HOW TO BRING DOWN THE TOTAL COST OF WIND FARM CONSTRUCTION

MAMMOET

SMARTER, SAFER, STRONGER

GROWING PAINS

As developers reach higher, project costs also skyrocket

Generating more renewable energy from wind is critical to decarbonizing the world and securing our future energy needs.

While wind turbines already generate more electricity than any other form of renewable technology, this is currently only a fraction of what we will need.

The world needs to build bigger, more powerful, and more efficient turbines in greater numbers. But this challenge goes beyond just the design of the turbines themselves. If growth is to be delivered at the speed required, then the techniques and technologies used to install wind farms needs to keep pace. In doing this we must also look at methods that reduce carbon emissions associated with these activities whilst keeping the Levelized Cost of Energy production (LCoE) as low as possible.

In this white paper, Mammoet explores how innovations in technology can help to achieve this – paving the way for emission-free onshore wind farm construction with shorter timeframes, fewer logistics requirements and lower costs. We will explore the challenges faced by and the limitations of traditional lifting systems for installing taller and heavier turbines, which prohibits the industry's ability to grow at the scale needed. We will also provide an insight into methodologies that allow onshore wind to break free from the shackles of conventional cranes, building taller, more sustainably and with greater cost-efficiency than ever before.

Our sector is growing – but so is the problem

Over recent years, growth in onshore wind installations has increased rapidly. New capacity added in 2020 totaled 86.9 GW, a substantial 59% increase compared to the previous year. However, to keep pace with targets such as the IEA Sustainable Development Scenario (SDS), this annual increase must rise to 108 GW by 2030. In striving for this, Europe alone is expected to add around 70 GW of new onshore wind farm capacity over the next five years.

Clearly, the most effective way of meeting these targets is to create larger turbines and place them in the most productive locations. The fewer turbines used, the lower the resources required for manufacture and installation. Subsequently, wind farms are growing taller, heavier, and more remote, in pursuit of this model.

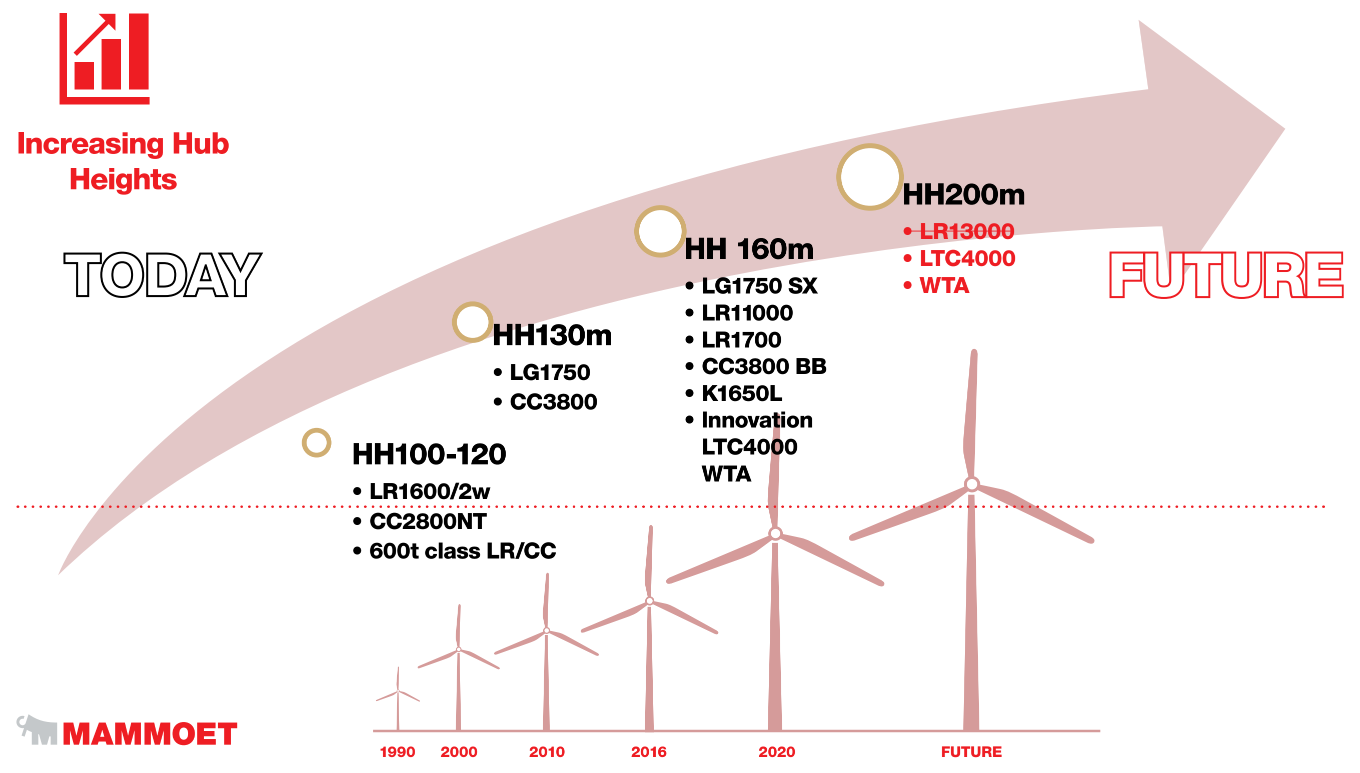
This has seen a doubling in turbine size over recent years, with average hub heights growing beyond 160m in the very near future. Over the next five years, we expect to see wind turbines that can produce over 10 MW per unit, with hub heights of more than 200m. Although this economy of scale is of course desirable, it does present an increasing level of technical challenge for developers and their supply chains.

As turbines grow taller, the fleet of lifting equipment capable of assembling them gets smaller and more in-demand, placing pressure on project schedules. These larger turbine components must also be transported across considerable distances, in turn requiring a greater scale of logistics equipment and infrastructure support – increasing the costs of finding a route to site, and civil works on site.

In other words, the average capabilities of the technology used to transport and install turbine components must evolve in parallel with the average turbine size. Yet whilst the size and scope of turbine technology has evolved over recent decades, lifting and logistics technologies have struggled to keep up.

The increasing demands placed on installation works has a direct impact on the cost and overall efficiency of a project. Obviously, increasing component sizes and hub heights require increasingly larger cranes to assemble them – which in turn has implications not only for rental costs but also project timeframes.

The bigger the turbine, the higher the civil costs



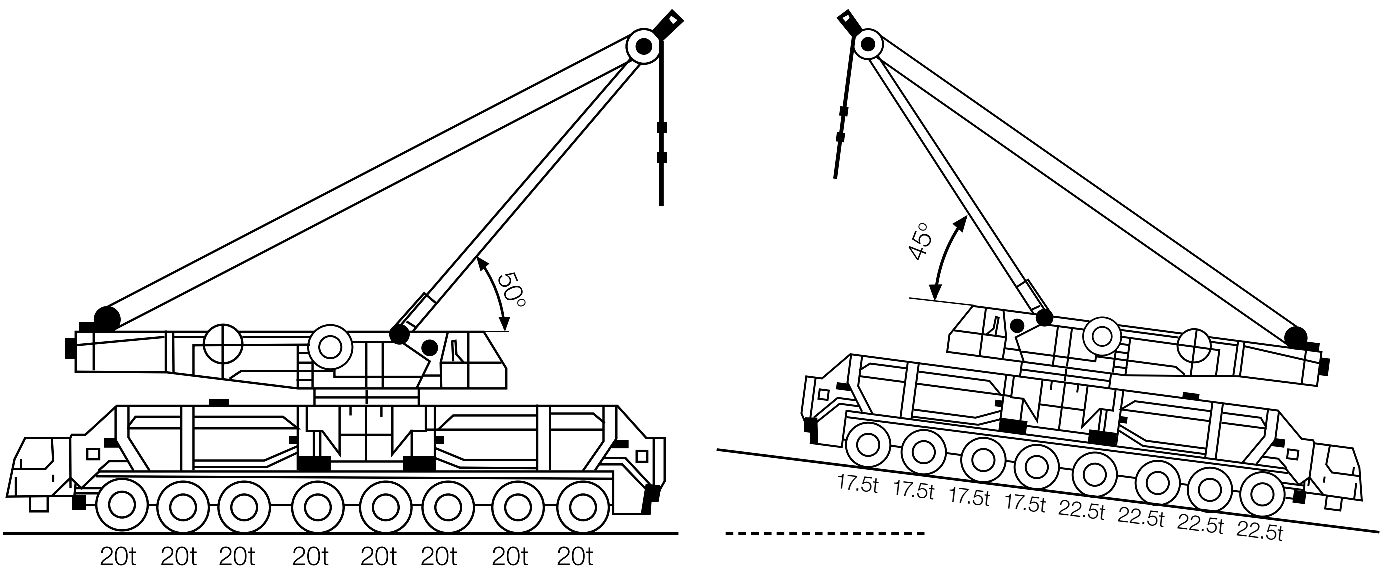
Increasing hub heights are rising beyond the reach of conventional cranes.

A LARGE FOOTPRINT

TO SEE THE LARGEST EXPENSE AT A WIND FARM, SIMPLY LOOK DOWNWARDS

To install a turbine with today's hub heights, a long boom is needed, which must be laid down next to each pad before and after assembly, and partially deconstructed to travel between pads. This means large hardstands must be built at significant expense, and workers remain on the clock for long periods of time doing work that is not construction.

Also, where 1.5MW nacelles weighed around 60t ten to fifteen years ago, the heaviest components of today can reach up to 136t and are starting to exceed the capacity of commonly available cranes. This is forcing developers to use heavier cranes that were not specifically built for onshore wind farm construction or have limited global availability – which can cause costs to escalate.



The axle loads of a commonly-used mobile crane on flat ground and a 13% incline.

"These heavier lifting machines bring further challenges," explains Carlos Moreno, Onshore Wind Segment Lead for Mammoet.

"Extra civil works can be required to accommodate convential cranes' larger working radius, along with wider areas to move counterweights, long boom down corridors and relatively lengthy processes to relocate the crane between turbine pads."

This relocation process brings hidden challenges; for example the specification of roads. A suitable mobile crane might exert 20t per axle on the ground when partially dismantled and travelling on a flat surface. If that journey takes place up a 13% incline, however, the rear wheels of the vehicle can place as high as a 22.5t load on the road below - almost double the axle limit of normal roads – and this is if weather conditions are calm.

So, money spent strengthening access roads on site can pay off many times over as cranes move smoothly from pad to pad over roads that do not require running repairs. Although these roads are temporary – sometimes used only once to their full capacity – the traffic they carry is severe.

While most of the industry views wind farms as lifting projects, their true workload lies in breaking down cranes, moving them from pad to pad and building them back up again. Relocation can amount to as much as two-thirds of the craneage and lifting scope of each project, depending on the site topology and relocation strategy. To achieve the highest level of profitability cranes and equipment need to be moved quickly from one turbine assembly site to the next.

To illustrate the scale of this issue, a suitable mobile or crawler crane typically requires up to 50 trucks to mobilize all necessary components from one pad to the next – a process that takes place every three to five days, for every turbine on site. As cranes grow, this number will only increase; meaning roads will be used more, and possibly further strengthened, driving up costs.

Turbine blades have also grown over the last 15 years, with blades of over 80m now in use. Installing these enormous items require special care, as the larger their surface area, the greater the force they experience when the wind blows. Therefore, better and more efficient lifting means are required to stabilize them and avoid potentially costly standby periods on site.

AGAINST THE CLOCK

THE MANY ENEMIES OF THE FAST BUILD PHASE

Every minute lost during construction of a wind farm is multiplied many times over, elsewhere in the project. Land topology can delay civil works; civil works can delay delivery to site; which in turn can delay build rate – and no two locations are the same.

“Costs are heavily dependent on the nature of each specific project.” explains Niall McDermott, Operations Manager, Onshore Wind for Mammoet.

“A greater number of wind farm locations are being considered because they have the capacity to achieve higher yields from stronger winds. However, by their very nature, these locations are in increasingly remote and exposed environments.

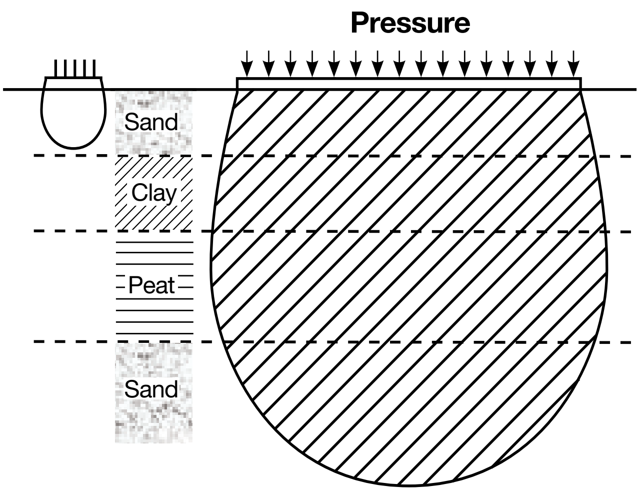
“In many cases, the high wind speed at the installation site can mean it is unsafe to carry out the installation as planned. Costs can quickly escalate here, as it becomes necessary to extend the rental period for the crane.

“There is also the knock-on effect of this delay, impacting the overall project timescale, which in turn sees costs adding up to allow for additional accommodation and other costs to keep direct and indirect personnel on site for longer.”

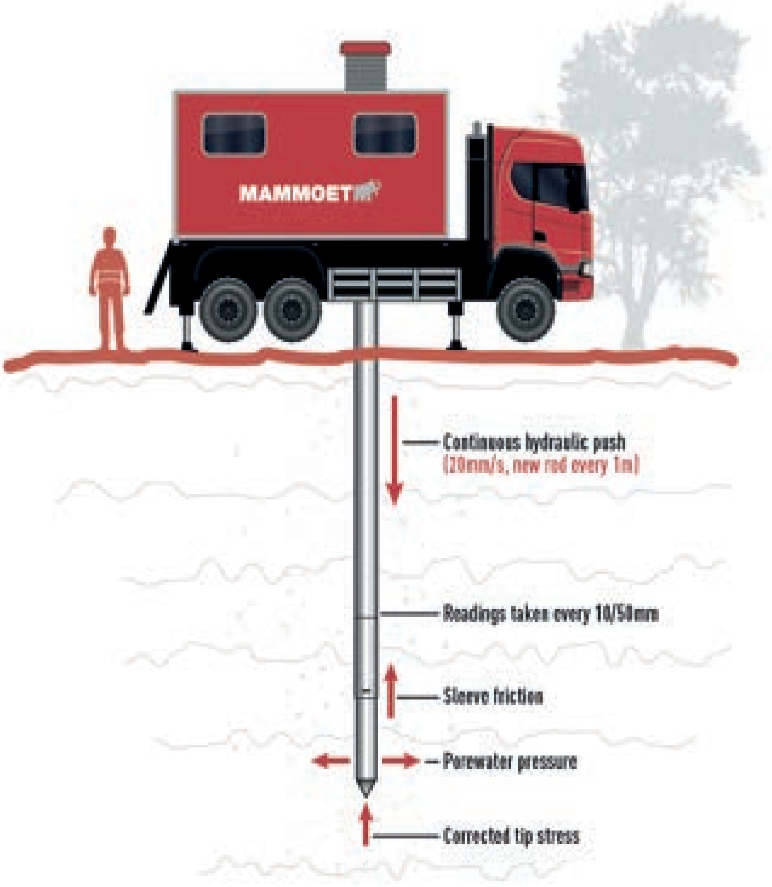
The bigger the crane, the more civil works

Bigger crawler cranes need more space to mobilize and demobilize at each project site, meaning greater investment in balance of plant (BOP) work, for example by constructing larger hardstands. However, these bigger cranes will also be heavier, and exert greater pressure on the ground – and these forces are experienced differently as they pass downwards through sub-soil layers.

This creates greater cost in civil works to ensure areas have the required ground bearing pressure to support the heavier equipment and loads. The composition of sub-soils is rarely 100% known, so investing in a thorough ground survey can reduce the risks inherent in building on uncertain ground, leading to a reduction in delays and civil works optimized to ensure the job is completed efficiently.



Influence of applied load on soil, by sub-soil type and depth



Cone Pressure Test ground surveys establish which sub-soils are present and which loads they can safely withstand.

Bottleneck in crane technology

There are many other factors affecting the choice of the right main cranes and hence civil work requirements, such as obstacles on site, longitudinal and transversal inclines, power lines, permitting requirements, the ability to cut trees, road width, gate openings, bridges, clearance height, hub height and boom configuration available. All of these factors determine which crane is appropriate, its relocation process and resources required to perform each task - which in turn translate into civil works requirements.

WORKING TOGETHER

INNOVATING THE LIFT SAVES WEEKS ELSEWHERE

As civil works can have a huge effect on productivity and depend so closely on the choice of crane, **close cooperation between developers, OEMs and crane providers is vital** to optimize overall project costs during wind farm construction.

Looking beyond the 'here and now' of increased costs, Mammoet also foresees an impending challenge in whether some formats of traditional cranes will be able to operate safely and cost-effectively at the heights and weights demanded by growing turbine sizes. Typically speaking, specialized lifting technologies available today are limited to around 165m hub height, creating a clear lift height ceiling.

This situation is complicated further by the limited availability of suitable equipment – the pool of cranes capable of lifting the largest turbines is already small. As demand increases, there simply won't be enough cranes available to keep up with the numbers required. These factors add up to a potentially serious bottleneck

Paving the way to emission-free windfarm installation

in the race to increase the world’s energy generation capacity from onshore wind. Cranes might not be available, may be prohibitively expensive, or require civil works at an unviable cost to make the lifting surface safe.

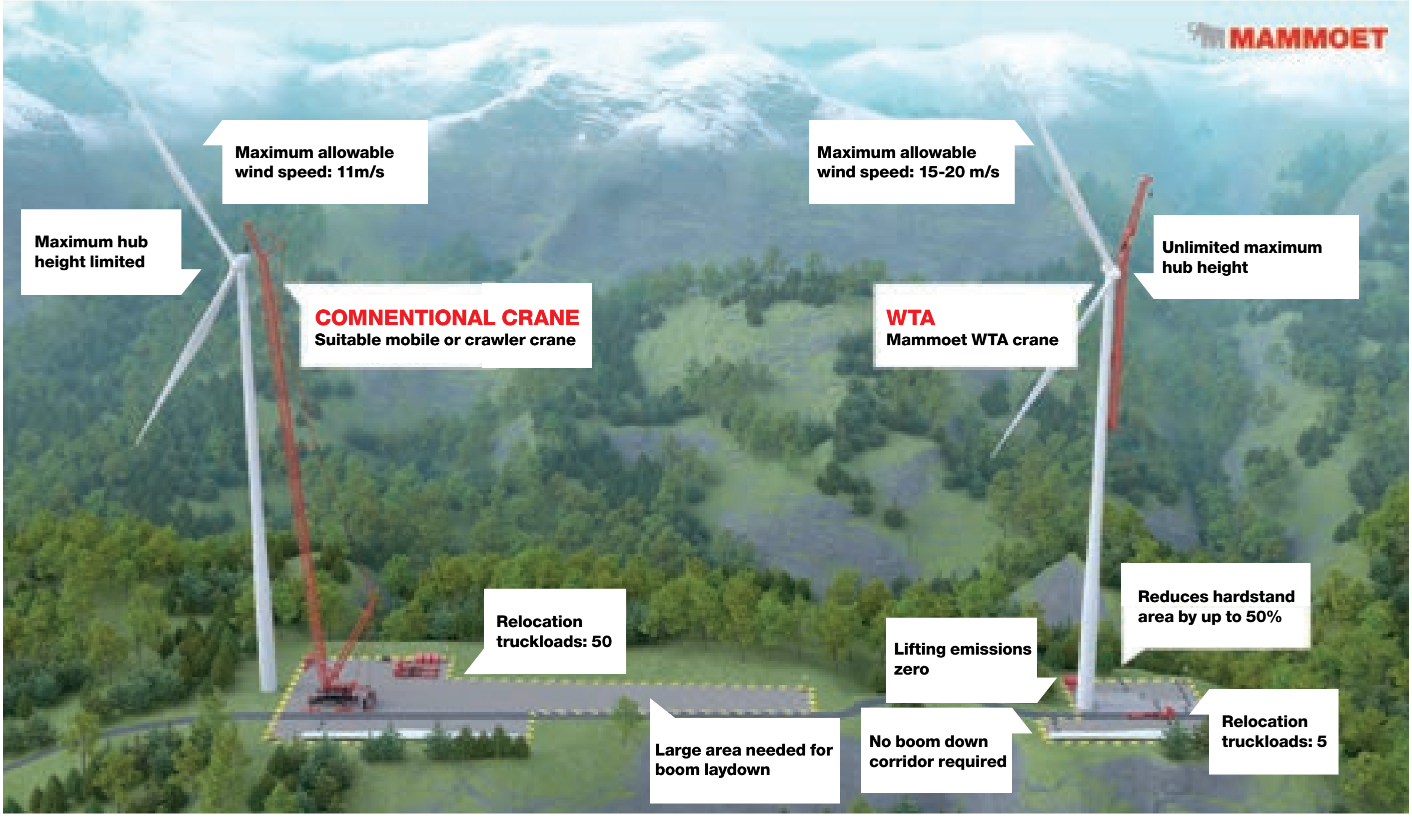
Pieter Jacobs, Head of Onshore Wind for Mammoet, explains:

“The industry continues to experience great change; pushing turbines higher to tap into more reliable flows in more remote environments where the wind is stronger, to achieve better yields. It also continues to develop more advanced but typically heavier generation technology.

“This lack of innovation is not sustainable, and the limits of some conventional equipment will soon be reached, both for assembly and maintenance. New solutions are needed to ensure lifting technology does not become a bottleneck for the expansion of wind power.

“Mammoet is taking a leading role in the future of onshore wind. We are innovating to find better ways to install wind turbine components, through the development of technologies and techniques. This will create new construction efficiencies so our customers can deliver cost-effective projects while generating more renewable energy in a de-carbonized way.

“There are ways the industry can side-step concerns about hub height, efficiency and ground conditions – ways that can get these assets online quicker, contributing to the energy transition and paying back the investment made in them sooner.”



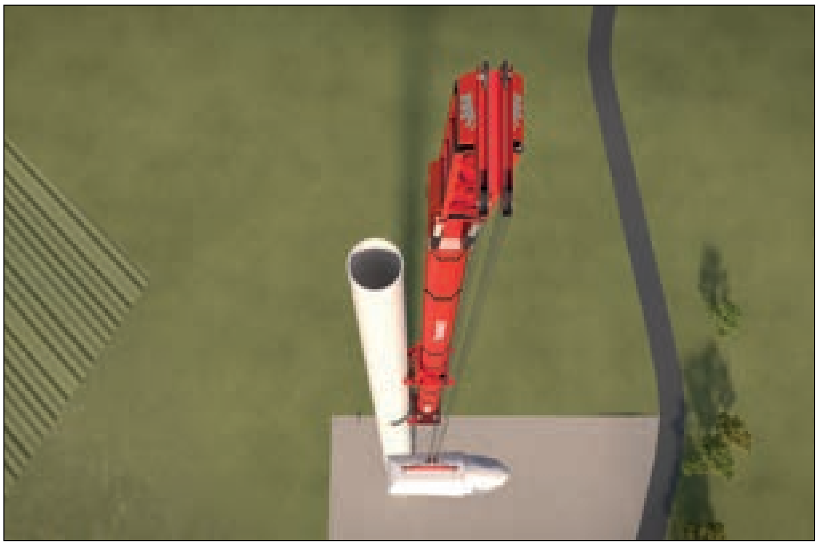
Mammoet WTA compared to an industry-standard mobile crane.

CLIMBING HIGH

THE FUTURE OF WIND LIES AWAY FROM CONVENTIONAL CRANES

Mammoet has explored the multiple areas of onshore wind projects that could benefit from a fresh approach. Whilst it might be feasible to produce bigger cranes in existing formats, this creates issues of its own as mentioned above: more parts to get to site, needing potentially greater groundwork requirements and having lower resilience to wind conditions - leading to lengthened schedules, greater emissions, and increased costs.

We therefore researched alternative lifting systems that could help the industry to break free from these concerns. Our answer was the Wind Turbine Assembly (WTA) climbing crane.



The WTA is entirely electric-operated, making it **one of the first onshore wind cranes to generate zero emissions.** What's more, because it needs just five truckloads to travel from pad to pad, significantly fewer emissions are generated as it is relocated around site, with fewer staff tending to it. The WTA uses the turbine's tower as its point of support, meaning that the maximum installable hub height limit becomes theoretically limitless, allowing developers to **reach higher towards stronger, more reliable winds.**

The crane will enter the market shortly, ushering in an era of wind farm construction that can happen more **quickly**, **safely**, and **efficiently** than ever before.

RUNNING THE NUMBERS

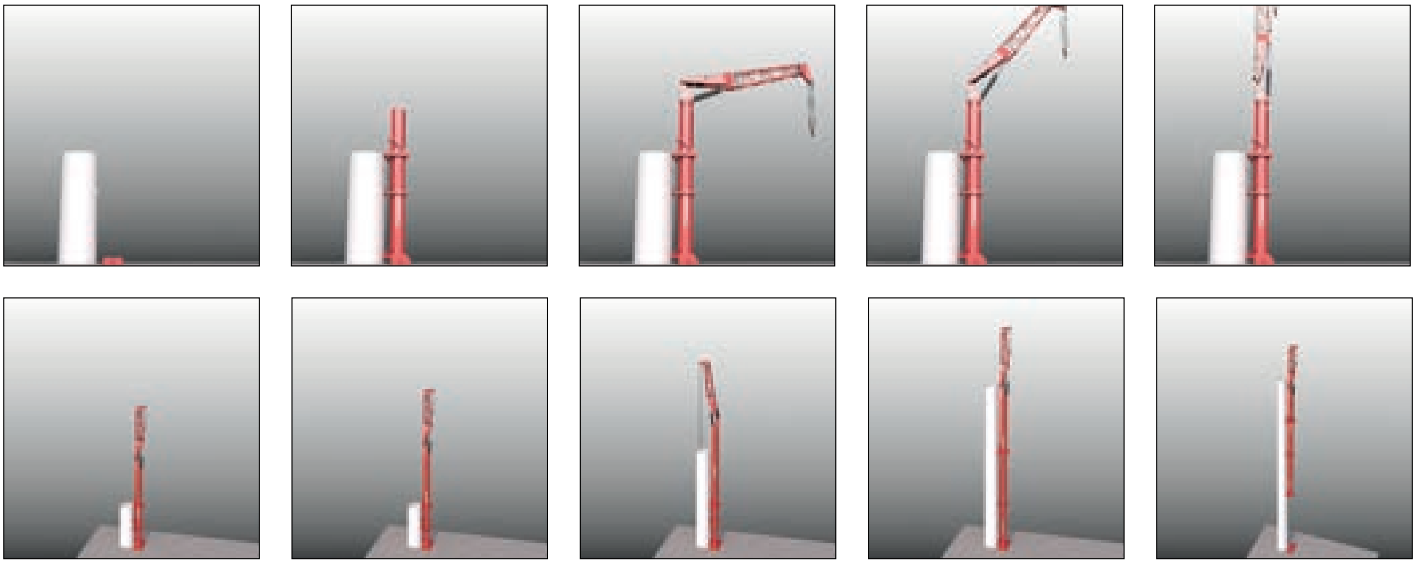
How does the WTA stack up in the field?

The WTA has the capacity to drive down wind farm construction emissions significantly. To prove this, Mammoet studied a seven-turbine wind farm project completed in Finland.

This study found that a conventional crane fleet consisting of a LTM 1750, GMK 5150, LG 1750, LTR 1100 and LTM 1130 required hardstands to be constructed that generated 647.3t of CO_2; worked a total of 152 hours, emitting 15.3t of CO_2; and were transported by 50 truckloads around site, generating 13.4t of CO_2. This made a total of **676t of CO_2 for the conventional crane approach.**

On the other hand, a fleet consisting of a LTM 1500, GMK 5150, WTA, LTM 1300 and LTM 1250 would require smaller handstands, whose construction would emit 419.4t of CO_2. These cranes would work the same 152 hours with 10.3t of CO_2 emitted –none from the WTA; and be transported in 12 truckloads around site, emitting 3.5t of CO_2. The total emissions for the WTA solution would therefore be **433.2t of CO_2 – a saving of nearly 250t of CO_2 emissions.**

So, when compared with a conventional crane approach, the WTA r**educes crane carbon emissions by around 33%, reduces civil works emissions by 35%** and s**aves 74% of emissions on transport** during mobilization and relocation.



The WTA can keep working when conventional crawler cranes cannot. It operates in wind speeds up to 20 m/s – compared to around 11 m/s for conventional wind cranes - reducing downtime during construction and extending the build season. This shortens the duration of projects, making equipment hire more cost-effective and allowing the site to vacate sooner – reducing auxiliary carbon emissions.

As a climbing crane, the WTA obviously has a significantly reduced footprint relative to crawler or mobile cranes and is much smaller and lighter than these cranes too - reducing the need for substantial groundwork on site. Hardstand pads can be smaller – around around half the size of a mobile or crawler crane equivalent - and ground pressure requirements are also significantly minimized.

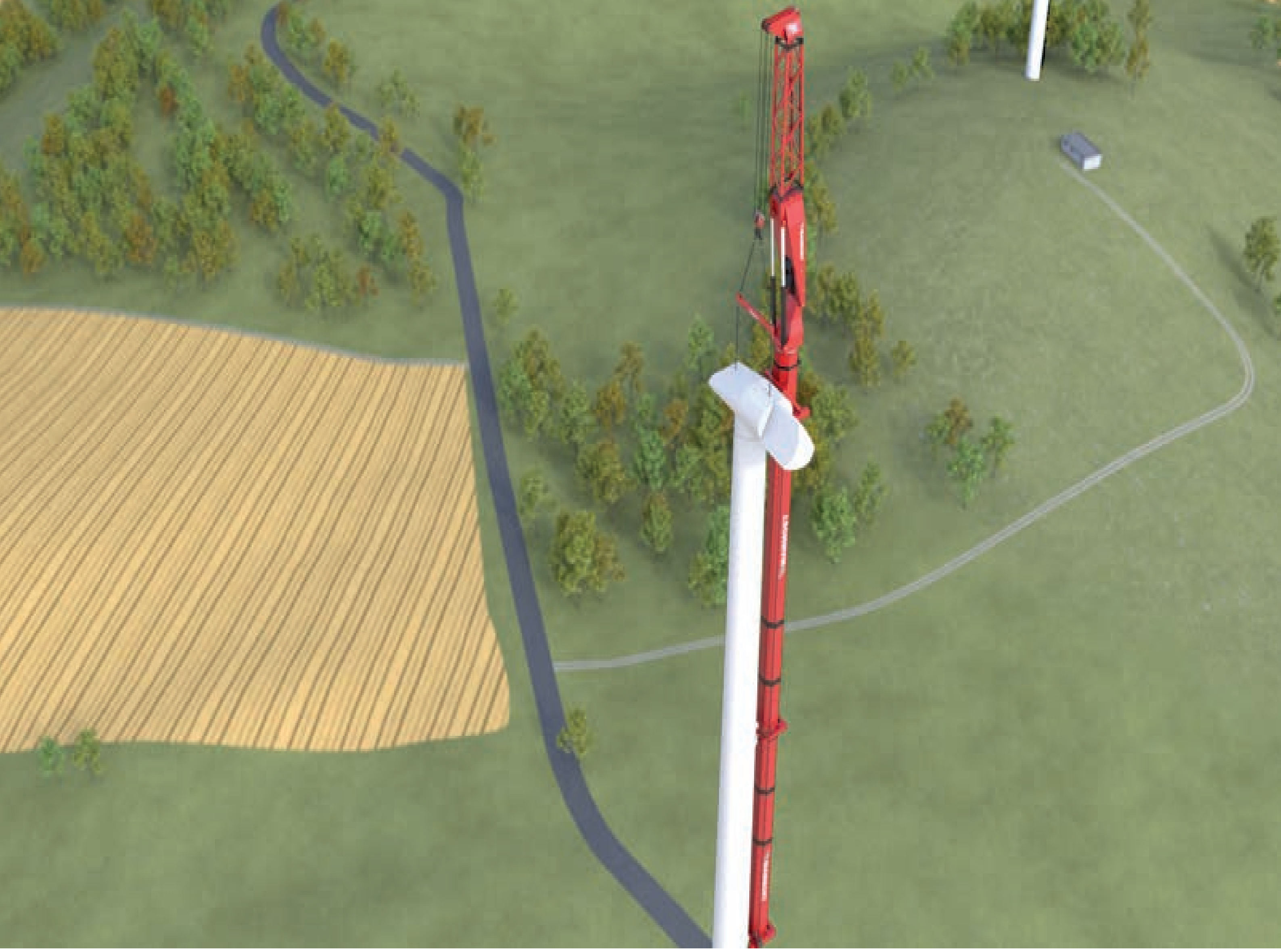
WTA: KEY BENEFITS

- Reduces carbon emissions compared with conventional cranes
- Reduces wind downtime during construction
- Reduces hardstand requirements
- Lowers mobilization costs
- Lowers relocation costs and time
- Lower resources required during relocation process
- Overall, this will lead to a total reduction of the installation time required per turbine and therefore installation costs per turbine

Total emissions (tonnes of CO_2)

Mammoet conducted a study of a recent seven-turbine project undertaken in Finland to assess the carbon emissions from the WTA compared to a conventional crane installation solution. The results were clear.

	Conventional crane	**WTA**	**Reduction (%)**
Hardstands	647.3	419,4	**5%**
Trucks	13.4	3.5	**74%**
Cranes	15.3	10.3	**33%**
Total	676	433.2	**36%**

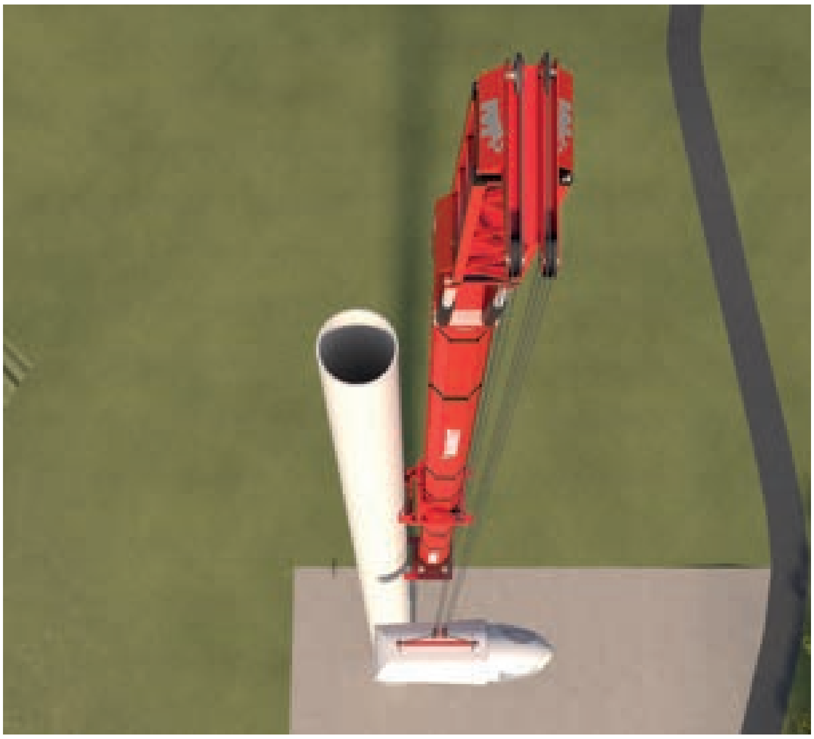


The system's small size also means quicker and more cost-effective mobilization and relocation between turbine locations once on site. A conventional mobile or crawler crane will need around 50 truckloads to mobilize to site, while the WTA needs just nine. A crawler or mobile crane will then need 50 truckloads between each pad, and the WTA only **five.** This makes the crane quicker and cheaper to move, bringing down overall project costs.

The reduction in relocation time of the WTA is around 50% compared to using crawler cranes. This can shave weeks off wind farm construction schedules, lowering total construction costs.

The long-term solution

As well as meeting the short-term needs of the industry to build quickly and in large volumes, the WTA's emissions-free operation means it can support wind farm construction into the future.



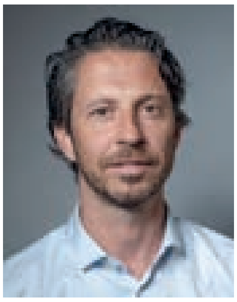
Carlos Moreno, Global Segment Lead, Onshore Wind for Mammoet concludes:

“Going forward, I am convinced that reaching hub heights beyond 165m and installing heavier components cost-efficiently will be key for turbines being built over the coming years.

“With existing crane technology being at the very edge of capability today, it is inevitable that the industry embraces a long term, cost-effective and safe solution that will allow the continued transition to a truly sustainable energy model”.

For more information on Mammoet’s services in the onshore wind sector, visit **mammoet.com/onshore-wind.**

Talk to Pieter Jacobs on LinkedIn:



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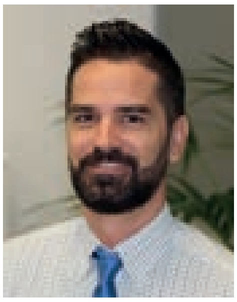

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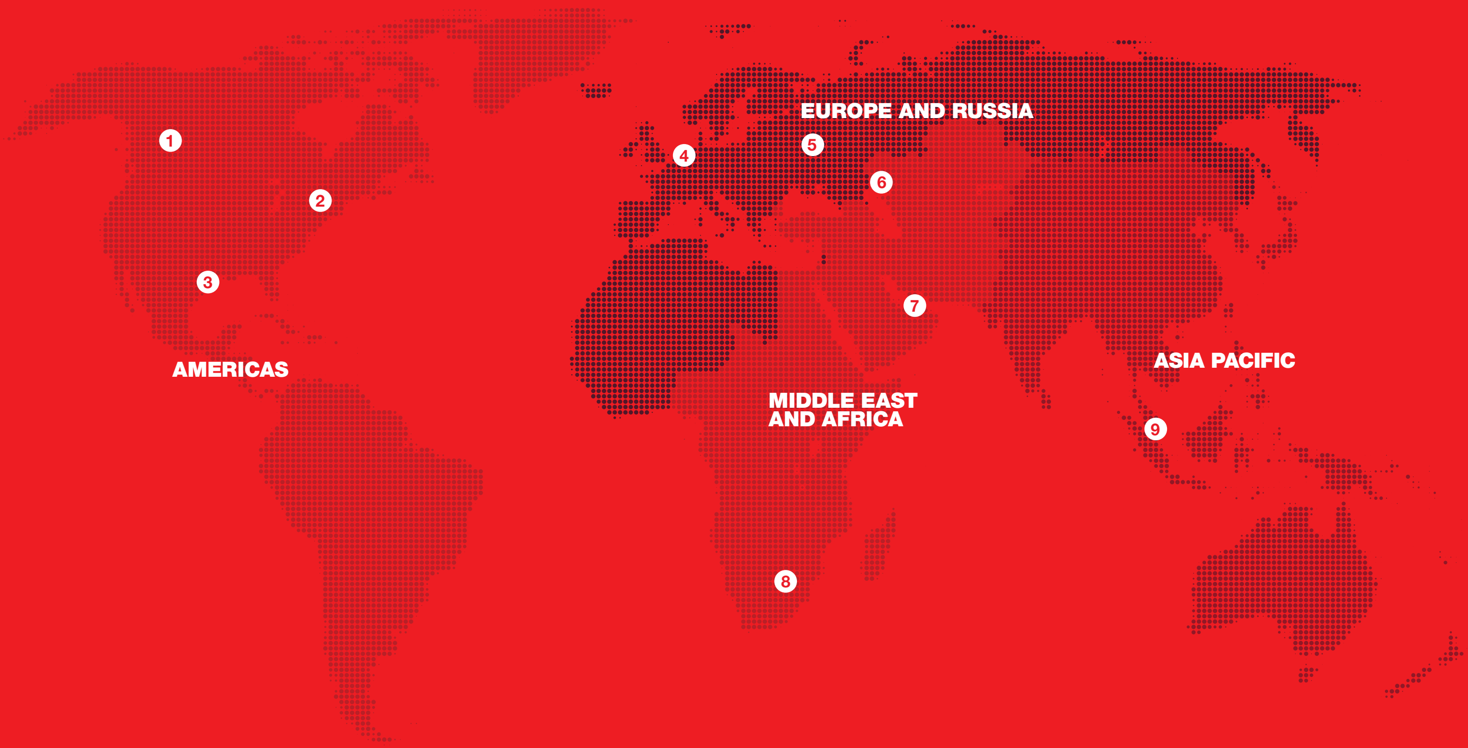

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