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Buoyant Gravity Based Foundations for Offshore Wind Infrastructure Challenges

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Abstract

The concept of self-buoyant Gravity Based Foundations (GBF) has emerged as an alternative to the conventional lifted GBFs, with the initiative to negate the need for heavy lifting. This study outlines the technical criteria for infrastructure that can facilitate industrial application of self-buoyant GBFs. Total weight and initial draft are deemed to be the parameters that impose the most demanding requirements. The existing supply chain capabilities in terms of available infrastructure are critically assessed by evaluating the harbour characteristics, which leads to the identification of the most suitable ports. Based on the overall comparison of the demands imposed by the foundation requirements and the resources available in the market, the aspects of foundation design with the most potential for improvement, as well as the most beneficial areas for infrastructure upgrading are identified. These are proposed, as a set of recommendations in order to address the logistic challenges that can impede the implementation of self-buoyant GBFs.

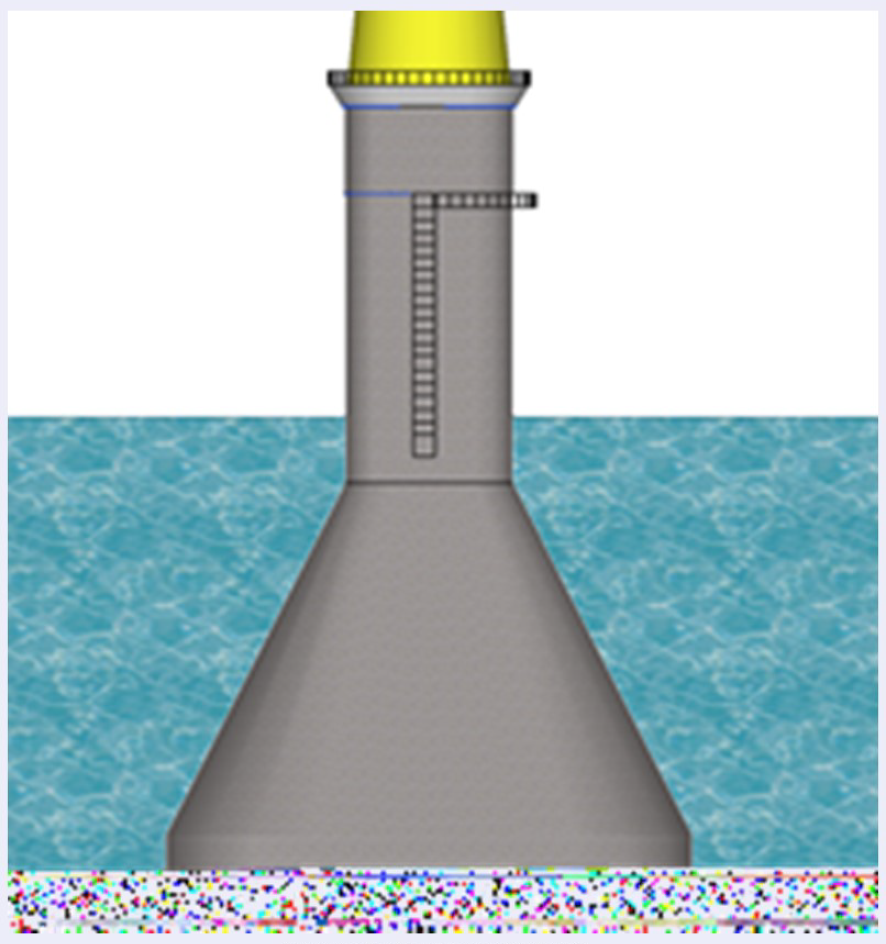

Figure 1: Buoyant GBF [3]

Objectives

- Outlining the infrastructure criteria that should be provided to meet the requirements for industrial implementation of self-buoyant GBFs;
- Reviewing the current competencies of existing ports/harbours in fulfilling the outlined requirements;
- Developing a GIS tool capable of mapping out the existing ports and their main characteristics. The GIS tool allows selection of the relevant criteria from the database, and making choices regarding the most suitable port options for the given set of criteria.
- Identifying the most promising areas of improvement/refinement with regards to both foundation design and infrastructure upgrading and reporting as a set of recommendations;

Infrastructure characteristics

Despite the importance of overcoming the technical challenges and the design barriers, it can be expected that availability of suitable infrastructure will be the key factor in determining the viability and cost-competitiveness of the buoyant GBFs, given the existing capabilities in the offshore wind industry. The criteria imposed on the infrastructure are identified based on the results of a parametric study that has been conducted for predicting the suitable configuration, structural and hydrodynamic specifications of the self-buoyant GBFs in water depths ranging from 25 to 60m. These port criteria include:

- Port's depth
- Port's quay length
- Availability of dry dock
- Air-draft restriction
- Port's tidal range
- Port's location
- Port's quay load bearing capacity
- Construction/ storage area at the port

Figure 2: GBF construction at port of Oostende [5]

Buoyant GBF's specifications in different water depths

Offshore wind projects are moving further from shore and in deeper waters. e.g. the average figures show that minimum water depth for round 3 offshore projects in the UK (currently, the lead country in the offshore wind industry) is 30m[4]. For this study, six consented offshore wind projects in the North Sea, located in the range of 25-60 m have been selected. In table 1, the height of bottom cylinder, the base diameter, initial draft and the weight of the buoyant GBFs for a range of water depth (25m - 60m) are shown. The estimated specifications of the foundations has been determined based on the analyses conducted for verifying the stability during load-out and incremental ballasting.

The effect of lateral hydrodynamic loads on the stability have not been taken into account, although these may become an important source of instability if the marine operations are conducted in adverse weather conditions. Water ballasting has been considered during installation. It should be noted that the requirements of geotechnical stability may require sand ballasting once the substructure is in-place.

Water depth (m)	Height of Bottom Cylinder (m)	Diameter of Base (m)	Initial draft (m)	Weight (MN)
25	12.5	23.5	7.53	32.05
30	13.5	25	7.67	36.94
35	16	30	7.52	52.15
40	17	30	7.86	54.51
45	18	31	8.02	59.4
50	18	32	7.96	62.8
55	19	33.5	8.02	69.32
60	20	35	8.07	76.14

Table 1: Buoyant GBF specifications in 25 - 60 m depth range [3]

GIS Application

In order to assess the suitability of some of the existing infrastructure for the manufacture of these foundations, ten ports have been evaluated using the GIS tool. The selected ports are Able-Humber port, Hull-ABP, Harwich Navyard port, Port of Cromarty, Eyemouth Harbour, Port of Great Yarmouth, Able-Seaton port, Port of Le Havre, Port of Zeebrugge, and Port of Oostend.

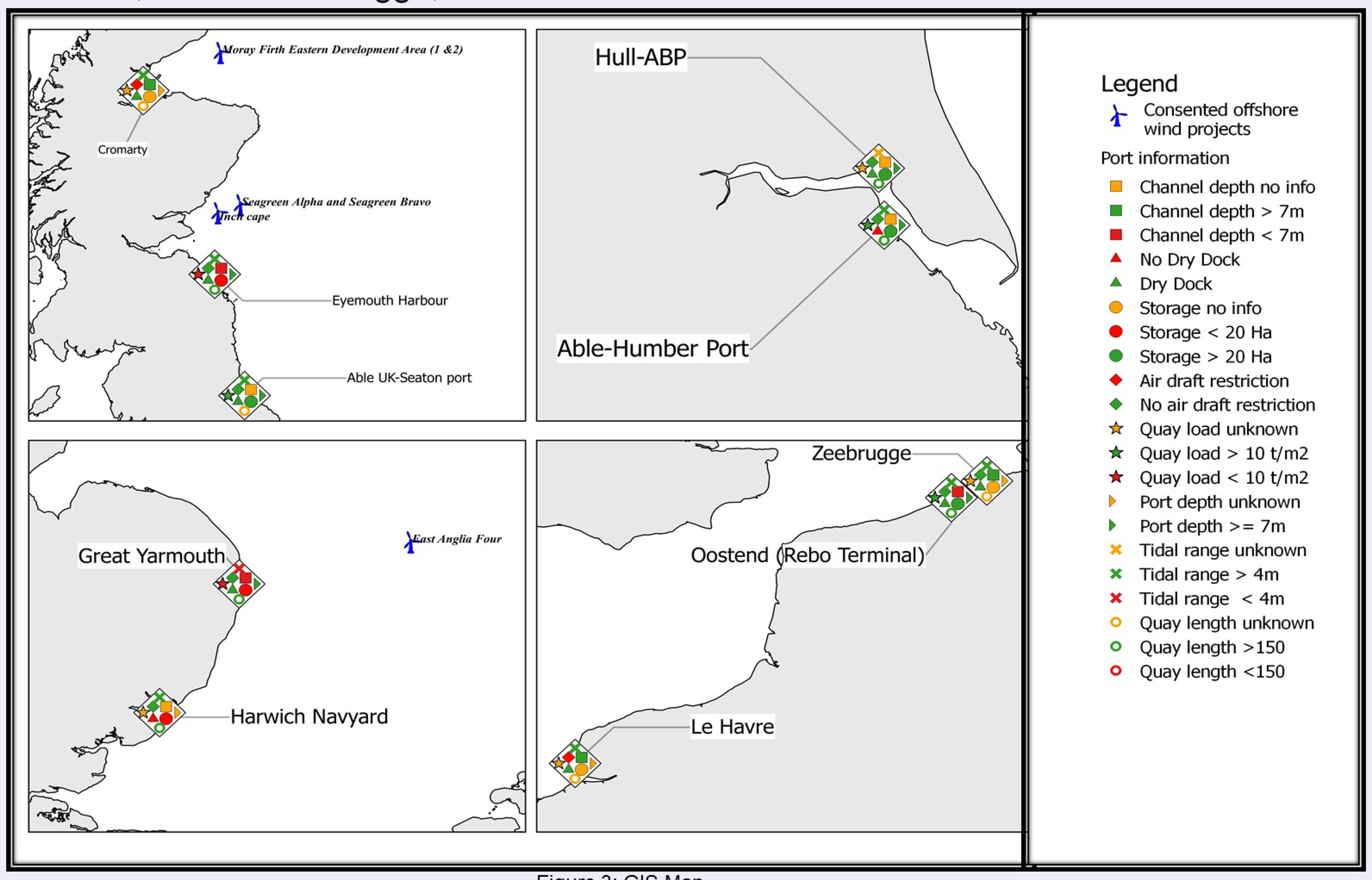

Figure 3: GIS Map

Results

Based on the **available** data for the selected ports[1,2], the GIS analysis shows that

•80% of the ports have a dry dock (20%: no dry dock available)

•60% of the ports have a depth of 7m (40%: limited data)

•80% of the ports have no air-draft restriction (20% : have restrictions)

•60% of the ports have quay lengths over 150m (40% : limited data)

•40% of the ports have storage areas of above 20ha (30% : storage area <20ha, 30%: limited data)

•30% of the ports have quay load bearing capacities above 10 t/m^2 (20%: quay load bearing capacities <10 t/m^2, 50 %: limited data)

Although the port data is limited, it can be inferred that the **ports' depth**, and the availability of **heavy load quays** and **large storage areas** could be the bottlenecks in the manufacture of these foundations, and they are among the areas requiring further improvement.

Limitations of the study:

While the database is still being populated with accurate technical parameters, the port capabilities have been evaluated based on publically available information for the purpose of demonstrating the capabilities and potential of the final GIS database tool. Also, the results obtained from the shortlisting exercises have been provided as an example and may be subject to change following the final population of the database.

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