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Rising winds

As a new generation of larger, higher, wind turbines become commonplace around the world, wind farm developers will need to look at employing larger lattice and telescopic crawler cranes to install them. Will North reports.

10 years ago, a typical wind farm job may have required no more than lifting a 120 tonne nacelle to a height of 80 to 100 metres. That is all changing, the machinery housing alone on wind turbine generators such as Enercon's 7MW E-126 or Repower's 5MW 5M can weigh around 120 tonnes. Add to this its contents, such as the 220 tonne generator and a rotor and hub that can add a further 320 tonnes and you have a fully assembled nacelle that weighs more than 600 tonnes. All of which will needs to be placed on top of a 135 metre high tower, ideally all in one go. While such turbines are still very much at the cutting edge of the market three to four megawatt turbines are rapidly becoming the norm.

This demands both a step change in lifting capacities at height, and new approaches to performing the job. A 120 tonne nacelle could still have been delivered to site complete using fairly standard trailers or transporters. Today's larger nacelles must usually be delivered separately and assembled on site, ideally on the ground, but if not then at height.

Both approaches have their own risks. Assembling the nacelle on the ground reduces the risk of working at height, or installers working in the machinery housing being crushed as the generator drive train is lowered into the open machinery housing at 130 metres. But lifting a fully assembled nacelle requires a substantially larger crane.

A Manitowoc ML 650 VPC lifting and installing individual rotor blades

Telescopic crawler cranes, such as this 220t Liebherr LTR 1220 are ideal assist cranes on wind projects

Material handling and assist

Moving the individual components around site and assembling them is often done most efficiently with a telescopic crawler crane - which can also be used to assemble and disassemble the large lattice crawler crane required for the main lifts - while the larger models that are now required can also install the initial sections of the turbine tower. While these jobs can be done with a wheeled crane, they require suitable set up spots to deploy their outriggers. A tele crawler can also pick & carry components from the trailer or laydown area to the lift location.

Operating very large crawler cranes on site poses its own challenges. Wind farm landowners often want to use the land around the turbines for their own purposes, typically for more traditional farming, even during the construction phase. So, road widths are all too often narrower than is ideal and not always particularly well prepared. Each turbine requires large volumes of concrete, and even piles to create a solid foundation, so when it comes to the temporary hard standings required for the cranes and installation equipment developers typically seek to keep the surface area as small as possible. Limitations such as these require careful planning when it comes to moving the crane around the site and setting up. It may even require the use of innovative crane designs.

While the wind farm investors' ideal may be to build scores of five or seven megawatt wind turbine generators on one massive open site, such locations are limited. In many cases, particularly in Europe, developers are obliged to install turbines on smaller, more difficult sites, such as wooded hill tops, posing challenges when it comes to getting components and cranes to site, without sacrificing too many trees. In other places, there may be practical or regulatory limits to the height of the turbines, leaving plenty of work for smaller cranes.

On many jobs today, a 650 to 800 tonne crawler will suffice, but for that ideal wind farm, the requirement can jump to three or four lattice crawlers of around 1,000 tonnes capacity, with long, strengthened main booms and heavy duty fixed jibs, assisted by a couple of telescopic crawlers of around 200 tonnes capacity.

A Demag CC 6800-1 at work on a wind farm project. In Europe, wind turbines are increasingly installed on wooded hills, posing additional challenges to crane owners

Setting up and moving on unpredictable ground

Setting up a large lattice crawler for work on a wind farm poses some unique challenges. So too does getting wind turbine components to each installation location. At the core of both problems are two features of efficient wind farm construction: space and pace. Compared to a busy refinery, a wind farm may look like a wide open space. But the ground is not at all suited to heavy equipment, and any site preparation works will, where possible, be temporary so that the land can be restored to agricultural use once construction is complete. As a result, the amount spent on such preparation tends to be limited and is a key factor.

On many other heavy lift projects, large cranes often remain on site for weeks or even months at a time. So, taking a few extra days to assemble the crane is not such a big part of the project schedule, and on site crane moves are less frequent and relatively short in terms of distance while the ground condition is usually known and good. Such sites are also less likely to be in wind hotspots, so booms can usually be left up overnight.

Wind farms however are unique in that they require a series of relatively quick heavy lifts, just a few hundred metres or so apart, but with grassland, sand or other unpredictable terrain in between. Assembling and dismantling the crane for each turbine is both costly and time consuming, so operators strive to move cranes between turbines as intact as possible. This has led to numerous overturns in the 'no man's land' between turbines. To avoid this and achieve a target pace of completing up to four or five turbines each week, innovative solutions are required.

As already mentioned, building proper hard standings around a turbine purely for the short installation phase, is costly and not environmentally sound. So, developers seek any solution to minimise the size and cost of the hard standing. To summarise the key design challenges for manufacturers is to create a crane that requires the minimum amount of space, that can be rapidly assembled and disassembled and moved quickly, without sacrificing capacity.

Ingo Noeske is vice president of the crawler cranes business unit at Tadano Demag and has worked on products for the wind turbine industry since the 1990s. He adds another factor that crawler cranes are typically designed to work on ground that is no more than 0.3 degrees off level, while the hard standings around a turbine are usually sloping, to allow for drainage. Ground mats can help level up an inclined hard stand, while spreading the weight over a wider area. Crane manufacturers also offer wider track pads to reduce ground bearing pressure and increase stability, but as cranes used in the sector get larger, and pressure to keep hard stands as small as possible remains, new approaches are required.

Noeske suggests the use of levelling jacks/outriggers, or pedestal cranes, or perhaps self-levelling tracked undercarriages. Talking very speculatively, he even points out the walking tree harvesters used in the forestry industry, which have their wheels or tracks mounted on hydraulic legs, along the lines of Tuepen's Puma 46 platform.

While mounting a 1,000 tonne crane on hydraulic legs may just be a vision at this stage, a pedestal base with outriggers is however already a well established option for large cranes. ALE, now part of Mammoet, used a reconfigured 1,200 tonne Gottwald AK912 as a pedestal crane for many years. Using a pedestal base can certainly help reduce the ground preparation needed.

More recently Demag has supplied pedestal versions of its 650 tonne CC 3800, the PC 3800-1, to the wind industry. It has also worked with Sarens and Faymonville to develop a version that integrates with a self-propelled trailer. The crane superstructure, complete with pedestal tub, is transported on the heavy trailer, which converts to a self-propelled transporter on site. The outriggers are installed on the crane which can then lift itself free of the trailer and create the pedestal base. The transporter can either be removed or left in position. The rest of the crane is then assembled. Once the lift has been completed, the Superlift system is usually removed, and the transporter then moves the crane to the next turbine via the wind farm roads to the next turbine, either under its own power or towed.

The crane carried out its first job in 2018, when it was used at the Renkenberge wind farm in Germany to erect four turbines, three of which were 159 metres high.

Another approach to minimising the size of hard standing is to reduce the amount of counterweight required, an extending counterweight can

The Teupen Puma work platform is an example of hydraulic levelling legs

A 35+ year old 1,200t Gottwald AK 912 as a pedestal crane

Sarens used a Demag PC 3800-1 pedestal crane, alongside a CC 3800 crawler to install two Enercon wind turbines at the Bouwdokken wind farm in the Netherlands. The pedestal's outriggers can level the crane by up to 2.1 degrees

help if space allows. Manitowoc has pioneered the concept with its Variable Positioning Counterweight (VPC) system on its MLC650 which has a nominal capacity of 650 tonnes. Product manager Brennan Seeliger claims that the VPC allows the crane to complete turbine lifts that would otherwise require a 1,000 tonner, especially when using the VPC-Max version, that extends the crane's counterweight radius even further. "Counterweight systems such as the VPC and VPC-Max affect many aspects of crane work, including reductions in ground bearing pressures, transportation and assembly/disassembly procedures, as well as boosting capacities."

Liebherr offers two ways to maximise the effect of a given counterweight. Its V-Frame, a hydraulically adjusted folding arm, moves the suspended ballast, back and forth adjusting the radius as needed. When erecting a long main boom, far more counterweight is

At the South Plains II wind farm in Lockney, Texas, Mortenson used a Manitowoc MLC650 VPC to assemble 175 tonne nacelles on the ground, for 91 turbines, before raising them to 91 metres

required to raise the boom than is needed for a given lift. Another solution the company offers is to split the ballast tray, using the company's VarioBallast system.

Cologne based Colonia Spezialfahrzeuge used a new Liebherr LR 1800-1.0 with VarioBallast to erect four Enercon wind turbines in North Rhine Westphalia, involving lifting loads of 89 tonnes to hub heights of 160 metres. The crane was rigged with 171 metres of main boom and a 12 metre fixed jib. Wolfgang Winkler, one of the operators on the job said: "The 400 tonnes of derrick ballast is only required to raise the main boom. After this, we simply unbolt the centre pallet, the remaining 80 tonnes of suspended ballast, plus the central and turntable ballast are more than enough for the lifting work."


Colonia's LR 1800-1.0 on its first outing

Demag has its own detachable ballast system, 'Split Tray', which works with or without the company's Boom Booster kit, discussed in more detail below. Noeske says: "You need a lot of counterweight to raise the boom, but only a third of that for the lift itself. So, you simply disconnect the Split Tray, leaving just the counterweight necessary for the lift."

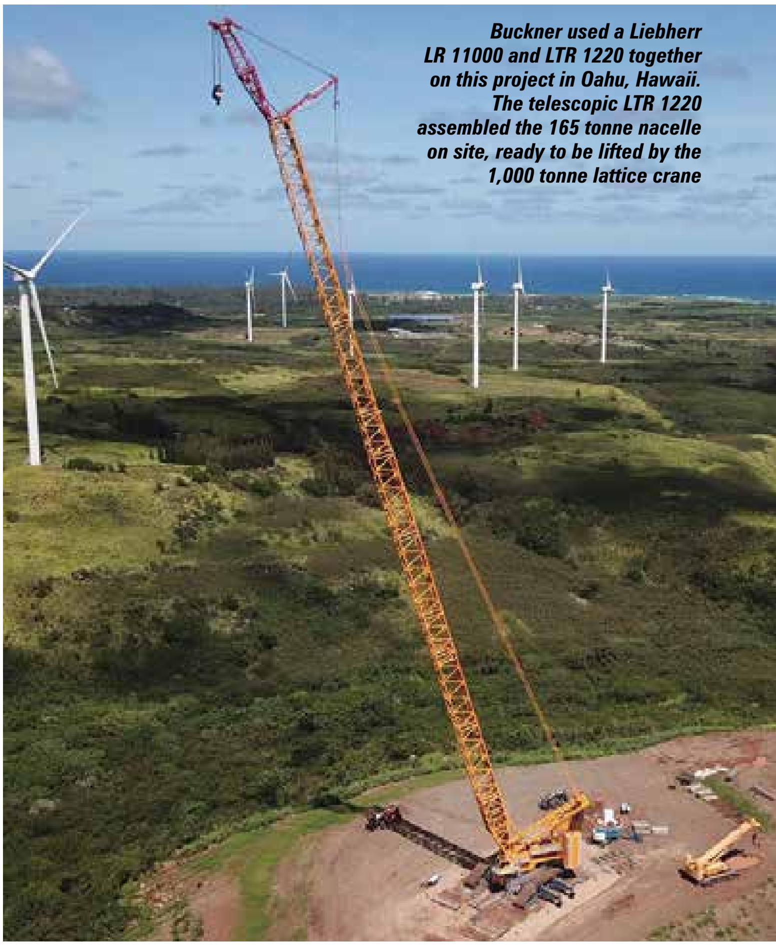
Systems like Split Tray and VarioBallast have another advantage on wind farms: they keep the extra counterweight close at hand. So, when you need to bring the boom down before moving to the next turbine, or in the case of high winds, it is there ready to be reattached.

Assist cranes

As already mentioned, smaller crawler cranes are used to assemble the big crane while also unloading and installing turbine components. Telescopic crawlers are an increasingly popular choice for this work. At one time a 100 tonne tele crawler was considered large, although 200 tonne plus machines are now becoming more popular. Manufacturers such as Link-Belt, Liebherr, Tadano and Demag have all launched higher capacity models in the past few of years.

Link Belt product manager Scott Knight says: "Our smaller tele crawlers - the TCC-1200 and TCC-1400 - have been very popular for use in laydown yards and as assist cranes, but the real highlight has been the 250 ton/ 230 tonne TCC-2500. Around 65 percent of those delivered so far have found their way into the wind energy sector."

"TCC-2500 will offload the trucks, set a couple sections of the tower and then assemble the larger lattice crawler when it arrives, before moving on to the next tower to start the same process over again. The beauty of a tele crawler is its ability to move from one tower to the next, and even back to the first tower to tail-in the hub and blades."


Buckner used a Liebherr LR 11000 and LTR 1220 together on this project in Oahu, Hawaii. The telescopic LTR 1220 assembled the 165 tonne nacelle on site, ready to be lifted by the 1,000 tonne lattice crane

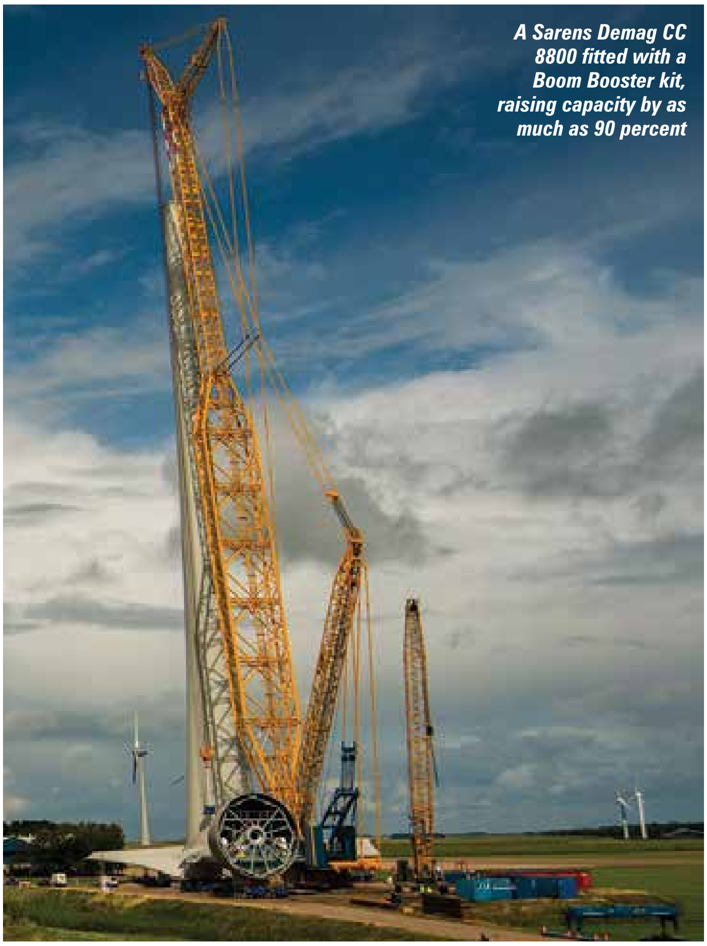
Thomas Persson is international sales director at Buckner HeavyLift Cranes in the USA. He was previously a senior sales manager at Mammoet, working on onshore and offshore wind projects, and the first employee of the Buckner/BMS joint venture KranWind. Buckner runs 18 of Liebherr's 1,000 tonne LR 11000 in its fleet, with three more on the way. They are mostly used on US wind farms. However, Persson is working on building the company's wind energy business in Europe, where he expects the first jobs will use Liebherr's 750 tonne lattice boom truck crane, the LG 1750 SX.

Buckner recently installed a series of Vestas V136 4.2MW turbines in Hawaii. The company has a Demag CC2800 based on the island, but as the client wanted to assemble the nacelle on the ground and lift it as a complete unit, a larger crane was required.

Permit and transport costs prevented the 165 tonne nacelle from being transported in one piece. So, the machinery housing, drive train, and hub all arrived separately. Buckner used a 200 tonne Liebherr LTR 1220 tele crawler to assemble the nacelle, while the 1,000 tonne


The LR 1800's VarioBallast and V-Frame systems


R.J. Corman Railroad Services used a 230 tonne Link-Belt TCC 2500 from All to unload and position more than 1,000 wind turbine components on two projects in Kansas prior to installation


A Sarens Demag CC 8800 fitted with a Boom Booster kit, raising capacity by as much as 90 percent

LR 11000 lifted it into place. In naturally windy environments, every high lift poses a risk, and can involve postponements if high or gusting winds are forecast. Persson points out that assembling the nacelle on the ground for a single lift reduces the chances for accidents or delays.

Performing the lift

For the heavy wind turbine lifts most big crawlers use similar configurations: a long, strengthened, main boom, and a short heavy duty fixed jib. Manitowoc offers a 'Wide Boom' kit on the MLC 650 with 3.5 metre wide sections, which also boost the crane's nominal capacity from 650 to 700 tonnes.

Demag has its 'Boom Booster' system, which can be used in lengths from 24 to 102 metres, enabling a 650 tonne CC3800-1 to lift 92.5 tonnes to heights of up to 174.5 metres. The system increases the crane's capacity by as much as 65.3 percent.

Liebherr's SX system similarly increases the capacity of its 750 tonne lattice cranes, the LR 1750/2 crawler and LG 1750 truck crane, which employ the same superstructure. The base SX system increases the boom width to 3.5 metres, while on the SX2 and SX3, two or three six-metre wide, 14 metre long sections further strengthen the boom, allowing the 750 tonners to match a 1,000 tonne crane on long boom work.

The six metre wide SX2 or SX3 sections made up of two halves, bolted together on site. For transport the halves are slightly offset so that they can mesh together like gear wheels to obtain a 3.5 metre shipping width. The SX3 configuration allows an LR 1750/2 to lift components of up to 127 tonnes to hub heights of 166 metres.

Lifting and installing blades

In a perfect world the blades and hub would be assembled on the ground and lifted in a single piece, however the risks of catching the wind during a lift often results in lifting one blade at a time and installing at height. However, this involves its own risks, a hundred metres or more off the ground.

One possible solution comes from Australian based Verton. Its Windmaster system uses a gyroscope system to allow remote control of the load, eliminating a tagline. The Windmaster, due to launch midyear, combines four battery powered gyroscope pods with two composite panel wind vanes, mounted on either end of a lifting beam. The wind vanes rotate under computer control, controlling the torque that the wind applies on the load. While the gyroscopes can precisely position the blade or hub for them to be bolted in place.

Verton's Windmaster system


Hüffermann Krandienst used the SX2 boom strengthening kit and VarioTray ballast system on this Liebherr LR 1750/2 to install three 135 metre high Enercon E-101 wind turbine generators at Siggelkow Wind Farm in Mecklenburg Western Pomerania

Moving on

As soon as one turbine is completed it's on to the next one, often using inadequately prepared tracks. Most often, this means at least partially derigging in order to travel safely between turbines. Noeske says: "In the past, you saw a lot of cranes travel with the hundred metre boom and 12 metre jib, fully raised. We saw a lot of accidents. In an ideal world you can do this, that is a crawler crane's big advantage. But there are unknown conditions when tracking across a field, including voids created by irrigation or drainage pipes which is why we see so many cranes tip and fall."

"With a hundred metre boom, it is often still safe to travel. But as wind turbines get ever taller and booms longer this is no longer an option. In most cases, some of the boom must be removed. It may be safe to keep the crane's superlift ballast system in place and perhaps 80 metres of main boom. Often, an adapter can be used to keep the long boom close to the ground. But some disassembly will be required."

Features that can help make things easier include built in walkways on boom sections and hydraulic pin pulling, while boom sections can be removed and transported in three section, 36 metre elements, helping speed up the process."

Future bottleneck?

For now, there is still plenty of work for lattice crawlers of between 650 and 1,000 tonnes. But as turbine sizes continue to rise and become the norm, will the industry hit a supply bottleneck?

I asked contacts at Liebherr and Demag about this. They were understandably reluctant to share commercially sensitive information on production capacity. However, Liebherr says that it is currently producing 10 to 15 LR 11000s a year, alongside its 600, 750, and 800 tonne lattice crawlers. As 1,000 tonne cranes take over more wind turbine work, what will happen to all those 600 to 700 tonne models? Estimates suggest that there are more than 1,600 such units in operation around the world, a large portion of them employed on wind turbine installation work.

Moving crawler cranes on wind farms can be treacherous