A New Partnership in Offshore Wind

npow.org.uk

How Did It All Come About?

In 2017 the bid proposal for this innovative, collaborative project was one of eleven that were accepted and supported in the first tranche of UKRI-funded **'Prosperity Partnership'** projects. It was a new type of funding package that was created to bring about impactful collaborations between industry and academia. The scheme has proved to be very successful and further rounds of support have been allocated to new projects in all subsequent years.

Our collaboration brought together two major players in the Offshore Wind (OSW) sector; **Siemens Gamesa Renewable Energ**y (SGRE) and **Ørsted**. It partnered them with three world-leading academic institutions, The **Universities of Sheffield, Durham** and **Hull**, in a **£7.73M**, 5.5-year research programme.

This project is part of a wider collaboration – Project AURA – that includes all the consortium partners as well as the Offshore Renewable Energy Catapult, the Advanced Manufacturing Research Centre, and local government on Humberside, offering support in research and development and in training and mentoring of UK suppliers through to full commercialisation.

OUR VISION was to forge a new partnership that uses leading research insight to reduce the levelised cost of energy by creating the next generation of intelligent OSW technology and for the innovation and breakthroughs that we create to be accelerated into the commercial activities of our industrial partners.

OUR AMBITION was to exemplify the opportunities identified in the Government's Industrial Strategy for bringing together regional institutions and businesses with research excellence and innovation support by aligning our research to the UKRI Prosperity Partnership objectives:

- **Productivity** (innovative technologies to reduce the levelised cost of wind power and drive the UK supply chains)
- **Resilience** (energy security and efficiency) and,
- **Connectedness** (big-data techniques in population-based monitoring).

The Partners

With almost 29,000 of the brightest students from over 140 countries, learning alongside over 1,200 of the best academics from across the globe, the **University of Sheffield** is one of the world's leading universities. A member of the UK's prestigious Russell Group of leading research-led institutions, Sheffield offers world-class teaching and research excellence across a wide range of disciplines.

sheffield.ac.uk

Durham University is distinctive – a residential collegiate university with long traditions and modern values. We seek the highest distinction in research and scholarship and are committed to excellence in all aspects of education and transmission of knowledge. Our research and scholarship affect every continent. Durham is a world top 100 university with a global reputation for excellence in research and education, and we are a respected member of the Russell Group of leading research-intensive universities.

durham.ac.uk

The University of Hull has been changing the world and changing lives since 1927. In a rapidly altering world, our research is responding to some of the biggest global challenges. Our current work ranges from health to habitats, food to flooding and supply chains to slavery. We have appeared twice in Universities UK's list of '100 discoveries by British universities that have changed the world'.

hull.ac.uk

Siemens Gamesa Renewable Energy is the world's #1 provider of wind power products and solutions, with a market share of more than 17% in 2017. The company has installed products and technology across the globe, with a total installed base of close to 85 GW. Siemens Gamesa offers one of the industry's broadest product portfolios, with both offshore and onshore technology as well as industry-leading service solutions, helping to make clean energy more affordable and reliable.

siemensgamesa.com

The **Ørsted** vision is a world that runs entirely on green energy. Ørsted develops, constructs and operates offshore wind farms, bioenergy plants and innovative waste-to-energy solutions and provides smart energy products to its customers. Headquartered in Denmark, Ørsted employs 5,600 people, including over 900 in the UK. Ørsted's shares are listed on Nasdaq Copenhagen (Orsted). In 2017, the group's revenue was DKK 59.5 billion (EUR 8.0 billion).

orsted.co.uk

The Engineering and Physical Sciences Research Council (EPSRC) is the UK's main agency for funding research in engineering and the physical sciences. EPSRC invests around £800M a year in research and postgraduate training, to help the nation handle the next generation of technological change.

ukri.org

CC Jensen are the global leader in oil maintenance with more than 60 years of experience designing and manufacturing oil filtration solutions for the removal of particles, water, acidity and oil degradation products from hydraulic oils, gear oils and diesel fuels. Their filter inserts are made of 100% natural cellulose fibres from sustainable resources: no metal, no plastics, and no chemicals. Research shows that 80% of oil-related failures and breakdowns are caused by contaminated oil so preventive oil maintenance is an important factor to ensure optimum equipment reliability and avoid system breakdown.

cjc.dk

The Collaboration

The opening of SGRE's new £310M offshore wind turbine blade factory in Hull was a milestone for the industry.

It coincided with increased investment in operations and maintenance activities to service the ever-growing capacity of OSW farms, especially by the world's largest OSW developer, Ørsted. One of the barriers to achieving the required cost reduction in the OSW industry has been the presence of disconnects in the delivery chain between the turbine developers and the wind farm operators. But here, for the first time in the UK, SGRE and Ørsted jointly participated in a fundamental research programme to co-create and co-influence their research and development roadmaps. By aligning the project's outputs to those roadmaps, we ensured that the research was specifically targeted towards issues and problems that our industrial partners were facing and that allowed us to maximise the impacts and outputs for everyone's benefit.

The creation of the new collaboration between the Universities of Durham, Hull and Sheffield has accelerated the academic impact of our work and has increased the transfer of leading research capabilities into related fields: equipment design, condition monitoring, structural health monitoring, and blade manufacturing and instrumentation.

In April 2020 we were delighted to welcome **CC Jensen** to the project, to work closely with our teams at Durham University and Ørsted on Work Package 3.

They are global leaders in oil maintenance with more than 60 years of experience designing and manufacturing oil filtration solutions for the removal of particles, water, acidity and oil degradation products from oils and fuels.

"Ørsted have a long-standing strategic partnership with Durham University in offshore renewable energy research. The Prosperity Partnership project allowed us to continue that successful relationship and to foster new collaborations with Siemens Gamesa Renewable Energy, the University of Sheffield and the University of Hull."

Dave Bould, Lead Research and Development Specialist, Ørsted

"SGRE have been working with the two departments at the University of Sheffield for many years; together, they run a Renewable Energy Research Centre in Sheffield and have a strong and successful record of previous collaborations. The focus and scope of this project required additional expertise in other fields, and Ørsted, Durham University and the University of Hull perfectly complemented the knowledge and expertise of the other partners."

Chris Briggs, Siemens Gamesa Renewable Energy

The Research

Development of Novel Modular Generators and Converters

The University of Sheffield and Siemens Gamesa Renewable Energy.

Professor Zi-Qiang Zhu, University of Sheffield, Department of Electronic and Electrical Engineering.

Background: New generations of offshore wind turbine generators are becoming increasingly larger, creating significant difficulties with their manufacture and transportation. In addition, there are a number of ways in which the performance of the generator, the heart of the turbine, can be improved.
Solution: Our research has developed advanced, modular, balanced 3-phase direct-drive permanent magnet wind power generator systems, with particular emphasis on improving manufacturability, transportability, reliability and performance.

Structural Health Monitoring (SHM) of Wind Turbine Blades

The University of Sheffield, Siemens Gamesa Renewable Energy and Ørsted.

Professor Nikolaos Dervilis, University of Sheffield, Department of Mechanical Engineering.

Background: The blades are the most expensive components of a wind turbine, and can be in excess of 100m in length. Current SHM technologies are limited by the fact that monitoring systems are often retro-fitted and make use of sensors already present on the turbine for other purposes.
Solution: Our research responded directly to the industrial drive and academic need to create, for the first time, automatic, online and continuous technologies for damage detection, location, severity assessment and prognosis in offshore wind structures and systems.

Novel Condition Monitoring and Fault Detection Techniques and Technologies

Durham University, Ørsted and CC Jensen.

Professor Simon Hogg, Durham University, Department of Engineering.

Background: The move to far OSW farms in UK waters will result in a step-change in the impact of unplanned maintenance outages on the operational cost of OSW energy. Further improvement in condition monitoring techniques for earlier and more reliable detection, diagnosis and prognosis of emerging faults is critically important in driving down the cost of OSW energy and securing its place in energy systems of the future.
Solution: Our research has improved condition monitoring techniques for earlier and more reliable detection and diagnosis of emerging faults in wind turbine components.

Investigation of Novel Blade Technology and Array Cables

The University of Hull and Siemens Gamesa Renewable Energy.

Professor James Gilbert, University of Hull, School of Engineering.

Background: As wind turbines get larger, the design and manufacture of critical components becomes more difficult. In particular, longer blades need to have more complex structures and more precise manufacture if they are to extract the maximum energy from the wind over their lifetime and survive hostile conditions at sea. Similarly, the lost revenue resulting from cable damage can be very significant and so it is crucial to understand how cables behave on the seabed where they are exposed to natural and man-made hazard.
Solution: Our research has established advanced modelling and design techniques for novel blade structures and embedded sensing systems capable of monitoring manufacturing processes and operational loading of blades. Tools have also been developed to model seabed behaviour and anchor penetration to help understand the risks which subsea cables are subjected to and hence improve planning of installation.

The Outcomes

High energy costs and the growing impact of climate change means that sustainable energy is of critical importance. Offshore wind power is key to helping the UK achieve its CO2 emissions targets, and provide affordable, efficient energy.

Addressing the energy trilemma (issues of cost, security, and sustainability) is a huge challenge and increasing the production of renewable energy is crucial to our future.

The UK needs resilient, green energy sources to achieve those emissions targets and offshore wind will play a very important role. Environmentally friendly, natural energy sources will help us fight climate change and reduce our dependence on polluting energy sources, such as oil, coal, and gas.

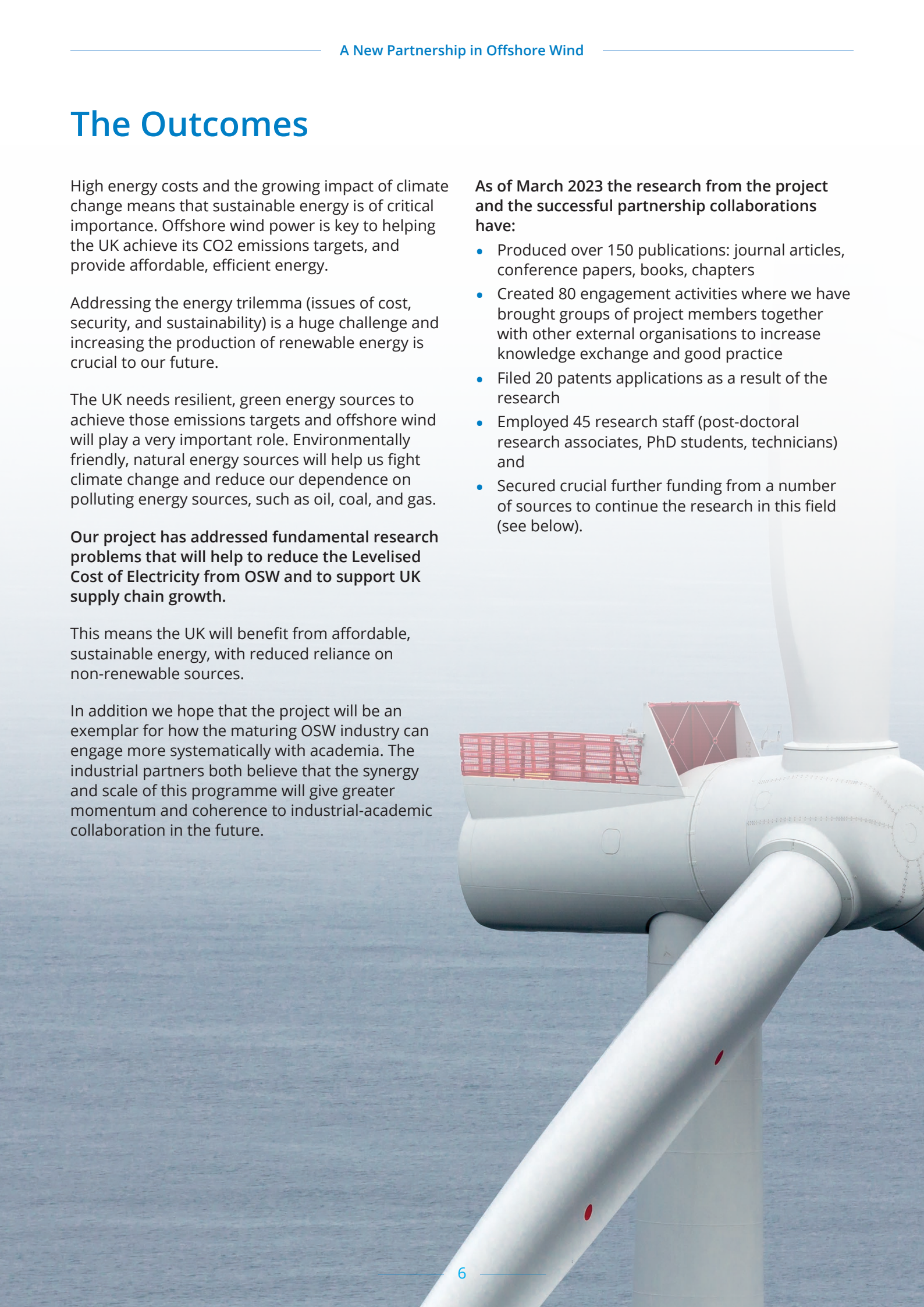
Our project has addressed fundamental research problems that will help to reduce the Levelised Cost of Electricity from OSW and to support UK supply chain growth.

This means the UK will benefit from affordable, sustainable energy, with reduced reliance on non-renewable sources.

In addition we hope that the project will be an exemplar for how the maturing OSW industry can engage more systematically with academia. The industrial partners both believe that the synergy and scale of this programme will give greater momentum and coherence to industrial-academic collaboration in the future.

As of March 2023 the research from the project and the successful partnership collaborations have:

- Produced over 150 publications: journal articles, conference papers, books, chapters
- Created 80 engagement activities where we have brought groups of project members together with other external organisations to increase knowledge exchange and good practice
- Filed 20 patents applications as a result of the research
- Employed 45 research staff (post-doctoral research associates, PhD students, technicians) and
- Secured crucial further funding from a number of sources to continue the research in this field (see below).



What Next?

The research from the project, and the successful collaborations within it, have already led to substantial amounts of additional funding being awarded to develop our ideas and innovations even further. The total value of the awards is in excess of £18M. Here are some of the highlights...

Aura Centre for Doctoral Training (CDT) in Offshore Wind Energy and the Environment; £5.5M funding from the Engineering and Physical Sciences Research Council (EPSRC) and the Natural Environment Research Council (NERC).

The Aura CDT is led by the Energy and Environment Institute at the University of Hull with partner universities Durham, Newcastle and Sheffield. It integrates the core strengths of each institution in environment, engineering and energy and works closely with over 20 international industry partners. It is unique in its cross-disciplinary engagement of engineering and environmental scientists, industry and policy makers. 4-year PhD scholarships provide the opportunity to develop and integrate practical examples in taught courses across the first year with industry-led and challenge-led projects, followed by three years of focused doctoral research. This will develop cutting edge research and solutions to the environmental and engineering challenges facing the offshore wind industry.

Revolutionising Operational Safety and Economy for High-value Infrastructure using Population-based SHM (ROSEHIPS); EPSRC-funded research grant.

This 5-year grant, worth £6,326,800 and led by the Department of Mechanical Engineering at the University of Sheffield, brings together a wide range of partners including: AMEY, Arqiva, Cellnex, COWI, Department for Infrastructure (Northern Ireland), Devon County Council, DYWIDAG Systems International, ETH Zurich, Los Alamos National Laboratory, Polytechnic University of Milan, Sengenia Ltd, Siemens Gamesa, Technical University of Denmark, Translink, University of Leuven, Vattenfall Wind Power Ltd and Xilinx. The project will extend and exploit Population Based Structural Health Monitoring, developing machine learning, sensing and digital twin technology for automated inference of health for structures in operation now, and drive new standards for safer, greener structures in future. The Programme brings together the perfect team, mixing complementary skills in machine learning and advanced data analysis with expertise in new sensor systems and insight into complex infrastructure systems.

Offshore Burial Cable: How Deep Is Deep Enough? follow-on EPSRC-funded project.

Professor Will Coombs from Durham University is the Principal Investigator on an exciting new research project worth a total of £1.4M. The project partners are Cathie Associates Limited, Global Offshore, Lloyd's Register Group, Ørsted, The Crown Estate and Dundee University. £464,312 has been contributed by EPSRC. This project will provide an industry usable anchor penetration model allowing the offshore wind sector to answer the key cable burial question – how deep is deep enough?

Continuation of collaboration between Siemens Gamesa Renewable Energy and the University of Sheffield.

A new research collaboration, worth £900,000, has been signed with research beginning in May 2022. It will allow the partnership between the two organisations to develop even further and will build on the work of the Prosperity Partnership project by investigating further developments for high power density, direct drive, permanent magnet generators. It also offers a continuation of employment for our graduate and post-graduate researchers and provides an excellent opportunity for those staff to develop the right skills to enter the industry and help meet skills shortages.

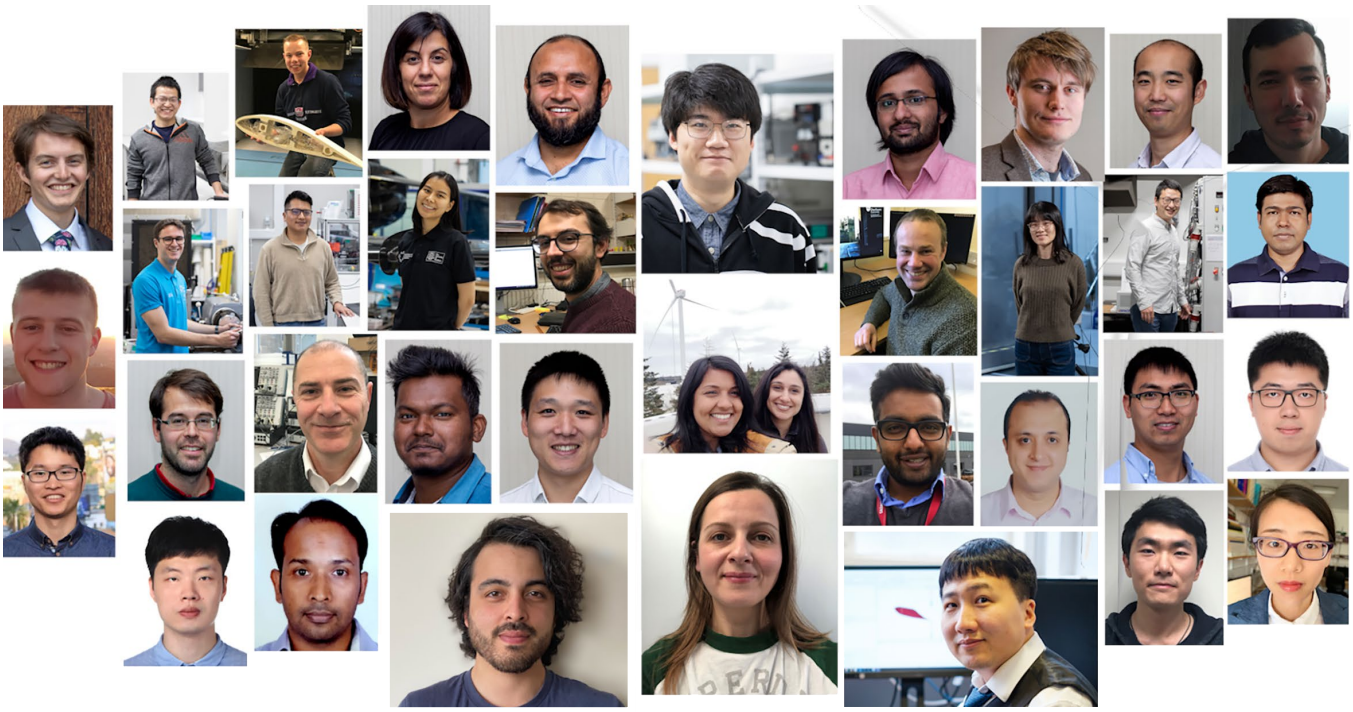
Heterogeneous Fibre Optic Sensor Arrays to Monitor Composite Manufacture (H-FOAM); EPSRC-funded research grant.

The University of Hull has been awarded funding for a £1.25M project on the use of fibre optic sensors to monitor the manufacture of large composite structures. The project is led by Prof James Gilbert of the Department of Engineering and also involves colleagues at the University of Sheffield's Advanced Manufacturing Research Centre (AMRC) with support from Siemens Gamesa Renewable Energy in the UK and Denmark. The work will extend research started as part of the Prosperity Partnership project and will apply the approach to improve the quality of complex composite structures such as wind turbine blades.

But, it is crucial that further continued funding is made available to develop more new innovations that can ensure offshore wind power becomes ever more efficient and affordable and helps us to meet an even greater percentage of our growing energy needs in a carbon-free, sustainable way.

The People

The research has been carried out by a fantastic team of Post-Doctoral Researchers, PhD students and Technical staff from all the participating partners. Together with the academic and industrial supervisors and engineers, the project had people from 20 different nations making critical contributions.



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