TELWIND - Integrated Telescopic tower combined with an evolved spar floating substructure

PO.095

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Abstract

Levelised Cost of Energy (LCoE) is a main design driver for offshore wind turbines in deeper water. The presented evolved spar floating foundation combined with a Telescopic tower will reduce the costs of offshore wind. The objective is to design a revolutionary integrated floating substructure concept which shall enable a radical step forward for cost–effective and industrially deployable deep water offshore wind.

The research activities within this project are executed by a strong multidisciplinary team of 8 project partners, funded by the European Commission in a Horizon2020 program.

Objectives

The proposed floating concept is an innovative wind-specific evolution of the Spar Type floating structure. These are well established, inherently stable, systems, based on keeping the centre of gravity of the system below its centre of buoyancy.

Cost reduction will be achieved by:

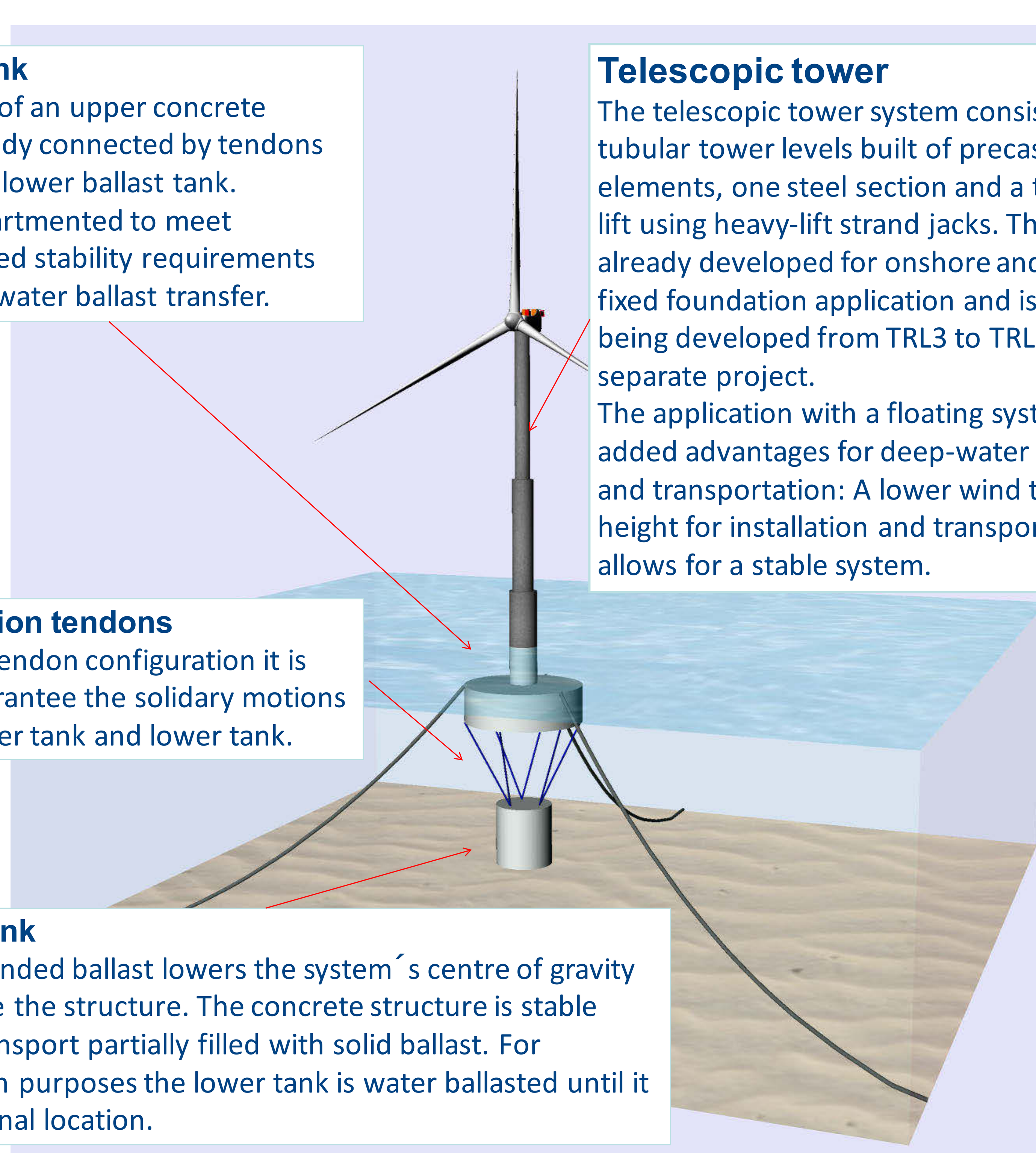
1. Using highly reduced material usage and low cost material: concrete
2. Simple and reliable manufacturing and installation processes.

Methods

Two main novel and ground-breaking systems unite in the TELWIND floating substructure to generate a low-cost integrated system and its simple, fast and economical self-installing process:

1. the evolved spar configuration with **suspended ballast tank**
2. the **self-erecting telescopic tower**

The floating substructure is based on an evolved spar configuration with solidary suspended ballast.



Upper tank
It consists of an upper concrete floating body connected by tendons to a heavy lower ballast tank.
It is compartmented to meet standardized stability requirements and allow water ballast transfer.

Telescopic tower
The telescopic tower system consists of tubular tower levels built of precast concrete elements, one steel section and a tower self-lift using heavy-lift strand jacks. This system is already developed for onshore and offshore fixed foundation application and is currently being developed from TRL3 to TRL7 in a separate project.
The application with a floating system gives added advantages for deep-water application and transportation: A lower wind turbine height for installation and transportation allows for a stable system.

Suspension tendons
The steel tendon configuration it is key to guarantee the solidary motions of the upper tank and lower tank.

Lower tank
The suspended ballast lowers the system´s centre of gravity to stabilize the structure. The concrete structure is stable during transport partially filled with solid ballast. For installation purposes the lower tank is water ballasted until it gets the final location.

A preliminary experimental tank test of the conceptual fundamentals of the solidary suspended ballast tank is performed proofing the feasibility of the innovation.

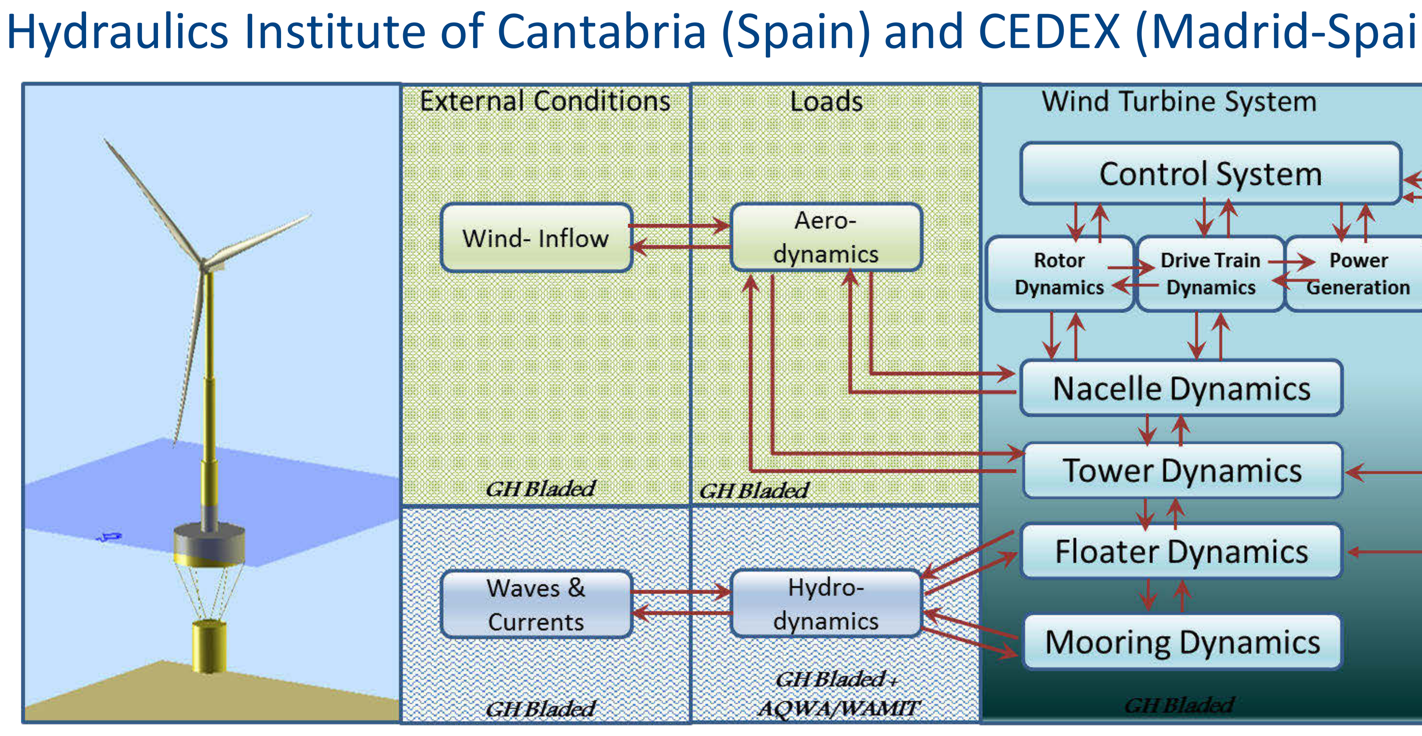
The main activities of the H2020 TELWIND project are :

- Research on the overall stability analysis and detailed structural design
- Suspension tendon design including laboratory testing
- Motions: Fully coupled aero-hydro-servo-elastic simulations
- Construction and installation assessment
- Extensive tank testing campaign in operating and installation conditions
- CapEx and OpEx estimate and financial feasibility study for a single installation and array integration in a multi-megawat floating offshore wind farm

Currently, based on an outline design of the floating substructure first simulations based on a fully coupled model with a 5 MW reference wind turbine are executed.
Main requirements for the design are:

1. Stabilizing the system and mitigate the motions in operating and survival conditions as a guarantee of reliable and safe wind turbine operation.
2. Stabilizing the controller
3. Prevent slack in the tendons

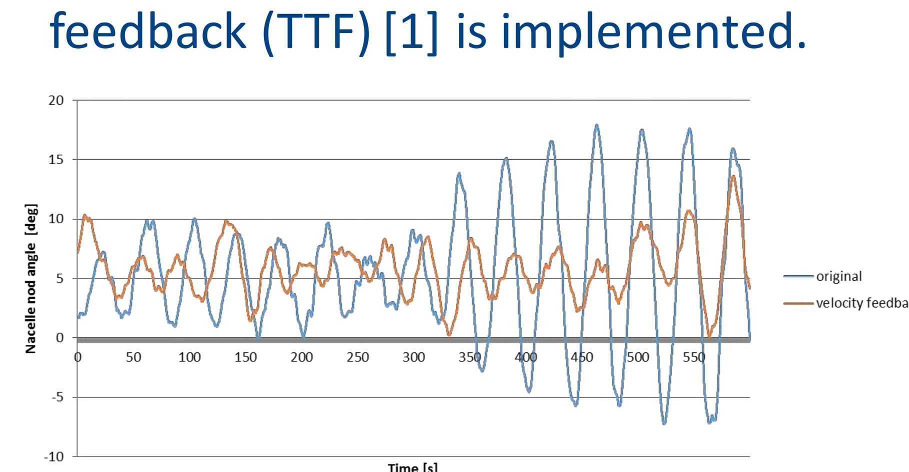
Fully coupled results will be contrasted with the results provided by industry accepted commercial codes from the O&G sector and a purpose-built in-house code. The results will be validated later with scale tests performed in the Hydraulics Institute of Cantabria (Spain) and CEDEX (Madrid-Spain)

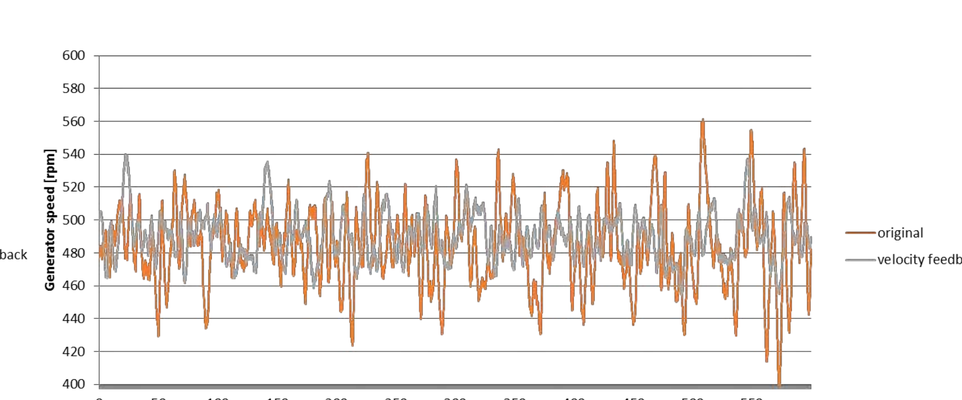


Results

Based on available predesigns, the expected capital expenditure for the TELWIND fully installed system is aligned with actual costs of fixed offshore turbines and an important saving in installation expenditures is expected.

First simulations based on a fully coupled model show good results. Stability of the floating wind turbine and mitigation of motions is reached by additional control features. A pitch command based on tower top fore-aft velocity feedback (TTF) [1] is implemented.





Conclusions

The design of TELWIND leads to a reduction of LCoE of offshore wind at deep water. The concept will provide important material savings of the floating structure, reduce installation costs by avoiding the need for offshore heavy lift equipment and keep the in-shore assembly works within limited drafts, heights and widths to profit from existing in-shore infrastructure.

First simulation have shown that the system can be stabilized by implementing additional control features to meet the requirements.

References

[1] *Control development for floating wind, Feike Savenije, ECN wind energy*