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Site characterization of foundation soil for Offshore Wind Farms - an example from the German North Sea

Stefan Kreiter (1), Tobias Mörz (1,2), Jan F. Metzen (2), Daniel A. Hepp (1), Benjamin Ossig (1), Daniel Otto (2), Lukasz Socko (2), Hanno Keil (1), Volkhard Spieß(1), and Dierk Hebbeln (1)

(1) MARUM – Center for Marine Environmental Sciences, University of Bremen, Germany (skreiter@uni-bremen.de), (2) Geo-Engineering.org GmbH, Bremen, Germany

The promising possibility to reduce CO2 emissions from energy production by the erection of offshore wind farms caused a boom of wind farm projects in the German North Sea. The projected wind turbines have overall heights of up to 200 m above sea level and require considerable foundation depths of up to 50 m pile length in the subsoil. Little experience exists concerning the optimal geotechnical site characterisation for such projects. As approximately 80 considerable sized foundations are needed per wind farm, costs have to be minimized to help making renewable energies competitive.
The cost effective and save design of the foundation depends on a reliable knowledge of the upper 50 to 100 m of the subsoil. The marine subsoil of the German North Sea is in general a favourable foundation soil, but Quaternary buried glacial and fluvial valleys introduce heterogeneities, which have to be accurately mapped and considered for the installation planning.
Necessary site investigations combine geophysical exploration, core drilling and cone penetration testing. At the same time they have to be in accordance with the national approval procedure which is organised in Germany in several steps.
Here, an industry-financed and scientifically-accompanied geotechnical site characterisation of one exemplary offshore wind farm project is presented (partners: RWE-Innogy, ENOVA and MARUM; Initiative "germanwind"). In order to image the lateral highly heterogeneous sedimentation environment in the North Sea a dense net of high resolution multichannel seismic lines was acquired using the University of Bremen shallow water seismic equipment. This provided seismic images of 1.5 m lateral resolution and 2-3 m vertical resolution therefore overcoming the low signal penetration of conventional boomer seimics and the low resolution of conventional multichannel seismics.
The seismic survey was complemented with push cores and cone penetration tests at 14 sites, each reaching down to about 50 m sediment depth. These sites where chosen on the base of the seismic survey, the published geological knowledge and the projected wind turbine locations. All results combined allowed for establishing a conclusive geological and geotechnical model of the area. In heterogeneous areas additional 40 sites were sampled and sounded to allow for a reliable foundation design.
In the course of the presented site characterisation several previously unknown buried valleys were mapped and sampled for the first time.