TOWIN JIP – FOWT towing resistance and dynamics

Objective

The objective of the TOWIN JIP is reduce the cost of the towing operation of floating offshore wind turbines (FOWT) by safely increasing the towing speed and expanding the operational criteria. Detailed objectives include:

a. Test and validate methods for accurate prediction of towing resistance in calm water and in waves.
b. Improve insight into the physics of VIM, possible galloping and tow stability in calm water, in current and in waves. Propose semi-empirical calculation methods.
c. Test and validate methods for simulation of the towing operation and prediction of related dynamic motions and towing line loads.
d. Use the tools of a., b. and c. to investigate optimum tow arrangements and mitigation solutions.

The focus in on semi-submersible and spar type of substructures.

Background

While the market for offshore floating wind turbines is expected to increase exponentially in the next decade and further on, one challenge to be addressed is the reduction of LCOE to a competitive value. Part of the costs are related to towing of the FOWTs from the manufacturing site to the wind park. Even more significant in terms of cost will be maintenance activities involving replacement of large components, which also require towing to port. Due to limited number port infrastructures fitted for the purpose, the travelling distance may be quite large for many projects implying operations classified as weather unrestricted (> 72 hours). Altogether, a significant number of towing operations will be needed to install and operate FOWT parks.

The existing procedures and technology for towing of offshore structures has been developed within the oil and gas sector. While this experience will certainly be transferred to the new offshore wind industry, there are important differences which need to be addressed, namely: the different geometry and mass characteristics of the new structures, the much larger number of structures and required operations and the related economy fundamentals. One expects a stronger need for improved efficiency while keeping the safety of the towing operation. This requires an increased insight into the physics of the problem, validated numerical procedures for design and planning and technical solutions to improve performance.

There are several challenges related to the planning and execution of the tow operation. While these are in fact partly related, or coupled, the challenges can be listed as:

- Estimation of the extreme mooring line tensions, due to uncertainties in prediction of towing resistance and dynamic effects.
- Possibility of flow induced motions (FIM), namely vortex induced motions (VIM) and Galloping (e.g. yaw instabilities).
- Possibility of complex coupled motions trigged by FIM and/or instabilities.
- Limited weather windows complying operational criteria.

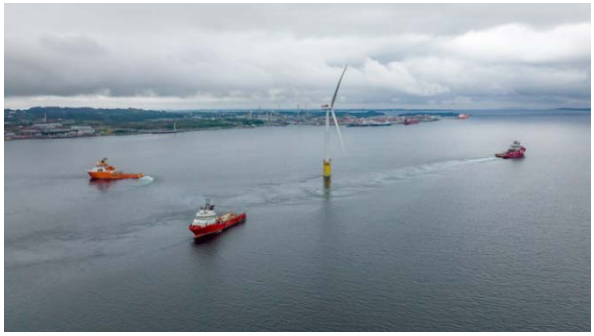

Figure 1 Tow-out of Hywind Tampen FWT. Source: Jan Arne Wold/Woldcam/Equinor [1].

Methods and scope of work

The project objectives will be achieved by combining the existing best knowledge, model testing, field data and numerical modelling.

WP1: Prediction of towing resistance

Towing resistance has two main components which can be estimated independently: calm water resistance and added resistance in waves. FIM may also add to the drag loads. A semi-empirical model will be proposed for the first, based on the cross flow and strip method approach. Added resistance in waves is a 2nd order load with a mean and a slowly varying component. The second is important for the dynamic responses of the tow line [2]. The loads will be based on full QTFs of wave drift forces, with a semi-empirical method for small forward speed effects tested recently in another JIP [3].

WP2: Time domain FIM solver

This WP will establish design method(s) for prediction of VIM and galloping for floating platforms by use of semi-empirical methods. The VIM model will be based on the VIVANA-TD load model [4]-[6], which includes vortex induced force terms. While the model has been validated for VIV responses, the project will generalize it for VIM.

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Some initial studies for a spar platform show promising results [7]. A galloping model based direction dependent current coefficients and instantaneous relative velocities will be tested.

WP3: Model tests and field data

Model tests with a generic FWT in a wave basin is the main scope of this WP. The purpose is to (a) identify the resistance in calm water and added resistance in waves and (b) the dynamic responses during towing in calm water and in waves, including conditions with FIMs.
Field data is of great value for validation of numerical methods and will be used if made available by some of the Participants.

WP4: Towing studies and recommendations

This WP starts with calibration and validation of the numerical models of WP1 and WP2 based on model tests and field data. The related force models will also be integrated into a simulator of the towing operation (SIMO will be used for demonstration purposes).

Second, the numerical procedures will be demonstrated with a representative case study to investigate optimum tow arrangements and mitigation solutions for excessive dynamic responses.

Finally, the project results will be summarized into a set of recommendations for numerical modelling of the tow operation.

Project Deliverables

The project will have the following deliverables:

- Report with state of the art
- Model tests report
- Report with methods/tools for prediction of: towing resistance, FIM, towing stability and towing line loads.
- Report with optimum tow arrangements for representative scenarios.
- Recommended practice for simulation of the tow operation.

Organization

TOWIN is a Joint Industry Project executed by SINTEF Ocean. A project Steering Committee will be established comprising one member from each Partner and with meeting twice a year.

The TOWIN JIP aims at the following participants:

- Energy companies
- Offshore contractors
- Designers of floating wind turbines
- Wind-park developers
- Classification Societies and regulatory authorities.

The project will tentatively start during Q1 of 2024 and have a duration of 2 years.

Participation fee

- Energy companies: 60 kEUR per year.
- Other: 20 kEUR per year.

Total of two payments corresponding to two years. The tentative total budget is 500 kEUR.

References

[1] Durakovic, 'First Hywind Tampen Floating Wind Turbine Heads Offshore', *Offshore Wind*, Jun. 03, 2022. https://www.offshorewind.biz/2022/06/03/first-hywind-tampen-floating-wind-turbine-heads-offshore/ (accessed Oct. 14, 2022).

[2] Brun-Lie, Thekla, 2021. Numerical simulations of offshore towing of floating wind turbines. MSc thesis, NTNU.

[3] SINTEF Ocean, 2021. Assessment of the EXWAVE 2 methods to predict low frequency motions of FPSOs. Report no. OC2021 F-068.

[4] M. J. Thorsen, 'Time Domain Analysis of Vortex-Induced Vibrations', PhD Thesis, Norwegian University of Science and Technology, Trondheim, Norway, 2016.

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[6] S. Kim, 'Non-Linear Time Domain Analysis of Deepwater Riser Vortex-Induced Vibrations', PhD Thesis, Norwegian University of Science and Technology, Trondheim, Norway, 2021.

[7] E. Passano, G. Grytøyr, H. Haslum, H. Lie, and D. Yin, 'Simulation of VIM of an offshore floating wind turbine', in *Proceedings of the ASME 2022 41st International Conference on Ocean, Offshore and Arctic Engineering*, Hamburg, Germany, 2022, no. OMAE2022-79006.

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