FLOTANT has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 815289

Innovative, low cost, low weight and safe floating wind technology optimized for deep water wind sites

PROJECT ACRONYM: FLOTANT
PROJECT TITLE: Innovative, low cost, low weight and safe floating wind technoloy optimized for deep water wind sites
FUNDING: EU-H2020-LC-SC3-RES-11-2018,
Grant agreement: 815289
EU Financial contribution: 4,9 million Euros

START DATE: April 1, 2019
DURATION: 36 months
PARTNERS: 17 partners from 8 countries
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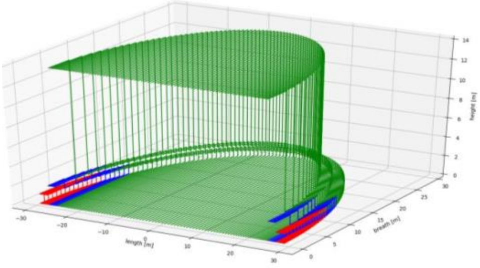
Objectives

The main objective of FLOTANT project is to develop the conceptual and basic engineering, including performance test of the mooring and anchoring system and the dynamic cable to improve cost-efficiency, increased flexibility and robustness to a hybrid concrete and plastic floating structure implemented for deep water wind farms. Innovative solutions will be designed to be deployed in water depths from 100m to 600m, optimizing the LCOE of the floating solution (85-95 €/MWh by 2030).

Solutions proposed by FLOTANT

Design basis

Design Basis include wind and wave conditions, as well as limiting conditions established to ensure safe operations and a reasonable commitment between structural integrity and met-ocean conditions regarding the two selected sites (West of Barra-Scotland, UK and Gran Canaria-The Canary Islands, Spain).

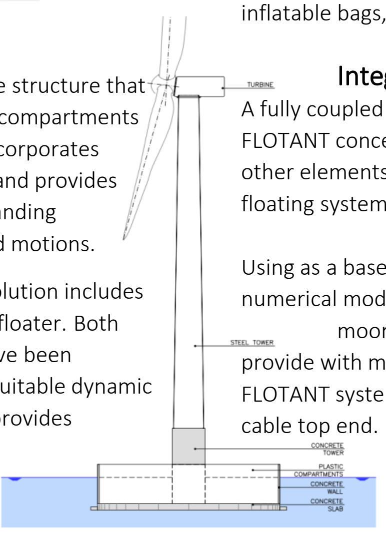


An intensive and detailed study of the most suitable buoyancy materials for the floating structure has been performed, including both thermoplastic and thermosetting material from different processing technologies and with different configurations (polymeric foams, solid blocks, flexible and inflatable bags, hollow tanks, etc.).

Naval architecture of the floater

The floater concept consists of a concrete structure that provides the rigidity to a group of plastic compartments that provide the buoyancy. The design incorporates a heave plate to reduce the movements and provides enough stability to comply with the demanding requisites stablished regarding angles and motions.

The naval architecture of the FLOTANT solution includes static and dynamic studies regarding the floater. Both stability and wave interaction analysis have been performed to ensure initial stability and suitable dynamic behaviour of the floating system. It also provides the frequency-dependent hydrodynamic coefficients needed for the integrated modelling.



Integrated modelling and global performance

A fully coupled aero-hydro-servo-elastic numerical model of the FLOTANT concept has been developed to provide inputs for other elements and evaluate the global performance of the floating system.

Using as a base the aeroelastic model, a hydrodynamic numerical model of the floater including the proposed mooring configuration has been set up and tuned to provide with motions and loads in different locations of the FLOTANT system, e.g. floater, tower top and base, exporting cable top end.

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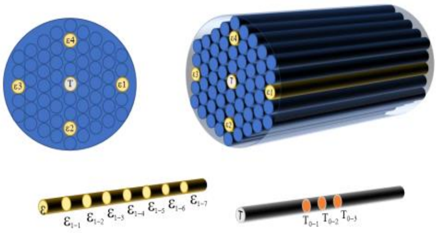
Smart mooring lines concept

The solution is based in a redundant architecture including several Fibre Bragg grating (FBG) strain sensors distributed in several Fibre Optics (FO) arrays enabling the monitoring of lines' load. Thermal strains compensation is performed by introducing another FO line with encapsulated temperature sensors. These sensors' output provides an accurate temperature reading nearby the strain sensors thus enabling to account for the strains caused by changes in the temperature.



Mooring polymer springs

The polymer springs developed can deliver significant reductions in load and fatigue for the whole mooring system for both locations as follows:

Senario	Load Reduction	Fatigue Reduction
West of Barra	~35%	~38%
Gran Canaria	~45%	~60%

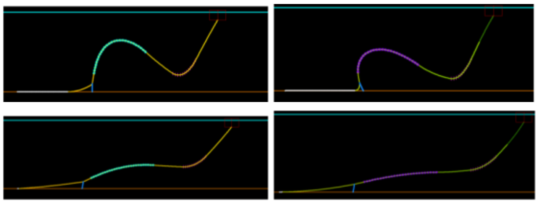
Furthermore, new manufacturing process for polymer springs, made of Hytrel® 5556, and metal structure can achieve 30-40% of cost reduction.

Antifouling and anti-bite properties

Different plastic materials have been developed for mooring cables, power cables and floater. The methodology based on the standards ASTM D3623 and ASTM D6990 and the design of the experiments have allowed us to select the most suitable antifouling and anti-bite additives, which are being evaluated in real sea conditions.

Dynamic modelling of power cable

To investigate the behaviour and performance of the power exporting cable a numerical model of the cable has been setup. The initial model only considers the cable itself but at later stages, a model including the full platform with the export cable will be implemented.



This numerical model will provide with tensions and curvatures to the developer of the power cable.

Power evacuation optimization and cost reduction

A new XLPE insulated core with aluminium conductor of the dynamic 72,5 kV cable has been designed and manufactured. The overall design of the dynamic cable incorporates a new novel outer armouring and new outer jacket with integrated antifouling and anti-bite additives.

FLOTANT will enable to test mechanical and electrical characteristics of this dynamic power cable.

Cost reduction remains a crucial necessity

A reverse LCOE analysis was performed which presents an initial techno-economic model of the FLOTANT system for the sole purpose of defining initial cost targets for the system components. By defining an LCOE cost target to be achieved in 2030 with the deployment of a wind farm of 50 turbines of 12MW using the FLOTANT innovations, a preliminary budget available for each component was calculated. The obtained values will be updated as the LCOE model is refined and more information on the FLOTANT components becomes available.

The cases to be studied for the FLOTANT project were defined. Two locations are considered: West of Barra with 100m water depth is used as design and business case, and Gran Canaria with 250m water depth is used as second business case. Therefore, two different European locations have been analysed.

Reference cases were defined based on publicly available data from existing developments, which will be used to create a floating offshore wind farm baseline that the FLOTANT technology can be compared to.

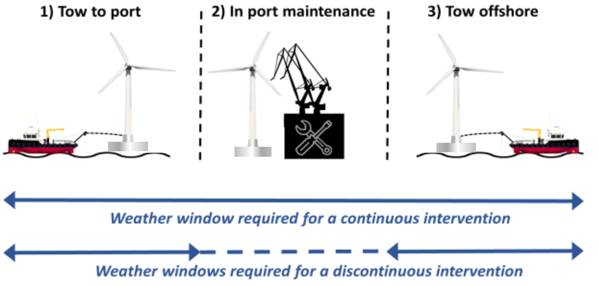
FLOTANT failure modes, effects and critically analysis (FMEA)

The results of this assessment were obtained through several workshops involving components' developers and manufacturers. The analysis defines the details of FLOTANT innovative components, especially concerning their reliability and maintainability. Thus, the failure modes of each component are identified, their criticality assessed and suitable mitigation measures provided.

O&M tools improvements

The computational models that will be used to estimate the key performance indicators of FLOTANT project and optimise the O&M strategies, have been improved with the capabilities to model the operational lifecycle of floating wind turbines. These include:

- Capability to model onshore maintenance operations. This new feature and its two variants are shown in the following figure.



- Ability to take into account disconnection and reconnection activities;
- Possibility to include components external to the device but affecting various devices (e.g. substations, maintenance hubs, etc.);
- Capability to take into account the position of each device, and related distance from O&M port, by defining a different vessel transit time for each device.

Scientific publications

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Rinaldi, G; Thies, P; Johanning, L; McEvoy, P; Georgallis, G; Moraiti, A; Cortés Lahuerta, C; & Vidmar, M. "Informing Components Development Innovations for Floating Offshore Wind Through Applied FMEA Framework." *Proceedings of the ASME 2020 39th International Conference on Ocean, Offshore and Arctic Engineering*. *Volume 2A: Structures, Safety, and Reliability*. Virtual, Online. August 3–7, 2020. ASME.

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Rinaldi, G; Thies, P; Johanning. "Improvements in the O&M modelling of floating offshore wind farms". *Proceedings of the RENEW 2020 4th International Conference on Renewable Energies Offshore*. *Volume: Developments in Renewable Energies Offshore*. Virtual, Online. October 12-15, 2020. CRC Press.

García-Teruel, A; Jeffrey, H. "The economics of floating offshore wind – A comparison of different methods". *Proceedings of the RENEW 2020 4th International Conference on Renewable Energies Offshore*. *Volume: Developments in Renewable Energies Offshore*. Virtual, Online. October 12-15, 2020. CRC Press.

Grivas, K; Moraiti, A; Georgallis, G; Rinaldi, G; Thies, P.R.; Johanning, L. "Dynamic HV cables with AL conductors for floating offshore wind turbines: A cost and behavior comparative study". *Proceedings of the RENEW 2020 4th International Conference on Renewable Energies Offshore. Volume: Developments in Renewable Energies Offshore*. Virtual, Online. October 12-15, 2020. CRC Press.