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Offshore geotechnical challenges of the energy transition

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Offshore wind is the most mature of the offshore renewable energy technologies and has a significant role to play in the energy transition. 2000 GW of offshore wind capacity is anticipated globally by 2050 in order meet the targets of the Paris Agreement [1]. These ambitions correspond to a 35-fold increase compared to current installed offshore wind capacity, which has taken three decades to achieve, thus requiring an installation rate between now and the mid-century far out-stripping that currently achieved [2]. The pace and scale of offshore wind ambitions to support the energy transition present a range of challenges for the offshore geotechnical sector and the broader offshore wind sector, with impacts across the supply chain regarding availability of raw materials, vessels, equipment and personnel, and across each stage of the life-cycle of the projects from marine spatial planning, site investigation, design, manufacturing, installation, operation and decommissioning. To address these challenges, the sector faces key imperatives, including (i) to determine where best to place future offshore windfarms to meet technical, social and environmental requirements and identify where technology and knowledge gaps exist, (ii) to improve efficiency in deriving geotechnical design parameters in order to alleviate pressures on people, vessels, equipment and labs for site investigation and interpretation of test results; (iii) to improve efficiency of design outcomes, i.e. to achieve greater capacity:weight efficiency for foundations, anchors and mooring systems to ease supply chain, manufacturing and installation pressures, while maintaining necessary reliability; (iv) to improve time efficiency to complete designs in order to make design calculations and processes less time- and personnel-intensive to carry out; and (v) to improve the life-cycle cost of delivering the necessary offshore wind to enable a net zero future through considering the end of engineered life at the design stage.

Figure 1 illustrates the magnitude of the projected and necessary growth in offshore wind globally to 2050 in terms of installed offshore wind capacity and number of turbines, with an indication of the associated geotechnical implications for this pace and scale of growth.

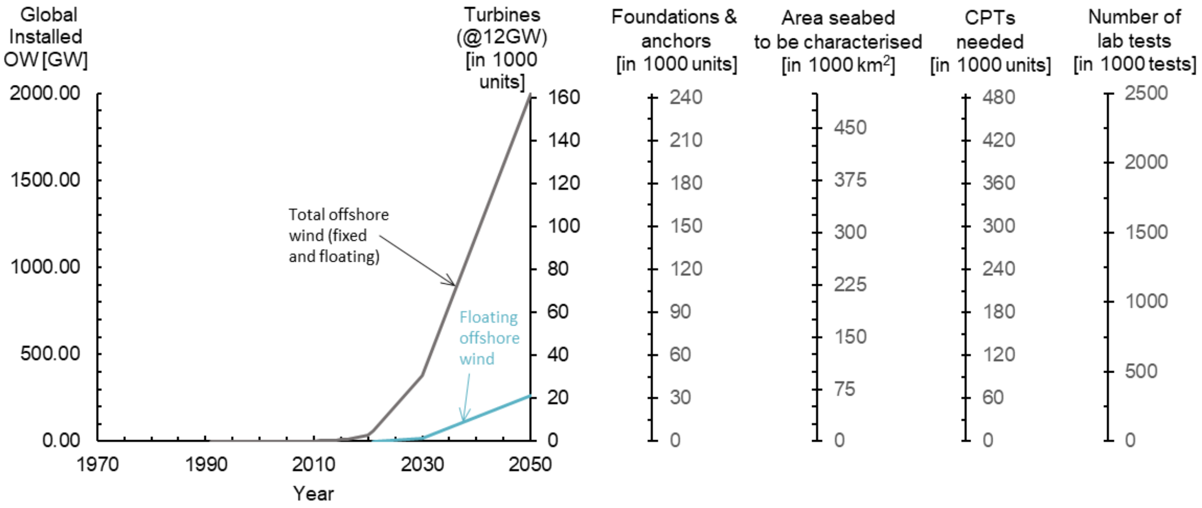

Figure 1: Scale and pace of challenge for offshore geotechnical engineering to meet offshore wind ambitions (Image after [3], data from [2])

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Potential solutions to address the identified challenges and associated imperatives include those to address specifically geotechnical challenges, but also geotechnical solutions to offshore wind challenges beyond the seabed. For example, (i) use of geospatial mapping and analysis to determine the available seabed areas for future offshore windfarms and identify suitable foundations or anchors for particular regions, which can in turn inform on supply chain or critical technology and knowledge gaps [4]; (ii) innovations to increase efficiency of offshore site investigation, including software [5] [6] and hardware approaches [7] to facilitate seabed characterization at meaningful spatial and temporal scales; (iii) innovations in design philosophy, concepts and methods to improve design outcomes for foundations and anchoring systems, including whole life geotechnical design [8], novel moorings and anchors [9] [10] [11] and integrated design [12]; (iv) creation of optimization design tools that can directly address the design question, avoiding numerous ad hoc individual analyses to hone in to a workable solution [13] [14]; and (v) methods to inform on requirements for end of engineered life, e.g. retrieval or stability if left in situ beyond the design life [15] [16], and geospatial mapping to understand the distribution of assets at the end of engineered life in order to plan for recycling or disposal [17].

Contributor statement

Susan Gourvenec: Conceptualisation, investigation, methodology, writing- original draft, writing- review & editing.

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