Wind Trade And Manufacturing

A Deep Dive

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BloombergNEF

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Section 1. Executive Summary

12,000 tons

Potential demand for rare earths from wind turbines by 2029

$2.6 billion

The value of wind equipment imported into the U.S. in 2019

126GW

Wind turbine nacelle manufacturing capacity in 2020

The following is an in-depth examination of wind manufacturing and trade trends produced under an ongoing partnership between BloombergNEF and the Energy Security & Climate Change Program at the Center for Strategic and International Studies in Washington. This report focuses exclusively on the wind industry and offers a deeper-dive look at current global competitive dynamics. Similar reports covering the solar PV and battery storage sectors have been published separately and are also available for download at both CSIS.org and BNEF.com.

1. The primary components contained in a typical utility-scale wind turbine are foundations, towers, blades, hubs, and drivetrains. The drivetrain sits within the nacelle atop the tower and converts the rotational energy from the blades into electricity.
2. Concrete is the predominant material used in onshore wind farms (by weight), while steel takes the lion's share for offshore projects. Concrete, land-based foundations and steel sub-sea foundations contribute the majority to this, but nacelles and towers also require steel. Concrete tends to be locally sourced, whereas China remains a key global steel producer.
3. Demand for rare earths in wind turbines will triple by 2029 to 12,000 metric tons per year of oxides. Direct-drive permanent magnet generators make up 10% of the onshore market today and 70% of the offshore market. Over 60% of 2019 rare earth production was in China.
4. The U.S. is one of only five countries that can produce all major components contained in a wind turbine. The others are China, India, Spain, and Germany. A total of 39 nations have plants that can produce equipment for at least one major segment of the wind value chain.
5. The U.S. imports relatively few completed wind turbine generating sets (assembled nacelles, blades, hubs, and associated electronics). The country commissioned over 9GW of wind capacity in 2019 but imported less than 400MW in generating sets that year.
6. While the U.S. has the capability to manufacture certain volumes of each major component, it relies significantly on other nations for component imports. The U.S. imported just over $2.6 billion of wind equipment in 2019. Wind blades and hubs were the largest dedicated segment.
7. There are fewer factories to produce gearboxes globally than for any other major wind component. Gearboxes are comparatively easier to transport than other major components, obviating the need to localize supply. Most factories are in China, followed by Germany, Spain, India, and the U.S.
8. Precision-made bearings help shafts or blades rotate while withstanding continuous variable loads and harsh environments. The U.S. is both the second largest manufacturer globally – a fifth of all bearings factories are located in the U.S. – and a major importer of bearings.
9. There are nine tower factories in the U.S., six of which are owned by U.S. companies. Despite the earlier imposition of tariffs, U.S. companies still import some towers, typically when they are cheaper due to lower steel and labor costs elsewhere.
10. China central government policy-making in the 2000's helped establish the world's largest national wind-turbine value chain within the country's borders. Foreign turbine-makers, which

had been growing sales locally quickly, lost market share after China imposed local-content requirements.

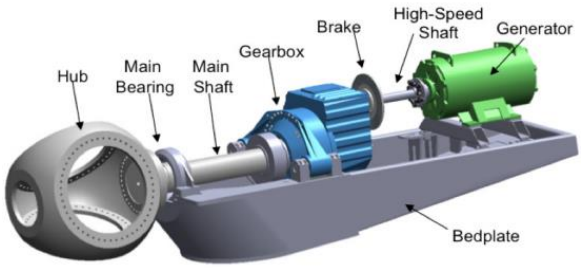
11. Those requirements were lifted in 2010 after domestic players had established dominant positions. China's policies have created market inefficiencies, namely overcapacity. Chinese turbine manufacturers have to date had little success in exporting final products overseas.
12. Over half the manufacturing value of a typical completed wind turbine installed in the U.S. accrues to the U.S. Towers and blades are often made domestically. Chinese manufacturers have a greater presence in gearboxes, converters and bearings but these represent only 25% of a turbine's final cost.
13. There are other costs associated with wind turbine installations that, by definition, accrue value locally. Taking a typical wind project's development and "balance of plant" costs into account would push the total share of value accrued in a typical U.S. wind turbine to 70%.

Section 2. Wind

2.1. Primer

Today's utility-scale wind turbines consist of the following primary components: foundations, towers, blades, hubs, drivetrain and nacelles. The drivetrain sits within the nacelle and converts the rotational energy from the blades into electricity (Figure 1).

Figure 1: High-speed geared wind turbine drivetrain configuration



Source: NREL

There is no single industry standard for drivetrains; all have generators but not all have gearboxes. There are three main types of drivetrains: high-speed geared, medium-speed geared and low-speed direct-drive. High-speed and medium-speed drivetrains use gearboxes to step up blade motions into faster rotation of the generator shaft, which induces electrical current. Low-speed direct-drive turbines do not use gearboxes. Instead, they convert the slow rotational torque from the blades directly into electricity using permanent magnets generators (PMG). Shedding the gearbox allows for a more compact nacelle and fewer moving parts, saving maintenance costs. However, PMGs are much heavier than induction generators and use rare-earth metals, which are costly and sensitive to price fluctuations.

Table 1 provides a summary of key characteristics of the wind sector.

Table 1: Summary of wind supply chain characteristics

	Number of factories	Largest manufacturer (country)	Market concentration (Country)	Market concentration (Company)	Adjacent industries	U.S. reliance on imports	Barrier to entry	Value
Overall	564	China	Med	Med	N/A	Med	Med	High
Nacelle	143	China	High	Med	Steel	Low	High	High
Blades	155	China	High	Med	Glass fiber	Med	High	Med
Towers	107	China	High	Low	Steel	Low	Low	Med
Generators	50	China	Low	Med	Power generation	Med	Med	Low
Gearbox	40	China	High	High	Automotive and industrial	High	High	Med
Bearing	69	China	Med	High	Automotive and industrial	Med	Med	Low

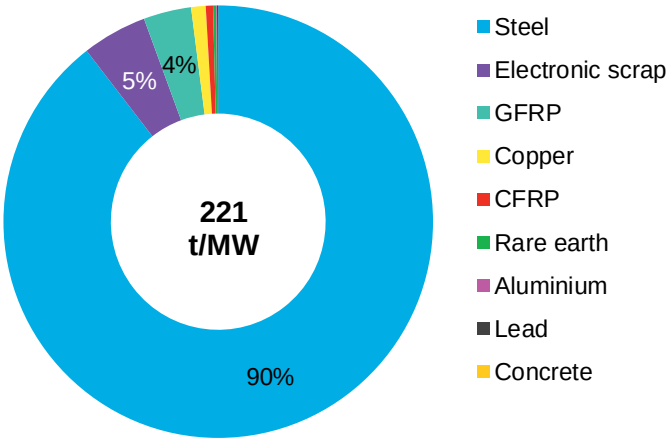
Source: BloombergNEF

2.2. Materials

Concrete and steel

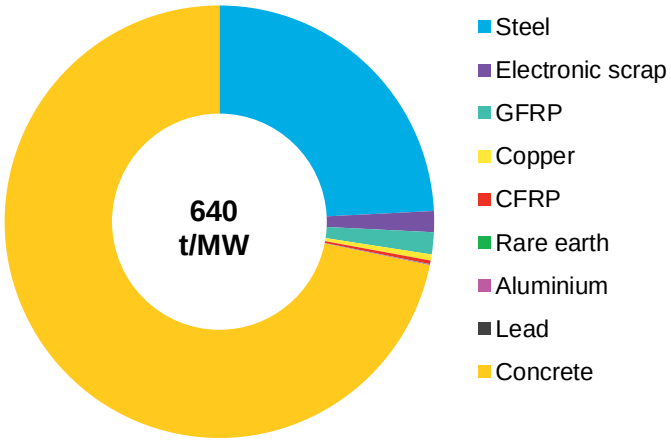
Concrete is the predominant material used in onshore wind farms, while steel takes the lion's share of the weight for offshore (Figure 2, Figure 3). Concrete, land-based foundations and steel sub-sea foundations contribute the majority to this, but the nacelle and tower also demand steel. Concrete tends to be locally sourced, whereas China remains a key steel producer.

Figure 2: Materials breakdown for an offshore wind farm, 2020



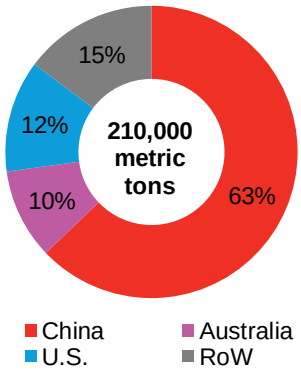
Source: BloombergNEF. Note: GFRP = Glass fiber reinforced plastic, CFRP = Carbon fiber reinforced plastic.

Figure 3: Materials breakdown for an onshore wind farm, 2020



Source: BloombergNEF. Note: GFRP = Glass fiber reinforced plastic, CFRP = Carbon fiber reinforced plastic.

Figure 4: Global rare earth production, 2019



Source: U.S. Geological Survey, BloombergNEF

Glass fiber reinforced plastic

This material is primarily used in wind turbine blades. Leading suppliers Hengshi, Jushi and Hexcel are based in China, Japan, and the U.S., respectively. All three also have facilities in Europe as well. Most production comes from China but could soon become more localized in response to recent policy measures: the EU recently placed large tariffs on glass fiber reinforced plastic from China (and from Chinese companies operating outside of China).

Rare earths

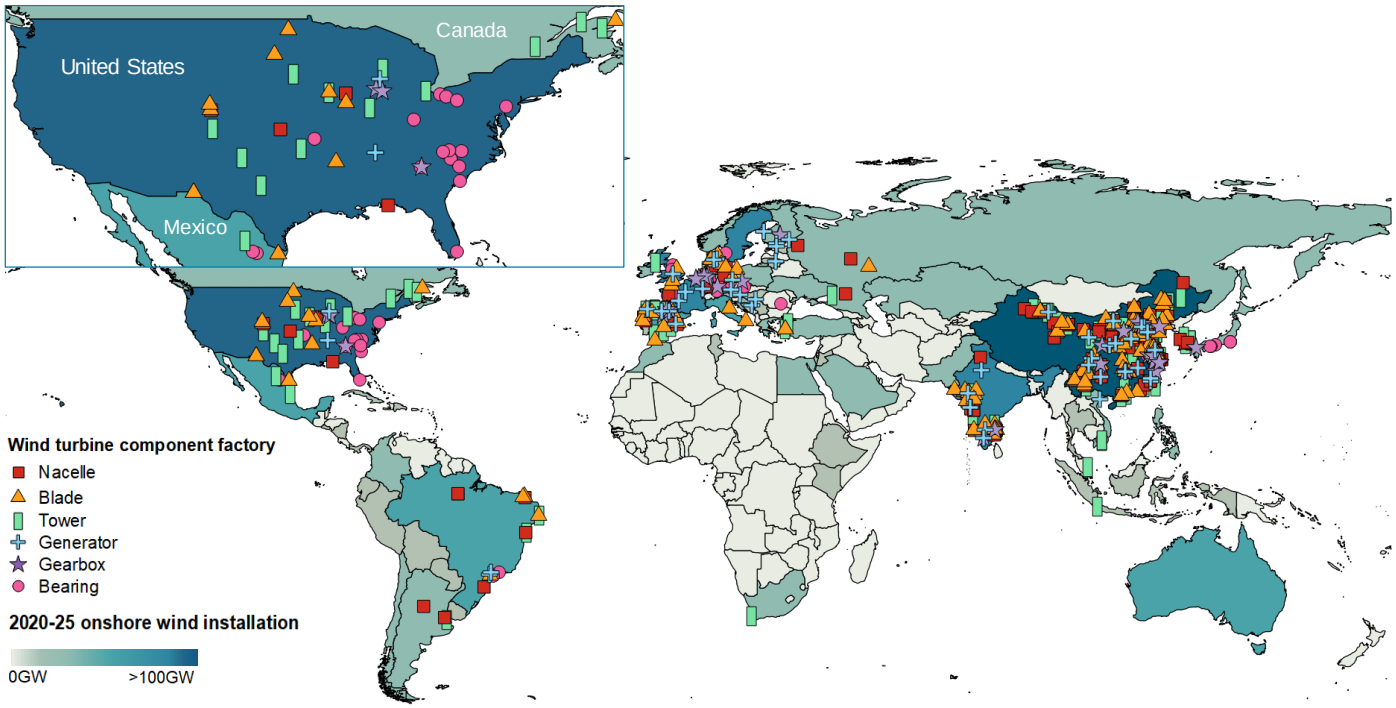
Permanent magnets make electrical motors and generators more efficient and enhance their performance. They are therefore used for electric motors in electric and hybrid vehicles as well as generators used in wind turbines. Neodymium-iron-boron (NdFeBo) and Samarium-cobalt (SmCo) magnets are the most common permanent magnets in the market. BNEF anticipates demand for rare earths for use in wind turbines will triple by 2029 to 12,000 metric tons of rare-earth oxides. This will be driven by the overall growth in installed capacity and the rising market share of direct-drive turbines with permanent magnet generators in the offshore market.

China today controls much of the rare earths market (Figure 4) and this stands to pose challenges for U.S. wind manufacturers that use direct-drive permanent magnets generators rather than gearboxes. Direct-drive generators make up roughly 10% of the global onshore market today and 70% of the offshore market.

2.3. Manufacturing

The wind supply chain has both local and global characteristics. The industry is deploying ever larger turbines to capture more resource and reduce levelized costs of energy (LCOE). Larger turbines require larger and heavier components that are more costly to ship. This would appear to be pushing the industry toward localizing supply chains as much as possible. Today, Europe, China, India and U.S. are major wind manufacturing hubs (Figure 5) but each imports certain materials and components. We expect the U.S. to install roughly 60GW of wind between 2020 and 2025, compared to 135GW in China over the same period. Such imports are typically higher quality or lower cost than what is otherwise available locally.

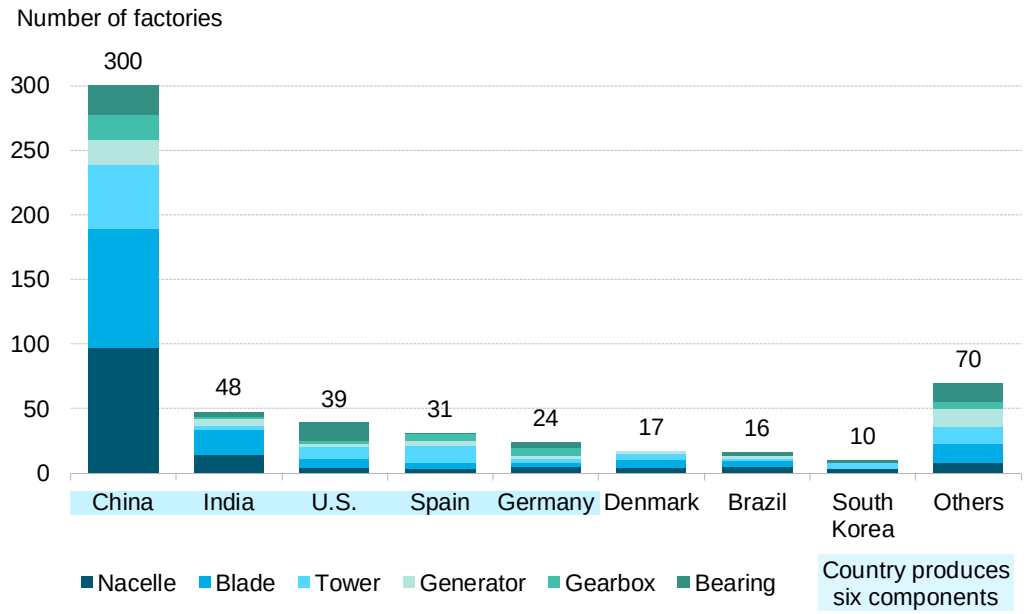
Figure 5: Global wind supply chain footprint



Source: BloombergNEF. Note: Data as of September 25, 2020, including operational factories only.

More than half the world's wind turbine manufacturing or assembly plants are located in China, thanks to strong local demand and a geographically disperse value chain (Figure 6). The technical complexity of wind turbines ensures that only a few countries can have relatively complete supply chains. Of the 39 countries that make utility-scale wind equipment, only China, India, Spain, Germany and the U.S. can produce all six major components – nacelles, blades, towers, generators, gearboxes, and bearings.

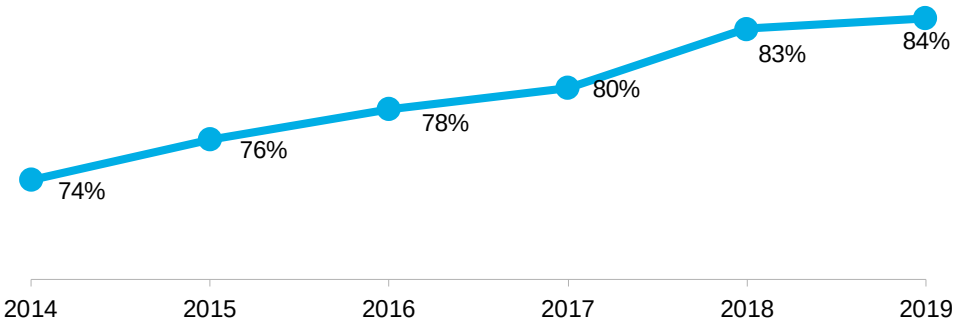
Figure 6: Number of factories by country



Source: BloombergNEF. Note: Data as of September 25, 2020.

The global wind turbine manufacturing sector has become considerably more consolidated in the past few years. In 2019, the top 10 turbine makers met 84% of total worldwide demand, up from 74% in 2014 (Figure 7). However, consolidation is far lower in the largest wind market, China, than in Europe or the Americas. This is mainly due to the active participation of state-owned conglomerates with deep pockets and strong manufacturing capabilities.

Figure 7: Share of global market supplied by the top ten wind turbine makers



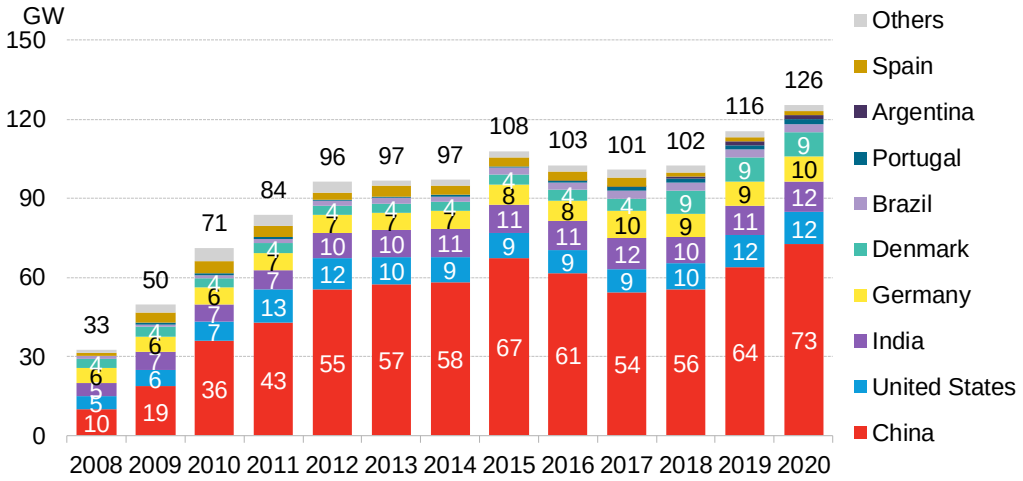
Source: BloombergNEF

Nacelle

Global wind turbine nacelle manufacturing capacity tripled from 2008 to 2012. The majority of the additions took place in China, which boosted its manufacturing capacity more than fivefold (Figure 8). The Chinese government introduced a 70% local-content requirement in 2005 and feed-in tariffs in 2009 which created unprecedented opportunities for domestic players. By the time the

government lifted the local-content requirements in 2010, foreign turbine makers had lost majority market share to Chinese competitors.

Figure 8: Wind turbine nacelle manufacturing capacity by plant location

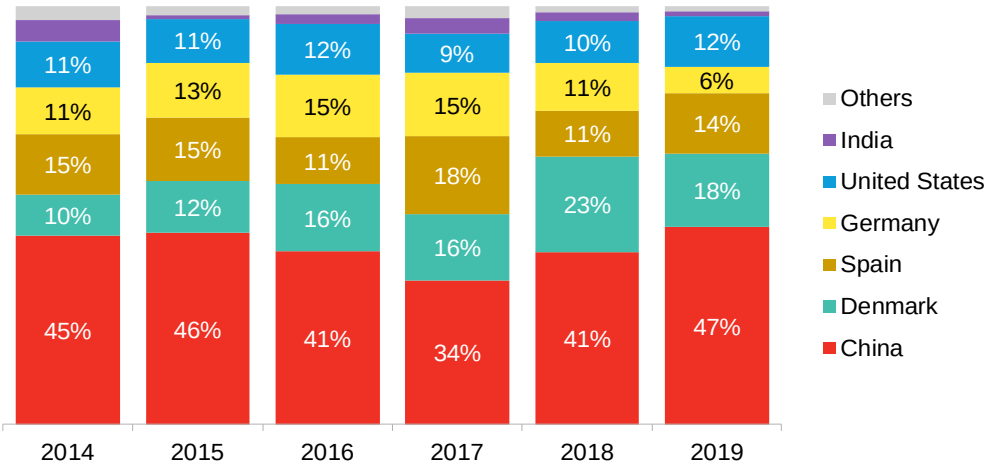


Source: BloombergNEF

But China was not alone in seeing growth. Total nacelle manufacturing capacity in both India and the U.S. also doubled 2008-2012. Global manufacturing capacity then remained relatively flat for a number of years as there was sufficient capacity to meet overall demand.

Today, the market is dominated by a relatively small number of players headquartered in five nations. Major firms in China, Denmark, Spain, Germany, and U.S. made up 98% of global wind market share in 2019 (Figure 9). European and U.S. turbine makers often export their equipment while Chinese firms almost entirely serve their home markets.

Figure 9: Wind turbine nacelle maker market share by country of domicile

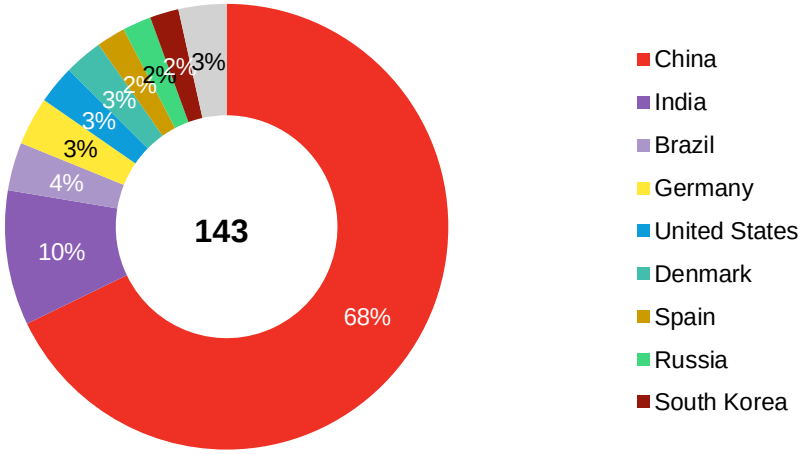


Source: BloombergNEF

Some 97 wind turbine nacelle factories are located in China, accounting for 68% of the global total (Figure 10). Nine more are under development to keep up with demand for large-scale projects in the northern part of the country and an emerging offshore wind market.

Assembling wind turbine nacelles is the last step in the manufacturing process before the equipment is shipped to sites for installation. To cut transportation costs, nacelle factories are often located close to major demand centers. Countries with many factories either have strong local demand or are home to multiple turbine makers. Local-content requirements have also played big role. In Brazil, for instance, developers seeking cut-rate financing from Brazil's National Development Bank (BNDES) must agree to use locally sourced equipment. This domestic-content rule was instrumental in the build-out of a wind supply chain in Brazil.

Figure 10: Commissioned wind turbine nacelle factories



Source: BloombergNEF

China's unconsolidated wind market

The massive volume of nacelle manufacturing capacity in China illustrates both how policies created a major domestic wind market – and significant local inefficiencies. Many of the country's wind turbine nacelle factories are today dramatically underutilized. In 2018 the market was 60% over-supplied for nacelles as some plants were nearly entirely idle.

Provincial governments historically enticed turbine manufacturers to establish local factories to supply equipment to local projects. But once those projects were complete, such plants were not necessarily poised to compete across the rest of the country, let alone to export.

The presence of state-owned entities in the market has seen China buck the global trend toward consolidation in equipment manufacturing. These manufacturers have deep pockets and are resilient to challenging market environments. As a result, the country's three largest privately-owned firms, Goldwind, Envision, and Mingyang, only account for 48% of the country's manufacturing capacity.

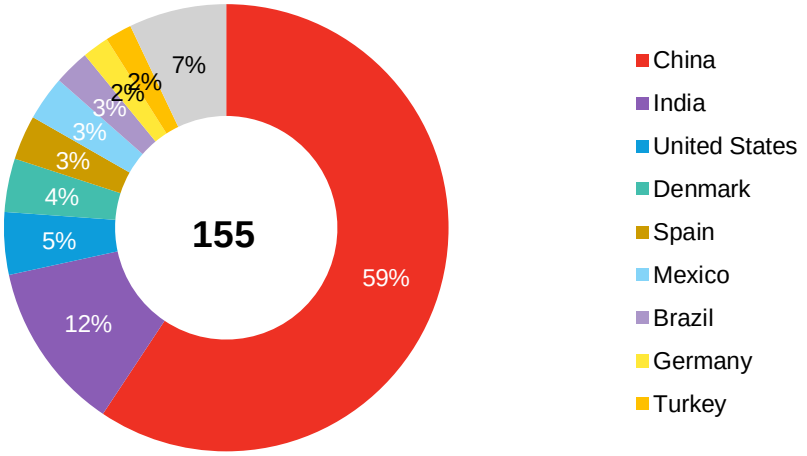
By contrast, concentration in the U.S. is much higher. The three largest turbine makers – GE, Vestas, and Siemens Gamesa – together own over 90% of the country's manufacturing capacity. Given transportation challenges and costs, countries like the U.S. with existing nacelle capacity are unlikely to import a large number of turbines.

Blades

Outside China, most turbine makers are sufficiently vertically integrated to use blades produced in-house. Arizona-based TPI Composites is the only major independent blade maker left outside China and India, after GE acquired LM Wind in 2017.

By contrast, China is still home to many independent blade makers who serve turbine manufacturers not wishing to vertically integrate (Figure 11). India is also a blade-manufacturing hub. Producing blades remains labor intensive, giving India a cost advantage to export blades to other markets while supplying products to local projects.

Figure 11: Commissioned wind turbine blade-manufacturing plants



Source: BloombergNEF

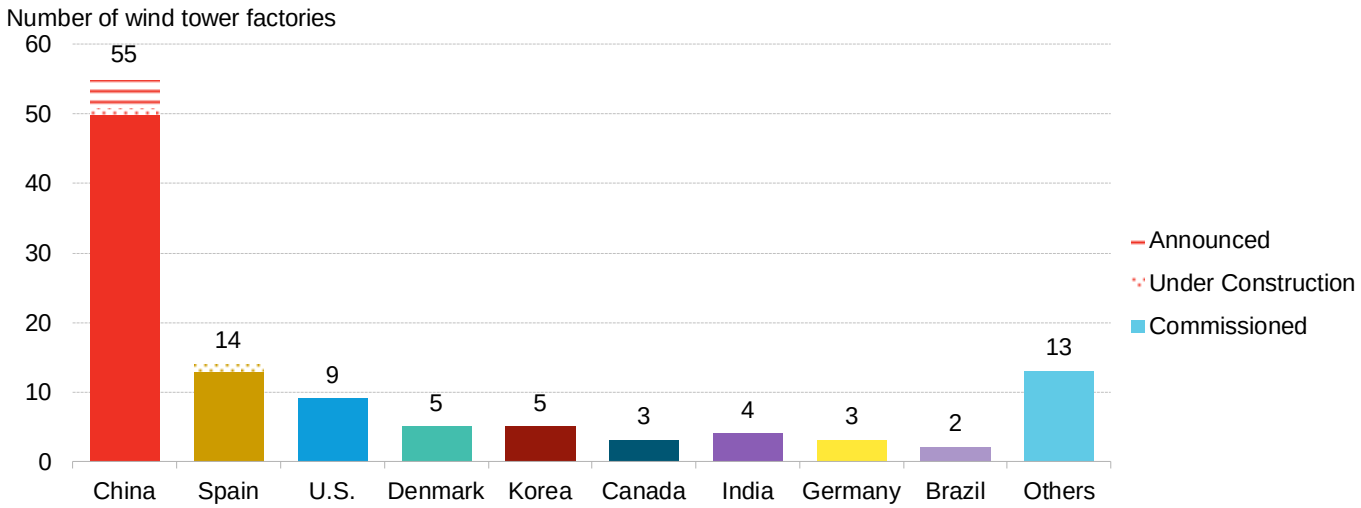
Towers

Roughly half the world's commissioned wind tower manufacturing plants are located in China. Many are owned by state-owned conglomerates, with only a smattering of private sector companies involved. There are five new manufacturing facilities under development in China, one in Spain and none disclosed elsewhere.

Spain is a distant second with 13 such plants on line (Figure 12). Towers are often supplied by local companies, although a few companies have global footprints. Among them are Spanish-based GRI and Windar Renovables. There are nine tower factories in the U.S., six of which are owned by American companies. U.S. firms import some towers, which may be cheaper due to lower-cost steel and labor available elsewhere.

Transportation challenges and low technical barriers to entry to have led to relatively quick build-outs of tower-making plants in markets where demand has spiked. Such facilities also benefit from being located in countries with mature steel-production industries.

Figure 12: Wind tower factories



Source: BloombergNEF.

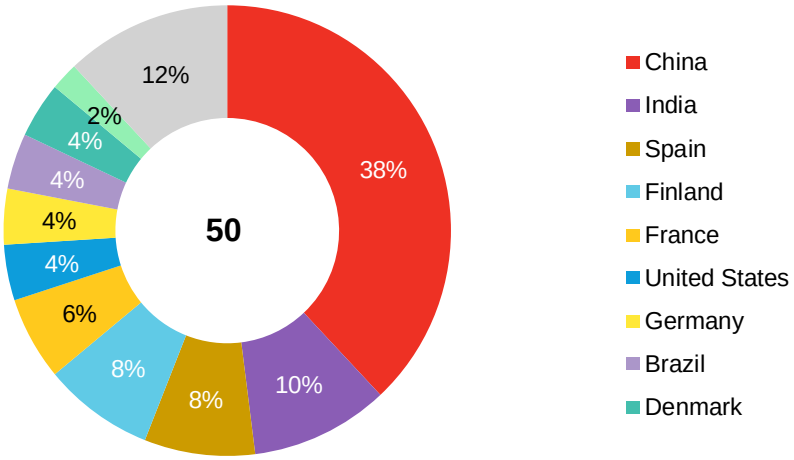
Generators

Some 80% of the world's generator factories are located in China and Europe (Figure 13). Generator market share in China is fairly concentrated between CRRC Yongji and CRRC Zhuzhou Electric. Together, they own 13 of China's 19 generator-making plants.

European companies dominate markets outside China. Generator factories are spread across Finland, France, Germany, Denmark, Spain, and Austria. Major turbine makers Vestas, GE, Siemens Gamesa and Suzlon all produce their own generators or use products offered by parent companies, though they still procure products from third-party suppliers.

The geographic distribution of wind generator factories does not necessarily match demand for final wind turbines. Many wind turbine generator manufacturers also provide products like motors and electronic equipment to a wide range of industries.

Figure 13: Commissioned wind turbine generator manufacturing plants



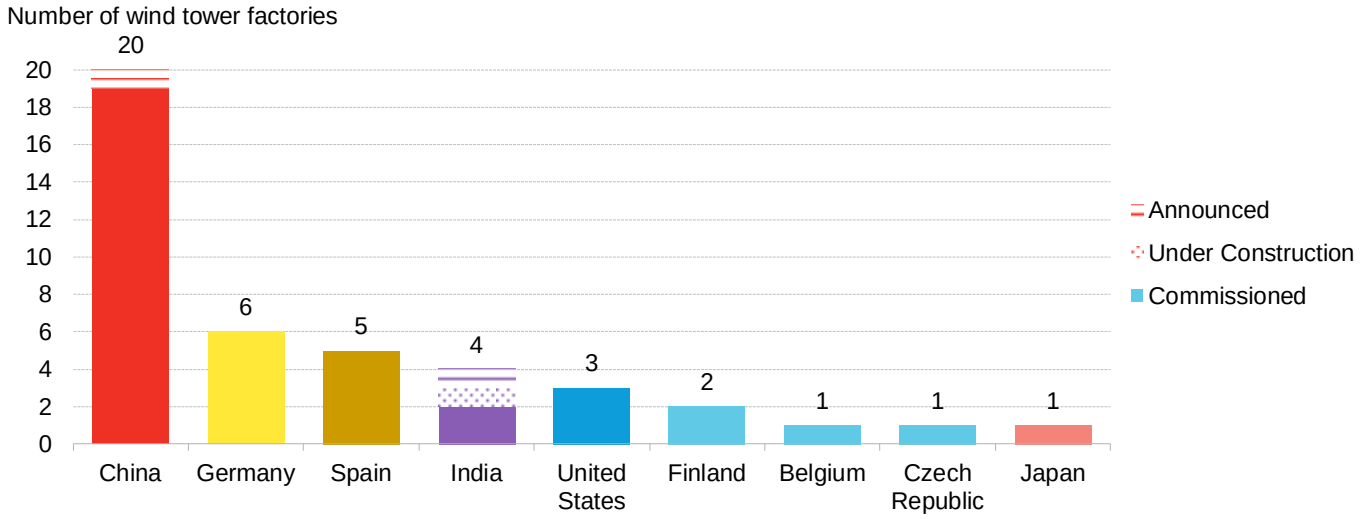
Source: BloombergNEF

Gearbox

There are fewer manufacturing plants to make gearboxes online worldwide than for any other major wind component. Gearboxes are smaller than other components and easier to transport, largely obviating the need for localized supply. Countries that are home to wind turbine gearbox manufacturers also often have gearbox plants. China has the most gearbox facilities, followed by Germany, Spain, India, and the U.S (Figure 14).

ZF Wind (Belgium), Flender (Germany), and NGC (China) dominate today's wind gearbox market after a decade of market consolidation. NGC, one of GE's suppliers, is building its first overseas factory in India, due to the impacts of U.S.-China trade disputes.

Figure 14: Wind turbine gearbox manufacturing plants



Source: BloombergNEF

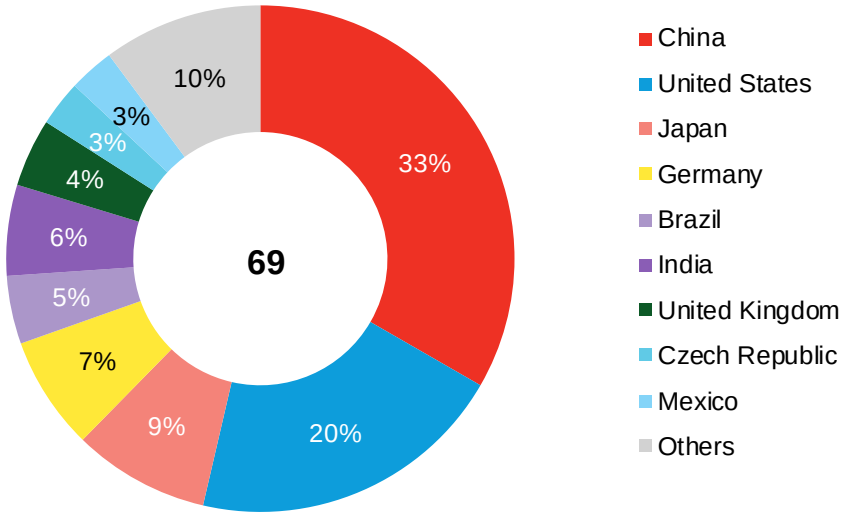
Bearings

Bearings are necessary to help shafts or blades rotate millions of times while withstanding variable loads and harsh environments. The challenge of making extremely precise bearings that meet reliability requirements has created high barriers to entry for potential newcomers.

While China has a mature wind supply chain and that includes bearing factories (Figure 15), it still must import large-diameter bearings from Europe. German, Swedish, Japanese, and U.S. manufactures dominate the high-end bearings market for the latest large onshore and offshore wind turbines. Ohio-based Timken is the only globally competitive bearing maker headquartered in the U.S.

Wind is one of many sectors that use precision bearings so the industry generally does not dictate where bearing factories are located. The U.S. and China have over half the world's plants that make such bearings, thanks to strong demand from their automotive and industrial sectors.

Figure 15: Operating plants that make bearings for use in wind turbines



Source: BloombergNEF

2.4. Trade flows

Deciphering wind imports and exports is hindered by inadequate customs classifications and insufficient data transparency. For our analysis of the wind equipment trade flows, we have relied on a combination of United States International Trade Commission, Lawrence Berkeley National Laboratory and company data. The same components used in wind turbines are also used in multiple other industries which makes it much harder to isolate sector-specific trade. Within clean power, this issue is most problematic for wind because both PV and batteries have more sector-specific components. Because of the overlap between wind and other industries, some component-level customs data can overestimate or underestimate trade values.

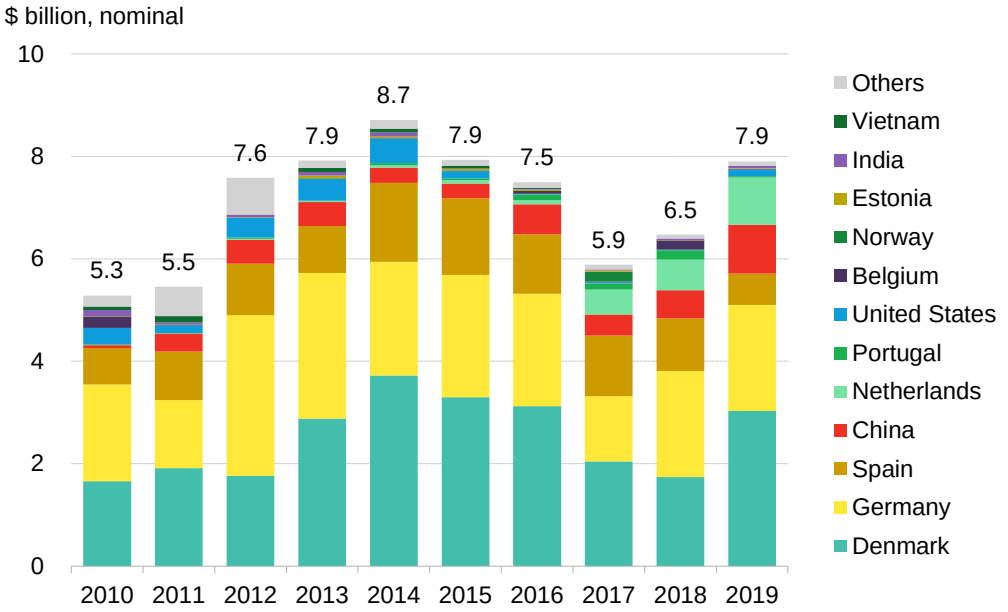
Exports

Europe is the leading region for exports of wind turbine generating sets (assembled nacelles, blades, hubs, and associated electronics). Within Europe, Spain, Germany and Denmark are each home to major turbine makers and accounted for the largest share of European output. The wind generator set export market is smaller than that of individual major wind components as manufacturers tend to assemble such sets closer to the locations where they will be installed to reduce transportation costs.

Despite having the most wind equipment manufacturing plants, China accounts for just a fraction of generator set exports. While Vestas, GE, Siemens and Gamesa all export generator sets produced from plants they own on Chinese soil, Chinese-headquartered firms have had limited success shipping such equipment to overseas markets (Figure 16).

The U.S. has exported far less than European countries and has done so mainly to Canada and Brazil. Its export volume has fallen gradually since 2015. Today, U.S.-produced wind turbines go almost entirely to U.S. projects.

Figure 16: Exports of wind power generating sets, by location of plant



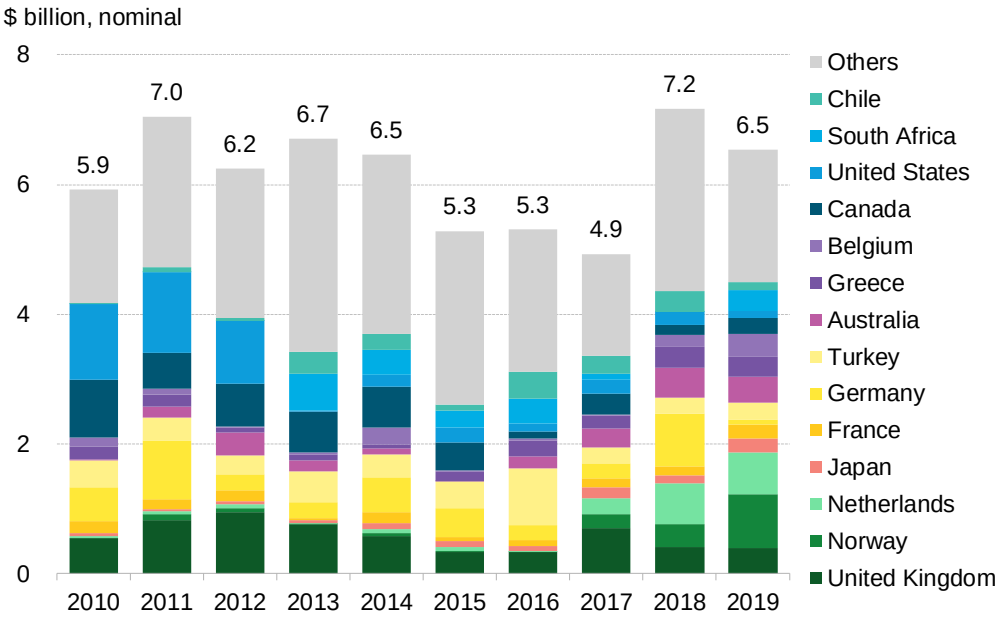
Source: BloombergNEF. Note: Wind turbine generating sets refer to both utility-scale and small wind turbines, including nacelles, blades, hubs, and electronic equipment. We assume the bulk of exports are for utility-scale generating sets. The chart shows location of plant and so includes foreign manufacturers with factories located in China that serve other markets.

Imports

The market for wind turbine generators is quite geographically diverse with no less than 125 countries bringing in such equipment in 2019. Some 21 countries imported more than $100 million of equipment. Smaller nations that lack sufficient demand to convince manufacturers to build plants locally tend to have to import as a result.

Europe is a major importing market, with the U.K., Norway, the Netherlands, France and Turkey leading the way (Figure 17). Each country has brisk demand for turbines, but lacks sufficient local manufacturing capacity. The relatively efficient flow of goods and services within the EU has allowed major markets such as the U.K. to import from its neighbors (though once Brexit is complete, this could change). Europe as a whole also imports some products from the Americas and from Asia.

Figure 17: Imports of wind turbine generating sets by importing country

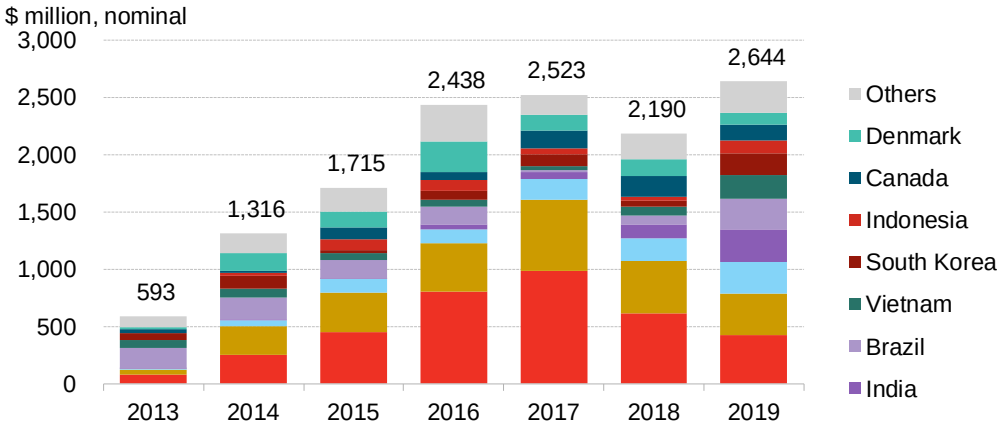


Source: BloombergNEF. Note: Wind-powered generating sets refer to both utility-scale and small wind turbines, including nacelles, blades, hubs, and electronic equipment. A total of 125 countries imported wind turbine generating sets in 2019. The 21 countries (not including those on the chart) that imported more than $100m are Ukraine, Denmark, Turkey, Russia, Sweden, Taiwan, Chile, Spain, Argentina, Vietnam, Poland, Mexico, Indonesia, Finland, Austria, Serbia, Egypt, Kazakhstan, South Korea, Bolivia, Peru, Morocco.

U.S. imports

U.S. imports of all wind power-specific equipment – a category that includes both generating sets, plus blades and hubs, towers, generators and other relevant components – rose sharply from 2013-2016 but have since stabilized (Figure 18). Asian nations accounted for 48% of what the U.S. imported in 2019, with the balance coming from European and Americas nations. Imports from China hit nearly $1 billion in 2017 but receded to less than $500 million in 2019. However, China remains the largest supplier of such equipment to the U.S. thanks to its manufacturing expertise and the low prices its firms offer. The bulk of Chinese exports to the U.S. of wind equipment come in the form of components, not as wind turbine generating sets.

Figure 18: U.S. imports of all types of wind-power equipment by exporting nation



Source: BloombergNEF, USITC, Berkeley Lab. Note: Data derived from Berkeley Lab estimates. Some data based on trade categories not exclusive to wind. Wind-specific imports include wind-powered generating sets, blades and hubs, towers, generators and other relevant components. The total import value may include products that cross borders multiple times.

Wind generator sets

Considered solely on a finished turbine (wind generator set) basis, the U.S. imports relatively little compared to the size of overall demand. The country commissioned over 9GW of wind-generating capacity in 2019 but imported less than 400MW of wind generator sets that year.[1] As the world's second largest demand market for equipment, major turbine makers GE, Vestas, Siemens Gamesa, and Nordex all have assembly facilities on U.S. soil. Because nacelle manufacturing capacity rarely represents a supply chain bottleneck, few generator sets come in complete form to the U.S. In fact, U.S. imports of finished wind generating sets have fallen since 2017.

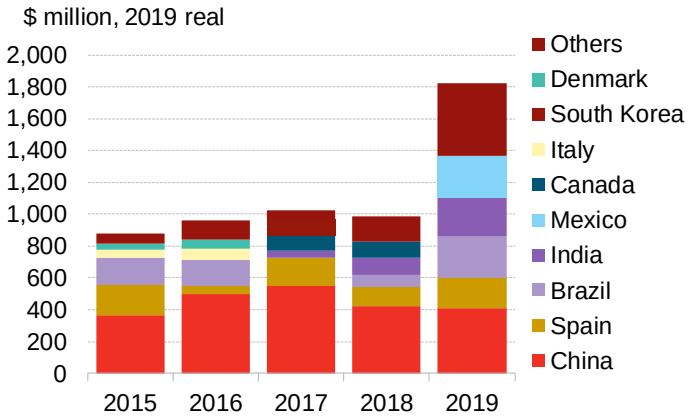
Wind blades, hubs and towers

The largest segment of U.S. imports on a dollar basis is represented by a category that includes wind blades, hubs and towers. Combined, this equipment accounted for $1.8 billion in U.S. imports in 2019, up sharply from just under $1 billion in 2018. China accounted for 22% of the 2019 total (Figure 19). Brazil, Mexico and India were other prominent suppliers. Around 85% of all imported blades heading to GE, Vestas and Siemens Gamesa in the U.S. came from Brazil, China and India. All three countries have well established wind supply chains and benefit from low labor costs. This is particularly important in the labor-intense blade segment of the value chain.

Over half of tower imports to the U.S. on a dollar basis in 2019 came from Asia, primarily Indonesia, Vietnam, and India. At one time, Asia supplied over 80% of towers to the U.S. with China accounting for about half that. After the U.S. imposed tariffs on towers in 2012, however, Asia's share dropped to an average of 49%. Imports from China plummeted to close to zero (Figure 20).

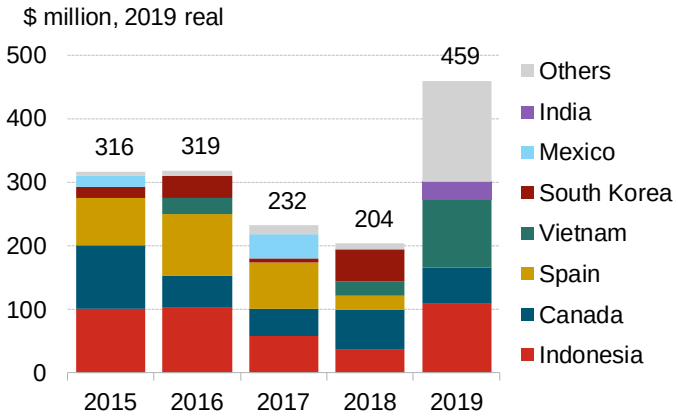
[1] Assuming the turbine price is $0.77 million/ MW.

Figure 19: U.S. wind blades and hubs imports



Source: BloombergNEF, USITC, Berkeley Lab. Note: Data derived from Berkeley Lab's estimates. Some data is based on trade categories that are not all exclusive to wind.

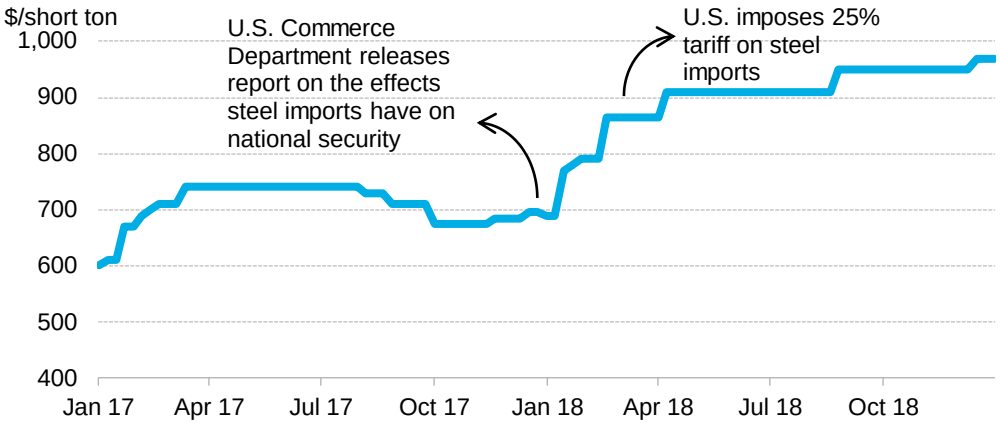
Figure 20: U.S. wind towers imports



Source: BloombergNEF, USITC, Berkeley Lab. Note: Data derived from Berkeley Lab's estimates. Some data is based on trade categories that are not all exclusive to wind.

Various U.S. policy measures have both boosted and buffeted the wind tower sector. Tariffs on towers were implemented in 2012 with the aim of protecting American tower manufacturers Broadwind and Arcosa Wind (formerly Trinity Structural Towers). However, separate tariffs imposed by the U.S. on foreign-made steel undermined domestic tower who then faced higher input costs. The March 2018 tariffs pushed U.S. steel plate prices up and import prices rose to match. Wind tower imports doubled from the previous year (Figure 21).

Figure 21: North America steel plate spot price



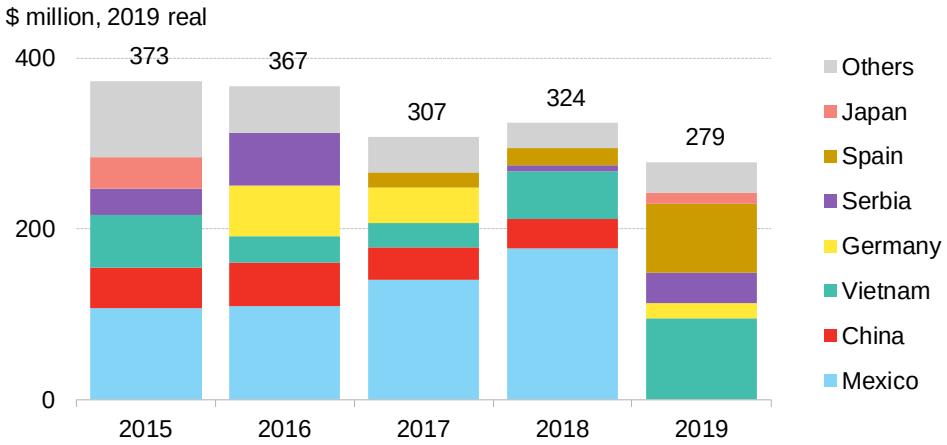
Source: Bloomberg Terminal Note: This is the ex-works price where the buyer pays the transport costs.

Wind generators

Imports of wind generators and parts have fallen moderately since 2015 (Figure 22). The U.S. previously imported generators and parts from countries such as Mexico, but imports from the former collapsed in 2019. In Asia, generators primarily come from China and Vietnam. GE's factory in Vietnam is likely to be the major supplier of generators from that country.

The sudden drop of imports from China and Mexico should be viewed with caution as the underlying import data may be insufficient or inaccurate. We did not identify a clear policy or market changes that would have resulted in such a change.

Figure 22: U.S. wind generators and parts imports



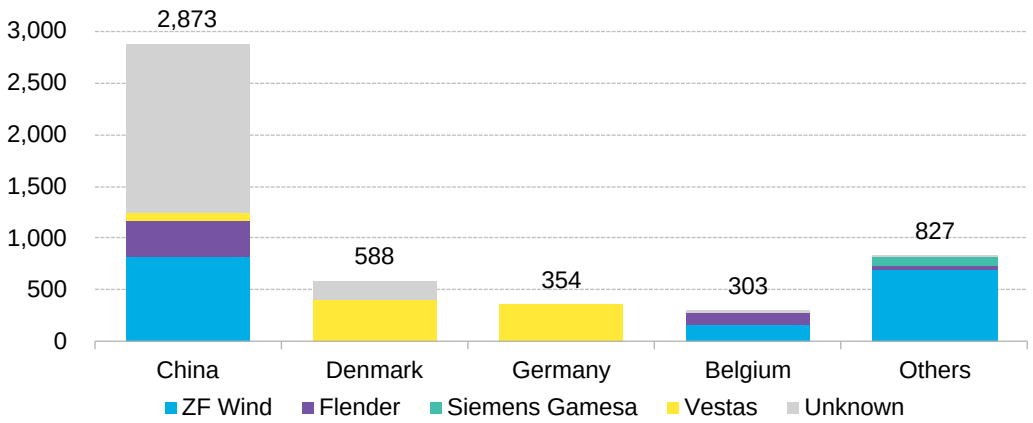
Source: Source: BloombergNEF, USITC, Berkeley Lab. Note: Data derived from Berkeley Lab's estimates. Some data is based on trade categories that are not all exclusive to wind.

Gearboxes

Over half of all gearboxes imported to the U.S. came from China, which is also the only country to host factories from all three of the world's major standalone gearbox manufacturers – ZF Wind, Flender, and NGC (Figure 23). It is unclear what manufacturer provided a large portion of U.S. imported gearboxes from China 2019 due to trade data shortcomings. BNEF believes NGC supplied the majority of these.

Europe is the second largest exporting hub thanks to plants operated by ZF Wind in Germany and Flender in Belgium. Vestas does not itself make gearboxes but procures them from European suppliers then exports. India will soon have three major gearbox makers once NGC commissions its new plant there.

Figure 23: Unit imports of gearboxes to the U.S. by location plant, 2019

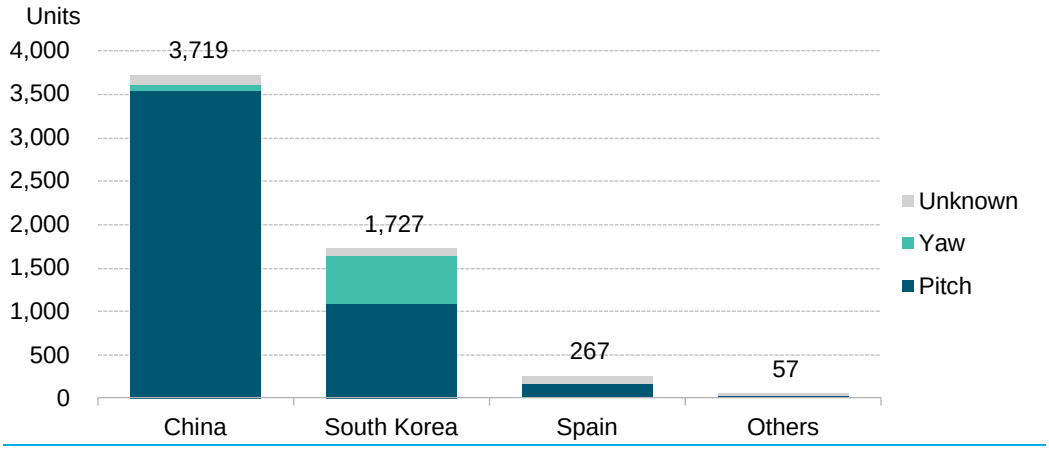


Source: BloombergNEF. Note: Data is based on bill of lading, custom declaration, and cargo manifest relevant to GE, Vestas, and Siemens Gamesa. Vestas does not manufacture gearboxes, but procures them from Europe and ships them to the U.S. Data might not be entirely complete due to lack of disclosure associated with some imports.

Bearings

Wind turbines use bearings in their main shafts, gearboxes, generators, and yaw and pitch systems. Unfortunately, import data is only useful in shedding light on yaw and pitch bearing imports[2]. China and South Korea supplied 94% of yaw and pitch bearings imported by the U.S. in 2019 (**Error! Reference source not found.**).

Figure 24: 2019 U.S. yaw and pitch bearing imports



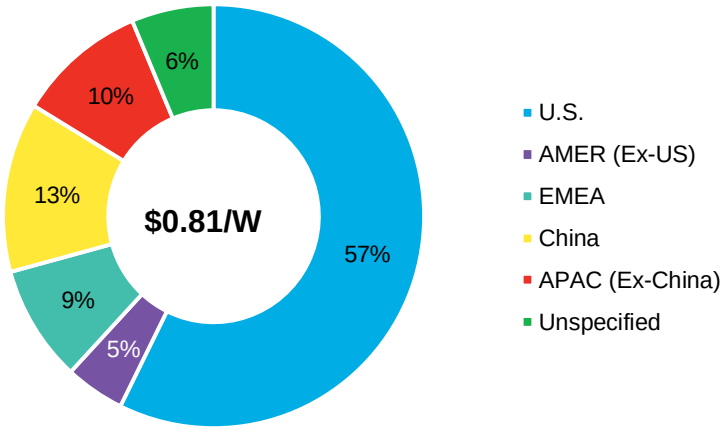
[2] Analysis for gearboxes and bearings is based on bill of lading, custom declaration, and cargo manifest data relevant to GE, Vestas, and Siemens Gamesa, rather than customs statistics. As a result, some imports might not be included due to data availability constraints.

Value break-out

Of three sectors examined by BNEF for this study, wind is the only one where over half the manufacturing value of a typical piece of equipment installed in the U.S. accrues in the U.S. (Figure 25). This is partly because many components such as towers and blades – which represent just over half the value of a typical wind turbine – are often made domestically. Chinese manufacturers have a greater presence in the global supply of gearboxes, converters and bearings but these represent only 25% of a turbine's final cost.

Beyond manufacturing, there are other costs associated with the actual installation of a wind turbine at a project. By definition, virtually all of this value accrues locally. Taking a typical wind project's development and "balance of plant" costs into account would push the total share of value accrued in a typical U.S. wind turbine to 70%.

Figure 25: Value break-out of average wind turbine installed in the U.S.



Source: BloombergNEF, USITC, Berkeley Lab. Note: Includes blade, tower, gearbox, generator, converter, bearing, yaw & pitch, and balance of nacelle.

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