Report 2022
Task 30

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Offshore Code Comparison Collaboration, Continued with Correlation and unCertainty (OC6)

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The present extension of IEA Wind Task 30, named the Offshore Code Comparison Collaboration, Continued, with Correlation and unCertainty (OC6), was initiated in 2019.

The goal of OC6 is to validate engineering-level offshore wind modelling tools that consider the simultaneous loading from wind and waves, as well as the interaction with the structural dynamics of the system and its control algorithms (aero-hydro-servo-elastic tools). In addition, the OC6 project includes higher-fidelity models (such as computational fluid dynamics models - CFD) to better understand the underlying physics. A three-way validation is performed where both the engineering-level modelling tools and higher-fidelity tools are compared to measurement data. The results will be used to help inform the improvement of engineering-level models, and/or guide the development of future test campaigns.

In 2022, Phase III of the OC6 project was successfully completed. A total of 29 companies from 10 different countries participated in this phase, which included research organisations, as well as industry participants (e.g., certification agencies, electric utilities, testing laboratories, designers, and engineering consultancies). This phase investigated the accuracy of different aerodynamic modelling approaches in predicting loads in floating offshore wind systems, which experience significant motions due to wind and waves. High-fidelity and mid-fidelity models were validated against measurements conducted at Politecnico di Milano's wind tunnel, using a robotic excitation system to move a wind turbine independently in surge and pitch directions. The project's findings provide valuable insights into modelling the aerodynamics of floating wind systems, leading to the development of more reliable and optimised designs.

Introduction

The OC3 (Offshore Code Comparison Collaboration) – OC6 projects were created under the Wind framework of the International Energy Agency (IEA) to address the need to verify and validate the load predictions of coupled modelling tools for offshore wind design. These projects have proven to be vital to the companies developing and improving the numerical modelling tools used to design offshore wind systems, as well as designers, certifiers, and research institutes who apply these tools for design, research, and instruction (see Table 1 for current OC6 members).

Within the previous OC3-OC5 projects, differences were observed between the modelling approaches and the measured data, and often times the reason behind the differences was not well understood. The focus of the OC6 project is to develop more focused validation projects to better understand some of these observed differences and to address other modelling/validation aspects that were outside the scope of the previous OC projects. The focus of these studies is physical phenomena that have demonstrated a large impact on accurately modelling the global response behaviour of offshore wind systems, and will be investigated through measurement data obtained across multiple test

Table 1. Countries Participating in Task 2022.

	COUNTRY	INSTITUTION(S)
1	**China**	Task 30: China General Certification Centre, China State Shipbuilding Corporation, Dalian University of Technology, ClassNK, CSIC Haizhuang Windpower Co., Ltd
2	**Denmark**	Task 30: Technical University of Denmark (DTU)
3	**France**	Task 30: Bureau Veritas, Électricité de France, IFP Energies Nouvelles, PRINCIPIA, Vulcain Engineering, EDF Task 47: Onera
4	**Germany**	Task 30: Hamburg University of Technology, University of Stuttgart Task 47: Technical University of Berlin
5	**Ireland**	Task 30: University of Galway and Wood Group
6	**Italy**	Task 47: Politecnico di Milano , University of Florence
7	**Netherlands**	Task 30: Maritime Research Institute Netherlands, WyndTek Task 47: Netherlands Organisation for Applied Scientific Research (TNO), TU Delft
8	**Norway**	Task 30: Norwegian University of Science and Technology, Institute for Energy Technology, 4Subsea
9	**Spain**	Task 30: Centro Nacional de Energías Renovables, eureka!, Tecnalia, Universitat Politècnica de Catalunya, SAITEC Offshore, IH Cantabria, SENER, IDOM, UPV/EHU, Coremarine, Siemens Industry Software
10	**U.K.**	Task 30: DNV, Newcastle University, University of Strathclyde, Queen's University Belfast, University of Plymouth
11	**U.S.**	National Renewable Energy Laboratory, Shell

campaigns. In addition, the OC6 project will employ higher-fidelity models. such as computational fluid dynamics models, to better understand the underlying physics of the phenomena. This will constitute a three-way validation where both the engineering-level modelling tools and higher-fidelity tools will be compared to measurement data. The results will be used to help inform the improvement of engineering-level models, and/or guide the development of future validation campaigns.

Progress and Achievements

The OC6 project consists of four phases, focused on four different phenomena critical to the accurate modelling of offshore wind systems. In 2022, activities for Phase III were completed, and work was initiated on Phase IV.

Phase III was focused on gaining a better understanding of the aerodynamic modelling needs for floating offshore wind systems that will experience large motions due to the compliance of the support structure. Numerical models of the Technical University of Denmark 10 MW reference wind turbine were validated using measurement data from a 1:75 scale test performed during the UNsteady Aerodynamics for FLOating Wind (UNAFLOW) project and a follow-on experimental campaign, both performed at the Politecnico di Milano wind tunnel (see Figure 1).

Validation of the models was performed by comparing the loads for steady (fixed platform) and unsteady (harmonic motion of the platform) wind conditions. The platform was forced to oscillate in the surge and pitch directions under several frequencies and amplitudes, resulting in a wind variation that impacts the rotor loads (e.g., thrust and torque). For the tested conditions, the system response was almost steady state aerodynamics, with only a small hysteresis observed in airfoil performance when undergoing angle of attack variations in attached flow.

Although the rotor speed and blade pitch angle were held constant during the Phase III experiments, in real wind turbine operating

Figure 1. The 1:75 scaled DTU 10 MW reference wind turbine in the Politecnico di Milano wind tunnel.

conditions, the surge and pitch variations would result in rotor speed variations and/or blade pitch actuations, depending on the wind turbine controller region that the system is operating. Additional simulations with these control parameters were conducted which indicated the need to account for dynamic inflow when there are changes in the flow conditions due to rotor speed variations or blade pitch actuations in response to surge and pitch motion. Numerical models that did not account for dynamic inflow effects predicted rotor loads that were 9% lower in amplitude during rotor speed variations and 18% higher in amplitude during blade pitch actuations (see Figure 2). A summary of the findings from this study has been recently published in Wind Energy Science, Volume 8 [1], along with the Definition Document for this phase in the OC6 Phase III Definition Document [2].

A separate working group was created in Phase III to focus on the validation of the wake behaviour, led by the University of Florence. The findings from this work are being reviewed presently and will be published in 2023.

Phase IV was also initiated in April 2022 and is focused on validating the accuracy of the coupled dynamic response (aero, hydro, and structural) of a 1:43 scale model of the Stiesdal Tetraspar floating wind system under combined wind and wave loading. This novel design features multiple, connected, thin members as well as a hanging keel for stability. These features offer an opportunity to assess the capabilities of floating wind design tools to model the hydrodynamics of a more advanced, sleek design. Furthermore, an internal loading through tension measurements in the keel lines. Both engineering models and high-fidelity models are being developed in this phase.

Additionally in 2022, the Definition Document for Phase I of the project was published [3], as well as some of the final simulation results from the CFD modelling work [4].

Highlight(s)

During Phase III of the project, IEA Wind Task 30 collaborated with participants from IEA Wind Task 47. Task 47: TURBulent INflow Innovative Aerodynamics (TURBINA) is focused on validating aerodynamic modelling approaches, typically regarding land-based turbines. Additionally, it discusses approaches for obtaining the measurements needed for the validation of MW-scale turbines. Participants in Task 47 were allowed to freely participate in Phase III of Task 30. The collaboration was fruitful, as it resulted in a broader integration of knowledge from those focused on aerodynamic models with those more focused on offshore wind applications.

Outcomes and Significance

Through the work of the OC6 Phase III project, 29 academic and industrial partners from 10 different countries validated their modelling approaches and tools for the prediction of aerodynamic loads and wakes of floating wind systems. This work has shown that the motion of the turbine itself does not require an unsteady aerodynamic modelling approach to

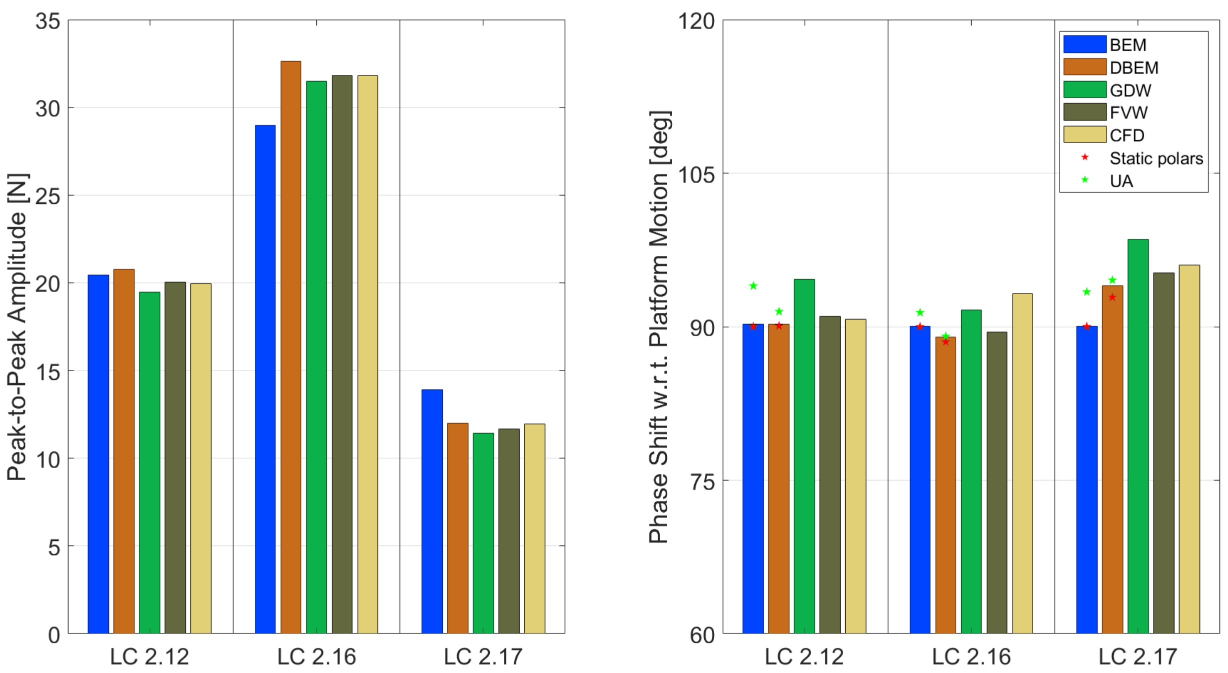

Figure 2. Left: Aerodynamic rotor thrust peak-to-peak amplitude in Load Case (LC) 2.12 (constant rotor speed and blade pitch), 2.16 (varying rotor speed), and 2.17 (varying blade pitch). Right: Phase shift with regard to the platform motion.

accurately predict the loads in the turbine. However, a realistic condition where blade and rotor speed control are included will need unsteady aerodynamic models for accurate load prediction. The project's findings provide valuable insights into modelling the aerodynamics of floating wind systems, which will lead to the development of more reliable and optimised designs.

The modelling information and simulation results from the OC6 Phase III project have been made available to the public through the U.S. Department of Energy Data Archive and Portal, https://a2e.energy.gov/projects/oc6. The data set developed during the UNAFLOW project is also available at Fontanella [5]. Public availability is furthermore intended to provide a platform for additional research in the area.

Next Steps

The OC6 project will be completed in the following year and involves finishing Phase IV's work focused on wind and wave modelling of the innovative Stiesdal TetraSpar design. Similar to Phases I and III, a subgroup dedicated to CFD work will have more detailed discussions on these models. Additionally, the Task members will concentrate on developing a new IEA Wind Task that builds on the previous success of the OC3 – OC6 projects. We will hold multiple planning meetings to identify the new project's needs and focus. Currently, we are developing a phenomenon and identification ranking table to pinpoint any outstanding modelling and validation requirements, which will aid in defining the new project's focus.

References

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