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ENERGÍAS RENOVABLES
ADltech

ENGINEERING HIGH COMPUTED NEEDS FOR OFFSHORE WIND DEVELOPMENTS

EERA Workshop

How Wind Energy can make the most of advances in High Performance Computing (HPC) ?

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1- From Onshore to Offshore



Source NREL

Design, simulation, certification, wind farm design, wind farm control, digitalization, value chain, commissioning, O&M, exploitation, logistics, manufacturing, decommissioning, reuse, recycle...



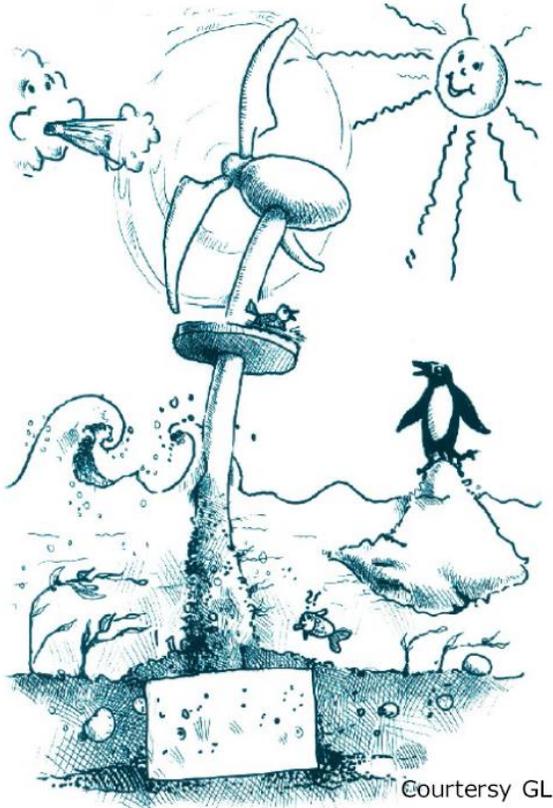
Onshore Engineering Standards

- IEC Winds: I, II, III, S: max // mean // EoG 50 years // EoG 1 year
- IEC Turbulence intensity
- Wind direction: DC error // fast wind direction changes
- Failures: actuators, sensors, network,...
- Idling situations
- Start - ups and shut downs
- Transportation, installations...

One full iteration deals with Fatigue and Extreme set of load cases

+/- **4000** load cases

2- Engineering Standards IEC 61400 EdX



Offshore Engineering Standards

- All onshore situations plus
- Waves: amplitude and directions
- Currents : amplitude and directions
- Ice: floating and iced surface
- Fix structures
- Floating substructures
- Mooring system
- New failures

One full iteration deals with Fatigue and Extreme set of load cases

Over **450.000** load cases (112 times onshore case)

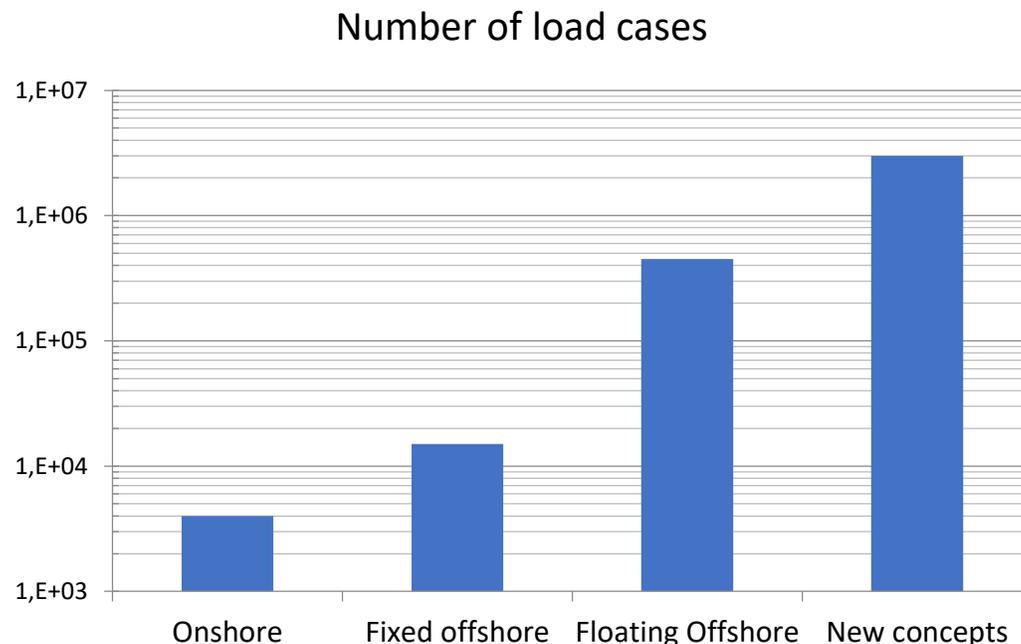
2- Engineering Standards IEC 61400 EdX

Some funny things about sea, waves and floating substructures

- Lower frequencies of waves comparing with wind speed
- Lower frequencies for floating substructures

Onshore simulation needs: Initialization + **600 seconds** for longest simulations

Offshore simulation needs: Longer initialization + **3600 seconds** for longest simulations



Do we need 112 to 750 times the computing time effort for every iteration?

Some funny things about sea, waves and floating substructures

- Lower frequencies of waves comparing with wind speed
- Lower frequencies for floating substructures

Then, **onshore** simulation needs:

Initialization + **600 seconds** for longest simulations

Then, **offshore** simulation needs:

Longer initialization + **3600 seconds** for longest simulations

Do we need [112 to 750] x6 computing time effort?

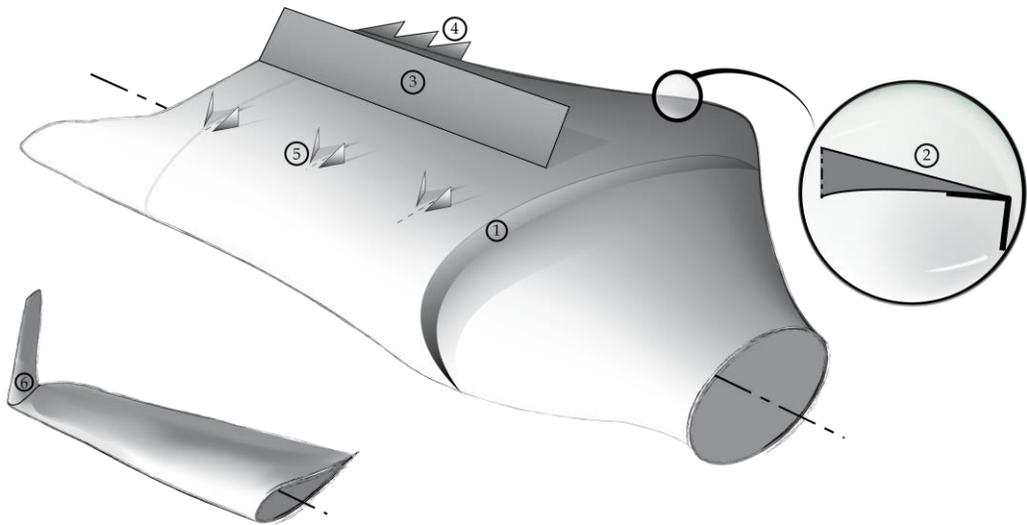
3- Large-Flexible wind turbine simulation challenges

LCOE reduction force to larger and flexible wind turbines

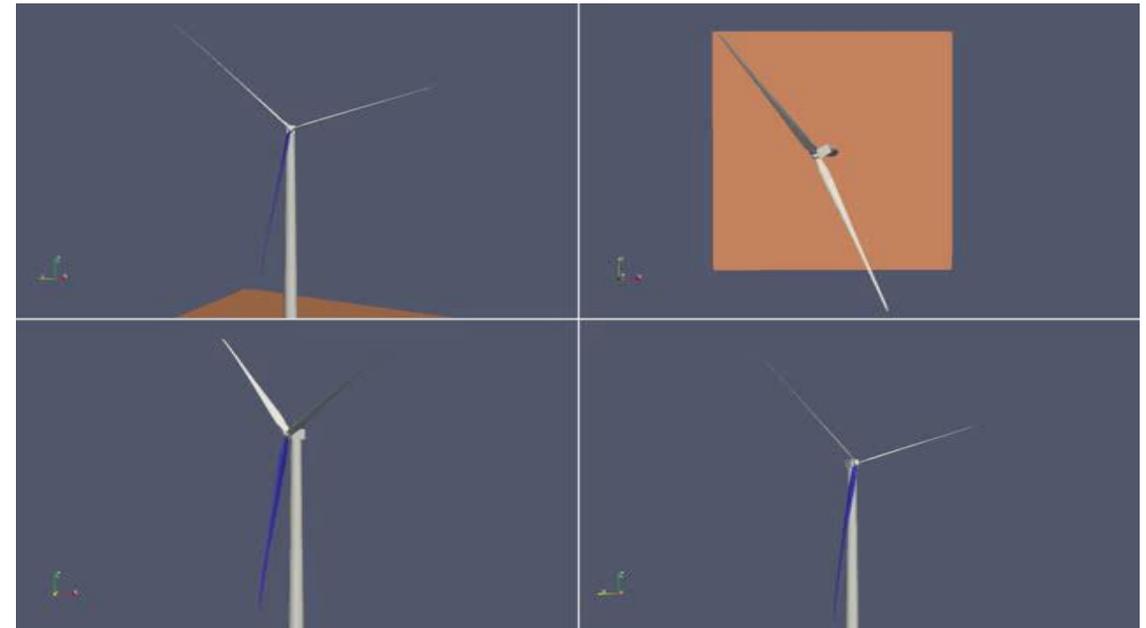
30/50 objectives force Europe/World to massive floating offshore deployment

Which challenges do we face in terms of design, analysis and simulations?

BLADE Technology



Simulation challenges



AeroWindQ3D @CENER

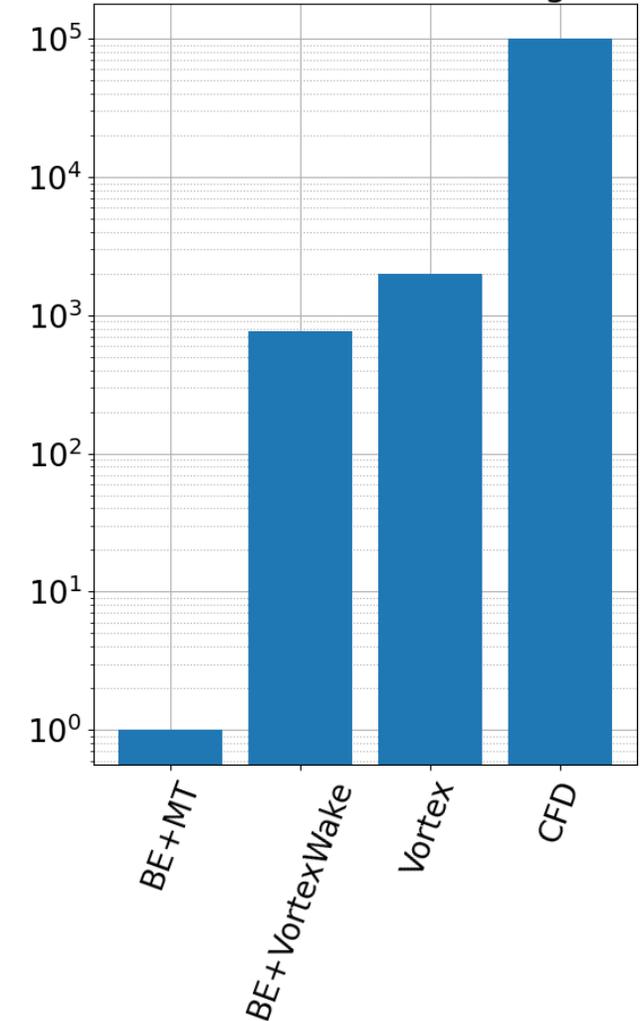
3- Large-Flexible wind turbine simulation challenges

Blade modelling increases computation effort in coupled simulations:

Levels of **Aerodynamic** Modelling

- BEMT offshore case requires de order of **1 computing sec/simulated sec** in 1 core
- Vortex wake computation requires in the **32 computing sec/simulated sec** in 24 cores, which deals with **770 times** BEMT computing BEM effort
- Complex aerodynamic + Vortex wake computation requires **2000 times** BEMT computing effort
- Blade and wake resolve with CFD requires **100.000 times** BEMT computing effort

estimation Aero modelling cost

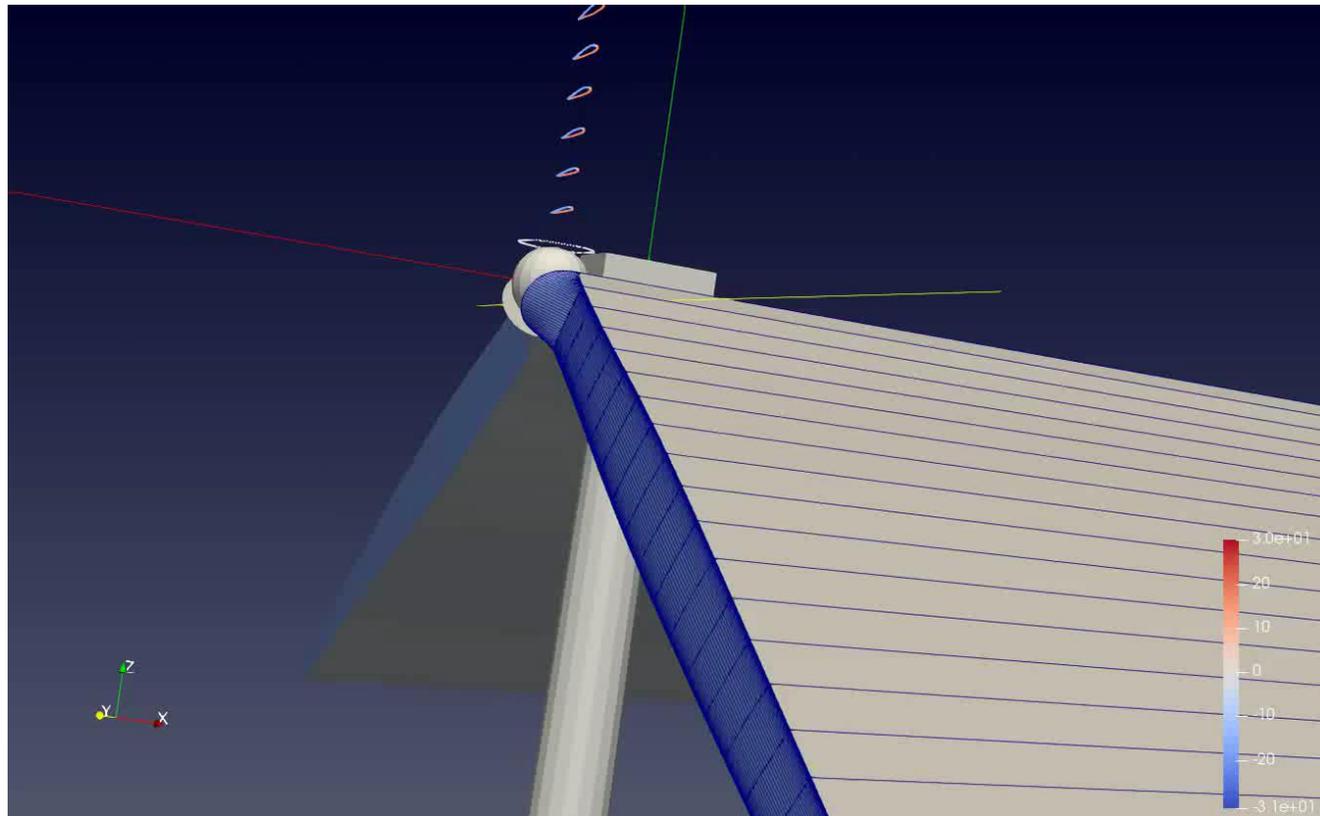


3- Large-Flexible wind turbine simulation challenges

Blade modelling increases computation effort in coupled simulations:

Levels of **Structural** Modelling for coupled simulations

FEM modelling requires **28 times** than classical modal analysis



AdapFoil ©CENER

3- Large Flexible wind turbine simulation challenges

Floater is the main drive in the CAPEX for FOWT

Market expectations opens the door to a good number of new solutions for floaters

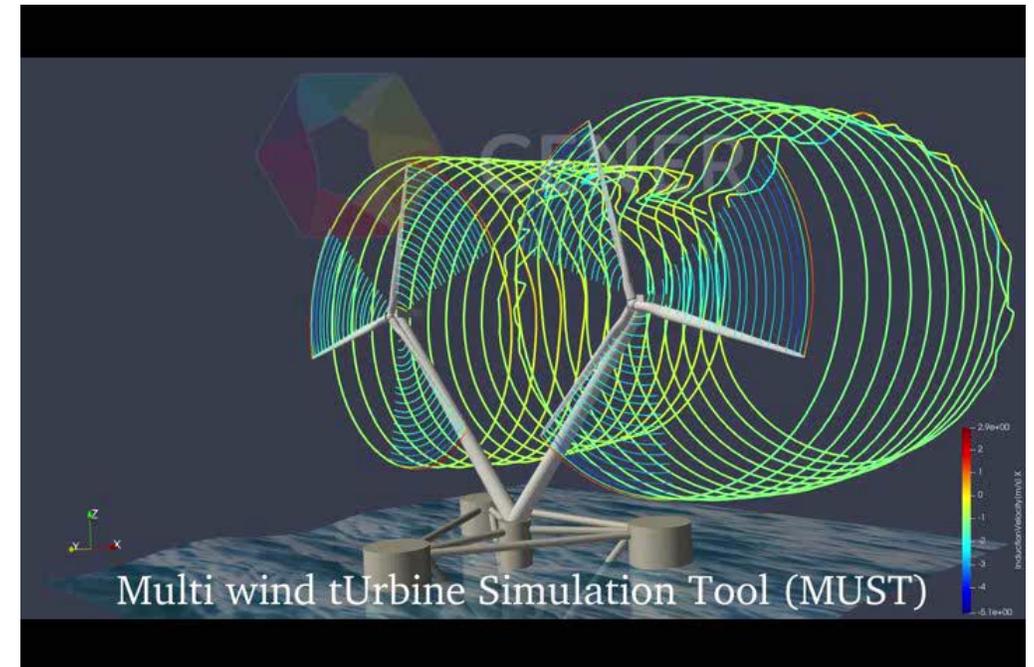
Among others, those focused on **multi wind turbines** for the same floater

Floater Technology



Simulation challenges

MUST @CENER



4- Coupling hydrodynamics and aeroelasticity

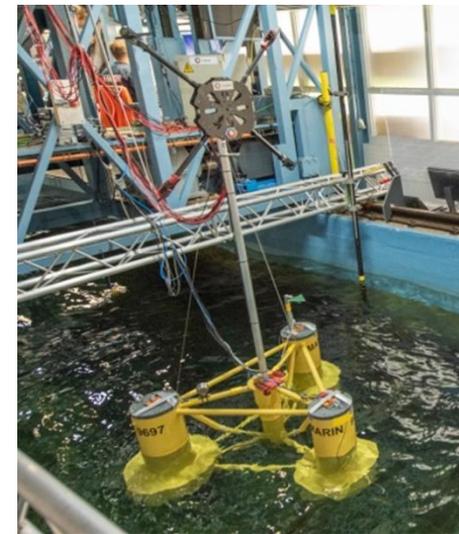
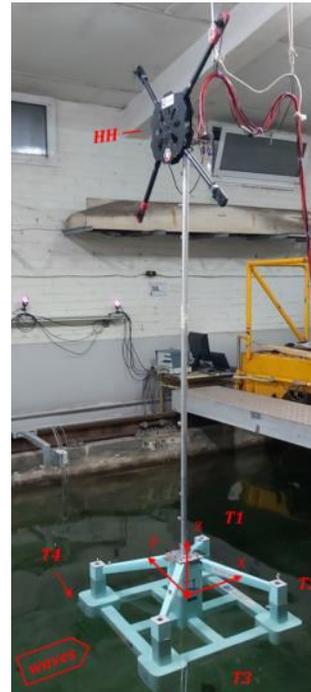
Coupling **hydrodynamics** increases computational effort by a factor of **+60%** with respect to onshore simulations

There exists dedicated different levels of fidelity tools

- Simplest tools are integrated with aeroelastic tools by reduction hypothesis
- Commercial and open access dedicated softwares offers coupling with different aeroelastic models

Needs for:

- floater design and characterization
- coupled analysis
- tank test validation
- field test validation

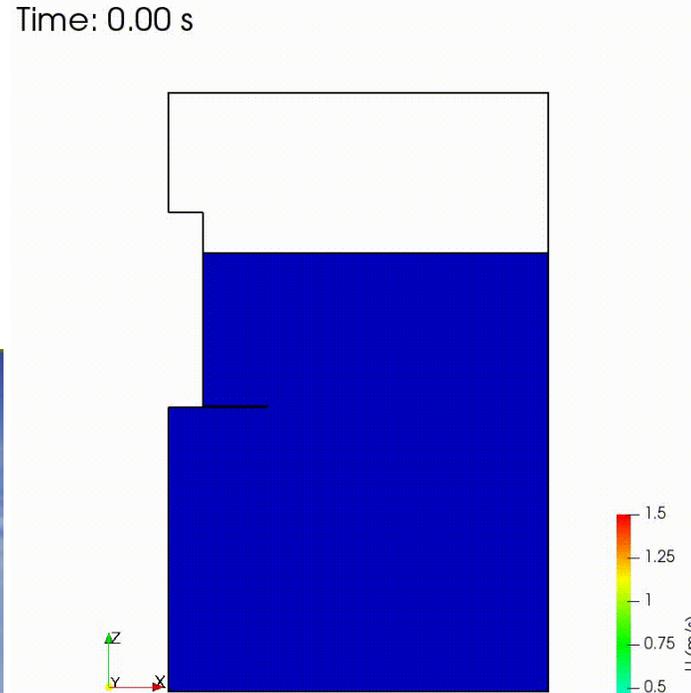
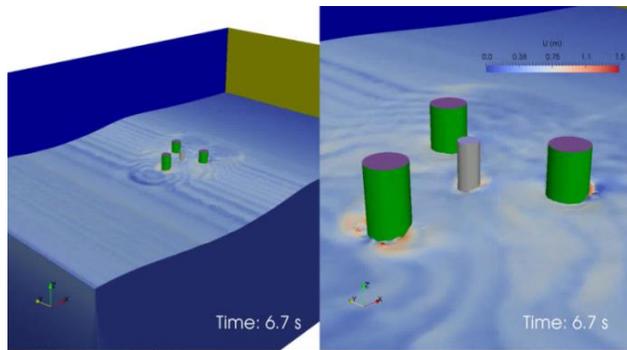


4- Coupling hydrodynamics and aeroelasticity

CFD computation a new option to safe costs

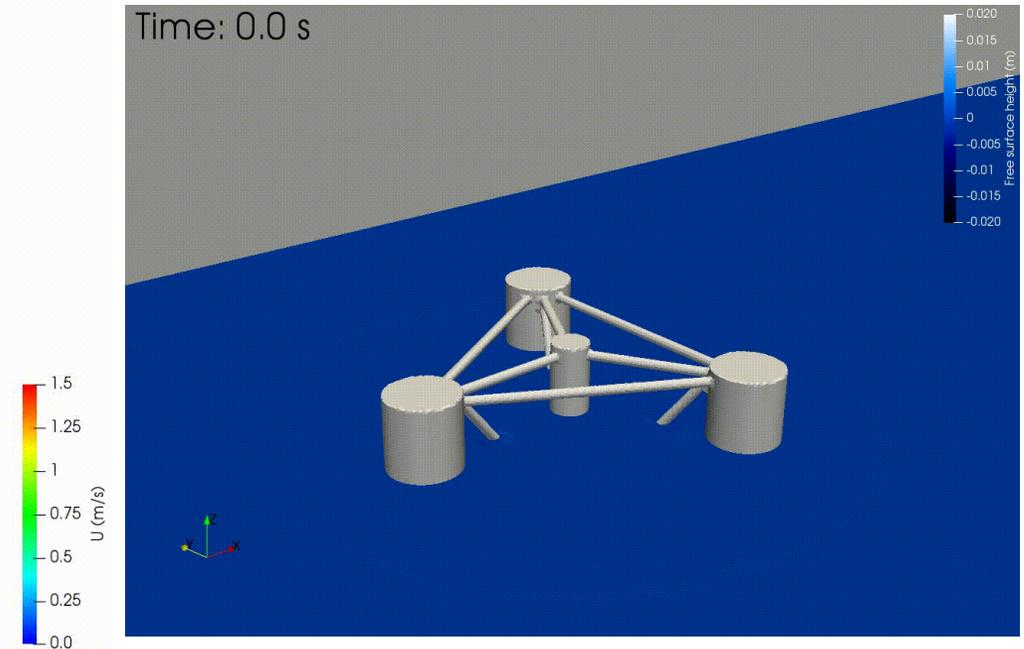
Floater Technology

Floater Design process



Simulation challenges

cenerFOAM ©CENER



Components: columns, tendons, pontoons, heave plates

Cases: free decay, forced movements, weathervaning, marine maneuvers...

5- Coupling hydrodynamics and aerodynamics

FLOATING OFFSHORE WIND TURBINE SIMULATION:

MESHES

- Rotor Mesh: 2 M Cells
- Platform + Tower Mesh: 2 M Cells
- Background Mesh: 3 M Cells

Total Mesh: **7M Cells, 2GB**

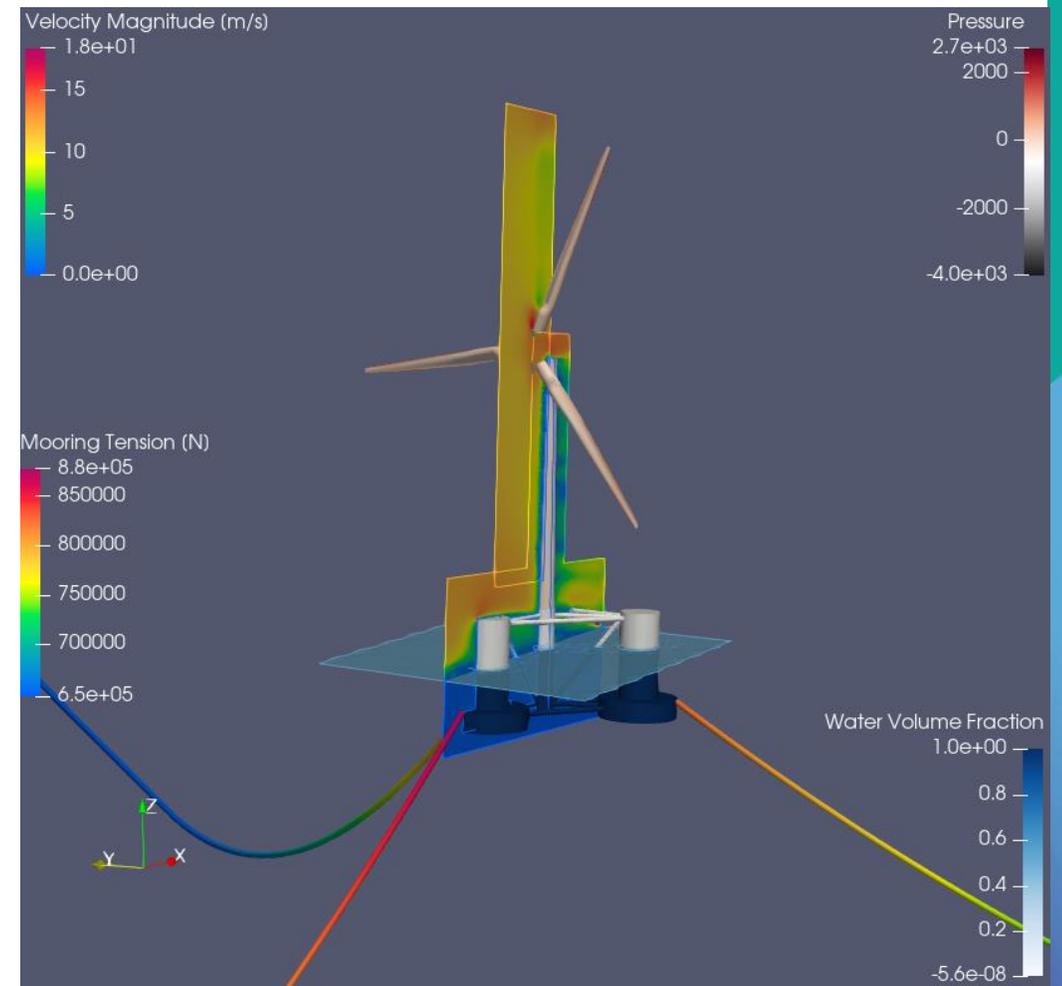
Mooring lines modelled w/ Moody

Simulation time: **69 secs**

Decomposition: **48 cores**

Total CPU time for the simulated time: **20 days**

Time-step folder size: 2 GB



6- Summary and tendencies

Design standards requires between 112 to 750 times more cases in offshore than in onshore

Dynamics of floaters requires longer simulations reaching to more than 6 times longer simulations due to dynamics

Hydrodynamics impose longer simulations for its own complexity multiplying by a factor of +60% the computational costs

Hydrodynamics can be computed at several levels of fidelity and with different levels of integration with the WT

Floater motions, longer and flexible WT, impose new needs that require higher precision simulations increasing in a factors from 28 to 20.000 times for specific load cases simulations

So.....

$[112 \text{ to } 750] * 6 * 1,6 * [28 \text{ to } 20.000] = \text{“COMMON SENSE”} + \text{higher computation effort}$

Let's use common sense....

.... but definition of common sense by www.wordnik.com:

“Sound judgment not based on specialized knowledge.”

... while by grandmas states that is:

“ the less used of the senses”

Be aware when high computed resources are uncountable and available!!

Muchas Gracias

