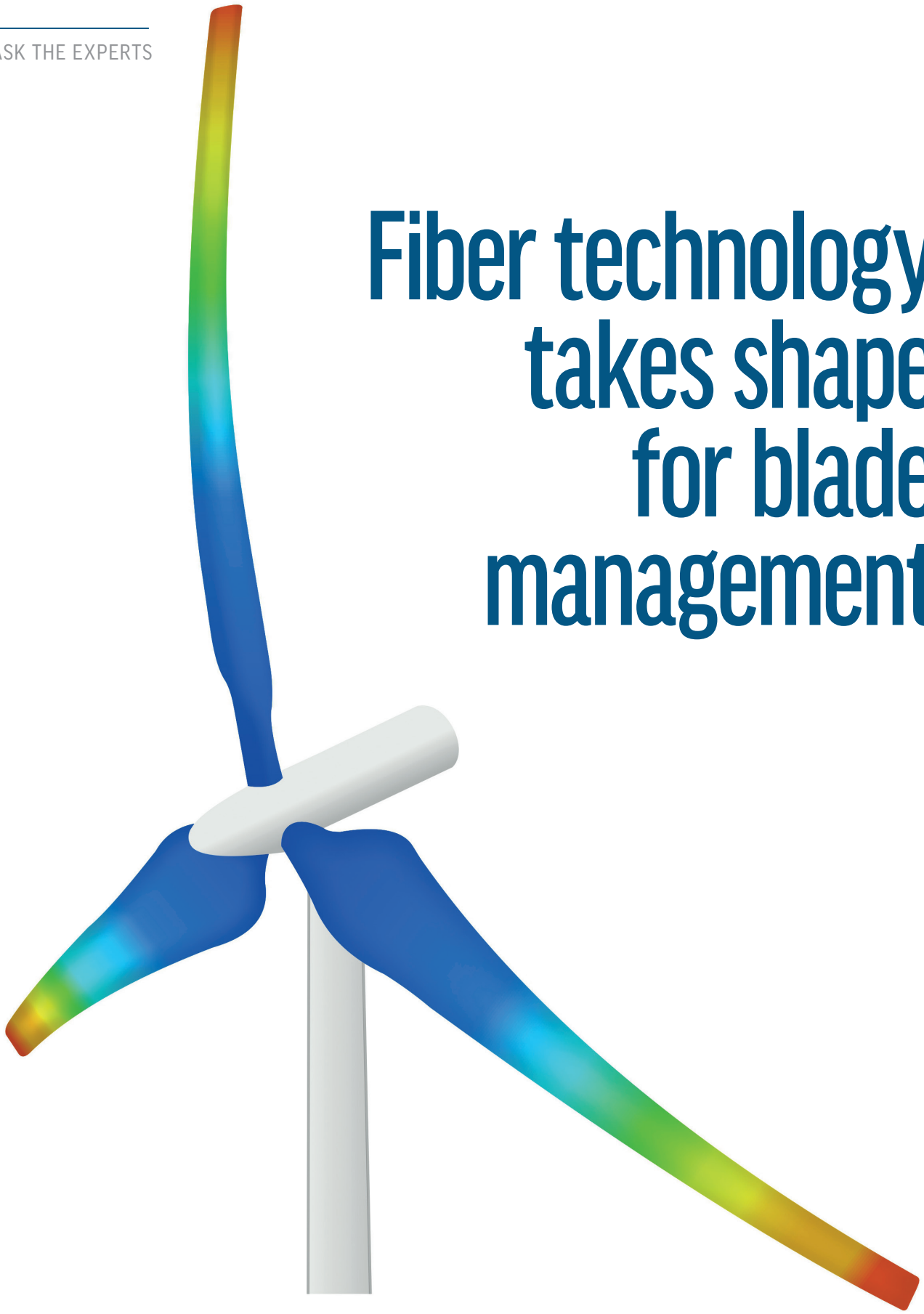
Fiber technology takes shape for blade management



Detecting damage in turbine blades at an early stage can go a long way to ensuring their efficiency is maximised. PES was keen to learn from Fibersail's Pedro Pinto CEO and co-founder, Carlos Oliveira, co-founder and executive director about the possibilities for using fiber optics in monitoring blade performance and condition. Could it be a shape changer for the industry?

PES: Welcome to PES Wind Pedro and Carlos, it's lovely to speak with you both. First of all, would you like to introduce Fibersail to our readers?

Pedro Pinto: Sure! As we understand, wind turbine blades, being the forefront structures converting wind into kinetic and electrical energy, are key drivers of turbine performance. With blades getting longer and more flexible for efficiency reasons, they get more critical, thus it is also crucial to reliably monitor them. Monitoring is essential for wind turbines to perform at their best during their entire lifetime, maintaining the lowest possible operational costs.

Fibersail provides a solution to tackle the industry needs by bringing an innovative way of monitoring blade performance and condition through its proprietary shape sensing technology. Our solution allows the measurement of the blade's deflection and tip position in real time, independently from design models or blade variations. We think this is a unique approach that will set a new standard in the industry.

PES: Can you explain a little bit about the technology behind the Fibersail system? It's fiber optic, is that right?

PP: You're right. The Fibersail system is based on fiber optic technology and takes full advantage of its proven fit to the operational conditions of wind turbines. However, it was designed to solve many of its current limitations.

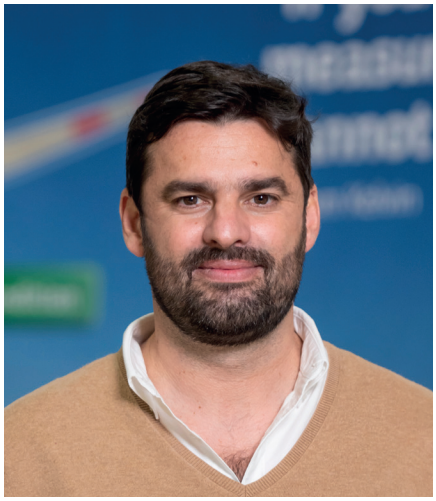
Fibersail proprietary technology comprises a composite beam that adds robustness, with embedded parallel arrays of FBGs that adds resolution and temperature immunity. That sits inside a sliding sleeve that allows for a reduction of loads in the sensor, extending its operational life for 30 plus years. By measuring the local curvature in each cross-section, our algorithm reconstructs the shape of the beam, thus, the shape of the blade in every instant.

The sensor has the same length as the blade and is installed or retrofitted from root to tip, meaning that blade deformations are measured and not extrapolated or inferred. This provides access to blade flapwise and edgewise deflections, along with the torsion measurements from root to tip during its operation.

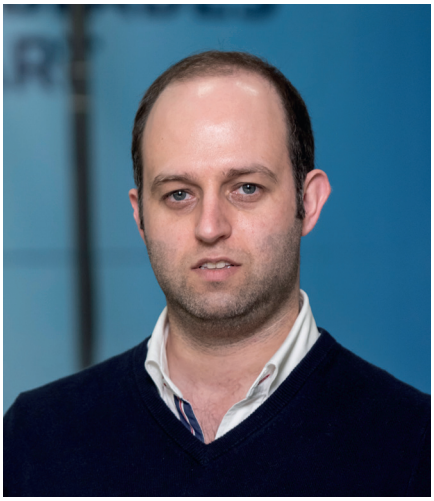
PES: So how does that work in terms of measuring blade performance and condition, in layman's terms?

Carlos Oliveira: The technology is aimed at monitoring blade deflections and tip positioning during operation, to control loads and detect early-stage failure modes during their lifetime.

Wind turbine manufacturers can take advantage of this specific blade information to improve the efficiency of turbine controls and blade designs, and to support wind turbine operators to reduce OPEX through predictive maintenance schedules.



Pedro Pinto



Carlos Oliveira

Being able to detect excessive deflections and structural changes, the system will reduce the risk of failures and consequently the need for excessive safety factors, allowing the increase of turbine performance under safe conditions.

Reducing risks while increasing performance and reducing costs with predictive maintenance will have a huge impact in the reduction of the wind LCOE, with clear benefits for the entire industry.

PES: Does the technology work with any blade type and size?

CO: The technology is designed to be plug-and-play, working in any structure with deflections, as required. It has been tested to measure shape and deflections from 1 meter sensors to 100 plus meters, allowing us to work with any blade size and type.

Although its value proposition is greater for longer and massive blades, like the ones being developed for the offshore environment, onshore fleets, or near end-of-lifetime turbines, where reliable measurements are needed, can greatly benefit from the unique information we provide to optimize operations and calculate lifetime extensions.

PES: Is this the first time such technology has been used in this way, that you are aware of?

PP: Even though Fiber Bragg Grating technology has been around for over 20 years, and single point strain sensing along the blade to infer loads and deflections have been used in the past, this is the first time that a shape sensor is used in such a way, to independently measure the continuous deflection and tip positioning of a blade. It represents an innovative solution for the wind turbine industry.

PES: What do you think are the main advantages of using fiber optic technology in wind farming?

PP: Fiber optic technology is proven to be of very high resolution, immune to lightning strikes and electromagnetic interference, lightweight, and has unlimited cable length for distributed sensing.

On top of that, we add the advantages of using it embedded on a specific composite profile for unmatched scalability, robustness and reliability.

PES: With access to real-time blade information at their fingertips, how can wind turbine operators make best use of the findings do you think?

CO: Although wind turbines are designed to operate for more than 25 years, they need to be regularly inspected to keep high operational and efficiency coefficients. By digitizing the blade's structural behavior, operators can make use of real-time blade information to detect imbalances and underperformances, detect early-stage failures and mitigate them at lower cost, or move towards a predictive maintenance model, where OPEX are optimized in line with turbine needs.

The monitoring of excessive deflections can also reduce the risk of failure of the turbines, with potential impact in insurance costs and, consequently, increasing the asset valuation through continuous lifetime assessment.

In the future, wind turbine controls will also be able to use blade deflection and tip positioning information to operate turbines based on the operator performance and strategy needs, and within the safety limits of the turbines.

PES: Has the Fibersail system been tested in a real-world environment yet? If so, what have the results been like so far?

PP: Fibersail has been testing its largest shape sensors on bench tests for accuracy, resolution, and reliability over their

lifetime. Currently, our first field sensor is installed in a turbine under operation and further operational deployments are planned in the coming months with some major industry stakeholders.

The results are very promising, confirming that the system has a high resolution and low noise signal from the real-time blade deflection measurements. The operational measurements will be compared with other technologies and used to enhance the algorithms with additional features.

PES: How does this technology help with things like maintenance costs and blade performance in the long run?

CO: Early-stage damage detection based on deflection changes will allow proper planning of maintenance activities, with huge impact in offshore operations, to fix the problem while the damage is still small and no major component changes are needed, greatly reducing maintenance costs.

In the long run, component level remaining lifetime calculation and damage detection like leading-edge erosion shall also provide invaluable insights to optimize maintenance costs and keep blade performance at its optimum throughout the turbine lifetime.

PES: Does it also have the potential to help with things like blade design or risk assessment, do you think?

CO: Certainly. Blade deflection measurement and tip positioning information are crucial for numerical model validation and optimizing the design of lighter and longer blades, maximizing its efficiency while reducing its safety factor envelope.

PES: Safety is obviously a big consideration for wind farmers; how does fiber optic technology help in this regard?

CO: Digitizing the blade's structural performance allows the detection of changes and failure modes at early stages. By reducing operational risks, the need for regular visual inspections and the amount of time workers are deployed and at risk, operators can ensure higher safety levels on their wind farms.

PES: What potential do you think such technology offers for the future of wind farming?

PP: Fibersail shape sensors will bring more reliable data to wind turbine design and operations. More data means more information and intelligence that allows wind turbines to become smarter and able to operate in different modes, selected in accordance with asset owners' strategy and needs. With Fibersail technology, wind turbines will be able to operate on a maximized performance mode, to extract the maximum MW/h possible under safety factors, or work on an extended lifetime mode, to focus on preventing excessive loads while producing efficiently.

PES: For Fibersail then, what is your road to market from here? How long do you think it will be before this technology is in general use?

PP: Our technology is currently being tested in bench tests and in operation to prove its reliability to withstand many years of operation without the need, or with reduced need for maintenance.

Different pilot tests are programmed for the next 18 months, and more are in discussions to be deployed. We expect to enter the market with a general use technology, both for new and existing blades, before the end of 2023 for the onshore market and one year later for the offshore market.

PES: With your offices being based in Portugal and the Netherlands are you planning to enter the market mainly in Europe or do you see yourselves going global?

CO: Europe is our primary market due to our location and extensive knowledge of the European industry. This is where we are proceeding with interest from the major industry stakeholders, so it is the first market to conquer.

Once scale in the first market is proven and customers want to expand our technology into their worldwide portfolio, Fibersail intends to reach American and Asian markets as well, as part of our strategic growth plan.

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