Case studies for the Danish EUDP project “IEA OES Task 10 Phase III – WEC Modelling”

Milestone M1 report

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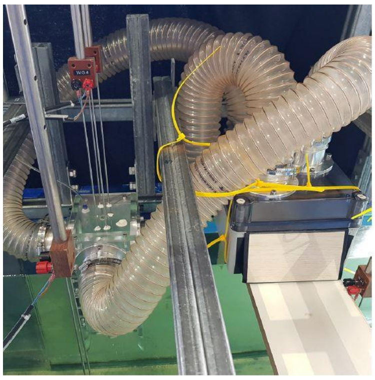

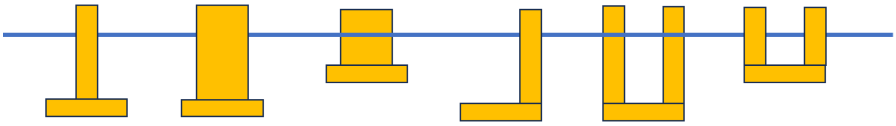

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Contents

1 Background

The project "IEA OES Task 10 Phase III – WEC Modelling" is a publicly-funded research project under the Danish Energy Agency EUDP grant with Journal no. 134232-510153, see Figure 1. As part of the initial period of the project, a selection of three test cases has been defined under WP2 (see Figure 2). The present report forms the deliverable for Milestone "M1: Case studies defined".

Nøgletal

Period: 2023 - 2026
Funding year: 2023
Own financial contribution: 0.82 mio. DKK
Grant: 1.69 mio. DKK
Funding rate: 67 %
Project budget: 2.51 mio. DKK

Kategori / Category

Programme: EUDP
Project type: IEA
Case no.: 134232-510153

Deltagere / Participants

BUILD - Institut for Byggeri, By og Miljø - AAU (Main Responsible)

Partners and economy

Partner	Subsidy	Auto financing
BUILD - Institut for Byggeri, By og Miljø - AAU	0,79 mio. DKK	0,34 mio. DKK
Development v/Kim Nielsen	0,19 mio. DKK	0,12 mio. DKK
Danmarks Tekniske Universitet (DTU)	0,49 mio. DKK	0,21 mio. DKK
FLOATING POWER PLANT A/S	0,22 mio. DKK	0,15 mio. DKK

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Figure 1: Overview of the Task 10 – Phase III project [https://energiforskning.dk/en/node/16789].

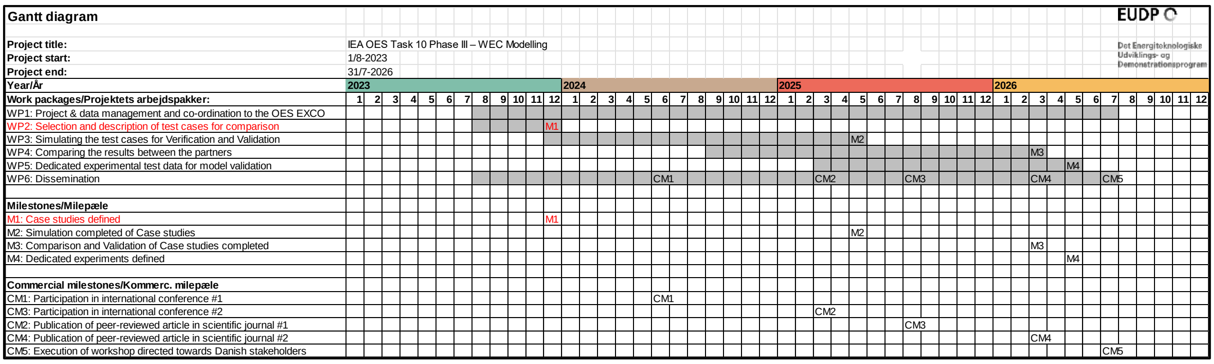

Figure 2: Gantt chart for the Task 10 – Phase III project. WP2 and M1 are highlighted with red font.

2 Case 1: Oscillating Water Column

The Oscillating Water Column (OWC) case will follow up on previous work during the first two phases of the project. Experiments have been conducted at DTU with the chamber shown in Figure 3, using both one- and two-way power absorption. To achieve one-way absorption, a lightweight passive valve allowed air to pass easily into or out of the chamber, and then forced air through an orifice plate (simulating the turbine) during the opposite part of the cycle. This passive valve did not seal perfectly. In addition, passive valves of this type have inertia that may influence their performance. The role of air compressibility in the performance of the OWC also remains unclear and requires controlled investigation. We therefore propose the following future experiments to deal with these shortcomings:

1. Design and build an active venting valve that can be accurately controlled to give a fast response with better sealing, and thus less loss of energy on the passive stroke.
2. Modelling of air-compressibility effects inside the OWC by adding an equivalent extra air volume scaled to the real full-scale air dynamics.
3. Experimental confirmation of the power loss due to air flow through the orifice plate. The head loss coefficient was originally measured to be Cd=0.64 in a quasi-static test for an orifice plate of 14mm diameter. Is this value still accurate under dynamic conditions over a range of frequencies? Is it the same for other diameters?

Testing may be undertaken at DTU, or at other facilities (for example in Ireland).

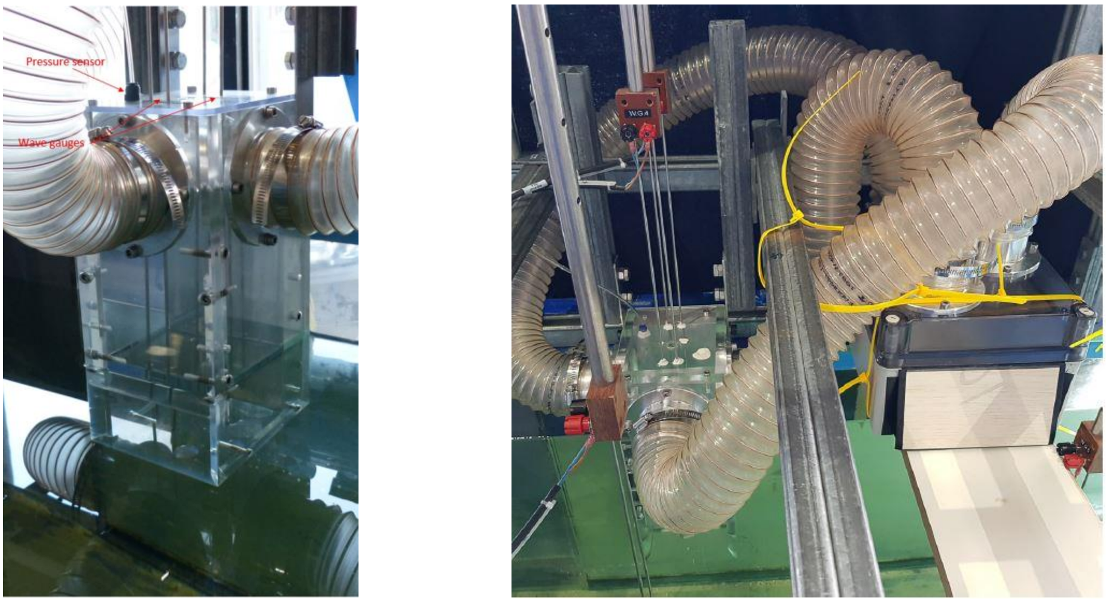

Figure 3: The DTU OWC chamber in the wave tank with the one-way venting valve system attached.

3 Case 2: Sphere

The sphere cases are a continuation of previous work which includes a series of simple but highly accurate experimental datasets for validation of numerical models. The work includes:

1) **Decay (completed)**, completed as part of the "Task 10 Phase II" project, and published in 2021 [https://www.mdpi.com/1996-1073/14/2/269]
2) **Excitation (ongoing)**. Tests and calculations are complete, analysis and publication are under way.
3) **Radiation (in preparation)**. Initial test trials have been completed for prescribed heave motion, but the final tests for surge and heave await the arrival of a new actuator and slide-system that has been ordered, but not yet received.
4) **Freefloat (planned/proposed).** Uncontrolled and freely floating and/or passively moored setups.
5) **PTO (planned/proposed)**. Controlled tests with power absorption in waves.

The heave decay test case is illustrated in Figure 4 and the excitation case is illustrated in Figure 5.

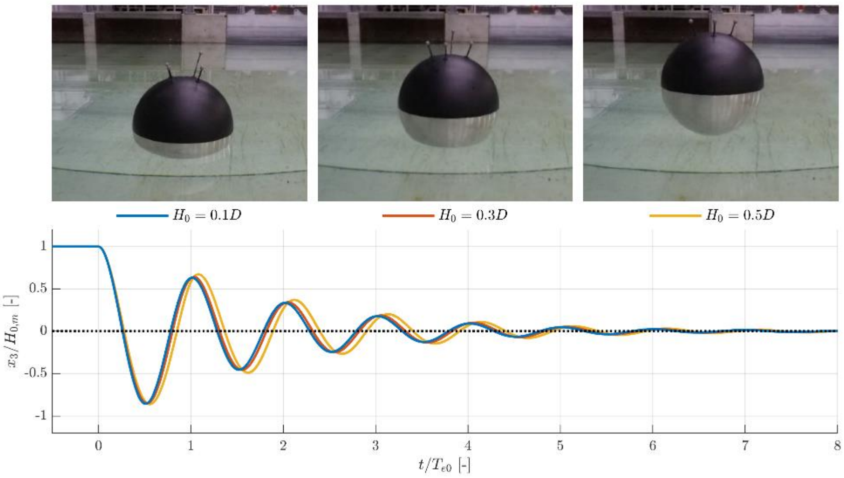

Figure 4: Sphere heave decay test case [https://www.mdpi.com/1996-1073/14/2/269].

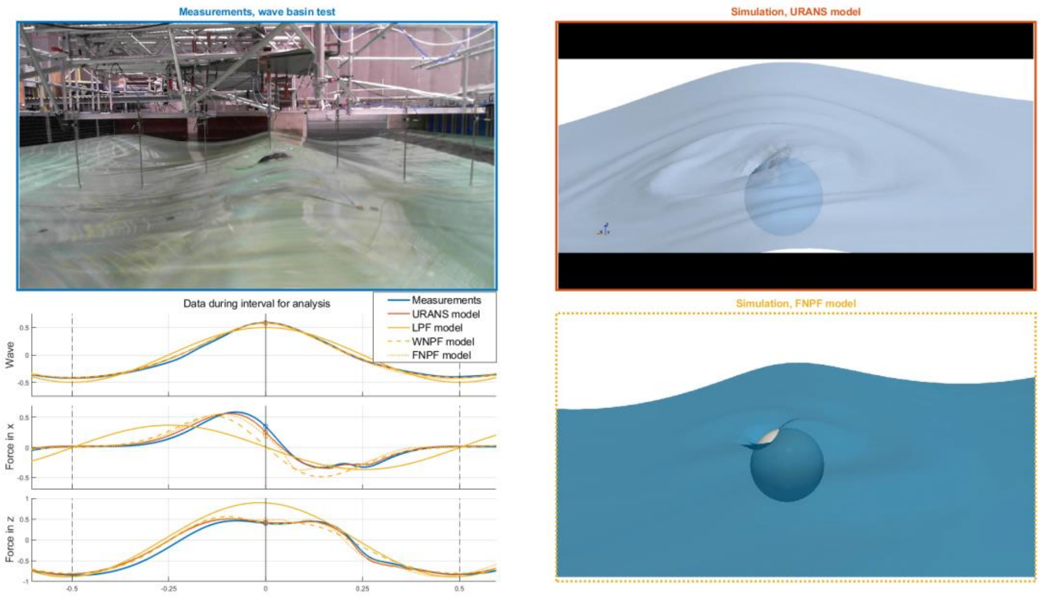

Figure 5: Sphere excitation test case R12. Screenshot from animation.

4 Case 3: Simple components in isolation and combination

Case 3 is a new test case that has not been investigated previously. It will include several types of simple geometries which are used as "building blocks" for floating platforms for offshore wind and wave-energy deployments. These cases are defined to cover possible simple *components in isolation* (one single element, see examples in upper part of Figure 6) and simple *components in combination* (see examples in lower part of Figure 6). The components in isolation include single platform legs that penetrate the water surface (example a1, a2 and a3 in Figure 6, where the width and draft of the leg could be a parameter for investigation), and submerged heave plates of various sizes and draft as illustrated in a4, a5 and a6 in Figure 6. The components in combinations will interact hydrodynamically, and are therefore more complicated to model correctly, but they better represent the correct behaviour and shape of typical platforms. Cases could include a leg with a heave plate (example b1, b2, b3 and b4 in Figure 6), and shapes with two legs connected by a heave plate (example b5 and b6 in Figure 6). In b5 and b6 there is a stronger hydrodynamic interaction, as the wave generated by the motion of the structure will be trapped between the two legs.

The following activities are suggested:

1) A general setup for making forced oscillations is constructed. Measurements of forces will be included in the connection between the fixation to the oscillation mechanism and the object.
2) Initial tests are completed on the sphere (the Case 2 radiation tests)
3) Excitation and radiation tests are completed for a simple leg (like a1 Figure 6)
4) Excitation and radiation tests are completed for a variety of object configurations, possibly also including combined radiation and excitation tests.

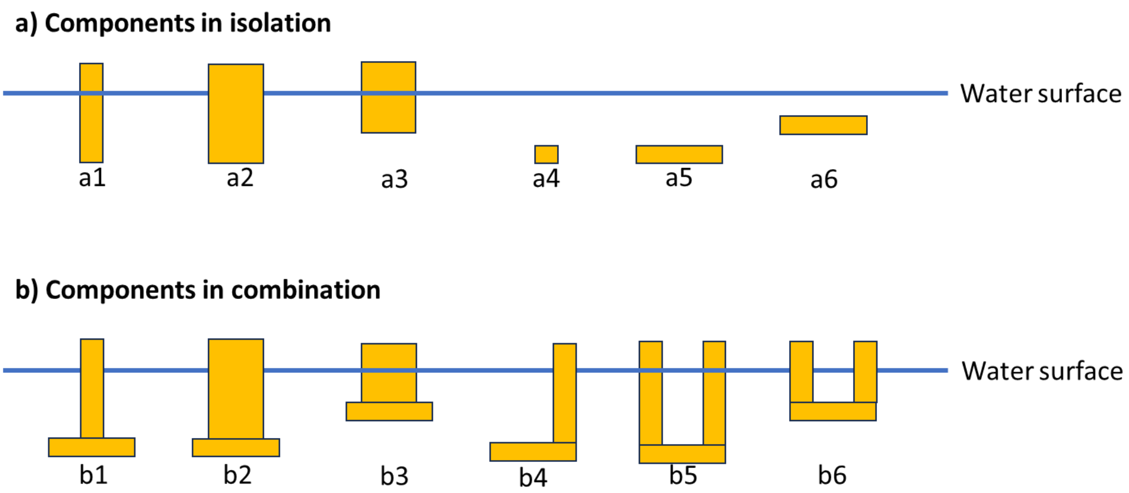

Figure 6: Illustrative examples in a view from the side of possible geometries for Case 3. Upper part a is for components in isolation. Lower part b is for components in combination.

Studies on non-surface-piercing geometries, i.e., test cases with submerged elements shown as a4-a6 in Figure 6, will include additional investigations for deeply submerged elements to enable easier separation of viscous and potential effects as free surface effects are then negligible.

The Case 3 studies will be coordinated with plans for related activities in the IEA Task 30 group.

The work for Case 3 is co-funded by the EUDP project "Competitive Renewable Energy Platforms Based on Shipbuilding Methods (HydroFlex), Project no: 640232-511381. All experimental tests and the majority of the CFD calculations will be performed within HydroFlex.