RE ENERGISE
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CATAPULT
Offshore Renewable Energy

THE ROBOTICS REVOLUTION

ROBOTIC SOLUTIONS: THE REVOLUTION REQUIRED FOR NET ZERO AND BEYOND

THE ECONOMIC OPPORTUNITY FOR ROBOTICS IN OFFSHORE WIND

THE BIG DATA OPPORTUNITY

FOREWORD

Nikos Pronios, Innovation Lead - Robotics & Autonomous Systems/Artificial Intelligence at Innovate UK

Are robots now commonplace in our society? Maybe not quite yet, but they are certainly much more prevalent in our day to day lives. From driverless cars to robot vacuum cleaners, autonomous supermarkets to drone deliveries, robotic systems are replacing many of the everyday tasks we describe as the 6Ds – dirty, dull, dangerous, distributed, difficult, and dear (expensive).

In offshore renewable energy, robotics and autonomous systems are now becoming part of the everyday operations and maintenance of our offshore power stations and are vital to the growth of the sector, ensuring its rapid scale-up is cost effective and safe. The use of aerial, surface and underwater uncrewed vehicles, either remotely-operated or autonomous, is quickly becoming the go-to method for inspection across the wind industry. Remotely operated vehicles are providing high-quality survey data and autonomous underwater vehicles, already in use in the oil and gas sector, are being tested commercially around offshore wind installations.

Last year we saw the development of MIMRee (Multi-platform Inspection, Maintenance & Repair in Extreme Environments), one of the world's first fully autonomous multi-robot system for the inspection and repair of offshore wind turbines. This solution combined an uncrewed surface vehicle, uncrewed aerial vehicle, and crawling spider robot with sensors and end-effectors to detect and repair blade defects.

ORE Catapult, through its unique testing facilities and partnerships with organisations such as the Net Zero Technology Centre (NZTC), ORCA Hub and Innovate UK, is at the forefront of this robotics revolution in offshore renewables. In this edition of ReEnergise, we look at the game-changing innovations and ecosystems catalysing change to improve the industry's productivity and enabling UK companies to capture the value from these developments to the benefit of our economy.

CONTENTS

ROBOTIC SOLUTIONS: THE REVOLUTION REQUIRED FOR NET ZERO AND BEYOND

Our clean energy revolution is in full swing, with the UK actively moving from fossil fuels to renewable energy sources such as offshore wind. If the UK is to meet its Net Zero targets by 2050, our offshore wind capacity needs to expand more than seven times over. This future scale-up of operations, pushing into ever deeper waters, will need the help of robotics and autonomous systems (RAS) for everything from design to maintenance and repair.

Accelerating and investing in the development of advanced RAS should help to alleviate the risk of erecting thousands of wind turbines on the UK's coasts without the operations and maintenance technology to ensure that not only routine maintenance, but also pre-emptive maintenance tasks can be carried out safely to ensure these wind farms can perform at full capacity. This will extend the life of components and turbines at sea, supporting the industry's waste reduction drive.

Investment in robotic solutions provides the UK with an unparalleled opportunity to leverage our competitive advantage in developing offshore wind with our world-leading robotics and autonomous systems sector to develop solutions for a global market.

What is unique about the robotics market is the potential for the cross-application of technologies. It is likely that the solutions created for offshore wind which will maximise performance, increase efficiency and improve safety will be adapted to work across multiple other sectors. As we continue to work towards achieving Net Zero, it is clear that robotics will play a key role. The opportunity this presents for the UK is significant – across the supply chain we can create jobs, upskill our energy workforce, build export potential and add value to our economy.

But the work doesn't stop when we achieve Net Zero. The commercial roll-out of RAS in offshore wind can drive upskilling and job creation across the UK, long after the 2050 deadline. In the shorter term, robotics can support the skills agenda, particularly bridging the gap in skills resulting from rapid industry growth by allowing optimisation of work that humans currently do. It also leverages a diversity of skills into the industry, using robotics and automation skills from across sectors in the UK to support the shortage in the wind sector.

At ORE Catapult, we support many robotic technologies that have already shown great promise for the offshore wind sector, including robots that can crawl turbine blades to conduct repair and maintenance, robots that can perform subsea cleaning and inspection tasks, and uncrewed vessels that provide a power and communication hub for remotely-operated and autonomous underwater vehicles.

These are just some examples of the cutting-edge robotics research and development in offshore wind that is already taking place, right here in the UK. We are building a reputation as a pioneer and expert in this field, which opens up a multi-billion pound domestic and export market over the coming decades.

Robotics technologies will not only help us on our journey to achieve Net Zero by 2050, but also secure the UK a world-leading position in both RAS and offshore wind sectors for years to come.

ORE CATAPULT'S ROBOTICS AND AUTONOMOUS SYSTEMS ECOSYSTEM

Technology readiness

ORE Catapult provides world-leading test, validation and demonstration facilities for the advancement of robotics technology, as well as data and digital integration. Our primary demonstration sites in Blyth, Grimsby and Levenmouth, in addition to our regional operations around the UK, provide extensive support for technology developers, SMEs and innovators to de-risk and prove performance of early-stage and mature robotic concepts.

Offshore Wind Robotics and Autonomous Systems Centre

The new £3m offshore wind robotics centre in Blyth, funded by the UK Government's Getting Building Fund through the North East Local Enterprise Partnership, will allow robotic technology developers to access assets and expertise in both representative onshore and live offshore demonstration environments across inspection, maintenance and repair for aerial, subsea and surface applications.

Operations and Maintenance Centre of Excellence

The O&M Centre of Excellence (OMCE) in Grimsby is a national hub for enhancing the UK's world leading position in offshore wind operational performance. It acts as a catalyst for innovation, technology, cross-sector collaboration and best practice, with a focus on robotics and autonomous systems, to enhance safety, reduce cost and support the growth of UK O&M.

7MW Levenmouth Demonstration Turbine

The Levenmouth turbine provides a live operating environment to test, validate and demonstrate aerial, surface and subsea robotic technology for remote turbine inspection.

Engineers walk the bridge out to ORE Catapult's Levenmouth Demonstration Turbine

Collaborative Ecosystem Solutions

ORE Catapult plays a central role in building a strong, collaborative ecosystem amongst key stakeholders in the industry and academia to create partnerships and meet current robotic challenges, as well as to anticipate the future needs of robotics in offshore wind. We also work in partnership with OEMs and wind farm operators to develop and manage innovation challenges, enabling these industry leaders to engage with the UK supply chain to discover and develop robotic solutions.

ORCA Hub

ORE Catapult and ORCA Hub are joined in a formal collaboration to use their combined research expertise and unique test facilities to undertake joint research programmes, as well as developing skills by supporting MSc and PhD projects.

GE Renewable Energy 'Stay Ashore!'

This £9 million R&D programme in partnership with GE Renewable Energy aims to improve reliability, drive down operating costs and improve the safety of offshore wind operations, by minimising the time people have to spend offshore. This includes new robotic and digital solutions for operating and maintaining wind turbines remotely.

European Offshore Wind Deployment Centre (EOWDC)

ORE Catapult has a jointly funded collaboration with Vattenfall to give innovators in the offshore wind supply chain the opportunity to test and demonstrate technologies in real-world conditions at Vattenfall's wind farm off the coast of Aberdeen. Several robotics developers are now scheduled to demonstrate at the site over the coming months.

Supply Chain Growth

ORE Catapult leads on programmes and joint initiatives that support the development of a nascent UK industry for robotics, helping the UK supply chain with the business support they need to access and grow in the offshore wind industry.

Launch Academy

The Launch Academy technology accelerator programme is designed to enhance the UK's offshore wind supply chain, enable greater UK content and support cost reduction through innovation. The programme offers legal, marketing, accountancy, IP, HR and investor readiness support as well as modules delivered by ORE Catapult, including technology assessment, supply chain readiness and business case review.

Technology, Innovation and Green Growth for Offshore Renewables (TIGGOR)

TIGGOR is a £3.5m programme designed to boost supply chain growth and productivity in the North of Tyne and wider North East England region's offshore wind and subsea sectors, providing funding, growth and market entry opportunities for businesses.

Fit 4 Offshore Renewables (F4OR)

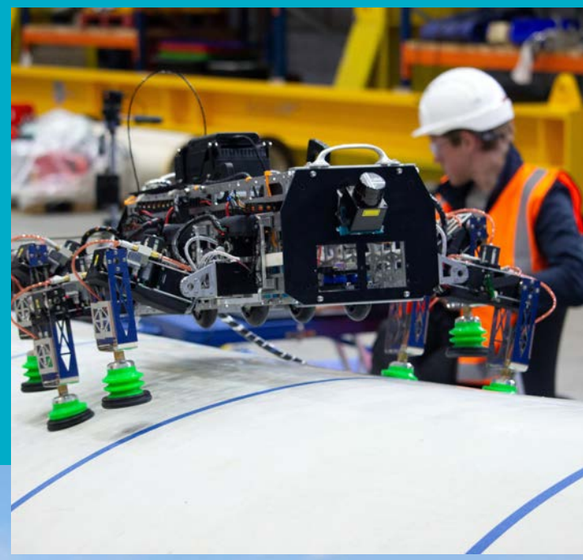
F4OR is a unique service to help the UK supply chain get ready to bid for work in the offshore renewable energy sector. The programme supports the development of an increasingly competent and competitive supply chain – maximising UK opportunity, both domestically and globally.

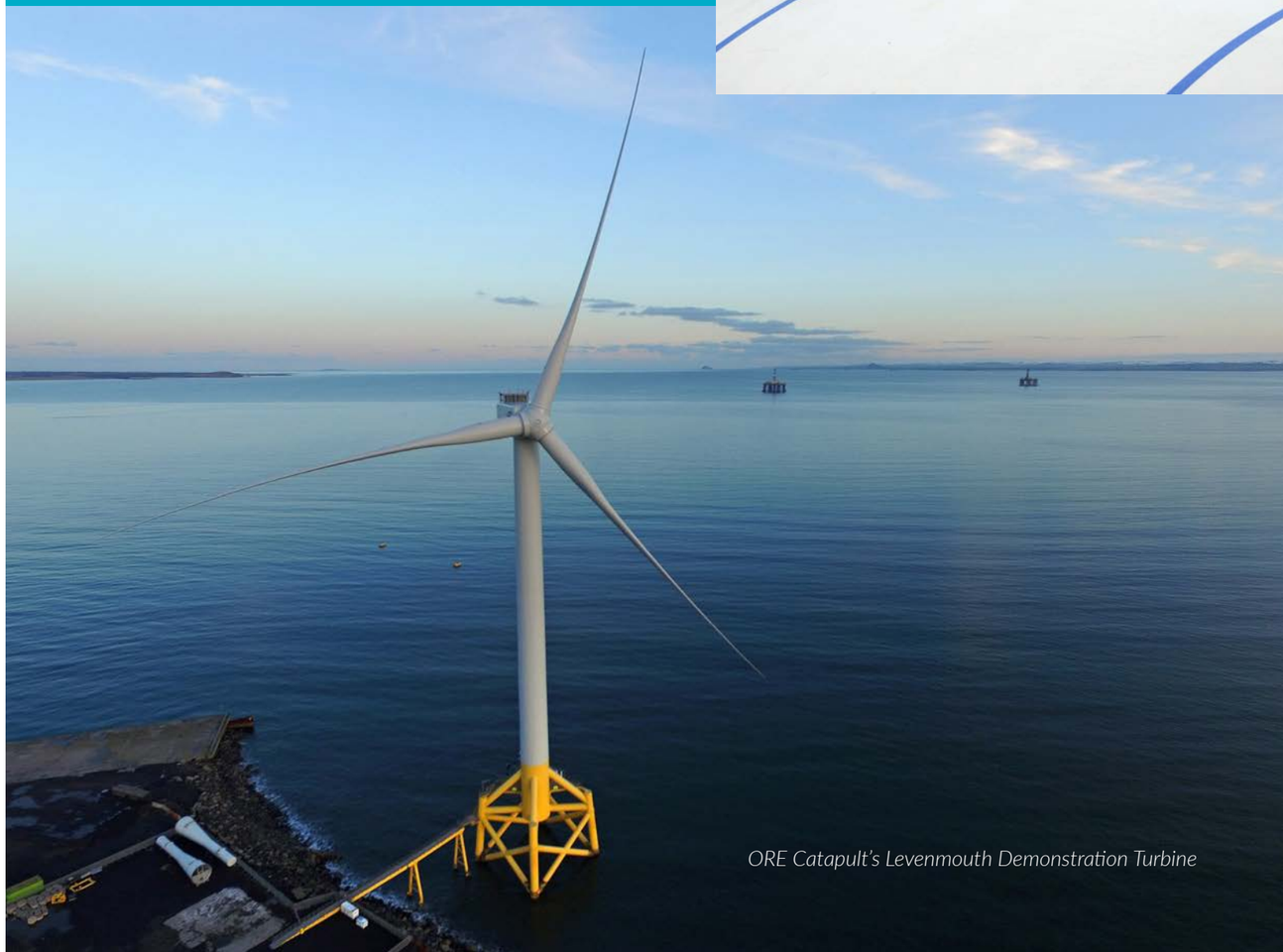
Market Insights

ORE Catapult provides the offshore wind industry with world-leading research, analysis and insights to understand the current landscape and future direction of robotics. This work is providing greater understanding of the economic opportunity and helping to build market confidence by demonstrating the value of robotic solutions.

ORE Catapult's analysis and insights services provide macroeconomic studies, industry reports, cost modelling and market studies to provide our key stakeholders with the vital information they need to support market entry, investment and future business decisions.

Early BladeBUG model testing at ORE Catapult's National Renewable Energy Centre, Blyth





ORE Catapult's Levenmouth Demonstration Turbine

THE ECONOMIC OPPORTUNITY FOR ROBOTICS IN OFFSHORE WIND

Gavin Smart,
Head of Analysis and Insights

With the UK targeting a seven-fold increase in offshore wind capacity by 2050, comes the need for more streamlined and autonomous operations and maintenance (O&M) activity. As wind farms are set to be located in deeper, more remote, often challenging, waters, securing safe access for humans will be a significant industry challenge.

Projected UK Market for Robotic Solutions in the Offshore and Onshore Wind, Oil & Gas and Nuclear Energy Sectors

£350m — **£400m** — **£430m**

2030 — 2040 — 2050

Projected Global Market for Robotic Solutions in the Offshore and Onshore Wind, Oil & Gas and Nuclear Energy Sectors

£7.2bn — **£8.1bn** — **£8.4bn**

2030 — 2040 — 2050

Projected Market Value of Robotics for Offshore Wind in the UK

£55m
2030

£110m
2040

£190m
2050

The potential for robotics is virtually limitless, with applications across the offshore wind value chain, including site survey and consenting, installation, operations and maintenance (O&M), and decommissioning. This presents significant opportunities for technology developers, SMEs and innovators not just to serve the rapidly growing UK market but also to export innovation to offshore wind markets around the world.

In a recent report, *The Economic Opportunity for Robotics in Offshore Wind and Key Energy Markets*, I wanted to explore these market opportunities for robotics within offshore wind and the wider supply chain. The market opportunity is a compelling one: a high growth industry that is set to grow at least seven-fold by mid-century, requiring a transformation in its operations and maintenance as assets push into deeper, more remote and tempestuous waters. Many of the technologies being designed for this sector are adaptations of existing technologies for similar environments in the oil and gas, shipping and nuclear industries.

Offshore wind is our natural starting point for this analysis of the economic opportunity the growing demand for robotics represents, but we also look to onshore wind, nuclear and offshore oil & gas as 'spin-off sectors' that many of the same technologies will also find natural homes in.

We estimate that within the UK market for O&M, robotic solutions in these industries will grow from £350m in 2030 to £400m by 2040 and £430m by 2050. But the market doesn't stop at the English Channel. Globally, we expect a similar growth trajectory, starting at £7.2bn in 2030 to £8.1bn by 2040 and £8.4bn by 2050.

This export potential is significant, with the rest of Europe accounting for roughly 20% of the global market and rest of the world (RoW) accounting for roughly 75% across the forecast period. From a UK perspective, offshore wind and offshore oil & gas are by the far the largest domestic markets in the industries analysed here.

With offshore wind going through a period of unprecedented growth and with operators continually seeking innovative ways to maximise performance and minimise time spent by personnel offshore, innovators can see offshore wind as the ideal route into a growing market with broad application across multiple industries.

We estimate that the UK offshore wind O&M market for RAS will double in size from £55m in 2030 to £110m in 2040, with a further 70% growth to £190m by 2050. While offshore wind is now becoming the catalyst for robotics innovations of its own, many will also have applications well beyond wind.

Offshore wind O&M robotics will be a significant market in its own right but is forecast to be a relatively small share of the overall O&M RAS market, with our analysis suggesting the offshore wind industry will grow from 5% of the market in 2030 to 11% in 2040 and 17% in 2050.

As we continue to work towards achieving Net Zero, it is clear that robotics will play a key part. The opportunity this presents for the UK is significant – across the supply chain we can create jobs, upskill our energy workforce, build export potential and add value to our economy.

FROM CONCEPT TO COMMERCIALISATION:

SUPPORTING INNOVATION THROUGH OUR OFFSHORE WIND ROBOTICS CENTRE

With strong emphasis placed on the role of robotics in the continued growth of offshore wind, we must consider just how we take these technologies through from concept to commercialisation.

With this in mind, ORE Catapult has broken ground at its National Renewable Energy Centre in Blyth on a multimillion-pound offshore wind robotics centre. The £3m centre, funded by the UK Government's Getting Building Fund, through the North East Local Enterprise Partnership, is set to be is set to be the first of its kind in the UK dedicated to offshore wind, enabling robotic technology developers to access representative, onshore and offshore test and demonstration environments.

The robotics centre will include a state-of-the-art control centre from which robotic developers can operate their test and demonstration programmes.

Visualisation of ORE Catapult's National Renewable Energy facility, including a new offshore wind robotics centre.

The facilities will enable subsea, surface and aerial robotics to carry out inspection, maintenance and repair trials on assets such as turbine blades, towers, onshore subsea and simulated seabed environments, as well as deploying technology into the North Sea for live offshore demonstrations.

The centre will form key R&D infrastructure behind the drive to increase robotic intervention in the safety, cost reduction and efficiency of offshore wind farm operations, a market potentially worth £1.3bn by 2030.

The new facility expands our current demonstration offering available to technology developers, including the Levenmouth Demonstration Turbine. Several innovators developing aerial, surface and subsea robotic technologies for remote turbine inspection have benefited from demonstrating their technology in a live operating environment. The new robotics centre takes this one step further allowing developers to truly see how their technology will work when deployed on an offshore wind farm.

Tony Quinn, Test and Validation Director at ORE Catapult, noted: *"This investment underlines the Catapult's commitment to supporting the UK's rapidly growing offshore wind sector from Blyth, remaining at the forefront of technology development and research. This is crucial as projects to deploy the largest offshore wind turbines in the world gather pace, and so accelerating UK-led technology and research to market becomes a priority – and that's a role ORE Catapult will continue to play with its latest research and development assets."*

This investment in the world's most advanced robotics facilities will be crucial to placing the UK in pole position to lead this future market, primarily in offshore wind, but also in multiple other industrial sectors with shared challenges. Our aim is that the construction of the new centre will add to the world-leading infrastructure in our region and encourage more businesses to invest and locate in the North East.

£3M

Investment in New Robotics Facilities at ORE Catapult's Blyth Facility

THE BIG DATA OPPORTUNITY

Offshore renewables projects are relentless producers of big data. While the sector's turbines are generating clean electricity, a complex network of sensors and systems are generating and logging information about the condition and performance of everything involved.

This includes the robotic operations and maintenance solutions soon to become commonplace at offshore wind farms. Remotely operated vehicles are providing high-quality survey data and autonomous underwater vehicles are being tested commercially around offshore wind installations.

All of this data presents huge opportunities to aid complex decision-making for project owner/operators, but one of the industry's key hurdles is a lack of specialist data analytics and artificial intelligence (AI) expertise to exploit it.

However, this is beginning to change. Rapid advances in robotics, autonomous capabilities and artificial intelligence are enabling activities in these harsh environments to be undertaken using unmanned systems.

This is why data engineers and data scientists are working alongside our innovation projects to develop experimental machine-learning approaches, often using our 7MW Levenmouth Demonstration Turbine in Fife as the testbed to see what works and what doesn't. Machine learning is suited to the kinds of big data projects we are increasingly seeing in the wind industry (10,000 samples +). It offers us a way to cut costs and has the advantage of yielding cluster modelling that can be presented in easy-to-understand 2D and 3D models.

Looking further into the future, we need to evolve today's data and digital technologies to fit a much bigger and more radical revolution in how offshore wind farms look and operate. By mid-century, data acquisition will need to stretch across a far wider scale of operations, incorporating everything from supersized turbines to small, community-managed assets that combine with tidal, hybrid wind-wave and floating platforms. Data will run through the robotics that will operate tomorrow's turbines and the autonomous vessels that will deliver cargo and components, feeding into mission planning software.

There is an exciting engineering journey ahead for offshore wind's next 30 years and data analysis will be at the heart of it. Rather than bolting on these technologies, offshore wind farms and their components will be designed around them.

HOW ‘FUTURISTIC’ ARE THESE ROBOTIC SOLUTIONS?

Robotic applications are expected to revolutionise the way that operations are currently done, by automating processes, putting robots in the hazardous environments and moving humans to safer supervisory roles, and improving the way offshore wind farms produce clean energy. But in what capacity are we likely to see these robotic solutions on our wind farms over the next few years and how long before these ‘futuristic’ innovations are commonplace in offshore wind?

Results from an *Offshore Wind Innovation Hub Report* produced this timeline for the deployment of robots in the offshore wind sector, highlighting that we really are only at the beginning of what is an exciting technology advancement journey for the industry.

2025-2030

Robotic applications will be similar to those currently used today but their capability will be improved iteratively, and inspections will be more frequent.

Aspects of autonomy such as navigation and localisation will increase for individual robotic systems in aerial, surface, and subsea environments.

Operations will start to be monitored live by people onshore at remote operation centres. The quantity of data captured will significantly increase and more machine learning and AI will be used to analyse it. These data will continue to feed digital twins of turbines, as they are today, to support turbine monitoring by people onshore.

As confidence in robots grows, the sector will start to consider how future turbines could be designed to be more robot friendly. However, robots will still be reliant on people, people will still travel offshore for operations and vessels will therefore still be required for logistics and onsite support, including remote control of the platforms, data retrieval and safety.

2030-2040

The next decade is expected to revolutionise the way that operations take place. Much of the innovation being demonstrated today will be realised and new devices and concepts will be demonstrated and tested.

Aerial, turbine and subsea surveys and inspections will be carried out by robots as a matter of default. Robots will start to carry out multiple tasks that include inspection as well as minor maintenance and repair. They will also start to be used for activities in the construction and decommissioning phases, as well as for safety applications.

Autonomy will be more common and experience an increasing level of acceptance. The communication between onshore and offshore sites will have improved to allow more work to be monitored and controlled at onshore remote operation centres.

Turbines that have been designed with robot operations in mind will start to be installed. These turbines will also have embedded sensors for wind farm IoT and full implementation of digital twins for onshore turbine monitoring. This, plus the use of AI, for operational planning support as standard will enable proactive inspection, maintenance, and repair activities.

2040 & beyond

This period is expected to be the beginning of the implementation of full field autonomy. Full resident system solutions for UAS, AUV and turbine crawlers will be permanently based on the wind farms, with docking and charging systems in place to support this capability. Robots will be able to self-diagnose their own faults and in certain cases self-heal and self-certify.

Most turbines will have been designed to accommodate robots rather than people. 'Smart' turbines and robots will work symbiotically, so most O&M operations will be carried out by robots, with many being able to carry out multiple tasks.

People will largely work onshore, only required offshore for major or unusual turbine maintenance and repairs, the collection of damaged or faulty robots for maintenance and repair, or to work alongside robots on installation and decommissioning activities.

NEWS ROUND UP

ETZ Ltd and ORE Catapult to Collaborate on Development of World Leading National Floating Wind Innovation Centre

ORE Catapult CEO Andrew Jamieson, ETZ Chief Executive, Maggie McGinlay, Scottish First Minister Nicola Sturgeon and ETZ Chairman, Sir Ian Wood at the launch of the National Floating Wind Innovation Centre

In partnership with ETZ Ltd, ORE Catapult is set to co-invest and collaborate in a world-leading National Floating Wind Innovation Centre in Aberdeen, dedicated to accelerating the commercialisation of floating offshore wind throughout the UK and supporting the incubation of new products, services and businesses within the sector. The initial focus of the Centre will be digital simulation and modelling, moving to the testing and validation of the key components of floating structures, including moorings and anchors, dynamic cables and electrical systems.

The £9m centre is being developed to ensure that the North East of Scotland and wider UK capitalise on the massive opportunity created by the Scottish seabed leasing round, ScotWind, which will drive the development and demand for floating offshore wind.

Twenty more Scottish Businesses to Get Fit for Offshore Renewables

Twenty businesses based in North East Scotland are ready to reap the rewards from our Fit For Offshore Renewables (F4OR) Programme, funded by the Energy Transition Zone (ETZ) Ltd and delivered in partnership with the Nuclear AMRC and Opergy.

The latest round of the programme received 48 expressions of interest, from which 20 companies were selected. This brings the number of companies in Scotland supported through the Catapult's industry-leading supply chain growth programme to 49, with 12 already achieving F4OR 'Granted Status'.

North East Scotland has a strong heritage of offshore operations from its world-leading role in the global oil and gas sector and is well placed to take advantage of the vast opportunity ahead with offshore wind. As a result, preparing companies to be in the best possible position to bid for work within the sector off the back of ScotWind is a key component of the North East Scotland F4OR programme.

Smart O&M Solution to Revolutionise Wind Turbine Performance Monitoring

Artificial intelligence pioneer, Cognitive, joined forces with RWE and the Catapult to accelerate the commercialisation of their innovative Wind AI technology, bringing about a step-change in wind turbine performance monitoring. Wind AITM is a real-time, hyper-accurate solution and, in an industry first, proved that it can identify performance degradation with a less than 1% error. This quantum leap in real-time accuracy means that Wind AITM can provide a unique opportunity to optimise operations and maintenance practices.

PROJECT ROUND UPS

Amphibian

Amphibian, developed by Cambridge-based Innvotek, is an amphibious robotic platform for maintenance and cleaning of subsea structures and vessels. It combines a unique set of mechanical and digital capabilities, with the ultimate aim for teams of Amphibians to work together in the offshore wind, shipping and oil & gas sectors. The platform is now commercialising after being fully tested and validated at ORE Catapult's National Renewable Energy Centre.

BladeBUG

ORE Catapult has supported London-based BladeBUG with testing, demonstration and business support to develop its novel robotic crawler for blade and other wind turbine inspection tasks. ORE Catapult has helped BladeBUG secure Innovate UK grants, providing engineering expertise and access to test facilities to validate the technology. BladeBUG has just concluded a project with another SME supported by ORE Catapult and Innovate UK - EchoBolt. By combining the two technologies, they have adapted BladeBUG to inspect bolts for loss of tension on turbine structures too.

Honuworx

Honuworx is developing a subsea robotic system, known as Ridley, a submersible deployment and operations platform for large subsea robots that delivers a cost effective and more environmentally friendly alternative to large vessel-based subsea systems. Ridley will open the door to a more ambitious Honuworx concept - Loggerhead, which will utilise an uncrewed submersible robotic vessel as a mobile power and communications hub for ROVs and AUVs.

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