From marine energy to floating offshore wind projects:

Experiences……

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In collaboration with

SEAPOWER scrl – Consortium with University of Naples Federico II

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Avanzamento delle Energie Rinnovabili Marine: strategia Europea, attività in corso in Italia, e aggiornamento del piano d'azione nazionale del Cluster-BIG

Roma, 24-25 Febbraio 2022

We are an applied research group made by 22 researchers and we mainly work in three different fields:

1. **Marine currents (vertical and horizontal axis hydro turbine) and wave energy converters**
2. **Small/Medium horizontal and vertical axis wind turbines**
3. **Very large PV fields in Sicily (~ 100 MW each)**

From the Academia to the real world: technology transfer through a consortium born out of the University research group

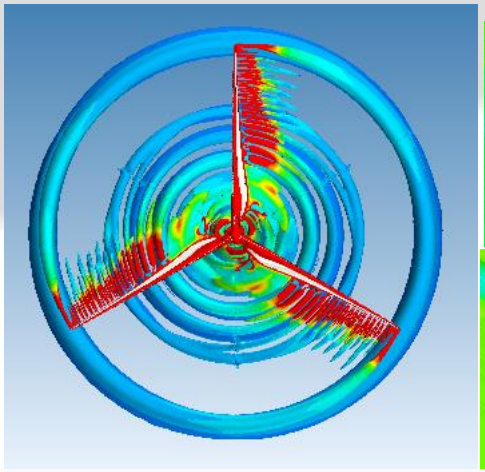
SEAPOWER scrl
Consorzio con l'Università di Napoli Federico II

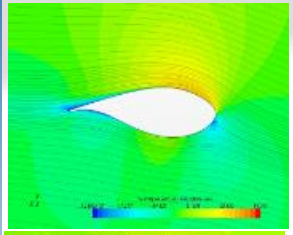
Public/private non profit consortium for renewable energy
www.seapowerscrl.com

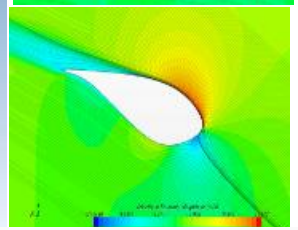
In the field from more than 25 years!!

Experience in design, manufacturing and test

Wind Turbines

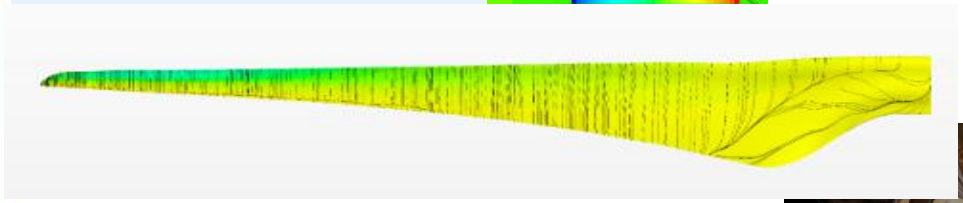


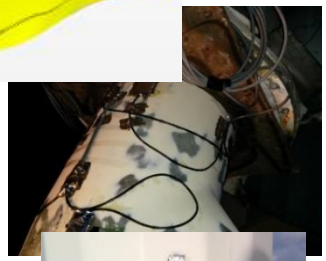


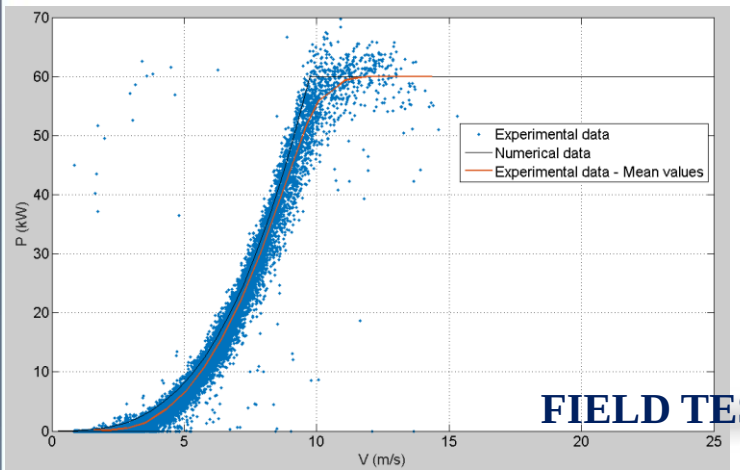


Numerical tools for rotor performance optimization

Manufacturing cost reduction







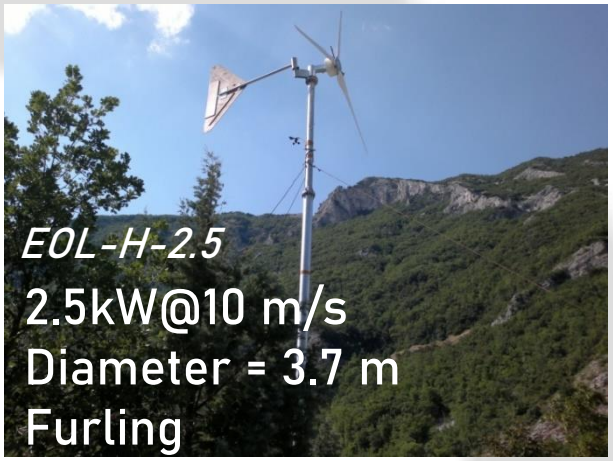
FIELD TEST

Projects developed in wind turbines field

EOL-H-5

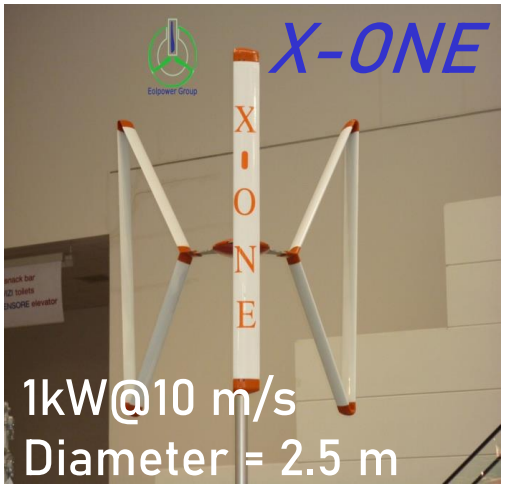
5kW@9 m/s
Diameter = 6 m
Passive pitch

60kW@10 m/s
Diameter = 20 m
Variable pitch



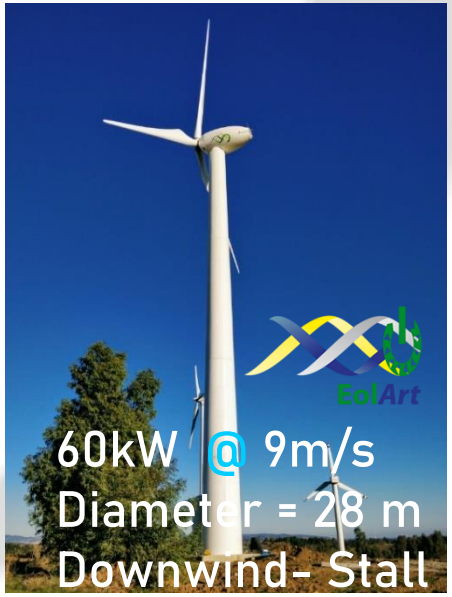
EOL-H-2.5
2.5kW@10 m/s
Diameter = 3.7 m
Furling

X-ONE



1kW@10 m/s
Diameter = 2.5 m

60kW@9.5 m/s
Diameter = 21 m
Variable pitch



60kW @ 9m/s
Diameter = 28 m
Downwind- Stall

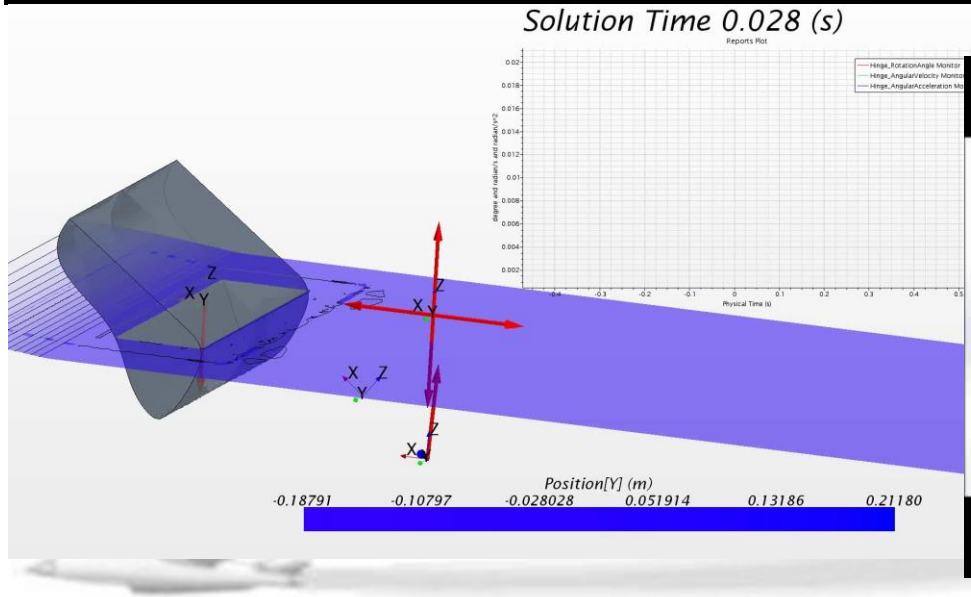
Several different wind turbine typologies have been designed according to IEC 61400-1

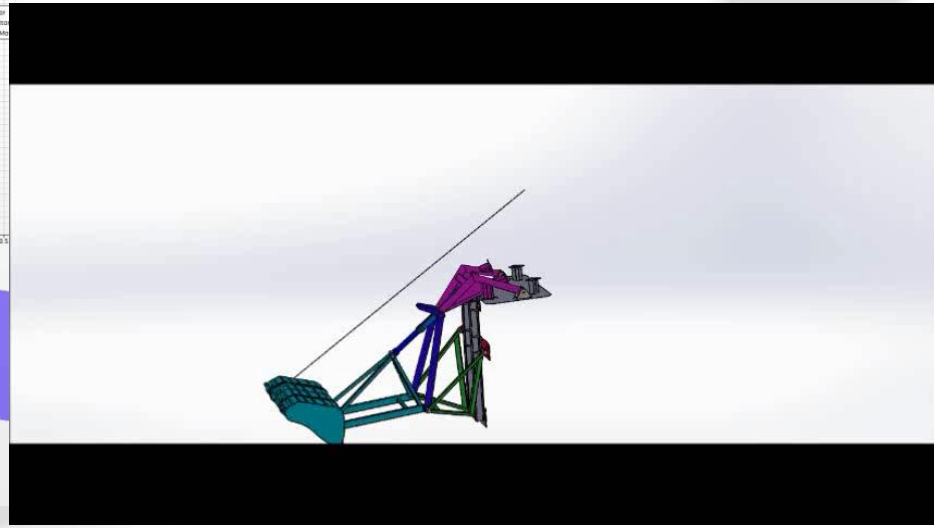
Experience in design, manufacturing and test

Ocean Devices

- Wave Ampl. & Freq.: 0.24 m – 0.35 Hz
- Wave Power: 3.5 kW
- Mechanical Power: 2.6 kW (η_{Buoy}=74%)
- Electrical Power: 2.0 kW (η_{global}~60%)

- Immersed volume: 5 m^3
- Dry Buoy Weight: 2700 kg

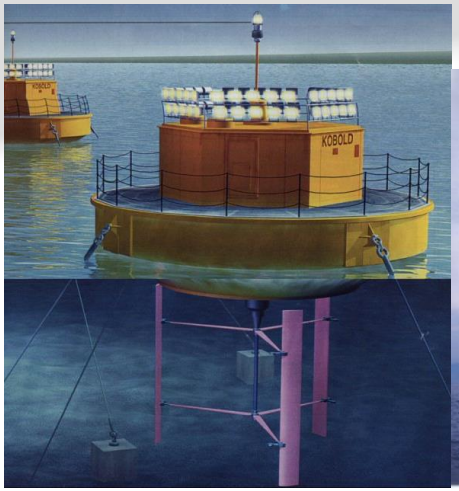




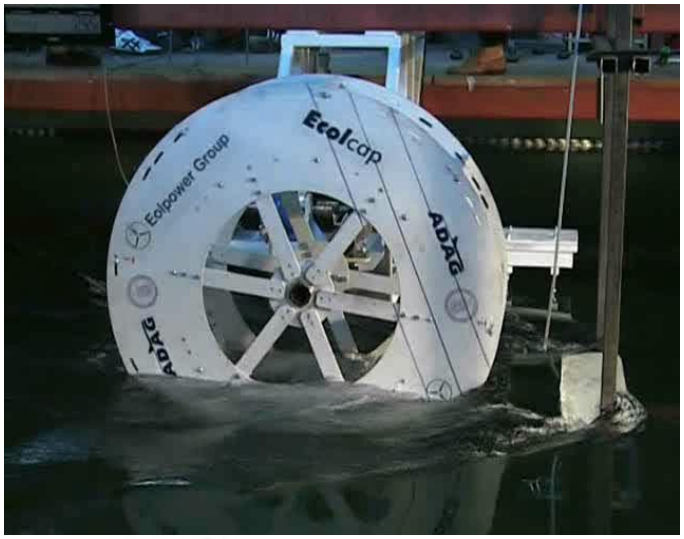
Energy from river and tidal currents: deployed prototypes

First Vertical Axis Hydro Turbine in the world!! –KOBOLD (1997-2013)

This turbine has the longest time world record of being operative in the water



KOBOLD



River Power

Tidal current energy (2005- to date): GEMSTAR

- No visual impact
- Self towing winch
- Pops up for easy maintenance
- Very stable
- Self aligning
- Very stable also with 1 turbine inoperative
- Easy transportability
- Easy and fast to deploy

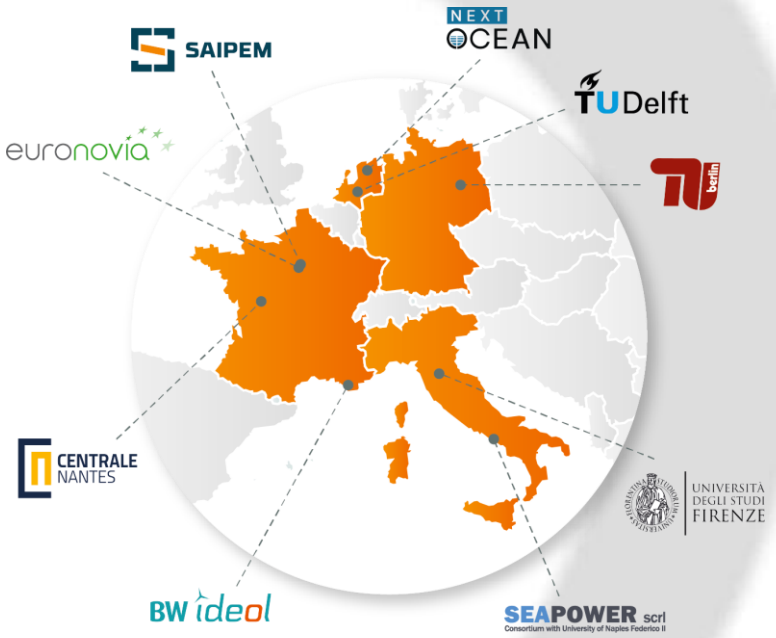
GEM – first generation (2005-2012)

Tested in water in Venice Lagoon in 2012

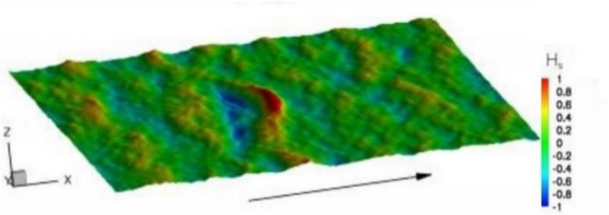
Introduction

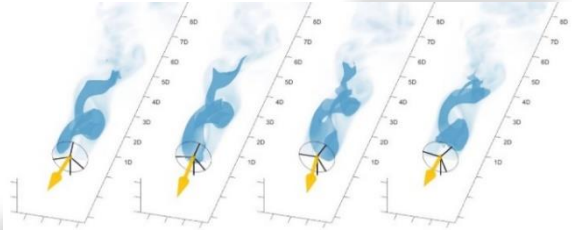
SEAPOWER scrl Consortium with University of Naples Federico II is part of the european research project **FLOATECH** THE FUTURE OF FLOATING WIND TURBINES

- The project started in January 2021 and will continue for 3 years.
- It is focused on the increase of economical competitiviness and technological innovation of the floating offshore wind energy sector in the international and european market.
- The project partners are universities and research centers, with industrial advisors.



Software development *Qblade-Ocean*



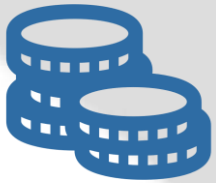


Technology Development*: Active Wave Control, Active Wake Mixing*

SEAPOWER activities in FLOATECH

SOFTWARE DEVELOPMENT TO SIMULATE FLOATING WIND TURBINES

DEVELOPMENT OF THE CONTROL TECHNOLOGIES TO INTEGRATE WAVES FORECAST AND FOR WAKE MIXING

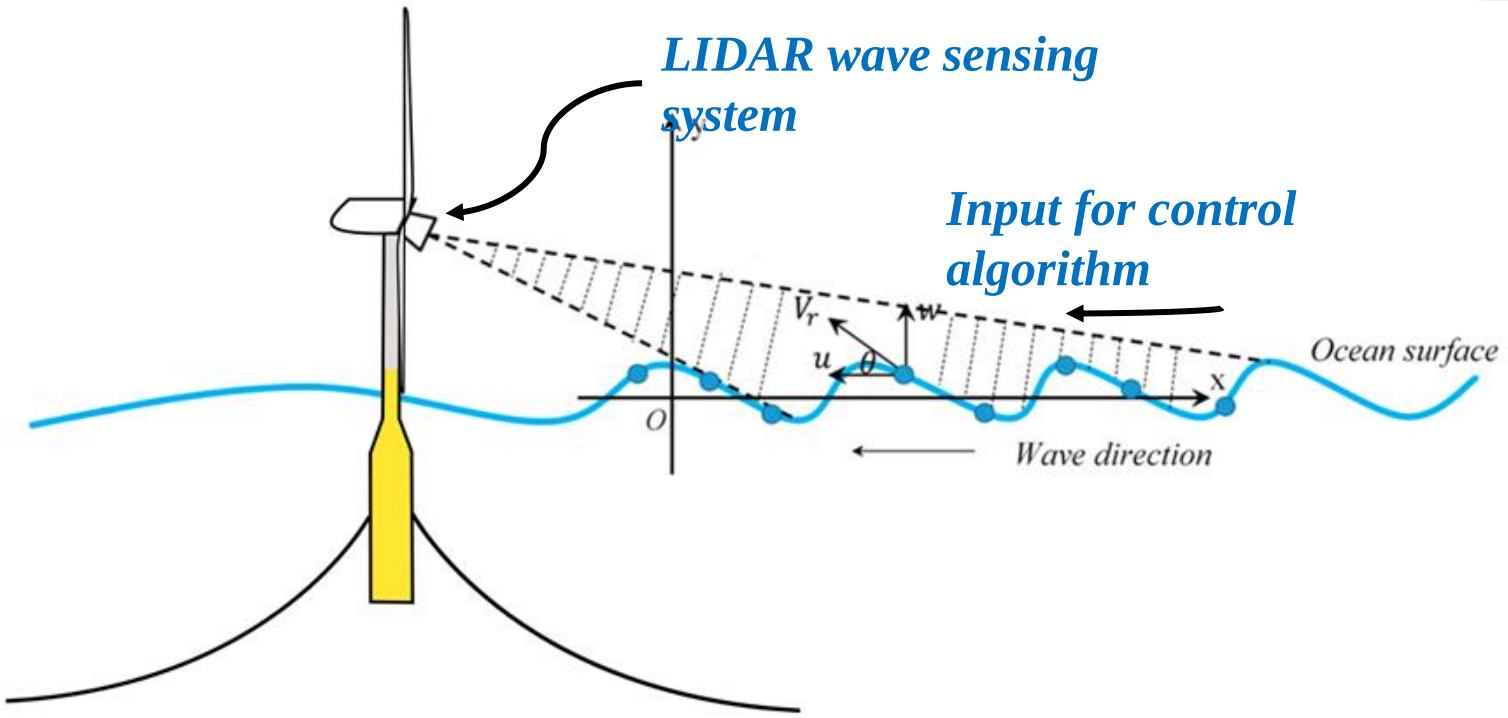


DEVELOPMENT OF A COMPLETE COST MODEL FOR FOWT

- SEAPOWER participates to innovative active control technique and to floating platform design and optimization.
- SEAPOWER leads and coordinate the activities for the development of a model to estimate the cost of energy generated by floating offshore wind turbines.
- The model takes account of new technologies, such as those developed in the project with the objective of reducing the cost of energy.

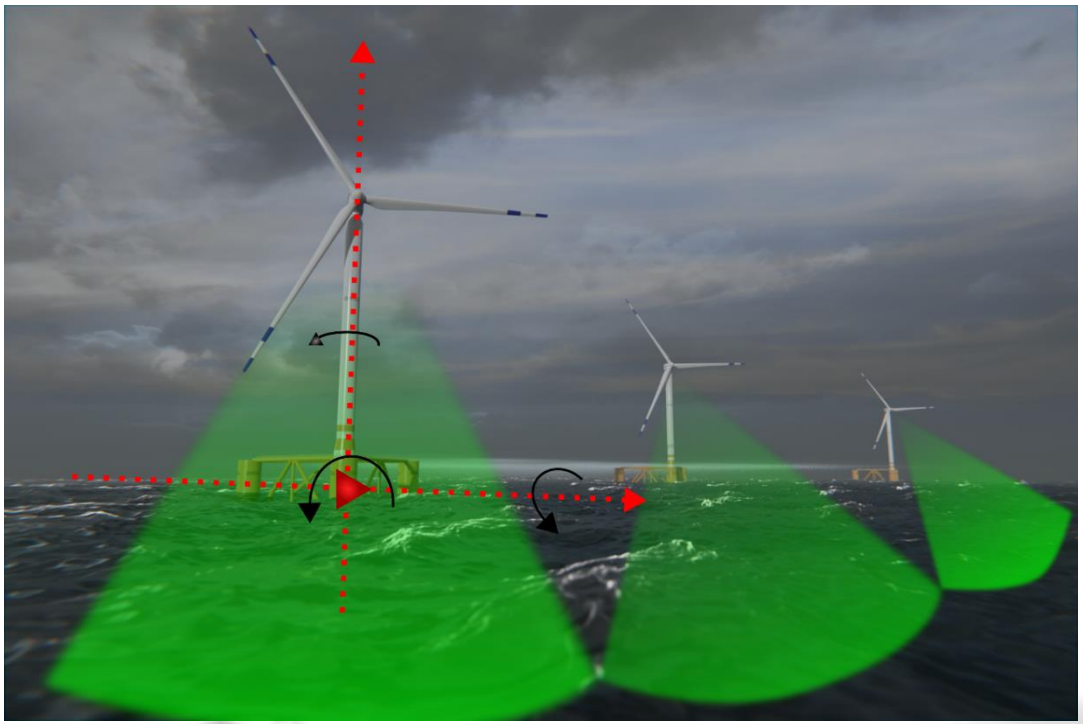
AWC – Active Wave Control

The first technology addresses the impact of the waves on the platform stability. This new technology combines an open-source **feed forward control algorithm** and a **wave sensing system** for an active wave-based control of floating wind turbines.



AWC – Active Wave Control

Deterministic wave prediction and induced platform motions are exploited through an ad-hoc controller enhancing the ability of the generator to compensate for platform motions and loads induced by waves, while limiting fatigue loads.

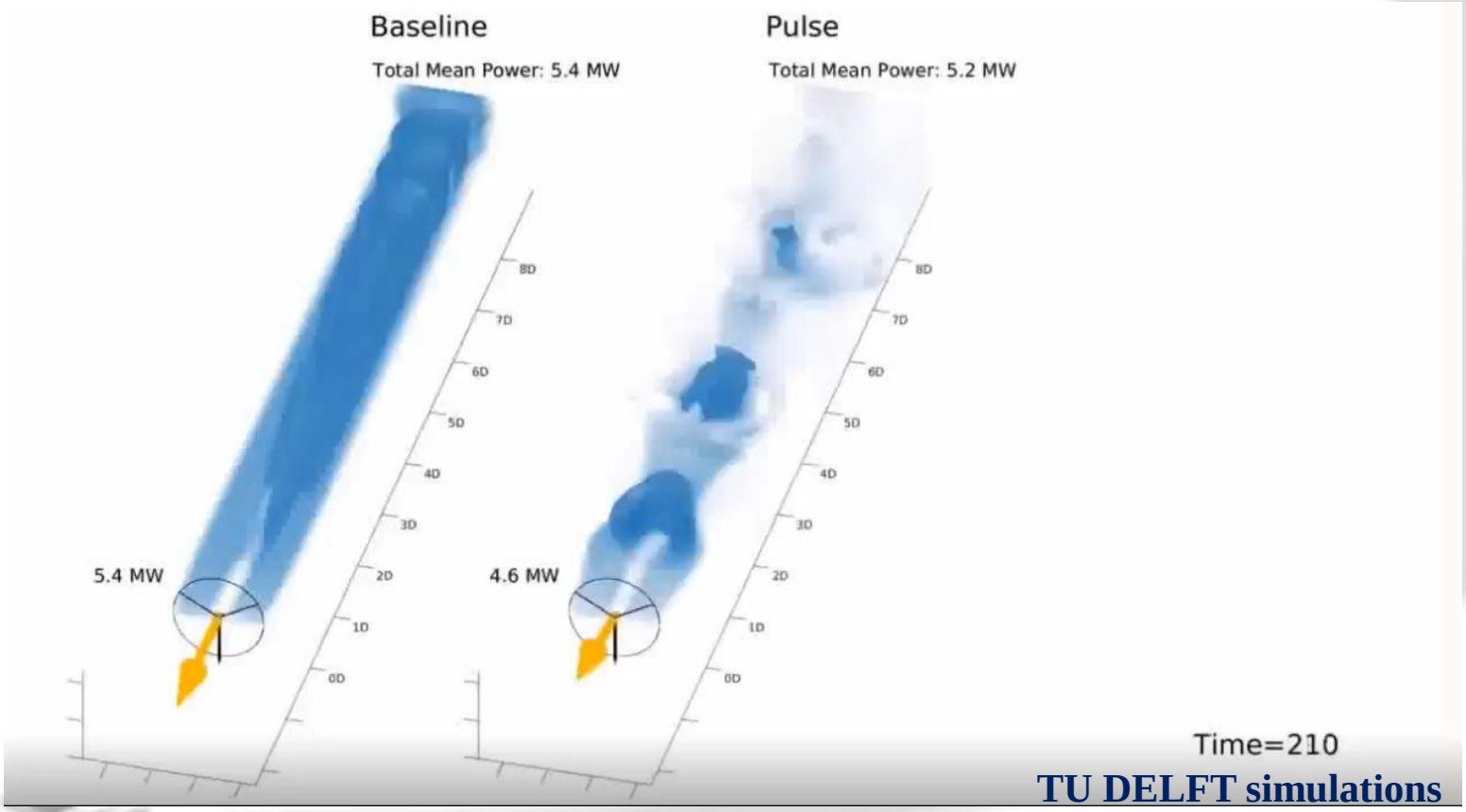


Expected Benefits ✓

- Limited motion of the entire structure
- Limited oscillations of wave-induced loads
- Limited fatigue loads

AWC – Active Wake Mixing

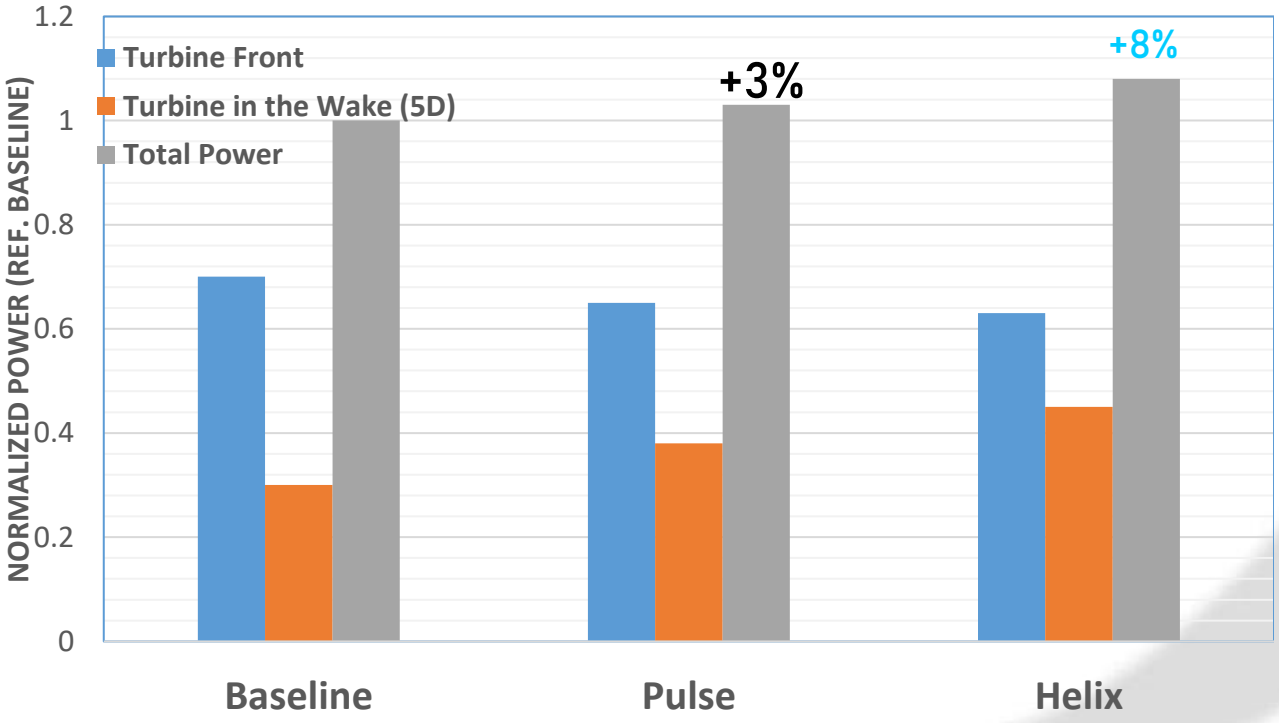
The second control technology focuses on the **wakes** of the floating turbines. This project will synergize this novel active wake mixing control with **floating offshore wind farms** in pursuit of enhanced mixing of the wakes. Two techniques are being investigated.



TU DELFT simulations

AWM – Active Wake Mixing

Power production of the two-turbine wind farm for different control strategies, showing the limited power loss at turbine 1 with all control methodologies. The power gain at turbine 2 results in a farm-wide increase in power production.

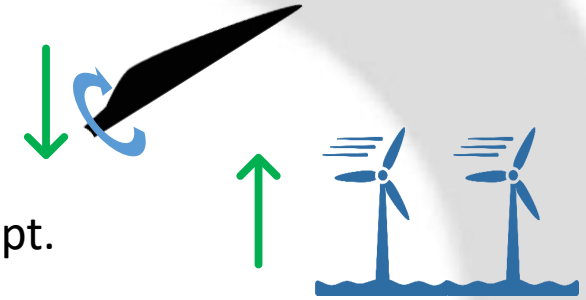


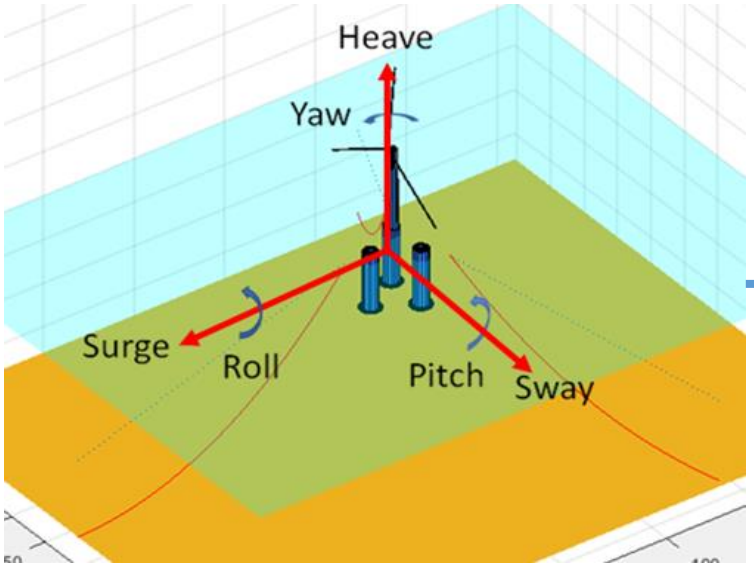
Video and data extracted from the original work: *Frederik, J. A., Doekemeijer, B. M., Mulders, S. P., & Wingerden, J. (2020). The helix approach: Using dynamic individual pitch control to enhance wake mixing in wind farms. In Wind Energy (Vol. 23, Issue 8, pp. 1739–1751). Wiley. https://doi.org/10.1002/we.2513*

AWM – Active Wake Mixing

The additional degrees of freedom could be exploited for the FOW control called active wake mixing, through either:

- reducing the **loads** on the blade pitch actuators.
- amplifying the benefits of the wind farm control concept.

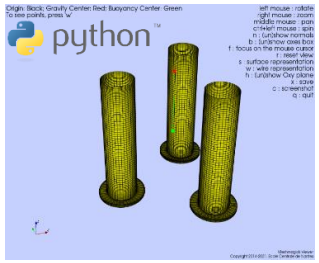




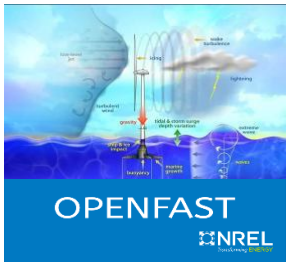
- Possibility of exciting platform 6 DOF to amplify the effect of blades pitch actuators and to reduce their loads
- For "pulse" control exciting pitch and surge motions
- For "helix" control exciting yaw motion

Design of Floating Platforms for AWM

This technology will also rely on the innovative design of floaters. SEAPOWER is currently employing its expertise in marine structures to design and optimize the floating platforms for AWM control through the development of an iterative dedicated optimization software.

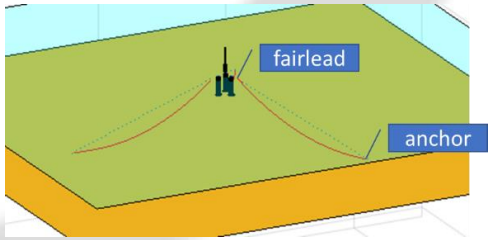


GENERATION OF NEW CONFIGURATION



SIMULATIONS TO SEARCH FOR DESIRED RESPONSE

FINAL GEOMETRY OF FLOATER AND MOORINGS

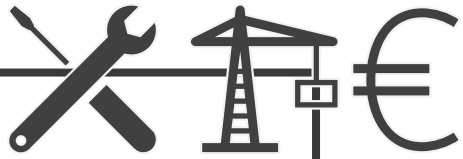


CHECK REQUIREMENTS

Design Variables
Spar Dimensions and Inertial Characteristics
Mooring Characteristics
Anchor Point Position
Fairlead Position

Levelized Cost of Energy Model

SEAPOWER is developing a model to investigate LCoE improvement due to the integration of new control technologies on floating offshore wind turbines.



Variation of CAPEX and OPEX

Development of a cost model accounting for:

- additional components needed by the technologies (sensors, data collecting, etc),
- effects of technologies on the wind turbine design (structures and components size) and its lifetime

Variation of Annual Energy Production

Uncertainty quantification techniques accounting for different wind distributions and sea conditions in representative sites in Europe.

LCOE

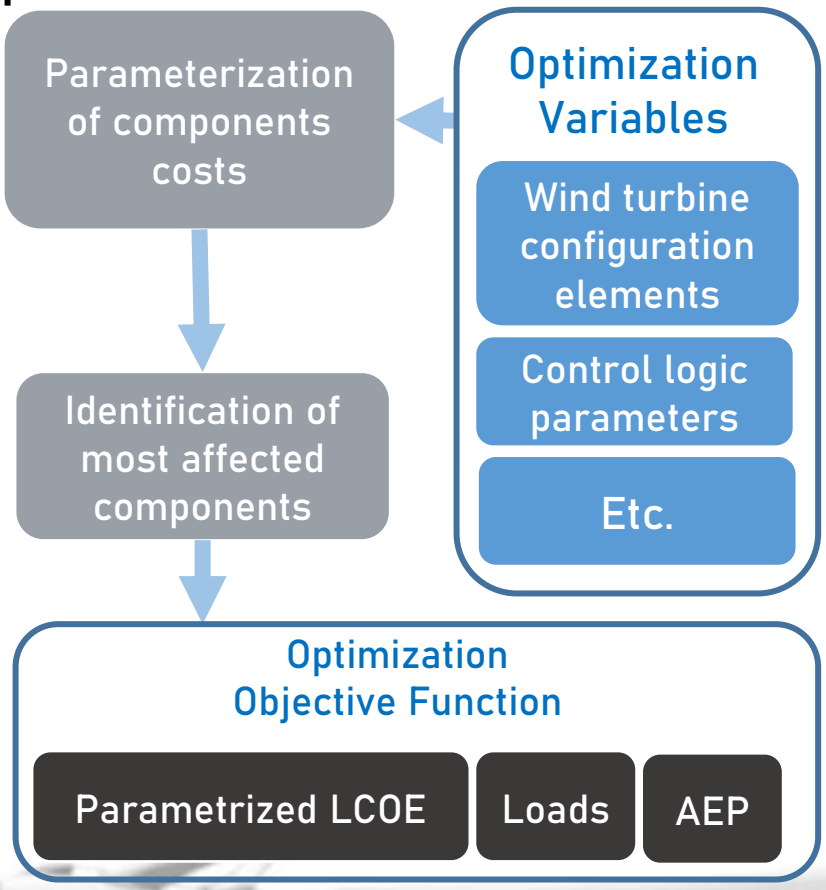
COSTS *OVER LIFETIME*

———————

ENERGY PRODUCED *OVER LIFETIME*

Levelized Cost of Energy Model

Final Objective: parameterised expression of LCoE to be introduced into the objective function of floating wind turbines and farms optimization.



1. Evaluation of costs most affected by the new control strategies.
2. Parametrization of these costs as functions of optimization variables.
3. Objective function definition.
4. Optimization process.

Golfo di Pozzuoli

Grazie per l'attenzione!!!!!

GEMSTAR TETHERED POWER

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE
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