Universidad de Huelva
Escuela Técnica Superior de Ingeniería

MMT Symposium
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ANALYSIS OF TURBINE MORPHOLOGY FOR TIDAL LOW-SPEED FLOW ENERGY EXTRACTION

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Introduction

Tidal energy harnesses the power of ocean tides to generate electricity, offering a highly predictable and renewable energy source due to the regularity of tidal cycles

- Predictability.
- Renewable and Sustainable:.
- High Energy Density.
- Environmental Benefits.
- Long Lifespan.
- Minimal Visual Impact.
- Coexistence with Marine Life.

Introduction

Tidal turbines are devices designed to harness the kinetic energy from ocean currents and tidal flows, converting it into clean, renewable electricity.

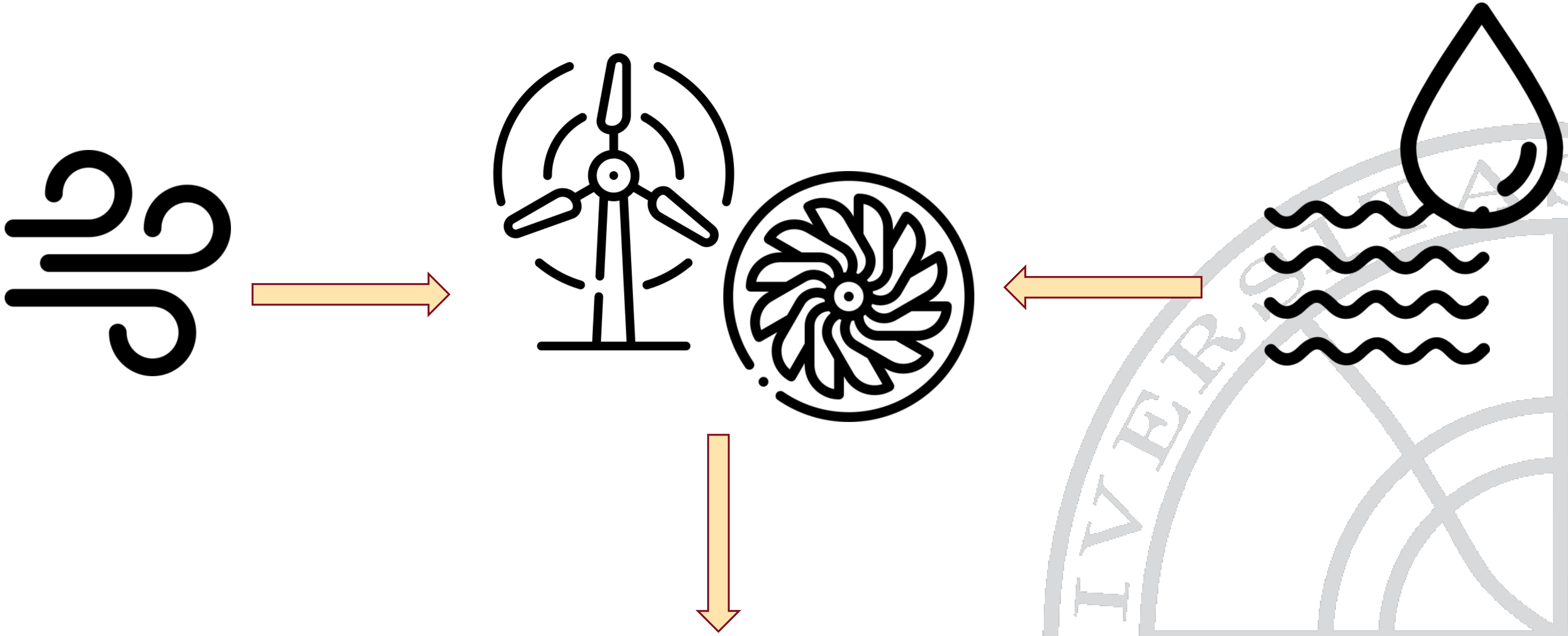
Pros

- Predictability.
- Renewable and Sustainable:.
- High Energy Density.
- Environmental Benefits.
- Long Lifespan.
- Minimal Visual Impact.
- Coexistence with Marine Life.

Cons

- High Initial Costs.
- Installation and Maintenance Challenges.
- Environmental Impact.
- Site Specificity.
- Energy Transmission.
- Intermittent Power Generation.
- Mechanical Design

Introduction



- Mechanical turbomachinery design
- Fluid dynamics

Methodology

Dynamics of rotating machinery

$$P = T \cdot \omega$$

- $T = \frac{Ke}{r} - F_d \cdot r$

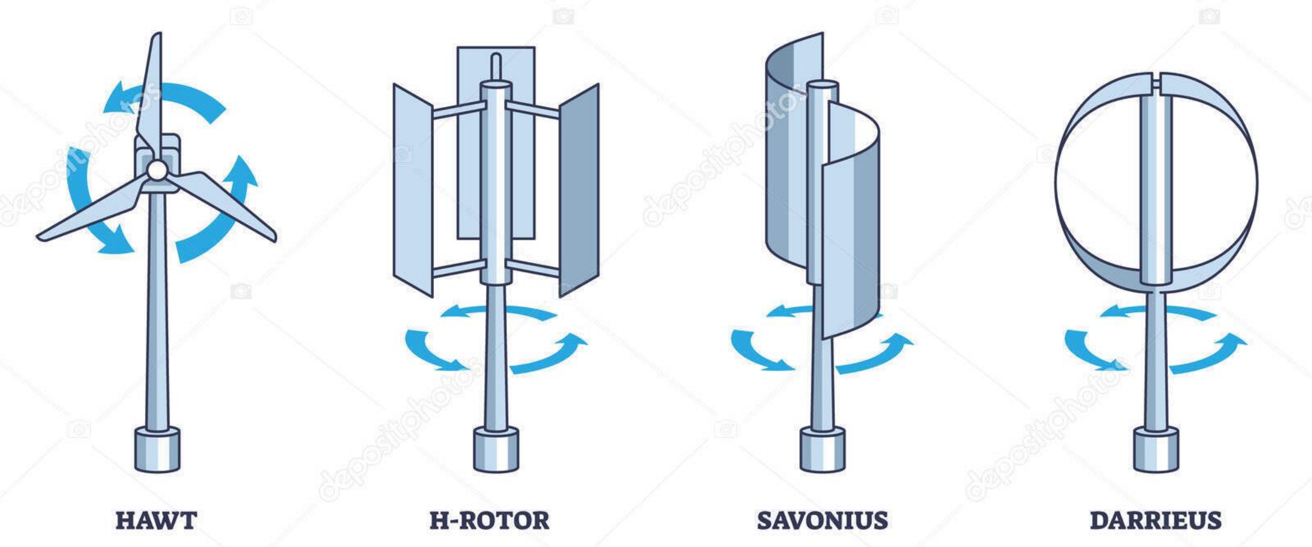
Where: T = torque; r = radius; Ke = kinetic energy; F_d = The total Drag force

- $F_d = 0.5 \cdot \delta_w \cdot A_b \cdot {c_w}^2 \cdot C_d$

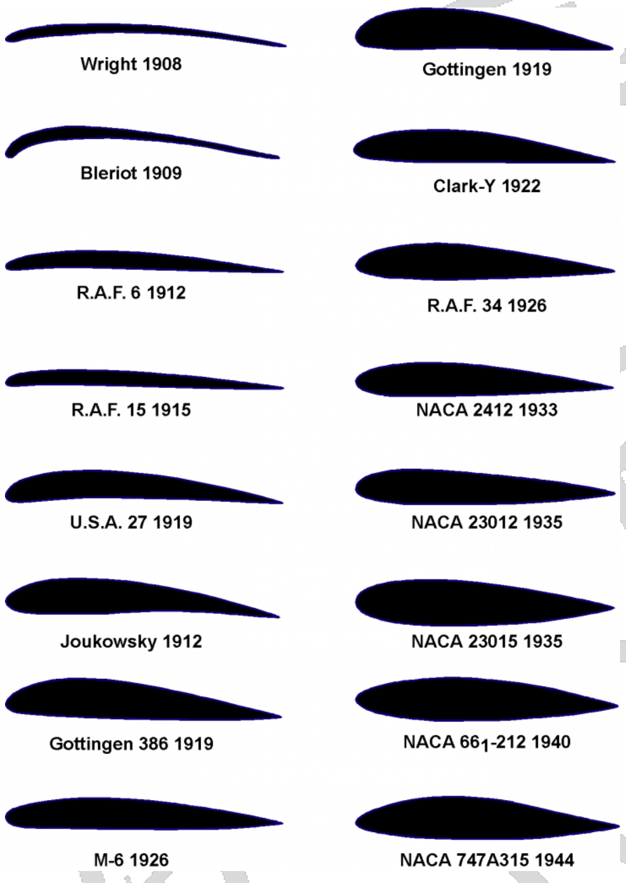
Where: δ_w is the water density; A_b is the projected blade area; c_w is the water speed and C_d is the drag coefficient of each type of blade.

Methodology

Typical wind-tidal turbine morphologies

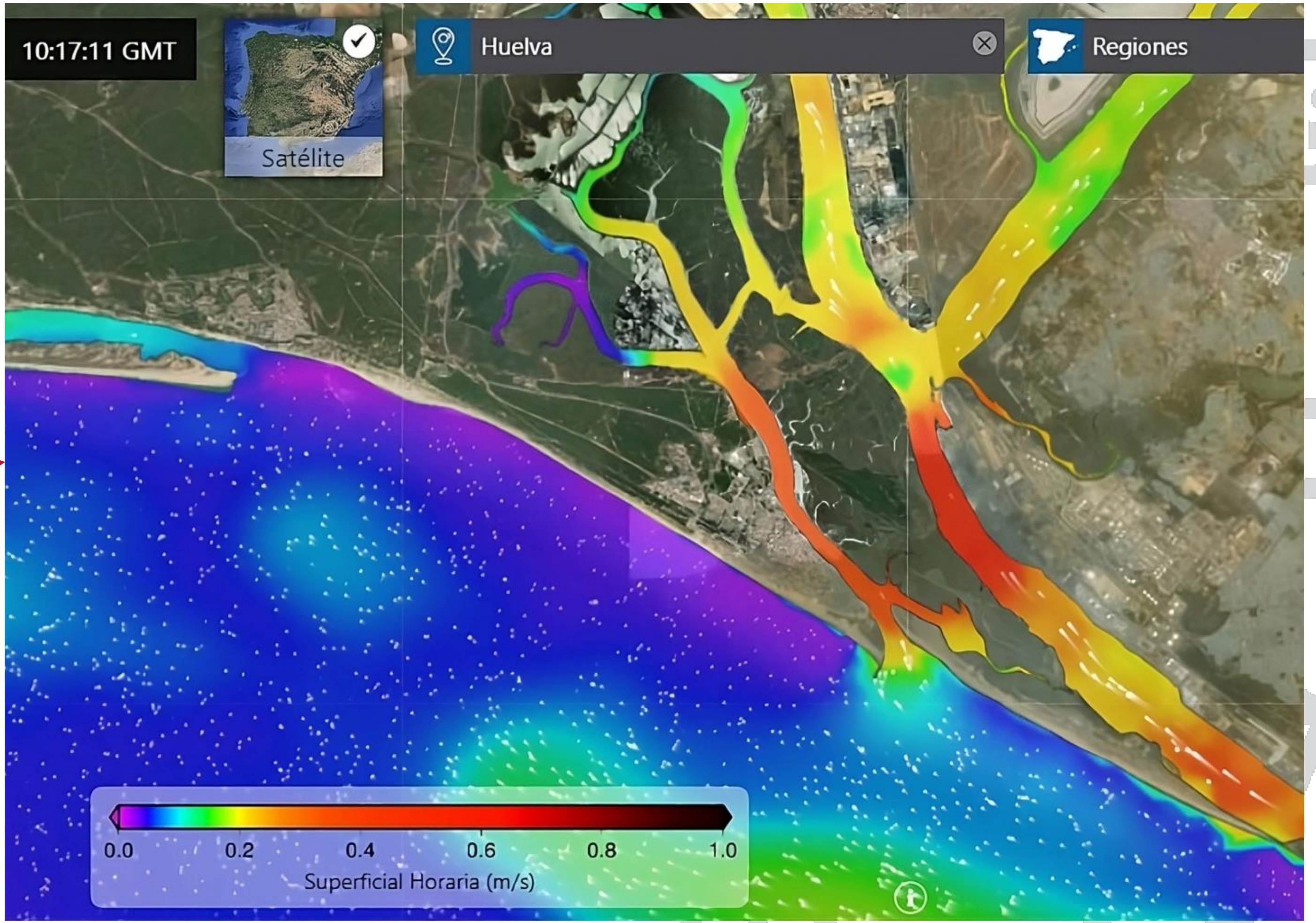


Wing profiles



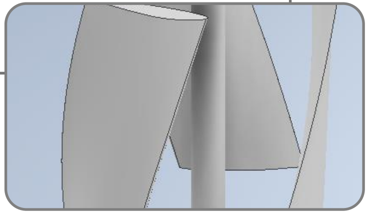
Methodology

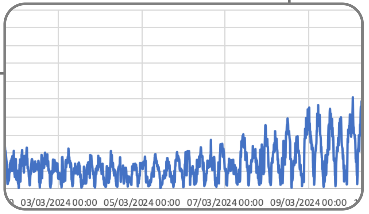
Study case location

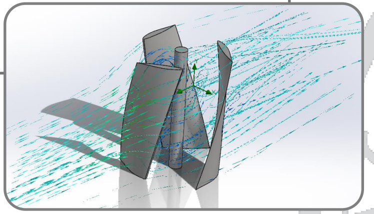


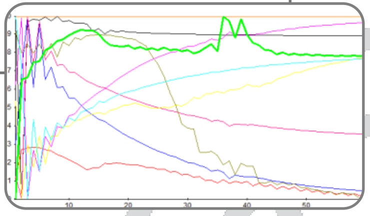
Methodology

3D modeling → On site measurements → CFD simulations → Analysis



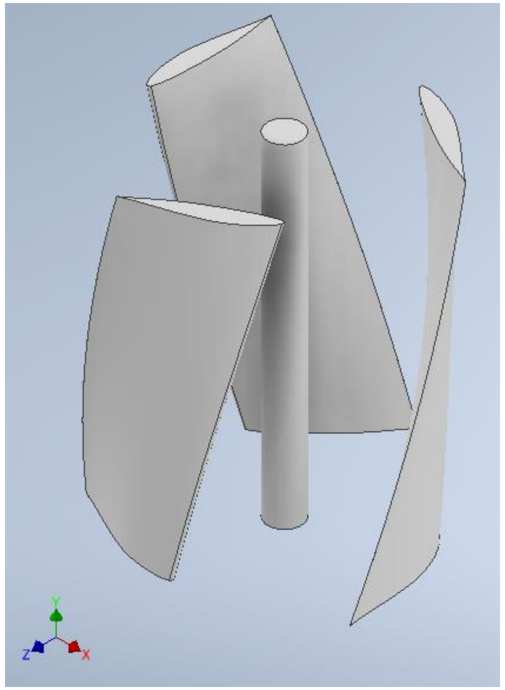




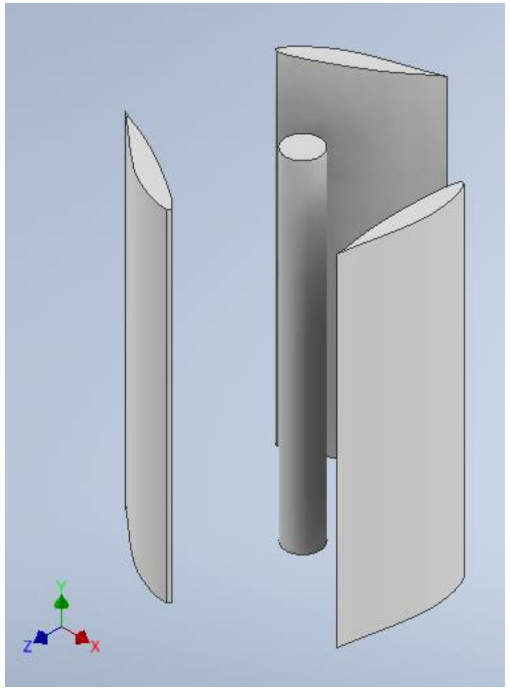


Results & discussion

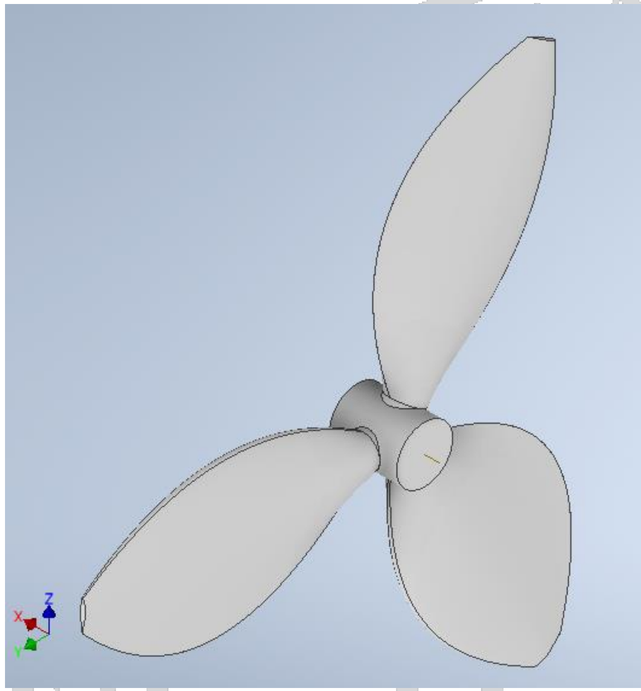
- 3D modelling



Model 1



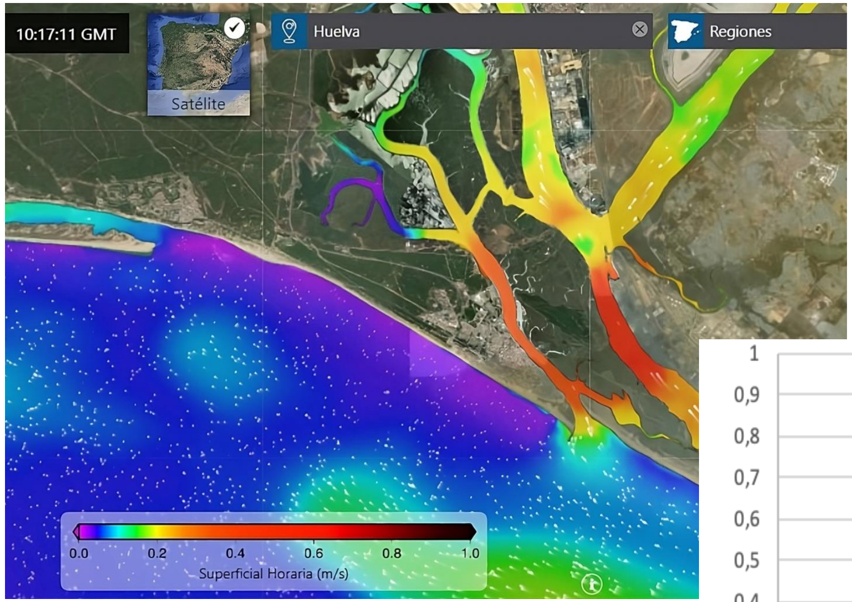
Model 2

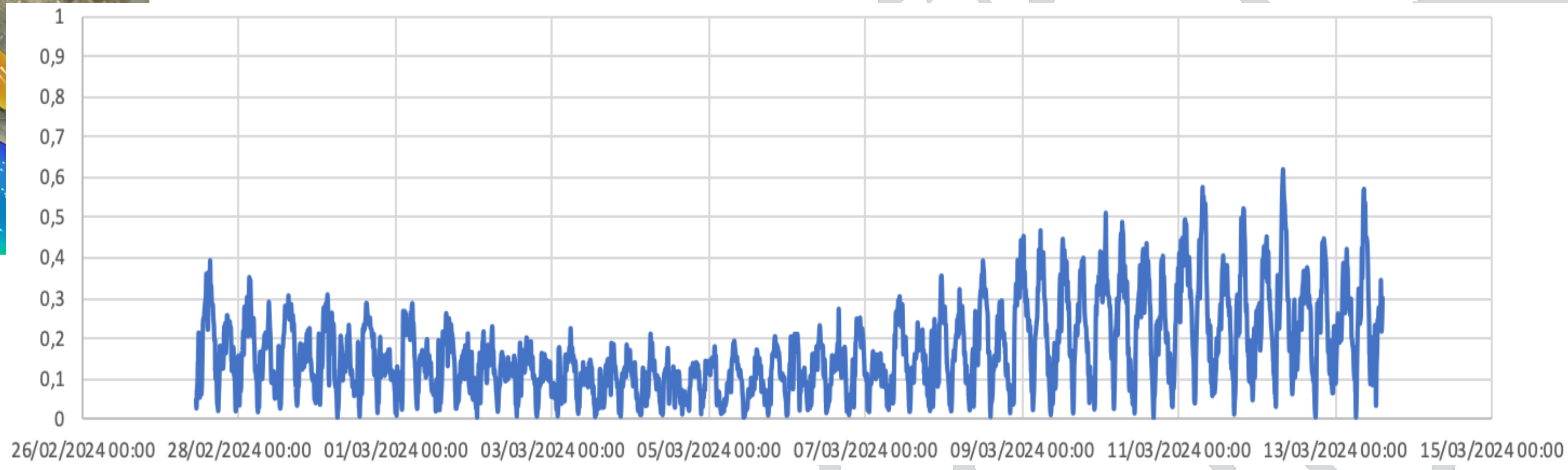


Model 3

Methodology

- On site measurements: current velocity (m/s)

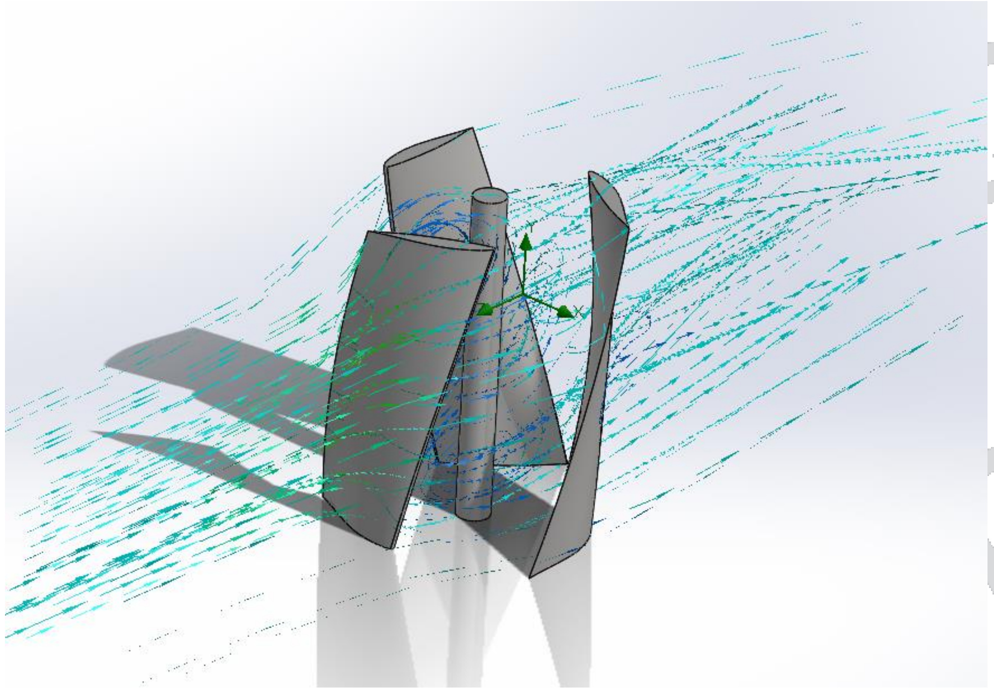


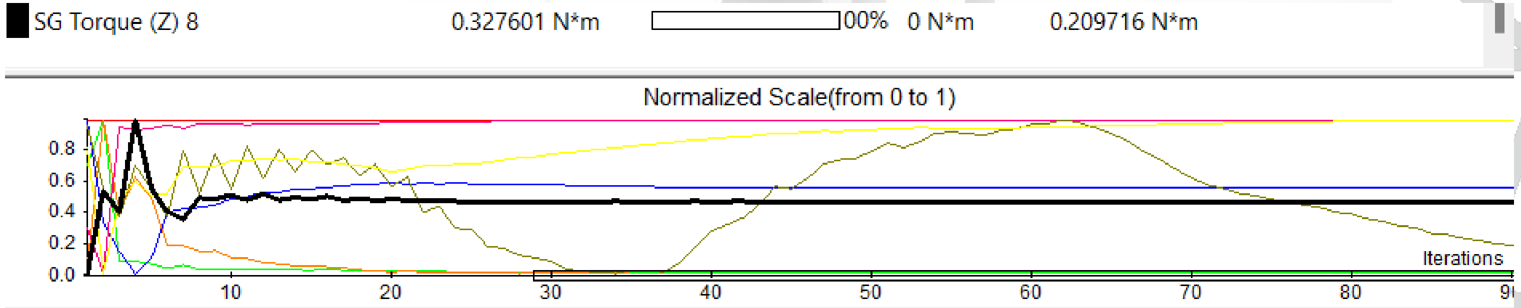


Methodology

- CFD simulation.

- Boundary conditions: (Based on previous measurements)
  - Mass flow
  - Pressure
  - Fluid speed
- Rotating region:
- Defining objectives:
  - Torque
  - Radial velocity
  - Friction forces
  - Turbulence intensity

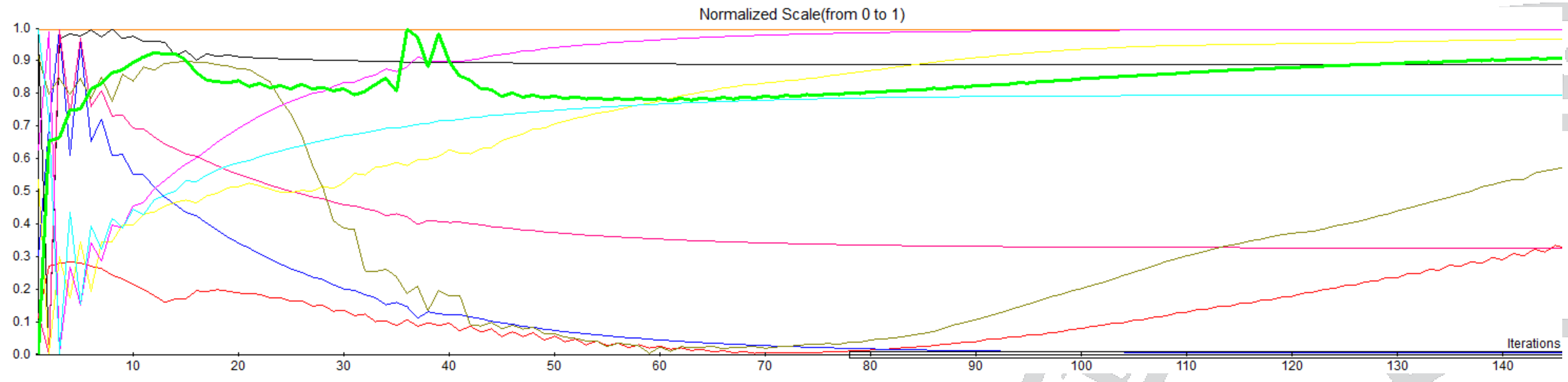




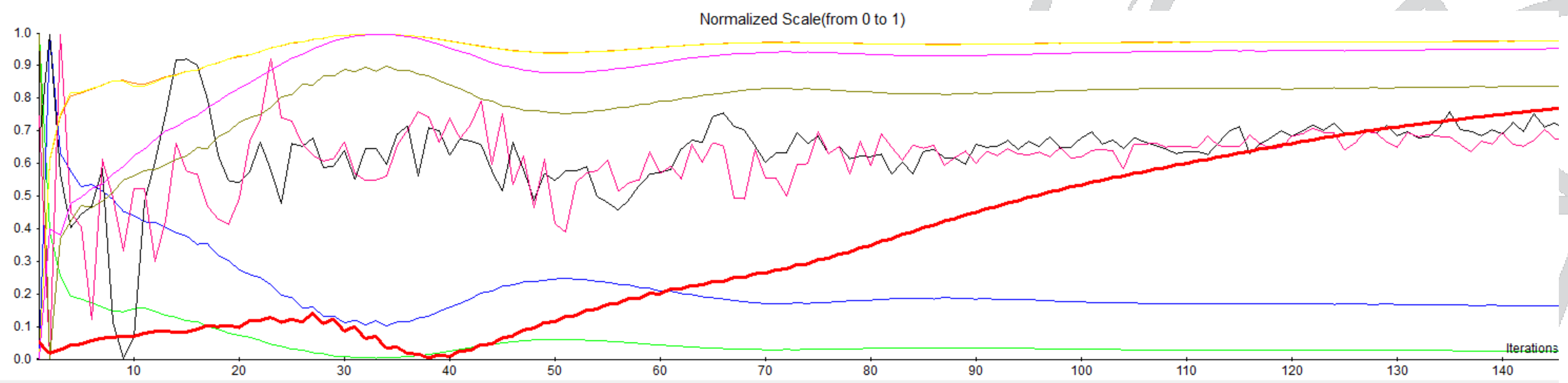
Results & discussion

- Radial velocity (m/s)

Model 1
0.03221 m/s



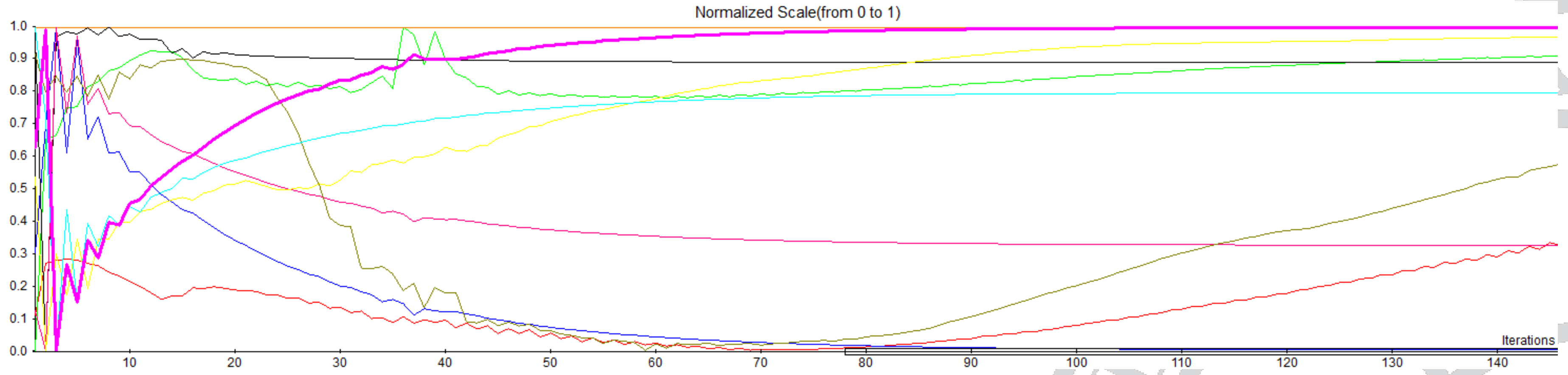
Model 3
0.01605 m/s



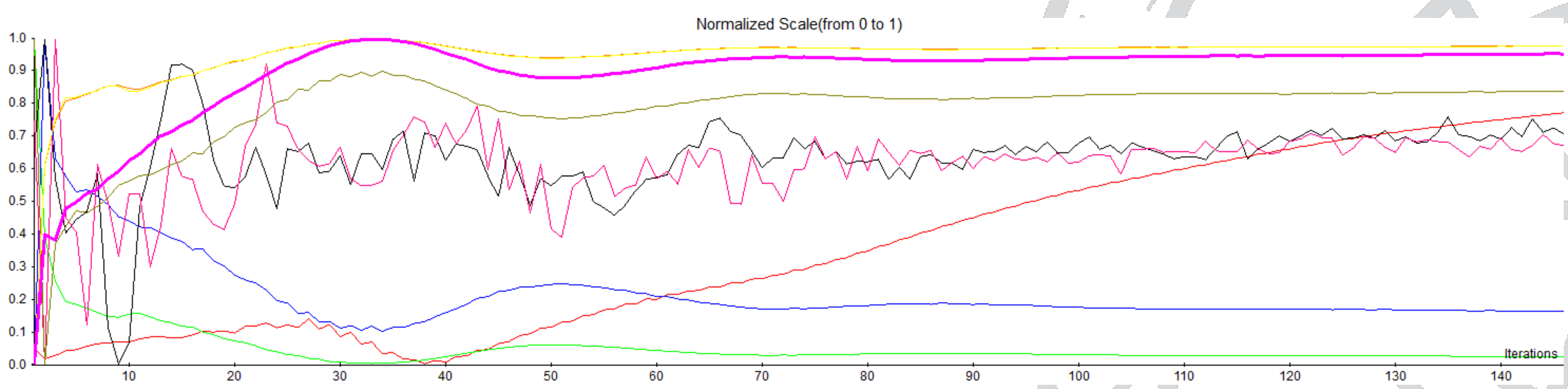
Results & discussion

- Torque (N·m)

Model 1
4.11 N·m



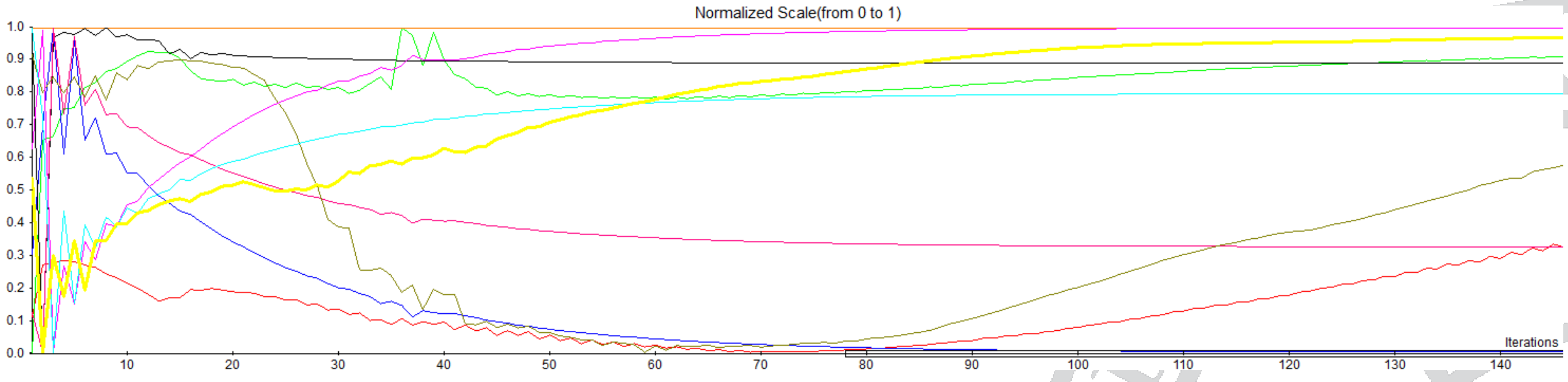
Model 3
2.088 N·m



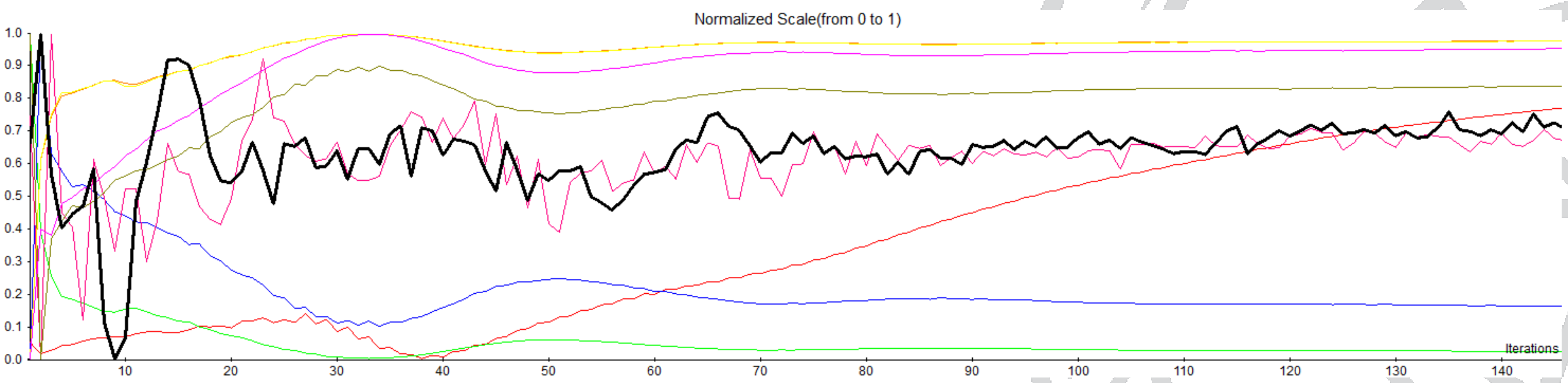
Results & discussion

- Friction forces (N)

Model 1
0.3618 N



Model 3
0.0002 N



Conclusions

Conclusions

- Promising insights into the performance Type 3 model design under low-speed conditions.
- The different flow patterns and efficiency metrics associated with different morphologies underscore the potential for optimizing turbine shapes to enhance performance in environments characterized by reduced flow velocities.
- Additionally, vertical axis turbines present further advantages such no-orientation need so, reduced manufacturing and maintenance costs.
- Tailoring turbine morphologies to suit specific dynamics of rotating machinery and fluid dynamics, it becomes feasible to improve energy extraction efficiency and overall performance.

Further research

- Refining turbine designs and validating their efficacy through experimental testing in real-world settings.

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Thank you!

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NextGenerationEU

MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

Plan de Recuperación, Transformación y Resiliencia

Junta de Andalucía
Consejería de Universidad, Investigación e Innovación

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