Steadfast economic benefit from real time wave measurements

One of the key challenges facing any offshore wind operator, and one which has high significance for their success, is around the accessibility of assets. However, a new study by Trios Renewables, the University of Strathclyde and wave sensor specialists Miros has, for the first time, provided evidence of the potential benefits of direct wave measurements for offshore wind farms.

The requirement to continually take operation-critical decisions, which determine when to deploy maintenance and repair crews, is an ongoing issue, with those decisions being taken against the backdrop of the potential impact on capital and operational costs.

Accessing turbines at the optimum time to ensure operational efficiency and avoid lost production, while guaranteeing crew safety, means there is a continual process of evaluation of data to inform decision-making.

Led by Strathclyde University's David McMillan, reader in wind energy, wind and renewables engineer Erik Salo and Miros' vice president renewables Maggie McMillan, a pioneering study has been launched. It has its origins in a Knowledge Transfer Project on the economic benefit of increased instrumentation in direct wave measurement.

David and Erik have now joined forces as directors of Trios Renewables, with Sally Lockwood, former operations manager at Robin Rigg offshore wind farm, offering Operations & Maintenance (O&M) wind advisory services to the sector.

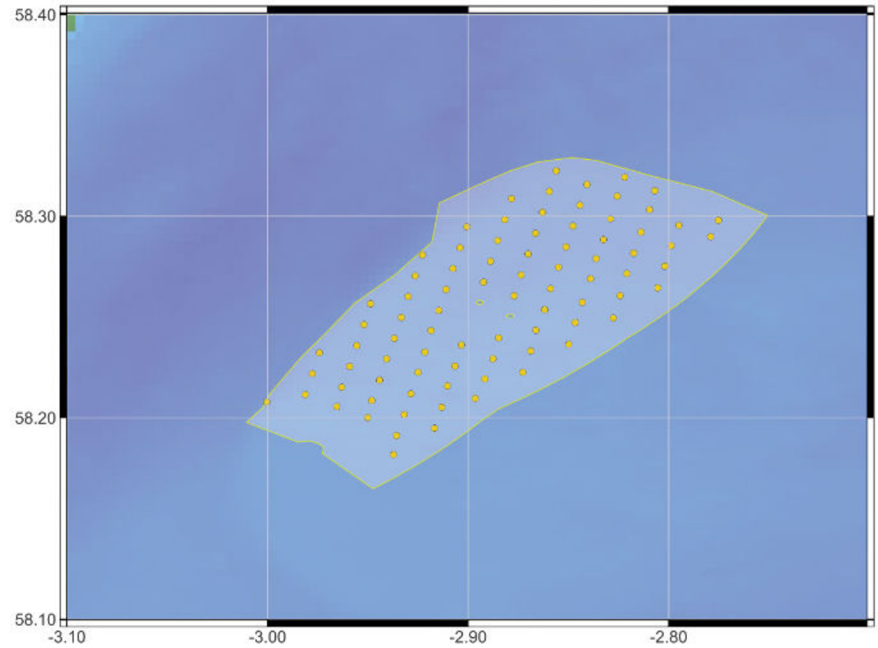

Figure 1. Data from a case study of an existing, modern Scottish offshore site with 7 MW turbines are used as a benchmark for the effectiveness of different approaches to measurement as one part of the model

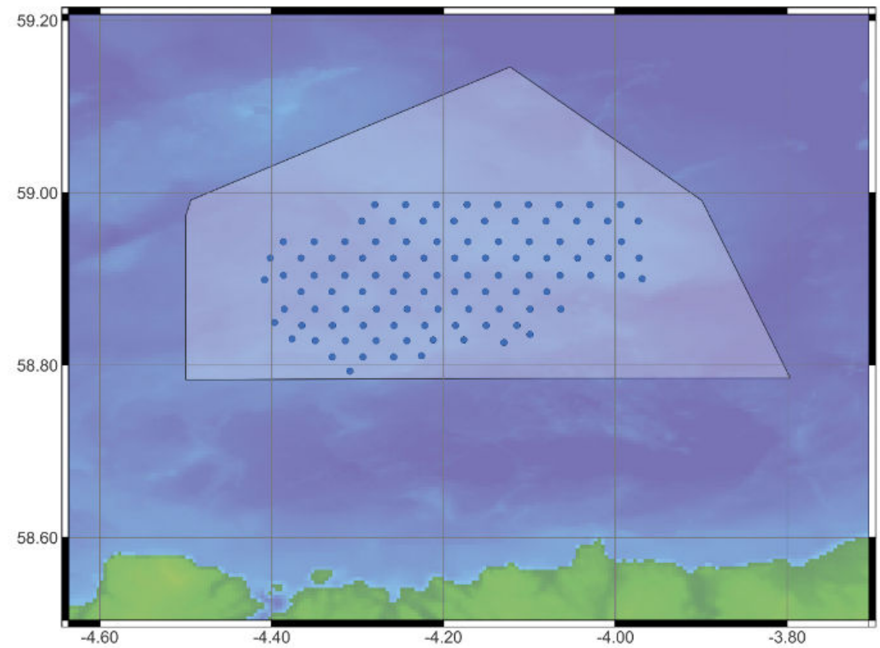

Figure 2. Additional case study of a Scotwind site, which is expected to be operational by 2030, was used as a second set of benchmark data on the effectiveness of different approaches to measurement

Miros specialises in delivering crucial sea state and weather data to offshore wind farms and their operational eco-system. Its dry-mounted IoT-sensors provide highly accurate, real-time measurements to inform vessel access decisions, as well as offering input to port and coastal monitoring and asset integrity systems.

Making waves

For production efficiency of any offshore wind farm, a key issue is the dynamic nature of the wave climate surrounding the site.

In most cases, operators rely on a weather forecast service, to provide the necessary data on which they base crucial decisions about whether or not to dispatch vessels for O&M purposes.

Typically, the process entails reviewing the weather forecast and taking one point measurement which provides a single significant wave height, or Hs number, for the entire site.

The operator examines the weather trend, formulating a dispatch plan for its vessels based on this information, therefore an isolated value for the area can only offer a very broad approximation of conditions across the site.

However, this approach fails to take full account of the fact that turbines at one part of a site will experience different wave conditions from those on another.

As part of this valuable study, an important consideration was that future wind farms are likely to feature 15-20 MW turbines, expected to be industry standard by 2030, which will tend to increase turbine spacing to allow for downstream wake effects.

What's the point?

Many of those directly involved in the operational side of offshore wind recognise the huge importance of site accessibility and the value wave measurement plays in achieving efficient access.

However, these individuals often have minimal input at the design stage or any involvement in the procurement or project financing process.

In the wider offshore community, there is a marked lack of awareness of the economic value of direct wave measurement with the vast majority of existing sites having limited spatial ocean measurement technology installed.

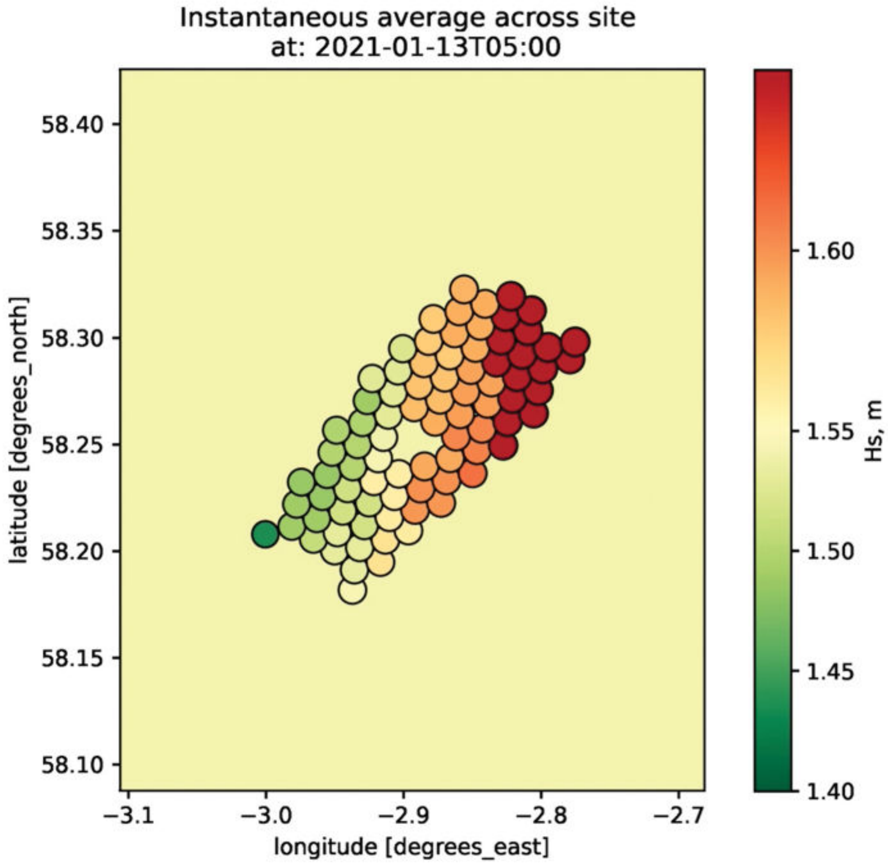

Figure 3. IoT-enabled sensors in multiple locations increase the amount of real-time data on sea state conditions across the site and make it much easier for efficient dispatch decisions on which turbines to access at any given time

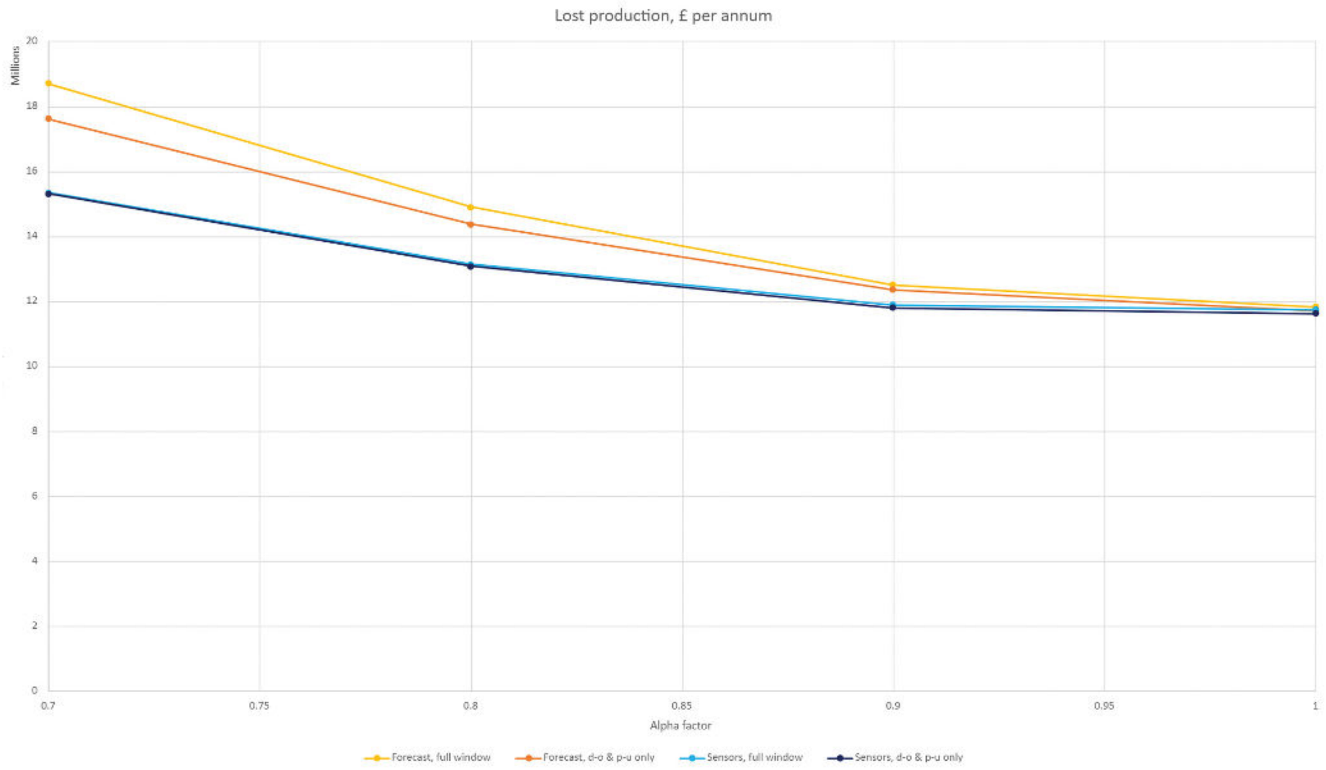

Figure 4. The results clearly showed that lost production on the sensor-enabled site was reduced by a factor of typically around 1%, a potential saving of more than £1 million per annum

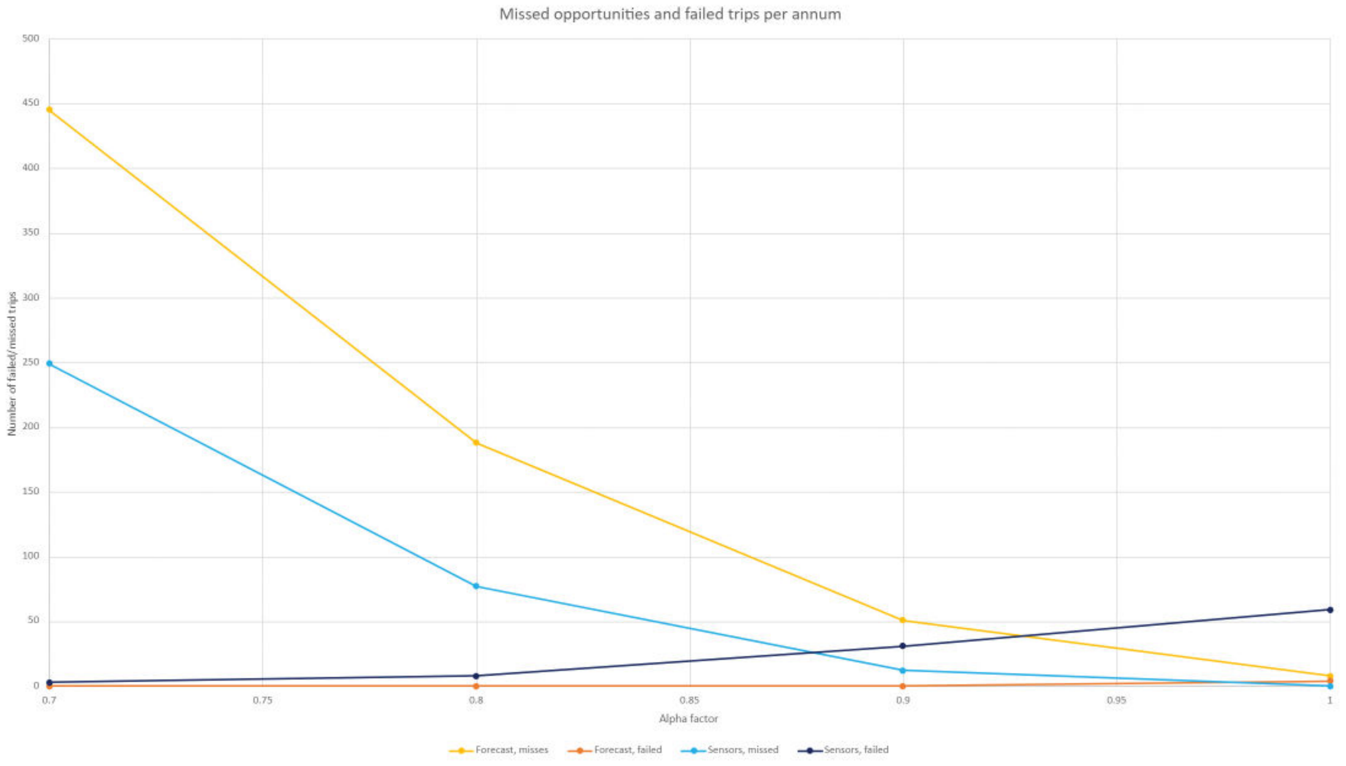

Figure 5. The results of the study demonstrate that met-ocean sensors provide more advantage in more risk-averse scenarios, a description which can be applied these days to the vast majority of operators

Amongst turbine manufacturers, investors, foundation manufacturers and procurement teams, wave instrumentation can often be seen as a responsibility that doesn't fall within their remit.

Between one and four measurement devices per site are planned for, with often only one installed.

For the team at Trios and Miros, this failure to communicate a persuasive economic case for instrumentation was the impetus behind this collaborative study with the aim being to provide a cost benefit analysis (CBA) which would inform the wider wind community, the insurance industry and the investor community of the conceivable benefits of improved measurement.

Tale of two models

The Trios model aimed to quantify the value both in operational uplift and lower costs of spatially distributed real-time Hs measurement. This was compared to a standard forecast strategy when using either data source as the decision aid for workboat dispatch decisions.

The model used two case studies, an existing offshore site, a modern Scottish site with 7 MW turbines (see Figure 1), and a Scotwind site (see Figure 2) expected to be operational by 2030, as a benchmark for the effectiveness of different approaches to measurement.

The first scenario, business-as-usual, assumed Hs access conditions were the same at every location across the site while the second, with Miros sensors deployed, used simulated distributed real-time measurements at five sensor locations across site.

In this scenario, a daily work schedule was created for turbines requiring access on a given day, based not on average values, but interpolated values with a higher spatial resolution for each individual turbine location.

The key factors for consideration in both scenarios included successful trips with vessel dispatched and jobs completed with no safety issues or aborted transfers. It also considered failed trips, where work wasn't completed due to a weather window being too short and missed opportunities, including any vessel dispatch decision, based on sensors or forecasts, that results in a failure to utilise a weather window which could lead to thousands of pounds of lost production.

To go or not to go

Rather than adapt an off-the-shelf OPEX model, Trios' approach was to build a model of the appropriate quality and resolution to produce a viable CBA for improved measurement.

To ensure the decision-making rules applied to the data streams mirrored real world operational decisions they were validated by incorporating Sally Lockwood's experience as former operations manager at Robin Rigg offshore wind farm.

Both scenarios were modelled with a one-hour resolution for one year, based on 10 visits of either 5 or 10 hours per turbine per annum, with the same Hs data used for both.

A key element of the analysis was the assumption that two different operational philosophies exist across different operators. One which takes a KPI-based approach, and a second which is more operationally risk averse. When comparing a sensor-led approach to forecast, the level of risk taken by the operator is reflected by the alpha factor, essentially the safety margin for go/no-go decisions.

The results

The aim of the study was to demonstrate the substantial potential of instrumentation by quantifying the size of the performance and financial improvement which can be unlocked by its use.

By using IoT-enabled sensors in multiple locations, there is a substantial increase in the amount of real-time data available on conditions across the site, making it much easier to make efficient dispatch decisions on which turbines to access at any given time. (see Figure 3)

The results clearly showed that deployment of sensors at various locations across a site would enable operators to fully utilise their opportunities for site visits. Lost production on the sensor-enabled site was reduced by a factor of typically around 1%, but ranging from 0.2% to 7.7% or 9.6% for first and second case study, respectively, a potential saving of more than £1 million per annum. (see Figure 4)

The increase in data provided meant that decision-making was greatly enhanced, allowing weather windows to be identified earlier than a standard business as usual strategy and enabling earlier and more efficient vessel dispatch. This benefit would be enhanced further on a site with automated dispatch planning, which is becoming more prevalent in offshore wind, as a key uncertainty in an optimised schedule is the Hs condition at each turbine location.

The sensor-led scenario produced typically around three times as many unsuccessful vessel trips where the conditions were unsuitable for a transfer. However, in such cases the vessel master will have the final say and will be able to avert excessive risks, i.e. a transfer will not be attempted at all costs whenever sensors show an opportunity. Instead, the vessel will abort the mission if there is any chance of danger to personnel or assets.

The main impact, therefore, is economical, with time and fuel being wasted. However, due to the scale of the turbines, a moderate possibility of an unsuccessful transfer often pays off against the otherwise certain lost production until the next access opportunity presents itself.

With different levels of risk aversion leading to different decision-making, the results of the study (see Figure 5) demonstrate that met-ocean sensors provide more advantage in more risk-averse scenarios, a description which can be applied these days to the vast majority of operators.

Lower alpha factors lead to a higher success rate of vessel visits but also more missed opportunities where a job could have been completed but the decision was made based on the data not to attempt it.

Higher alpha factors, on the other hand, mean an operator's approach which could be described as more optimistic where vessels are dispatched in more marginal conditions.

This means more access opportunities are exploited, but at the price of working in worse conditions which sometimes leads to jobs being aborted.

The optimum middle ground is different for each site and each operator's strategy, as well as the type of decision aid they use. Benefits were found to be greatest on sites where marginal access conditions were more common, such as sites with a more energetic wave climate or those where vessels with lower Hs limits were used. Essentially this means that additional instrumentation on site could reduce operational uncertainty, improve safety and possibly even justify the use of more economical small vessels.

This study suggests that while forecasts can and do help operators predict and avoid the worst of working conditions, and avoid aborted missions, the number of missed opportunities can be significantly reduced with the help of distributed direct measurement.

- https://miros-group.com/markets/renewables/
- https://trios-renewables.co.uk/
- https://www.strath.ac.uk/

David McMillan, University of Strathclyde

Reader in Wind Energy

Email: d.mcmillan@strath.ac.uk

David is on a professional and personal mission to help achieve long-term, sustainably low-cost offshore wind power projects. Innovation, cost reduction, local content, how do we balance it all? 17 Years, 10GW and counting...

As a Reader at the University of Strathclyde, he focuses on topics like Reliability Analysis, Decision Analysis, Probabilistic Modelling, and Applied Statistics to be applied in Wind Energy, Asset Management, Energy Policy, and Energy Security.

Erik Salo, Trios Renewables

Wind and Renewables Engineer

Email: erik@trios-renewables.co.uk

Erik helps wind farm operators unlock O&M cost savings and achieve operational uplift by better exploiting the data they already have. He is most inspired by collaborative projects where the industry meets academic excellence and coding mastery, and enjoys contributing to the open-source community. Erik's rapidly growing portfolio includes several unique offshore wind models and the cost reduction of more than 15 GW of wind energy projects.

Maggie McMillan, Miros

Vice President, Renewables

Email: maggie.mcmillan@miros-group.com

With more than a decade spent working within the supply chain in the ever evolving energy sector, Miros' Maggie McMillan has been riding the renewable wave since 2014. As a staunch advocate, and catalyst, for the continued rise of offshore wind, Maggie embodies Miros' commitment to enhance the safety, sustainability and performance of offshore operations.