

# Wind Propulsion Systems for Sustainable Commercial Ships

## Background:

Shipping is the backbone of global trade, moving over 80% of the world's goods across the seas. But this comes at a cost to the environment, as maritime transport is responsible for about 3% of total annual anthropogenic greenhouse gas emissions. As the industry seeks sustainable solutions, Wind Propulsion Systems (WPSs) are making a comeback, with a growing number of installations worldwide demonstrating their potential to reduce emissions and fuel costs.

Yet, the widespread adoption of WPSs in commercial shipping is not plain sailing. Each WPS performs best under specific routes, ships, and operational constraints, making it difficult to determine the most cost-effective solution. Without careful evaluation, installations may fail to achieve expected savings or underperform, slowing the transition to greener shipping.

## Project Description:

This PhD research addresses these challenges by developing a novel optimization framework for WPS deployment. The model evaluates cost-benefit trade-offs to identify the best WPS installation design for different operational needs, balancing fuel savings, emissions reduction, and investment costs. This framework supports informed decision-making for shipowners and operators and ensures fair comparisons between WPS technologies. The results highlight that there is no one-size-fits-all solution; instead, success depends on a tailored approach. Optimized designs can significantly shorten payback periods and boost profitability, while poor designs can extend payback times by over 150%.

This research paves the way for smarter, data-driven WPS deployment, unlocking its full potential and accelerating the transition to a sustainable, cost-effective shipping industry.

## Final outcomes:

The project produced 6 articles which can be found here:

Article 1: Reche-Vilanova, M.; Bingham, H. B.; Fluck, M.; Morris, D.; and Psaraftis, H. N. Propeller and Engine Performance of Commercial Windships: Benefits and Trade-Offs. *Journal of Ship Research* (2024): <https://onepetro.org/JSR/article-abstract/68/01/1/540806/Propeller-and-Engine-Performance-of-Commercial?redirectedFrom=fulltext>

Article 2: Reche-Vilanova, M.; Kaltenbach, S.; Koumoutsakos, P.; Bingham, H. B.; Fluck, M.; Morris, D.; Psaraftis, H. N. Predictive Surrogates for Aerodynamic Performance and Independent Sail Trim Optimization of Multiple Wind Propulsion System Configurations. *Journal of Sailing Technology* (2025): <https://onepetro.org/JST/article/10/01/19/663075/Predictive-Surrogates-for-Aerodynamic-Performance>

Article 3: Reche-Vilanova, M.; Bingham, H. B.; Fluck, M.; Morris, D.; and Psaraftis, H. N. Cost-Benefit Analysis and Design Optimization of Wind Propulsion Systems for a Tanker Retrofit Case. *Journal of Maritime Transport Research* (2025): <https://www.sciencedirect.com/science/article/pii/S2666822X25000048>

Article 4: Reche-Vilanova, M.; Bingham, H. B.; Fluck, M.; Morris, D.; and Psaraftis, H. N. Preliminary Study on the Propeller and Engine Performance Variation with Wind Propulsion Technologies. *Proc. of the the RINA Wind Propulsion Conference* (2023), London, United Kingdom: <https://orbit.dtu.dk/en/publications/preliminary-study-on-the-propeller-and-engine-performance-variati>

Article 5: Reche-Vilanova, M.; Bingham, H. B.; Fluck, M.; Morris, D.; and Psaraftis, H. N.. Optimal Deck Position of Rotor Sails and DynaRigs for a Bulk Carrier Retrofit Installation. *Proc. of the*

*SISDO Conference* (2023), Glen Cove and Kings Point, New York, United States:

<https://orbit.dtu.dk/en/publications/optimal-deck-position-of-rotor-sails-and-dynarigs-for-a-bulk-carr>

Article 6: Reche-Vilanova, M.; Morris, D.; Ward, H.; Azcueta, R.; Leslie-Miller, M.; Bingham, H. B.. Development of Machine-Learning Surrogates for Hydrodynamic Performance and Wake-Field Prediction of Windships. *Proc. of the RINA Wind Propulsion Conference* (2024), London, United Kingdom: <https://orbit.dtu.dk/en/publications/development-of-machine-learning-surrogates-for-hydrodynamic-perfo>