

# Tidal Turbine Benchmarking Project: Stage 2a – Head-on Waves

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## Introduction

- Stage 1 steady flow experiments and blind prediction campaign ran successfully during 2021 - 2023.
- Follow-on Stage 2 waves on current experiments carried out in 2025 – 2026.
- Workshops held for the blind prediction exercise of Stage 2a Head-on Waves, in order to:
  - improve accuracy of modelling techniques
  - improve confidence in the use of modelling techniques
  - quantify modelling errors for different techniques under different loading scenarios
- **12 research groups** from across the world contributed **16 submissions** in several modelling approaches:
  - Blade Element Momentum (BEM), Actuator Line (AL) (uRANS/LES), Blade Resolved (BR) (RANS/uRANS), Boundary Integral Equation Model (BIEM) and Lifting Line Vortex-based Method
- Project website: <https://supergen-ore.net/projects/tidal-turbine-benchmarking>

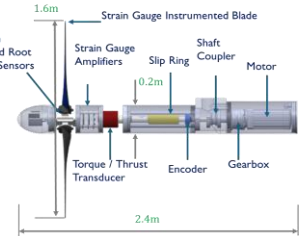


## Key Research Questions

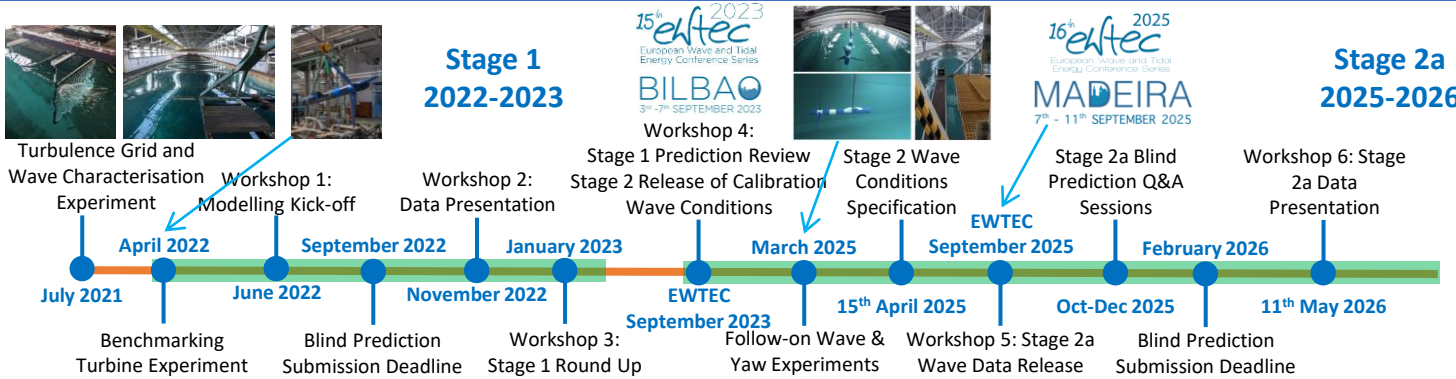
- How can knowledge of **dynamic loading** be used to **reduce overdesign**?
- How does the **hostile current, turbulence, shear and wave** environment drive **dynamic loading**?
- How can experimental investigation inform numerical model development?

## Device and Instrumentation

- Careful hydrodynamic design
  - Efficient and well-defined hydrofoil profile
  - Post-critical blade Reynolds number
- Highly instrumented rotor
  - 100 strain gauges to measure individual blade loads
  - Shaft mounted transducer for torque and thrust measurement
  - Shaft rotary encoder for speed and position

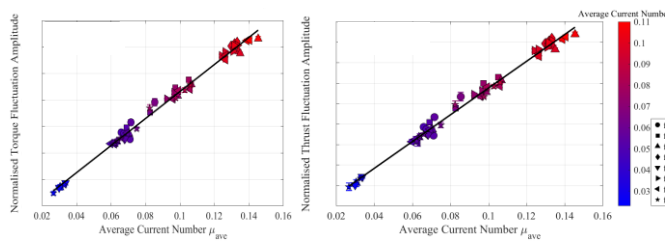


## Project Timeline

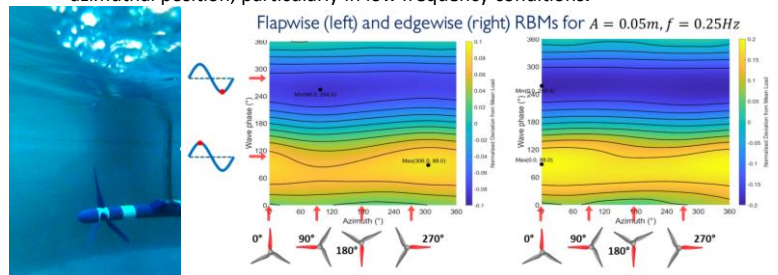


## Experimental Details

- **Linear increase** in load fluctuation amplitude divided by time-averaged mean load when plotted against **average current number**.
- Torque is approximately **twice as sensitive** to current number as thrust.
- Load fluctuation amplitude is **constant** with respect to **frequency ratio**.

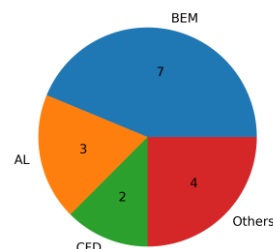


- **Peak loading leads the wave crest**, illustrating **added mass effects** due to wave kinematics.
- Peak RBM loads are **dominated by wave conditions**, with limited impact of azimuthal position, particularly in low frequency conditions.



## Blind Prediction Exercise

- Workshop held at EWTEC 2025 to open the blind prediction exercise.
- Follow-on Q & A sessions held from October to December 2025.
- Final prediction submission deadline on 23<sup>rd</sup> February 2026.
- **12 research groups** submitted **16 datasets** using methodologies of different fidelity levels.
- At least **8 submissions** received for all priority cases.
- Data release workshop 11<sup>th</sup> May 2026



| Sub Counts         | Wave Frequency [Hz] |       |       |       |       |       |       |    |
|--------------------|---------------------|-------|-------|-------|-------|-------|-------|----|
|                    | 0.225               | 0.250 | 0.300 | 0.350 | 0.400 | 0.450 | 0.500 |    |
| Wave Amplitude [m] | 0.025               | 8     | 8     | 13    | 8     | 9     | 3     | 2  |
|                    | 0.035               | 2     | 3     | 3     | 3     | 3     | 8     | 2  |
|                    | 0.050               | 12    | 15    | 15    | 8     | 15    | 8     | 14 |
|                    | 0.075               | 2     | 3     | 8     | 8     | 8     | 2     | 2  |
|                    | 0.100               | 2     | 3     | 15    | 8     | 16    | 3     | 2  |

**Blue: Best quality Exp. data** **Green: Limited Exp. data available** **Priority: Priority cases for exercise**  
**Priority: overlap cases from both 2022 and 2025 campaigns - previously specified for benchmarking**

## Acknowledgements

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