High-Fidelity High-Performance Modelling of Renewable Energy Systems

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Offshore Ocean platforms, Offshore Wind Turbines (fixed or floating) and Wave Energy converters (WEC) are often designed, analyzed via potential-flow or empirical-based tools. This is due to gained experience and trust on these type of tools in the past, to the generally lower influence of viscosity in wave-related phenomena and their low computational cost. Nowadays, with the democratization of viscous-flow tools (CFD, or Computational Fluid Dynamic), and HPC (High-Performance Computing) hardware, almost all fields of Maritime problems are seeing an increased use of these higher-fidelity tools. This is true for ships, underwater vehicles, offshore platforms and several other ocean engineering systems. But for Renewable Energy Systems the use of high-fidelity CFD has been less widespread. At WaVEC-Offshore Renewables Institute (www.wavec.org) and at University of Duisburg-Essen, ISMT Institute (www.uni-due.de/IST/index_en.shtml) we promote the use of CFD to analyze Renewable Energy Systems. But the problems to analyze involve multi-physics (fluid and structure), moving structures, moorings, control systems, hydrodynamic and aerodynamics, unsteady calculations, turbulent flows and complex geometries. This implies large problems and high computational times. Also, in order to increase the credibility of these calculations, modern Verification&Validation (V&V) techniques involve several calculations in order to estimate numerical uncertainties. High-Performance-Computing (HPC) resources are of paramount value for these types of high-fidelity calculations, which permit to analyze all these structures with more accuracy, more physical aspects and ultimately to decrease their (LCOE) costs.

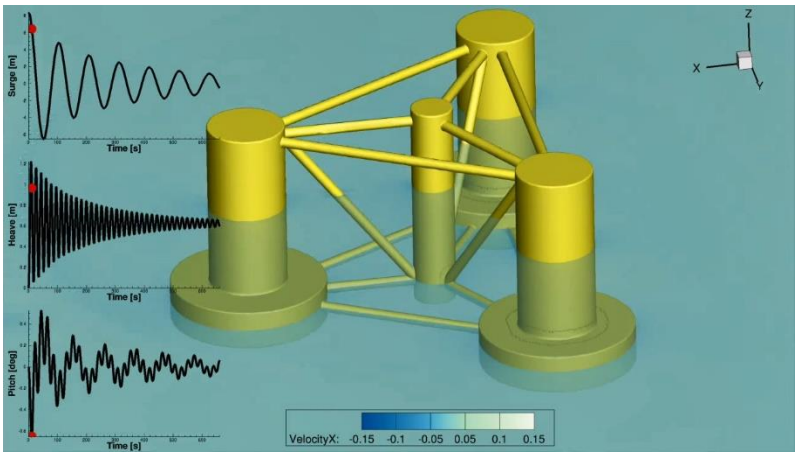

Fig.1 – Unsteady non-linear RANS calculation of a Floating-Offshore Wind Turbine Platform. Calculation took around 3 weeks in 200 cores of a modern HPC cluster. Click for **animation**.

In this presentation, ongoing high-fidelity and high-performance CFD work related with the simulation of Floating Offshore Wind Turbine (FOWT) platforms [1,2] will be presented (see example in the figure and movie below). First, an introduction on FOWTs is given. Afterwards the open-usage/open-source CFD code ReFRESCO (www.refresco.org) used is introduced and its performance assessment in two HPC clusters (MagnitUDE in Germany and Navigator in Portugal) is shown. Afterwards, some aspects related to modern Verification techniques [3] used to assess the accuracy of the results are considered. Finally, the flow and motions of these FOWT are analyzed and Validation against existing experimental data presented. All this will be accompanied with HPC aspects like memory consumption, CPU times, MPI communication and total computational costs.

References

1. Burmester, S., Vaz, G., Gueydon, S. and Moctar, B. O., *Investigation of a Semi-Submersible Floating Wind Turbine in Surge Decay using CFD*, in Ship Technology Research, December2018.

2. Make, M. and Vaz, G., *Analysing Scale Effects on Offshore Wind Turbines using CFD*, In Journal of Renewable Energy, Volume 83 pages 1326-1340, November 2015.

3. Verification and Validation of Industrial CFD, Course at OMAE2019, Glasgow, Scotland, June2019.