 Offshore pile driving equipment and personnel provided by MENCK

Balancing power and precision to advance renewable energy

Advancing offshore wind energy demands a blend of power and precision, especially as turbine sizes increase. Innovative hydraulic hammers, like MENCK's MHU fleet, play a crucial role in securely driving larger monopiles into challenging seabeds. Fabian Hippe, Sales Director, Acteon Marine Foundations, explains to PES how this technology balances efficiency and environmental protection, driving sustainable energy projects forward.

PES: Welcome to PES, Fabian. Offshore renewable energy developers are encountering difficulties with foundation installation equipment and technology, aren't they? Could you talk us through some of the challenges you've observed?

Fabian Hippe: Increasing turbine sizes require larger foundations and higher turbine hub heights, revealing technology gaps and limitations in existing and traditional installation equipment. This has created a need for more powerful installation tools with greater precision to manage the risk of structural damage and environmental harm.

Many offshore renewable development areas are emerging outside traditional oil and gas regions, which have historically been well explored and understood with established geotechnical frameworks. Unexplored regions contain natural soil deposits, presenting a challenge because understanding them takes time. We detect new natural materials whose reactions and interactions with operations like dynamic loading remain poorly understood.

As we venture further offshore, increasing water depth complicates matters as soil conditions change again. We explored this in more detail in a recent interview with PES on laying the foundations for improved soil management.

Not knowing the foundation soils probably bears the largest risk overall, where the ability to adjust quickly and effectively to these conditions is crucial for economic and low risk developments.

Lastly, the availability and reliability of suitable installation equipment remain a challenge. Technologically, some elements are at the absolute limit of current capabilities. For example, large forgings needed for some installation equipment components for pile driving and drilling have reached the limits of global manufacturing capabilities.

PES: How can foundation installation experts like Acteon respond to these challenges?

FH: From understanding soil conditions, identifying sites, and conducting pre-engineering and preliminary front end engineering design analysis, to deriving concepts and directions for wind farm development, Acteon plays a crucial role, particularly through its Geo-services and Advanced Systems Engineering business lines in the early stages of the offshore wind farm lifecycle.

We develop novel concepts in close cooperation with our customers during the engineering phases to ensure tailored foundation solutions that remain commercially and operationally viable.

Although Acteon does not own any vessels, we provide mission critical installation equipment such as advanced impact hammers, pile top and subsea drills, and grouting technology services to support the installation phases. Developers prioritise innovative equipment and technology integration. Being a vessel agnostic group allows us to collaborate more easily and broadly. We offer synergetic technologies from our business lines across the group, sharing insights, intellectual properties, best practices, and personnel, resulting in a diverse service offering. This type of scalable, flexible solution might not be possible if a developer sources each service from separate companies.

Additionally, Acteon holds strong partnerships across our supply chain and customer base. These networks and strong partnerships, dating back to the company's oil and gas heritage, enable open discussions about challenges and the development of equipment to overcome constraints now seen in the renewables space. For example, MENCK, a brand in Acteon's Marine Foundations business line, quickly innovated by building automated pile driving monitoring systems to address the risk of structural failures and project delays.

These systems allow us to digitally monitor the progress of pile driving and project performance for each hammer blow using, among others, global navigation satellite system technology. This market requested requirement addressed a specific project challenge, and we extended and integrated the technology into a solution that benefits all our customers. Further development on this digital front enables MENCK to drive full situational awareness throughout the installation process using data and data analytics.

PES: One ongoing development is a new generation of hammer; the MHU 6000W hydraulic pile driving equipment. How does this address the renewable industry's need for installing the next generation of monopiles and turbines to generate more gigawatts (GW)?

FH: I like to refer to everyday experiences to contextualise the development of new technology. Imagine someone wants to hang a big picture on a wall and needs to drive a nail into it. The size of the hammer chosen at home depends on the weight and dimensions of the picture, which determine the appropriate nail size needed for support, as well as the hardness of the wall. Similarly, the

Fabian Hippe

size of a pile driving hammer in offshore wind installations depends on the size of the turbine, the depth of the water, and the condition of the seabed. The larger and more demanding the task, the more powerful the hammer needs to be.

Developing pile driving technology involves balancing what needs to be installed with what will be used to install it. A small hammer cannot drive a massive pile. A large diameter, heavy pile, which we now see more of, encompasses significant embedded surface area and may require a lot of energy to overcome soil resistance. However, driving becomes easier if the hammer is heavier, although it is the balance between all variables that allows safe and economic installations.

Hammer configuration for deep water installation

A MENCK hammer ready for mobilisation

MENCK has responded to developers' requirements to install larger, heavier piles by designing the newest and largest hammer in its market leading MHU fleet: the MHU 6000W. Delivering a minimum energy of 200 kJ and a maximum of 6,250 kJ, the MHU 6000W operates both above and under water. It features a pile sleeve anvil adapter ring for piles with top diameters of up to 9 m. With a project specific pile adaptation, piles with even larger top diameters could be installed. It relies on known and trusted technology characteristics while extending operational and situational insights into the installation process and equipment performance.

This makes the new generation of MHU hammers more resilient and increases safety performance, aiding safer and more efficient installation execution.

PES: Do you foresee the MHU 6000W improving installation efficiency?

FH: Absolutely. We could use a smaller hammer to do the same job, but we would encounter significant wear and tear on both the machinery and the pile, along with installation inefficiencies. Most piles do not require the hammer's maximum energy, but the hammer's weight itself supports a smoother installation. This applies to both the fatigue induced into the pile during pile driving and various environmental concerns and challenges linked to the pile driving process.

MENCK's journey began in the oil and gas industry, where operators prioritised reaching first oil as quickly as possible. This meant the faster we could install the pile, the better, so we designed our equipment to offer 'the biggest bang for the buck.'

However, through over 20 years of renewables market engagement, we have addressed numerous environmental concerns that have arisen over that time and are now prominent. Oil and gas installations used to involve one jacket with a few piles, but now we drive hundreds of piles at once for wind farm developments, significantly impacting the environment of the region in which we operate. This is one of the main reasons for oversizing the hammer and running a heavier hammer at lower energy levels to reduce noise emissions into the water column and dynamic stresses within the pile due to the pile driving process.

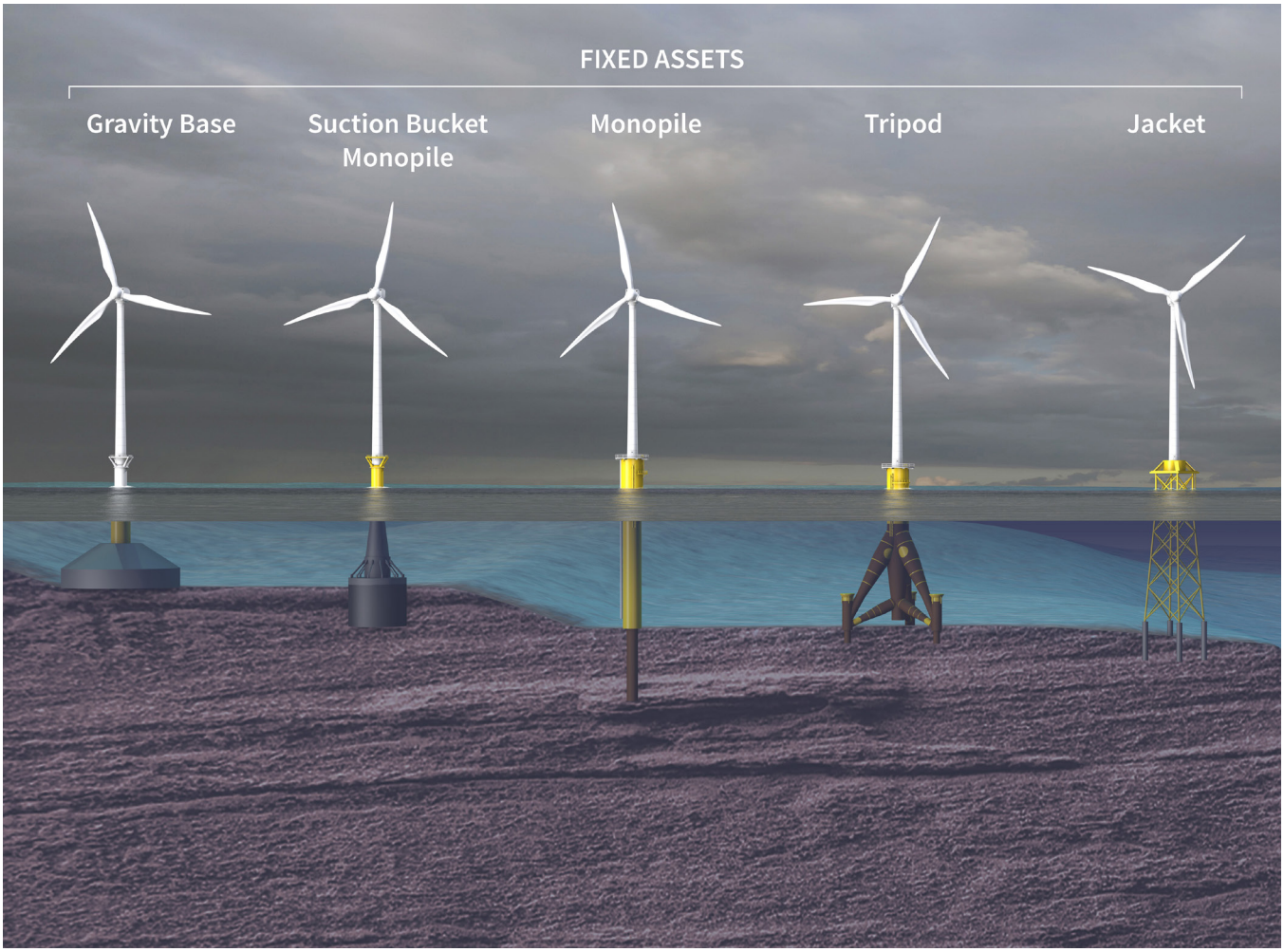
PES: Beyond noise mitigation, does the MHU 6000W incorporate any other eco friendly features?

FH: A few years ago, we completed a challenging installation on a bridge project in Bangladesh. This project allowed us to innovate by eliminating the grease used to lubricate the ram weight and replacing it with a high heat resistant polymer composite material that reduces friction. Our pile driving equipment now minimises the use of hydrocarbon based grease, addressing an environmental concern. Lead also poses environmental and health concerns. The bridge project enabled us to innovate in this area by eliminating metal compounds from our systems and protecting our people and the environment from dust created during the maintenance of pile driving equipment.

The MHU 6000W now features a virtually grease free system and uses biodegradable hydraulic fluids, significantly reducing environmental threats and adding a new dynamic to commercial considerations. A significant part of this innovation is linked to a newly developed main valve system, which offers greater resilience and significantly smaller size, contributing to more economical operations.

PES: Is there the potential for new territories and opportunities for developers to present themselves with this technology?

FH: Yes, particularly if they pursue developments on the political agenda to achieve energy targets, such as the anticipated 30 GW for Germany, to meet global energy sustainability targets of 250 to 300 GW. Understanding this dynamic and appreciating the scale of piles and foundations to be installed in the next five years, the industry needs to find space for these projects. Developers will inevitably venture into unexplored territories.



Fixed bottom offshore wind foundation types

It is desirable to install offshore wind in regions where people live to ensure proximity to electricity consumers. However, this brings us to areas where we have never worked before, confronting us with formations and soil types we have never encountered. We know these formations exist, but we have never been asked to install anything man made into them. Now, we are starting to understand how these formations react and what challenges they may present.

The MHU 6000W technology allows us to drive even larger piles in tougher environments or longer piles in deeper waters and can drive underwater. We anticipate that the monopile of yesterday will become the jacket pile of tomorrow, meaning jacket piles will increase in size, and we need to be ready to drive them at scale.

A decade ago, we installed a four meter pile and called it a monopile; now we see four meter and five meter piles serving as jacket pile foundations. Although the resistance we need to overcome to install them is similar to what we experienced ten years ago, they are now being installed in different environments. We considered the capability and flexibility to adapt to these environments in the design and fabrication of the new installation tooling that MENCK provides.

PES: What about handling obstructions that may be encountered during pile driving?

FH: Hopefully, we will not encounter obstructions in the seabed because the geotechnical investigation identifies the formations throughout the installation depth. However, when installing piles in natural deposits with diverse properties, obstructions can still occur even after the site characterisation stage.

We have encountered locations where piles drive easily in some areas, while others refuse. This could be due to an old, covered up channel or something not uncovered during the soil investigation because it was so localised. Therefore, there is always a risk of anomalies.

Although we have technology and investigation techniques to understand pile and soil interactions, we continuously learn about the dynamics of pile penetration. We develop new techniques to predict resistance based on soil formation data and insights. Acteon holds a large database of geotechnical and pile installation data, which we combine to investigate and understand how piles behave in various soil formations worldwide. Applying these learnings to any new arena delivers immediate value to our customers.

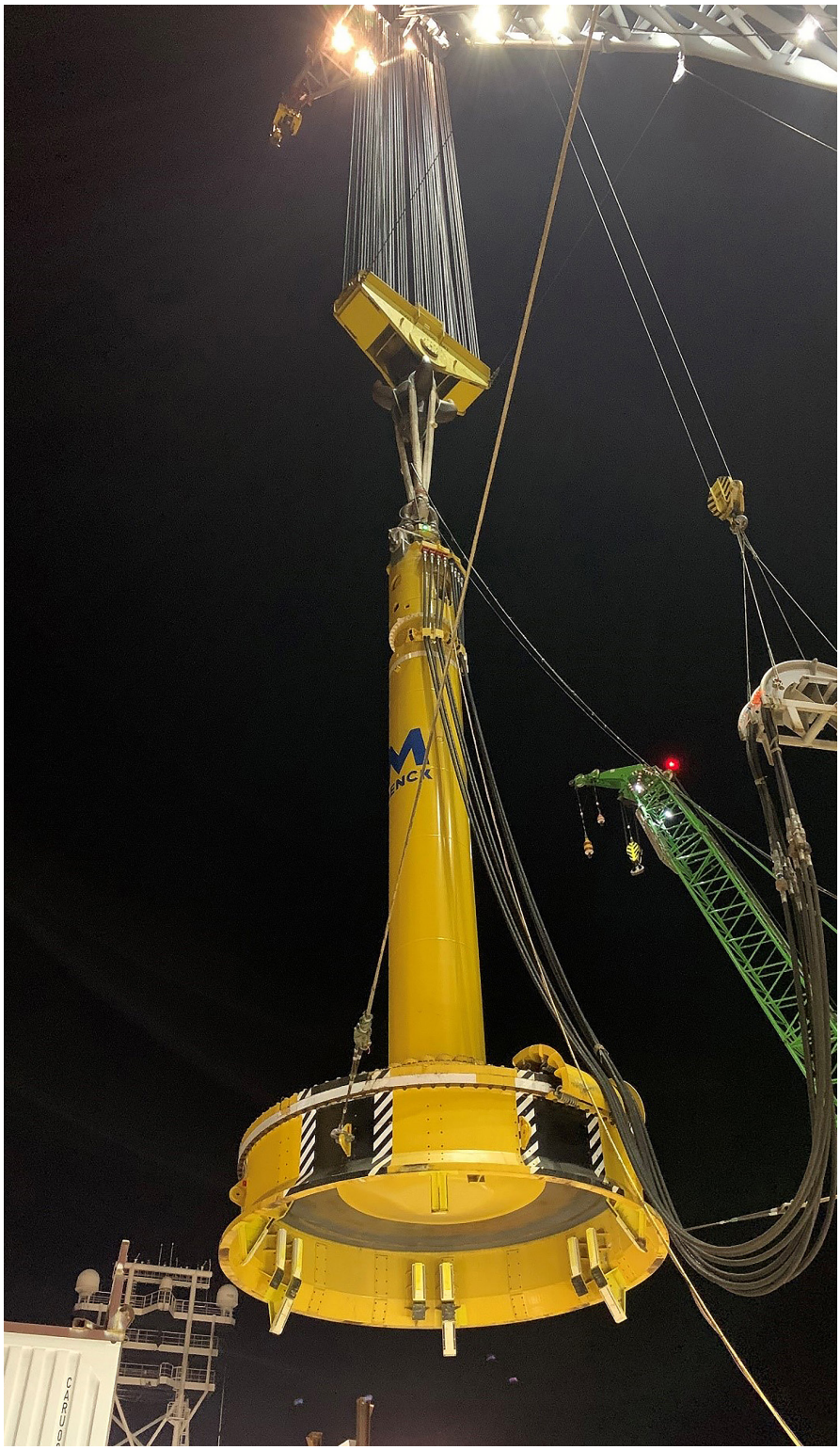
PES: Regarding local content and in-region assembly, how does MENCK approach localisation for the delivery of pile driving equipment, and are there plans for local manufacturing or assembly to support regional markets?

FH: Local content is often requested in many regions, driven by political agendas. MENCK's technologies are fully modular, allowing easy transport of a hammer to any country, where it can be fully assembled and operated. We have submodules in the hammer that can only be disassembled or assembled in our workshop, but these assemblies are significantly lighter and easily transportable by air freight or vessel. Therefore, the ability or constraints are less of a concern, and we usually take parts of those assemblies along with installations that are significantly distant from our home base.

Employing or using a local workforce for pile driving can be challenging because it is such a niche. For example, the East Coast US has a union operating on some installations in a

support capacity, but they do not lead those installations. We can supplement our team and crew with these experts, but it involves assessing the risks and benefits. We regularly do this with our customers on projects, but we always have our own personnel on site leading and supervising the operation of our equipment.

Offshore wind in the US is currently being mobilised from Europe. This is largely due to the limitations linked to established infrastructure and expertise in Europe, as well as permitting and regulatory limitations in the US. The established infrastructure and manufacturing capabilities in Europe currently make it more efficient for contractors to mobilise from European ports for US based projects. As the US continues to invest in its offshore wind industry, this dynamic may shift in the future.



A MENCK hammer being used on Vattenfall's Hollandse Kust Zuid I–IV (HKZ) offshore wind farm project in the Netherlands

PES: Can you share some example projects where the MENCK hydraulic hammer has achieved efficiencies on large wind turbine developments?

FH: We worked on a wind farm project in Taiwan, where we replaced the previous technology with an innovative, integrated approach to pile driving whilst addressing a significant pile run risk. In collaboration with our customer, we developed a step by step procedure to drive the pile and reduce the risk of a pile run. Simultaneously, we developed digital technology to increase situational awareness of how the pile reacted and drove by monitoring data from every single blow. We are expanding this to develop it further with different engineering value chains.

We aim to introduce digital technology to the market, allowing us to connect various commercial systems used in offshore wind installation onboard the vessel. This technology will enable us to monitor and connect to any hammer and pile installation from anywhere in the world, giving us remote access and insights to identify anomalies and provide support from experts from our organisation 24/7 whenever needed during pile driving. Anomalies can subsequently be linked to events that may have occurred outside the actual operation of the pile driving hammers, providing further insights into the installation and raising awareness of the encountered situation.

We installed piles for jackets on another Taiwanese wind farm, where we innovated an automated pile driving monitoring system to measure the set, understand the penetration, and replicate that to a blow count equivalent number, whereas previously we would have just counted blows.

Balancing power and precision are crucial in deploying the next generation of hydraulic hammers for offshore wind installations. These advanced tools are essential in driving monopiles into challenging seabeds, ensuring the stability of wind turbines.

The evolution of these hammers reflects the industry's response to the growing demand for renewable energy, combining power with the precision needed to protect delicate marine environments. This technology not only accelerates project timelines but also embodies the innovative spirit driving the global shift toward sustainable energy.

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