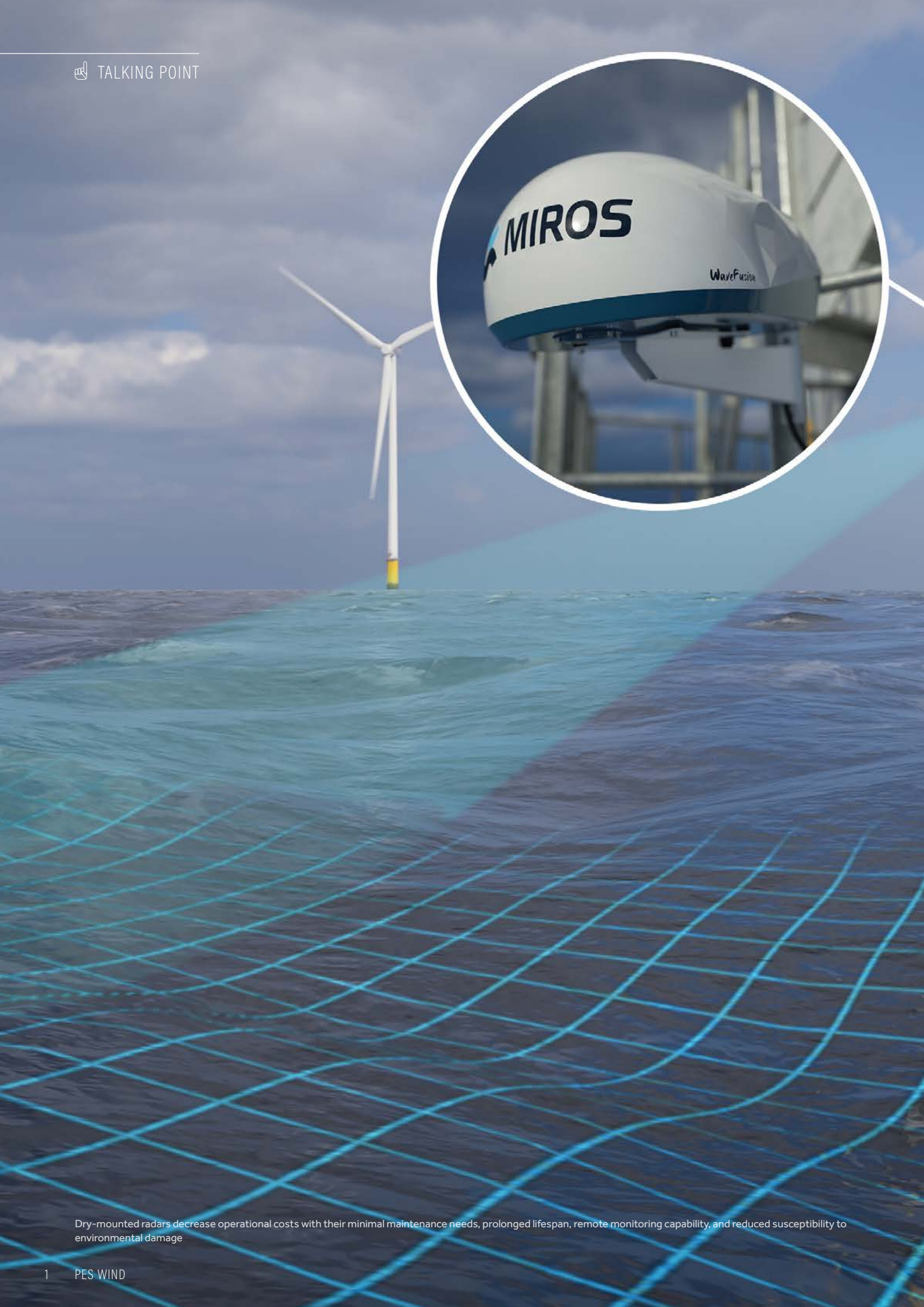


Dry-mounted radars decrease operational costs with their minimal maintenance needs, prolonged lifespan, remote monitoring capability, and reduced susceptibility to environmental damage

Switching to dry-mounted wave radars: why and when?

From enhancing safety and reliability to streamlining operations and optimizing maintenance, the advantages of dry-mounted wave radars in wind energy are poised to revolutionize the industry. Miros explores the intricacies of this transition and the impact it could make on the future of offshore wind operations.

Accurate sea state information has always been fundamental for ensuring the safety and effectiveness of offshore operations, no matter the sector. While that is a fact and one that is unlikely to ever change, how industry monitors the marine environment is constantly evolving and improving.

Historically, wave buoys have been the sector's preferred method for gathering sea state information and while they do have their uses, there are also limitations.

As the industry grows, offshore wind developers are constantly looking to refine and optimize their offshore installation and O&M operations. For that, new cutting-edge technology providing reliable data is needed.

Dry-mounted wave radars, which are fixed to turbines or other offshore platforms, already play a vital role in ensuring safe offshore operations and preserving asset integrity.

'They represent the future of real-time sea state monitoring,' explains Lars Ivar Leivestad, Sales Manager Offshore Wind at Miros Group, the ocean insights leader world-renowned for its reliable high-accuracy, real-time wave sensors and disruptive technology.

It can, however, be difficult for a developer to know exactly when to swap out their offshore wind wave buoys for a dry-mounted wave radar. To help companies make that decision, Leivestad and Richard Chen, Miros'

A dry-mounted wave sensor can be installed and begin gathering data as soon as there is a fixed or floating structure in the water

Technical Manager Offshore Wind, sat down to answer some commonly held questions, set out the many benefits of using wave radars and explain how Miros' technology can streamline operations and improve safety offshore.

What are the benefits of replacing a wave buoy with a dry-mounted radar?

Dry-mounted radars are less exposed to the elements and therefore require lower maintenance, last longer, and can be remotely monitored as they are less vulnerable to environmental damage. No matter what stage of development an offshore wind farm is at, replacing your existing technology with a dry-mounted wave radar can yield numerous improvements, many of them instantly. All that is required is the first fixed foundation to be in place.

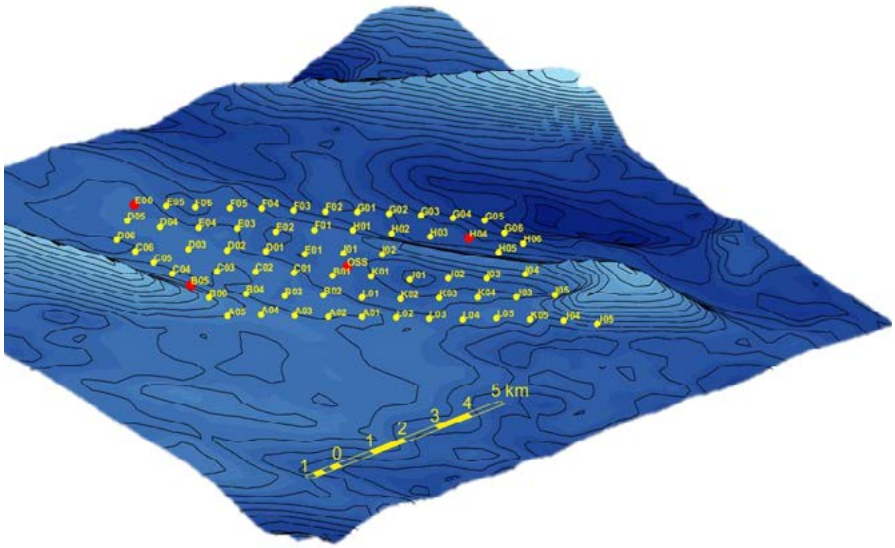
By replacing your wave buoy you remove the need for associated mooring systems, thereby streamlining the installation process and reducing the costs of installing hardware, as well as the potential impact on surrounding marine ecosystems.

Then there is the safety aspect to consider. Installing and maintaining buoys offshore can be challenging and potentially risky work, especially when the weather is bad and the sea rough. But dry-mounted radars are not as exposed to the elements and can be monitored remotely. The result is the increased reliability and accuracy of data, providing valuable information for the design, construction, and operational phases of an offshore wind farm.

Our IoT-enabled wave radars give the user an up-to-the-minute picture of the sea state, meaning they can make accurate judgments and respond instantly to changing weather conditions. This is crucial for optimizing the installation and operation of offshore wind farms, as well as ensuring the safety of personnel, vessels, and equipment.

By switching to Miros' dry-mounted, cloud-enabled sensor technology, customers can utilize all services available on the Miros Cloud platform. Along with the Sea-state-as-a-Service subscription users also benefit from system integration with

Enhancing maritime safety and operational efficiency, the Miros Forecast app integrates ocean condition forecasts with real-time measured ocean data, visualizing the comparison in an intuitive and dynamic dashboard for better decision-making



SPOT takes in historical wave data from the offshore wind farm location, bringing together bathymetry data and the coordinates of turbines or platforms

other offshore wind monitoring and control systems, allowing for a comprehensive and centralized approach to sea-state data management. It allows live and historical data to be shared across multiple different stakeholders; an invaluable feature given the number of groups that are crucial to the delivery and upkeep of an offshore wind project.

Why are additional sensors beneficial once the installation phase stops and the operational phase begins?

The deployment of numerous sensors is crucial, and ensuring their accurate positioning is vital for the safety and efficiency of operations. A dry-mounted wave sensor can be installed and begin gathering data as soon as there is a fixed or floating structure in the water. Ideally, an offshore wind developer should already have multiple sensors in place during the installation phase to build up a picture of the offshore environment.

But multiple wave buoys are too costly, and their data is rarely connected to one user-interface in real-time. Once a few foundations are in place you can begin to deploy multiple dry-mounted sensors to reliably gather more accurate sea-state data.

Take Equinor, SSE Renewables and Vårgrønn's Dogger Bank A wind farm. It spans 515km2 in area and is 131km from shore at its closest point, meaning multiple sea state variations. During both installation and O&M, various operations will take place in parallel and the sail time across the site is very high, so it is imperative that stakeholders have access to real-time sea state condition information in granular detail.

During the installation phase many different types of vessels are on site and various operations are carried out at, or near the same time, whereas similar vessels are used for most O&M tasks. Offshore wind developers are now building centralized control centers with one big focal point that will look after anywhere between five and 12 offshore wind farms during the O&M phase. However, those that are going through the construction phase have their own dedicated control centers due to the variation of operations and vessels involved.

As a project moves into the operational phase, sensors can easily be placed in different sections of the wind farm, so the data provides a more rounded picture of the conditions. Even between turbines there may be differences in the water depth that could lead to large disparities in wave heights and sea state.

This information is crucial for developers to optimize their O&M activities. Real-time wave data allows operators to target periods of lower wave intensity, reducing downtime and improving the availability of wind turbines. When opting for the Sea-state-as-a-Service solution, the measured ocean conditions will ensure the safety of maintenance crews during transfer to and from offshore wind turbines.

Moreover, understanding wave conditions is vital for understanding and measuring the impact of waves on turbine structures over a prolonged period. Our advanced technology gives users access to historical data that helps in planning maintenance interventions to address structural integrity issues caused by wave-induced stresses. This can differ between neighboring turbines, let alone between different segments of the wind farm that may be miles apart. That is why deploying multiple sensors is of paramount importance, and why getting their position right is essential to safe and effective operations.

How do dry-mounted radars fit with the Sea-state-as-a-Service model?

Companies face no financial risk, and asset owners have a minimal upfront investment.

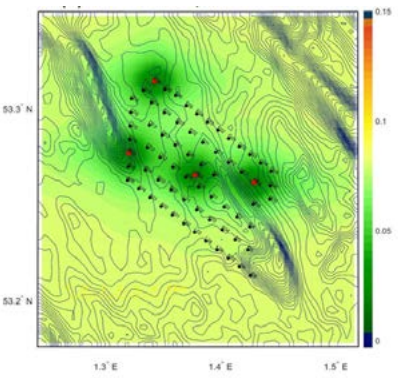
As we have said before, the future of sea state monitoring is subscription based. Our scalable Sea-state-as-a-Service model makes it simple for clients to install our top-of-the-range system and add sensors as their wind farm moves from one phase to the next. By opting for the subscription service, rather than buying the hardware outright, users also benefit from premium support and guaranteed uptime, including an advantageous sensor warranty and the latest Microsoft Azure cybersecurity.

In the rare event that any issues with the system arise, our skilled engineers will solve them remotely and will carry out the work on location if required. This leads to a much quicker resolution in most cases. Even if the issue cannot be fully resolved remotely, we would already have a better idea of how to tackle it before we physically visit the sensor. Whereas, if you decide to purchase sensor hardware without the as-a-Service benefits, you will be responsible for maintaining the kit and will have to pay for support when needed.

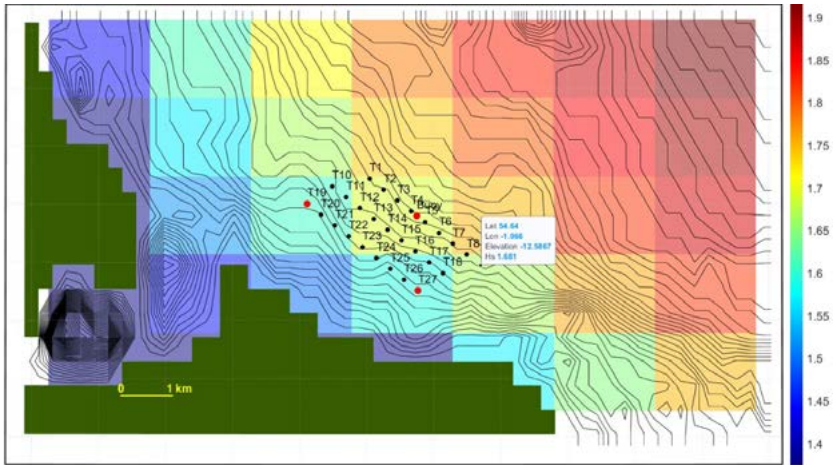
There is no economic risk for subscribers and the upfront investment for asset owners is low because Miros owns, insures, and maintains the sensors under the as-a-Service offering. As a project moves into the O&M phase, the combined radar and subscription service means upgrades can be planned strategically, improving the capacity factor of wind farms, and reducing costly turbine downtime.

How can developers ensure they get their sensor placement correct?

We can help developers find the optimal locations for sensors with our unique SPOT (Sensor Placement Optimisation Tool) software. SPOT takes in historical wave data from the offshore wind farm location, bringing together bathymetry data and the coordinates of turbines or platforms. The algorithm calculates wave variation in this area and lets us input the number of sensors that are to be installed on-site. SPOT then



SPOT calculates and highlights the optimal locations for placing wave radars



Miros can tailor the SPOT formula to match wave height limit for the vessel type that will operate in the wind farm to support sail or no sail decisions

highlights the optimal locations for placing these radars.

For example, if the west side of a wind farm tends to have more uniform waves than the east side, the algorithm will recommend placing fewer sensors on the west side and more on the east to give the operators the most critical sea-state understanding. Furthermore, the algorithm can be customized to focus on wave heights near your operation vessels' operation limit.

If a site will mainly be serviced with crew transfer vessels (CTVs) with an operational wave height limit of two meters, Miros can tailor the formula to be most sensitive at wave heights of 1.5 m to 2.5 m, and not take into calculation when wave height is below 1 m or above 3 m when the sail or no sail decision is clear.

I have already purchased wave buoys, why should I invest in dry-mounted radar systems?

Dry-mounted radars decrease operational expenses with their minimal maintenance needs, prolonged lifespan, remote monitoring capability, and reduced susceptibility to environmental damage. Offshore wind developers understand the value both wave radars and wave buoys bring. While wave radars provide more real-time data available for remote-access, wave buoys can be useful during pre-construction before any assets are in the water. Most offshore wind developers will rent wave buoys during this time, and swap to more comprehensive advanced wave radars system once assets are in water.

For those that have purchased their own wave buoys, they may prefer to have them on rotation at one site and add further wave radars across their turbines to enhance sea-state understanding. Other sites may simply stop putting money into maintaining wave buoys, since the cost of maintenance is generally higher than subscribing to a dry-mounted wave radar system.

Switch now to realize instant enhancements

The move from traditional wave buoys to advanced wave radars represents a significant leap forward in the offshore wind industry's drive for accurate and up-to-date sea-state information. The continuous evolution of monitoring technologies underscores Miros' commitment to safety, efficiency, and environmental responsibility.

The advantages of adopting dry-mounted radar systems are multifaceted. Not only do they eliminate the need for complex mooring systems, streamlining installation processes and reducing costs, but they also mitigate safety risks associated with offshore operations. The ability to remotely monitor and maintain these radars, even in adverse weather conditions, enhances their longevity and operational efficiency, ensuring a prolonged and reliable service life.

Miros' IoT-wave radars have been tested and are developed for use in the harshest ocean conditions. As a result, they offer an immediate improvement in sea-state monitoring, providing up-to-the-minute data crucial for optimizing offshore wind farm installation and operation. Moreover, the comprehensive and centralized approach enabled by our Sea-state-as-a-Service subscription model further enhances the usability and accessibility of this technology.

As offshore wind projects move from the construction phase to the operational phase, the deployment of additional sensors becomes essential. Miros' SPOT provides a tailored solution for optimal sensor placement, considering historical wave data, bathymetry, and specific operational vessel limits. This ensures a well-rounded understanding of sea-state conditions across different segments of the wind farm, contributing to effective O&M planning, enhanced operational safety and overall project success.

miros-group.com

Richard Chen, Technical Manager Offshore Wind

Richard Chen is a dedicated Technical Manager for Offshore Wind at Miros.

With a career spanning both the wind industry and information technology, he brings a wealth of experience and expertise and seamlessly merges his knowledge of wind farms and cloud computing to provide invaluable support to customers.

Richard's unwavering commitment to staying at the cutting edge of new technologies and exploring potential integrations underscores his passion for innovation and driving progress in the industry.

Lars Ivar Leivestad, Sales Manager Offshore Wind

Lars Ivar Leivestad is a seasoned Sales Manager for Offshore Wind at Miros, with a comprehensive operational, technical, and commercial background within the energy sector.

Lars Ivar brings a unique blend of technical prowess and strategic management skills to his role, making significant contributions to bringing real-time ocean insights to the forefront of the offshore wind sector.