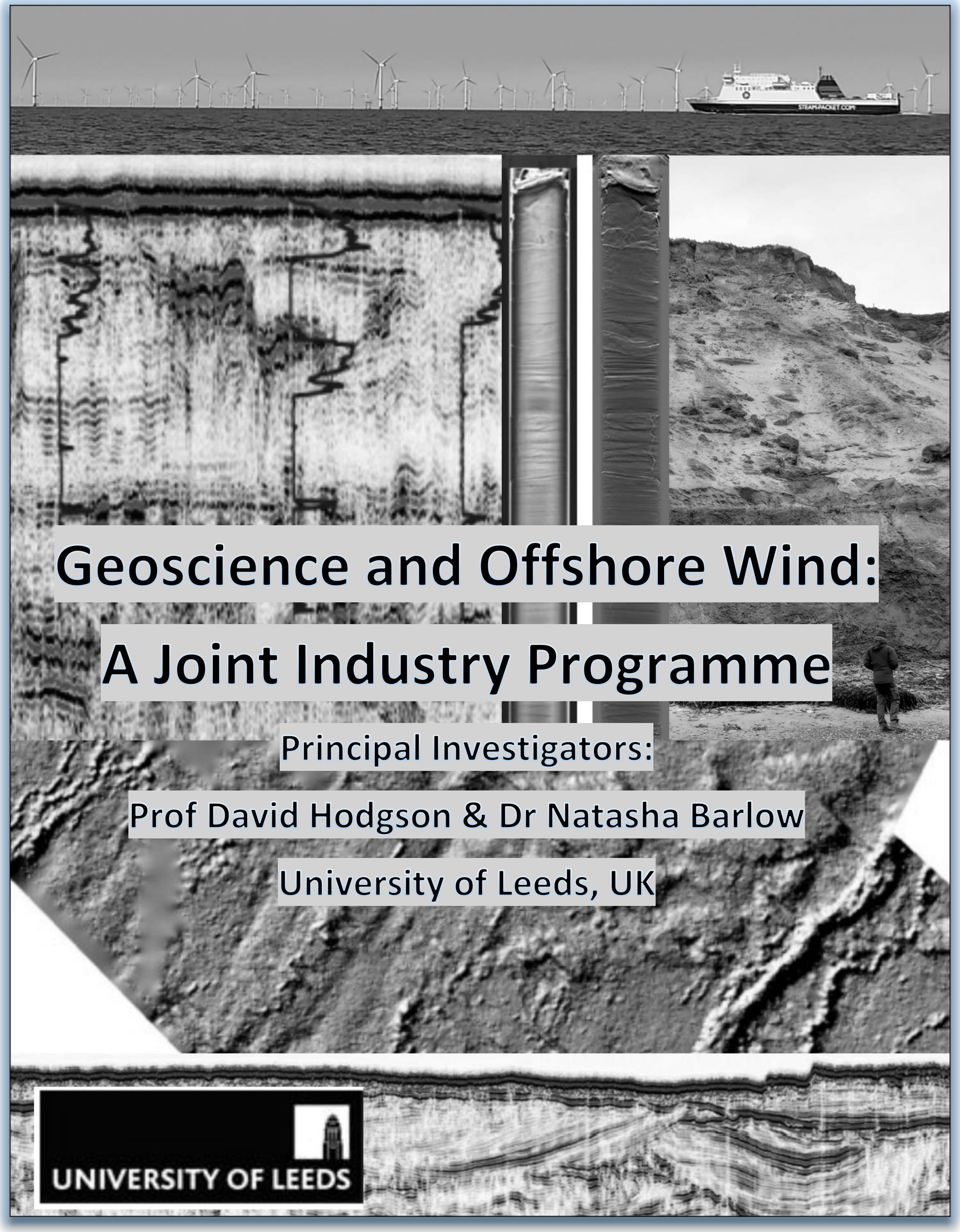

Geoscience and Offshore Wind: A Joint Industry Programme

Principal Investigators:

Prof David Hodgson & Dr Natasha Barlow

University of Leeds, UK

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Executive summary:

The ambitions to grow offshore wind requires tremendous steps forward in engineering capabilities, alongside close integration with geoscience understanding, in order to increase the scale of deployment. Geosciences, and geoscientists, are integral to the whole lifecycle management of offshore windfarms, from initial site evaluation, foundation and layout design, through installation, and operations and maintenance, to lifetime extension, repowering and decommissioning strategies. Therefore, it is essential that the skills and training of geoscientists are focused on meeting these challenges. This proposed Joint Industry Programme (JIP) will train PhD students in the use of offshore datasets, the integration of geophysical and geotechnical data, in order to advance the development of ground models that capture geological information.

Geoscience has a crucial role in ensuring the sustainable growth of offshore wind energy. All developments, from monopoles and cable routes to anchor points for floating wind, require a detailed understanding of substrate conditions (Fig. 1).

Investigations of industry site survey datasets have revealed the detailed architecture of the submerged landscapes at the foundation of development sites, demonstrating an unexpectedly high degree of variability in substrate properties; a result of the advance and retreat of large ice sheets over northern Europe many times. This heterogeneity needs to be captured in detail to improve cost effectiveness, and minimise environmental impacts, of siting seabed infrastructure.

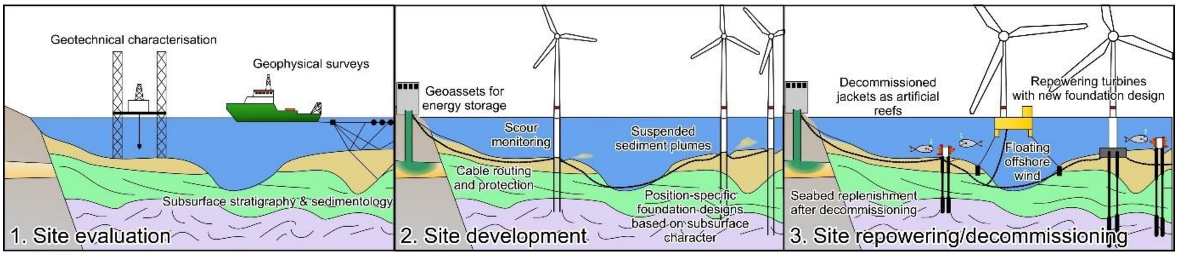


Fig. 1: Geoscience inputs are needed throughout windfarm lifecycles. Adapted from Velenturf et al. (2021)

Track record:

David Hodgson (DH) is Professor of Sedimentology and Stratigraphy at University of Leeds (UoL), and is recognised internationally for his sedimentological and stratigraphic research on a wide range of depositional environments. DH has led multiple joint industry programmes that have been co-designed and co-produced with more than 25 industry partners.

Natasha Barlow (NB) is Associate Professor of Quaternary Environmental Change at UoL, and is an international expert in landscape change over glacial-interglacial cycles. NB currently leads a major European research project (RISeR) reconstructing palaeo-environments and sea-level change in the North Sea, and a leading member of a joint UK industry-academia Engineering Geology working group.

DH and NB have worked together on geophysical datasets for nearly a decade. DH has established links with the offshore wind industry via two PhD students, co-supervised with the British Geological Survey, who have investigated submerged landscapes using datasets collected for site surveys. NB and DH have also published work using open access Dutch industrial datasets, and 4 recent PhD students are now employed in the offshore wind industry.

Rationale for a JIP approach:

The offshore wind industry is under pressure to be more environmentally and economically sustainable, benefit communities, and grow a more diverse and inclusive workforce, whilst expanding into more challenging locations (greater water depths, more severe storms).

Joint Industry Programmes (JIPs) are an established co-production mechanism with direct linkage between University researchers and a consortium of partners. This approach establishes a constructive forum to share ideas, and to effectively translate research to stakeholder benefits, and design outputs that are delivered in a form to suit the end users.

The JIP proposed here will strengthen and expand partnerships between University researchers and geoscientists in the offshore wind industry to accelerate translation of outcomes from research into practice and identify industry needs. A steering group will meet annually to monitor progress, and share ideas.

To avoid issues of data confidentiality the scope of research will use datasets in the public domain.

We propose that the first phase of the JIP is costed to cover one studentship, time for the Principal Investigators to visit partner offices, and to run a field workshop for partners.

1 x PhD studentship:	£80,000
Field workshop running costs:	£10,000
Principal investigator time and travel:	£10,000
Total:	£100,000
Minimum consortium partners:	5
Per partner costing:	**£20,000**
	(or 2 instalments @ £10,000)

The risk of now proceeding with the JIP is low. If there are less than 5 partners the University of Leeds have agreed to underwrite the JIP to the minimum value. If we attract more than 5 partners then we will discuss on how to allocate the extra funding via the Steering Group.

Research studentship:

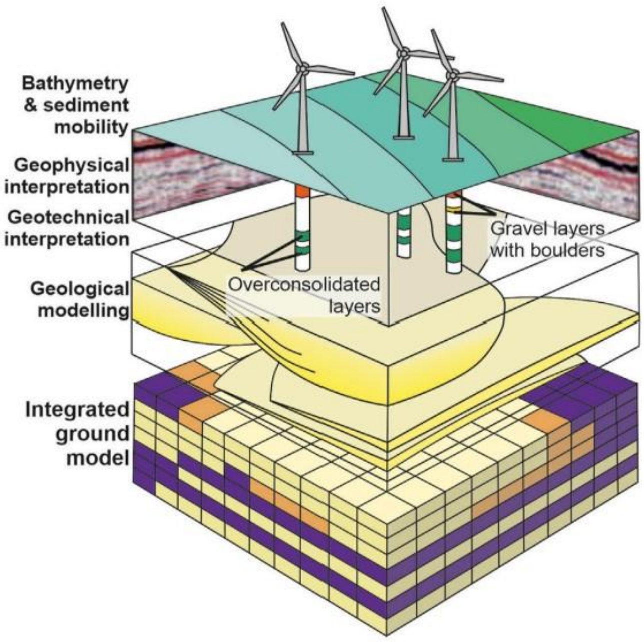
Developing 3D ground modelling workflows using publically available subsurface datasets

A crucial step in the integration of geophysical and geotechnical data is the construction of three-dimensional ground models of offshore windfarm sites. Improved modelling workflows need to augment sedimentary and stratigraphic understanding by incorporating information from analogue datasets to populate geological information below seismic resolution, such as faults and the dimensions and stacking patterns of sedimentary architectural elements (e.g. channel-fills). Three-dimensional geological characterisation of subsurface volumes is standard practice during the exploration, appraisal, and development of oil and gas fields (e.g., Bentley and Smith 2008), and carbon storage sites (e.g., Jiang et al., 2013). These models are then upscaled to simulate the flow of fluids through the prospective reservoir. These workflows, and expertise, are readily transferrable to the offshore wind development sites, to complement the geotechnical-focussed ground models.

This studentship will seek to blend geological and geotechnical approaches to develop 3D ground models that permit bespoke design of turbine foundations and cable routes (Fig. 2).

The uptake of three dimensional geological models as a standard approach is particularly important in many prospective development areas, such as the North Sea and Irish Sea, where the subsurface stratigraphy has been demonstrated to be highly heterogeneous (e.g., Clare et al., 2012; Liingaard et al., 2012; Eaton et al., 2020), undermining cost-effective placement of monopoles (Fig. 3). A scenario-based approach will be undertaken with different grid designs and monopile depths showing a range of intersections with the substrate. Grid resolution is a particularly important consideration as future developments in offshore wind are focused on very large (“XXL”) turbines (>8 m wide foundations).

The workflow will accommodate future innovations in ground model development such as dynamic bathymetry, and sediment mobility layers (Figure 2), to account for the substrate architecture and erodibility with seabed hydrodynamics. Improved modelling of sediment suspension and scour would assist the modelling of habitat creation and modification provided by hard surface creation to increase seabed biodiversity.



To minimise issues around data confidentiality and sharing of outcomes, this studentship will use publically available data. Prospective areas include offshore Netherlands, and the Irish Sea. Any dataset that is documented in detail will also reveal new insights into palaeoenvironmental change in the North Sea during the Quaternary. Although the main deliverable will be workflows for integration of geotechnical and geological datasets in 3D geological models.

Figure 2: Recommended integrated three-dimensional ground models that capture sediment mobility, and integrate geophysical, geological (including geomorphological) and geotechnical information.

Partner benefits of **supporting Geoscience and Offshore Wind Joint Industry Programme**

Establishing co-production mechanisms: We will employ several co-production mechanisms, including seminar series, field workshops, and virtual fieldtrips, plus a co-developed 'How to build better ground models' workshop. DH has extensive experience of running JIP field workshops and steering group meetings, and they provide an effective forum to strengthen partnerships and identify common goals, and share challenges of embedding geoscience understanding into offshore wind developments. Unlocking collaborations between engineers and geoscientists will initiate interdisciplinary research and impact, lead to changes in practitioner decision-making and asset team composition, and improve cost effectiveness of developments through adoption and integration of geoscience knowledge.

Economic benefits: The co-development phase of this JIP has demonstrated a strong convergence in the challenges facing this fast evolving industry in embedding geoscience knowledge into workflows, and opportunities for unlocking the academic-industry cycle of research. Offshore wind companies have global development interests, meaning that the deliverables will accelerate economic benefits through changes in practitioner decision-making, commercial adoption of knowledge, and research gap identification, and learning and participation impacts by closing skills gaps.

Shaping future research: The Joint Industry Programme model establishes a two-way collaboration. Through discussions in the field workshop and steering group, the PIs will be able to better understand the challenges facing the business, and collaboratively identify science gaps for this studentship and future phases. This will establish a cycle of collaborative research, and multiple phases of the JIP.

Recruitment: To meet green job targets, there need to be skilled graduates, and support for the transfer of skilled workers from other sectors, but the rapid growth of the offshore wind industry has outpaced curricula changes and development of clear skills pathways. The sector has highlighted the potential to retrain skilled workers from the oil and gas industry (e.g., Arcelay et al., 2021), a sector that is expected to decline, but with workers who have skills and experience needed for low carbon applications (Hastings and Smith, 2020). The PhD student will be a well-trained, and known, potential recruit for one of the partners.

Sharing outputs: By adapting experiences for the efficient and effective exploitation of data and research with the O&G sector, we will co-create a range of NERC science outputs hosted on the Crown Estate's MDE platform. Example content includes synthesis material from published literature linked to primary data to support desktop studies, and uninterpreted and interpreted seismic and borehole data, to support staff transition for other sectors, and the wider supply chain.

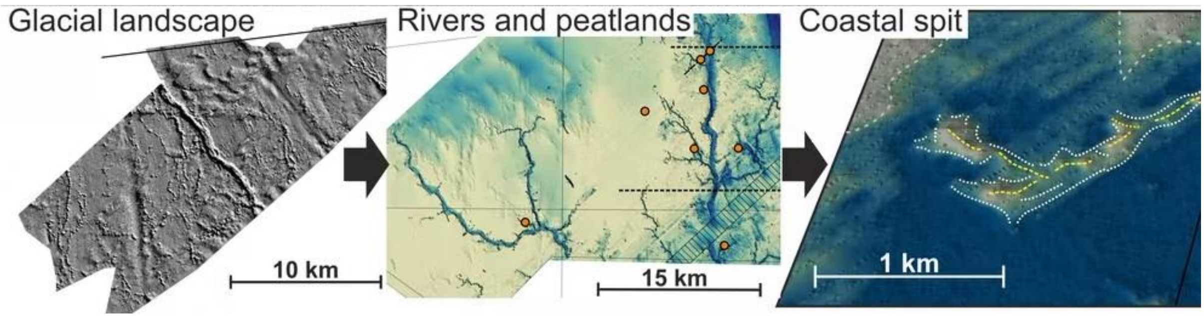


Figure 3: Windfarm data from the Dogger Bank reveals submerged landscapes. A) Glacial landforms provide evidence of an ice sheet 23,000 years ago. B) The ice retreat left a low relief terrestrial landscape dissected by rivers that attracted early humans. C) Formation of a sandy spit as the landscape became coastal, prior to inundation by the sea, forcing the settlers to migrate. From Barlow and Hodgson, 2021.

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