This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 791875.

Developing the Next Generation 12+ MW Offshore Wind Turbine for Clean and Competitive Electricity

Comparative Simulation Study of 6 MW and 15 MW Offshore Wind Turbines for Fixed and Floating Foundations

Motivation

Offshore wind energy is a vital component of the global transition to renewable power, but the increasing size of turbines introduces significant logistical complexities. Since installation and vessel operations account for 15–20% of the levelized cost of electricity, optimizing these processes is essential for economic viability. Floating wind installations offer a transformative alternative by allowing for onshore pre-assembly and streamlined transport via tugs. However, the industry currently lacks sufficient real-world data to provide reliable efficiency and cost estimates for these floating systems at scale. This research addresses the gap by systematically comparing the performance of bottom-fixed and floating systems of different size under realistic weather conditions to inform future decision-making.

Methodology

The study utilizes a discrete-event multi-agent simulation model created in AnyLogic to evaluate different offshore installation strategies. Researchers developed four distinct models to analyze both 6 MW and 15 MW turbines for bottom-fixed and floating foundation scenarios. The simulation incorporates critical factors such as real sea routes, specific process durations, and equipment requirements for each campaign. To ensure realistic results, the model uses historical weather data from 1979 to 2017 to calculate the impact of weather-related downtime. Specifically for floating systems, the methodology tracks seven main campaigns, including anchor installation, floater load-out, and offshore commissioning.

Results

The installation of a wind farm of 600 MW (consisting of either 100 x 6 MW or 40 x 15 MW turbines) located in the North Sea around in Germany 80 km from the coast is simulated. The simulation results reveal that bottom-fixed systems maintain shorter project durations, with 15 MW turbines requiring 471 days compared to 883 days for floating systems. In both scenarios, transitioning to larger 15 MW turbines provides notable efficiency gains because fewer units are required to reach energy targets. However, floating installations are significantly more vulnerable to weather disruptions, with cable laying and commissioning tasks experiencing delays of up to 51% and 58%. For bottom-fixed structures, foundation installation remains the most time-intensive and weather-sensitive task, particularly when using smaller 6 MW turbines. Ultimately, while floating systems are currently more time-consuming, they remain the only viable solution for deep-water sites where fixed foundations are impractical.

Category	Foundation Type	6 MW Turbine (100 units)	15 MW Turbine (40 units)
Total Project Duration	Bottom-Fixed	852 days (Average weather)	**471 days** (Average weather)
	Floating	1,175 days (Average weather)	**883 days** (Average weather)
Weather-Related Delay	Bottom-Fixed	8% total project delay	**2%** total project delay
	Floating	13% total project delay	**22%** total project delay
Most Sensitive Task	Bottom-Fixed	Foundation (34% delay)	Cable laying (38% delay)
	Floating	Commissioning (42% delay)	**Commissioning (58% delay)**

Simulation results - Fixed vs. Floating Systems for 6 MW and 15 MW Turbines

Source
1. Oelker, S.; Ait Alla, A.; Rippel, D.; Freitag, M.: Simulation-based feasibility analysis of large offshore wind turbine installation. In: Chung, J. S.; Buzin, I.; Kubat, I.; Lim, F.K.; Peng, B.-F.; Reza, A.; Van, S. H.; Wan, D.; Yamaguchi, S.; Yan, S. (eds.): The Proceedings of the 35th (2025) International Ocean and Polar Engineering Conference. International Society of Ocean and Polar Engineers (ISOPE), Cupertino, USA, 2025, pp. 259-264

ReaLCoE's vision is to unleash the full potential of offshore wind energy
€35/MWh LCoE Goal, +12MW WEC Capacity, ~32 mio € Total Budget, 42 month project duration

SCAN ME

Join the ReaLCoE community!
Further information about the ReaLCoE Programme can be found on our website: ReaLCoE.eu