U.S. Wind Power Blowing Hot as New Installations Flourish

Jack McGuinn, Senior Editor

Remember the U.S. wind energy revolution?

For most wannabe players at the time, the "revolution" started and ended without them. In a rather brief timespan most U.S.-based manufacturers discovered that the playing field was not a level one. Before long, the wind industry consolidated around four intimidating competitors — GE/Alstom, Siemens/Gamesa, MHI/ Vestas and Nordex/Acciona.

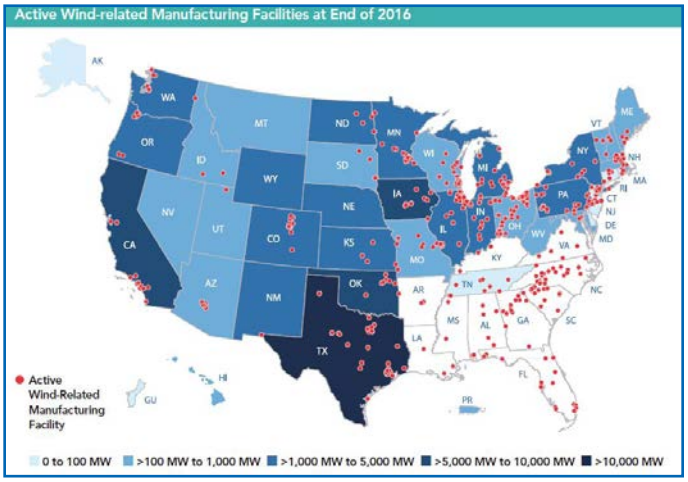
But guess what? Wind installations — both land- and off-shore-based — are popping up in various sectors of the country like dandelions.

Check out these numbers from the American Wind Energy Association's (AWEA)'s 2017 annual report:

- As of January 2017, the U.S. nameplate generating capacity for wind power — 82,183 megawatts (MW) — is exceeded only by China and the European Union.
- The U.S. wind manufacturing sector consists of more than 500 manufacturing facilities spread across 41 states, producing the more than 8,000 components that comprise a typical wind turbine.
- In 2016, the U.S. wind energy supply chain included eight utility-scale blade facilities, nine tower facilities, and four turbine nacelle assembly facilities, all spread across 14 states.
- Ninety-five% of the wind power capacity installed in the U.S. during 2016 used a turbine manufacturer with at least one U.S. manufacturing facility.
- Major manufacturing facilities have the capability to produce approximately 11,700 MW of turbine nacelles, more than 11,000 individual blades, and more than 3,150 towers annually.

2017 Wind Project Installations:

- The U.S. wind industry installed 2,000 MW of wind capacity during the first quarter, the strongest first quarter for installations since 2009 and the second strongest first quarter ever. Installation activity was stronger than the first three rters of 2016 combined.
- There are now 41 states with utility-scale wind projects. North Carolina commissioned the 208 MW Amazon Wind Farm US East, with all wind output contracted to Amazon Web Services. This is only the second wind project to be built in the Southeast and the first to be built in 12 years.
- Twelve states commissioned a total of 25 projects during the first quarter. Texas led with 724 MW, followed by Kansas (481 MW), New Mexico (242 MW), North Carolina (208 MW), and Michigan (149 MW).
- There are now 84,143 MW of installed wind capacity in the United States, with more than 53,000 wind turbines operating in 41 states, plus Guam and Puerto Rico.
- GE Renewable Energy, Siemens, and Vestas captured a combined 88% of the U.S. wind turbine market during the first quarter.



Courtesy AWEA.

Wind Capacity Under Construction or in Advanced Development

- There are now 9,025 MW under construction and 11,952 MW in advanced development, a combined 20,977 MW of wind capacity, the highest level since AWEA began tracking both categories at the beginning of 2016.
- Project developers announced 4,466 MW in combined new activity during the first quarter, including 668 MW in new construction announcements and 3,798 MW in new advanced development announcements.
- 42% of combined activity is located in Texas and the Plains states, with an additional 37% located in the Midwest.

(Source: AWEA)

Looking to get some perspective regarding the above numbers, we put some questions to three individuals intimately familiar with renewable energy — **Peter L. Kelley**, vice president, public affairs, American Wind Energy Association; **Jeff Mclaughlin**, P.E., Machine Builder Specialists; and **Bruce Neumiller**, CEO, Gearbox Express.

Can you point to what in the last two years has been the most significant manufacturing/technological breakthrough for wind turbines?

PETER KELLEY (PK)

Digitally managed wind farms that operate an entire array of turbines as a unit, and that save money through condition monitoring and predictive maintenance, are the way of the future and are helping further drive down costs.

JEFF MCLAUGHLIN (JM)

Manufacturing: 1) "Repowering" of wind turbines has significantly changed the dynamic for service and repairs. 2) The commissioning of off-shore wind turbines in the U.S. From a technological perspective, the life prognostication of bearings and gears has changed O&M (operations and maintenance) from reactive to proactive, and the success of more "direct drive" (or gearless) turbines is a prelude to where the industry is heading.

BRUCE NEUMILLER (BN)

The improvement in technology comes from a better understanding of wind conditions and of operational parameters of wind turbines in North America. Better monitoring of the machines in recent years has led to better technology.

What has impacted the wind turbine industry most over the past year or so?

PK.: Stable federal policy has enabled bumper crops of new wind farms across the most wind-rich states, driving penetration in Iowa for instance close to 40% wind, and over 10% in 14 states. That in turn has brought further cost savings through economies of scale and U.S. manufacturing.

JM.: Consolidation of the wind turbine OEMs, including—GE/Alstom, Siemens/Gamesa, MHI/ Vestas and Nordex/Acciona.

BN.: Repower definitely gets the gold award for this. It has put the entire industry in turmoil as owners try to figure out whether or not they are going to repower. It also has put strain on aftermarket companies, as the owners were essentially "on hold" for about six months while trying to determine their course of action.

Can you explain why there are fewer wind installations in the southeastern U.S. and, to a lesser extent, the midwestern and eastern states?

PK.: The wind resource at 80 meters is lower than in the rest of the country, partly because of tree cover as well as how the wind blows across the country. At 110 meters, though (where turbines are now reaching), we will see more wind farms there like the new one in North Carolina that serves Amazon Web Services.

JM.: Some states (Texas and Iowa to name two) have encouraged more renewables—especially wind energy.

BN.: This is primarily driven by the wind conditions. As the technology improves and allows for capturing enough wind in low wind conditions, we will see more development.

How vertical is the industry becoming re: gears, gearboxes, bearings, nacelles, rotors, etc.? Can even a good-size independent job shop ever hope to land some of that work? Or when the smoke clears will only GE, Vestas and Siemens be left standing?

PK.: There are 8,000 parts in a wind turbine, so there is a robust supply chain including over 500 U.S. factories with 25,000 workers as of the start of 2017. The manufacturers you name do have the lion's share of the U.S. market, but other manufacturers are working to re-enter the market and expand their share.

JM.: The turbine companies for the most part have been "systems or component integrators," purchasing gearboxes, generators, towers and even blades, but usually keeping their focus on certain components like power electronics. This has ebbed back and forth over the past 20 years with little net change. Much sourcing by the turbine OEMs has moved to the Orient in the past 10 years, including gearboxes.

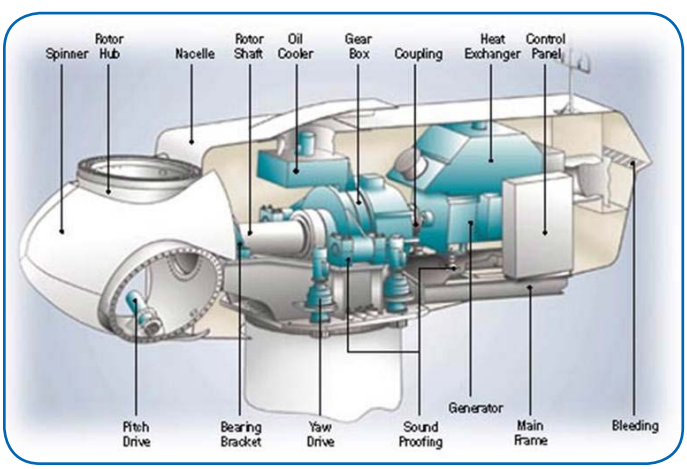
BN.: The industry is not vertical and I actually believe it will become less vertical as companies focus on what their core competencies really are. That being said, mergers and acquisitions are trending (e.g., Nordex/ Acciona, Siemens/Gamesa, ZF/Bosch Rexroth). Scale is necessary to compete, in terms of access to the best technology and lower selling, general and administrative expenses.

Most OEM turbine gearboxes intended for the U.S. market are made in Asia and Europe. Why is that? And, while the numbers are better for U.S. wind gearbox repair, that begs the question: if we can fix them here, why can't we make them here?

PK.: ZF Hanson in Georgia and Winergy in Illinois are examples of U.S. gearbox makers.

JM.: All components can be made in the U.S. with the specified quality. However, the casting suppliers (for housings) that could produce the quantities of castings needed are out of business. Most OEM gearboxes were originally sourced in Europe (where the gearboxes were designed) but production is now centered in China. The U.S. supply base for castings, bearings, gears and gear raw material has been hit hard.

BN.: We can and do make them here, but the turbine OEMs are faced with pressures to keep costs as low as possible; hence looking to source gearboxes in Asia or



Courtesy AWEA.

Europe. It's essential to look at the entire lifespan of the gearbox to determine cost savings.

As installations seem to be proliferating, the need for their maintenance and repair grows. Is that part of the industry demand being met?

PK.: Yes, through a combination of OEMs, in-house maintenance by owner-operators, and third-party shops such as Shermco.

JM.: The service provider industry is growing rapidly and the number of jobs created by this market segment has been outstanding!

BN.: Today most needs are being met. But, come 2025—when the installed base has aged even more—the services market will also "proliferate" in size.

How if at all has global warming/climate change affected the wind energy industry? Is it "good for business?"

PK.: We focus on the economics which are excellent these days, as long-term contracts for wind out-compete even natural gas prices expected in the near future. Public health and environmental savings are real too; he Harvard School of Public Health estimated over $7 billion a year in avoided health care and hospital costs—just from SOX and NOX emissions avoided.

JM.: Renewable energy sources—including wind and solar—are of importance to everyone for numerous reasons, including climate change.

BN.: The focus on climate change has opened many doors to discuss a variety of energy sources, to fund exploring new and improved technology for harnessing wind energy, and to work together to find solutions. Wind energy is no longer seen as "alternative," thanks to the increased focus.

Have there been engineering/logistical improvements that facilitate on-site maintenance and repair?

JM.: Yes, such innovations as the self-climbing crane and material handling devices that can easily be transported uptower have greatly facilitated this and the savings to the owner/operators from this approach has been tremendous!

BN.: While some companies have really focused on up-tower service, we are now starting to see gearboxes that have had $20–40,000 or more worth of up-tower work done in the recent past, come in our door. The owners are questioning what sounded initially like a good idea. Was it worth it?

And there also have been advancements in crane technology, and we expect the trend to continue. Traditional cranes are expensive; newer, self-hoisting systems can do the job for half the cost. As acceptance in the industry increases, up-front capital cost will reduce and the in-and-out cost could be as low at $50,000 to $75,000.

Are "hybrid steel" gears impacting wind gearbox manufacture?

JM.: Wind turbine gears are high precision and have high load carrying capacity; they specified using European carburizing grade steels (Cr Ni Mo steels). These grades offer very high strength with the appropriate heat treatment.

The design direction of the gearbox OEMs has been to greater power density (lower cost) gearboxes, designing with the X-plus methodology that not only increases the bending strength capacity of the gears, but also increases the working pressure angle and significantly increases the forces on the bearings. There is a need for further engineering development with newer design approaches, such as "high contact ratio" and/or dual pressure angle (hypoid) types of gears, that could potentially reduce the forces on the bearings but still retaining the high bending strength.

How might 3-D printing be used in the wind power industry? Aside from 3-D's impressive prototyping capabilities, are 3-D-printed production gears coming anytime soon?

JM.: The strength requirements are demanding and the 3-D print and additive manufacturing processes requires further development.

BN.: Gearing for wind energy application is among, if not the most, demanding in existence, requiring absolute precision and it's too soon to say if any 3-D-printed production will be able to meet those extremely high standards.

Acknowledging the usual underlying causes (design, lubrication, etc.), is bearings failure still the top reason for premature breakdowns—or something else?

JM.: Bearing failures are predominant (see response above on X-plus gears).

BN.: White-etch-area (WEA) axial cracking of high-speed and intermediate bearings is the single largest observed failure in young wind turbine gearboxes. It took the entire wind industry by surprise, and no turbine/gearbox model is immune to it. After significant public and private researching—most notably NREL GRC (Gearbox Reliability Collaborative) and Argonne National Laboratory—there appears to largely be consensus on its causes and what can be done to prevent it.

Beyond WEA cracking, improper bearing setting and or material impurities can lead to infant mortality and generally manifest as a failure within five years.

Aside from accessibility, is gearbox lubrication more complex in wind turbine applications than in other extreme conditions applications? Are, for example, turbine gearbox lubrication requirements materially different from a gearbox/paper mill application?

Photo courtesy Brad Romano.

JM.: The gearbox lubrication system is extremely important, providing the following; a) an oil film to separate metal surfaces from contacting each other; b) reducing sliding friction; c) stabilizing the temperature of the gearbox (gears and bearings); d) facilitating the removal of wear particles to the filter; and e) inhibiting rust and corrosion.

BN.: Lubrication is the lifeblood of any gearbox application. Having said that, gearboxes used in wind turbines tend to contaminate more easily due to the labyrinth seal technology used, making filtration even more important.

Are synthetic lubricants being used more with any regularity over non-synthetics?

JM.: Synthetic lubricants have been in extensive use in wind turbines since the 1980s.

BN.: Most, if not all, wind gearboxes are running synthetic lubricants. **PTE**

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