

CASE STUDY

Ben Xu
Northumbria
University at
Newcastle
Offshore Renewable
Energy Catapult

The Challenge

This interdisciplinary project addressed key engineering challenges in the offshore renewable energy sector, focusing on the performance, durability and optimisation of critical components. Offshore systems operate in complex environments where mechanical, thermal and electromagnetic forces interact, often leading to accelerated degradation and reduced reliability. A central challenge was understanding how subsea cables behave under these multiphysics conditions, particularly how combined environmental and operational stresses affect long-term performance. In parallel, there was a need to improve the design and reliability of turbine blade leading-edge protection systems, which are exposed to harsh conditions including erosion, impact and temperature variation. A further challenge lay in supporting system-level optimisation through improved composite design and advanced modelling techniques. Across all areas, existing approaches often relied on simplified, single-physics models that failed to capture the complexity of real-world offshore environments. This created gaps in predicting failure mechanisms and limited the ability to optimise designs for durability and performance. The project therefore aimed to develop a more integrated understanding of materials behaviour and structural performance, combining experimental investigation with advanced modelling. By doing so, it sought to generate insights that could improve reliability, inform design decisions and support innovation across offshore renewable systems.

Innovation

Ben Xu, working with Offshore Renewable Energy Catapult, undertook a comprehensive programme combining modelling, experimental work and sector-wide analysis. The collaboration included a horizon scan of recent developments in offshore renewable energy, published in *Materials World*, which contextualised the research within broader industry trends. For subsea cables, the project revisited existing models and extended them through detailed experimental testing and advanced finite element analysis. This enabled a deeper understanding of stress distribution, contact mechanics and the influence of environmental factors such as waves and currents. The modelling work incorporated nonlinear behaviour and multiphysics interactions, moving beyond traditional simplified approaches. In parallel, a mechanical-electrical coupling model was developed to better represent the behaviour of long cable systems under operational conditions. This work supported the establishment of a new sustainable engineering research capability, strengthening the link between fundamental research and applied engineering. For turbine blades, the project applied composite design and finite element modelling to optimise leading-edge protection systems. This included aerodynamic assessment, lightning protection considerations and design optimisation, alongside engagement with the UK supply chain to explore manufacturing and implementation challenges. Overall, the innovation lay in integrating advanced modelling techniques with practical engineering considerations, enabling more realistic and scalable solutions for offshore renewable infrastructure.

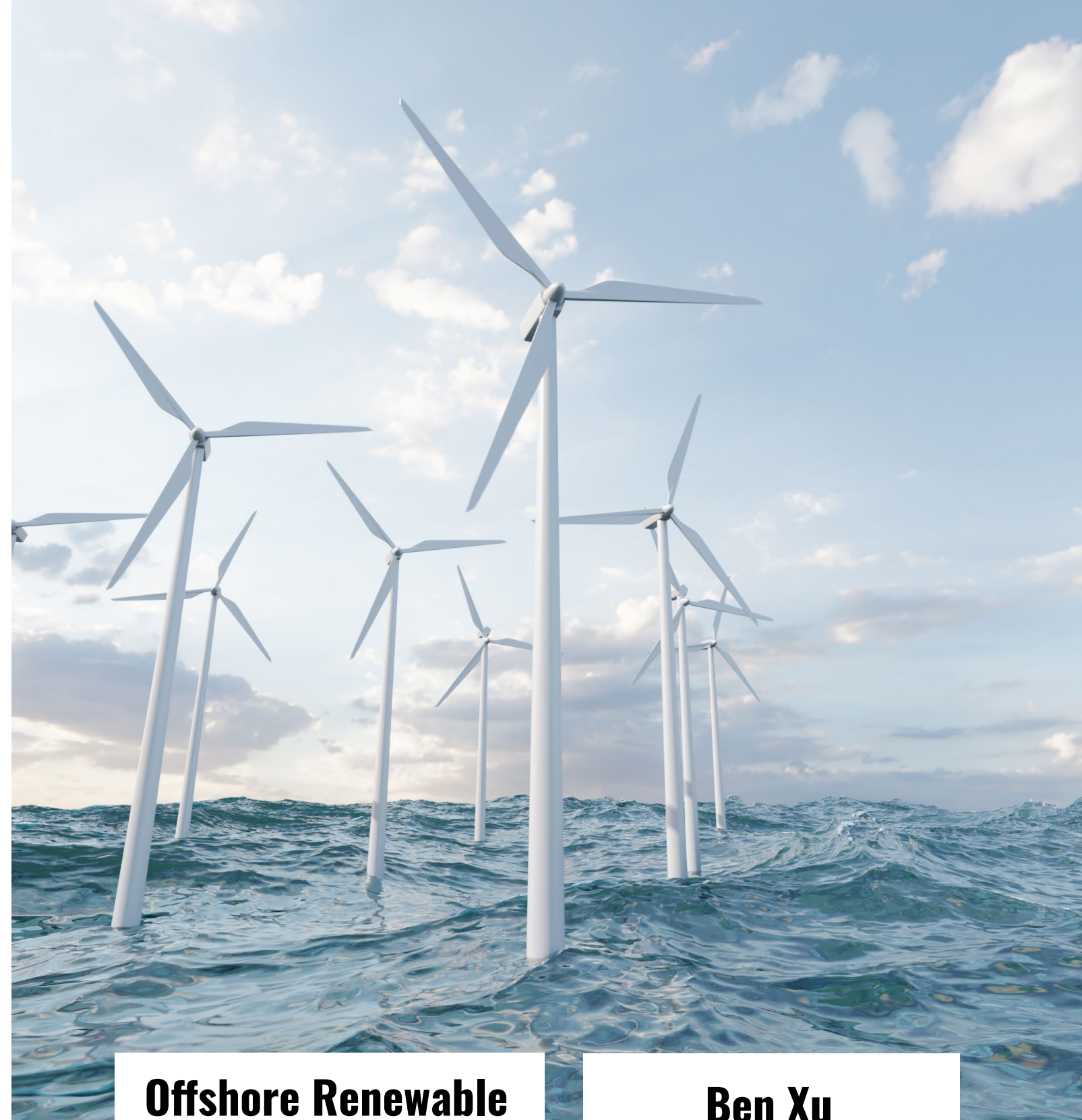
Result

The project delivered significant advances in understanding how offshore renewable components behave under complex, real-world conditions. It demonstrated that failure mechanisms in systems such as subsea cables and blade protection cannot be accurately predicted using single-physics models. Instead, performance is governed by the interaction of multiple physical processes, including mechanical loading, thermal effects and electrical behaviour. New modelling approaches were developed to capture these interactions, supported by experimental validation. The work provided detailed insights into stress localisation, material degradation and failure mechanisms, as well as identifying optimal design

parameters for composite systems. It also established reproducible methods for analysing and optimising materials at different scales. Importantly, the research highlighted that effective modelling requires a balance between complexity and practicality. While fully coupled multiphysics models are valuable in critical areas, simpler models can still play a role in early-stage design, provided their limitations are understood. The project also contributed to a strong body of academic outputs and enabled successful funding bids and collaborations. It supported the development of new research capabilities, including a dedicated engineering laboratory, and strengthened links between academia and industry.

Impact

The project has had a broad impact across research, industry collaboration and international engagement. It directly contributed to the successful award of a major European COST Action network on ocean tribology, supporting collaboration between academic and industry partners across multiple countries and providing training and professional development opportunities in the offshore sector. The research has also informed discussions on supply chain resilience, sustainability and technological innovation within offshore renewable energy. Engagement through industry symposia and international events has highlighted the importance of integrating digitalisation, advanced materials and circular economy principles to improve system performance and reduce environmental impact. International collaboration has been further strengthened through participation in a major UK-China symposium, which brought together policymakers, researchers and industry leaders to address shared challenges in offshore wind, including materials recycling, lifecycle design and large-scale deployment. In addition, the work is contributing to the development of emerging industrial standards for grid design and control in offshore energy systems. It has also supported high-profile initiatives such as the TIGGOR2 project, which was shortlisted for a Global Offshore Wind Award, demonstrating recognition of its relevance to the sector. Overall, the project has advanced both technical understanding and collaborative networks, positioning the research to influence future design practices, policy development and innovation in offshore renewable energy systems.



Offshore Renewable Energy Catapult

~~“This project shows how Earth observation research can be translated into accessible, user-facing outputs that help researchers and policymakers better understand the environmental conditions that contribute to climate-related displacement.”~~ – Andy Norris



Ben Xu

~~“Satellite data is incredibly powerful, but its real value in the climate displacement space is not in tracking people directly. Instead, it helps us understand the environmental disruptions and recovery processes that shape displacement risk.”~~

