Global Wind Supply Chain Series: Article 3: Wind turbine tower supply chain trends 2022



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1. Executive summary

Executive summary – wind turbine tower supply chain







Towers' pricing is expected to remain elevated for at least the next 2-3 years

- Commodity prices are expected to normalize • further, but will not fall to pre-pandemic levels
- Soaring electricity prices have an outsized impact on tower manufacturing, as an energy intensive industry
- Complex logistics of oversized towers have ٠ exposed the global towers supply chain to significant cost risk

Tower supply is highly fragmented, regionalized and outsourced for both onshore and offshore

Protectionism through tariffs and domestic content requirements are reshaping tower supply chain

- OEMs are increasingly deploying 3rd partv suppliers in an effort to better control costs, mitigate risks and focus on core business
- Global oversupply in the tower market to meet 2020 peak installations have pressured industry profit margins and is expected to balance by 2025.
- More than 800GW of wind energy is expected to be installed between 2025-2030, driving the need for supply chain to ramp up to manufacture next generation tall towers

- Domestic low-cost steel production, lower labour costs and significant local scale provides a competitive advantage to Chinese and Asian tower suppliers.
- Europe has joined the US in imposing tariffs on Chinese steel towers to shield its local industry
- Domestic requirements, tariffs and high logistics costs are driving the tower supply chain to localise regionally
- In contrast with onshore segment, offshore is mainly dominated by European suppliers serving western markets

2. Global and Regional Tower Supply and Demand

Onshore Towers: Oversupply and necessity for upgrading facilities

China and India have large excessive capacity that currently is deployed in other industries than wind

Regional supply and demand for wind turbine towers, '000 sections



Source: Wood Mackenzie,

Note: Including only wind related suppliers; Demand figures are based on 2021 grid –connected installations; Supply figures are based on max facility capacity as per Wood Mackenzie's estimation; In China we estimate 4 sections due to restrictions of transportation and coating paintings, while in the rest of the world we assume 3 sections

Key tower supply chain trends:

- European towers remain localized, due to the utilization of taller towers which increases logistics costs for foreign supply.
- Turbine OEMs are further increasing the outsourcing of towers, with worlds largest tower manufacturing factory in Colorado sold to CS
 Wind by Vestas, and currently operating at less than 50% design capacity (due to pre-IRA uncertainty)
 - Direct tower sourcing from Chinese developers, who can utilise the
 domestic steel supply base and choose from a wide range of nonwind suppliers, is amplifying further the fragmentation on Chinese tower market.

Key supply chain challenges for towers:

- Exposure to steel price and complex logistics of oversized components have exposed the global supply chain to significant cost risk.
- Tariffs on Chinese manufactured towers have driven much of the globalized supply to southeast Asia Indonesia, Vietnam, Philippines, South Korea.

EMEA and the USA requires further investments for new facilities and upgrades

- On a global level, WoodMac is estimating an oversupply of 4k sections. However, considering the height increase, upgrades required to meet the new standards, as we expect the deployment of the first 8MW-class onshore turbines before the end of the decade.
- On a regional level, the USA and EMEA requires heavy investment to considered self-sufficient and reduce dependency and costs due to imported towers logistics and tariffs 5



Offshore Towers: New facilities and upgrades are essential to meet demand

Offshore tower segment is characterised by oversupply the last 6+ years. This trend is expected to reverse by 2025, as offshore demand surge three-fold

Regional supply and demand for offshore wind turbine towers, Sections



Key supply chain trends

Supply chain trends:

 SGRE & Vestas have strong relationships with Danish suppliers Valmont and Welcon, as they grew alongside the nascent European market. Conversely, GE has established relationships with newer suppliers in Southern Europe, such as Haizea.

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- New growing offshore markets and local content policies will drive future tower facilities
- US market will likely see multiple new facilities to supply surging demand, exploiting the recently voted Inflation Reduction Act (IRA), in which the level of tax credits awarded is impacted by local content of the project

Key supply chain challenges for towers:

- Steel price increases and complex logistics of oversized components expose global supply chain to significant cost risk
- FiT phase out on Chinese offshore segment triggered a frenetic installation pace, which except from a proof of supply chain resilience, aggravate oversupply on the market

1,031 Supply chain requires investment to meet the increased demand

• Overcapacity will persist until 2025 with existing capacity. However, considering the time lag effect, offshore industry will start feeling the supply tightening from 2023-2024 for project deliveries in 2025 and onwards. Therefore, offshore growth is expected to peak in the second half of the decade, requiring 2.3k additional sections.

Source: Wood Mackenzie

Note: China's capacity is based on WoodMac's assumptions, Find out more about WoodMac's Offshore Services here

3. Tower supplier trends



Tower supply is highly fragmented, regionalized and entirely outsourced

Nordex and Enercon are the only (top-15) OEMs with significant in-house tower manufacturing capacity, deploying hybrid and concrete towers solutions from conventional or mobile facilities located close to installation sites

Top tower manufacturer capacities, 2021e, tonnes

Turbine OEMs' in-house tower manufacturing shares, 2021e



Source: Wood Mackenzie

Note: Market shares are based on Wood Mackenzie's installed capacity estimation during 2021 and not on the sales volumes; *In-house manufacturing includes different towers' segmentation

Chinese suppliers dominated the offshore market, delivering 87% of towers

FiT phase out in China resulted in a record year for the offshore segment, benefiting domestic players who utilized their strong portfolio to meet soaring local demand

Offshore towers market share, 2021e

Offshore tower market share per OEM, 2021e



Note: Based on grid-connection volumes, CS Wind's volumes include towers manufactured with ASM and Chin Fong

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GE is strengthening ties with Haizea, defying the multisource trend on OFF towers

Chinese OEMs have the most diversified SoW, exploiting their domestic supply base; SGRE and Vestas have strong links with Danish suppliers

Turbine OEMs Offshore towers demand, 2021-2026e (no. of towers)



Turbine OEMs offshore tower sourcing trends*, 2015-2020



Source: Wood Mackenzie

Note: * Based on grid-connection year and on disclosed orders, **Only known and awarded orders

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Turbine OEMs offshore tower sourcing

Western suppliers are suffering from increased costs and supply chain woes

Inflated commodities and power prices are widening the cost gap between European and Chinese suppliers



Factors impacting profitability				
Factor	Western	China	Comments	
Steel	\bigcirc		Average 10 year price of Chinese steel has been 30% cheaper than European	
Scale effects			Standardization of towers' geometries & domestic steel supply chain tap scale effects	
Logistics			Western tower logistics have been skyrocketing, while transportation complexity increases	
Labor costs			Labour can comprise 8% of tower's cost in western markets	
Manufacturing process	\bigcirc		CO2 sensitivity and power prices in Europe are key cost drivers	
Commercial arrangements			Tower out-of-scope for Chinese OEMs, sourced direct as EPC item	
Technology			Deployment of alternative towers solutions reduces steel exposure	
Diversification			Chinese tower suppliers highly diversified to other industries	

Source: Wood Mackenzie, Public financial statements

Note: Chinese Suppliers: Titan, Guangdong No.2 TSP Group, ZPMC, Western Suppliers: Broadwind, Welcon, Valmont

Duties imposed on EU wind towers imports

After US, EU Commission imposes punitive levy on towers imports from China

Protectionism on western markets is forcing tower suppliers to restructure supply chain and raise their pricing

Country **Towers tariffs** imposed (%) 7.2% - 19.2%

Duties imposed on US* wind towers imports



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Made-in-EU towers were 22% more expensive than Chinese

The Commission confirmed that towers at an annual value of €300M were taking place at dumped price; European OEMs opposed the measures fearing supply chain limitations and project delays



EU Commission rules against China towers

- In December, 2021, the EU commission ruled that Chinese towers caused material injury to the EU
- Chinese State presence on the ownership of steel suppliers
- Direct State intervention on the pricing and cost of the steel sector
- State presence on the financial and raw material markets distort further markets principles - resource allocation to strategic important market segment
- Chinese bankruptcy and property laws are not in line with EU regulations

Economic situation of EU tower's industry

- During the period 2017-2020:
- Production dropped 10%
- Capacity utilization fell from 56% to 49%
- · Production capacity marginally increased
- Sales dropped by 7%
- Consumption increased by 14%
- Chinese imports increased by 54%

Source: Wood Mackenzie, EU Commission

Note: Prices and cost are nominal values, *Logistics included, **Tariffs were imposed for both onshore and offshore, however the practical implementation refers only to onshore as there are not any offshore tower imported from China

4. Tower demand trends

Onshore flat GW demand and larger turbine ratings reduce demand for tower sections

Deployment of bigger turbines and higher hub-heights increases the volume of steel per MW required, which further exposes the tower industry to commodity price volatility risk Global onshore tower section demand, 2010e-2030e Global tonnes of steel onshore wind towers, 2010e-2030e



AMER APAC EMEA

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Soaring offshore demand from 2023-2030 drives tower market expansion by double

Next generation offshore turbines launched by the end of decade will require up to 6 sections, while current products require up to 3

Global offshore tower section demand, 2015-2030e



Source: Wood Mackenzie

Note: China's demand in sections and steel is based on Wood Mackenzie's estimation

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Global tonnes of steel for offshore wind towers, 2015-2030e

New or closed onshore towers facilities, 2020-2025e



China is further enhancing its dominance on the onshore towers segment by bringing approx. 8GW of new additional capacity

New tower facilities are expected, but not yet announced, in the US to meet domestic content bonus in IRA

Enercon Arcosa CS Wind /TSP -Longma Heavy Industry Titan -Qingdao Tianneng -Qingdao Tianneng Sinohydro 4 Titan -Qingdao Tianneng Shut down Under construction Planned Operating since 2020 Upgraded facility

Sections Steel oversupply in China

2900

200

- Steel demand in China is -6% YTD while production continued to grow month-on-month in H1 2022
- Steel demand failed to keep pace with supply
- However, freight rates, tariffs and increasing importance of CO2 emissions during steel manufacturing in Western markets, are balancing the low steel price and preventing the Chinese entry to western offshore markets

OEMs are focusing exclusively on outsourcing

- Vestas divested its tower facility in Colorado and sold it to CS Wind: a measure that entails Vestas further focusing on core business
- Enercon continues supply chain footprint restructure with the closure of it Magdeburg tower facility
- New facility extension in China to meet soaring domestic demand and exports to proximate markets
- Recently voted IRA will spur future tower facilities in the USA, as towers are a requisite to meet local content
- CS Wind announced a further expansion of its Colorado facility in anticipation of rising demand

Source: Wood Mackenzie

Note: Due to space limitation on slide Qingdao Tianneng Electric Power Engineering Machinery is referred as Qingdao Tianneng; included only wind related manufacturers

New markets and domestic source requirements will spur future offshore facilities

It takes at least two years to build a new facility; the supply chain ramp up should have already started considering that 64% of this decade offshore volume will be installed from 2025 and onwards

New offshore tower facilities, 2020-2025e



Note: Included only wind related manufacturers, For further information on offshore towers, please review Offshore Wind Towers Dynamics

Permitting challenges for new facilities

 An offshore tower facility can be built in just two years; the construction phase is not the challenge. The challenge is to attain building permits and commitments from buyers and investors

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New markets surge

3000

- Offshore wind's global expansion is driving new towers facilities in emerging markets like the USA and Poland
- Proximity to offshore wind hubs is crucial to minimize the logistics costs and challenges from transferring longer towers
- Local content requirements are another major driver, as towers do play a key role to meet local content

Entry of Chinese suppliers on western offshore markets

- In contrast with the onshore segment, offshore is mainly dominated by European suppliers on western markets
- High shipping costs and national steel tariffs have prevented Chinese supplier entry
- Increasing attention to CO2 emission is also another reason that prevent massive Chinese entry. A tower manufactured in China produces <u>288%</u> more CO2 emissions than a tower produced in Denmark (excl. transportation)

5. Commodity and raw material contribution – Tower key cost drivers

Onshore cost drivers

Towers drive 8% of Wind CAPEX, and are the 2nd most expensive turbine component

Towers are a significant driver of cost, particularly when considering the high contribution to logistics spend

Should Cost of Onshore Wind Project, % of EPC CAPEX cost



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Metals account for nearly 76% of towers costs, with steel plate accounting for over half of towers costs

Onshore towers, % of Total Cost By Material or Labor Input



Steel Plate

- Plate prices have been trending higher in the past year and is up by 2% YOY as of August. Prices have stayed relatively high compared to other metals as demand remained steady
- In addition to the support from demand, the US steel plate supply is concentrated, enabling the market to maintain pricing during the past year
- However, the start of operations of 1.2 million st/yr Nucor's new steel plate mill later this year can add a downward pressure on prices

Other Metals (Aluminum, Copper, and Stainless Steel):

- Prices of aluminum and copper have dropped in recent months from recent highs due to overall weaker demand, down 7% and 15% YOY, respectively as of August. However, downside supply risks coming from rising energy costs in Europe, increased fuel costs, and continued supply disruptions are forecasted to underpin lower prices
- Stainless steel prices are up 31% YOY, but they have dropped slightly from muted demand last month. Prices are forecasted to reverse course as supply is forecasted to drop in the near-term due to stalled recovery from COVID lockdowns in China

Rising US plate prices widening the cost difference between US and China

Domestic steel production is giving strong competitive advantage to Chinese tower manufacturers



Anti-dumping measures against Chinese steel

- Towers are the most hard hit component from anti-dumping duties due to high use of steel, as governments around the globe are protecting domestic steel industry
- In 2021 the European Commission was the latest authority that passed legislation and imposed an anti-dumping duty on onshore and offshore tower orders from Chinese suppliers, ranging from 7.2% up to 19.2%
- Tower suppliers in China are highly diversified, allowing them to exploit better economies of scale and maximize utilization achieving higher cost reductions

Barriers for Chinese suppliers

- · High shipping/logistic costs, especially as towers are increasing their size
- · Long lead times, driven by shipping times and port congestions
- Tariffs imposed by western markets to support domestic suppliers
 High fuel prices, driven by increase logistics requirements
- Increased attention on carbon emission, as western OEMs and suppliers are seeking alternative approaches to decarbonise their supply chains

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Source: Cost Intelligence, a Wood Mackenzie Supply Chain product, World Bank. Note: Logistics are not included

Onshore towers input costs have surged 90% compared to pre-pandemic levels

Towers prices have starting falling from recent highs heavily led by steel plate and metals price decreases, but remain elevated in 2022



• Towers prices hit bottom in May-20, driven by the massive build cycle and favourable raw materials supply pricing.

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 Since the onset of the COVID pandemic, prices have risen by over twofold before falling in recent months

Base scenario

- Towers prices are expected to increase by roughly 6% over the next two years
- Further price increase is expected due to inflated labour, rising energy and fuel costs
- The global metals market will drive the price of towers, prices will continue to be dependent on supply limitations and demand outlook

High/Low scenario

- Further price escalation is expected in the event of higher fuel prices, which will affect raw materials, transportation, production costs and will push inflation even higher
- Low scenario is likely if inflation will retreat from current historic heights and oversupply situation persists

Historic towers prices

Offshore cost drivers

Offshore tower cost/MW to steadily decline and plateau by the end of the decade

Increases in steel prices are the main contributor to a 65% hike in cost per MW from 2021 to 2023



OFF Towers cost/MW development, 2019-2026, Indexed, (2019=100)

Source: Wood Mackenzie

Note: Excluding China and Vietnam. Excludes suppliers' margins, transport cost, and costs associated with carbon pricing. For further information on offshore towers pricing, you can review <u>Offshore Wind Towers Dynamics</u>

Onshore is experiencing higher volatility

- Offshore projects have significant time gap between order execution, therefore the cost peak on offshore towers is expected by 2023
- Economies of scale due to larger turbines and project size deployment

Other factors affecting towers' cost (excl. steel)

- Weight is probably the most sensitive factor for total costs. Weight is affected due to expanded diameters, which directly impacts the complexity and size of welds and the consumed materials. Thus, it becomes the most sensitive factor for total costs
- While logistics are not included on tower suppliers' scope, the manufacturing location does have an impact on landed costs
- Offshore towers market is characterized by oversupply, which is adding another pressure to suppliers' thin margins. A balanced market is expected beyond 2025
- Flanges are sourced from 3rd parties, therefore there is limited control from towers' suppliers 26



Stability in Chinese plate prices has widened the cost gap between China and Europe

Anti-dumping tariffs combined with high fuel and transportation costs currently shield the offshore European market from being undercut from Chinese suppliers which have a significantly lower cost base.

Cost breakdown of a 450t tower manufactured in 2022*, EUR 1,111,589



Tower cost per MW China vs European cost base*



Grid-connection year

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Steel plate price Europe vs China (2016 to 2031)



Steel supply year

Note: *Excluding transportation costs and suppliers' profit margins. Import tariffs from EU to China are modeled here as 11.2% but can range from 7% to 19% depending on the fabrication yard. Source: Wood Mackenzie

Primary tower cost drivers – raw materials, logistics, labour

First signs of relief from steel prices; still highly elevated from pre-Covid level

Steel production is anticipated to keep pace with demand, while prices are on normalization track, however significantly elevated in comparison with pre-pandemic levels



Factors affecting steel demand and pricing:

- Pandemic-infused lockdowns in China
- Extreme heat waves and power shortages in India
- Economic sanctions on Russia
- Ukraine has lost around 30-40% of its pre-war steelmaking capacity

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- Global economic slow down
- Policy intervention

Production trends

- The global supply will closely follow the demand trajectory
- China will continue to be the biggest steel producer, whereas India and Southeast Asia will be drivers of capacity additions
- Global majors will start abandoning the highly polluting BF-BOF route and switch to the less emissionintensive steelmaking

Source: Wood Mackenzie

Note: for further analysis on steel, please review Global Steel Strategic Planning Outlook - Q2 2022

Soaring logistics and long lead times are forcing a supply footprint restructure

Declining freight rates, which towered as much as 6x, cannot relief wind supply chain; LT are mounting to 20 weeks due to port congestions and zero-Covid policies, adding extra costs to distressed wind value chain

Logistics lead times (LT)

Container shipment prices, Indexed (Aug-19=100)



 Ocean trade volumes appeared to peak in May 2022, and Container Freight rates have fallen by nearly a third YTD amid slowing consumer demand, port bottlenecks, and macroeconomic headwinds

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- Logistics contribution to total costs:
 - Close to 20% is it sourced domestically
 - 30% if it is exported overseas (mainly India, China)

Plan to reduce logistics exposure

- OEMs are considering rail transportation as an alternative transportation mean to reduce exposure on road and sea freights. Suppliers located close to railways can benefit
- OEMs are seeking for strategic long-term partnerships with shipping companies (eg: Vestas – Maersk)
- Inventory build-up to avoid production stop due to long
 LT and shortages is coming with significant cost

Light at the end of the tunnel (?)

- The normalization of the red hot container market may happen at earliest Q4 2022 to – worst case scenario – late 2024
- However, the lack of specialized vessels for towers transportation poses a risk

Logistics and LT impact

Source: Freightos and Toepfer via <u>Cost Intelligence®</u>, a Wood Mackenzie Supply Chain product Note: TMI = Toepfer Multipurpose Vessel Index

Heated job market pushes higher labour costs while there is shortage of manpower

Historic-low unemployment rates shrink labour pool and increase wages, elevating further production costs



Regional trends

 In 2020 the average annual wage of a non-private Chinese employee increased by 7.6%

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- Average wage in EU has grown approx.
 12% since 2020. However, there are significant gaps between the countries
- In India and Mexico labour cost is offset by currency fluctuation

Low unemployment implications

- · Dip in productivity
- Rising wage inflation
- Shortage of skilled manpower

6. Key tower technology trends



Turbine towers are becoming taller in both segments to garner better quality winds and increase turbine AEP

Global tower trends 2020-2030e, hub height (m)



Regional tower growth trends - onshore

- Rapid technology adoption in China has impacted the tower heights in APAC region. Chinese developers ordered only in H1 2022
 <u>32GW</u> of the 5.0-6.99MW segment, equalizing the 2021 cumulative track record of this class
- Additionally, Chinese steel price is less volatile than in the US and European markets, allowing developers to procure higher towers. Also the business model of developers sourcing towers directly from the suppliers is not expected to change in the next years
- Migration to the next turbine generation in markets such as Nordics, Spain, Germany and UK will lead to growing tower height
- Tower heights are also growing in the USA, as GE and Vestas, who are controlling <u>84%</u> of 2021 installs, have already launched Cypress and Enventus respectively

Offshore tower growth trends

 Larger rotors with higher nameplate capacity are pushing offshore towers to almost 50% higher towers by the end of the decade

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Biography

Endri has more than 4 years of experience in the global wind industry. He is part of Wood Mackenzie's Global Wind Technology and Supply Chain team, where he serves Wood Mackenzie's research and consulting clients. His area of expertise includes – but not limited – global wind turbine technology trends, supply chain trends, turbine OEMs market share developments, product positioning strategies, wind CAPEX and LCOE development, while is (co) - authoring some of the industry leading reports, including Global Wind Supply Chain Trends, Global Wind Technology Trends and Global Wind OEMs Market Share Forecasts.

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