FROST & SULLIVAN

Market Engineering

Independent Market Study on Global and China's Wind Turbine Market

Presented to

MINGYANG SMART ENERGY
明阳智能
地蕴天成·能动无限

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Confidential

Terms and Abbreviations

Terms:

- **Compound Annual Growth Rate (CAGR):** The term for interest rate at which a given Present Value (PV) would "grow" to a given Future Value (FV) in a given amount of time. The formula for calculating CAGR is: (FV/PV)^(1/number of years)
- **Installed Capacity:** The intended full-load sustained output of power plant, usually denominated in MW or GW

Abbreviations:

GW	Gigawatt, 10^9 W	**MW**	Megawatt, 10^6 W
GWh	Gigawatt-hour, 10^9 Wh	**MWh**	Megawatt-hour, 10^6 Wh
KW	Kilowatt, 10^3 W	**NDRC**	National Development and Reform Commission of China
kWh	Kilowatt-hour, 10^3 Wh	**TW**	Terawatt, 10^12 W
LCOE	Levelised Cost of Energy	**TWh**	Terawatt-hour, 10^12 Wh
IEA	International Energy Agency	**MEIH**	Malaysia Energy Information Hub
EIA	U.S. Energy Information Administration	**NEA**	National Energy Administration of China
CMA	China Meteorological Administration	**IMF**	International Monetary Fund
GWA	Global Wind Atlas	**CREEI**	China Renewable Energy Engineering Institute

Research Scope

Independent Market Study on Global and China's Wind Turbine Market

Research Period	• Base year: 2021 • Historical: 2017 to 2021 • Forecasting: 2022E to 2026E
Service Market Scope	• Power Market • Wind Power Market • Wind Turbine Market
Geographical Scope	• Global • Selected Regions: U.S., Europe, China and Southeast Asia

Assumptions and Methodology

Assumptions:

The forecasts were made by Frost & Sullivan based on the following assumptions:

•The social, economic and political conditions in global and China currently discussed will remain stable during the forecast period;

•Government policies on power and wind power industries in China and major overseas countries discussed will remain consistent during the forecast period;

•The global and Chinese power and wind power market will be driven by the factors which are stated in this report.

Methodology:

In preparing the report, Frost & Sullivan has relied on the statistics and information obtained through primary and secondary research.

•Primary research includes interviewing industry insiders, competitors, downstream customers and recognised third-party industry associations.

•Secondary research includes reviewing corporate annual reports, databases of relevant official authorities, independent research reports and publications, as well as the exclusive database established by Frost & Sullivan over the past decades.

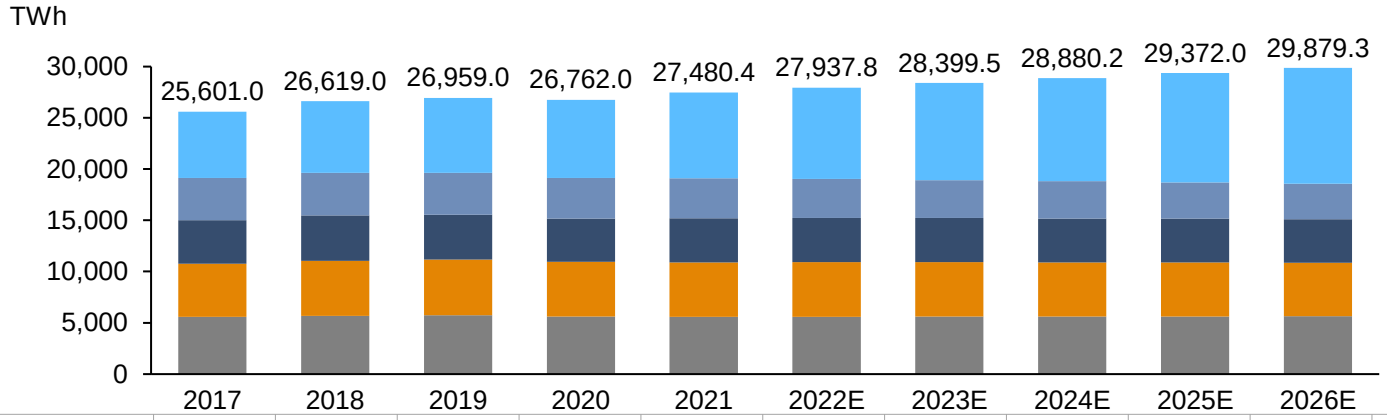
Content

1. Analysis of Power Market

Analysis of Power Market
Power Generation

- The global total power generation increased from 25,601.0 TWh in 2017 to 27,480.4 TWh in 2021, representing a CAGR of 1.8%, and is expected to further rise from 27,937.8 TWh in 2022 to 29,879.3 TWh in 2026, with a CAGR of 1.7%.
- China is the country with the largest amount of power generation in the world. Its total power generation increased from 6,452.9 TWh in 2017 to 8,376.8 TWh in 2021, with a CAGR of 6.7%. Its share in global total power generation was 30.5% in 2021. China's power generation is expected to further increase from 8,887.2 TWh in 2022 to 11,320.8 TWh in 2026, representing a CAGR of 6.2%. And its share in global power generation is expected to further increase to 37.9% in 2026.
- In terms of power generation in 2021, China was followed by US and Europe. The share of US was 15.7%, and that of Europe was 14.3%.

Power Generation (by region), Global, 2017-2026E



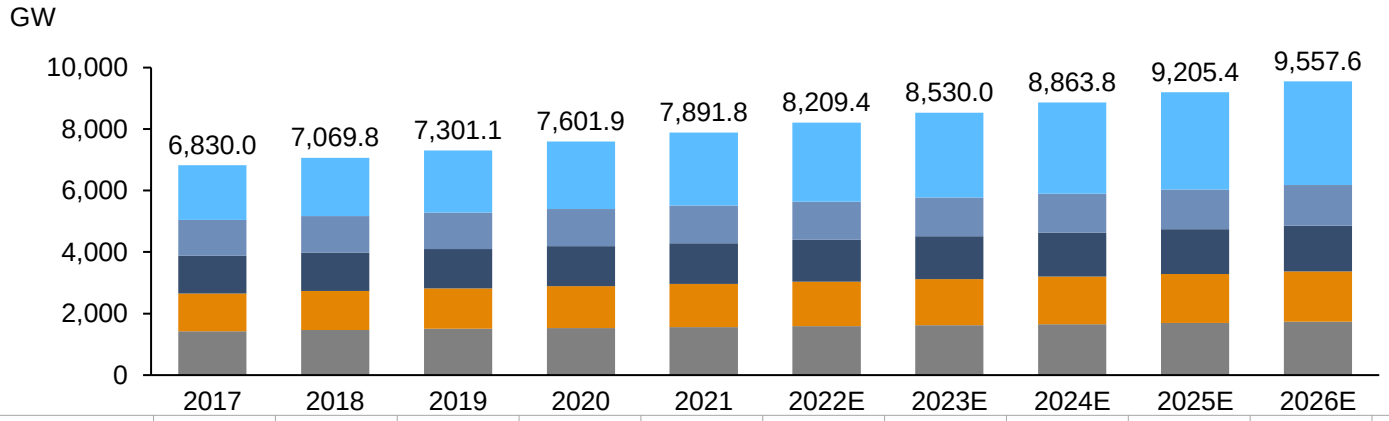
	2017	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E	CAGR (17-21)	CAGR (22E-26E)
China	6,452.9	6,994.7	7,326.9	7,626.4	8,376.8	8,887.2	9,466.7	10,068.9	10,684.9	11,320.8	6.7%	6.2%
Europe	4,127.0	4,136.0	4,080.0	3,952.0	3,917.0	3,812.1	3,714.3	3,632.8	3,529.2	3,436.4	-1.3%	-2.6%
US	4,264.0	4,434.0	4,371.0	4,243.0	4,312.0	4,305.6	4,297.6	4,289.0	4,280.0	4,270.5	0.3%	-0.2%
APAC excluding China	5,189.1	5,379.3	5,446.1	5,334.6	5,308.5	5,347.4	5,322.2	5,293.4	5,260.6	5,223.2	0.6%	-0.6%
Others	5,568.0	5,675.0	5,735.0	5,606.0	5,566.2	5,585.5	5,598.7	5,596.1	5,617.4	5,628.3	0.0%	0.2%
Total	25,601.0	26,619.0	26,959.0	26,762.0	27,480.4	27,937.8	28,399.5	28,880.2	29,372.0	29,879.3	1.8%	1.7%

Source: IEA, NEA, EIA, WindEurope, Frost & Sullivan

Analysis of Power Market
Installed Power Capacity (1/5)

- The global cumulative installed power capacity increased from 6,830.0 GW in 2017 to 7,891.8 GW in 2021, with a CAGR of 3.7%, and is expected to further increase from 8,209.4 GW in 2022 to 9,557.6 GW in 2026, with a CAGR of 3.9%.
- China is the country with the largest cumulative installed power capacity globally. Its capacity grew from 1,784.0 GW in 2017 to 2,376.3 GW in 2021, representing a CAGR of 7.4%, and its share in the global cumulative installed power capacity reached 30.1% in 2021. China's capacity is expected to further grow from 2,566.4 GW in 2022 to 3,380.4 GW in 2026, with a CAGR of 7.1%, and its share further growing to 35.4% in 2026.
- In terms of cumulative installed power capacity in 2021, China was followed by Europe and US. The share of Europe reached 16.9%, and that of US was 15.5%.

Cumulative Installed Power Capacity (by region), Global, 2017-2026E



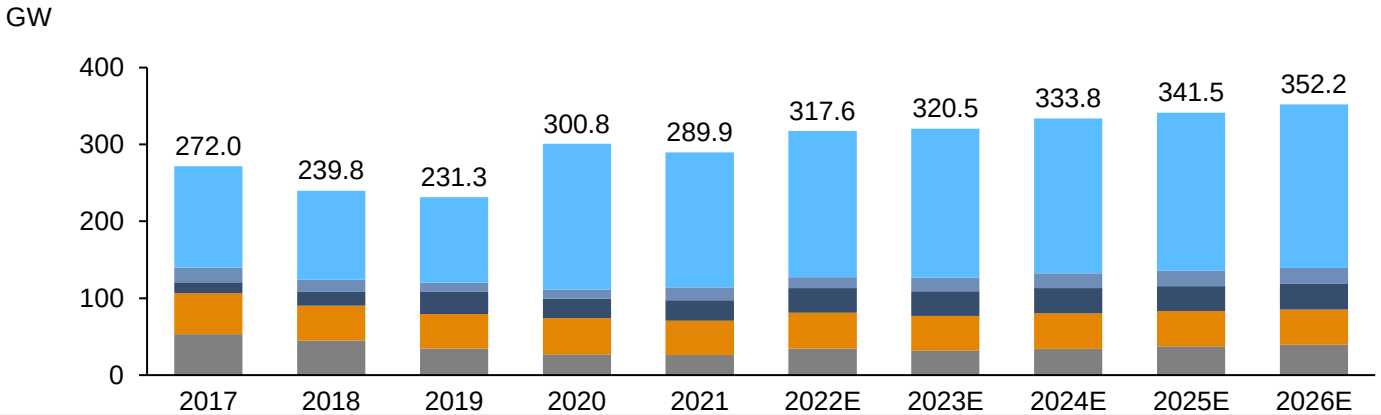
	2017	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E	CAGR (17-21)	CAGR (22E-26E)
China	1,784.0	1,899.7	2,010.7	2,200.4	2,376.3	2,566.4	2,760.2	2,961.7	3,167.7	3,380.4	7.4%	7.1%
Europe	1,231.0	1,249.0	1,278.0	1,303.5	1,330.2	1,362.1	1,393.9	1,426.9	1,459.5	1,493.0	2.0%	2.3%
US	1,169.0	1,185.0	1,197.0	1,208.5	1,225.3	1,239.6	1,257.4	1,276.5	1,296.4	1,317.3	1.2%	1.5%
APAC excluding China	1,222.0	1,267.3	1,312.3	1,359.5	1,403.9	1,450.8	1,496.3	1,542.4	1,588.2	1,633.9	3.5%	3.0%
Others	1,424.0	1,468.8	1,503.1	1,529.9	1,556.2	1,590.5	1,622.1	1,656.3	1,693.6	1,733.0	2.2%	2.2%
Total	6,830.0	7,069.8	7,301.1	7,601.9	7,891.8	8,209.4	8,530.0	8,863.8	9,205.4	9,557.6	3.7%	3.9%

Source: IEA, NEA, EIA, WindEurope, Frost & Sullivan

Analysis of Power Market
Installed Power Capacity (2/5)

- The global newly installed power capacity increased from 272.0 GW in 2017 to 289.9 GW in 2021, with a CAGR of 1.6%. And it is expected to further grow from 317.6 GW in 2022 to 352.2 GW in 2026, representing a CAGR of 2.6%.
- China leads in the amount of newly installed power capacity globally. Its newly installed power capacity grew from 132.3 GW in 2017 to 175.9 GW in 2021, with a CAGR of 7.4%. Its share in the global total newly installed power capacity was 60.7% in 2021. China's newly installed power capacity is expected to further increase from 190.2 GW in 2022 to 212.7 GW in 2026, representing a CAGR of 2.8%. And its share is expected to maintain at the level of 60.4% in 2026.
- In terms of the amount of newly installed power capacity in 2021, China was followed by Europe and US, the shares of which were 9.2% and 5.8%, respectively.

Newly Installed Power Capacity (by region), Global, 2017-2026E



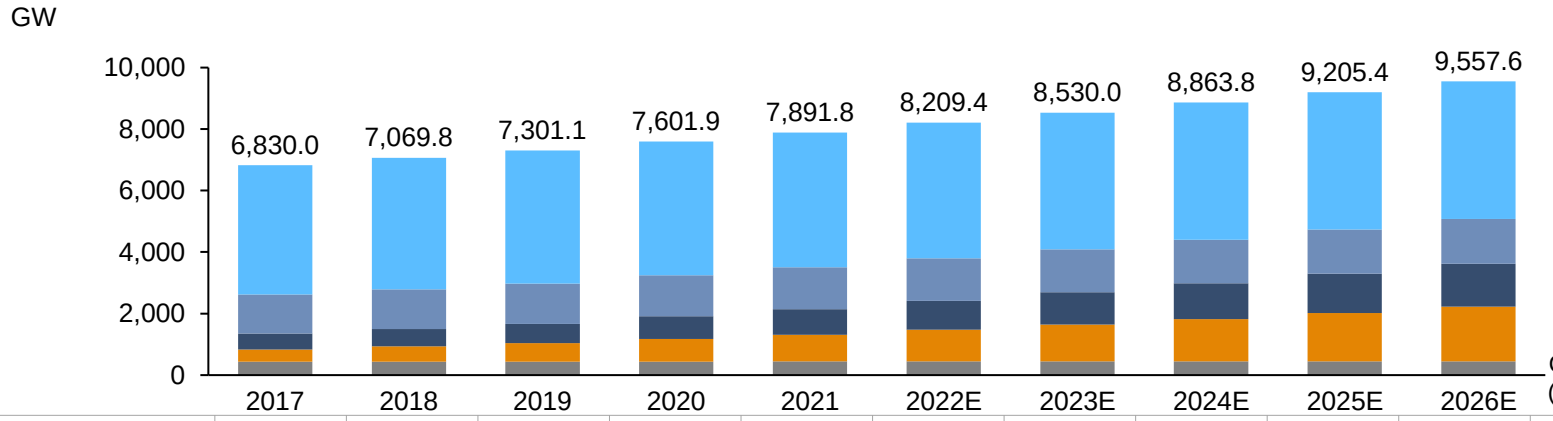
	2017	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E	CAGR (17-21)	CAGR (22E-26E)
China	132.3	115.7	111.0	189.7	175.9	190.2	193.8	201.4	206.0	212.7	7.4%	2.8%
Europe	14.0	18.0	29.0	25.5	26.6	31.9	31.8	33.0	32.6	33.5	17.5%	1.2%
US	19.0	16.0	12.0	11.5	16.8	14.3	17.8	19.1	19.9	20.9	-3.1%	10.0%
APAC excluding China	53.7	45.3	45.0	47.2	44.3	46.9	45.5	46.1	45.7	45.7	-4.7%	-0.7%
Others	53.0	44.8	34.3	26.8	26.3	34.3	31.7	34.1	37.4	39.4	-16.1%	3.5%
Total	272.0	239.8	231.3	300.8	289.9	317.6	320.5	333.8	341.5	352.2	1.6%	2.6%

Source: IEA, NEA, EIA, WindEurope, Frost & Sullivan

Analysis of Power Market
Installed Power Capacity (3/5)

- Among all energy sources, thermal power is the largest in terms of cumulative installed power capacity. However, its share in global total cumulative installed power capacity dropped from 61.7% in 2017 to 55.6% in 2021, and is expected to further decrease to 46.9% in 2026.
- Because of various encouraging policies issued by governments of different countries, the share of renewable energy, mainly including hydropower, wind power, and solar PV power has increased rapidly in recent years.
- The cumulative installed capacity of wind power also increased rapidly from 515.0 GW in 2017 to 831.8 GW in 2021, with a CAGR of 12.7%, and is expected to further grow from 941.8 GW in 2022 to 1,389.4 GW in 2026, representing a CAGR of 10.2%. Its share also increased from 7.5% in 2017 to 10.5% in 2021, and is expected to further grow to 14.5% in 2026.

Cumulative Installed Power Capacity (by power source), Global, 2017-2026E

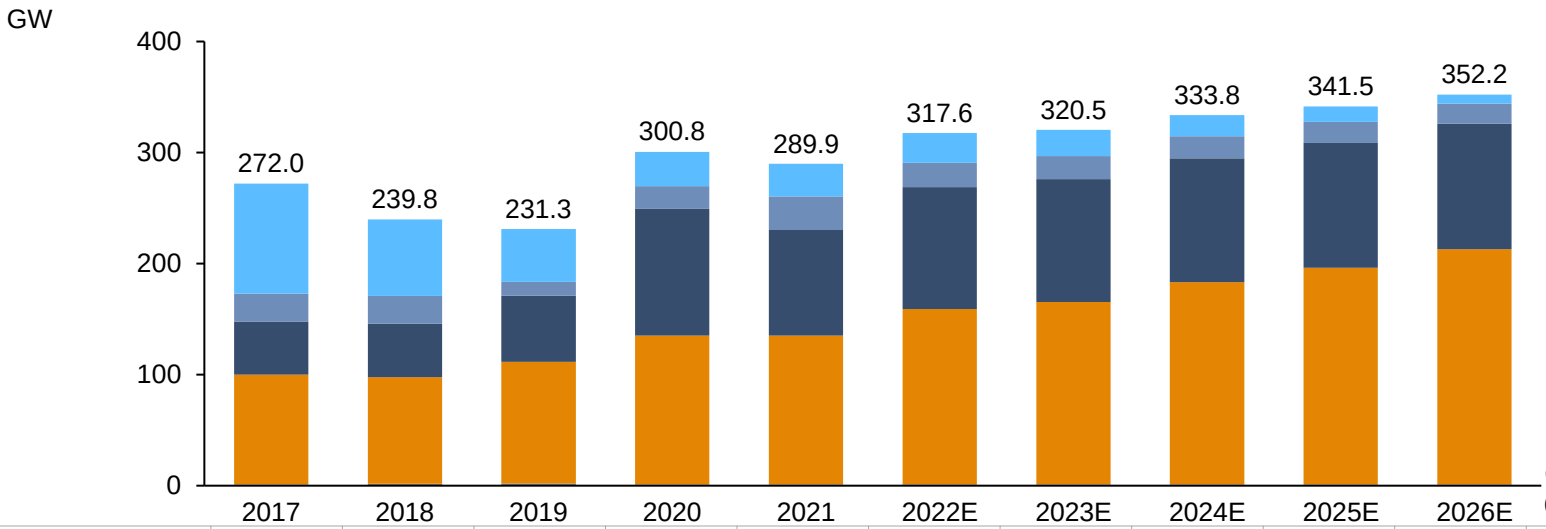


	2017	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E	CAGR (17-21)	CAGR (22E-26E)
Thermal Power	4,214.0	4,283.0	4,330.6	4,361.5	4,390.7	4,417.5	4,440.9	4,460.0	4,473.8	4,481.8	1.0%	0.4%
Hydropower	1,269.0	1,294.0	1,306.5	1,327.0	1,357.5	1,379.3	1,400.1	1,420.1	1,439.1	1,457.3	1.7%	1.4%
Wind	515.0	563.0	622.7	736.7	831.8	941.8	1,052.6	1,164.1	1,276.4	1,389.4	12.7%	10.2%
Solar PV	399.0	495.0	604.6	738.8	872.8	1,030.7	1,195.1	1,377.3	1,572.7	1,784.6	21.6%	14.7%
Others	433.0	434.8	436.7	437.9	439.0	440.1	441.2	442.3	443.4	444.5	0.3%	0.2%
Total	6,830.0	7,069.8	7,301.1	7,601.9	7,891.8	8,209.4	8,530.0	8,863.8	9,205.4	9,557.6	3.7%	3.9%

Source: IEA, NEA, EIA, WindEurope, Frost & Sullivan

Analysis of Power Market
Installed Power Capacity (4/5)

Newly Installed Power Capacity (by power source), Global, 2017-2026E



	2017	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E	CAGR (17-21)	CAGR (22E-26E)
Thermal Power	99.0	69.0	47.6	30.9	29.2	26.8	23.5	19.1	13.8	8.0	-26.3%	-26.1%
Hydropower	25.0	25.0	12.5	20.6	30.4	21.8	20.8	19.9	19.0	18.2	5.0%	-4.5%
Wind	48.0	48.0	59.7	114.0	95.1	110.0	110.8	111.5	112.3	113.0	18.6%	0.7%
Solar PV	99.0	96.0	109.6	134.1	134.1	157.9	164.4	182.2	195.4	211.9	7.9%	7.6%
Others	1.0	1.8	1.9	1.2	1.1	1.1	1.0	1.1	1.0	1.1	2.4%	0.1%
Total	272.0	239.8	231.3	300.8	289.9	317.6	320.5	333.8	341.5	352.2	1.6%	2.6%

Note: Wind power capacity refers to the capacity of grid-connected wind turbines, which have been connected to power grid.

Source: IEA, NEA, EIA, WindEurope, Frost & Sullivan

Analysis of Power Market
Installed Power Capacity (5/5)

Highlights

- Countries have put forward goals and commitments of reducing carbon emissions and accelerating development of renewable energy power. For example, China has a commitment of reaching carbon neutrality by 2060; the European Union has set a target that by 2030, renewable energy is expected to account for 40% of energy end use; while UK government has set a target that by 2035, electricity generation in UK will be fossil fuel free and from 100% renewable sources. As a result of favourable policies issued by governments of different countries, in terms of newly installed power capacity, the share of renewable energy of the total energy market, primarily consisting of hydropower, wind power, and solar photovoltaic power, has increased from 63.2% in 2017 to 89.5% in 2021, and is expected to increase from 91.2% in 2022 to 97.4% in 2026.

- Currently, in the era of grid parity, the development of the solar PV industry is mainly driven by the cost reduction and technological advancement. China is the largest producer of PV (photovoltaic) cells with total production volume of 198 GW in 2021. It is expected that the production volume of PV cells will reach 450 GW in 2026. Among different types of PV cells, N-type HJT (heterojunction technology) cell is of the highest solar conversion efficiency and is expected to be the fastest growing category with production volume growing from approximately 7 GW in 2021 to 93 GW in 2026 at a CAGR of 69%. As for wind power industry, in addition to favourable government policies, leading wind turbine manufacturers have been investing in R&D of wind turbines with higher unit power capacity and lower manufacturing costs, which would further drive sustainable development of the industry. Global newly installed wind power increased from 48.0GW in 2017 to 95.1GW in 2021, representing a CAGR of 18.6%, and it is expected to further grow from 110.0GW in 2022 to 113.0GW in 2026, representing a CAGR of 0.7%. The share of wind power increased from 17.6% in 2017 to 32.8% in 2021, and wind power is expected to become the major power source, contributing over 30% of total newly installed power capacity during the forecast period. The development of hydropower industry is entering a relatively stable stage and the focus of the industry is to improve efficiency.

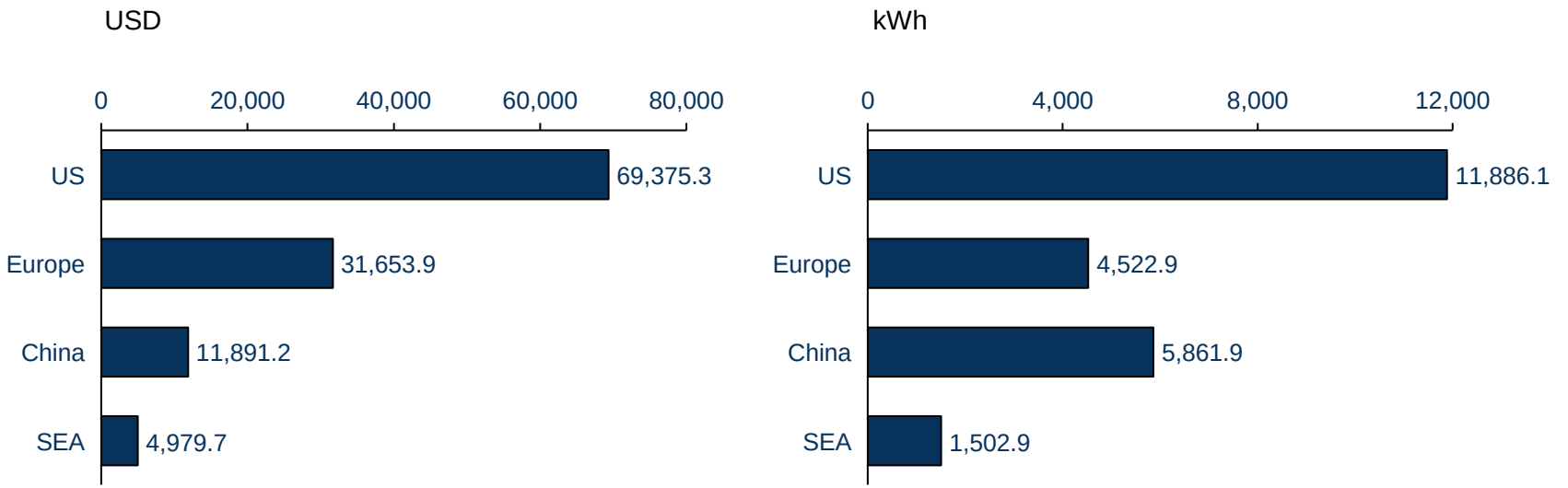
- In order to reduce the instability of wind and solar power, and make full use of hydrogen energy for long-term and large capacity energy storage, recently Chinese government has issued relevant policies to encourage enterprises to cultivate new application models of wind and solar power generation with hydrogen energy storage. Hydrogen is poised to play an increasingly important role in the decarbonization of energy in the upcoming decades, especially the green hydrogen, which is produced by electrolysis of water powered by renewable electricity. The hydrogen market in China is of great potential and is expected to reach approximately RMB 1.1 trillion in 2030. The integration of wind-solar-storage-hydrogen is an important development model in renewable energy sector and will play an increasing important role in realizing the national target of “carbon neutrality” by 2060.

Source: IEA, NEA, EIA, WindEurope, Frost & Sullivan

Analysis of Power Market
GDP and Power Consumption per Capita

- China's nominal GDP per capita was USD11,891.2 in 2021, which was still significantly lower than the levels of developed countries. The United States had a nominal GDP per capita of USD69,375.3 and European countries had an average of USD31,653.9 in 2021.
- The power consumption per capita in China's was 5,861.9 kWh in 2021. It was significantly lower than that of the United States, which was 11,886.1 kWh in 2021, indicating a growth potential for power consumption in China.
- The expected steady growth of China's economy is forecasted to drive the increase power consumption in China, which will stimulate the growth of China's power generation and power capacity.

GDP and Power Consumption per Capita, China & Major Economies, 2021



Source: IMF, NEA, EIA, Frost & Sullivan

Analysis of Power Market
Renewable Energy Target and Capacity

- A large number of countries in the world have put forward the goals and commitments of reducing emissions to net zero by 2050 and China has a commitment of reaching carbon neutrality by 2060. The development of renewable energy power is the key solution to reduce carbon emissions and has been accelerated in various countries. Governments in different countries have issued targets in medium and long terms to exert the critical roles of renewable energy in energy consumption.

Country/ Region	Renewable Energy Power Generation Capacity (2021)	Renewable Energy Power Generation Capacity (2030)	Key Contents
 PRC	1,063.0 GW	2,595.3GW	• By 2030, the share of non-fossil energy consumption will reach around 25%, and the cumulative installed capacity of wind and solar power generation will reach more than 1,200GW. By 2060, the share of non-fossil energy consumption will reach over 80%.
 EU	508.8 GW	796.4GW	• In 2030, renewable energy is expected to account for 40% of energy end-use.
 Spain	63.5 GW	107.1GW	• In 2030, renewable energy is expected to account for 42% of energy end-use. Renewable electricity generation in 2030 will represent 74% of the total consistent with a path towards a 100% renewable electricity sector by 2050.
 Italy	57.1 GW	71.4GW	• In 2030, renewable energy is expected to account for 30% of energy end-use. Renewable electricity generation in 2030 will represent 55% of the total consistent with a path towards a 100% renewable electricity sector by 2050.
 UK	49.6 GW	77.3GW	• By 2035, electricity generation in the UK will be fossil fuel free and from 100% renewable sources.

Source: Frost & Sullivan

Analysis of Power Market
Key Policies of Renewable Energy - China

Issuing Time	Country/ Region	Issuing Authorities	Industry Guideline	Key Contents
2021.10	PRC	The State Council	Notice on the Action Plan for Carbon Dioxide Peaking Before 2030 《关于印发2030年前碳达峰行动方案的通知》	• Emphasize both onshore and offshore wind power generation systems, promote rapid and coordinated development of wind power, improve industrial chains for offshore wind power, and encourage the construction of offshore wind bases. • Promote the recycling of retired wind turbine blades and waste of other emerging industries.
2021.10	PRC	The State Council	Working Guidance for Carbon Dioxide Peaking and Carbon Neutrality in Full and Faithful Implementation of the New Development Philosophy 《关于完整准确全面贯彻新发展理念做好碳达峰碳中和工作的意见》	• By 2025, the share of non-fossil energy consumption will reach around 20%. • By 2030, the share of non-fossil energy consumption will reach around 25%, and the total installed capacity of wind and solar power generation will reach more than 1,200GW. • By 2060, the share of non-fossil energy consumption will reach over 80%.
2021.10	PRC	National Energy Administration	Notice on the Active Promotion of Related Work in New Energy Power Projects to Connect as Much as Possible and to Generate More and Fully Electricity 《关于积极推动新能源发电项目能并尽并、多发满发有关工作的通知》	• Grid enterprises follow the principle of “connect as much as possible" and “generate more and fully electricity", to enhance coordination and speed up the supporting network construction of wind power and photovoltaic power generation projects, and to make full connection with the construction of new energy generation projects to ensure simultaneous commissioning.
2021.05	PRC	National Development and Reform Commision, National Energy Administration	Notice on the Renewable Energy Power Absorptive Responsibility Weight and Related Matters in 2021 《关于2021年可再生能源电力消纳责任权重及有关事项的通知》	• From 2021, at the beginning of each year, the renewable energy power absorptive responsibility weights for each province will be issued on a rolling basis.
2021.05	PRC	National Energy Administration	Notice on Matters Related to the Development and Construction of Wind Power and Photovoltaic Power Generation in 2021 《关于2021年风电、光伏发电开发建设有关事项的通知》	• In 2021, the national wind power and photovoltaic power generation will account for about 11% of the total electricity consumption in China, and will subsequently increase year by year to ensure that the proportion of non-fossil energy consumption in primary energy consumption will reach around 20% in 2025.

Source: Frost & Sullivan

Analysis of Power Market
Key Policies of Renewable Energy - EU/UK

Issuing Time	Country/ Region	Issuing Authorities	Industry Guideline	Key Contents
2021.07	EU	European Commission	Amendment to the Renewable Energy Directive to Implement the Ambition of the New 2030 Climate Target	• To increase the 2030 EU-level target of at least 32% of share of energy consumption from renewable sources to at least 40%.
2020.11	EU	European Commission	An EU Strategy to Harness the Potential of Offshore Renewable Energy for a Climate Neutral Future	• To have an installed capacity of at least 60 GW of offshore wind and at least 1 GW of ocean energy by 2030, with a view to reach 300 GW and 40 GW of installed capacity respectively by 2050.
2020.07	EU	European Commission	Powering a Climate-neutral Economy: An EU Strategy for Energy System Integration	• The need for increased electricity supply can, alongside other relevant onshore renewable power technologies such as solar or wind energy, partly be met by offshore renewable energy production. • The potential of offshore wind energy in the EU is between 300-450 GW by 2050.

Issuing Time	Country/ Region	Issuing Authorities	Industry Guideline	Key Contents
2021.10	UK	Department for Business, Energy & Industrial Strategy	Net Zero Strategy: Build Back Greener	• By 2035 the UK will be powered entirely by clean electricity, subject to security of supply. • 40GW of offshore wind by 2030, with more onshore, solar, and other renewables – with a new approach to onshore and offshore electricity networks to incorporate new low carbon generation and demand in the most efficient manner that takes account of the needs of local communities like those in East Anglia.
2020.12	UK	Department for Business, Energy & Industrial Strategy	ENERGY WHITE PAPER: Powering our Net Zero Future	• Target 40GW of offshore wind by 2030, including 1GW floating wind, alongside the expansion of other low-cost renewables technologies. • Generate new clean power with offshore wind farms, nuclear plants and by investing in new hydrogen technologies.

Source: Frost & Sullivan

Analysis of Power Market
Market Drivers of Global and China Wind Power Industry (1/2)

Market Drivers of Global and China Wind Power Industry

	Main Drivers
1	Favorable Government Policies
2	Abundant Wind Power Resources
3	Advances in Wind Power Technologies
4	Continuous Development of Energy Storage Technology
5	Increasing Geopolitical Instability

Drivers	Description
Favorable Government Policies	➢ To realize the commitments to net-zero, major countries and regions in the world are proactively promoting the development of renewable energy and wind power is one of the key solutions. Governments have introduced a series of guidance and supportive policies, such as subsidies and tax incentives, to accelerate the development of wind power. China is expecting an annual installation of more than 50GW of wind power during the 14th five year period. The German government has announced a goal to deploy 30 GW of offshore by 2030. The UK has targeted to deploy 30 GW of offshore wind by 2030.
Abundant Wind Power Resources	➢ Wind power is one of the safest, most reliable and non-polluting energy source, and there are abundant wind power resources in most of the regions of the world. Especially, with the continuous advancements in technologies, the potential of both onshore and offshore wind power resources will be fully developed. For example, China has abundant wind power resources in the southeast coastal areas and nearby islands, and the northwest desert areas, but the utilization rate of wind power resources in these areas need to be improved. The abundant wind power resources in the world provides substantial foundation for the development of wind power industry.

Source: Frost & Sullivan

Analysis of Power Market
Market Drivers of Global and China Wind Power Industry (2/2)

Market Drivers of Global and China Wind Power Industry

	Main Drivers
1	Favorable Government Policies
2	Abundant Wind Power Resources
3	Advances in Wind Power Technologies
4	Continuous Development of Energy Storage Technology
5	Increasing Geopolitical Instability

Drivers	Description
Advances in Wind Power Technologies	➢ The advances in wind power technologies, especially in wind turbines, promote the sustainable momentum for the development of wind power. Due to the technological advancements, the price of wind turbines per MW continues to decrease and the efficiency of wind farms keeps increasing. Global wind turbine manufacturers keep accelerating the production layout of large-capacity wind turbines, which promotes the continuous decline in unit cost of wind power. Technological progresses continue to increase the economy and feasibility of wind power, making it an increasingly applicable renewable energy source.
Continuous Development of Energy Storage Technology	➢ Utility-scale energy storage system can enable a greater feed-in of wind power into the grid by storing excess generation and by firming wind power output. Furthermore, particularly when paired with wind power generators, energy storage system provides reliable and cheaper electricity in isolated grids and to off-grid communities. The continuous development of energy storage technology, especially battery energy storage system, is a strong support for wind power.
Increasing Geopolitical Instability	➢ Currently the geopolitical conflicts in some parts of the world, like East Europe, have raised the price of fossil fuels significantly, and accelerated the deployment for renewable energy, especially wind power and solar power, in power generation. The military conflicts between Russia and Ukraine have led to energy crisis in Europe due to a significant increase in the price of crude oil and natural gas. As the International Energy Agency (IEA) issued "A 10-Point Plan to Reduce the European Union's Reliance on Russian Natural Gas", the acceleration of the deployment of wind energy in Europe will be a strong driving force for the development of wind energy.

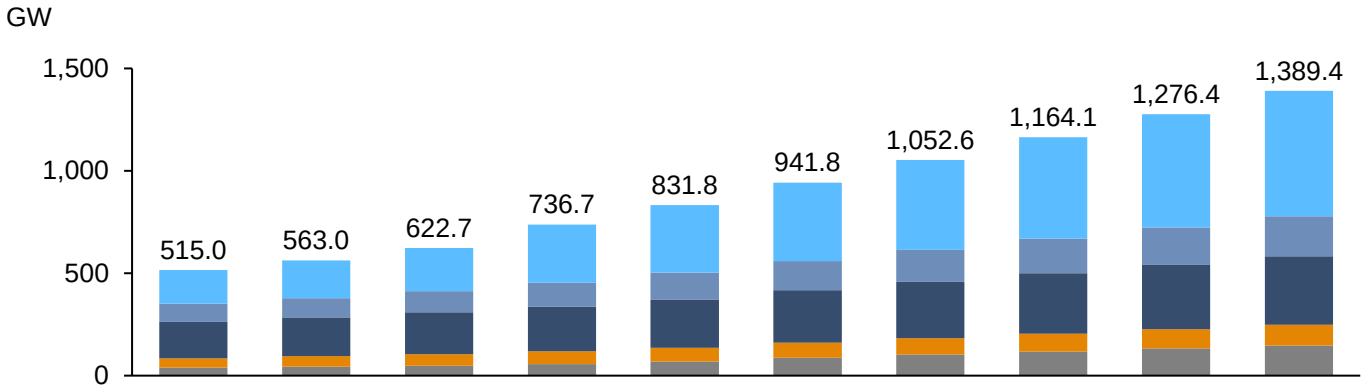
Source: Frost & Sullivan

2. Analysis of Wind Power and Wind Turbine Market

Analysis of Wind Power Market
Installed Power Capacity (1/2)

- Among all countries, China has the largest amount of cumulative installed wind power capacity. This is mainly due to the continuous issuance of various encouraging policies in the country. China's cumulative installed wind power capacity increased from 164.0 GW in 2017 to 328.5 GW in 2021, with a CAGR of 19.0%, and is expected to further grow from 383.3 GW in 2022 to 612.1 GW in 2026, representing a CAGR of 12.4%. The share of China's cumulative installed wind power capacity in the global total amount also grew rapidly from 31.8% in 2017 to 39.5% in 2021, and is expected to further increase to 44.1% in 2026.
- In terms of the amount of cumulative installed wind power capacity in 2021, China was followed by Europe and US, the shares of which were 28.4% and 15.9%, respectively.

Cumulative Installed Wind Power Capacity* (by region), Global, 2017-2026E



	2017	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E	CAGR (17-21)	CAGR (22E-26E)
China	164.0	184.3	210.1	281.5	328.5	383.3	439.1	495.8	553.5	612.1	19.0%	12.4%
Europe	178.0	189.0	204.0	219.0	236.0	256.0	276.0	296.0	315.0	334.0	7.3%	6.9%
US	88.0	95.0	104.0	118.0	132.0	141.8	155.0	168.3	181.8	195.3	10.7%	8.3%
APAC excluding China	46.0	50.7	56.0	61.4	67.2	73.2	79.5	86.2	93.2	100.5	9.9%	8.2%
Others	39.0	44.0	48.7	56.8	68.2	87.6	103.0	117.8	133.0	147.5	15.0%	13.9%
Total	515.0	563.0	622.7	736.7	831.8	941.8	1,052.6	1,164.1	1,276.4	1,389.4	12.7%	10.2%

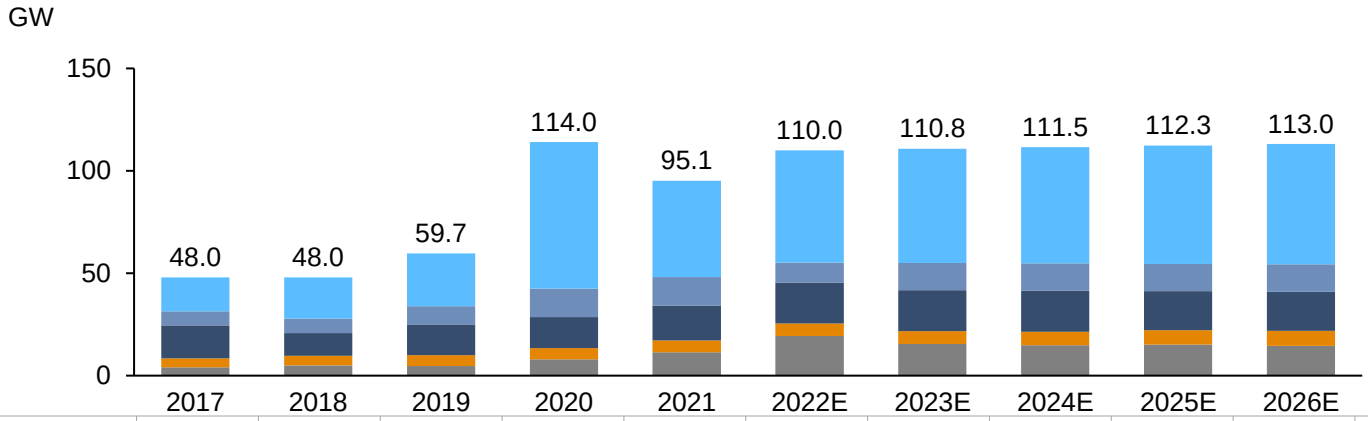
Note: Wind power capacity refers to the capacity of grid-connected wind turbines, which have been connected to power grid.

Source: IEA, NEA, EIA, WindEurope, Frost & Sullivan

Analysis of Wind Power Market
Installed Power Capacity (2/2)

- China leads in the amount and growth rate of newly installed wind power capacity among all countries, with the capacity growing from 16.5 GW in 2017 to 47.0 GW in 2021 at a CAGR of 29.8%. In particular, China's newly installed capacity of wind power reached its peak in 2020, mostly due to an installation rush in that year resulted from the phase out of the onshore wind power subsidies by year's end.
- China's newly installed wind power capacity is expected to maintain at a high level and increase from 54.9 GW in 2022 to 58.6 GW in 2026, representing a CAGR of 1.7%.
- In terms of the amount of newly installed wind power capacity in 2021, China was followed by Europe and US, the shares of which were 17.9% and 14.7%, respectively.

Newly Installed Wind Power Capacity* (by region), Global, 2017-2026E



	2017	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E	CAGR (17-21)	CAGR (22E-26E)
China	16.5	20.3	25.8	71.5	47.0	54.9	55.8	56.7	57.7	58.6	29.8%	1.7%
Europe	16.0	11.0	15.0	15.0	17.0	20.0	20.0	20.0	19.0	19.0	1.5%	-1.3%
US	7.0	7.0	9.0	14.0	14.0	9.8	13.2	13.3	13.4	13.5	18.9%	8.5%
APAC excluding China	4.5	4.7	5.2	5.5	5.7	6.0	6.3	6.6	7.0	7.3	6.5%	5.0%
Others	4.0	5.0	4.7	8.0	11.4	19.4	15.4	14.8	15.2	14.5	30.0%	-6.9%
Total	48.0	48.0	59.7	114.0	95.1	110.0	110.8	111.5	112.3	113.0	18.6%	0.7%

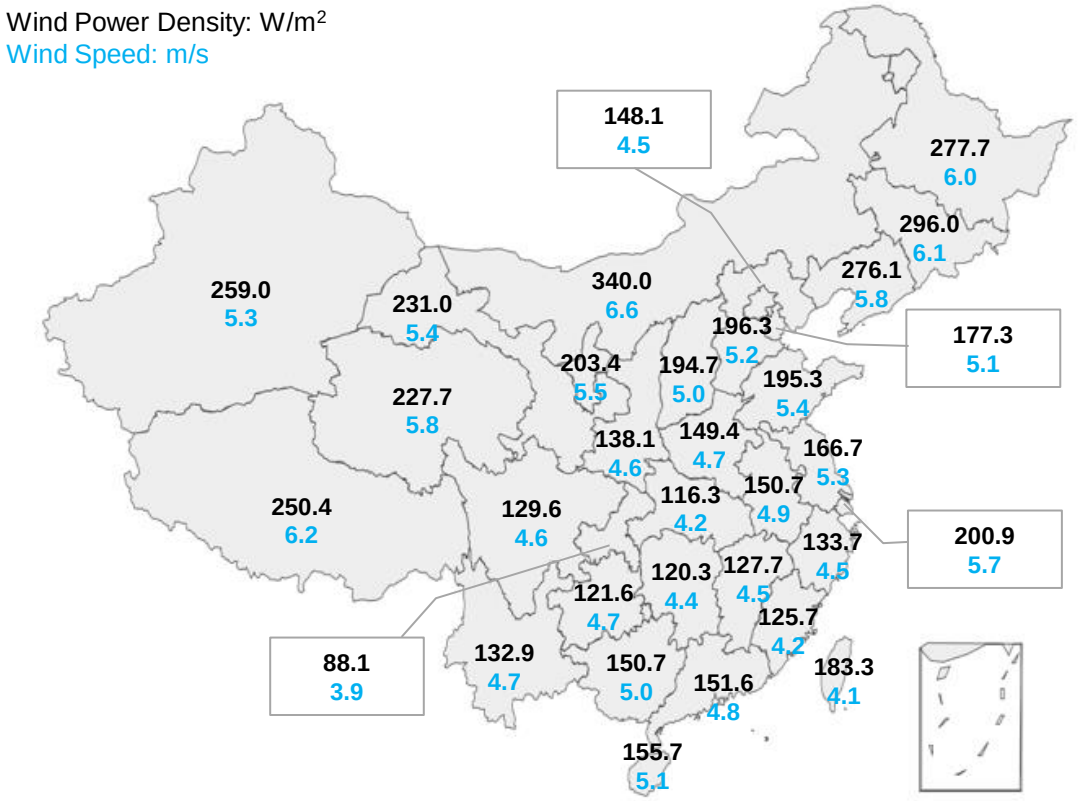
Note: Wind power capacity refers to the capacity of grid-connected wind turbines, which have been connected to power grid.

Source: IEA, NEA, EIA, WindEurope, Frost & Sullivan

Analysis of Wind Power Generation
Wind Power Density and Wind Speed in China

- The utilization of wind power requires the consideration of multiple meteorological properties. Wind power density is a quantitative measure of wind energy available at any location. It is the mean annual power available per square meter of swept area of a turbine, and is calculated for different heights above ground.
- Located in the subtropical monsoon climate zone in the junction of Eurasia and the Pacific Ocean, China has abundant wind power resource. Influenced by complex geographical conditions, wind power resources in China, measured by higher wind speed and wind power density are mainly distributed in the “Three Northern Area” and the southeastern coastal regions.

Wind Power Density and Wind Speed* (By Province), China, 2021



- Influenced by terrain environment of Tianshan Mountains, Beishan Mountains, Altai Mountains and Yin Mountains, strong west wind from Siberia follows the mountain ranges and leads to the abundance of wind power in the “Three Northern Area” in China. Wind power densities and wind speeds at the height of 70 meters above sea level in these areas are usually higher than 200 W/m^2 and 5.5 m/s separately.
- Because of the obstruction of Taihang Mountains and the Tibet Plateau, eastern and southern areas in China have relatively limited wind power resources, representing by average wind power densities less than 150 W/ m^2 and wind speeds less than 5m/s.
- With the help of monsoon climate, high air density and flat terrain, wind power densities in southeastern coastal regions of China are usually higher than 300 W/ m^2 and become proper locations for future wind power farms.

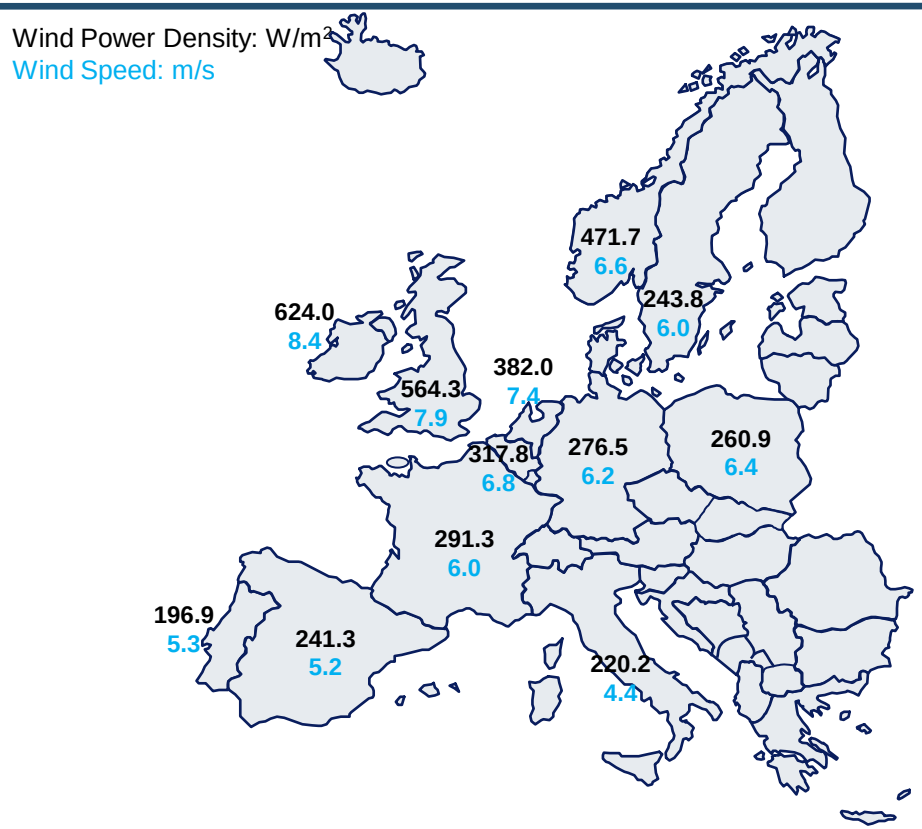
Note: The data represent the wind power density and wind speed at the height of 70 meters above sea level.

Source: CMA, GWA, CREEI, Frost & Sullivan

Analysis of Wind Power Generation
Wind Power Density and Wind Speed in Europe

- Located at the windward of westerlies and influenced by high thermal property difference between the Eurasia and the Atlantic and the vast flat terrain with high air density, major countries in Europe have abundant wind power resources, especially offshore wind power resources, in general.
- Because of the Pyrenees Mountains, Scandinavian Mountains and the Alps, strong west wind from the Atlantic follows the mountain ranges and makes the North Sea to be the best region of wind power in the Europe.

Wind Power Density and Wind Speed, Major Countries in Europe, 2021



- As the offshore islands of the Eurasia and unaffected by the obstruction of mountains, Ireland and the UK possess the best wind power resources among other European countries. In 2021, average wind power densities and wind speeds in Ireland and the UK exceed 550 W/m^2 and 7.5 m/s separately.
- Because of high capacity per unit, higher wind power density in offshore regions and the decreasing construction cost lead by technological advances, increasing number of European countries have attached importance to the development of offshore wind power resources. For instance, Netherlands have decided to double its accumulated offshore wind power capacity by 2030 and Germany has announced to improve the accumulated offshore wind power capacity in 2030 from 20 GW to 30GW.

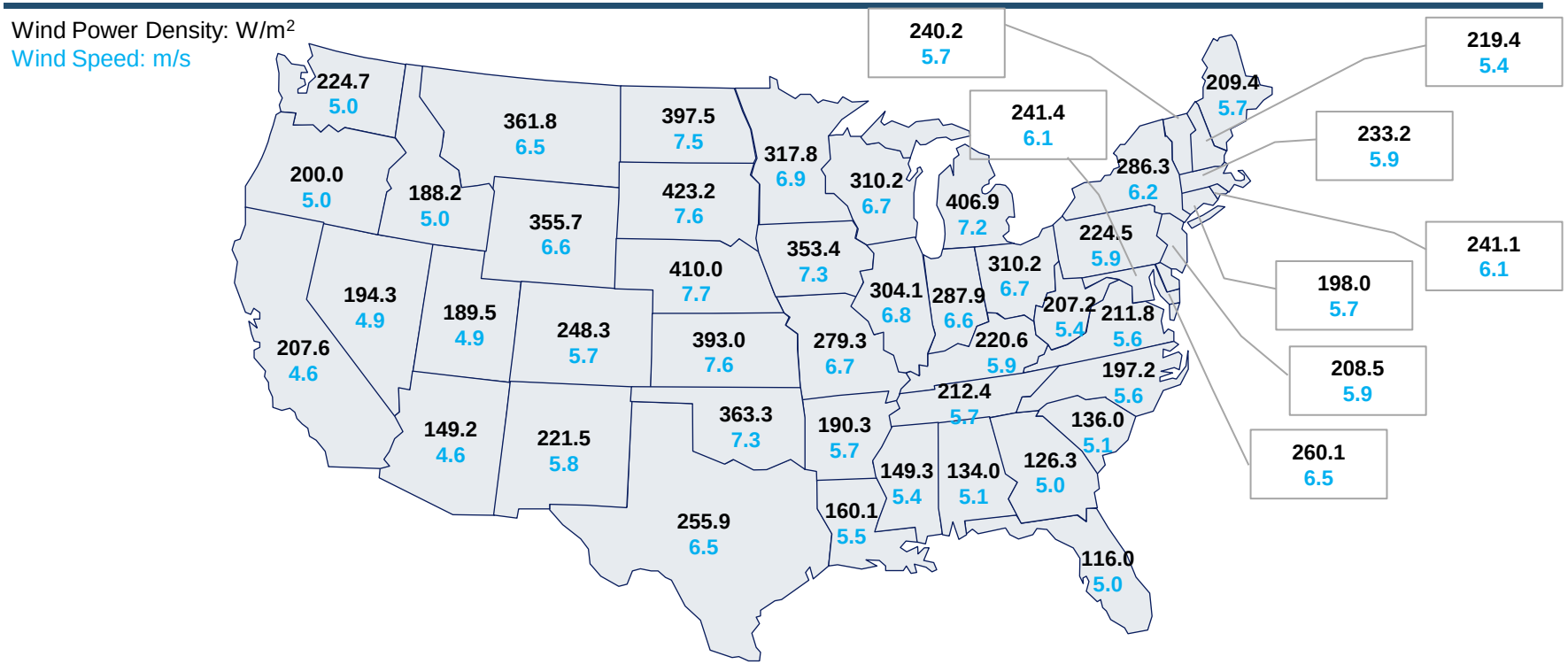
Note: The data represent the wind power density and wind speed at the height of 70 meters above sea level.

Source: GWA, Frost & Sullivan

Analysis of Wind Power Generation
Wind Power Density and Wind Speed in US

- Influenced by the Rocky Mountains and Appalachian Mountains both from north to south and lesser thermal difference between North American continent and the Atlantic compared to that between Eurasia and the Pacific Ocean, the US has remarkable temperate continental climate characteristic. Affected by flat terrain and the air mass flow in the north-south direction, the wind power in US is mainly distributed in Midwest regions and coastal regions.
- Currently, most of wind power farms in the US are located in onshore sites. The development of offshore wind power in coastal regions is relatively slow because of relatively higher cost. According to NREL, potential offshore wind power of the US exceeds 10.8 billion KW. And the US has accelerated the development of offshore wind power resources by setting 30 GW cumulative installed capacity by 2030 and quicker project approval.

Wind Power Density and Wind Speed, Major States in US, 2021



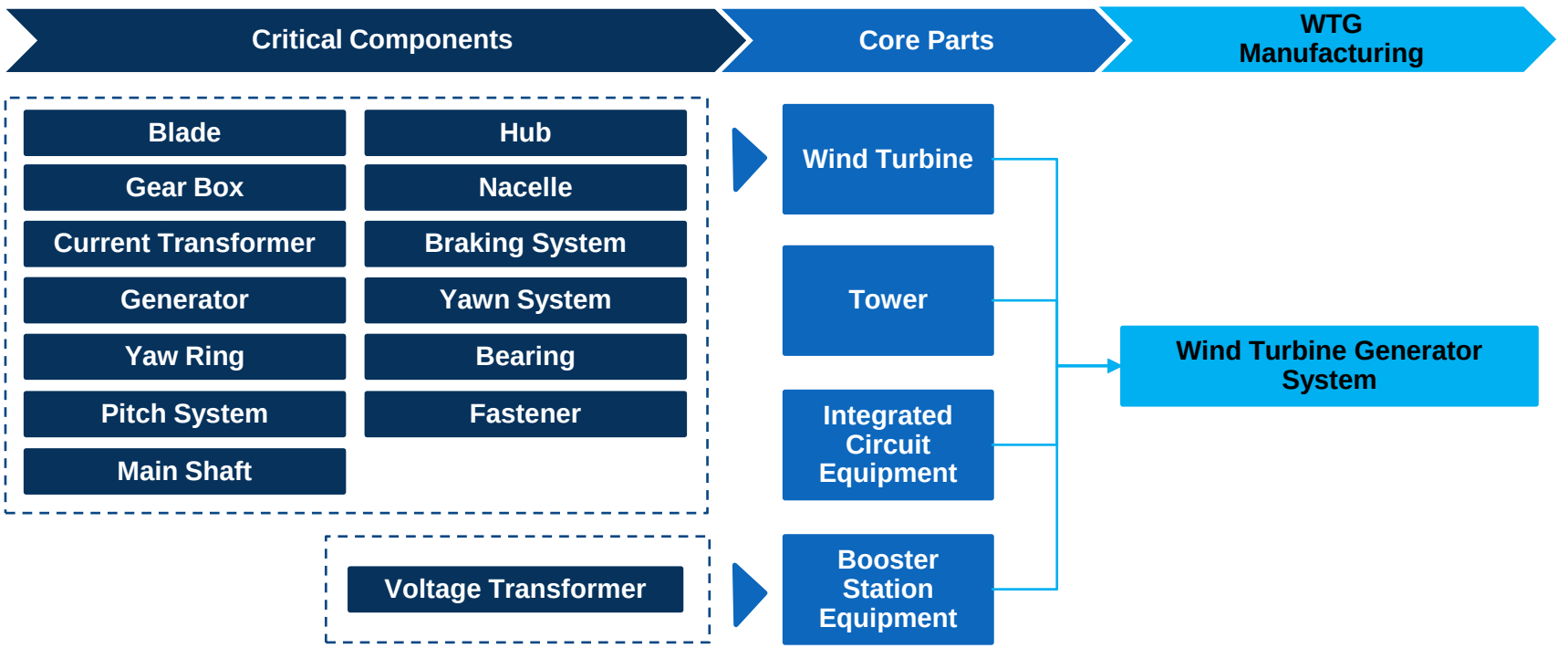
Note: The data represent the wind power density and wind speed at the height of 70 meters above sea level.

Source: NREL, GWA, Frost & Sullivan

Analysis of Wind Turbine Market
Value Chain (1/3)

- Wind turbine generator system mainly consists of several parts: tower, wind turbine, integrated circuit equipment and booster station equipment. A wind turbine turns wind energy into electricity using the aerodynamic force from the rotor blades, which is driven by the force of the lift created by difference in air pressure across the two sides of the blade when wind flows across the blade. The rotor connects to the generator, either directly or through a shaft and a series of gears (a gearbox) that speed up the rotation and allow for a physically smaller generator. This translation of aerodynamic force to rotation of a generator creates electricity. Tower is a critical component to support the main parts of wind turbine to a certain height from the ground. Integrated circuit equipment is designed for the transmission of electricity. Booster station equipment mainly consists of voltage transformer, which raises the output voltage of electricity to a higher level and then send the electricity out.

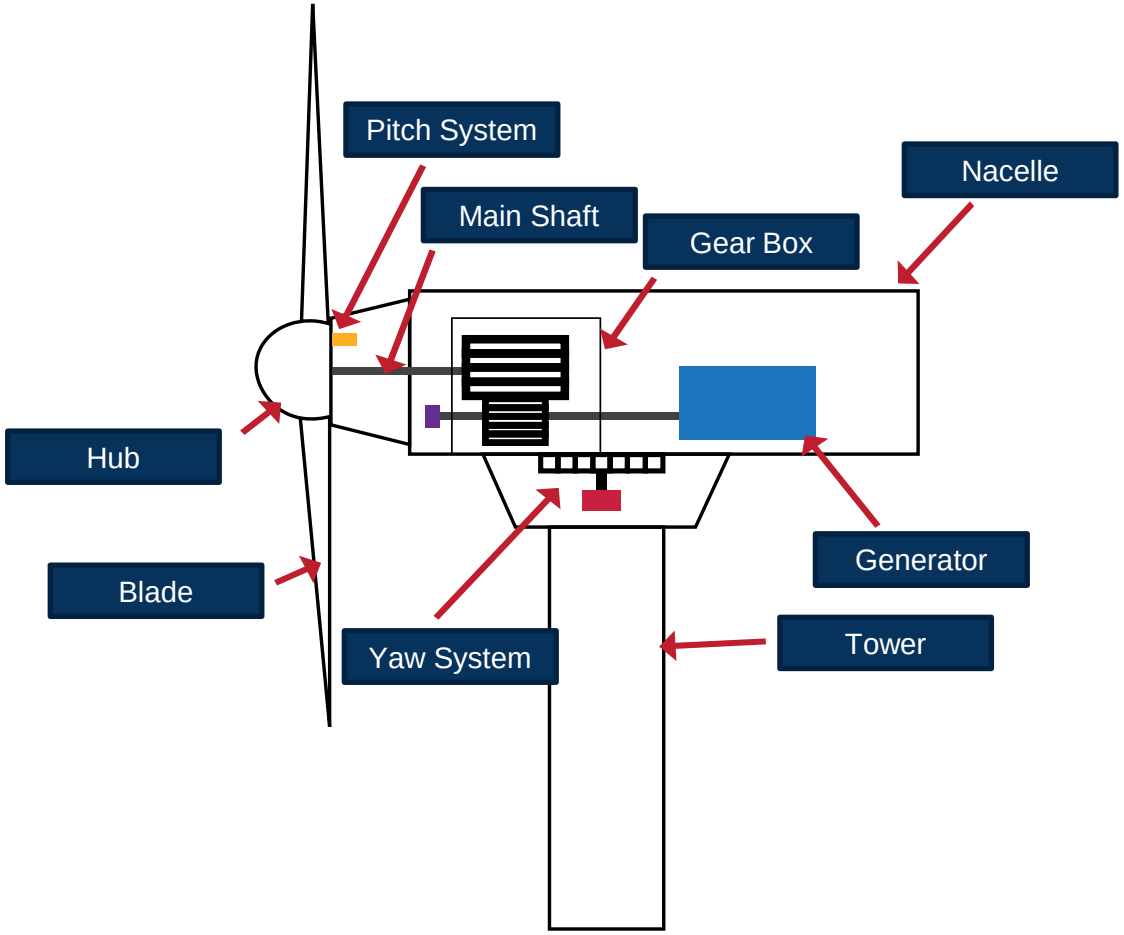
Value Chain of WTG Core Parts and Components



Source: Frost & Sullivan

Analysis of Wind Turbine Market
Value Chain (2/3)

Graph of WTG Core Parts and Components



Source: Frost & Sullivan

Analysis of Wind Turbine Market
Value Chain (3/3)

- The cost of wind turbine takes up the majority (approximately 50-60%) of the cost of wind turbine generator system. Wind turbine is the most important part of wind turbine generator system, which converts the wind's kinetic energy into electrical energy, and the top three core components in the wind turbine with the largest cost proportion are blade (20-25%), gear box (12-15%) and current transformer (4-6%). For wind turbine manufacturers, the production of many components are outsourced. Some wind turbine manufacturers are increasing the in-house production of components, especially the core components, which enables them to realize better cost control and higher profit margin. For example, the wind turbine manufacturers that have self-produced blades may have 2-3% higher gross profit margin than manufacturers that outsource the production of blades.

Average Cost of Each Part and Component of WTG

Core Parts	Core Component	Average Cost Proportion
Tower		25-30%
Wind Turbine	Blade	20-25%
	Gear Box	12-15%
	Current Transformer	4-6%
	Generator	3-5%
	Yaw System	2-4%
	Pitch System	2-4%
	Main Shaft	1-2%
	Hub	1-2%
Booster Station Equipment	Voltage Transformer	3-5%
Integrated Circuit Equipment	Cable	1-2%
Others		10-15%
	Total	**100%**

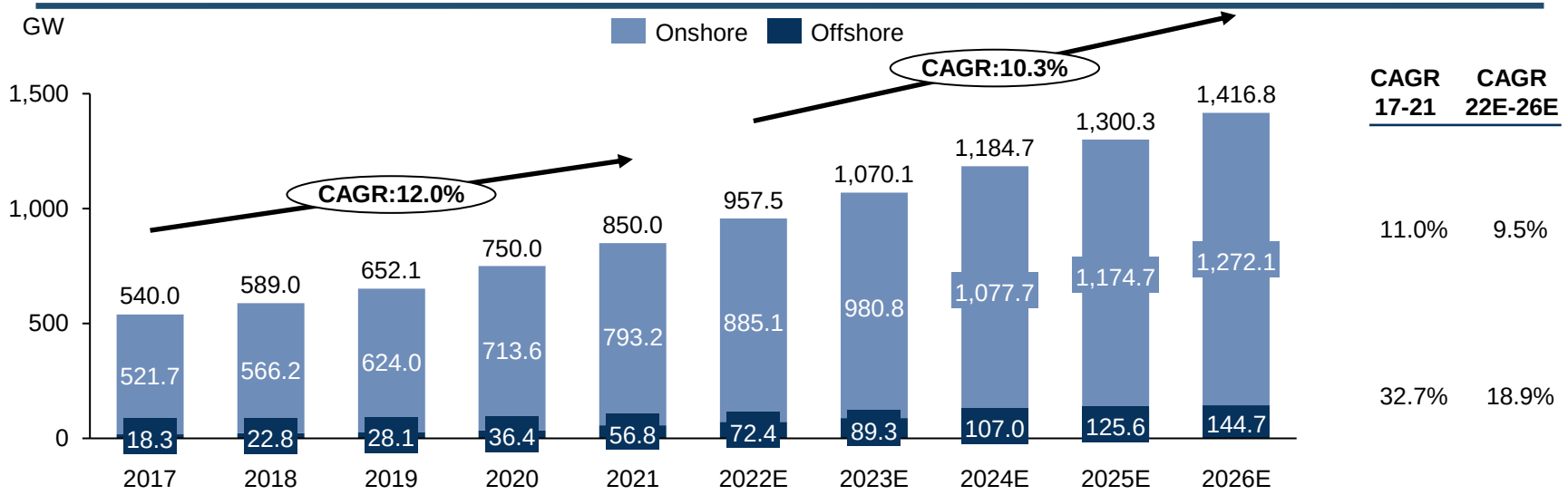
Source: Frost & Sullivan

Analysis of Wind Turbine Market
Installed Wind Power Capacity (1/13)

- As wind power is one of the key drivers to accelerate transition from fossil fuels to sustainable green energy, increasing number of countries including China, European countries and the US have made commitments to net zero or carbon neutrality targets partly through expediting wind farm construction and grid connection. From 2017 to 2021, global cumulative installed wind power capacity increased from 540.0GW to 850.0GW, representing a CAGR of 12.0%. Through technology innovations and economies of scale, wind power is expected to build its competitive advantage among renewable energies, and global cumulative installed wind power capacity is expected to reach 1,416.8GW in 2026 with a CAGR of 9.5% during the forecast period.

- By location, wind power can be classified into onshore and offshore wind power. Generally, onshore wind power dominates the market. In recent years, advances in technology have led to rapid development of offshore wind power. Compared to onshore wind turbine, offshore wind turbine has advantages of higher power generation efficiency and less land usage. Governments have set offshore wind power as a long-term strategy of wind power. Global cumulative installed offshore wind power capacity is expected to reach 144.7GW in 2026 with a CAGR of 18.9% in the forecast period. And the market share of offshore wind power is expected to increase from 6.7% in 2021 to 10.2% in 2026.

Cumulative Installed Wind Power Capacity* (onshore and offshore), Global, 2017-2026E



	CAGR 17-21	CAGR 22E-26E
	11.0%	9.5%
	32.7%	18.9%

Note: Wind power capacity in the following sections refers to the capacity of commissioned wind turbines, which have been correctly installed and it's ready for energy production.

Source: Frost & Sullivan

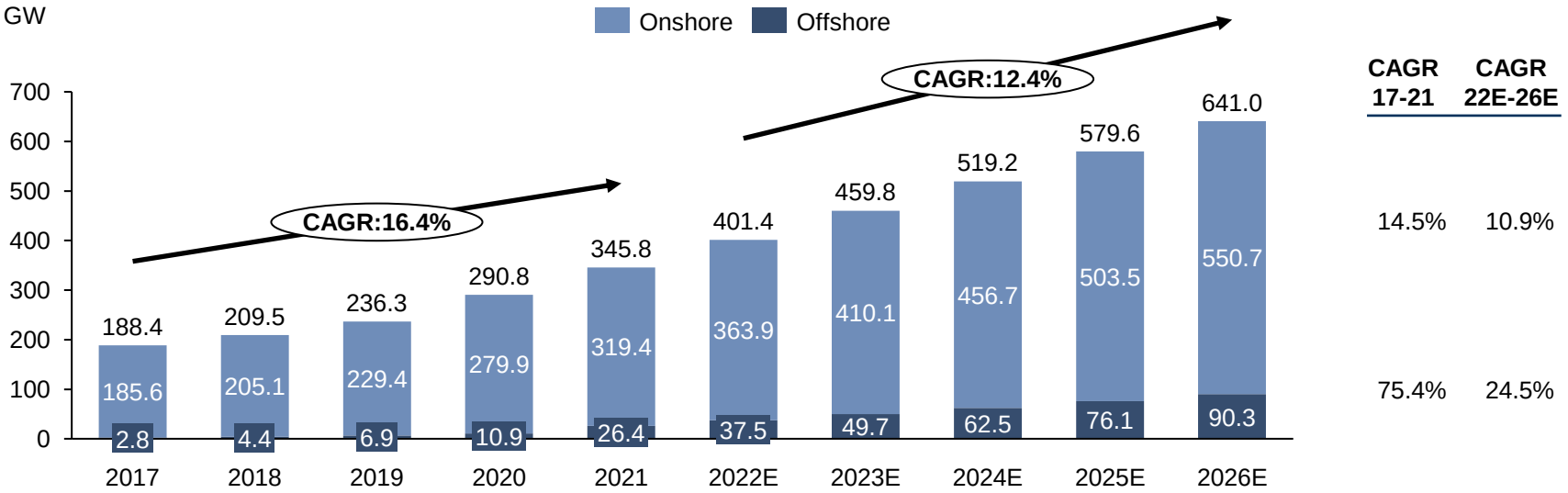
Analysis of Wind Turbine Market
Installed Wind Power Capacity (2/13)

- The cumulative installed wind power capacity in China increased from 188.4 GW in 2017 to 345.8 GW in 2021, representing a CAGR of 16.4% during the period. Chinese government has announced goal to reach peak carbon emissions before 2030 and achieve carbon neutrality before 2060. To support the commitment, more than 400 wind energy companies have jointly adopted the *Beijing Declaration on Wind Energy* 《风能北京宣言》, aiming for more than 50 GW of annual installations during the period from 2021 to 2025 and more than 60 GW from 2026 onwards. Favorable industrial policies such as financial investment, green credit, and environment tax will provide strong incentives to wind power market players companies in China, which will further facilitate the development of wind turbine market. Cumulative installed wind power capacity in China is expected to reach 641.0 GW in 2026, accounting for approximately 45.2% of global cumulative installed wind power capacity in 2026.

- China has been leading development of offshore wind power, accounting for 46.5% global cumulative installed offshore wind power capacity in 2021. From 2022 to 2026, cumulative installed offshore wind power capacity in China is expected to increase from 37.5 GW to 90.3 GW, representing a CAGR of 24.5%.

- In 2021, the average utilization of wind farm in China was 2,246 hours. Meanwhile, the average utilization of solar farm in China was 1163 hours.

Cumulative Installed Wind Power Capacity (onshore and offshore), China, 2017-2026E



Note: Wind power capacity in the following sections refers to the capacity of commissioned wind turbines, which have been correctly installed and it's ready for energy production.

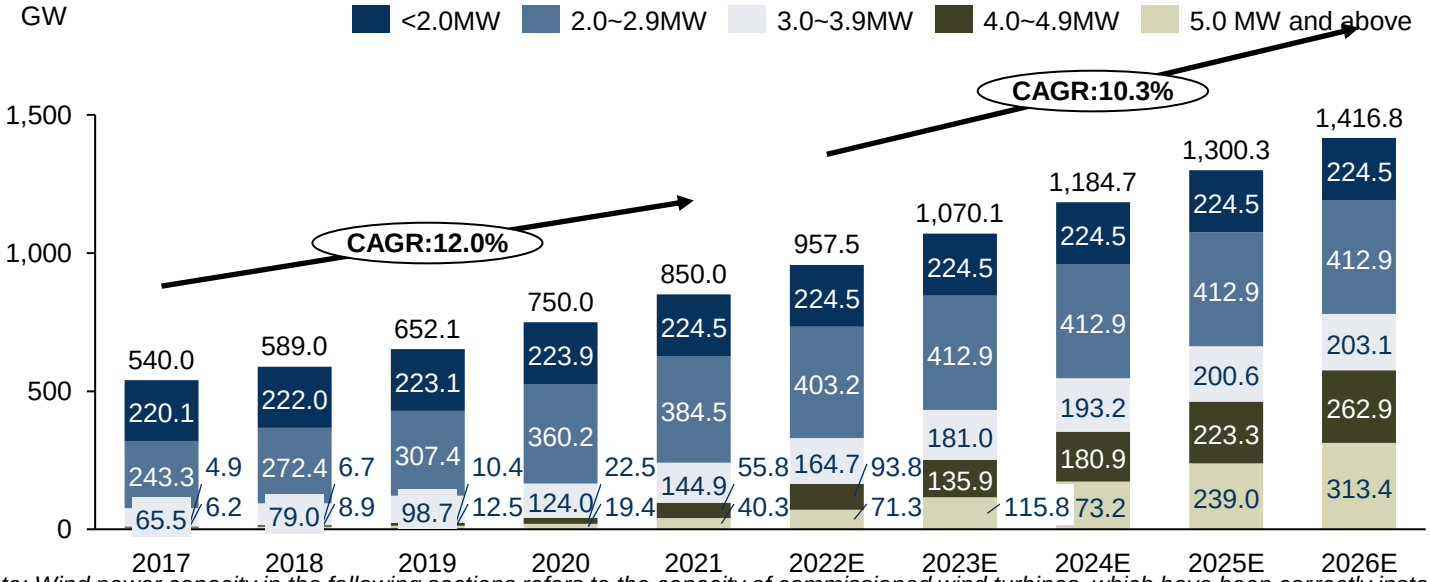
Source: National Energy Administration, Frost & Sullivan

Analysis of Wind Turbine Market
Installed Wind Power Capacity (3/13)

- Wind turbine with large unit capacity is a key trend. The increment in unit capacity of wind turbine can help reduce manufacturing, construction, and maintenance cost per MW, which helps improve profit margins of wind energy companies. For example, for a 100MW wind farm project, 50 units of 2 MW wind turbine could be reduced to 20 units of 5MW wind turbine, thus reducing number of units required for same wind farm scale. Considering limited land resources, wind turbine with large unit capacity can also alleviate concerns of insufficient wind farm sites. As wind turbine market becomes increasingly competitive, leading wind turbine manufacturers, such as Vestas, GE Energy, and Mingyang, have been investing heavily on large unit capacity wind turbine to improve their profits and establish their competitive advantages in the market.

- From 2022 to 2026, global cumulative installed power capacity of 4.0~4.9MW wind turbine is expected to increase from 93.8GW to 262.9GW, representing a CAGR of 29.4%; and global cumulative installed power capacity of 5.0 MW and above wind turbine is expected to increase from 71.3 GW to 313.4 GW, representing a CAGR of 44.8%.

Cumulative Installed Wind Power Capacity (by unit capacity), Global, 2017-2026E



	CAGR 17-21	CAGR 22E-26E
<2.0MW	0.5%	0.0%
2.0~2.9MW	12.1%	0.6%
3.0~3.9MW	21.9%	5.4%
4.0~4.9MW	84.0%	29.4%
5.0 MW and above	59.3%	44.8%

Note: Wind power capacity in the following sections refers to the capacity of commissioned wind turbines, which have been correctly installed and it's ready for energy production.

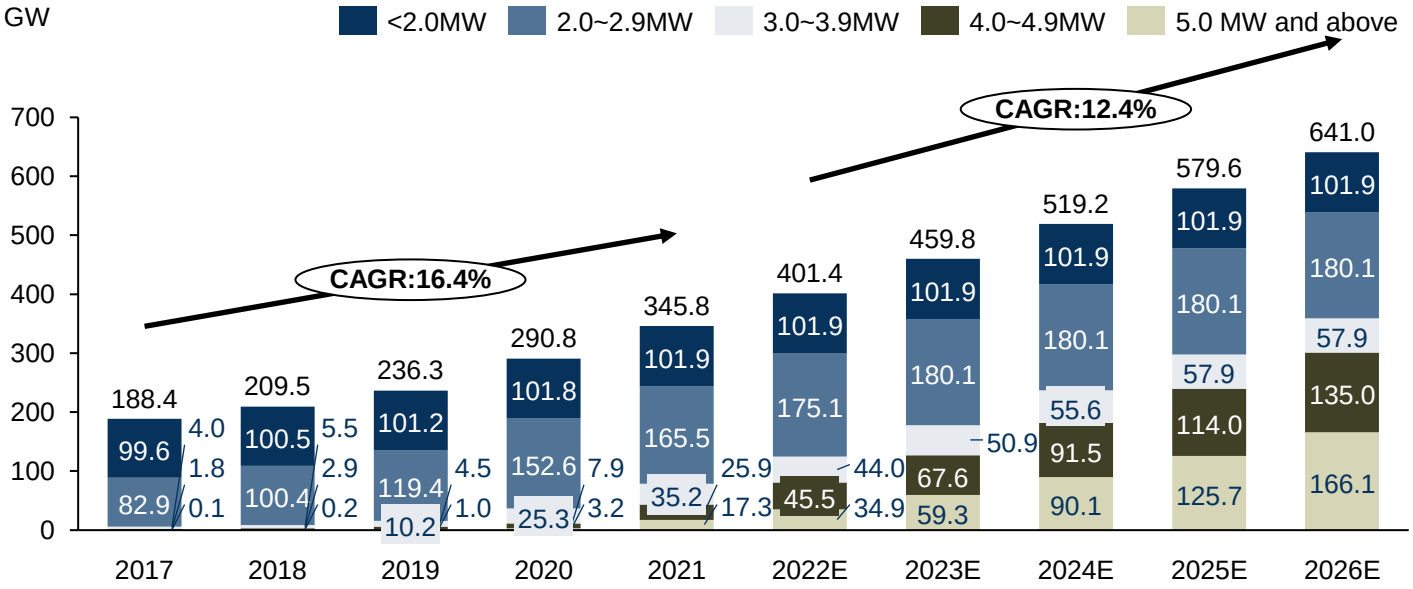
Source: Frost & Sullivan

Analysis of Wind Turbine Market
Installed Wind Power Capacity (4/13)

- As onshore wind turbine market in China entered into subsidy free era and on-grid price of wind power achieved grid parity with that of coal-fired power in 2021, wind turbine manufacturers in China sped up their development of large unit capacity wind turbine to ensure their profits, which could also further reduce LCOE of wind power. Meanwhile, increment in unit capacity of wind turbine could help leading wind turbine manufacturers such as Mingyang enhance their competitiveness, as development of large unit capacity wind turbine has higher capital investment and technology barriers. Due to severe and volatile natural environment, offshore wind turbine typically has extra costs in terms of construction, transportation, and maintenance compared to onshore wind turbine, unit capacity of offshore turbine typically falls in 5.0 MW and above to reduce average manufacturing cost per power capacity. With increasing market share of offshore wind power in China, large unit capacity wind turbine is going to have great potential in the forecast period.

- From 2022 to 2026, cumulative installed power capacity of 4.0~4.9MW wind turbine in China is expected to increase from 45.5 GW to 135.0 GW, representing a CAGR of 31.2%; and cumulative installed power capacity of 5.0 MW and above wind turbine in China is expected to increase from 34.9 GW to 166.1 GW, representing a CAGR of 47.7%.

Cumulative Installed Wind Power Capacity (by unit capacity), China, 2017-2026E



	CAGR 17-21	CAGR 22E-26E
<2.0MW	0.6%	0.0%
2.0~2.9MW	18.9%	0.7%
3.0~3.9MW	72.4%	7.1%
4.0~4.9MW	96.1%	31.2%
5.0 MW and above	270.1%	47.7%

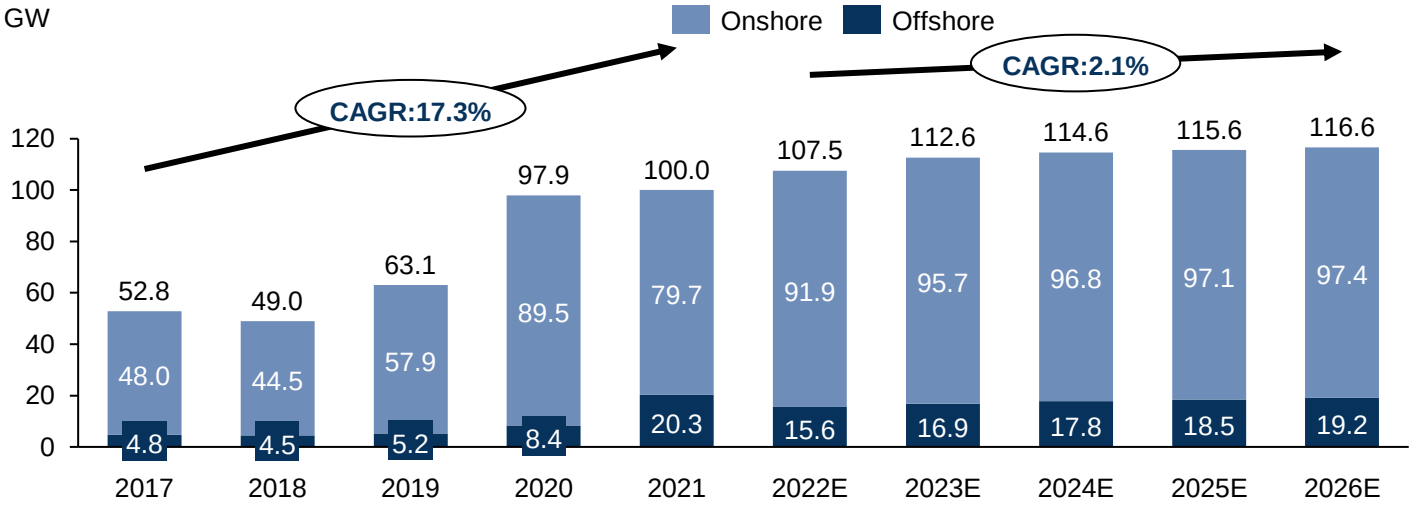
Note: Wind power capacity in the following sections refers to the capacity of commissioned wind turbines, which have been correctly installed and it's ready for energy production.

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Installed Wind Power Capacity (5/13)

- Global newly installed wind power capacity increased significantly from 52.8 GW in 2017 to 100.0 GW in 2021, representing a CAGR of 17.3%. The growth of global newly installed wind power capacity is mainly driven by the significant growth of onshore wind installations, particularly in China, due to the rush in installations before China entered into grid parity in 2021 (onshore wind projects in China installed from 2021 will no longer receive subsidies). Despite China's onshore wind power market entered into grid party in 2021, global newly installed onshore wind power capacity is expected to maintain sustainable growth in order to support net zero / carbon neutrality targets set by different countries in the coming years. For example, European Union has set the target that by 2030, renewable energy is expected to account for 40% of energy end use; while UK government has set the target that by 2035, electricity generation in UK will be fossil fuel free and from 100% renewable sources. Global newly installed onshore wind power capacity is expected to increase from 91.9 GW in 2022 to 97.4 GW in 2026, representing a CAGR of 1.4% in the forecast period.
- In recent years, advances in technology, such as development of hybrid-drive wind turbine and high unit capacity wind turbine, have led to the rapid development of offshore wind power. Compared with onshore wind turbine, offshore wind turbine has the advantages of higher power generation efficiency and requires less land usage. Governments have set offshore wind power as a long-term strategy of wind power. For example, US Energy, Commerce, and Transportation Departments announced to establish a target of employing about 77,000 workers for offshore wind power to deploy 30 GW of offshore wind by 2030. European Commission adopted strategy for offshore wind power, which targeted to increase Europe's total offshore wind capacity to at least 60GW by 2030, and to 300 GW by 2050. From 2017 to 2021, global newly installed offshore wind power capacity increased from 4.8 GW in 2017 to 20.3 GW in 2021, representing a CAGR of 43.4%. In 2021, offshore wind capacity installations accounts for over 15% of total global newly installed wind capacity. In 2026, global newly installed offshore wind power capacity is expected to reach 19.2 GW, representing a CAGR of 5.4% from 2022 to 2026.

Newly Installed Wind Power Capacity (onshore and offshore), Global, 2017-2026E



	CAGR 17-21	CAGR 22E-26E
Onshore	13.5%	1.4%
Offshore	43.4%	5.4%

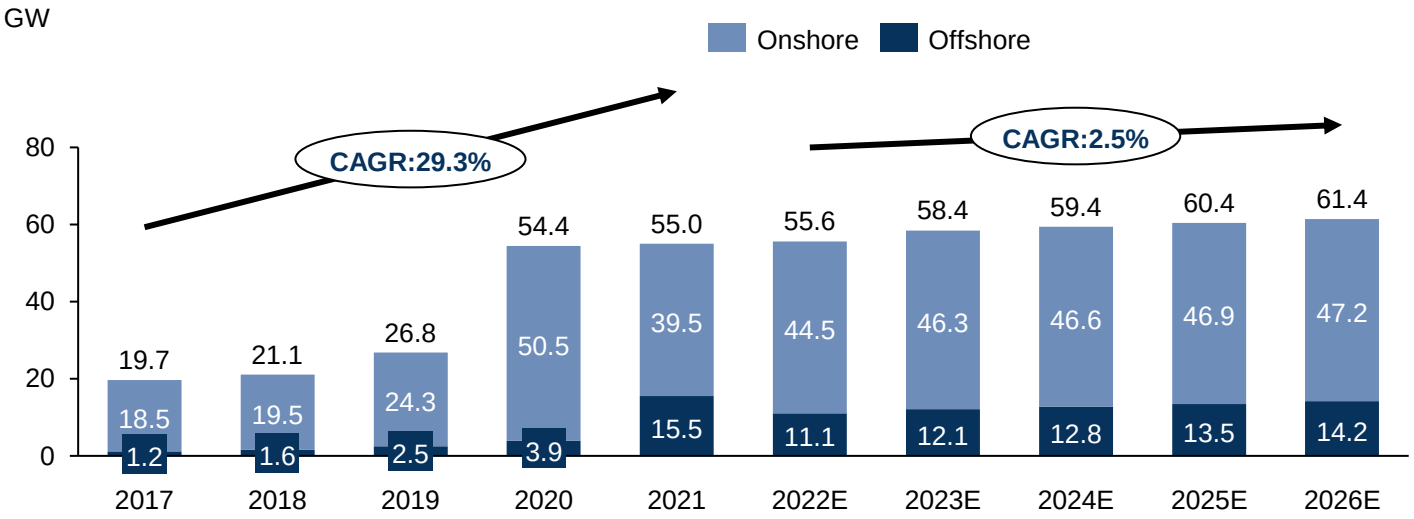
Note: Wind power capacity in the following sections refers to the capacity of commissioned wind turbines, which have been correctly installed and it's ready for energy production.

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Installed Wind Power Capacity (6/13)

- According to NDRC's notice on Wind Power On-grid Price released in May 2019 (《国家发展改革委关于完善风电上网电价政策的通知》), Chinese government will no longer provide subsidies on newly approved onshore wind power projects starting from 2021. Newly installed wind power capacity in China amounted to 50.5 GW in 2020, compared with 24.3 GW in 2019 and 18.5 GW in 2017, in light of China entering into grid parity for onshore wind projects. Newly installed onshore wind power capacity is expected to remain steady, ranging from 44.5 GW in 2022 to 47.2 GW in 2026. Despite China has entered into grid parity for onshore wind projects, newly installed capacity is driven by declining LCOE of wind power (due to improvements in wind power technology and power generation efficiency) and carbon neutrality target of 2060 set by the Chinese government.
- According to NDRC's opinion on the Promotion of Sustainable Development of Renewable Energy (《关于促进非水可再生能源发电健康发展的若干意见》) released in September 2020, the Chinese government will no longer provide subsidies on newly approved offshore wind power projects starting from 2021. As China has entered into grid parity for offshore wind projects after the end of 2021, newly installed offshore wind power capacity in China amounted to 15.5 GW in 2021, compared with 3.9 GW in 2020 and 1.2 GW in 2017. Post the peak installation year in 2021, China's newly installed offshore wind power capacity is expected to slightly decline. Regional governments such as Guangdong, Zhejiang, and Shandong have been releasing supportive policies to facilitate construction of offshore wind power projects. In June 2021, Government of Guangdong Province released Implementation Plan to Promote the Development of Offshore Wind Power (《促进海上风电有序开发和相关产业可持续发展的实施方案》) , which decided to continuously provide subsidies to newly installed offshore wind power projects in Guangdong. Driven by favorable policies from governments at different levels, newly installed offshore wind power capacity in China is expected to reach 14.2 GW in 2026 from 11.1 GW in 2022, representing a CAGR of 6.4% during the period.

Newly Installed Wind Power Capacity (onshore and offshore), China, 2017-2026E



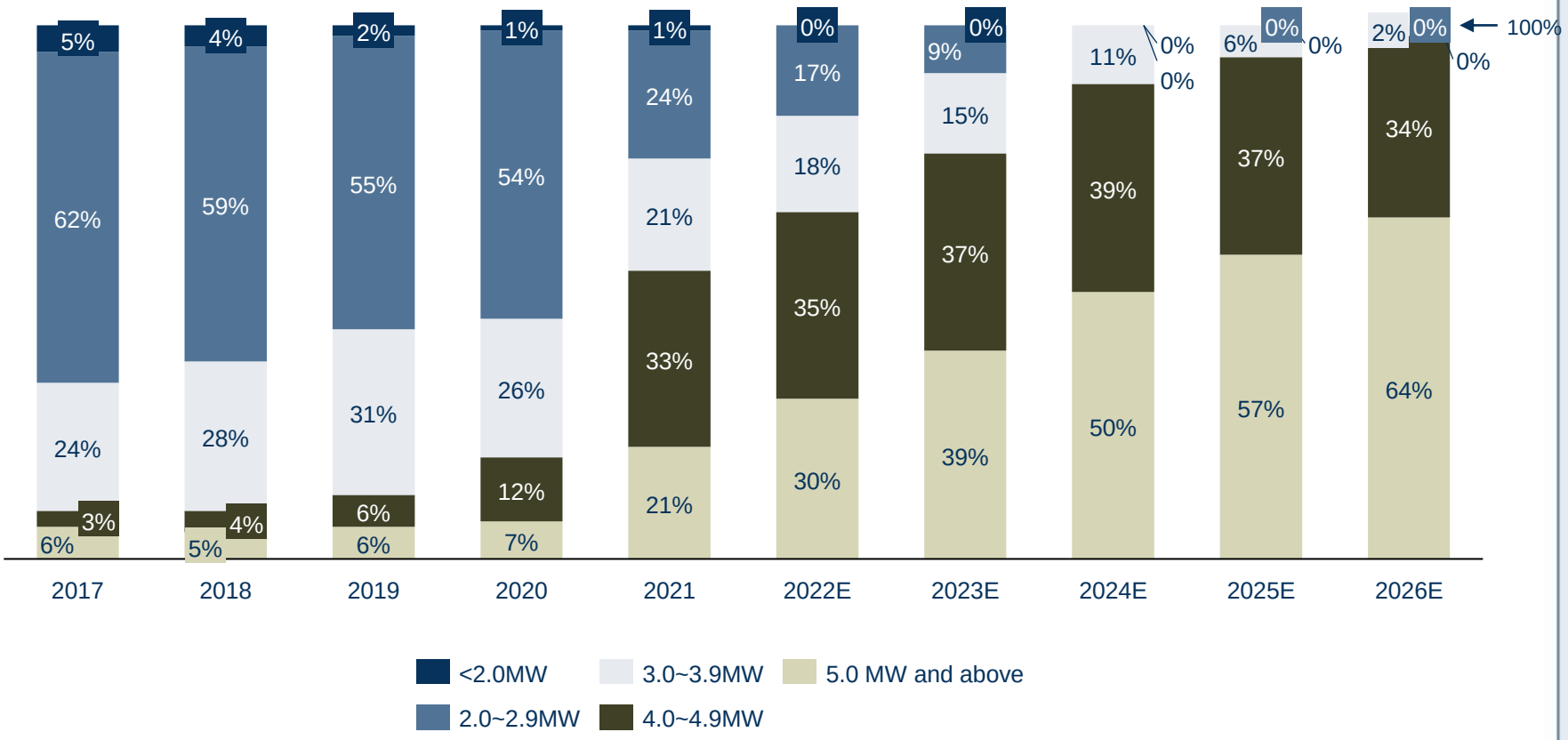
	CAGR 17-21	CAGR 22E-26E
Onshore	20.9%	1.5%
Offshore	91.1%	6.4%

Note: Wind power capacity in the following sections refers to the capacity of commissioned wind turbines, which have been correctly installed and it's ready for energy production.

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Installed Wind Power Capacity (7/13)

Market share of Newly Installed Wind Power Capacity (by unit capacity), Global, 2017-2026E



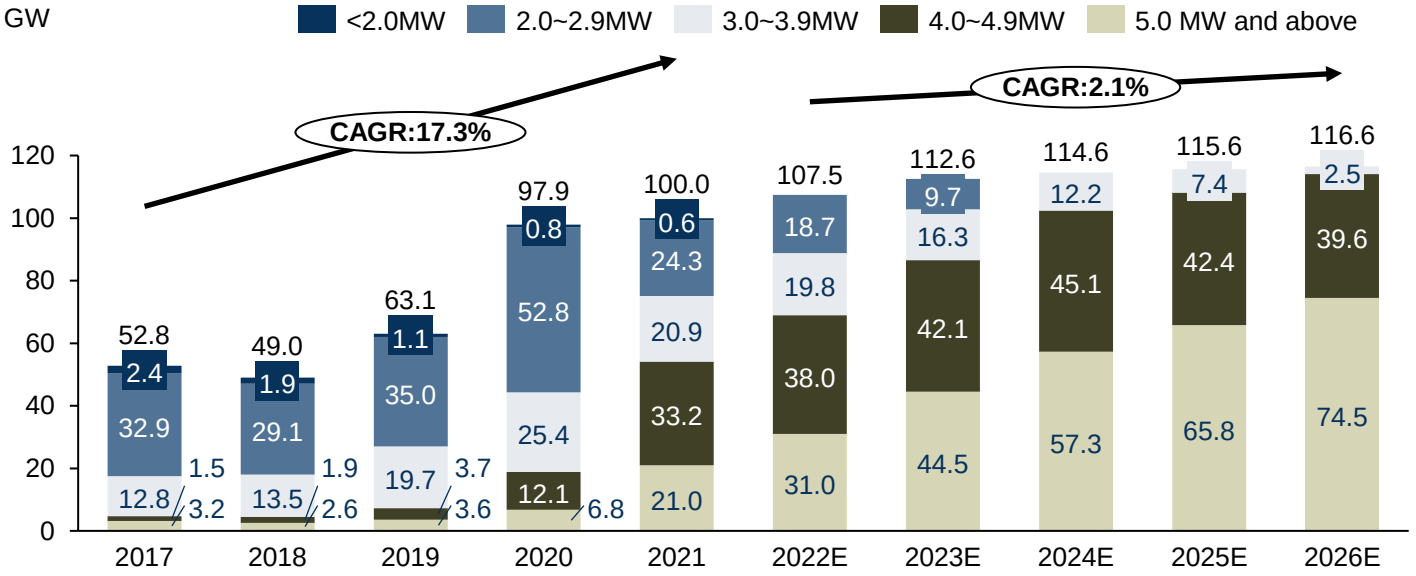
Source: Frost & Sullivan

Analysis of Wind Turbine Market
Installed Wind Power Capacity (8/13)

- To further increase wind power generation efficiency and lower cost, wind turbine with larger rotor size and higher unit capacity is expected to become the future trend of the market. Low capacity wind turbine such as <2.0MW is expected to be gradually phased out in the forecast period.

- By unit capacity, global newly installed wind power capacity of 4.0~4.9MW wind turbine is expected to increase from 38.0 GW in 2022 to 39.6 GW in 2026 representing a CAGR of 1.0%. global newly installed wind power capacity of 5.0 MW and above wind turbine is expected to increase from 31.0 GW in 2022 to 74.5 GW in 2026, representing a CAGR of 24.5%. 5.0 MW and above wind turbine is expected to become the fastest growing segment in the forecast period.

Newly Installed Wind Power Capacity (by unit capacity), Global, 2017-2026E



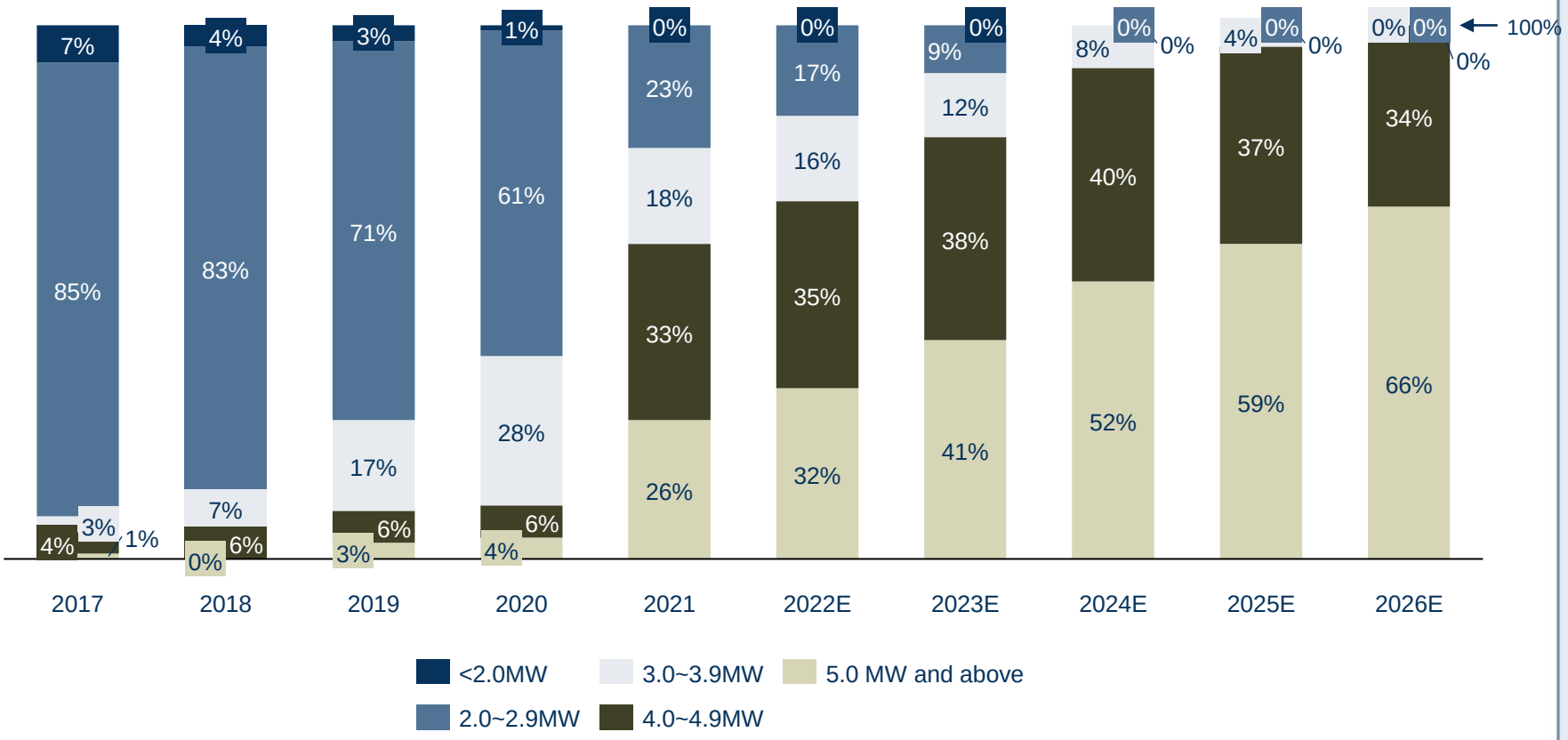
	CAGR 17-21	CAGR 22E-26E
<2.0MW	-30.2%	NA
2.0~2.9MW	-7.3%	-100.0%
3.0~3.9MW	13.0%	-40.3%
4.0~4.9MW	118.7%	1.0%
5.0 MW and above	59.5%	24.5%

Note: Wind power capacity in the following sections refers to the capacity of commissioned wind turbines, which have been correctly installed and it's ready for energy production.

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Installed Wind Power Capacity (9/13)

Market share of Newly Installed Wind Power Capacity (by unit capacity), China, 2017-2026E



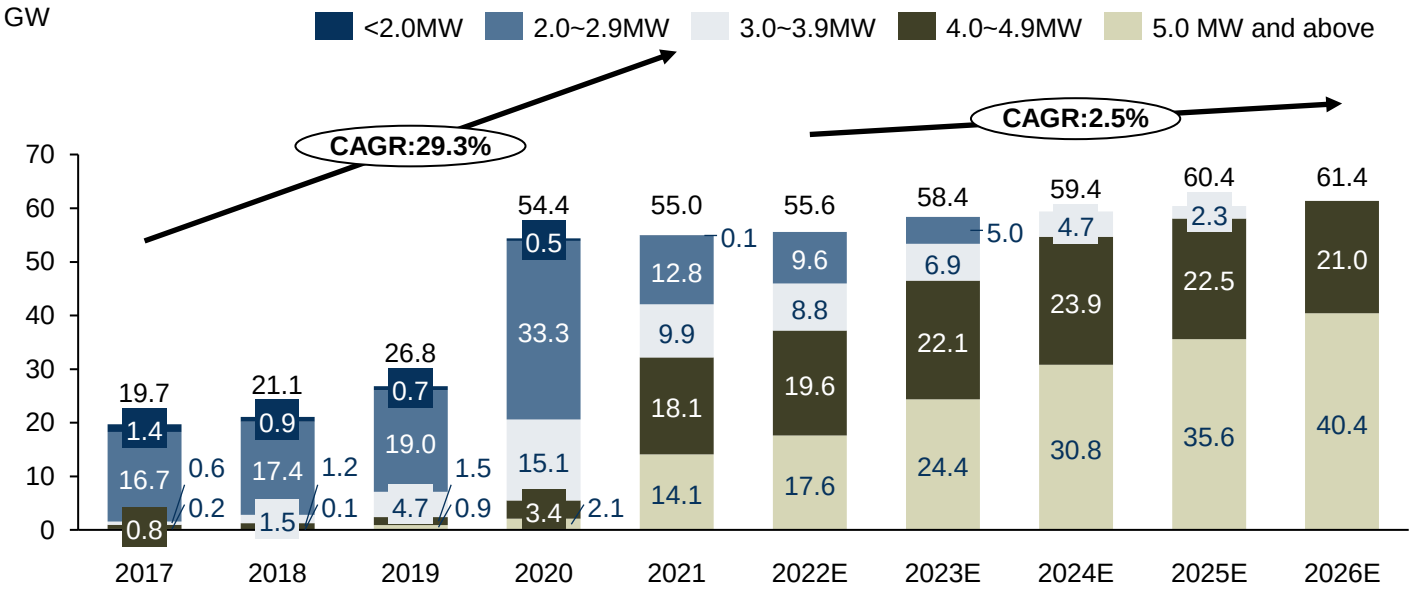
Source: Frost & Sullivan

Analysis of Wind Turbine Market
Installed Wind Power Capacity (10/13)

- With the phase-out of subsidies on wind power and arrival of wind power grid parity in China, the competition of the wind turbine market in China is expected to become increasingly intensive in terms of cost controlling, price and unit capacity of the turbine. The increment in unit capacity of wind turbine is expected to further reduce average manufacturing cost per power capacity of the turbine. From 2017 to 2020, the average capacity of onshore wind turbine installed increased from 2.1 MW to 2.6 MW, and the average capacity of offshore wind turbine installed increased from 3.7 MW to 4.9 MW. Wind turbine manufacturers have been investing heavily on larger unit capacity wind turbine to reduce average manufacturing cost per capacity and establish their competitive advantages in the market.

- By unit capacity, newly installed wind power capacity of 4.0~4.9MW wind turbine in China is expected to increase from 19.6 GW in 2022 to 21.0 GW in 2026 representing a CAGR of 1.7%; and newly installed wind power capacity of 5.0 MW and above wind turbine in China is expected to increase from 17.6 GW in 2022 to 40.4 GW in 2026, representing a CAGR of 23.1%. 5.0 MW and above wind turbine is expected to become the fastest growing segment in the forecast period.

Newly Installed Wind Power Capacity (by unit capacity), China, 2017-2026E



	CAGR 17-21	CAGR 22E-26E
<2.0MW	-48.3%	NA
2.0~2.9MW	-6.4%	-100.0%
3.0~3.9MW	104.2%	-100.0%
4.0~4.9MW	118.7%	1.7%
5.0 MW and above	220.0%	23.1%

Note: Wind power capacity in the following sections refers to the capacity of commissioned wind turbines, which have been correctly installed and it's ready for energy production.

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Installed Wind Power Capacity (11/13)

- Wind turbine can be mainly classified into double-fed, direct-drive and hybrid-drive wind turbines. Direct-drive and double-fed are two mainstream wind turbine types currently on the market. Compared with double-fed wind turbines, the volume of direct-drive is relatively large under the same capacity, and the lifting and transportation costs are relatively higher. However, due to the risk of damage, such as overloading of the gearbox, the operation and maintenance cost of direct-drive wind turbines is relatively low. Hybrid-drive, a technology that combines the advantages of direct-drive and double-fed, is catching up.

Types	Description	Strengths	Weakness
Hybrid-drive Wind Turbine	• The turbine is designed with both magnet and gearbox, which combines the advantages of double-fed and direct-drive wind turbines. • Compared to direct-drive technology, the hybrid-drive technology employs a gearbox to increase the speed of wind turbine. At the same time, the manufacturing costs and weight of the turbine are reduced. Compared to double-fed technology, the hybrid-drive technology effectively improves the operational efficiency of the wind turbines and reduce the loss of the gearbox at low wind speed.	• High efficiency • Large capacity • Smaller size • Lightweight	• Still in the early stage of development due to the high technical requirements
Double-fed Wind Turbine	• The turbine has a gearbox between the low-speed rotor and a higher speed electrical generator to increase the rotational rotor speed before feeding it to the generator. • However, gearbox is one of the highest-maintenance part of a turbine, that wind turbulence can cause enormous stress to the wheels and bearings in a gearbox, leading to defects in the turbine components and ultimately stopping the mechanism, which can in turn increase operation and maintenance costs of the turbine.	• Small-size • Lightweight	• Less reliable system • Excitation loss can be caused • Low efficiency • High maintenance cost
Direct-drive Wind Turbine	• The rotor of turbine is connected directly to the generator without a gearbox, and magnetic poles are placed in the generator to achieve the appropriate high output frequency. • Compared to double-fed wind turbine, direct-drive wind turbine with synchronous permanent magnet generator, has higher power efficiency, quieter operation and higher reliability. However, direct-drive turbine has higher manufacturing cost and heavier weight compared to double-fed turbine, due to raw materials such as permanent magnets.	• High efficiency • Large capacity • Needs no gearbox	• Large size and weight • High costs of transport and hoisting

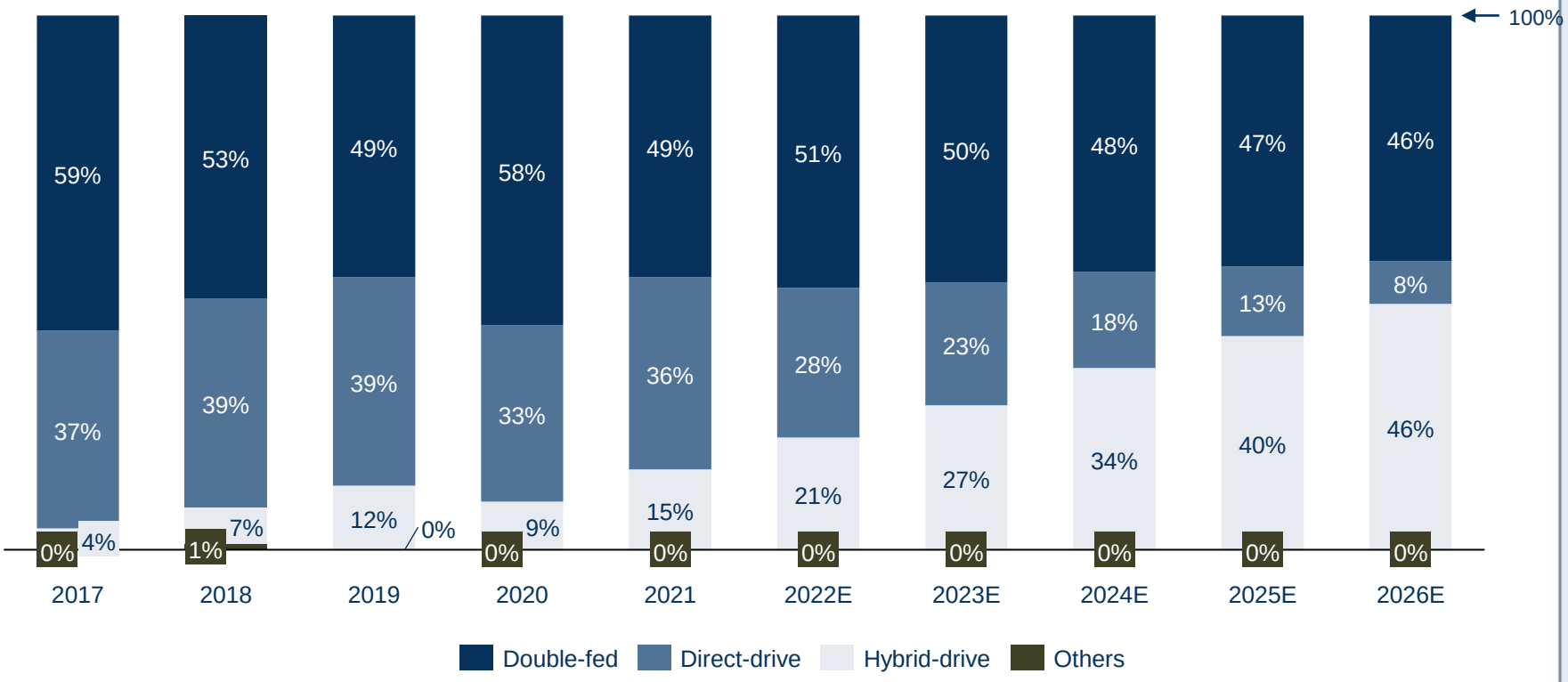
Others refer to wind turbine using technologies such as squirrel-cage asynchronous motor wind turbine (鼠笼式异步风机)

** Manufacturers are shown for illustrative purpose only and are not exhaustive*

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Installed Wind Power Capacity (12/13)

Market share of Newly Installed Wind Power Capacity (by type), China, 2017-2026E

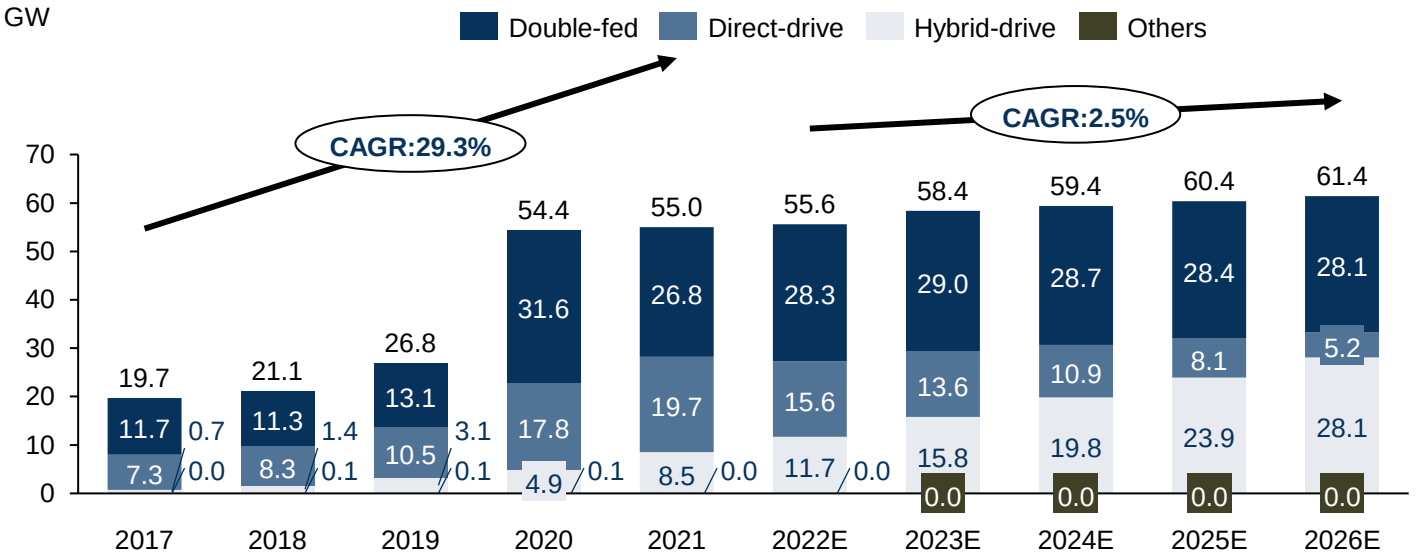


Source: Frost & Sullivan

Analysis of Wind Turbine Market
Installed Wind Power Capacity (13/13)

- Traditionally, the wind turbine market in China was dominated by double-fed and direct-drive wind turbines. Newly installed wind power capacity of double-fed turbine in China increased from 11.7GW in 2017 to 26.8GW in 2021 at a CAGR of 23.1%, accounting for a market share of 48.7% in 2021; and newly installed wind power capacity of direct-drive turbine in China increased from 7.3GW in 2017 to 19.7GW in 2021 at a CAGR of 28.3%, accounting for a market share of 35.8% in 2021.
- As the phaseout of subsidies on wind power and arrival of wind power grid parity in Chinese wind power market in 2021, the competition of the wind turbine market in China is expected to become increasingly intensive in terms of price, efficiency and reliability of the turbine. Hybrid-drive wind turbine combing advantages of double-fed and direct-drive wind turbines, can greatly reduce cost of the turbine, while maintaining comparable power efficiency and reliability. Leading wind turbine manufacturers such as Mingyang, Vestas and Shanghai Electric have successively announced their implementation of hybrid-drive wind turbine, and manufacturers such as Goldwind have also initiated their development of hybrid-drive wind turbine model since 2021. Newly installed wind power capacity of hybrid-drive wind turbine in China is expected to reach 28.1GW in 2026E from 11.7GW in 2022E. Among the newly installed wind power capacity in China, the proportion of wind turbines using the hybrid drive technology has increased from 3.3% in 2017 to 15.5% in 2021, and is expected to further increase to 45.8% in 2026.

Newly Installed Wind Power Capacity (by type), China, 2017-2026E



	CAGR 17-21	CAGR 22E-26E
Double-fed	23.1%	-0.2%
Direct-drive	28.3%	-24.0%
Hybrid-drive	90.2%	24.6%
Others	-2.9%	-100.0%

**Others refer to wind turbine using technologies such as squirrel-cage asynchronous motor wind turbine (鼠笼式异步风机)*

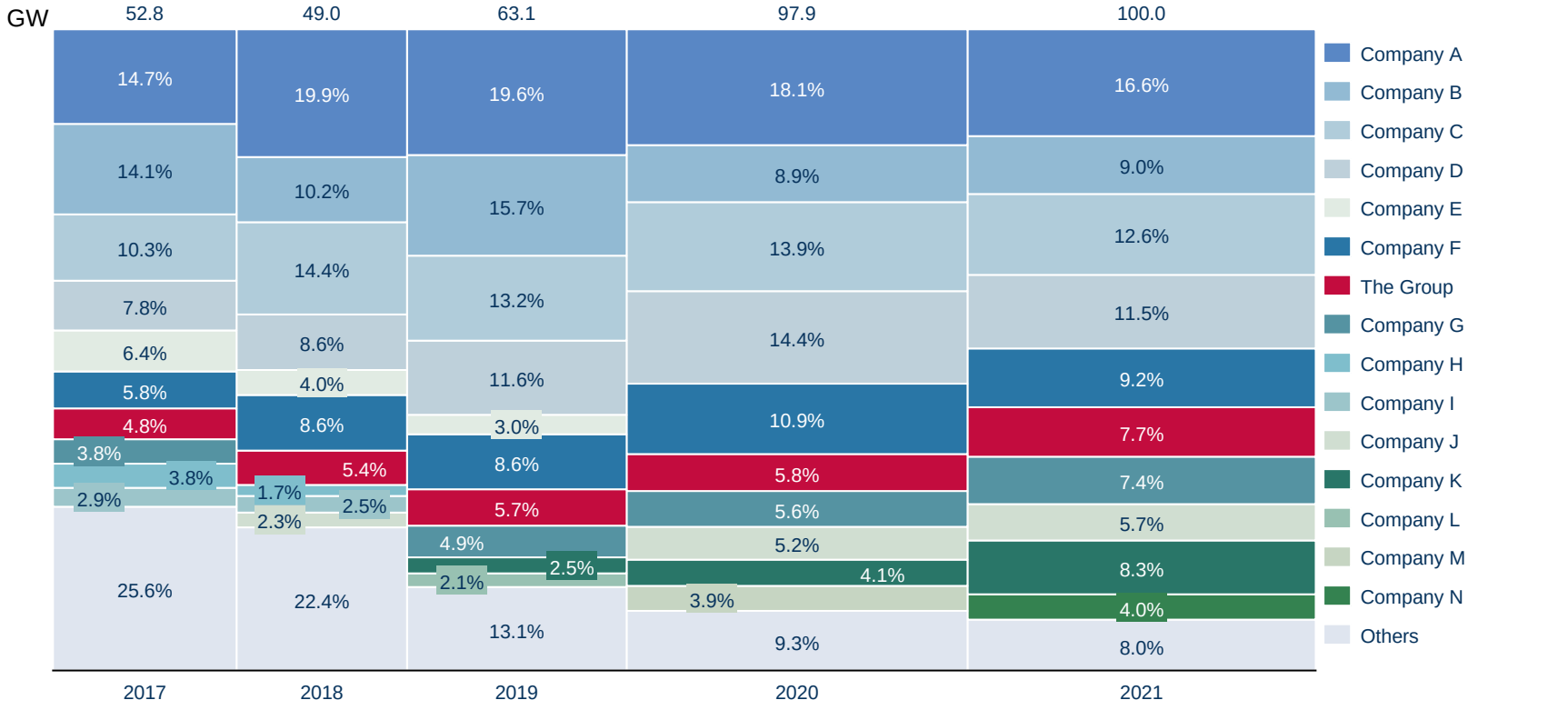
Note: Wind power capacity in the following sections refers to the capacity of commissioned wind turbines, which have been correctly installed and it's ready for energy production.

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Competitive Analysis of Wind Turbine Manufacturers (1/6)

- The global wind turbine market is becoming increasingly concentrated, and leading wind turbine manufacturers have been strengthening their competitive advantages in the market by focusing more on R&D and technological innovation of wind turbine models. The market share of top 10 wind turbine manufacturers increased from 74.4% in 2017 to 92.0% in 2021, in terms of newly installed capacity.

Market Share of Top 10 Wind Turbine Manufacturers (by newly installed capacity), Global, 2017-2021

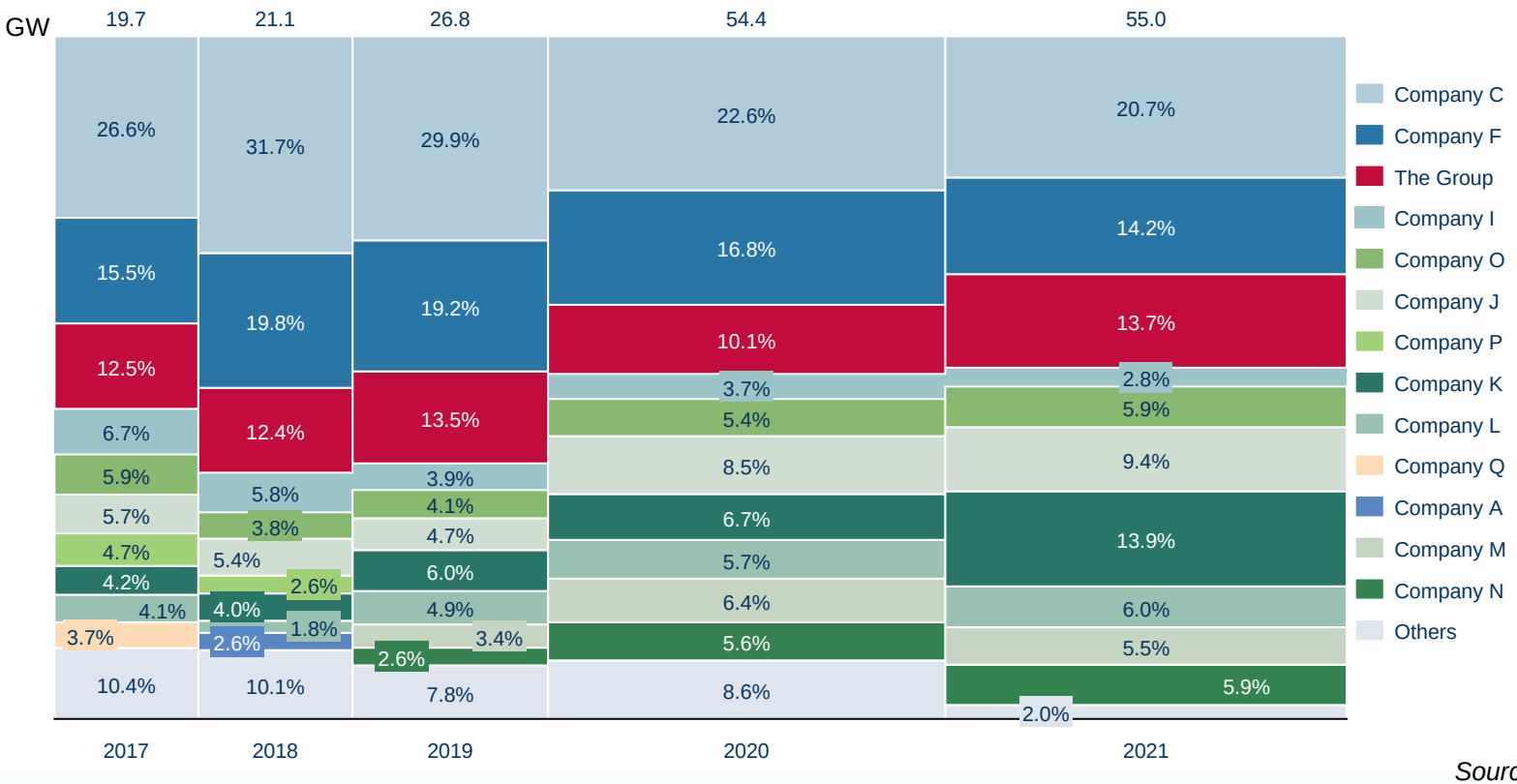


Source: Frost & Sullivan

Analysis of Wind Turbine Market
Competitive Analysis of Wind Turbine Manufacturers (2/6)

- Downstream customers of wind turbine manufacturers are generally large state-owned energy enterprises, which have strict bidding requirements on wind turbine suppliers in terms of product quality, manufacturing capacity, and reputation. As top 10 wind turbine manufacturers in China have established strong business relationships with downstream customers and built up strong technological innovation capabilities, the concentration of wind turbine market in China has rapidly increased, with top 10 wind turbine manufacturers' market share increased from 90.6% in 2017 to 98.0% in 2021.

Market Share of Top 10 Wind Turbine Manufacturers (by newly installed capacity), China, 2017-2021

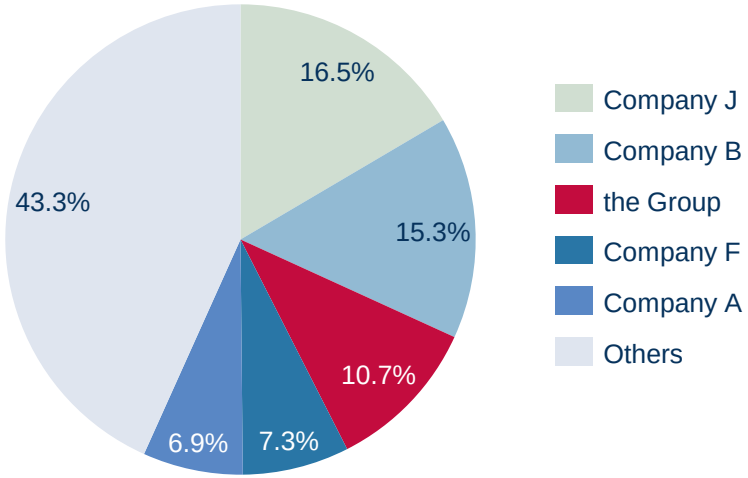


Source: Frost & Sullivan

Analysis of Wind Turbine Market
Competitive Analysis of Wind Turbine Manufacturers (3/6)

Top 5 Wind Turbine Manufacturers (by newly installed offshore capacity), Global, 2021

Total Newly Installed Capacity: 20.3 GW



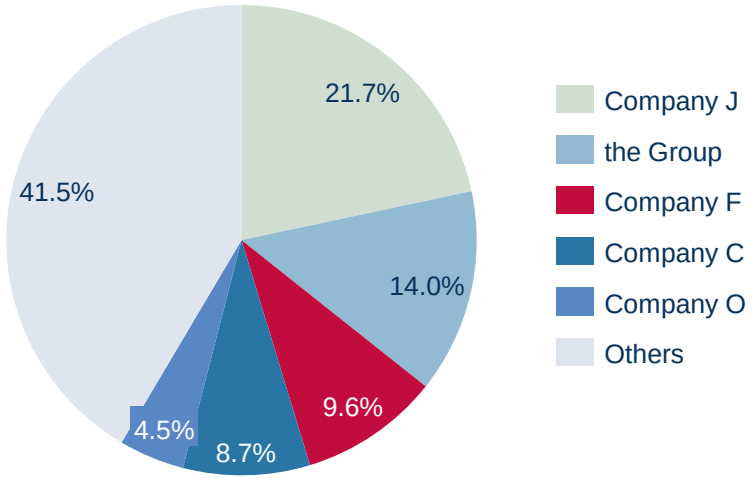
Rank	Manufacturer	Newly Installed Offshore Capacity (GW)	Market Share
1	Company J	3.4	16.5%
2	Company B	3.1	15.3%
3	**Mingyang**	**2.2**	**10.7%**
4	Company F	1.5	7.3%
5	Company A	1.4	6.9%
	Others	8.7	43.3%
	Total	**20.3**	**100.0%**

- Top 5 wind turbine manufacturers in the global market, in terms of newly installed offshore capacity, were Company J, Company B, Mingyang, Company F, and Company A, accounting for 16.5%, 15.3%, 10.7%, 7.3%, and 6.9% respectively in 2021. In terms of newly installed offshore capacity, Mingyang has been among the top 10 manufacturers globally in the past five years and significantly expanded its market share from 0.6% in 2017 to 10.7% in 2021.
- Mingyang has set the industry trend in developing larger wind turbines, with advantages including quick product updates, lower cost, and higher power generation efficiency. The Company already achieved mass productions of various offshore wind turbine models such as MySE 3.0MW, MySE 4.0MW, and MySE 6.0MW, etc.. In 2021, Mingyang successfully gained a market share of 10.7% in 2021, ranking the third in terms of newly installed offshore capacity.

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Competitive Analysis of Wind Turbine Manufacturers (4/6)

Top 5 Wind Turbine Manufacturers (by newly installed offshore capacity), China, 2021



Rank	Manufacturer	Newly Installed Offshore Capacity (GW)	Market Share
1	Company J	3.4	21.7%
2	**Mingyang**	**2.2**	**14.0%**
3	Company F	1.5	9.6%
4	Company C	1.4	8.7%
5	Company O	0.7	4.5%
	Others	6.3	41.5%
	Total	**15.5**	**100.0%**

- Top 5 WTG manufacturers in wind turbine market of China, in terms of newly installed offshore capacity, were Company J, Mingyang, Company F, Company C and Company O, accounting for market shares of 21.7%, 14.0%, 9.6%, 8.7%, and 4.5% respectively in 2021. In terms of newly installed offshore capacity, Mingyang has been among the top five wind turbine manufacturers in China for the past five years and expanded its market share from 2.6% in 2017 to 14.0% in 2021.
- At a time when the industry was dominated by small turbines, the Group took the initiative in manufacturing large wind turbines, which culminated in a leading position in the offshore wind turbine market segments of above 5.0MW and above 7.0MW, ranking first in both segments in 2021. Additionally, Mingyang released MySE 11MW-203 in July 2020 and has become the largest wind turbine manufacturer in China, in terms of production volume of 11.0MW wind turbines in 2021. When compared with its industry peers' wind turbines with diameters range from 150m to 180m, the Group's wind turbines in the same diameter range can generate up to 20% more power in average under the same conditions in PRC.
- In 2018, the Group successfully installed China's first greater-than-5MW anti-typhoon wind turbine, which was also at the time the largest anti-typhoon wind turbine in the world in terms of its rotor diameters. The Group also launched the world's first anti-typhoon floating wind turbine in 2021.

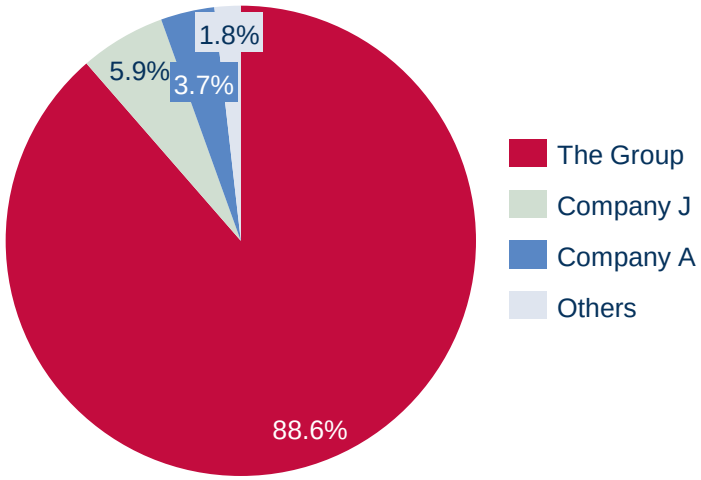
Note: The data of Mingyang is subject to change based on further inputs from the Company.

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Competitive Analysis of Wind Turbine Manufacturers (5/6)

Top 3 Hybrid Drive Wind Turbine Manufacturers (by newly installed capacity), China, 2021

Total Newly Installed Capacity:8.5 GW



Rank	Manufacturer	Newly Installed Capacity (GW)	Market Share
1	**Mingyang**	**7.5**	**88.6%**
2	Company J	0.5	5.9%
3	Company A	0.3	3.7%
	Others	0.2	1.8%
	Total	**8.5**	**100.0%**

- As the phaseout of subsidies on wind power and arrival of wind power grid parity in Chinese wind power market in 2021, the competition of the wind turbine market in China is expected to become increasingly intensive in terms of price, efficiency and reliability of the turbine. Hybrid-drive wind turbine combing advantages of double-fed and direct-drive wind turbines, enables manufacturers to significantly reduce cost of the turbine, meanwhile maintaining comparable power efficiency and reliability. Leading wind turbine manufacturers such as Mingyang, Vestas and Shanghai Electric have successively announced their installation of hybrid-drive wind turbine, and manufacturers such as Goldwind have also initiated their development of hybrid-drive wind turbine model since 2021.
- In 2019, the Group's hybrid offshore wind turbine MySE7.25MW was installed in Guangdong Province, which was China's largest offshore wind turbine model at the time being installed. Mingyang is the forerunner in the field of hybrid-drive wind turbine, which helps the Company gain first-mover advantages. In terms of newly installed capacity in 2021, Mingyang was the largest hybrid-drive wind turbine manufacturer in China, with a market share of 88.6% in 2021. In 2020, the Group launched MySE11-203, which was the largest offshore hybrid drive model globally at the time being launched.

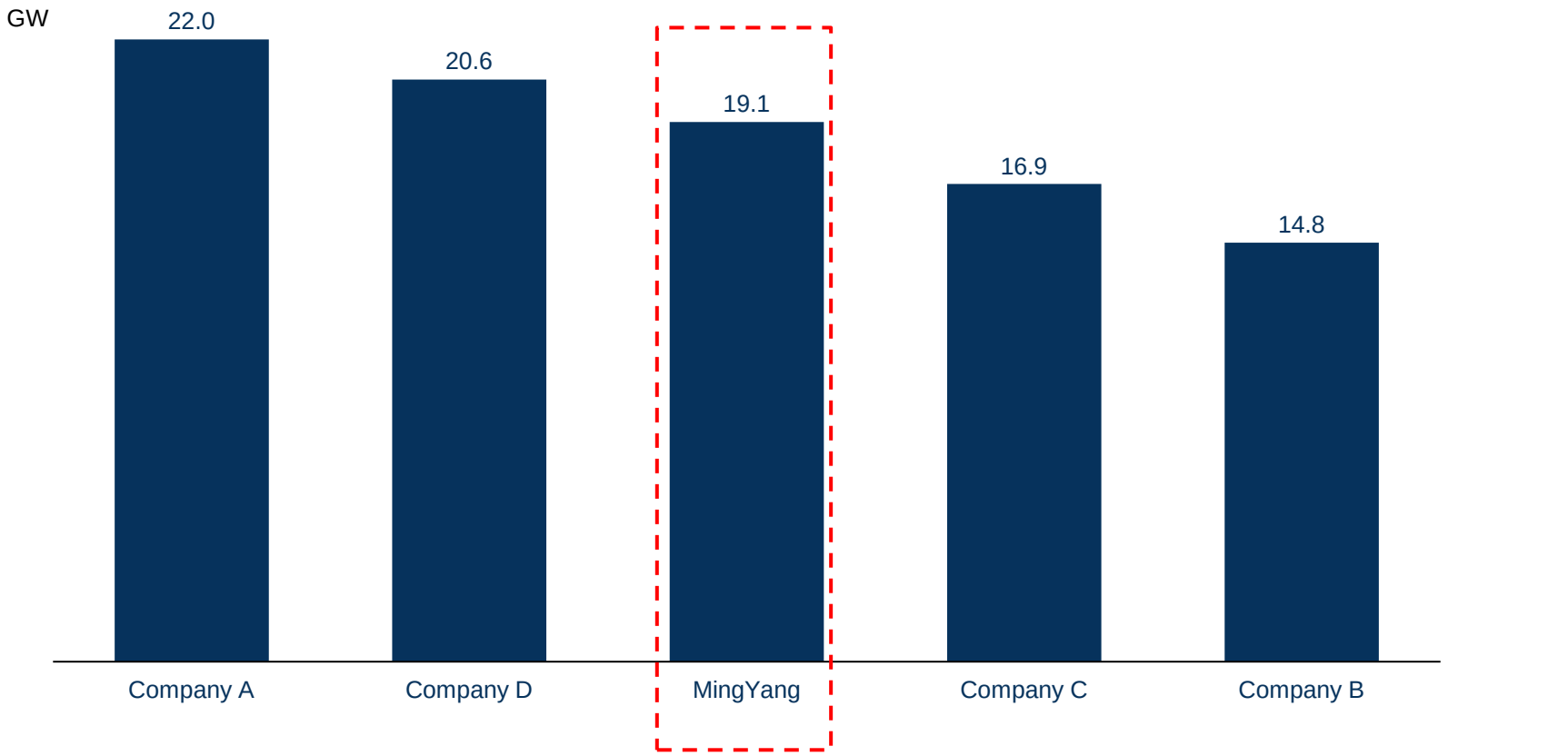
Note: The data of Mingyang is subject to change based on further inputs from the Company.

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Competitive Analysis of Wind Turbine Manufacturers (6/6)

- As at 31 December 2021, the Group ranked the third globally in terms of the total capacity of wind turbine order backlog.

Top 10 Major Wind Turbine Manufacturers (by order backlog), Global, 2021



Note: The order backlog amounts of peers are from their public disclosure or estimated based on their annual reports and public information

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Competitive Analysis of Wind Turbine Manufacturers (1/6)

- Double-fed, direct-drive and hybrid-drive are majority design types of wind turbines in the industry. In past decades, turbines using double-fed and direct-drive were widely adopted in the market. However, in line with the developing trend of larger wind turbine size, which results in heavier weight and higher cost of construction, more and more major manufacturers have increased investment in developing hybrid drive technology which can reduce the weight and cost of wind turbines.
- Starting from 2008, Mingyang was the first manufacturer that developed leading hybrid drive wind turbine using unique super compact drive (SCD) technology with superior lightweight characteristics compared to other major manufacturer.
- The Group pursues certification of its existing products to improve its overall competitiveness, and it has received several domestic and international industry certifications in recent years. For example, the Group has completed the sample verification of 58.8M blades in 2017 for its independently developed segmented blade design technology and obtained the DNV GL certification, making it the only domestic wind turbine manufacturer with such technology in the PRC as of March 31, 2022.
- Benefiting from the Group's strict quality control and continuous investment in R&D, the Group's products have been widely recognized by the market and industry as highly efficient and reliable, having low maintenance costs and achieving reliable power coordination with the rest of the grid.
- The Group successfully implemented the world's first integrated offshore wind power development project that combined offshore wind power generation, sea water hydrogen production and marine farming.

	MINGYANG SMART ENERGY 明阳智能	Company C	Company F	Company J	Company A	Company B
Major Wind Turbine Types	➢ Hybrid Drive (SCD) ➢ Double-fed	➢ Direct-drive	➢ Double-fed	➢ Double-fed	➢ Hybrid Drive	➢ Direct-drive
In-house Manufacturing Capabilities of Core Components	➢ Blades ➢ Transducer ➢ Variable-pitch controller ➢ Electric control system	➢ Generator	➢ Blades	➢ Blades ➢ Generator	➢ Blades ➢ Tower ➢ Generator	➢ Blades ➢ Generator ➢ Gear box
Number of New Model of Wind Turbines (Since 2017)	20	31	14	19	22	30

Source: Company's annual reports, public information, Frost & Sullivan

Analysis of Wind Turbine Market
Competitive Analysis of Wind Turbine Manufacturers (2/6)

- Typically, wind turbine manufacturers that produce their own blades typically have a 2%-3% higher gross profit margin than its peers in China who purchase blades. The Group's R&D expenditure in 2021 was RMB1,054.6 million, accounting for about 3.9% of its operating revenue during the same period. The Group's R&D-to-revenue ratio in 2021 is higher than average among its peers globally.
- The Group has one of the most comprehensive and forward-looking product portfolios among wind turbine manufacturers in China.
- The Group released its MySE3.0MW platform in 2016, which had the largest rotor diameter globally at time being launched.
- The Group is a pioneer in developing large capacity wind turbine and has developed the largest onshore turbine with 8.0 MW capacity. In 2021, the Group launched the self-developed 16MW MySE16.0-242 offshore wind turbine, which is currently the largest offshore wind turbine in the world. For the development of several cutting-edge technologies, including super compact hybrid drive technology, large capacity offshore wind turbine and deep-sea floating technology, the Group is usually a head of other competitor by more than 6 months.
- In January 2021, the Group won the order of the Italian company Renexia in Project Taranto to equip the 30MW Beleolico offshore wind farm off the coast of Taranto. This is the first commercialized offshore wind farm in the Mediterranean Sea and the first offshore wind turbine order obtained by a Chinese manufacturer in Europe.
- The Group independently established the 960MWh power storage station in Tongliao, Inner Mongolia, which is among the top ten largest power storage stations in the world in terms of standalone installed capacity (excluding pumped power storage stations).

	MINGYANG SMART ENERGY 明阳智能	Company C	Company F	Company J	Company A	Company B
R&D Spending/Revenue (2021)	3.9%	4.4%	NA	3.9%	2.8%	2.9%
R&D Staff Percentage (2021)	20.7%	30.0%	NA	27.3%	NA	NA
Largest Onshore Turbine Capacity	8.0 MW	7.2 MW	6.25 MW	6.25 MW	7.2MW	6.6 MW
Largest Offshore Turbine Capacity	16.0 MW	12.0 MW	8.0 MW	11.0 MW	15.0MW	15.0 MW
Average Turbine Availability*	99.60%	99.00%	99.87%	NA	97.00%	98.00%
Capacity Factor**	32.9%	NA	NA	NA	38.8%	48.1%

**Turbine Availability is the amount of time that the turbine is able to produce electricity over a certain period, divided by the amount of the time in the period. The average turbine availability is calculated based on data of several projects utilizing the wind turbine.*

***Capacity Factor is defined as the average output over a time period divided by its output if it had operated at full (rated) capacity over that time period. The data is based on the latest statistics of wind farms, which are available.*

Source: Company's annual reports, public information, Frost & Sullivan

Analysis of Wind Turbine Market
Competitive Analysis of Wind Turbine Manufacturers (3/6)

	MINGYANG SMART ENERGY 明阳智能	Company C	Company F	Company J	Company A	Company B
Average Nacelle Weight per MW*	27.0 tons	32.9 tons	NA	NA	32.2 tons	NA
Average Material Cost per kW** (2020)	509.8	NA	NA	$508.0	NA	NA
Average Sales Price per kW*** (2021)	$600.7	$648.0	NA	$784.0	$838.6	NA
Gross Margin Ratio (2021)	19.2%	17.7%	NA	16.4%	10.0%	2.4%
Period Cost Ratio (2021)	11.0%	14.9%	NA	13.9%	7.8%	NA
Net Profit Ratio (2021)	11.4%	6.8%	NA	2.1%	1.1%	-6.1%
EBITDA Ratio (2021)	18.7%	15.8%	NA	4.2%	8.4%	3.9%
ROE (2021)	18.4%	10.7%	NA	8.2%	3.7%	-14.1%
ROA (2021)	5.0%	2.9%	NA	1.7%	0.9%	-3.8%

** Average nacelle weight per MW is measured by the average nacelle weight of sampled models with capacities ranging from 3.6MW to 5.0MW.*
*** The average material cost per kW is calculated by dividing cost of raw materials by total capacity of sold wind turbine during FY2020.*
****Average sales price per kW is calculated by sales revenue of wind turbine by total capacity of sold wind turbine during the financial year.*

Source: Company's annual reports, public information, Frost & Sullivan

Analysis of Wind Turbine Market
Competitive Analysis of Wind Turbine Manufacturers (4/6)

	MINGYANG SMART ENERGY 明阳智能	Company C	Company F	Company J	Company A	Company B
Range of Products – Onshore Wind Turbine						
2.X MW	●	●	●	●	●	●
3.X MW	●	●	●	●	●	●
4.X MW	●	●	●	●	●	●
5.X MW	●	●	●	●	●	●
6.X MW	●	●	●	●	●	●
7.X MW	●	●	○	○	●	○
Range of Products – Offshore Wind Turbine						
4.X MW	●	○	●	○	●	○
5.X MW	●	○	●	○	○	○
6.X MW	●	●	○	●	○	●
7.X MW	●	○	●	●	○	●
8.X MW	●	●	●	●	○	●
9.X MW	●	○	○	○	●	○
11.X MW	●	○	○	●	○	●
12.X MW	●	●	○	○	○	○
13.X MW	●	○	○	○	○	○
14.X MW above	●	○	○	○	●	●

● Available ○ Not available

Source: Company's websites, public information, Frost & Sullivan

Analysis of Wind Turbine Market
Competitive Analysis of Wind Turbine Manufacturers (5/6)

	MINGYANG SMART ENERGY 明阳智能	Company C	Company F	Company J	Company A	Company B
Onshore WTG of Major Players (4.X MW)						
Power	4.0 MW	4.0 MW	4.0 MW	4.5 MW	4.2 MW	4.7 MW
Rotor Diameter	145/156 m	171 m	136 m	155 m	136 m	155 m
Tower Type	steel tube/compliant tower/hybrid tower	steel tube/hybrid tower	steel tube	steel tube/hybrid tower	Steel tube	steel tube
Hub Height	90 / 100 / 130 / 140 m	100 – 180 m / customizable	80 m or site specific	95 - 160 m / site specific	site and country specific	90 / 102.5 / 120.5 m and site specific
Cut-in Wind Speed	2.5 m/s	2.5 m/s	3 m/s	2.5 m/s	3 m/s	3 m/s
Cut-out Wind Speed	25 m/s	20 m/s	25 m/s	22 m/s	25 m/s	NA
Designed Lifetime	20 years	20 years	20 years	20 years	20 years	20 years
Operating Temperature	-30～+40℃	-30～+40℃	NA	NA	-20～+45℃	-20～+45℃
Survival Temperature	-40～+50℃	-40～+50℃	NA	NA	NA	NA

Source: Company's websites, public information, Frost & Sullivan

Analysis of Wind Turbine Market
Competitive Analysis of Wind Turbine Manufacturers (6/6)

	MINGYANG SMART ENERGY 明阳智能	Company C	Company F	Company J	Company A	Company B
Offshore WTG of Major Players (8.X MW)						
	8.3 MW	8.0 MW	8.0 MW	8.0 MW	8.0 MW	8.0 MW
Rotor Diameter	178 m	175 m	190 m	208 m	164 m	167 m
Tower Type	steel tube	steel tube	NA	steel tube	steel tube	steel tube
Hub Height	site specific	110 m or site specific	NA	site specific	site specific	site specific
Cut-in Wind Speed	3 m/s	3 m/s	NA	3 m/s	3 m/s	3 m/s
Cut-out Wind Speed	30 m/s	25 m/s	NA	25 m/s	25 m/s	25 m/s
Designed Lifetime	25 years	25 years	NA	25 years	25 years	25 years
Operating Temperature	-10～+40℃	-10～+40℃	NA	NA	NA	NA
Survival Temperature	-20～+50℃	-20～+50℃	NA	NA	-15～+25℃	NA

Source: Company's websites, public information, Frost & Sullivan

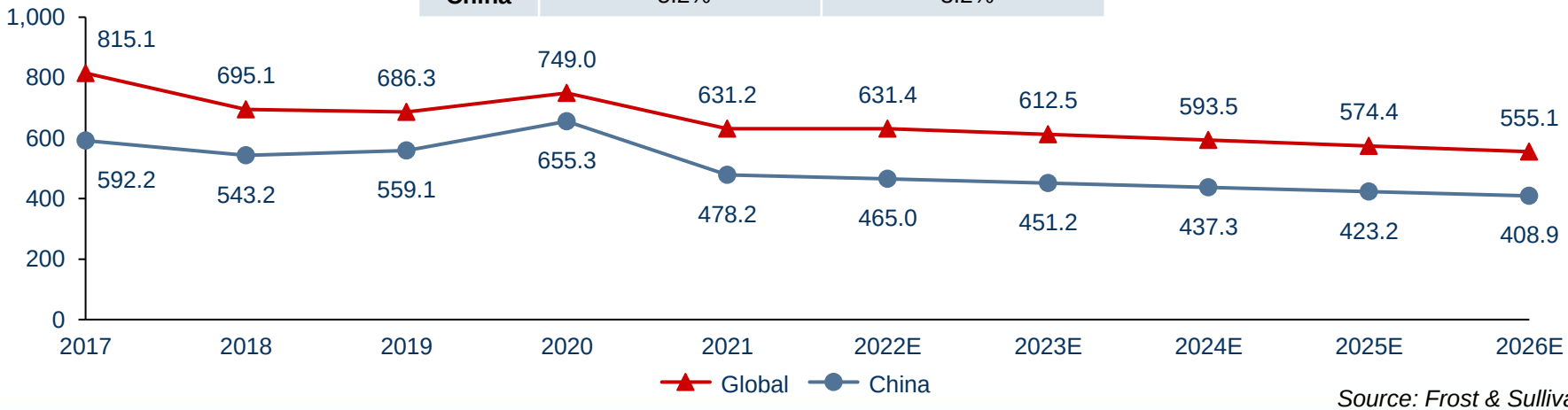
Analysis of Wind Turbine Market
Average Price of Wind Turbine

- The price of wind turbine is a crucial determinant in promoting the adoption of wind power. Driven by continuous technological advancements and increasing unit capacity, the average unit price of turbine in global market decreased from USD815.1 thousand per MW in 2017 to USD631.2 thousand per MW in 2021. The average unit price of turbine in the Chinese market has decreased from USD592.2 thousand per MW to USD478.2 thousand per MW during the same time period.
- Affected by the phaseout of China's subsidies for onshore and offshore wind power in 2020 and 2021, wind power projects in China before the deadlines increased dramatically, leading to the price fluctuation of turbine in China in 2019 and 2020. Starting from 2021, the average price of turbine in China will quickly return to the normal track.
- It is expected that the average unit price of turbine will further decrease to USD555.1 thousand per MW and USD408.9 thousand per MW in 2026 in global market and in China respectively.

Average Price of Turbine, Global and China, 2017-2026E

Thousand USD/ MW

	CAGR (17-21)	CAGR (22-26E)
Global	-6.2%	-3.2%
China	-5.2%	-3.2%

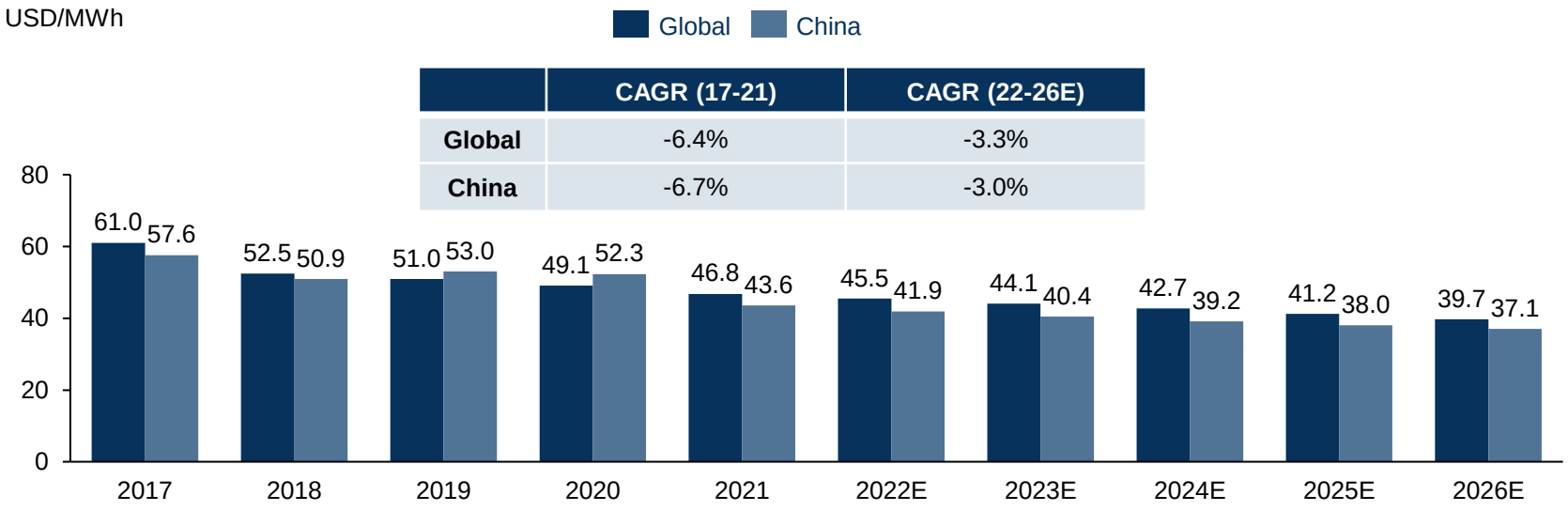


Source: Frost & Sullivan

Analysis of Wind Turbine Market
LCOE of Wind Power (1/2)

- Levelized Cost of Electricity (LCOE) represents the net present value of the unit cost of electricity, i.e. to generate one MWh electricity, over the total lifecycle of a power generating asset. It allows the comparison among different power generation stations on a consistent basis which makes it a significant indicator of power generation projects. Given the rapid development of technology and acceleration of industry scale expansion, LCOE of wind power is witnessing a downward trend in general.
- As a result of technological innovations, the LCOE of wind power has decreased from $64.4 MWh in 2017 to $52.7 MWh in 2021 globally. The LCOE of wind power has reached similar level to that of photovoltaics, approximately $50.0 MWh globally in 2021, which is conducive to large-scale promotion and application of wind power.
- The LCOE of onshore wind power in global market decreased from USD61.0 per MWh in 2017 to USD46.8 per MWh in 2021. During the same period, the LCOE of onshore wind power in China decreased from USD57.6 per MWh to USD43.6 per MWh. Because of the phaseout of subsidies for onshore wind power in 2020, newly installed onshore wind power capacity in China increased dramatically in 2019 and 2020. Increased demand influenced the price of turbines and other equipment, leading to increase of LCOE of onshore wind power temporarily.
- It is expected that the LCOE of onshore wind power will further decrease to 37.1 USD/MWh in China and 39.7 USD/MWh in global market in 2026.

LCOE of Onshore Wind Power, Global and China, 2017-2026E

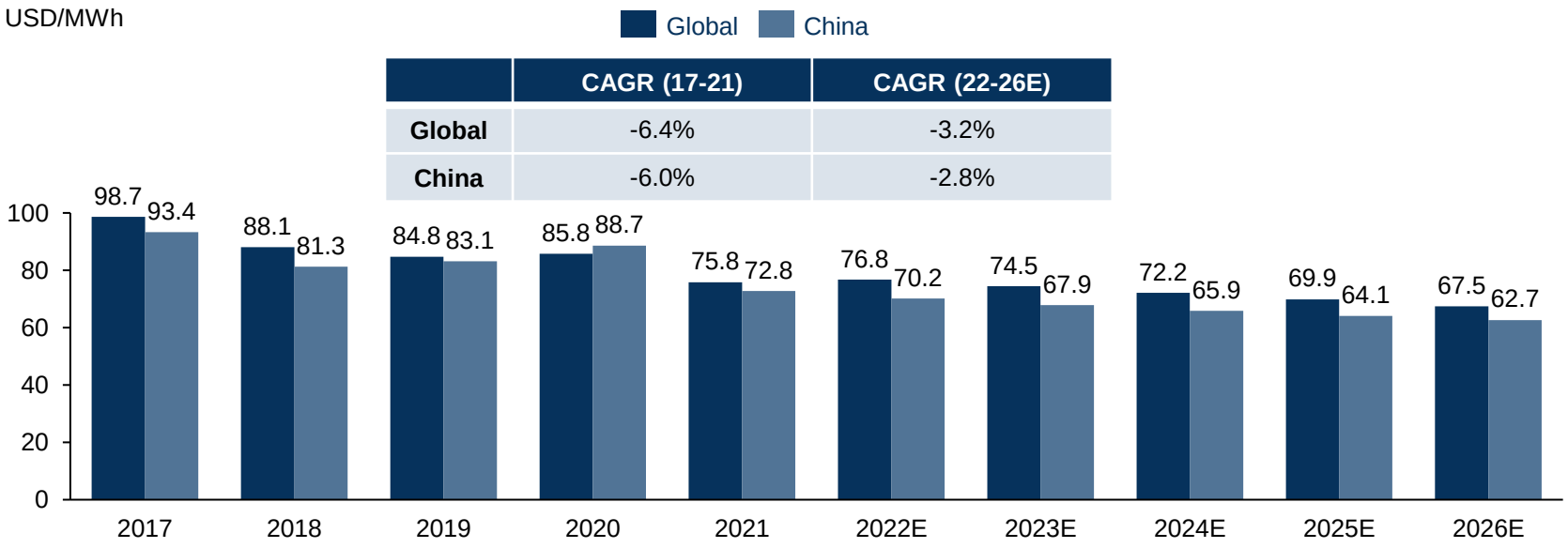


Source: Frost & Sullivan

Analysis of Wind Turbine Market
LCOE of Wind Power (2/2)

- Because of relatively higher design and manufacture requirements in response to corrosive and wet climatic environment, offshore wind power turbines are of higher cost compared to onshore wind turbines and increase the LCOE of offshore wind power farms. In 2021, the LCOE of offshore wind power was 72.8 USD/MWh in China and 75.8 USD/MWh in the world separately.
- Because of the phaseout of central level subsidies for offshore wind power in 2021, newly installed onshore wind power capacity increased dramatically in the years before the deadline in China, leading to increase of LCOE of offshore wind power temporarily in 2019 and 2020.
- It is expected that the LCOE of offshore wind power will further decrease to 62.7 USD/MWh in China and 67.5 USD/MWh in the world in 2026.

LCOE of Offshore Wind Power, Global and China, 2017-2026E



	CAGR (17-21)	CAGR (22-26E)
Global	-6.4%	-3.2%
China	-6.0%	-2.8%

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Market Trends (1/3)

1 Repowering and Old Turbines Replacement

- There are many old wind turbines with small capacity in operation, which have been utilized for more than 10 years at least. For example, in China, there are more than 11,000 old wind turbines with capacity of smaller than 1MW. The generating efficiency and availability of these wind turbines are at relatively low levels. These wind turbines are typically located in locations with high-quality wind resources. With technological advances, wind turbine manufacturers have the capacities to produce larger unit capacity wind turbines. As a result, this creates the demand for repowering and replacement of old wind turbines. An increasing number of wind turbine manufacturers are providing customized solutions to activate the market. From 2017 to 2021, the proportion of over 10-year wind turbines in the global market increased from 16.7% to 27.5%. In the future, with the wide application of wind turbines in power generation, it is estimated that the proportion of over 10-year wind turbines in the global market will continue to increase to 34.5% in 2026.

2 Digitalization and Intellectualization of Wind Power

- With continuous technological innovations, wind turbines will embark on the path of digitalization and intellectualization. Based on advanced technologies such as IoT gateways, real time analysis and robotic process automation, smart features, including real-time monitoring of wind turbines, remote fault diagnosis and predictive analytics are realized. Through comprehensive information interconnection and intelligent analysis, it will improve the management of wind turbines on multiple renewable energy stations significantly, which will improve power generation efficiency and reduce operating costs effectively.

3 Accelerated Development of Offshore Wind Power

- Offshore wind power has the advantages of abundant resources, high utilization hours of power generation, no land occupation and suitability for large-scale development. In addition, a large proportion of global population live in major coastal cities, and the establishment of offshore wind farms can effectively meet the demand for energy and electricity in nearby coastal areas. With the decline in construction and maintenance costs powered by technological advancements, the shares of offshore wind power will continue to increase in the future. It is estimated that the global offshore cumulative installed wind power capacity will increase from 56.8GW in 2021 to 142.1GW in 2026.

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Market Trends (2/3)

4 Deepened Market-oriented Reform of Wind Power

- With the continuous expansion of wind power market and the maturity of supply chain, technology and operation model, the competitiveness of wind power in the energy industry has been continuously improved. The Chinese government is continuously deepening the market-oriented reform of the wind power industry. As the wind power industry has gradually entered the era of parity and green power market-oriented trading mechanism has been gradually established, there are increasingly urgent need to reduce costs and increase efficiency in the wind power industry and increasingly high requirements for wind turbine manufacturers. Wind turbine manufacturers with better cost control and higher efficiency will have more competitive advantages.

5 Accelerated Development of Distributed Wind Power

- Offshore wind power has the advantages of abundant resources, high utilization hours of power generation, no land occupation and suitability for large-scale development. The total deep-sea wind resources in China with depth over 50m are estimated to be over 1,200 GW. Approximately 60% of deep-sea wind resources of China is located in waters with over 70km offshore distance. It is an inevitable trend for wind power projects to go from offshore to deep-sea. The global aggregate installed capacity of deep-sea floating wind power projects is estimated to exceed 6.0GW by 2030.
- In addition, a large proportion of global population live in major coastal cities, and the establishment of offshore wind farms can effectively meet the demand for energy and electricity in nearby coastal areas. With the decline in construction and maintenance costs powered by technological advancements, the shares of offshore wind power will continue to increase in the future. It is estimated that the global offshore cumulative installed wind power capacity will increase to144.8 GW in 2026 from 56.8 GW in 2021 and 13.6 GW in 2017.

6 Integration of Wind Turbine Supply Chain

- Intensified competition in the wind power industry has brought higher cost control needs to the wind turbine market. Backed by the continuous enhancement of technical capabilities, wind turbine manufacturers, in order to maintain profits and ensure the security of the supply chain, have further integrated the supply chain and enhance their capabilities of self-developing and self-producing core components. It is estimated that the wind turbines manufacturers that produce blades and generators independently could decrease their production cost by approximately 10-20% and increase their profit margin by around 5-10%.

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Market Trends (3/3)

7 Integration of Wind-Solar-Storage-Hydrogen

- In order to reduce the instability of wind and solar power, and make full use of hydrogen energy for long-term and large capacity energy storage, recently Chinese government has issued relevant policies to encourage enterprises to cultivate new application models of wind and solar power generation with hydrogen energy storage. As a result, more leading wind turbine manufacturers will incorporate the "integration of wind-solar-storage-hydrogen" into their business strategies and actively explore the optimal business models for the "integration of wind-solar-storage-hydrogen" in the future, providing solid support for the national target of "carbon neutrality" by 2060.

8 Gradual Transformation to Aftersales Service

- Currently the continuous growth of installed capacity and average age of wind turbine generators has contributed to significantly increasing demand for aftersales service market. Compared with the operation and maintenance service providers, wind turbine generator manufacturers possess more competitive advantages in industrial resources, which enables them to carry out the vertical extension in industrial chains and provide clients with aftersales service solutions. In the future, wind turbine generators will play a more important role in wind turbine generator aftersales service market, effectively improving the efficiency of wind turbine generator operation and maintenance.

9 Development of Hybrid Drive Technology

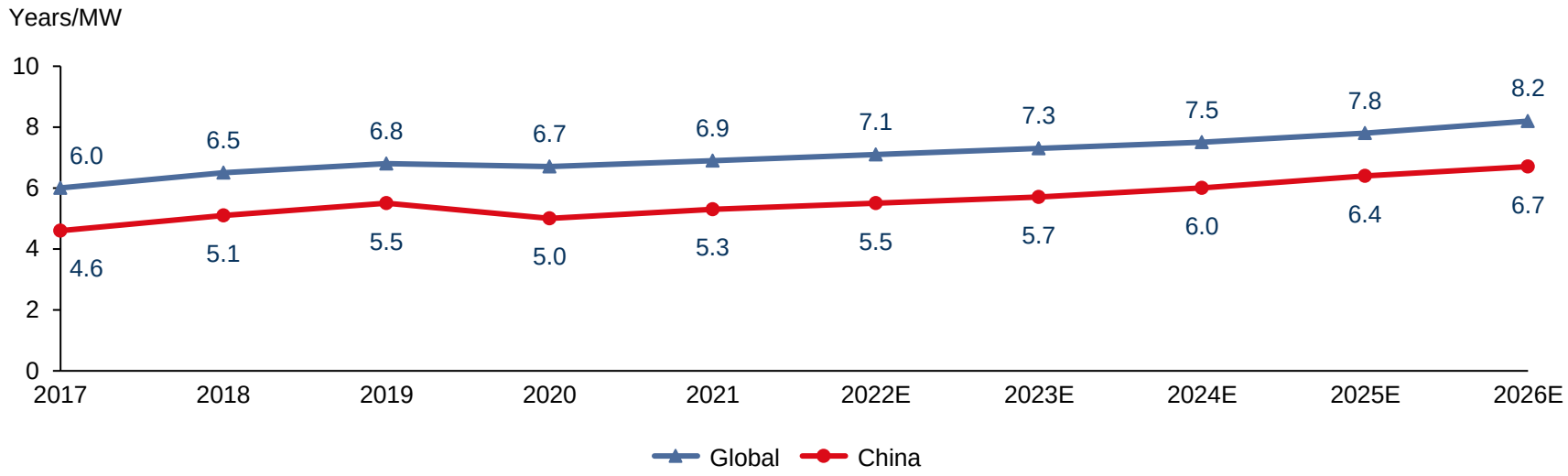
- The hybrid-drive wind turbine is designed with both magnet and gearbox, which combines the advantages of double-fed and direct-drive wind turbines. On the basis of direct-drive, the gearbox is added to increase the speed, which can reduce the loss of the gearbox during operation at a lower speed. At the same time, the manufacturing costs and weight of the turbine are reduced. As the phaseout of subsidies on wind power and arrival of wind power grid parity in Chinese wind power market in 2021, the competition of the wind turbine market in China is expected to become increasingly intensive in terms of price, efficiency and reliability of the turbine. Hybrid-drive wind turbine combing advantages of double-fed and direct-drive wind turbines, can greatly reduce cost of the turbine, while maintaining comparable power efficiency and reliability.

Source: Frost & Sullivan

Analysis of Wind Turbine Market
Average Age of Wind Turbines

- From 2017 to 2019, the average age of wind turbines increased from 6.0 years per MW to 6.8 years per MW globally. In 2020, the global newly installed wind power capacity increased by 90.8% from 2019. As a result, the average age of global wind turbines experienced a slight decrease. The average age of wind turbines in the world will continue to increase, and is estimated to grow to 8.2 years per MW in 2026.
- From 2017 to 2019, the average age of China's wind turbines increased from 4.6 years per MW to 5.5 years per MW. In 2020, China's newly installed wind power capacity connected to power grid increased significantly by 177.2% from 2019 and led to a decrease in average age of China's wind turbines. In the future, with the large scale application of wind power generation, the average age of China's wind turbines is forecasted to increase to 6.7 years per MW in 2026.
- Additionally, there are a large number of wind turbines which have been utilized for more than 10 years. It is estimated that in China, in 2025, the end year of 14th Five-year Plan, the scale of old wind farms with an operation time of over 20 years will reach approximately 1.1 GW, and the scale of old wind farms with an operation time of more than 15 years will reach around 44.5 GW. The increase of ageing wind turbines is bringing sizable demand for WTG aftersales services.

Average Age of Wind Turbines, Global and China, 2017-2026E

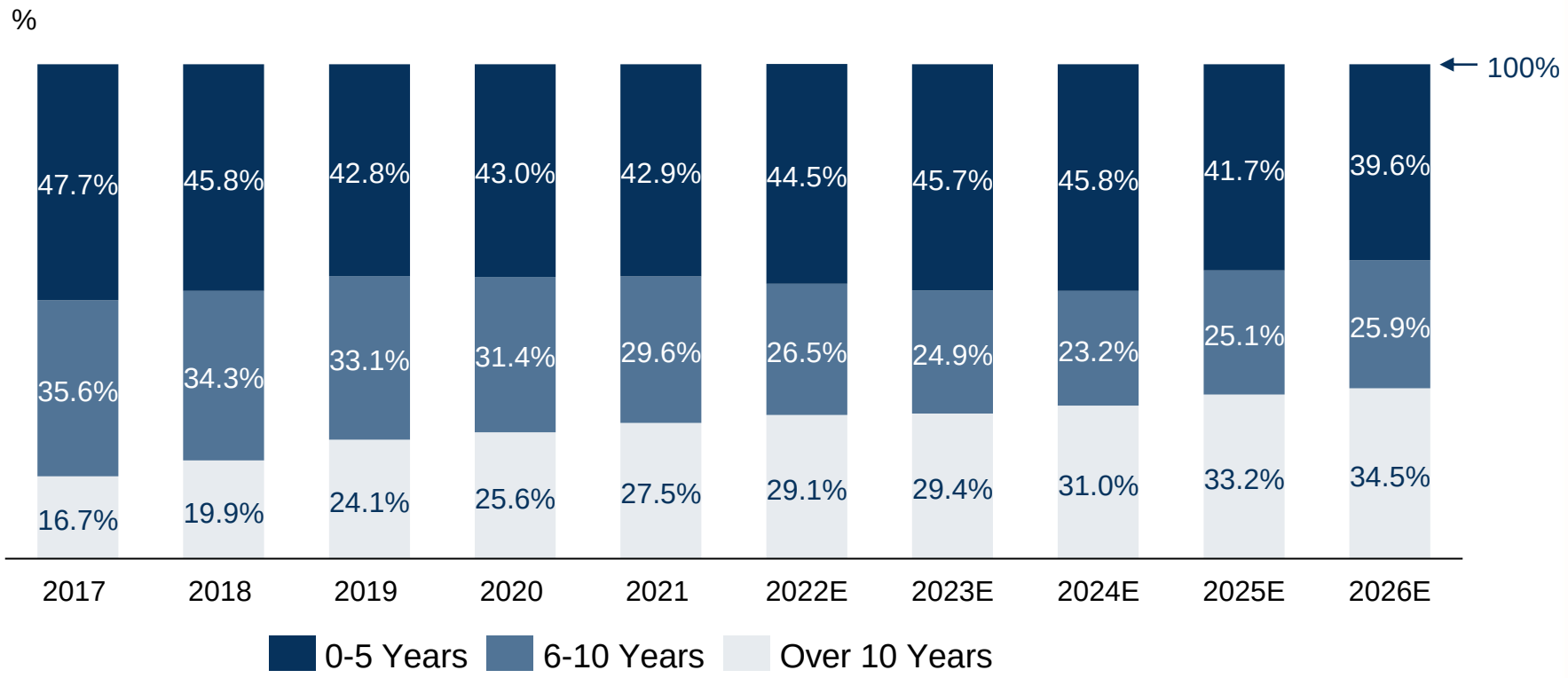


Source: Frost & Sullivan

Analysis of Wind Turbine Market
Distribution of Age of Wind Turbines - Global

- From 2017 to 2021, the proportion of over 10-year wind turbines in the global market increased from 16.7% to 27.5%. With the wide application of wind turbines in power generation in the future, it is estimated that the proportion of over 10-year wind turbines in the global market will continue to increase to 34.5% in 2026, which contributed to the increasing demand for WTG aftersales service.

Distribution of Age of Wind Turbines, Global, 2017-2026E

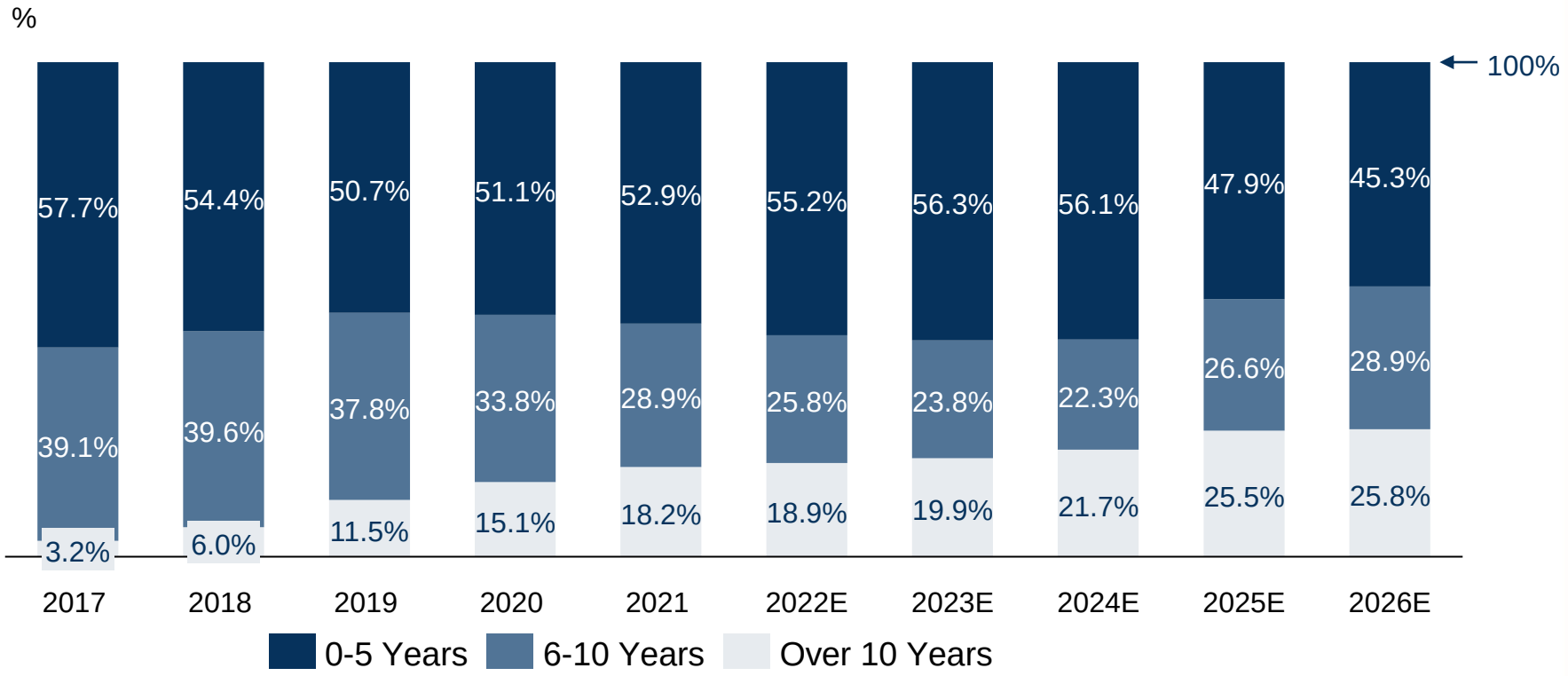


Source: Frost & Sullivan

Analysis of Wind Turbine Market
Average Age of Wind Turbines - China

- From 2017 to 2021, the proportion of over 10-year wind turbines in China's market increased significantly from 3.2% to 18.2%. With the large scale application of wind power generation, it is estimated that the proportion of over 10-year wind turbines in China's market will continue to increase to 25.8% in 2026, bringing the increasing demand for WTG aftersales service. It is also estimated that wind farms in China with operation period of over 20 years will reach approximately 1.1GW by 2025, and wind farms with operation period of over 15 years will reach approximately 44.6GW by 2025.

Age Proportion of Wind Turbines, China, 2017-2026E

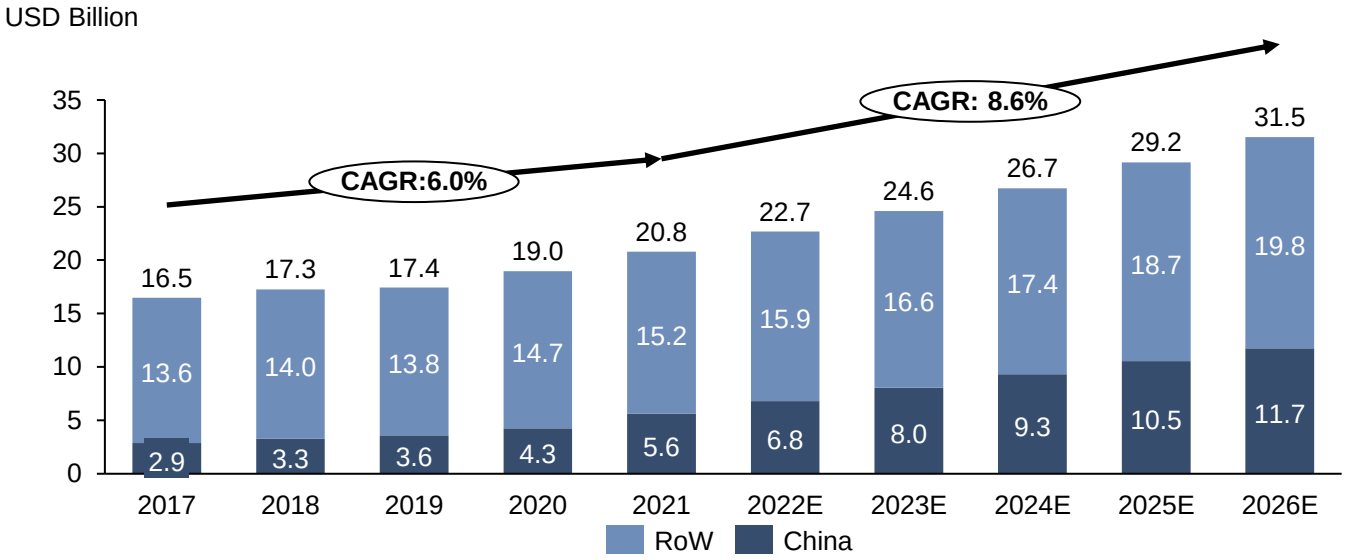


Source: Frost & Sullivan

Analysis of Wind Turbine Market
WTG Aftersales Service

- WTG aftersales service mainly includes maintenance and repairs, providing spares and consumables, upgrades, replacements, etc. In recent years, some of the leading wind turbine generator manufacturers have launched intelligent and digital aftersales service solutions, covering the whole life cycle of wind turbine generators, which can provide wind turbine generators with details management, effectively improve the efficiency and reduce the costs for wind turbine generator operation and maintenance.
- Currently Europe and the United States are the main markets for WTG aftersales service industry, due to the early development of wind power. From 2017 to 2021, global WTG aftersales service revenue increased from USD16.5 billion to USD20.8 billion at a CAGR of 6.0% and is estimated to grow to USD31.5 billion in 2026 at a CAGR of 8.6% from 2022.
- As China continues to focus on the application of renewable energy and rapidly increase installed wind power capacity, the potential space of China's WTG aftersales service market is enormous and is expected to increase significantly in the future. From 2017 to 2021, China's WTG aftersales service revenue increased from USD2.9 billion to USD5.6 billion at a CAGR of 18.2% and is estimated to increase to USD11.7 billion in 2026 at a CAGR of 14.6% from 2022.

WTG Aftersales Service Revenue, Global and China, 2017-2026E



	CAGR 17-21	CAGR 22E-26E
Global	6.0%	8.6%
China	18.2%	14.6%

Source: Frost & Sullivan

Thank You

Partner with you on the Road to Growth