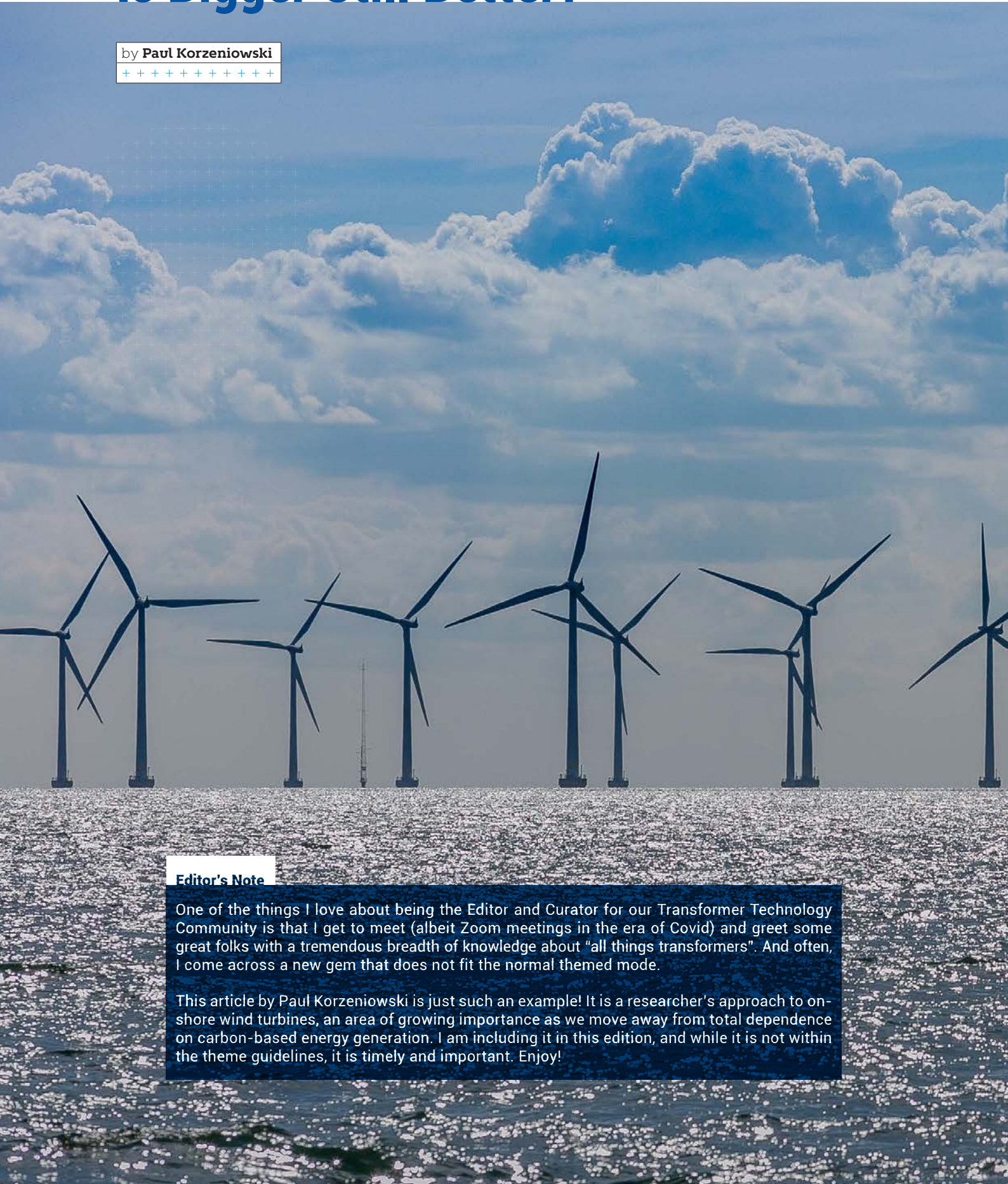


Onshore Wind Turbines: Is Bigger Still Better?

by Paul Korzeniowski
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Editor's Note

One of the things I love about being the Editor and Curator for our Transformer Technology Community is that I get to meet (albeit Zoom meetings in the era of Covid) and greet some great folks with a tremendous breadth of knowledge about "all things transformers". And often, I come across a new gem that does not fit the normal themed mode.

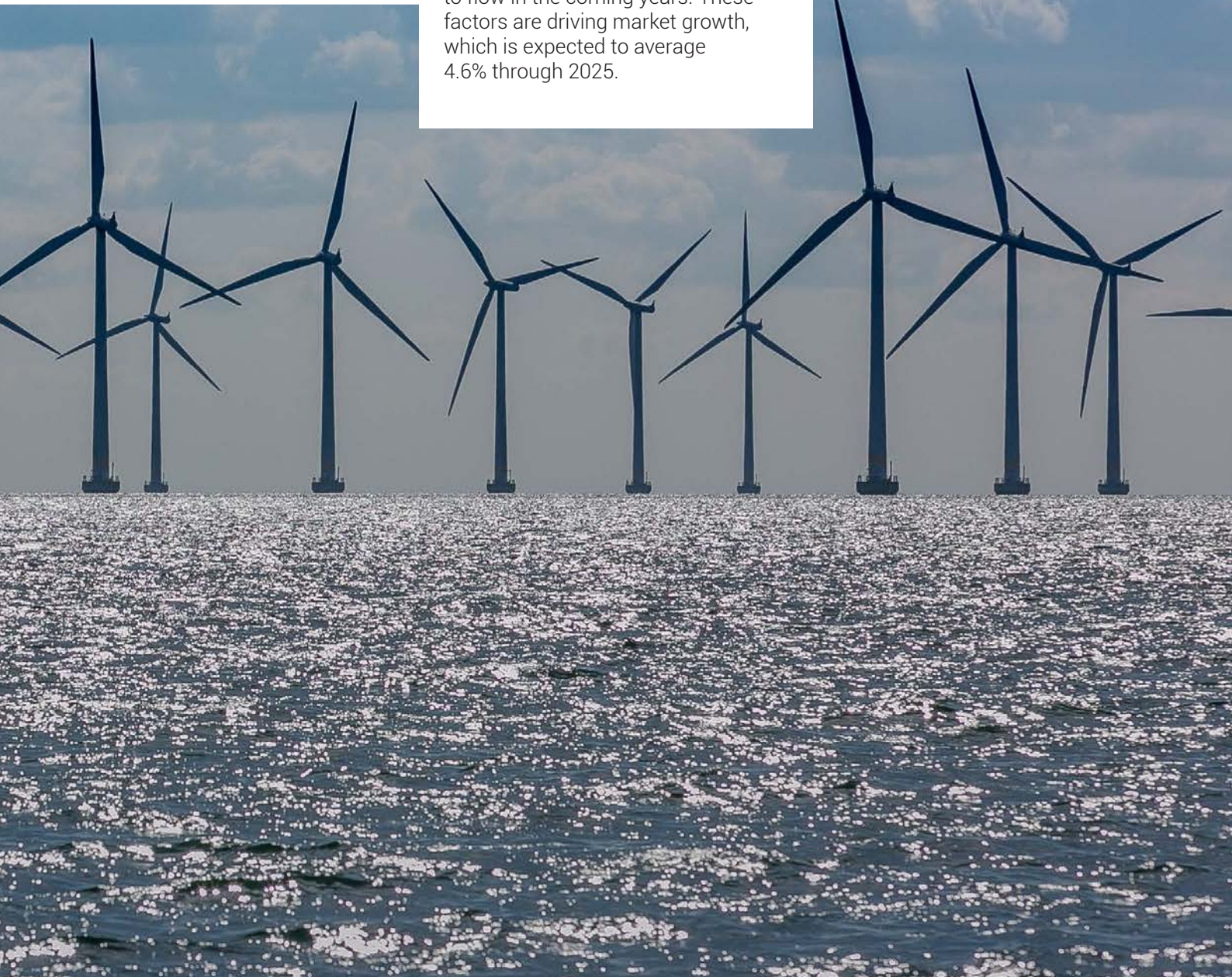
This article by Paul Korzeniowski is just such an example! It is a researcher's approach to onshore wind turbines, an area of growing importance as we move away from total dependence on carbon-based energy generation. I am including it in this edition, and while it is not within the theme guidelines, it is timely and important. Enjoy!



Paul Korzeniowski, BCC Research, is a market research analyst and energy industry consultant with more than two decades of experience. He is a contributing editor to a variety of business and industry publications, including *Energy-Biz*, *Forbes*, *Investor's Business Daily* and *USA Today*. His work has centered on determining major market trends in the development of new energy markets and on the emergence of new technologies such as wind turbines. He has authored reports on markets for emerging technologies, like the Internet of Things, data analytics, artificial intelligence and machine learning.

Many factors are driving increased energy demands across the globe. Urbanization is impacting impoverished areas in Africa, Asia, and South America. Concerns about the environment are growing and countries are trying to lower carbon emissions. As a result, interest in renewable energy is increasing. In fact, there is a growing chorus that considers climate change the most significant problem the world faces today. Onshore wind is a much more environmentally friendly energy source than alternatives such as coal, oil and natural gas. Consequently, wind is expected to become a more significant energy contributor in coming years. These solutions have been used for decades and are becoming popular energy sources in many countries. Onshore wind energy equipment sales generate billions in revenue globally. Long-term contracts ensure that revenue will continue to flow in the coming years. These factors are driving market growth, which is expected to average 4.6% through 2025.

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Large new wind turbine devices have been making their way to market. They offer vendors the opportunity to deliver more wind power at lower rates. However, the technology needed for these devices, and their transportation and installation hurdles, means there is limited acceptance. The adoption of such devices is taking place but should be a slow, steady growth rather than a dramatic surge.

However, not all of the signs are positive. Through the years, vendors struggled to build cost-effective business models, and the challenges are increasing. Delivering these systems is a significant, complex undertaking. Onshore wind solutions are complicated pieces of machinery that become more complicated every day. These systems are difficult to build, transport, deploy, and maintain. With computer technology evolving at a breakneck pace, the onshore wind system marketplace is ever changing.

To date, governments have been underwriting market development with various tax breaks and other incentives, but the offsets have been subject to the whims of different political parties. Changes in regulations in Germany have proven dire for three of industry's market leaders: Enercon, Nordex and Senvion. They have seen revenue plummet, sparking various transition plans, including selling off their core assets.

As a result, the onshore wind market is at a key transition point. The market is consolidating. The top four suppliers account for 69% of the market total. Moving forward, the emphasis is on building bigger turbines. While they do offer greater performance, they are complex and expensive to build. Vendors take on that work with no guarantee of success. Any significant missteps will result in additional consolidation, leaving the top suppliers in even more dominant positions.

Market Projections

The onshore market is showing growth, but its development has come in different global phases.

The technology first sprouted in Europe in areas like Denmark, where wind power had historical roots. Such areas have matured after investments by early market developers, Germany and the U.K. The U.S. has been near the front as well with a great deal of work taking place in large energy-producing and energy-dependent states, like California and Texas. Recently, Asia, due mainly to investments in China, has become the market bellwether. China has a number of wind projects that are coming online and others that are working their way into the pipeline. North America, which has been slow to adopt the technology, also shows promise. The European market has slowed down and its outlook is cautious during the next few years (Figure 1, Table 1).

Nordic Countries Spur European Growth

Vendors have had success with new European projects. In November 2019, Siemens Gamesa won the bid to supply the Stavro project, a large onshore wind order in Sweden. Stavro is located in the northern part of Sweden, northwest of Umeå, and divided into two sub-sites: Blodrotberget, with 40 turbines, and Blackfjället, with 22 turbines, for a total installed capacity of 254 MW. The 62 turbines built, each with a 4.1 MW rating, will help power a Google data center with clean energy as well as the area's paper and board business. The commissioning of the wind farm is scheduled for the end of 2021 and the project will be covered by a 30-year service agreement also delivered by SGRE. To connect to the country's grid connection, Siemens Gas and Power will create two 150/33 kV sub-sites.

In December 2019, Vestas was awarded a 101 MW order from Puhuri Oy, a developer and investor in wind energy overseeing the Parhalahti and Hankila developments in Northern Ostrobothnia, Finland. Both projects will use EnVentus V162-5.6 MW turbines with a 166 m hub height and a 25-year full scope service agreement.

In March 2018, Senvion installed

3.0M122 wind turbines for BayWa r.e. and its wind farm Les Landes, located in the French department of Haute Vienne. The turbines have a tip height of 200 meters.

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Despite headlines, the European market has been showing signs of maturity. With the continent showing low economic growth, governments have begun to cut back on their subsidies. As a result, fewer new projects are being undertaken, and growth is mainly coming from expansion to existing farms. Germany has been a staunch supporter but dramatically cut back its wind investment. This change forced vendors to take dramatic actions, like selling off product lines and reducing headcount, to remain viable.

China Drives Asian Growth

The Asian market grew at high rates in the 2010s. China, which had been on an unprecedented path of economic growth, began to emerge as the world's second-leading economic engine and the fastest-growing one among established nations. China has the world's largest population; it is the third largest country geographically, with abundant natural resources and a rapidly expanding economy. The country's GNP started to increase by double-digit numbers near the turn of the millennium. By 2019, the country generated \$13 trillion in GNP and

Region	2019	2020	2025	CAGR% 2020-2025
North America	7.2	7.6	9.3	4.1
Asia	6.9	7.5	10.4	6.8
Europe	7.7	8.0	9.9	4.4
Total	21.8	23.1	29.6	4.6

Table 1. Global market for onshore wind systems, by region, through 2025 (\$ Millions)
 [Source: BCC Research]

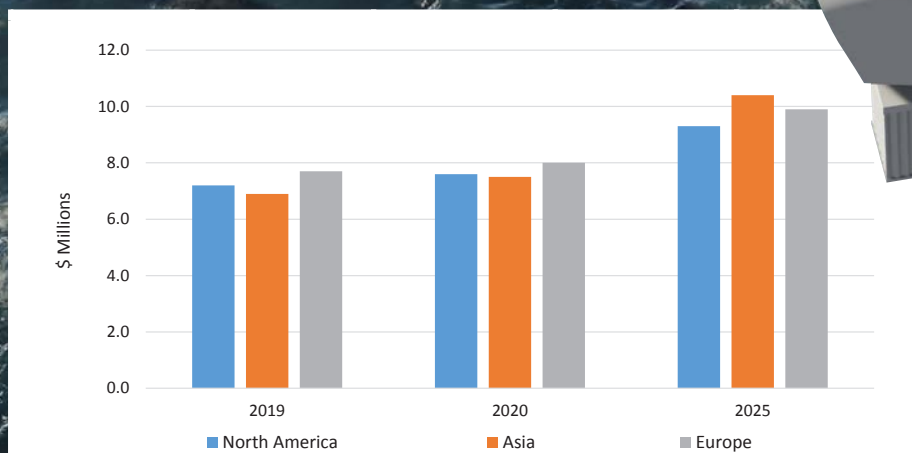


Figure 1. Global market for onshore wind systems, by region, 2019-2025 (\$ Millions)
 [Source: BCC Research]

became the world's second-largest economy. As successful as the U.S. was economically in the 20th century, China is on a more impressive path in the 21st century. As a result, the country has become a major market force. The changes moved the country to a prominent market position in many markets, including onshore wind.

China has an interesting business model. The country opened itself up and joined the world as a trading partner at the turn of the millennium, but it did so in such a way that would enable it to maintain control over its own markets. Foreign companies are not allowed to come into China by themselves; they had to partner with a Chinese firm, which is to always maintain the majority position in any joint venture. As a result, China maintains tight control over internal developments. In addition, the contract awarding process is done by local government officials, which has resulted in Chinese suppliers being in extremely strong positions to emerge as the winners in competitive bidding situations. With respect to wind energy, the end result is that the Chinese are cultivating their own wind turbine suppliers and shutting out much of the rest of the world. Domestic suppliers such as Envision, Goldwind, MingYang and SEwind command the bulk of the domestic market. A few outsiders have had some success.

Asia's Economic Growth Broadens

Other countries in Asia have also been gaining economic mass and market appeal. Japan has long had a strong economic foundation. Recently, India and South Korea gained momentum and are among the world's top ten GNP revenue generators. Taiwan has aggressive plans in the wind turbine market. The result of these developments is that a number of new projects are coming online in this region.

Interest Increases in the U.S.

The U.S. market has been slowed by the actions of the federal government, which had been offering

tax incentives and other incentives to encourage the growth of wind products. When the time period for those items was closing, utilities and vendors rushed to deliver those systems. The ongoing back-and-forth in the trade wars also had a chilling effect on the market. But some new projects were commissioned, nonetheless.

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MidAmerican Energy Company chose Siemens Gamesa equipment for the Southern Hills Expansion wind power project in Iowa, in August 2019. The plans include 21 SG 4.5-145 wind turbines, operating at 4.8 MW. This contract includes a service and maintenance agreement for three and a half years.

In December 2019, Vestas received an order for 149 MW of turbines, consisting of 12 V110-2.0 MW turbines and 57 V120-2.2 MW turbines for a wind project in the U.S. The order includes a multi-year service agreement. Turbine delivery will begin in the second quarter of 2020 with commissioning scheduled for the fourth quarter of 2020.

In August 2018, Potentia Renewables Inc., a Toronto-based company, opted for Goldwind turbines for its windfarm project.

Size Matters

Through the years, suppliers have tried to improve returns by moving toward larger turbines and bigger rotors. In the 1980s, turbines produced less than 0.1 megawatts. Today's systems supply multiple megawatts. The movement is driven by the desire for lower energy generation costs.

Wind systems generate more power in a few ways. One option is to build bigger rotors and blades. As a result, the turbine capacity increases because it engulfs a bigger area. Placing the blade higher up in the atmosphere also improves performance. There, winds blow stronger and more consistently, so the system creates more power during the day.

Large turbines are making headway in the market. A number of vendors have showcased their big blade systems. Goldwind Americas deployed its GW 3MW(S) Smart Wind Turbine test unit at the UL Advanced Wind Turbine Test Facility located at West Texas A&M University at the end of 2018. The 3-megawatt turbine has an assembled hub height of 130 meters and a blade tip height of 199.2 meters.

In May 2019, Senvion launched its latest turbine model, the Senvion 4.2 MW turbine, with two rotor diameters: the Senvion 4.2M140 and 4.2M148.

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Siemens Gamesa installed 42 4.X systems with 145-meter rotor units creating 4.8 MW of energy in China. The company will provide operation and maintenance services for five years at a 200 MW project developed by utility Xinjiang TBEA Group.

Suppliers are transitioning their systems from smaller designs generating less power to larger systems and more power. The bulk of their income comes from recurring revenue streams with existing long term (multiple decade) contracts. The newer, larger systems will come online in the next few years and account for larger slices of the overall market. The market now falls into three categories designated by turbine size: 90 meters and lower; 91 to 124 meters; and 125 and up (Table 2).

Size	2019	2020	2025	CAGR% 2020-2025
90 meters and less	9.1	8.8	8.3	(1.2)
91 to 124 meters	8.8	9.7	12.1	4.5
125 meters and up	3.9	4.6	9.2	14.9
Total	21.8	23.1	29.6	4.6

Table 2. Global Market for Onshore Wind Systems, by Size, Through 2025 (\$ Billions)
[Source: BCC Research]

Market Challenges

Progress has been slow and steady rather than dramatic for a variety of reasons. The increases in energy generation can be offset by higher expenses stemming from working with the more sophisticated equipment. The larger sizes stress system design and materials. As more force is exerted against the system, its elements bend, flex and in some cases even break. In 2008, one system crashed into the tower

after its braking system failed and it spun out of control. Vendors only fully understand all of the potential impact after studying devices that have been in the field for a while. Consequently, designs constantly morph.

In addition, the increased size makes it difficult to transport the different parts to project sites. Special equipment is needed to carry, secure and configure the devices, and the fact that farms are often located in remote regions exacerbates such issues.

Given the complexity of the systems, the investments needed to develop such products have been significant, costing hundreds of millions of dollars to design and deliver. When making such investments, conglomerates look for double digit returns. A transition point is occurring as many of the early wind turbines are ending their lifespans and seeing contraction. Vendors are rolling out larger systems, and they will account for a larger share of the market moving forward.