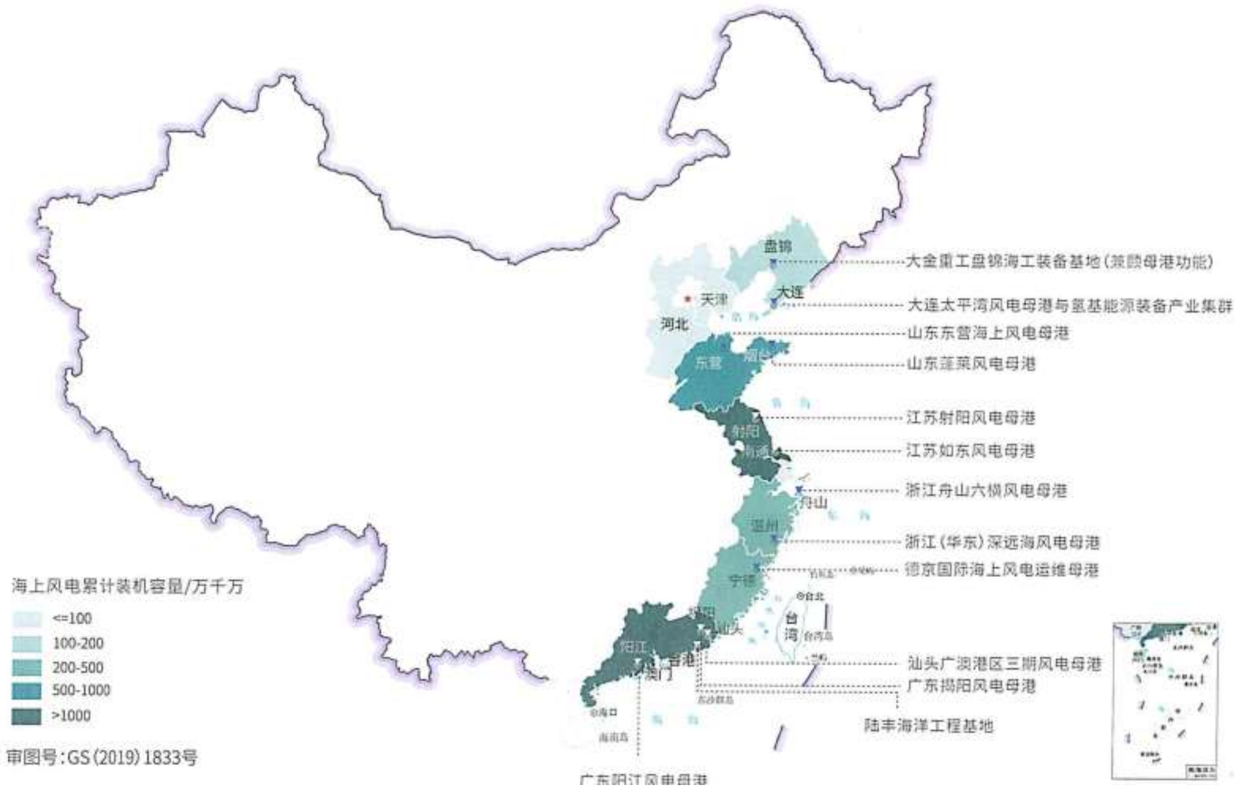
Supply Chain Development Status

Figure 2-33: China’s Offshore Wind Mother Ports. *(Ports include: Panjin Dajia Shipyard, Dalian Taiping Bay, Dongying, Penglai, Sheyang, Rudong, Zhoushan, Wenzhou, Fuqing, Zhangzhou, Shantou, Jieyang, Lufeng, Yangjiang)*.



(13) Vessels

The accelerated iteration of large-scale offshore wind turbines has prompted continuous optimization and upgrades of installation vessels. Following the "Baihetan" vessel's installation of the GW252-16MW turbine, China’s self-developed 4th-generation marine engineering installation vessel, "**Zhigao**," was completed in Nantong, Jiangsu, in February 2025. This vessel can operate up to 100km offshore with a lifting capacity of 3600 tons, shortening the installation cycle of a single turbine to 2–3 days—a 30% efficiency improvement over 3rd-generation vessels.

As of November 2025, Chinese shipyards have 12 offshore wind installation vessels under construction and 3 undergoing upgrades. Additionally, domestic shipyards such as **COSCO**, **CIMC Raffles**, and **CMHI** have won most of the installation vessel orders from major European operators (including Cadeler, Seaway7 ASA, Van Oord, and Havfram) over the past three years.

Shipowners worldwide now require large installation vessels with lifting capacities of no less than 1600 tons and operating water depths of no less than 50 meters. The share of new orders with lifting capacities above 1200 tons grew from 45% in 2020 to 80% in 2023. Currently, all 14 installation vessels under construction globally have lifting capacities above 1200 tons, and 50% of newbuilds exceed 2000 tons.

China and Europe are currently the primary leaders in global offshore wind development, possessing high-level marine engineering and vessel operation companies that hold the majority of the global market share for installation and construction.

As offshore wind farms age, O&M demand increases annually, and professional Service Operation Vessels (SOVs) will be increasingly favored by the market. While China currently has a gap compared to Europe in offshore wind O&M and SOV construction technology, domestic shipyards possess the manufacturing capability and have secured orders from European shipowners (Germany, Norway, France, Denmark). Although domestic investment has not yet focused heavily on SOVs, the O&M market outlook is bullish. As of November 2025, China has secured orders for 16 SOVs/CSOVs, with 6 currently under construction at shipyards including CMHI, Huangpu Wenchong, ZPMC, and Fujian Southeast Shipbuilding.

Table 2-4: Comparison of Major Installation Vessel Types.

Type	**Self-elevating**	**Self-propelled**	**Operation Mode**	**Typical Lifting Cap. (t)**	**Typical Water Depth (m)**
Heavy Lift Vessel	No	Yes	Combined	2000–2500	—
Bottom-sitting Vessel	No	No	Combined	700–800	Intertidal
Self-elevating Platform	Yes	No	Combined	1000–1500	30–50

Self-propelled Jack-up	Yes	Yes	Independent	1500–2000	30–50+

Figure 2-34: Shanghai Electric Wind Power SOV.

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Supply Chain Development Status

Table 2-5: Statistics on Vessel Counts of Global Top 10 Wind Power Installation Companies.

Rank	Shipowner	Country	Total	In Service	Under Construction
1	Cadeler	Denmark	12	9	3

2	Ouyang Marine	China	8	7	1
3	Nantong Marine Water	China	8	4	4
4	CCCC Haifeng	China	6	6	0
5	HEA Energy	UAE	5	4	1
6	ZITON	Denmark	5	5	0
7	DEME	Belgium	4	4	0
8	Longyuan Zhenhua	China	4	4	0
9	Van Oord	Netherlands	4	4	0
10	F. Olsen Windcarrier	Norway	3	3	0

(Source: Clarksons, compiled by CSSC Economic Research Center).

(14) Testing and Certification Platform

The service capabilities for supporting scientific equipment have reached international advanced levels. As China’s wind power R&D shifts from "following" to "leading," it is entering technical "no-man's lands," where new design theories require experimental research and ultra-large prototypes and components (bearings, gearboxes, generators) need comprehensive ground testing. Since the 18th National Congress, public testing platforms and quality inspection centers have been established, covering the full lifecycle of raw materials, components, and turbines for both onshore and offshore applications.

In terms of **turbine testing**, the Zhangbei CGC 50MW National Wind Power Equipment Test Platform is China’s only test wind farm fully compliant with IEC standards, capable of testing turbines up to 9MW. To meet the needs of large onshore turbines, CGC has signed agreements to build large-scale testing bases in Yiwu (Xinjiang) and Dongying (Shandong), which will support tests for 320MW-class wind power equipment upon completion.

In terms of **blade testing**, before the 18th National Congress, China only had platforms for blades under 100 meters. Currently, CGC’s national-level offshore wind equipment testing and service platform in Yangjiang features a lab capable of full-scale structural testing for 150-meter blades—the world's largest indoor blade lab. In September 2024, it completed static testing for the then-world-longest 147-meter blade.

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(2) Coastal regions actively promote the layout of the offshore wind power industrial chain

With the large-scale cluster development of offshore wind power, coastal areas have accelerated the layout of the industrial chain, forming several important offshore wind power industrial bases. Currently, coastal provinces such as **Jiangsu, Guangdong, Shandong, and Fujian** have built or are building professional offshore wind power industrial parks, covering the entire industrial chain including turbine manufacturing, supporting equipment, construction and installation, and operation and maintenance services. Among them, the industrial chain layouts in **Shantou, Guangdong** and **Yancheng, Jiangsu** are the most complete.

Table 2-6: Layout of Offshore Wind Power Industrial Bases in Coastal Provinces of China

This table uses "有" (Yes/Present) to indicate completed or confirmed construction, while blank cells indicate unconfirmed or no information.

Province	City	Complete Turbine	Core Components (Bearings, Gearboxes, Blades, Generators, Towers, Foundations, Submarine Cables, Castings)	Testing & Certification
Guangdong	Shantou	Yes	All categories except Castings	Yes
Guangdong	Yangjiang	Yes	All except Bearings/Gearboxes	Yes
Jiangsu	Yancheng	Yes	All categories except Castings	Yes
Jiangsu	Nantong	Yes	Blades, Towers, Foundations, Cables, Castings	-
Shandong	Dongying	Yes	Blades, Generators, Towers, Foundations, Cables, Castings	-
Shandong	Yantai	Yes	Bearings, Blades, Towers, Foundations, Cables	-

Zhejiang	Ningbo	Yes	Gearboxes, Cables, Castings	-
Zhejiang	Wenzhou	Yes	Gearboxes, Towers, Cables	-
Fujian	Putian	Yes	Generators	-
Fujian	Fuzhou	Yes	Blades, Generators, Towers, Foundations	Yes
Guangxi	Qinzhou	Yes	Blades, Towers, Foundations	-
Guangxi	Beihai	Yes	Blades, Generators, Towers, Cables	-
Hebei	Tangshan	Yes	Blades, Generators, Towers, Foundations, Castings	-
Liaoning	Dalian	Yes	Bearings, Blades, Towers, Cables, Castings	-

Hainan	Danzhou	Yes	-	-

Domestic Layout

(1) Constructing Base-based Offshore Wind Industrial Clusters

Currently, the development of offshore wind industrial clusters in China shows a strong momentum, having formed a pattern of large-scale and base-based development. Under the guidance of the national "14th Five-Year Plan," the construction of offshore wind bases in Guangdong, Fujian, Zhejiang, Jiangsu, and Shandong is being prioritized, creating five major offshore wind base clusters: Shandong Peninsula, Yangtze River Delta, Southern Fujian, Eastern Guangdong, and Beibu Gulf. According to statistics, approximately 32 offshore wind industrial parks have been laid out in coastal areas nationwide, covering completed, under-construction, and operational projects, with industrial cluster effects becoming increasingly prominent.

The development of offshore wind industrial clusters is of great significance. First, it reduces construction and operation costs through agglomeration effects and improves the scale of the industry. Second, it promotes synergetic development between upstream and downstream segments of the industrial chain and optimizes the industrial ecosystem. Third, it strengthens core technology R&D and innovation capacity cultivation, enhancing industrial competitiveness. Fourth, it attracts high-end talent, technology, capital, and other factors to gather, achieving efficient resource allocation. Fifth, it drives regional economic development, forming new economic growth points and providing strong support for achieving "dual carbon" goals.

Figure 2-36: Construction of Offshore Wind Industrial Clusters in Coastal Areas.

(Map highlights: Dalian Taiping Bay (Liaoning), Yingkou (Liaoning), Qinhuangdao (Hebei), Tangshan (Hebei), Dongying, Yantai, Weihai, Qingdao (Shandong), Yancheng, Nantong, Lianyungang (Jiangsu), Ningbo, Wenzhou (Zhejiang), Fuzhou, Putian, Zhangzhou (Fujian), Shantou, Yangjiang, Shanwei, Jieyang (Guangdong), Fangchenggang, Qinzhou, Beihai (Guangxi), Yangpu, Dongfang (Hainan)).

⊙ 辽宁省


铁岭市
阜新市
沈阳市
抚顺市
朝阳市
锦州市
辽阳市
本溪市
盘锦市
葫芦岛市
丹东市
鞍山市
营口市
大连市
塔筒：大金重工
机组：中车
机组：海装
铸件：大连加新克、华锐重工
轴承：斯凯孚、国威轴承、大冶轴、舍弗勒、瓦轴
塔筒：天能重工
叶片：双瑞叶片
海缆：山东万达
机组：海装、金风、远景、运达

⊙ 天津市


蓟州区
宝坻区
武清区
宁河区
北辰区
东丽区
西青区
津南区
静海区
滨海新区
齿轮箱：华建天恒
叶片：时代新材
齿轮箱：采埃孚、弗兰德
发电机：弗兰德海泰
叶片：东气、明阳智能、维斯塔斯
发电机：维斯塔斯
机组：东气

(2) Coastal Regions Actively Promoting Offshore Wind Industrial Chain Layout

Along with the development of large-scale offshore wind clusters, coastal regions have accelerated their industrial chain layouts, forming several important offshore wind industrial bases. Currently, coastal provinces such as Jiangsu, Guangdong, Shandong, and Fujian have completed or are constructing professional offshore wind industrial parks, covering the entire industrial chain from wind turbine manufacturing and supporting equipment to construction, installation, and O&M services. Among them, the industrial chain layouts in Shantou, Guangdong, and Yancheng, Jiangsu, are the most comprehensive.

Table 2-6: Layout of Offshore Wind Power Industrial Bases in Chinese Coastal Provinces/Cities

Province (District)	**City**	**OEM**	**Bearing**	**Gearbox**	**Blade**	**Generator**	**Tower**	**Foundation**	**Subsea Cable**	**Casting**	**Testing/ Certification**
Guangdong	Yangjiang	Yes	Yes		Yes	Yes	Yes	Yes		Yes	Yes
	Shantou	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jiangsu	Yancheng	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

	Nantong	Yes			Yes	Yes	Yes	Yes	Yes	Yes	Yes
Shandong	Dongying	Yes	Yes		Yes	Yes	Yes	Yes	Yes		Yes
	Yantai	Yes	Yes		Yes		Yes	Yes			Yes
Zhejiang	Ningbo	Yes		Yes		Yes		Yes	Yes	Yes	Yes
	Wenzhou	Yes		Yes		Yes	Yes		Yes		Yes
Fujian	Putian	Yes									
	Fuzhou	Yes				Yes	Yes				Yes
Guangxi	Qinzhou	Yes			Yes		Yes	Yes			

	Beihai	Yes			Yes		Yes	Yes			
Hebei	Tangshan	Yes			Yes	Yes	Yes				
Liaoning	Dalian	Yes	Yes		Yes		Yes	Yes		Yes	Yes
Hainan	Danzhou	Yes									

Note: "Yes" indicates established or confirmed construction; blanks indicate unconfirmed or no information found.

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Supply Chain Development Status

● **Liaoning Province**

- **Dalian:** Turbines: Haizhuang; Towers: Dajia Heavy Industry; Castings: Dalian Cas-Tech, Huarui Heavy Industry; Bearings: SKF, Guowei Bearing, Daye Shaft, Schaeffler, ZWZ.
- **Yingkou:** Castings: Yingkou details; Towers: Tianneng Heavy Industry.
- **Panjin:** Dajia Shipyard.

● **Tianjin City**

- **Binhai New Area:** Blades: Shuangrui Blade, Sinoma Blade, Mingyang Smart, Vestas; Subsea Cables: Shandong Wanda; Gearboxes: Huajian Tianheng, ZF, Flender; Generators: Flender, Vestas; Turbines: DEC, Haizhuang, Goldwind, Envision, Windey.

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● **Hebei Province**

- **Tangshan:** Blades: LM Wind Power; Turbines: Goldwind; Generators: DEC; Castings: Wenfeng Heavy Industry; Towers: Dajia Heavy Industry, Huadian Heavy Industry.
- **Qinhuangdao:** Turbines: Electric Wind Power, Mingyang, Envision, DEC; Generators: DEC; Blades: Envision, Shuangrui Blade, Guochuang Wind Blade.

● **Shandong Province**

- **Dongying:** Turbines: Envision; Blades: Shuangrui Blade; Subsea Cables: Shandong Wanda, ZTT; Generators: CRRC Yongji; Towers: Haily Wind Power, Tianneng Heavy Industry; Castings: Jinlei; Foundations/Jackets: Haily Wind Power.
- **Yantai:** Turbines: Haizhuang, Goldwind, CRRC, Sany, Electric Wind Power; Subsea Cables: ZTT, Qifan; Foundations/Jackets: CIMC Raffles, Dajia Heavy Industry, Penglai Juta; Towers: Dajia Heavy Industry; Blades: DEC, Dajia Blade; Bearings: Tiancheng Machinery.
- **Qingdao:** Bearings: Timken, Tiancheng Machinery; Turbines: DEC, Electric Wind Power, CRRC.
- **Weihai:** Towers: Dajia Heavy Industry, Haily Wind Power; Subsea Cables: ZTT, Qifan, Electrician Submarine Cable; Turbines: Mingyang, Envision; Bearings: Defengdan.
- **Binzhou:** Subsea Cables: Hanlan; Towers: Sinohydro Bureau 4, Tianneng Heavy Industry.

Supply Chain Development Status

● **Jiangsu Province**

- **Lianyungang:** Blades: United Power, Sinoma Technology; Turbines: Goldwind.
- **Yancheng:** Blades: Shuangrui Blade, Sinoma Technology, Time New Material (TMT), Upper Glass Institute, Huaen Wind Power; Generators: CRRC Motor; Gearboxes: Chongqing Wangjiang; Subsea Cables: ZTT, Hengtong Optic-Electric; Towers: Qiangsheng Wind Power, Taisheng, Tianshun, Tianneng Heavy Industry; Bearings: Jingye Bearing; Foundations: Changfeng Offshore; Turbines: Goldwind, Envision, Mingyang, Windey, CRRC.
- **Nantong:** Blades: Aerolane Tech, Zhongtong Chengfei; Subsea Cables: Tongguang, ZTT, Far East Cable, Yongding; Foundations: Nantong Marine Water, Zhenhua Heavy Industry, Rainbow, Taisheng, Haily Wind Power; Towers: Haily Wind Power, Taisheng; Castings: Guanda Special Materials, Hongde; Turbines: Haizhuang, Electric Wind Power.
- **Nanjing:** Gearboxes: NGC (Nanjing High Accurate Drive).

● **Shanghai City**

- **Pudong/Fengxian/Minhang:** Bearings: Schaeffler, JTEKT, NTN, SKF, Ankaiyi, Liebherr; Generators: ABB, Shanghai Motor; Blades: Aerolane Tech.

● **Zhejiang Province**

- **Ningbo:** Gearboxes: Hangzhou Advance Gearbox; Castings: Jiali Tech; Generators: CRRC Motor; Foundations: Taisheng, Wison Offshore; Turbines: Envision, Electric Wind Power; Subsea Cables: Orient Cable; Castings: Riyue Heavy Industries, Wingguan Group.
- **Zhoushan:** Gearboxes: Dongli; Turbines: Haizhuang.
- **Wenzhou:** Subsea Cables: ZTT; Gearboxes: Tongli Transmission; Turbines: Goldwind, Envision, Windey; Towers: Haily Wind Power.

● **Fujian Province**

- **Fuzhou:** Blades: LM Wind Power; Generators: CRRC Motor, Shanghai Motor; Towers: Sinohydro Bureau 4; Foundations: Mawei Shipbuilding; Turbines: Goldwind, DEC.
- **Putian:** Turbines: Electric Wind Power.
- **Zhangzhou:** Blades: Shuangrui Blade, CSSC Zhangzhou; Subsea Cables: Taiyang Cable, CNNC Huihai; Foundations: CITIC Heavy Industries; Towers: Fuchuan Yifan; Generators: ZD Motor; Turbines: Mingyang, Xinglan Wind Power.

● **Guangdong Province**

- **Yangjiang:** Subsea Cables: Orient Cable; Foundations: COOEC-Fluor; Towers: Dajia Heavy Industry, Guangdong Hydropower Bureau 2, Sinohydro Bureau 4; Generators: DEC, CRRC Motor; Castings: Longma Holdings; Blades: Mingyang, Sinoma Technology, DEC; Turbines: Goldwind, Mingyang; Bearings: LYC Bearing.
- **Shantou:** Towers: Qingdao Wuxiao; Generators: Electric Wind Power, CRRC Yongji; Blades: Shanghai Electric Blade, Sinoma Technology; Turbines: Goldwind, Electric Wind Power; Gearboxes: Dajia Transmission.
- **Jieyang:** Generators: ZD Motor; Subsea Cables: Hengtong Optic-Electric; Turbines: Envision, GE.
- **Shanwei:** Blades: Mingyang Smart; Towers: Tianneng Heavy Industry; Subsea Cables: ZTT; Turbines: Mingyang.

● **Guangxi Zhuang Autonomous Region**

- **Qinzhou:** Blades: Envision; Turbines: Mingyang; Foundations: Guangxi Wenchuan, Jinfeng Offshore; Towers: Jinfeng Offshore.
- **Beihai:** Turbines: Goldwind, Envision, Haizhuang; Subsea Cables: Qifan, Orient Cable; Towers: Tianshun, Sinohydro Bureau 4; Generators: CRRC Motor; Blades: Chengfei Blade.
- **Fangchenggang:** Turbines: Goldwind, CRRC.

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(This page in the original document contains relevant maps or images corresponding to the regional layouts mentioned above).

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(This page in the original document contains relevant maps or images corresponding to the regional layouts mentioned above).

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Figure 2-37: Cumulative Export Capacity and Share of Chinese Wind Power OEM Enterprises (End of 2024)

- (Unit: MW)
- Goldwind: 9791 (47.10%)
- Envision Energy: 6839 (32.90%)
- Windey: 1145 (5.51%)
- Mingyang Smart: 729 (3.51%)
- Dongfang Electric: 516 (2.48%)
- Sinovel: 388.5 (1.87%)
- Sany Renewable Energy: 343 (1.65%)
- CRRC: 295 (1.42%)
- United Power: 254 (1.22%)
- Electric Wind Power: 209 (1.01%)
- Others: 0.39% - 0.01%
  (Source: CWEA)

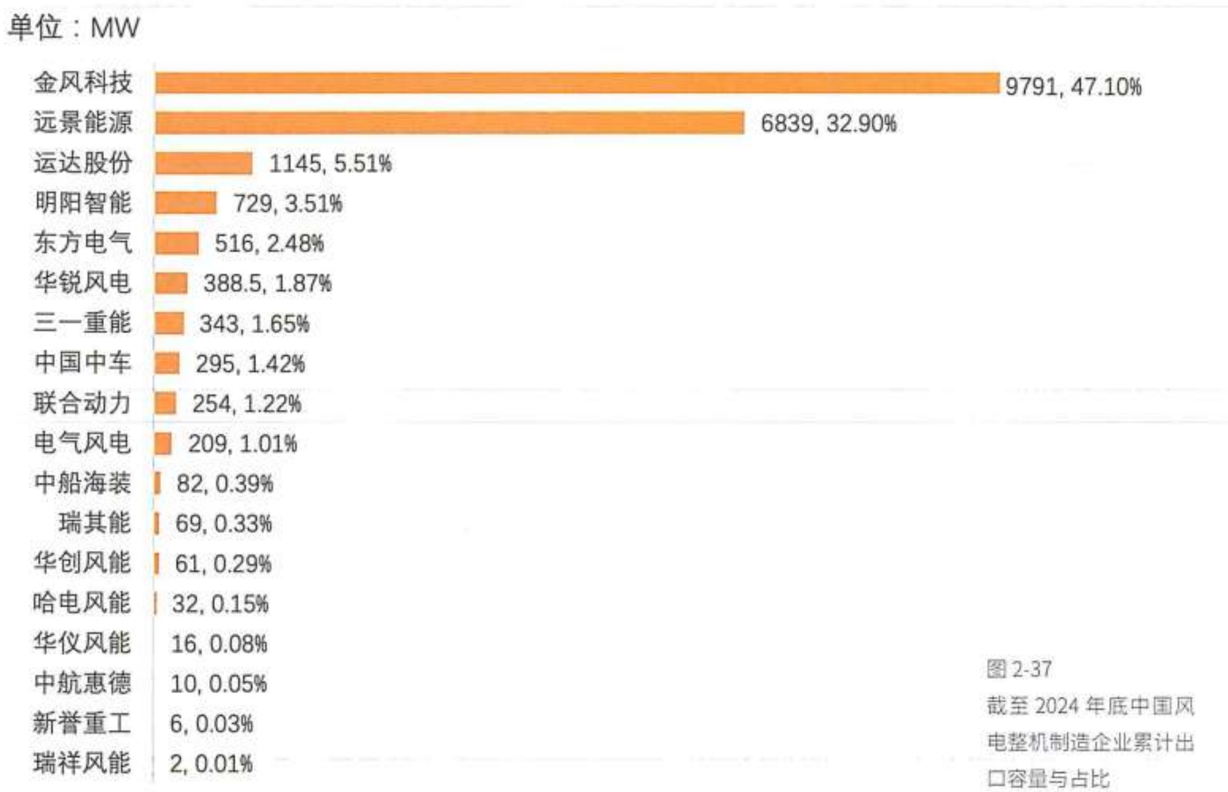

图 2-37
截至 2024 年底中国风电整机制造企业累计出口容量与占比

数据来源：CWEA

2.2.3 International Layout

As the competitiveness of Chinese enterprises strengthens, the pace of "going out" has accelerated. Beyond selling products to overseas markets, enterprises are establishing production bases and market service centers abroad. Through investing in factories in Brazil, Europe, Central Asia, and other regions, as well as exporting technology, they are transitioning from simple product exports to deep localized layouts, gaining significant advantages in price and delivery. The export price of Chinese wind turbines is approximately 20% lower than those of overseas manufacturers. While overseas manufacturers face risks of supply chain shortages and rising raw material prices, China possesses the advantages of a stable supply chain and stable delivery capabilities. Simultaneously, Chinese wind equipment manufacturers can provide flexible cooperation models, such as joint venture production and "Turbine + EPC" integrated solutions.

Turbines:

- **Goldwind:** Implements a localization-driven internationalization strategy, laying out a global R&D, manufacturing, and service network. By the end of 2024, it established a "1+1+6" R&D layout (Xinjiang National Innovation Center + Beijing Global R&D HQ + 6 R&D bases in Wuxi, Yancheng, Wenzhou, Germany, Denmark, and Australia), 7 regional centers, 5 global solution factories (Brazil, Pakistan, Vietnam, Australia, USA), and 3 international production bases (Brazil, Germany, Spain). The business model is transitioning from exporting main units from China to localized manufacturing.
- **Envision Energy:** Established an international engineering service center in India, a global innovation center in Denmark, a global wind engineering technology center in Germany, and a global blade innovation center in the USA. Its factory in Maharashtra, India, has an annual design capacity of 800 sets (approx. 4 GW).
- **Mingyang Smart:** Operates overseas R&D centers in Denmark, Germany, and the UK, and global service and synergy centers (offices) in France, Germany, UAE, South Korea, Japan, Vietnam, Philippines, and Brazil.

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International Layout (Continued)

- **Windey:** In 2024, the Windey International subsidiary was officially established. It operates the European Wind Energy Research Institute, an operations and maintenance (O&M) company in Hanoi, Vietnam, and research centers in Brazil and the United Kingdom.
- **Sany Renewable Energy:** Established a production factory in Kazakhstan and a research center in Spain. While deepening its presence in the Asia-Pacific market, it has successfully secured orders in the Latin American and European regions.

Key Components:

- **Blades:** Sinoma Technology (Brazil) Wind Power Blade Co., Ltd. was established in 2022 in Camaçari, Bahia. It is Sinoma Blade's first overseas controlled subsidiary, planned with four production lines. Partial production began in October 2023, and the first blade rolled off the line on November 29. Once fully operational, it will possess an annual capacity of 260 sets of wind blades, primarily supplying Brazil and its neighboring markets. Time New Material (TMT) is preparing its first overseas factory in Vietnam with a planned annual capacity of 400 sets, expected to be operational in the second half of 2025 to serve Southeast Asia and export to Europe and America.
- **Gearboxes:** NGC (Nanjing High Accurate Drive) has established overseas production and service bases in Sri City (India), Duisburg (Germany), and Fort Worth (USA).
- **Generators:** CRRC Yongji has established partnerships with world-leading original equipment manufacturers (OEMs) such as Vestas and Nordex and has signed contracts with international clients including Vensys, Adani, and Suzlon. Its products are exported to over 20 countries, including Denmark, France, Australia, Brazil, and Chile.
- **Converters:** Sungrow is currently establishing a production plant in India and maintains a research center in Germany.
- **Towers:** Dajia Heavy Industry was the first to realize the export of offshore wind engineering products and is the only supplier outside of Europe capable of providing ultra-large monopiles. It has supplied over 200 monopiles to the European market, maintaining a record of zero quality disputes for several years. According to Frost & Sullivan data, by sales value of monopiles in the first half of 2025, Dajia was the top offshore wind foundation equipment supplier in the European market, with its market share growing from 18.5% in 2024 to 29.1% in H1 2025. In September 2025, it delivered over 200 ultra-large monopiles to Europe, securing the honor of providing the "first non-European monopile" for several countries including Germany, France, and Denmark. Additionally, in May 2025, Dajia established a global floating R&D center in Madrid to integrate resources and provide one-stop floating foundation solutions.
- +2

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- **Subsea Cables:** Leading domestic subsea cable enterprises are actively expanding into overseas markets. They have established layouts in Canada, Southeast Asia, the Middle East, and Europe. Zhongtian Technology (ZTT) established O&M centers in Germany and the Middle East and is advancing the construction of a cable production base in Saudi Arabia to achieve localized service and delivery. In 2018, ZTT won a 155kV subsea cable EPC project in Germany, becoming the first Chinese cable company to enter the European market. Orient Cable and Hengtong Optic-Electric have also won orders in Vietnam, Portugal, and the Middle East.

Figure 2-38: Jiangsu Hengtong - 2021 Vietnam Tra Vinh 48MW Offshore Wind EPC Project.

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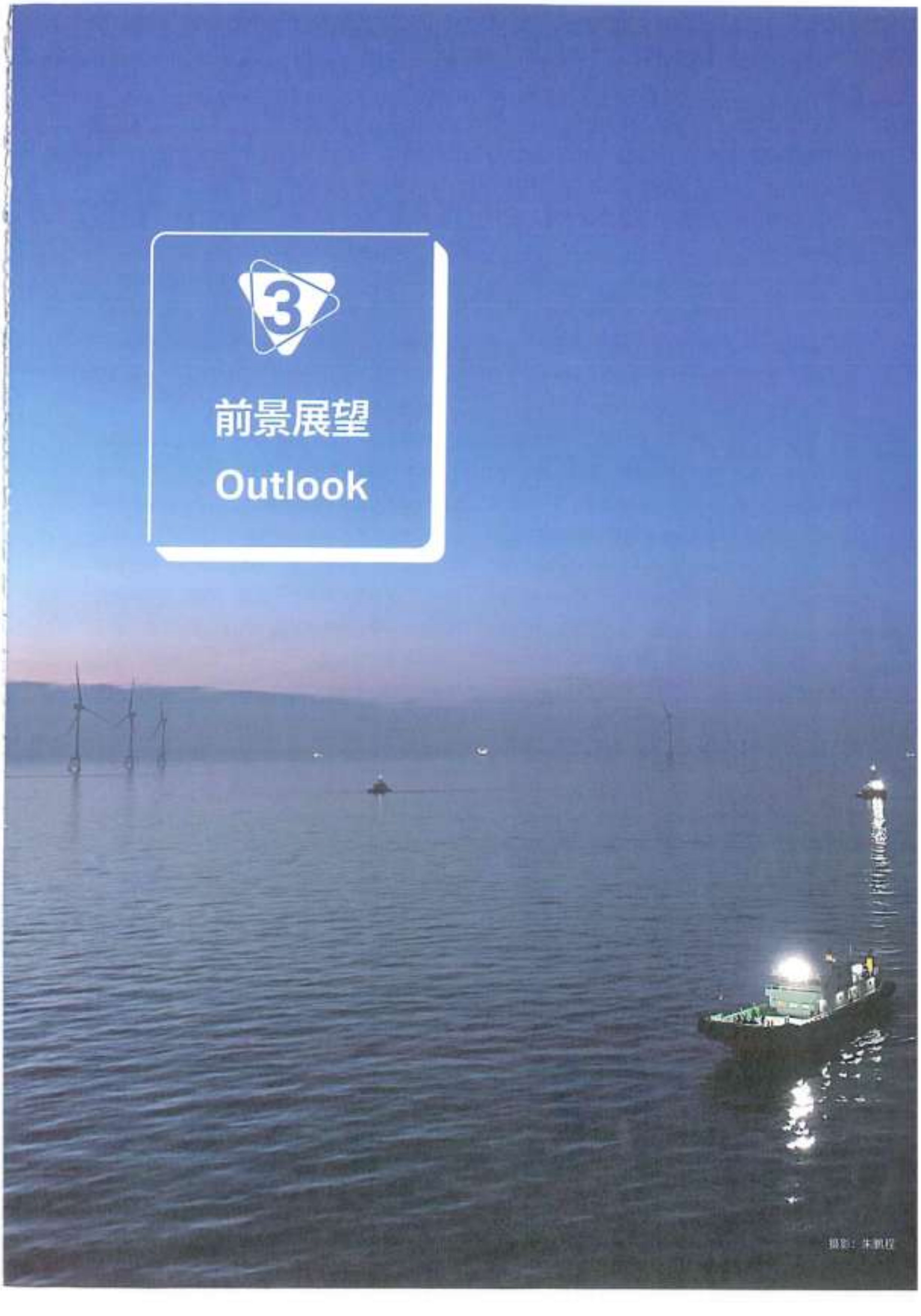

3 前景展望 Outlook

摄影：朱鹏程

3 Outlook

National Strategy and Top-level Design Providing Direction for China's Wind and Offshore Wind Development At the 2025 UN Climate Summit, President Xi Jinping announced China's new round of Nationally Determined Contributions (NDC) and proposed a strategic plan to strive for a wind and solar installed capacity of 3.6 billion kilowatts by 2035. Furthermore, the 6th meeting of the Central Financial and Economic Commission emphasized strengthening and expanding the marine industry and promoting the orderly construction of offshore wind power. This series of top-level designs highlights the strategic importance of the offshore wind industry in the national energy transition. The "Beijing Declaration 2.0" (October 2025) proposed that annual new wind capacity during the "15th Five-Year Plan" should be no less than 120GW, with offshore wind no less than 15GW. It is estimated that from 2025 to 2030, annual new installations will be approximately 15GW, reaching a cumulative scale of ~150GW by 2030.

From the perspective of coastal provinces, Guangdong ranks first in future market potential. Analysis of provincial mid-to-long term plans shows that deep-water (floating) projects account for approximately 60%, with most located in the Exclusive Economic Zone (EEZ) beyond territorial waters. In Guangdong, projects in the EEZ account for 66% of the total planned new capacity by 2030. After 2030, the vast majority of China's offshore wind projects will be located in the EEZ.

Costs in China's offshore wind sector maintain a downward trend. In 2024, construction costs ranged from 9,000 to 12,500 RMB/kW. It is roughly estimated that 2025 nearshore costs will be between 8,700 and 11,700 RMB/kW, further decreasing to 7,800-10,500 RMB/kW by 2030. Nearshore LCOE is expected to drop to approximately 0.25 RMB/kWh by 2030. Currently, floating wind costs are between 40,000 and 50,000 RMB/kW. With technological progress and scale, these are expected to fall below 20,000 RMB/kW by 2030, reaching commercial feasibility with an LCOE of 0.4-0.45 RMB/kWh.

Constructing a Brand New Offshore Energy Ecosystem Recently, "Offshore Wind +" integrated development has received increasing attention. The National Energy Administration's (NEA) "Guiding Opinions on Promoting Integrated Development of New Energy" (November) clearly states that China's new energy development is shifting from isolated modes to systematic, integrated, and collaborative models. This transformation aims to break boundaries between sub-systems, industries, and production/consumption to build a higher-level dynamic balance. In this context, the "Offshore Wind +" model (integrating Power-to-X, marine ranching, hydrogen, and integrated energy islands) is creating an innovative offshore energy ecosystem.

Core directions for integrated development include:

1. **Offshore Wind + Power-to-X (PTX):** Utilizing clean power for water electrolysis to produce hydrogen. This helps solve curtailment issues and provides zero-carbon raw materials for chemical and transport sectors.

2. **Offshore Wind + Marine Ranching / Blue Granary:** As nearshore space becomes limited, deep-water areas become carriers for the blue economy. Facilities can integrate monitoring and environmental regulation, creating a composite platform for "Power Generation - Ecological Restoration - Fishery Enhancement". It is worth noting that...