

# CIRCUIT

**CATAPULT**  
Offshore Renewable Energy

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## SEA CHANGE

### THE WAVE AND TIDAL EDITION

#### FEATURES

// **Preparing for the "triple test"**

Building confidence in wave and tidal energy

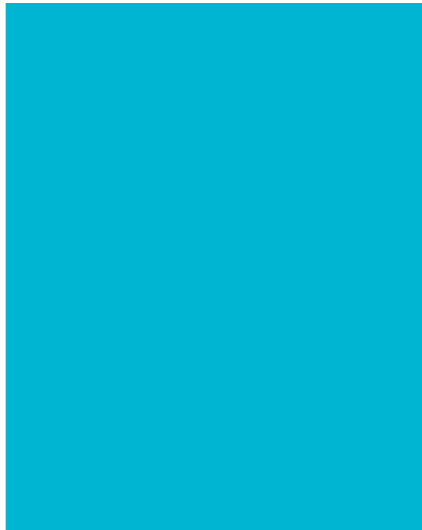
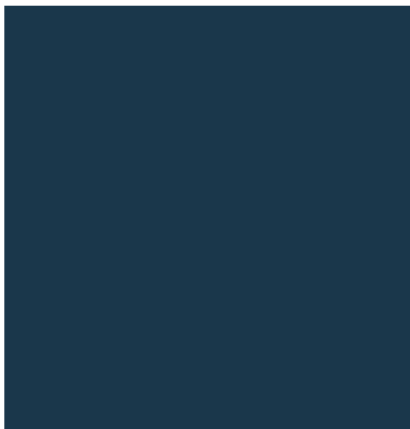
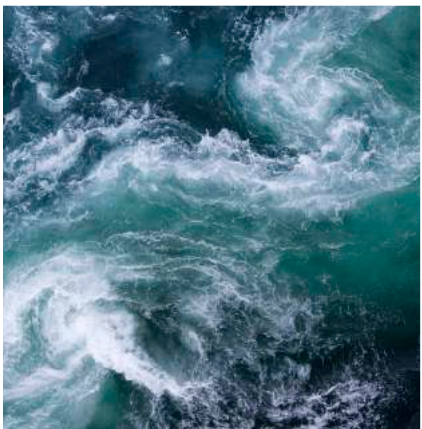
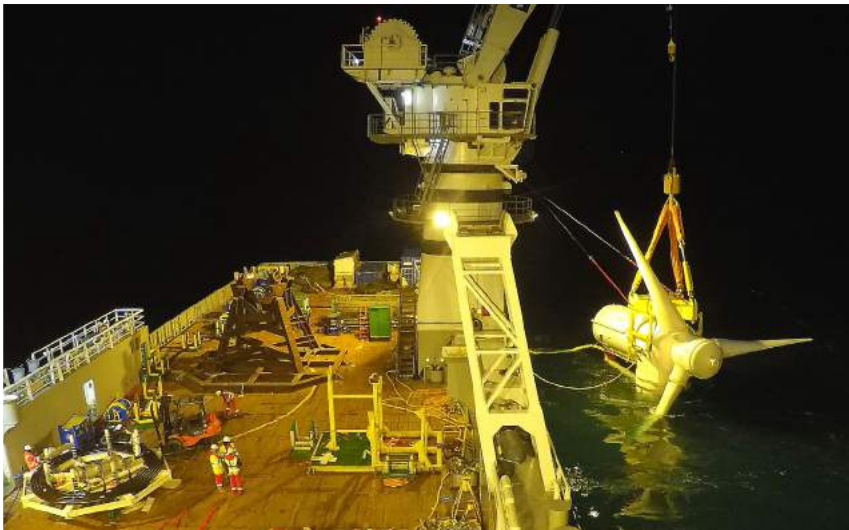
// **Marine energy project round-up**

Research & Development activities

// **Critical cross-cutting innovation**

Robotics and AI in offshore renewable energy





# SEA OF OPPORTUNITY

With a global marine energy market worth £76 billion, the potential for clean economic growth through wave and tidal technology research and commercialisation is enormous – making it one of the Catapult’s main focus areas.

## WELCOME

Guest forward by Alan Moore OBE,  
ORE Catapult Non-Executive Director



Alan Moore OBE

Anyone who spends time on the water knows what an unforgiving environment the ocean can be, but our wave and tidal pioneers could be forgiven for feeling that today the challenges they face onshore are even greater. A lack of dedicated revenue support means there is limited market to aim for and the high costs of constructing one-off prototypes are difficult to swallow for both public and private investors.

But against this back drop the industry is making headway. There have been major achievements in tidal energy, with beacon carriers such as Atlantis Resources and Nova Innovation taking strides in the development of arrays, with tidal power feeding into the

grid and huge advancements in the understanding of how to maximise reliable energy capture from this almost limitless and dependable resource. Wave energy remains less mature than tidal but we have seen promising developments in the key components needed for successful wave devices, led by Wave Energy Scotland. The challenge will be to successfully draw these component parts together into a device system – it would be great to achieve that milestone before the end of this decade.

The wave and tidal industry players have needed to be innovative and resourceful to secure finance through what has been a challenging period. The Catapult

and Renewable UK evidence-based assessment of how marine renewables meet the UK Government’s tests for cost reduction, UK competitive advantage and reduction in CO2 should help to build the case for a more positive policy framework for wave and tidal going forward.

As a veteran of the renewables industry, I remain confident that both wave and tidal energy have strong potential to deliver clean and predictable power and make a significant contribution to the UK economy, particularly in more remote coastal areas that have the greatest economic and social need.

## CONTENTS



PAGE 4

- 4 Preparing for the “triple test”**  
Building confidence in wave and tidal energy
- 6 Enabling future arrays in tidal**  
Flagship EU project driving tidal development
- 9 Marine energy project round-up**  
Research & Development activities



PAGE 10

- 10 Critical Cross-Cutting Innovation**  
Robotics and AI in offshore renewable energy
- 12 Project snapshots**  
Latest collaborative research projects
- 14 News round-up**  
Latest news and developments



PAGE 6



# PREPARING FOR THE “TRIPLE TEST”: BUILDING CONFIDENCE IN WAVE AND TIDAL ENERGY

The wave and tidal energy sectors are approaching an important juncture. Speaking at the launch of the UK Government’s Clean Growth Strategy in October 2017, Climate Change and Industry Minister Claire Perry announced the introduction of a new “triple test” to help determine financial support for emerging technologies.

Reinforcing the ultimate need for low carbon energy sources to be affordable, the Minister outlined three key requirements: that technologies deliver maximum carbon emission reduction, have a clear cost reduction pathway, and offer the opportunity for the UK to develop world-leading solutions in a sizeable global market.

“We are determined to create the best possible ecosystem for the private sector to invest and innovate,” said the Minister. As witnessed in the offshore wind industry, where costs have plummeted 50% in just two years, getting it right can have remarkable benefits.

Analysts and experts from across the Government and private industry are in agreement that the UK’s wave and tidal sectors have huge potential. But the next major hurdle is attracting the much-needed revenue support that will enable a clear pipeline for wave and tidal devices to scale up into commercial-scale arrays.

To examine how wave and tidal technologies can meet the new triple test criteria, RenewableUK and

the Catapult have launched a major initiative to produce an evidence-based objective report which will be submitted to the Department for Business, Energy and Industrial Strategy, as well as the Scottish and Welsh Governments. With input from an industry steering group, it is hoped that the study will pave the way for greater government support for wave and tidal technologies.

Miriam Noonan, a Financial Analyst at the Catapult, is one of the study’s authors. “We really wanted to engage individuals and organisations across the whole industry, so we distributed a quantitative and qualitative questionnaire to developers, supply chain participants and financial institutions to build up perhaps the most complete and wide-ranging view of the industry that has been undertaken,” says Noonan. “We looked for qualitative responses from wave and tidal technology developers, supply chain companies, and other key stakeholders.

“The cost reduction element of the study focuses on tidal. We looked for cost data from a cross-section of tidal technology developers and a limited sample for wave developers.



image above ▲

The power of our marine energy resources



Miriam Noonan

“The qualitative questionnaire is looking to understand what progress has been made so far, and how we can identify a pathway for the industries going forward. We’ve identified the key cost reductions made to date to provide some comfort in the credibility of many of the near-term cost reductions that have been proposed. We also sought input from technology and project developers on the UK supply chain’s particular strengths and weaknesses. And we asked supply chain companies their plans and ambitions around wave and tidal, and how they see the UK continuing as a global leader in the market.

“It all feeds into a cost reduction trajectory that incorporates the effects of economies of scale and learning by doing, as well as a number of specific cost reduction innovations. From these findings, we’ve estimated the reduction in the levelised cost of energy (LCoE) as a result.”

The launch of the study, at RenewableUK’s Wave & Tidal 2018 Exhibition & Conference on 28th February, is sure to be one of the conference’s major talking points. “The hopeful outcome is that it’ll give

a joined-up view of the industry with a message that all of the major players can get behind,” says Noonan. “With revenue support, the UK’s wave and tidal sectors will provide a positive economic contribution and new job opportunities across the UK, as well as helping the Government meet its clean growth targets.”





# FLAGSHIP EU PROJECT SET TO TRANSFORM THE TIDAL ENERGY SECTOR

The UK's tidal power industry is going from strength to strength, with Scotland leading the way. The Pentland Firth is home to MeyGen, the world's largest tidal array, and Orkney's European Marine Energy Centre is a global leader for the testing and demonstration of marine renewables. Not to mention the Catapult's own wave and tidal energy research, testing, engineering and commercialisation support services.



◀ image left  
Bluemull Sound Shetland

Scotland is also home to leading Edinburgh-based tidal energy developer Nova Innovation, an ORE Catapult 'Game Changer' and leader of a project partnership of nine European countries in the €20.2 million EU flagship tidal energy project Enabling Future Arrays in Tidal (EnFAIT).

With tidal energy a significant potential source of sustainable, predictable, low-cost energy, and a global ocean energy market worth £76 billion, it's estimated that marine energy could contribute billions to the UK economy by 2050, offering strong business growth and job creation opportunities.

The main objective of the EnFAIT project, which commenced in July 2017 and will run until June 2022, is to transform tidal energy production to realise the enormous opportunities on offer, building investor confidence and creating a commercial, bankable sector. It is focused on scaling up Nova Innovation's existing operational Shetland tidal turbine array of three 100kW devices in the Bluemull Sound. Ultimately, the project will

demonstrate the development, operation and decommissioning of six turbines over a five-year period to prove a cost reduction pathway for the sector, making tidal energy cost competitive with other forms of renewable energy.

What is truly unique about this project is that, for the first time, turbines in the array will be repositioned to explore the effects of array configuration on efficiency and on reducing the cost of energy, with computer modelling software used to determine the most efficient and effective layout.

Simon Forrest, Nova Innovation's Chief Executive, said: "This project will prove that the reliability and availability of tidal energy arrays can be increased significantly and that we can reduce the cost of tidal energy by at least 40%."

Nova Innovation was hailed one of our offshore renewable energy 'Game Changers' because of their revolutionary approach to transforming our understanding of tidal arrays in real-world conditions. >>





image above   
A tidal turbine. Credit: Nova Innovation Ltd

» They developed the world's first grid-connected offshore tidal array in Bluemull Sound, a project delivered with 80% Scottish supply chain content.

Vicky Coy, project manager at ORE Catapult, said: "Nova Innovation's success can be put down to its game changing approach to development – trying to understand how tidal turbines work not just in isolation, but when deployed in arrays. By starting small and testing incremental changes the company is, for the first time, developing a true understanding of how an array works, which is absolutely key to the commercialisation of this technology.

"We are working in partnership with the Nova Innovation team to provide evidence that this new approach to tidal array development could reduce the cost of producing electricity from tidal farms, giving investors around the world confidence in tidal energy."

**To find out more visit the EnFAIT project website [www.enfait.eu](http://www.enfait.eu)**



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 745862

#### The EnFAIT project objectives are to:

- // Deliver a step change in the lifetime cost of energy for tidal power
- // Prove that high array reliability and availability can be achieved with best practice maintenance regimes
- // Capture and disseminate substantial learning
- // Build investor confidence
- // Take a significant step towards creating a commercial, bankable tidal energy sector

# MARINE ENERGY PROJECT ROUNDUP

**With a global marine energy market worth £76 billion, the potential for clean economic growth through wave and tidal technology research and commercialisation is enormous – making it one of the Catapult's main focus areas.**

Our core Research and Development portfolio contains a number of projects that aim to accelerate the sector towards commercial take-off.

The flagship €20.2m **Enabling Future Arrays in Tidal (EnFAIT)** project is creating what will be the world's largest tidal array of six turbines at Nova Innovation's Bluemull Sound site in the Shetland Islands. The Catapult's role involves working on hydrodynamic modelling, focusing on array optimisation, and the communication and dissemination of the project's successes. The project aims to cut the cost of tidal energy by 40% – a target that, if achieved, will pave the way for rapid growth in the sector.

**RECODE**, in collaboration with a handful of European industry partners, is developing, demonstrating and validating a common set of four critical components for ocean energy devices and arrays. By rolling these common components out to marine energy technology developers, the considerable time and cost of developing bespoke parts is saved, allowing resources to be channelled into generation technologies.

**MaRINET II**, meanwhile, follows on from the successful first phase of the Marine Renewables Infrastructure Network, providing promising European ocean energy technology developers with subsidised access to the Catapult's world-leading test and demonstration facilities.

Following on from Reliability in a Sea of Risk 1, **RiaSoR II** is building on established testing practices from the automotive industry and applying them to field tests for wave energy converters, which must produce affordable energy in one of the most challenging natural environments on earth.

**MONITOR** is investigating the forces acting on the blades and structures of tidal energy converters and their impact on reliability, using laboratory simulations and testing at sea. By designing a monitoring system for the project devices, it aims to de-risk tidal energy converter development, improving capacity factors and reducing capital and operational costs, in turn fostering the growth of the sector.

The Catapult also maintains two online resources that facilitate knowledge sharing between researchers around the world. **The Wave and Tidal Knowledge Network** is a database of marine information from over 30 organisations in the UK and overseas, making it faster, cheaper and easier for organisations to learn more from each other. [www.waveandtidalknowledgenetwork.com](http://www.waveandtidalknowledgenetwork.com)

And the **Marine Energy Supply Chain Gateway** is the UK's database of organisations providing marine services and support. It opens up a sea of opportunity: creating new business partnerships, adding value to the supply chain, and ultimately boosting the UK's marine energy industry. [www.mescg.co.uk](http://www.mescg.co.uk)



# CRITICAL CROSS-CUTTING INNOVATION: WHAT PROJECTS CAN BENEFIT THE WAVE AND TIDAL SECTORS?

During RenewableUK's 14th annual Wave & Tidal Conference and Exhibition, ORE Catapult's Sector Lead for Wave & Tidal Energy, Simon Cheeseman, will present on the importance of Robotics and Artificial Intelligence (RAI) in offshore renewable energy. Here, he gives us a sneak preview of his presentation.



Simon Cheeseman

In response to the UK Government's Industrial Challenge, which recognised the importance of Robotics and Artificial Intelligence (RAI) and the need to develop UK-specific skills and related technology, I've been focusing on projects that demonstrate how RAI can support offshore renewables Operations and Maintenance activities and increasing performance, reducing cost and reducing the need for manned offshore operations.

Offshore renewables, like many other sectors, is looking at how RAI can help address the '6 Ds' - things that are dull, dangerous, dirty, distributed, dear (expensive) and distant.

Other sectors, such as aerospace and car manufacturing, are already using automation and robotics, and I believe that the offshore renewable energy industry is behind the curve. We have installed technology offshore that isn't built for robotic maintenance, either at surface level or subsea, and therein lies our challenge: to innovate and uncover technology that improves the current operation of offshore turbines and devices.

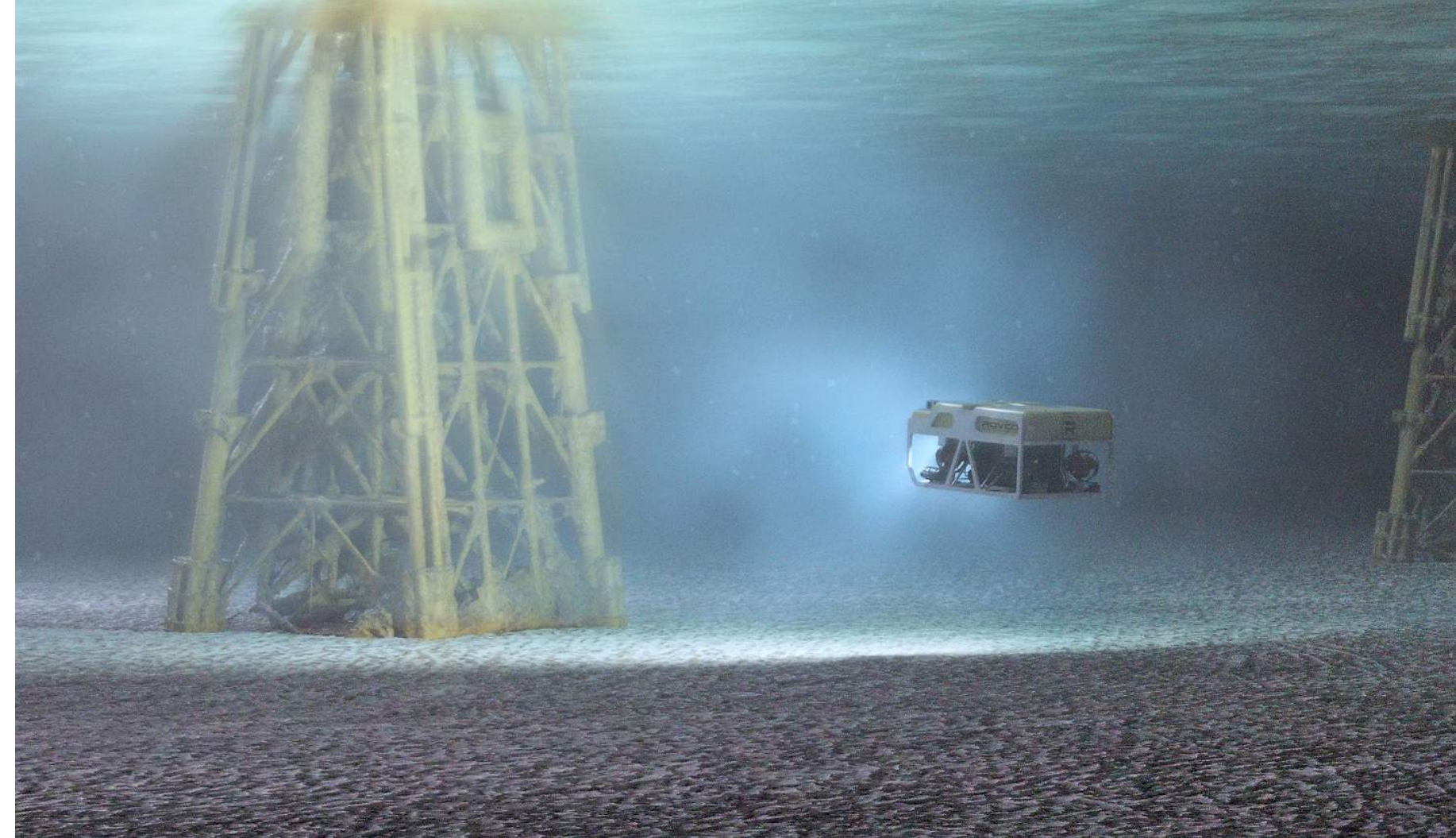


image above  
ROVCO's 3D underwater survey system. Credit: ROVCO Ltd.

ORE Catapult has a range of projects looking at specific themes where autonomous systems could make a major contribution. A good example is subsea surveillance, such as the monitoring of foundations, seabed cables and corrosion. Traditionally, a Remotely-Operated Vehicle (ROV) with a camera, tethered to a mother vessel, would carry out this kind of operation, which is often restricted by bad weather and poor sea states. However, if you can move to an autonomous underwater vessel that has a much wider operational window, can relay data to shore – only alerting technicians when there is something that warrants further human analysis (e.g. potential damage) – then there are huge cost savings and risk reduction associated with that transition to RAI.

For example, our project with survey company ROVCO aims to prototype and demonstrate the feasibility of a high-quality underwater stereo camera system with embedded computing to enable real-time, in-camera processing of underwater 3D images from an ROV video survey. We are due to start the test and demonstration of this technology at our marine test facility in Blyth later this year.

For offshore operations, the industry uses manned vessels to transfer spare parts and equipment offshore. However, our Windfarm Autonomous Ship Project (WASP) has been established to demonstrate the optimum means for integrating autonomous surface vessels with manned operations offshore. We will look at robotic cargo

capability, offshore parts supply, security and asset surveillance.

Parts supply alone, using autonomous vessels with robotic cargo capability, could enhance operational performance, reducing operational costs by up to 2.8% and reducing turbine downtime by around 13% due to more reliable and efficient operations – wider operating windows, greater mission flexibility and saving on crew costs.

Of course, what we are facing is an offshore logistical system that is set up for manned vessel operation, but if you want to integrate autonomous vessels, you need to change your infrastructure to accommodate RAI that works in conjunction with manned vessels. A lot of our work from now on will be looking at working with various key stakeholders and agreeing an outline roadmap and timeline for the phased introduction of autonomous vessels.

Who knows - with the introduction of driverless cars on shore, we could also witness the introduction of unmanned vessels working safely offshore.



# PROJECT SNAPSHOTS



## WASP

The Windfarm Autonomous Ship Project (WASP) project has been established to demonstrate the optimum means for integrating autonomous surface vessels with manned operations offshore. The project will carry out a comparative assessment of autonomous vessel performance and cost characteristics against manned vessel operations, such as robotic cargo capability, offshore parts supply, security, crew transfer, and asset surveillance. ORE Catapult will call together an industrial advisory board, including Ørsted, Lloyds Register and BAE Systems, to review project outcomes and comment on an outline roadmap for the phased introduction of autonomous vessels.



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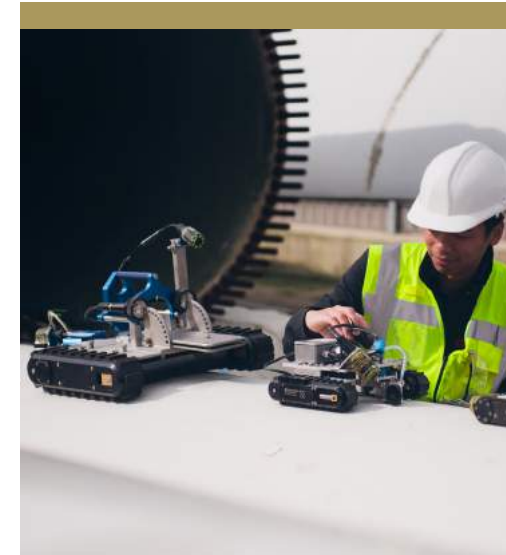
The Leading Edge For Turbines (LEFT) project will develop protective leading-edge infrastructure by means of a metallic protective insert for wind turbine blades to prevent erosion for the full 25 year turbine life, removing the maintenance and repair required on all current polymeric coatings on the market and enabling the next generation of larger wind turbine blades to emerge. Advances in erosion performance will allow the introduction of longer, lighter blades with higher tip speeds, improving power output per turbine. The successful development of the metallic protective insert during manufacture will lead to a significant reduction in operating costs for the offshore wind sector.



## Anemoi

ORE Catapult is currently collaborating with SMD and Magnomatics on InnovateUK-funded research and test validation for innovative ROV technologies. The Anemoi project will involve the development of novel ROV equipment to greatly improve the speed and performance of ROV operations and enable new system architectures in offshore wind farm operations. Our involvement in the project includes significant research into cable failure mechanisms and applied research trials in both our high voltage laboratory and subsea dock test facilities, which are due to begin in early 2018.

## Knowledge | Collaboration | Innovation



## ATAM

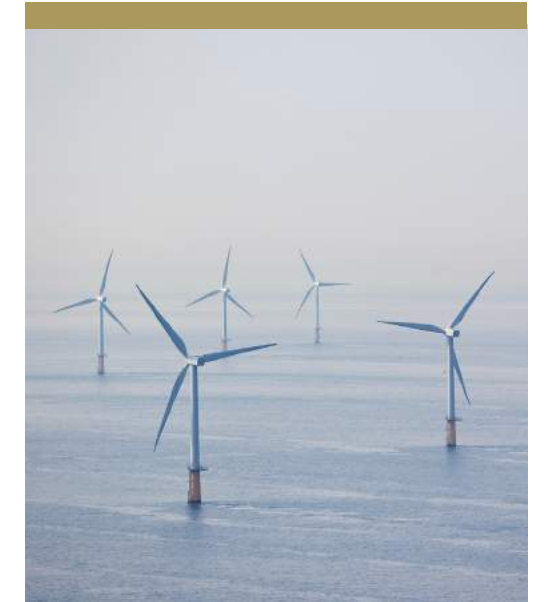
Remotely-operated vehicles (ROVs) like ATAM Group's MaggHD robotic crawler represent a breakthrough in offshore wind ROV technology. The MaggHD uses magnetic technology to grip and climb the turbine's tower, beaming back images of its blades using an in-built high definition camera. The dedicated 27m turbine Training Tower at the Catapult's National Renewable Energy Centre in Blyth provided a perfect platform for ATAM to test MaggHD's effectiveness in conditions similar to those experienced on an offshore wind turbine.

Engineers from the Catapult witnessed the test and supported ATAM with independent advice, making a number of recommendations to helping the Great Yarmouth-based firm develop its proof of concept and de-risk MaggHD as a solution for the offshore wind industry. And in forthcoming tests, the Catapult will help investigate the feasibility of adapting MaggHD to crawl inside turbine blades, an innovation which has the potential to yield enormous benefits in terms of cost and technician safety.



## AUV3D

Advancing Underwater Vision for 3D (AUV3D) is a project involving the prototype and demonstration of a high-quality underwater stereo camera system with embedded computing to enable real-time processing of underwater 3D from an ROV video survey. Whilst live 3D processing is already possible, it is a highly innovative application in an offshore subsea environment. The project is a result of a collaboration between Bristol-based ROVCO Ltd. and ORE Catapult, with funding secured from InnovateUK. The project began in November 2017, with testing in ORE Catapult's subsea docks due to take place later this year.



## TotalControl

TotalControl is a €4.8m European project being led by DTU and including several major EU research partners, focusing on advanced integrated control of large scale wind turbine arrays and individual turbines. Optimising the performance of Wind Power Plants (WPPs) can be done either through the layout (the relative positioning of the individual wind turbines) or by operational control. TotalControl has been established to develop the next generation of operational control tools for WPPs, covering both traditionally bottom-mounted concepts as well as floating turbines. ORE Catapult will be undertaking research in a number of work packages and utilising its 7MW Levenmouth Demonstration Turbine to support the project.



# NEWS ROUND UP



## UK set to seize £220m innovation opportunity from new UK-China offshore wind collaboration

Some of the UK's most innovative small businesses and universities are set to gain access to one of the largest offshore wind markets in the world, following an agreement between ORE Catapult, China's Tus-Wind and TusPark Newcastle to work together to advance offshore wind technology co-operation between the two nations.

The Research and Development Collaboration Agreement was signed at a ceremony at the British Ambassador's residence in Beijing, hosted by the BEIS Secretary of State the Rt Hon Greg Clark MP.

Greg Clark said: "International research collaboration and clean growth are key to our modern Industrial Strategy and this agreement will help to advance co-operation on offshore technologies with one of our largest global trading partners, unlocking further opportunities for projects across the UK and the rest of the world."



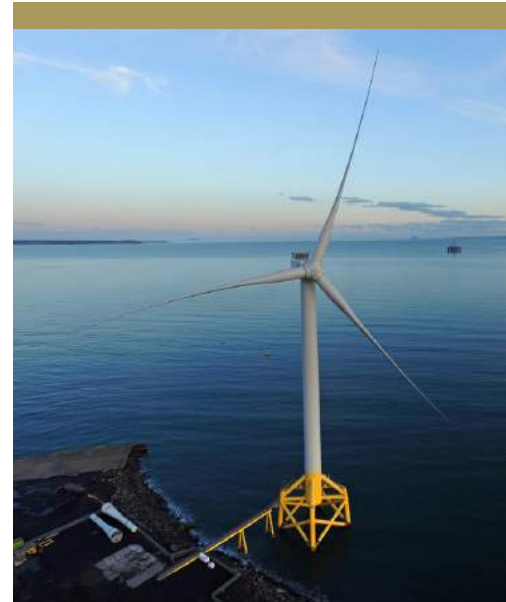
## £280k Lightning Impulse investment to spark cable development

ORE Catapult's world-class High Voltage (HV) Laboratory has been given a £280,000 boost with a significant upgrade to its lightning impulse (LI) test capabilities.

The upgrade, funded by InnovateUK, will support the development of high voltage cable systems and accessories, such as export cables and universal joints, helping to reduce export cable failure rates.

The new Lightning Impulse Generator enables the testing of equipment rated up to 275 kV for offshore renewable applications, as well as transmission and distribution markets. The impulse generator can also be used for superimposed lightning and switching impulse testing that is part of HVDC cable prequalification and type testing requirements.

Alex Neumann, ORE Catapult's HV Asset and Business Development Manager, said: "With export cables from the UK fleet of offshore wind farms experiencing failure rates higher than anticipated, there is great value in improved testing capabilities and equipment to improve cable performance and reduce maintenance and repair times, by providing, for example, third party qualification of universal repair joints. With this investment, we are supporting the very latest cable developments in offshore wind."



## New international collaboration to improve the performance of offshore wind turbine blades

A major, international €4 million research collaboration between 10 European partners is leading the development of seven novel offshore wind turbine blade technologies, which collectively could lower the levelised cost of energy (LCOE) of offshore wind by as much as 4.7%.

The Offshore Demonstration Blade (ODB) project is supporting the research, development and demonstration of wind turbine blade innovations, including aerodynamic and structural enhancements, blade monitoring systems and blade erosion protection solutions. These products will be developed and retrofitted to ORE Catapult's 7MW Levenmouth Demonstration Turbine in Scotland for demonstration purposes. The innovations will then be ready for deployment on existing or new offshore turbines.

Chris Hill, Operational Performance Director at ORE Catapult, said "This project aims to develop a number of innovative technologies that have huge potential to further reduce the cost of offshore wind. Having a dedicated platform on which to demonstrate these technologies, the Levenmouth Demonstration Turbine will improve our understanding of how they operate in real-world conditions and the impact they will have on blade performance, operations and cost of energy."

## Latest news and developments



## Bird backpacks and attack-proof sensors could help transform understanding of avian life

Miniature bird backpacks containing solar-powered GPS systems or tracking tags on tail-feathers could transform our understanding of how wild birds move around offshore wind farms.

The technologies are among the suggestions put forward by four pioneering companies, Pathtrack, Movetech Telemetry, Ornitela and Debug Innovations, responding to an innovation challenge from ORE Catapult, working on behalf of Moray Offshore Windfarm (East) Ltd (Moray East), with the project supported by Beatrice Offshore Wind Ltd, Marine Science Scotland and Highlands and Islands Enterprise.

The aim of the project is to find a more reliable and robust tag for seabirds that can deliver truly accurate data on bird behaviour over the course of 12 months and improve on existing, accepted methods.

Vicky Coy, ORE Catapult project manager, said: "Developing a tag that withstands a bird's natural behaviour is key to developing a greater understanding of their movements. It's more difficult than it sounds, but the solutions suggested are ingenious."

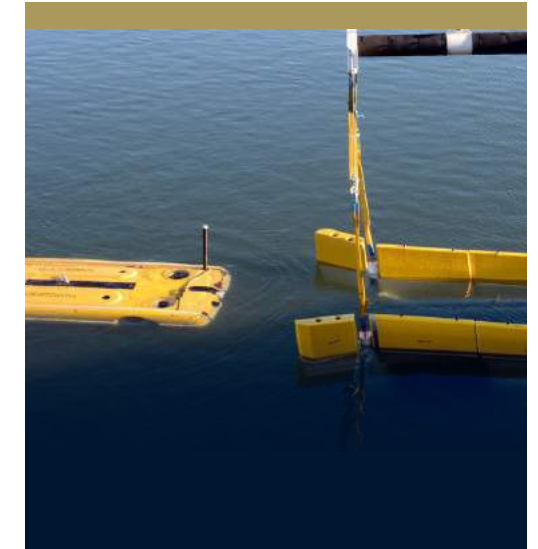


## Catapult seeks UK universities to partner in Electrical Infrastructures Research Hub

ORE Catapult is seeking to partner with UK-based universities to accelerate electrical infrastructure research and development activities relating to offshore renewable technologies. The activities will combine academic and industry skills and resources to better respond to industry's needs.

The technology innovation and research centre is establishing its second Research Hub, this time in Electrical Infrastructures. The new Research Hub will attract a five-year investment of around £700k from ORE Catapult and look to address a selection of key research topics and themes. The aim of the Hub is to build a stronger complementary offering of academic research, innovation, demonstration and representative testing for the offshore renewables sector.

Paul McKeever, ORE Catapult's Head of Strategic Research, said: "We know from our first research Hub launched this year that by pooling existing academic and industry skills and resources, we will be better positioned to respond to current electrical infrastructure challenges, driving forward key research and helping to leverage the vital public and private finance that will underpin the activity."



## World-first autonomous subsea survey and inspection system could save European wind farms £1.1bn

A Darlington-based subsea specialist is developing an innovative approach to enable autonomous underwater vehicles (AUVs) to remain at offshore wind farm sites without a support vessel. The move could shave £1.1 billion from the operating cost of Europe's offshore wind farms and would be a world-first in the sector.

Modus Seabed Intervention, in partnership with Osbit Ltd and ORE Catapult, is trialling an AUV docking station. The design will enable vehicle re-charging, as well as the upload of acquired data and download of mission commands.

"Since 2012, Modus has been focusing on the development of hybrid AUV systems to be deployed for subsea and seabed survey, and inspection," says Managing Director of Modus and project lead Jake Tompkins. "Part of our vision is to see AUVs becoming field resident, offering significant cost savings and quality benefits to the markets and our customers."



## ORE Catapult

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