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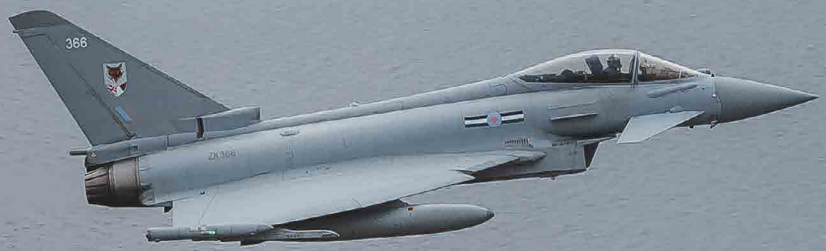
ROYAL AIR FORCE

Mitigating the adverse effects of offshore wind farms on air defence radar: concept demonstrations



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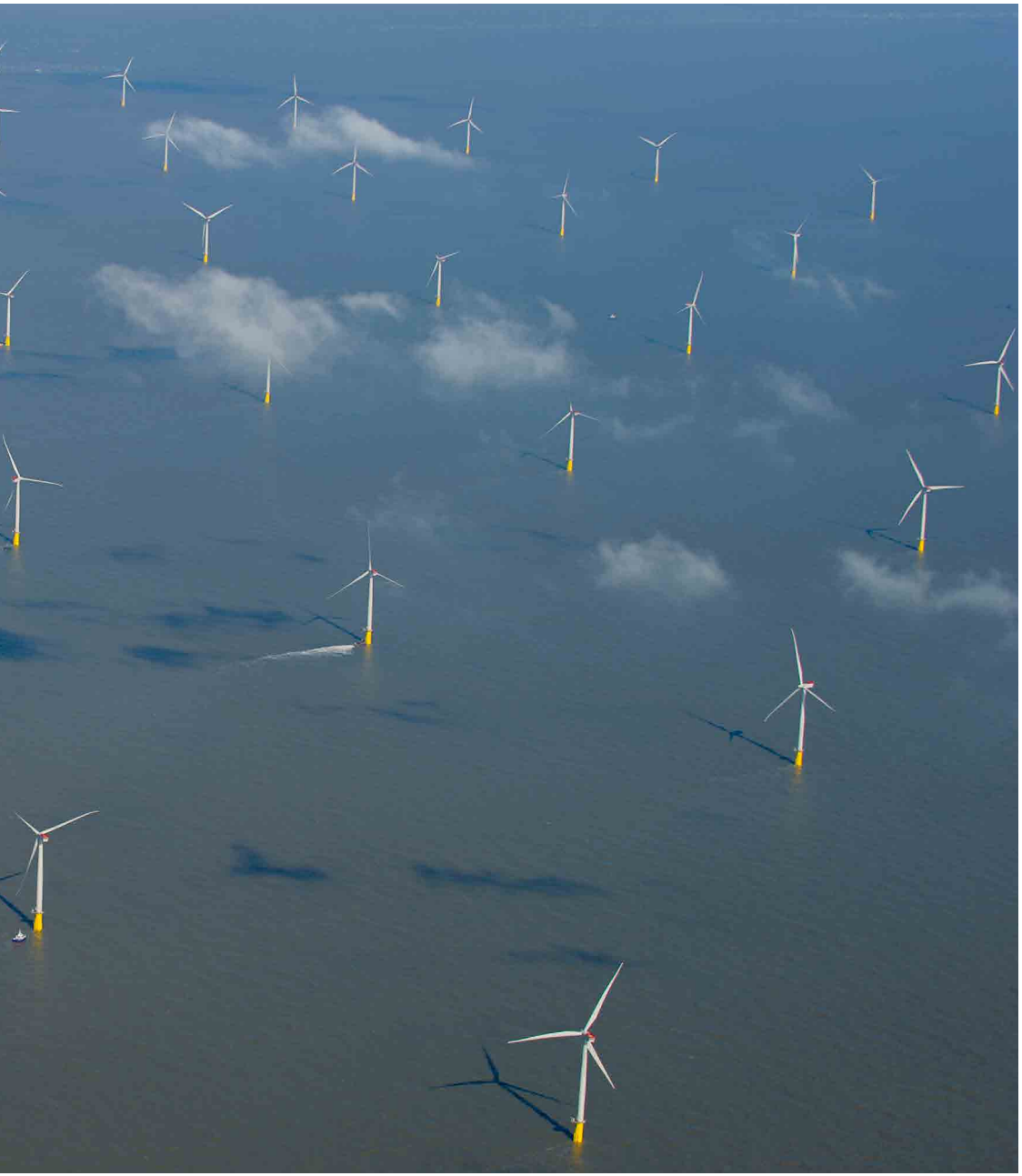

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MITIGATING THE ADVERSE EFFECTS OF OFFSHORE WIND FARMS ON AIR DEFENCE RADAR: CONCEPT DEMONSTRATIONS

Wind Turbines and Radar - The Need for Co-Existence

There has never been sharper focus on the importance of both offshore wind's contribution to UK energy security and net zero, and the importance of effective and robust defence of the UK homeland.

As the nation strives to meet our renewable energy targets, the need to find and implement technical measures to achieve coexistence of radar surveillance systems and wind turbines is both important and urgent. This report describes work that the MOD has undertaken, funded by the wind power industry, as a crucial step in identifying and assessing systems with potential to fulfil this requirement.

The Concept Demonstration Programme

The Windfarm Mitigation Concept Demonstration Programme, funded by the members of the Offshore Wind Industry Council (OWIC), and delivered by the MOD, has been an excellent example of MOD and industry working together. The programme aim was to identify whether solutions might be available to mitigate the adverse impacts that the next generation of large-scale windfarm developments would otherwise have on the UK's Air Defence System.

Detailed reports were briefed to the OWIC members funding this work, which has resulted in an important breakthrough with the Joint Air Defence and Offshore Wind Task Force identifying one or more technical mitigations that could potentially support windfarm developments in the medium term.

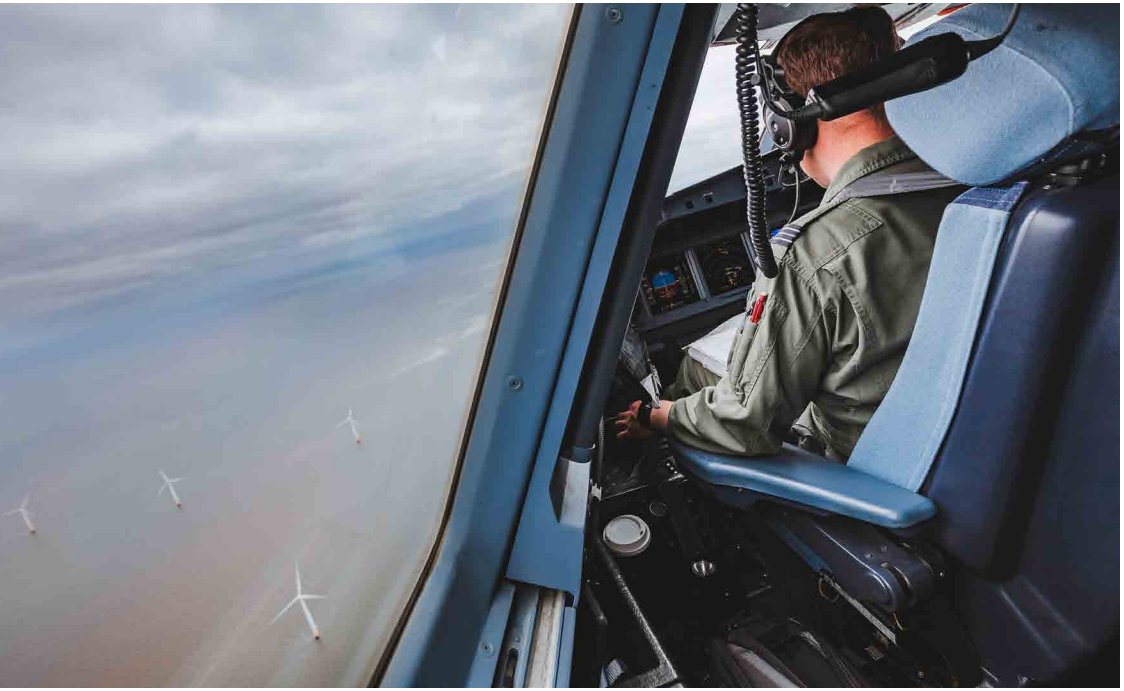
This evidence will now underpin the development of a detailed set of MOD requirements and preparation for the launch of a formal mitigation procurement competition.

The Feasibility Study

In support of the UK Government's 2019 Offshore Wind Sector Deal, the MOD has been working closely with the wind power industry to identify ways in which to maintain Air Defence (AD) surveillance capability in the presence and proliferation of new generation wind farms (WFs), comprising taller turbines in larger fields, expected from 2025 and beyond.

The detrimental impact of offshore WFs on the MODs AD Radar Surveillance task is well documented, with such effects likely to worsen by the increased size and scale of future planned WF installations.

Under the direction of the Joint MOD-Offshore Wind Industry Council (OWIC) AD Task Force (TF), formed in response to the 2019 Offshore Sector Deal, the MOD's Defence Equipment and Support (DE&S) began looking for evidence for a solution.



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In December 2019, the MOD issued an invitation for companies to submit proposals for high Technology Readiness Level systems believed to have the potential to mitigate adverse effects caused by offshore WFs to the UK's AD Primary Surveillance Radars (PSRs). This resulted in eighteen submissions, from thirteen companies, with a variety of proposed solutions including:

- Deployable Three-Dimensional (3-D) PSRs
- Mobile 3-D PSRs
- Permanent Two-Dimensional (2-D) PSRs
- Specialised 2-D 'Infill' radars
- 'Novel' radars (including passive and staring-array devices)
- 'Adjunct' systems designed to improve performance of a 3rd-party radar
- Electro-optical systems
- Application of Radar Absorbent Material to wind turbines

Each candidate system was reviewed and assessed by the MOD in a paper-based feasibility study. This filtered proposals into four categories with a view to conducting practical demonstrations, based primarily on the following three criteria:

- The current performance of each candidate, as evidenced by supporting material
- The potential of the solution to satisfy the MOD requirement
- The opportunities in 2020-21 to conduct practical demonstrations that would yield useful first-hand data

From Feasibility to Concept Demonstration

Following the feasibility study, 56 Sqn (one of the MOD's Test and Evaluation units), was tasked by the Joint TF to conduct a series of Concept Demonstrations (CDs) on those systems regarded as suitable at that time.

The aim of the CDs was to provide indicative performance assessments of the demonstrated capabilities of selected candidate AD Surveillance WF mitigation solutions in a real-life environment.

With these demonstrations prioritised according to their ranking in the earlier study, the intention was to see if there was potential for one or more of the candidates to deliver the future mitigation needed.

All candidates selected for the first series of CDs were self-contained and each was demonstrated as a 'stand-alone' sensor system. While it was raw sensor performance that was of primary interest at this stage, the solution ultimately selected will need to integrate with the MOD's C2 network, so an evaluation of connectivity will form the subject of future work.

It is important to note, also, that the purpose of the CDs was not to compare and contrast the candidates competitively with selection in mind, but to gather information collectively from the sample, that would allow the MOD to understand the current 'art of the possible'. In turn, this would help inform further MOD work to develop a set of requirements for windfarm mitigation.

Test Conditions

As far as possible, candidates were subjected to similar test conditions, in which sensors were located onshore looking out to sea at offshore WFs that were within line of sight of the radar. Dedicated test aircraft (predominately light aircraft but with some fast jet sorties) were flown over and around the wind farm and data gathered. Both real-time and sensor recordings were captured with the intent of determining, for each candidate:

- How well the sensor detected the aircraft in the WF-affected airspace
- How much unwanted 'clutter' was generated by the sensor as a result of the WF interference
- The positional accuracy of the detections made by sensor
- The ability to maintain tracking of a manoeuvring aircraft in the WF-affected airspace
- How the sensor may be utilised to maximise its contribution to the mitigation of adverse WF effects

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Equipment under Test

Of the 18 systems that entered the feasibility study, five were selected for the first series of CDs, entitled Campaign One. This comprised four PSR systems and one passive radar, the intention was to evaluate them in 2020.

A second group of candidates was earmarked for possible CDs in 2021 as Campaign Two. Because of Covid-19, however, rescheduling became necessary, with only two of the original planned Campaign One systems being assessed before the end of 2020.

Following reassessment in early 2021, a combined Campaign One (refresh) and Campaign Two was run in 2021, resulting in a total of eight systems being evaluated by the end of 2021, across nine demonstration events.

One system was subject to two demonstrations in order to gain comparable data. Most, but not all, of the trials took place at Remote Radar Head (RRH) Staxton Wold in North Yorkshire, using the Humber Gateway and Westermost Rough WFs as the test subjects.

It is acknowledged that neither WF is truly representative of the next-generation WFs but the combination of test site and available WFs was considered the best available.
Global travel restrictions meant that only five of the CDs were led by 56 Sqn; the other four events were conducted by the equipment manufacturers, utilising different operating sites and different WFs, but with 56 Sqn oversight and with recorded data passed to 56 Sqn for post-trial analysis. The equipment subjected to CDs comprised:

- One deployable long-range PSR.
- Three tactical 3-D PSRs
- One 2-D infill radar
- One 3-D infill radar
- One passive radar
- One electro-optical (camera) system

Test Method

Each MOD-run CD was assigned a five-day period with thirty hours of dedicated light aircraft flying using a Diamond DA-42, whose low radar cross section makes it a representative test subject.

A further two hours of Hawk fast-jet flying presented each sensor with the challenges of higher speed and high-acceleration manoeuvre. Pre-determined tracks at selected altitudes were flown in the vicinity of WFs according to an agreed test plan designed to ensure exposure to each of the known difficulties to be overcome by sensors dealing with WF-affected airspace. These include the combination of simultaneous low Doppler signature from subject aircraft and high Doppler signatures from wind turbines.

In the interests of consistency, WF turbine status was checked before the commencement of data capture, and whenever necessary during the demonstration, to ensure the number of turbines rotating within the subject WF, and their profile to the sensor met the threshold requirement.

Trial Constraints and Weather

Having scheduled the CDs well in advance they were subject to the vagaries of weather, with the result that not all test subjects were conducted in identical conditions.

With activity confined to five-day windows, there was little variation in weather within each trial period. Recognising the impact of weather, the MOD elected to demonstrate the electro-optical system during the late autumn / early winter of 2021, in order to increase the likelihood that the sensor would experience some of the more demanding conditions that would be encountered during eventual deployment.

But bad weather is only one possible confounding factor, and radar systems were demonstrated throughout the year displayed various seasonal environmental effects, such as anomalous propagation.

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Trial Results

In all, eight systems were assessed over an 18-month period and, from these, seven have shown some promise in certain areas of the performance studied, with one or more showing promise in all performance areas. It should be remembered, however, that only raw sensor performance was considered and not all the wider factors associated with a fully-implemented solution, such as C2 interoperability, and maintainability / availability.

Image: Equinor

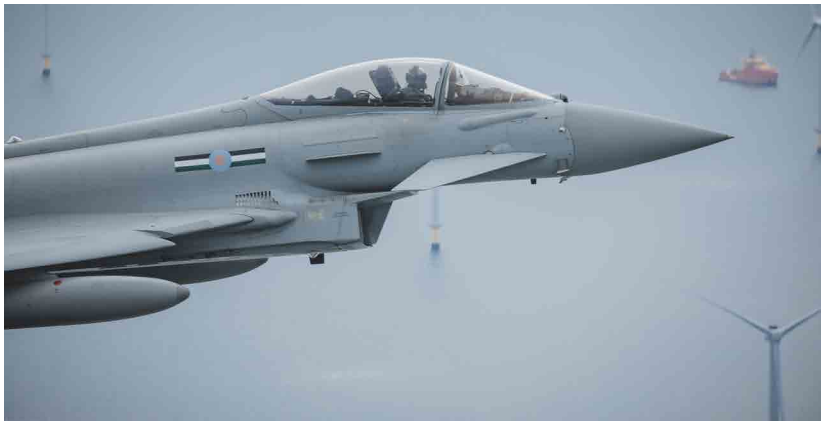
Recommendations

Two recommendations emerged from the CDs:

- Sufficient information was gathered from the CDs as to the current 'art of the possible', such that no further CDs need be conducted in the near term in an AD context.
- The evaluation of such systems that are selected competitively with a view to future procurement should be subjected to more in-depth evaluation than was the case under the five-day serials carried out for CDs, and should include, as a minimum, connection to a representative C2 system.

Conclusion

The Concept Demonstrations have enabled the Joint Task Force members to identify one or more technical mitigations that could potentially mitigate the adverse impacts of the next generation of offshore windfarms. The knowledge gained has also provided the MOD with the opportunity to develop a set of requirements to support the future procurement competition for mitigation equipment. Trials conducted through that competition will then provide the full evidence base for mitigation performance and, if successful, enable suitable mitigation to be deployed.



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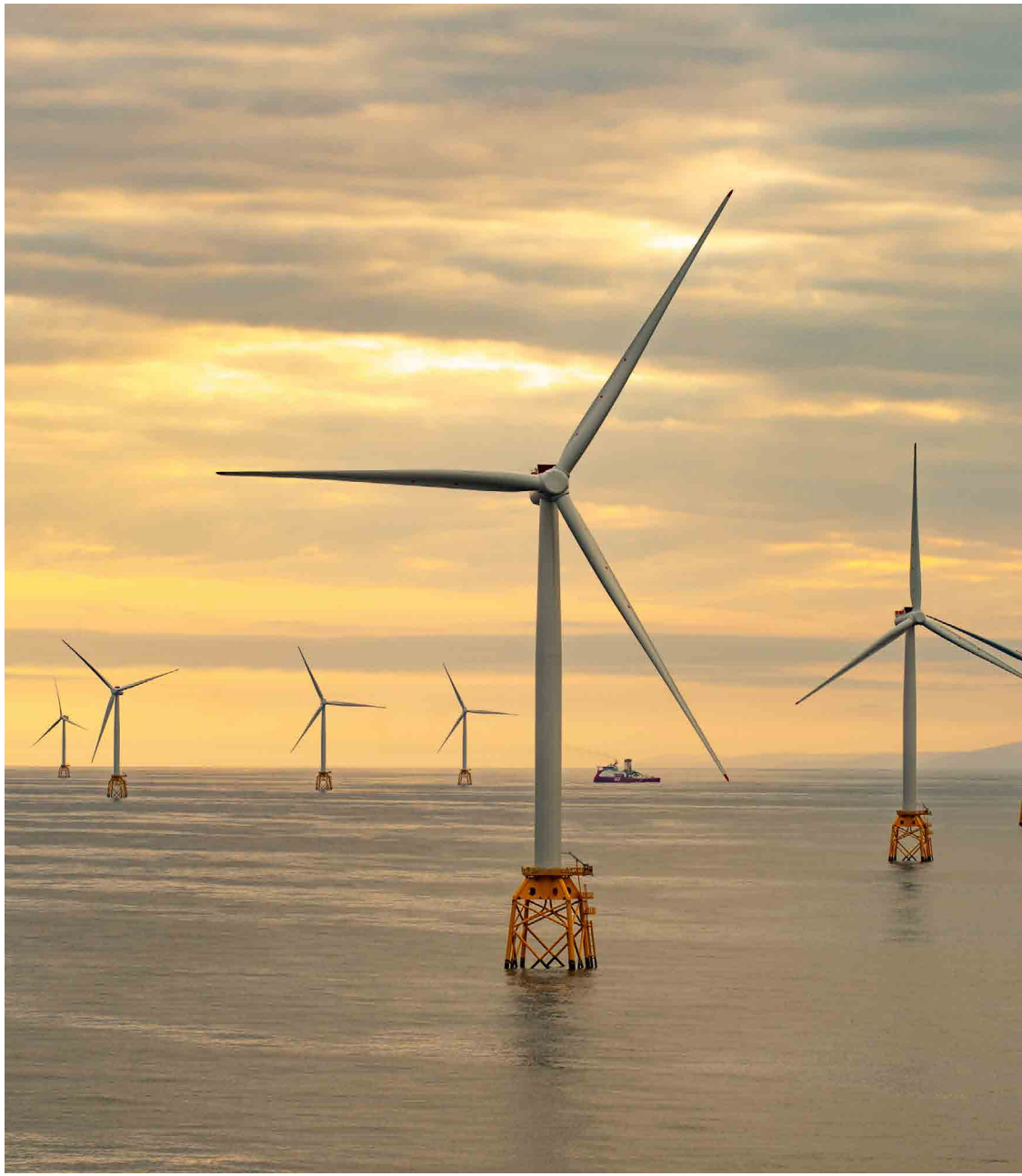
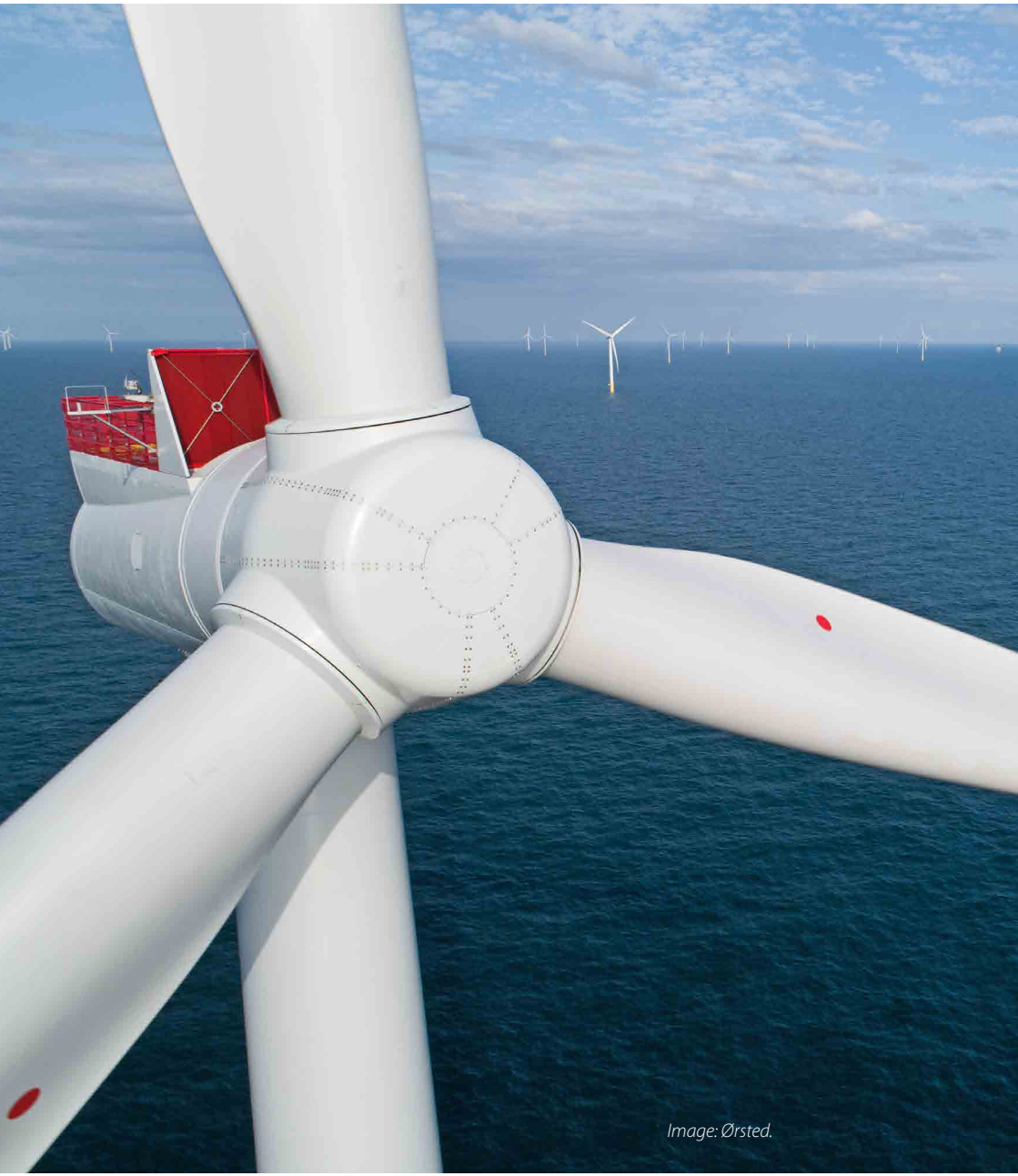


Image: Beatrice Offshore Windfarm Ltd



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