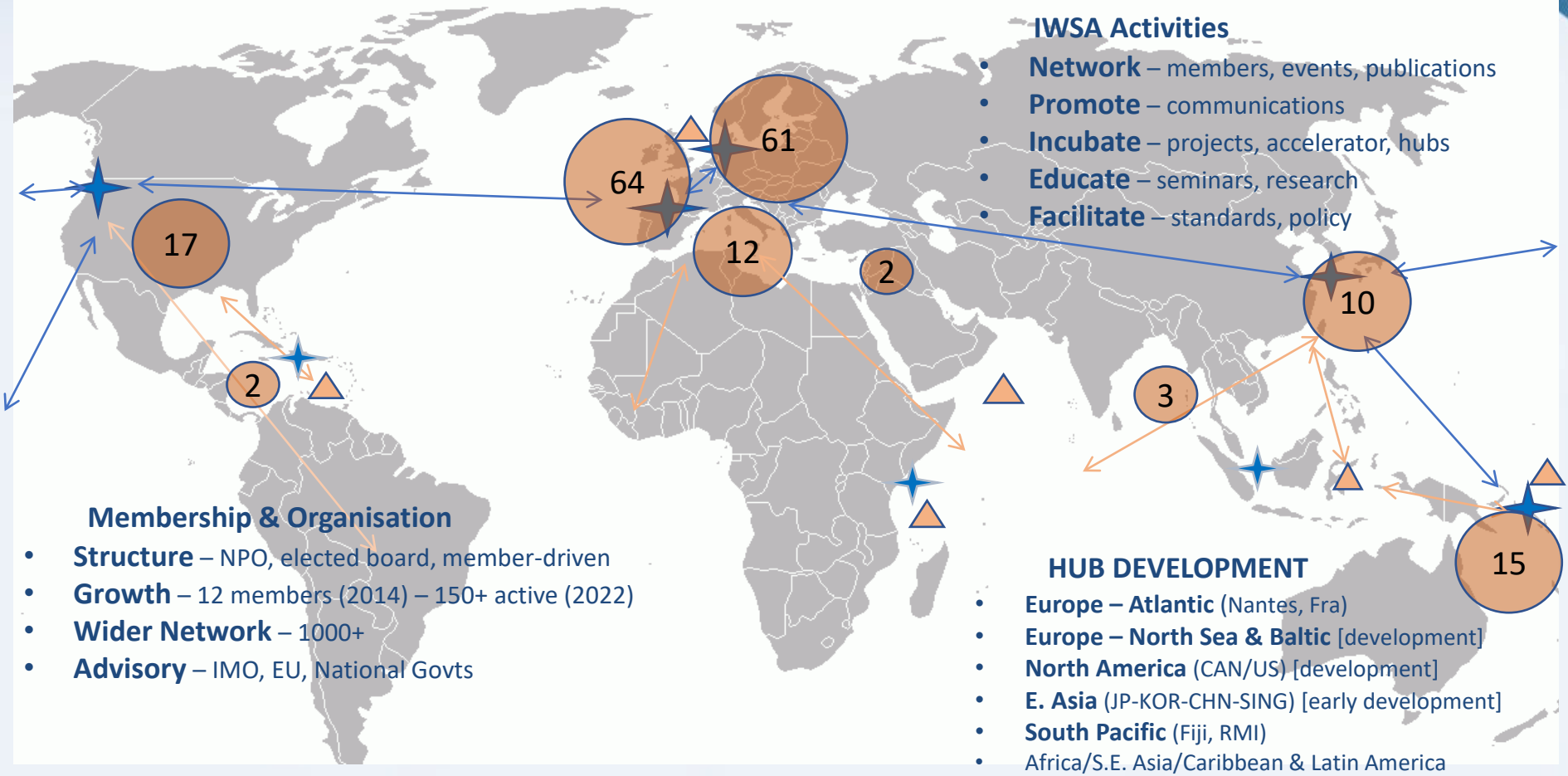
Wind Propulsion Systems, R&D & Decarbonisation of Shipping

IWSA
International Windship Association

International Windship Association Network

A unique, fast growing tech segment: significant decarbonisation & operational cost reduction potential



IWSA Activities

- **Network** – members, events, publications
- **Promote** – communications
- **Incubate** – projects, accelerator, hubs
- **Educate** – seminars, research
- **Facilitate** – standards, policy

Membership & Organisation

- **Structure** – NPO, elected board, member-driven
- **Growth** – 12 members (2014) – 150+ active (2022)
- **Wider Network** – 1000+
- **Advisory** – IMO, EU, National Govts

HUB DEVELOPMENT

- **Europe – Atlantic** (Nantes, Fra)
- **Europe – North Sea & Baltic** [development]
- **North America** (CAN/US) [development]
- **E. Asia** (JP-KOR-CHN-SING) [early development]
- **South Pacific** (Fiji, RMI)
- Africa/S.E. Asia/Caribbean & Latin America

Wind Propulsion Hubs | 2 IWSA Members | Traditional Sail Cargo Networks | Additional WP Hubs (proposed)

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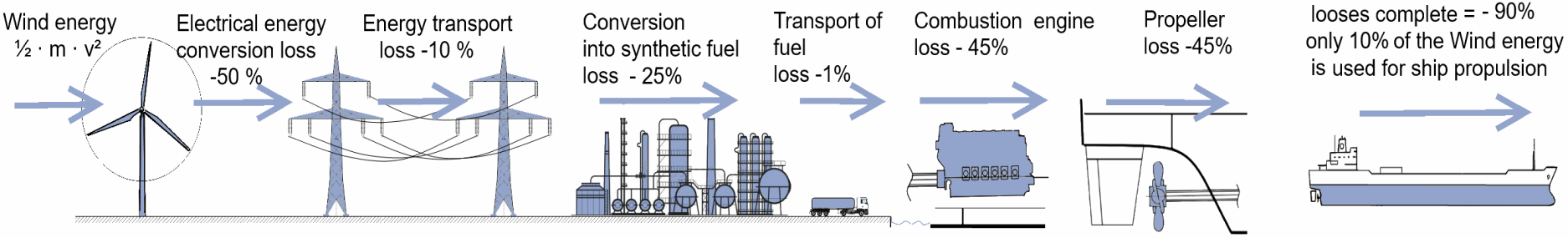
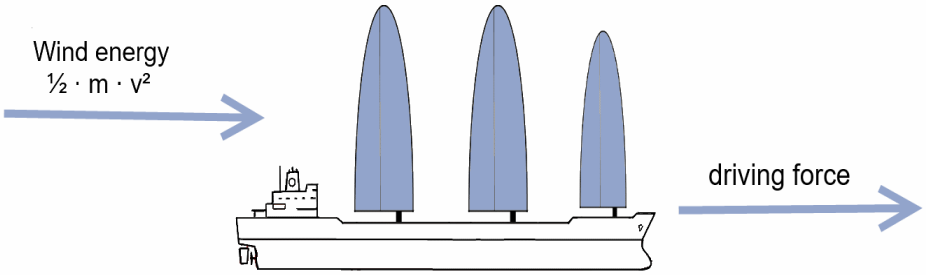
Direct Application of Wind Power

power 2 fuel concept: the long way from wind energy to driving force...



sailing ship : the short way from wind energy to driving force



advantages of a sailing ship:

- uses high wind potential on the open sea
- No losses due to energy conversion
- No losses due to energy transport
- No land-based infrastructure necessary
- One sailing ship replaces 10 land based wind power plants
- No fuel costs for the shipping company (wind is for free)
- less dependency of shipowners on fuel producers

Herbert Blümel ,2019

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What Wind Power Delivers…

Wind Energy

Zero - **Emissions**
Zero - **Cost**
Zero - **Volatility**
Zero - **Infrastructure**
Zero - **Storage**

Wind Propulsion Technology

Zero - **Development Time**
Zero - **Compatibility Issues**
Zero - **Additional Crew**
Zero - **CAPEX?**

RETROFIT
5-20% propulsive energy
& optimised up to 30%

OPTIMISED NEWBUILD
50-80%+ possible with
operational changes

Win-Win-Wind Situation

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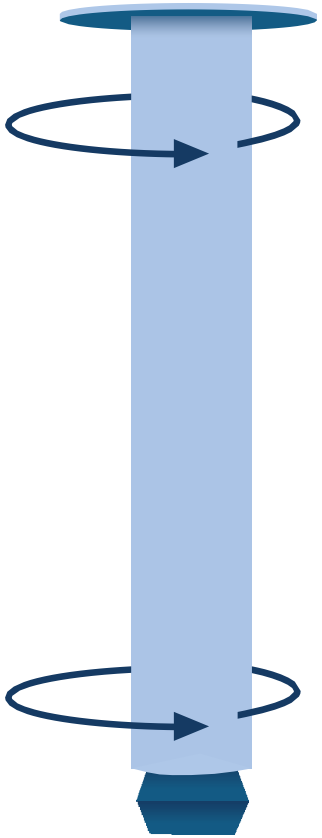
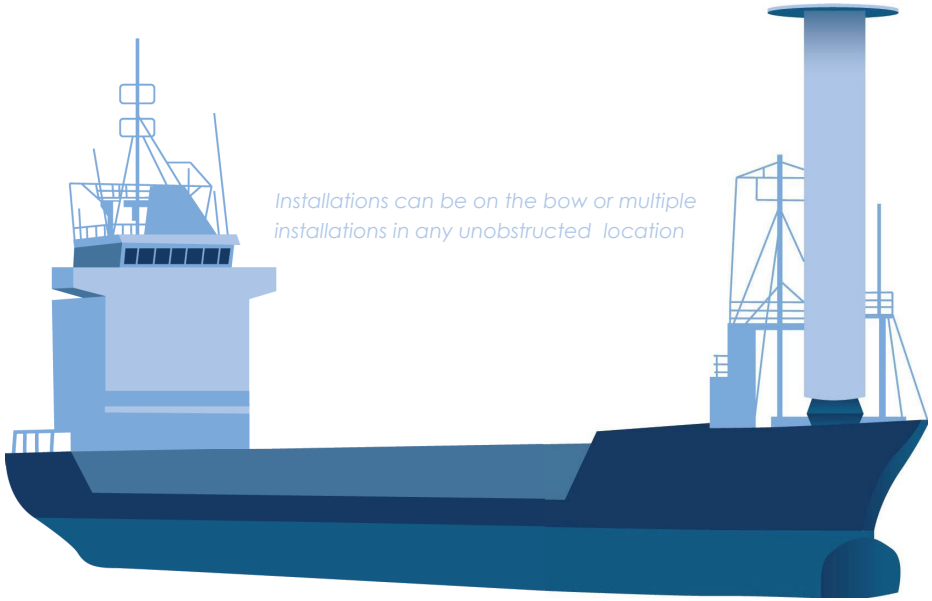


Rotor sail

Flettner Rotor or Rotor Sails are rotating composite cylinders with a top disc and possibly a bottom disc that are rotated at up to 300 rpm (dependent on size/application) by low power motors and as the wind catches the rig, they use the Magnus effect (difference in air pressure on different sides of a spinning object) to generate thrust. Systems already designed include ones deployed on rail systems, hinged and telescopic versions. The original concept was developed in the 1920's with a small number of installations, however the modern, upgraded version of these sails were first installed on modern vessels in 2010's.



Considerations

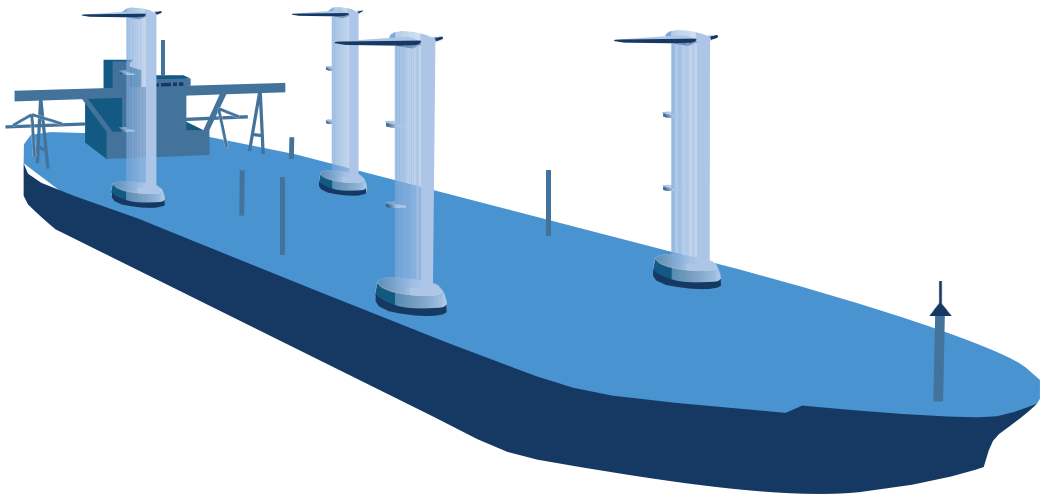
Deck space
Retractability
Navigation/Line of Sight
Beam/Head Wind Performance
Vibration/Motor

Installed Sizes (to date)
1m x 18m – 5m x 35m

Suction wing

Suction Wings (Ventifoil, Turbosail, eSAIL) are stubby, non-rotating wing sails with vents and an internal fan (or other device) that creates suction which pulls in the boundary layer around the wing generating enhanced effect. Installations to date have been deployed on the bow, stern and as deck containers and flatrack.

The system was originally designed and deployed in the 1980's



Considerations

Deck space
Retractability
Navigation/Line of Sight
Suction device

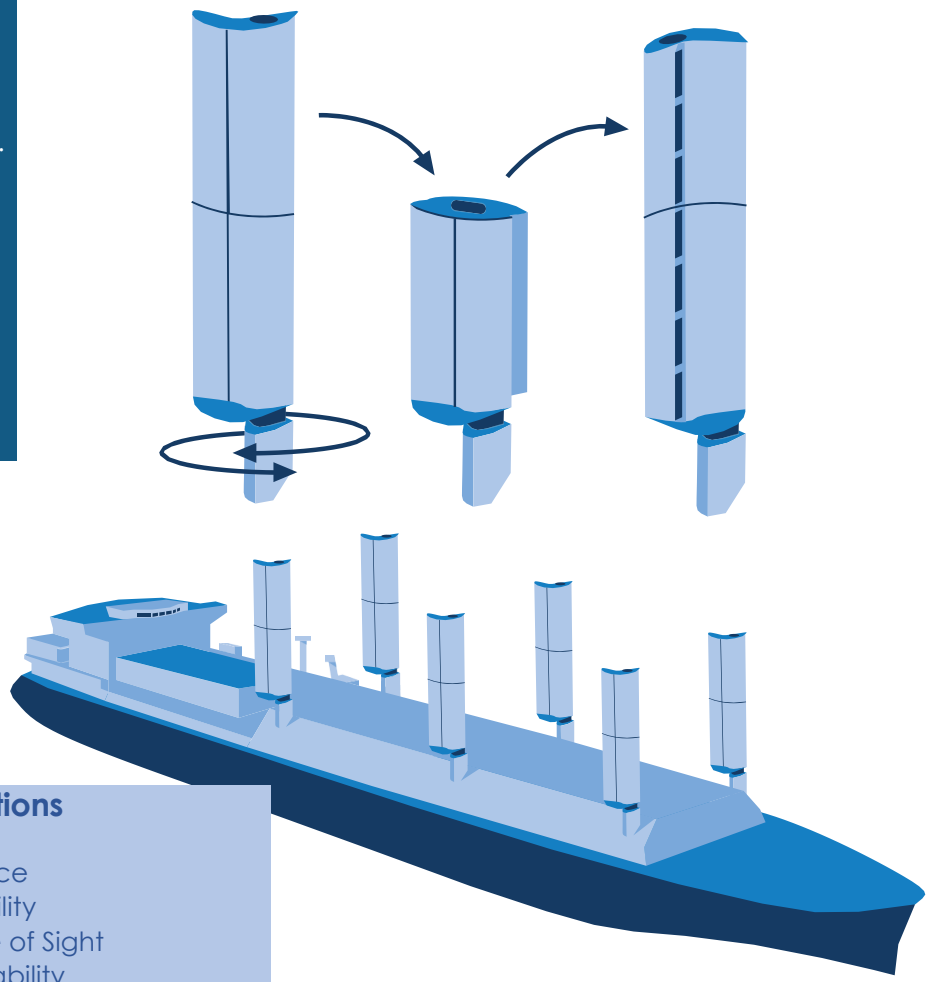
Installed Sizes (to date)
10m-17m

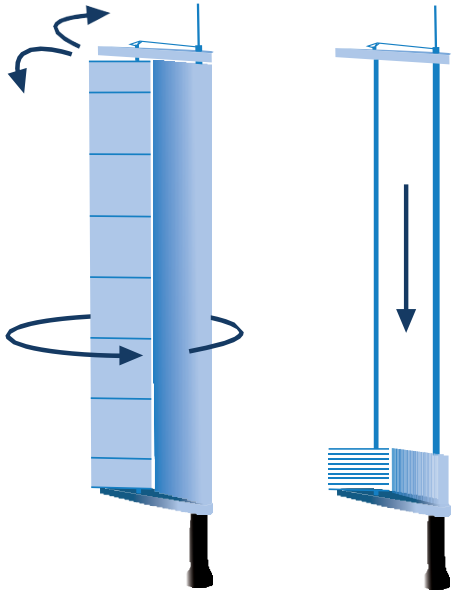
Hard sail

Hard or rigid sails are defined by the use of a rigid materials and design and these types of system have been used extensively in the racing world. There are quite a variety of different systems from wing sails, foils and JAMDA style rigs, some with single or multiple foils, others deploying movable flaps and some segmented. Some rig designs have solar panels for added ancillary power generation.

Note: There are also hybrid wing sails developed that have a rigid frame, but flexible soft coverings. Rigid sails were first deployed on modern commercial vessels in the 1970s and 1980's.

Single wing sail with flap and retractability



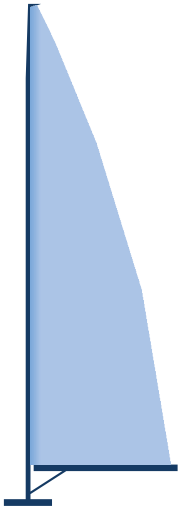


Hybrid wing sail with flap with soft membrane

Considerations

Deck space
Retractability
Navigation/Line of Sight
Windage/Stability

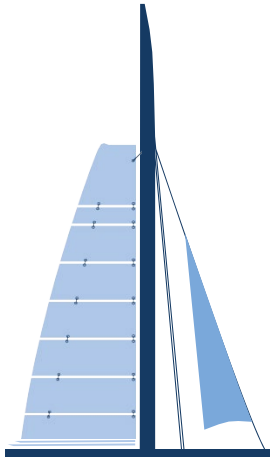
Installed Sizes (to date)
2m x 9m -15m x 35m



Soft sail & Hybrid sail

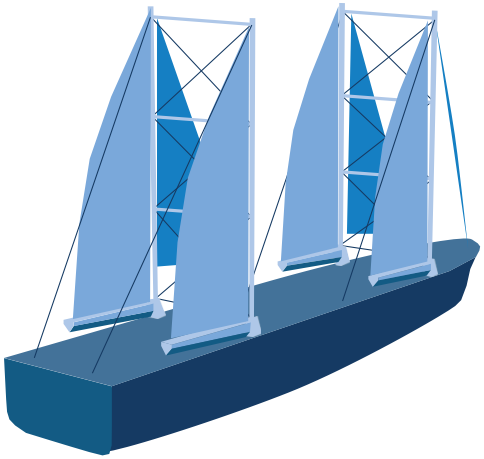
Soft sails come in a wide variety of configurations and these include both traditional sail rigs and new designs such as the dynarig system. Many of these systems are well-tested and their use has been extensive throughout the world both commercially and more prevalently in leisure sailing recently.

New robust materials & production techniques are lengthening their usability/lifespan and automated furling systems and control systems reduce the need for additional crew for large installations (smaller rigs can still be handled manually). Commercial applications require masts to be either retractable or foldable.



Hybrid rig design using furlable rigid panels and soft sail combo

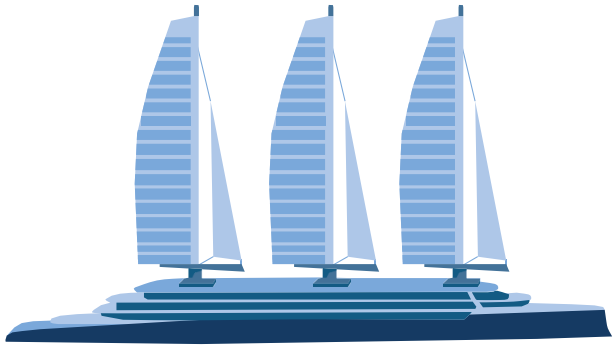
Auto-furling systems are configured for large traditional soft sail installations

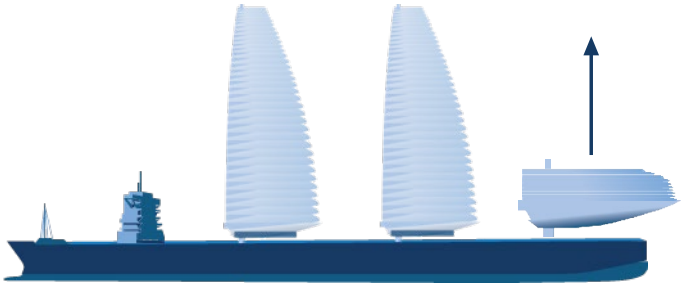


Considerations

Deck space
Retractability
Navigation/Line of Sight
Windage/Stability
Material longevity

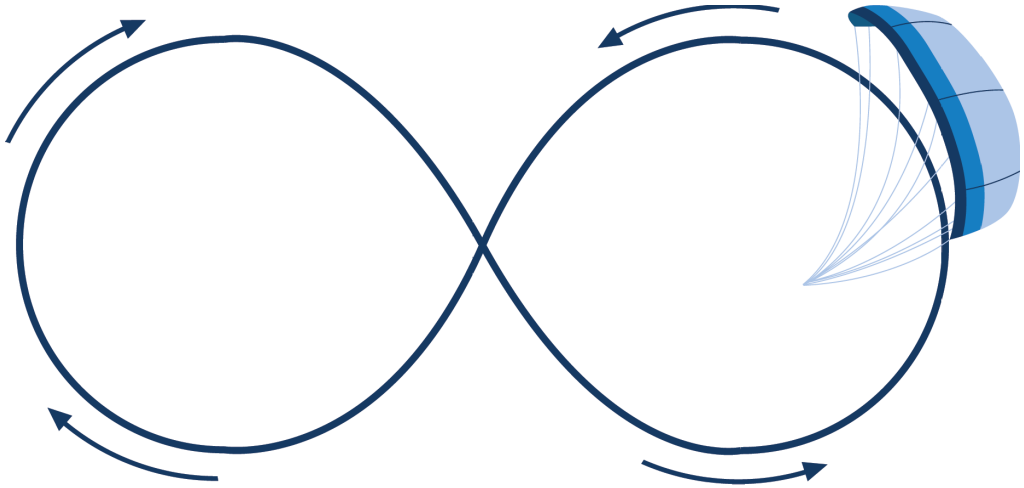
Sizes
highly variable/flexible





One of many new designs, this one is using an inflatable sail system

Dynamic kite example with a figure of eight deployment to enhance power delivered



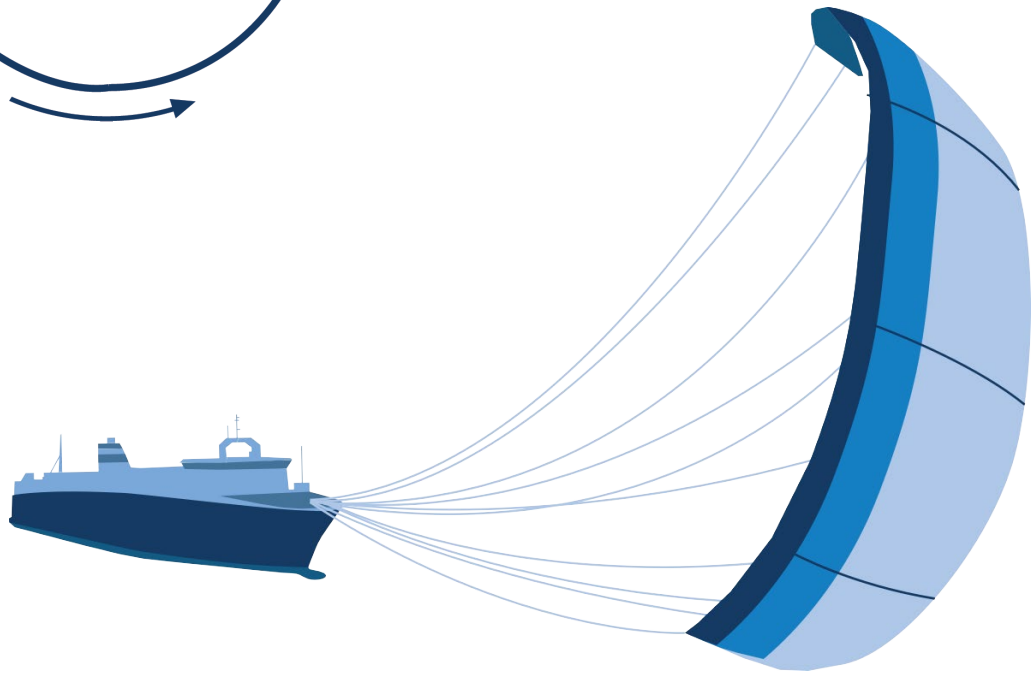
Considerations

Wind Resources/Direction
Deployment/Retrieval
Control systems
Material longevity

Sizes
(deployed/designed)
500m2 – 1000m2

Kite

Kites are deployed at over 200m above the vessel with a tether attached to the bow of the vessel to assist with propulsion. The kites take advantage of constant winds at those high elevations and can either be passive (maintain a single position) or dynamic (controlled deployment in a figure of eight or other configuration to maximise thrust). Kites are primarily generating thrust however the tether could also be used to generate electrical energy. First generation towing kites were first deployed in the 2010's.



Turbine

Turbines using marine adapted wind turbines to either generate electrical energy or a combination of electrical energy and thrust. Turbine systems are being designed that are both vertical and horizontal configurations.

Considerations

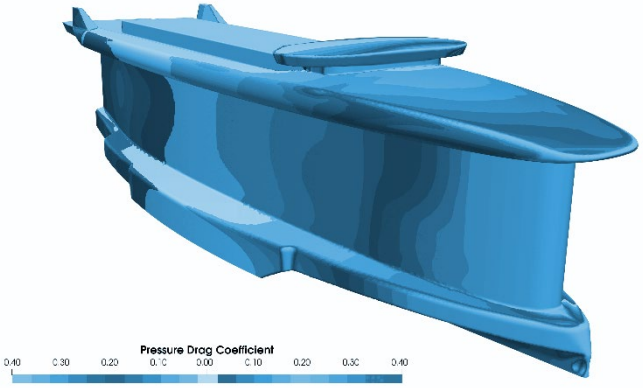
Wind Resources/Direction
Mountings/Forces
Vibration/Stability
Material longevity

Sizes
Containerised or Free Standing

Considerations

Stability / Ballast
Extreme Weather Performance
Ship Type / Adaptation

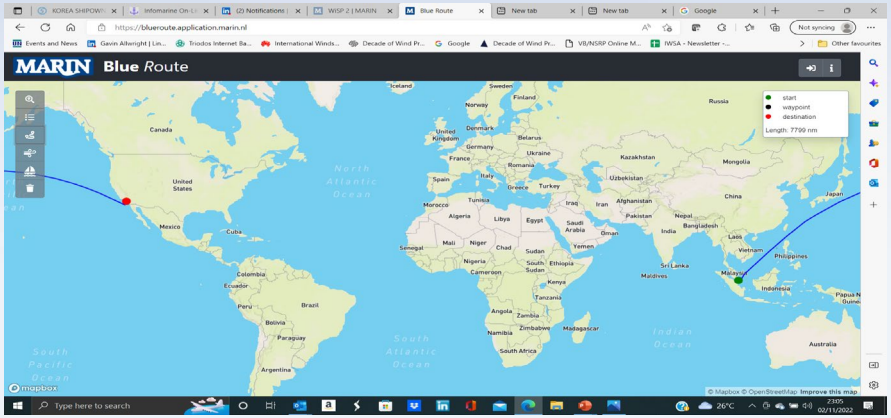
Sizes
Vessel Size

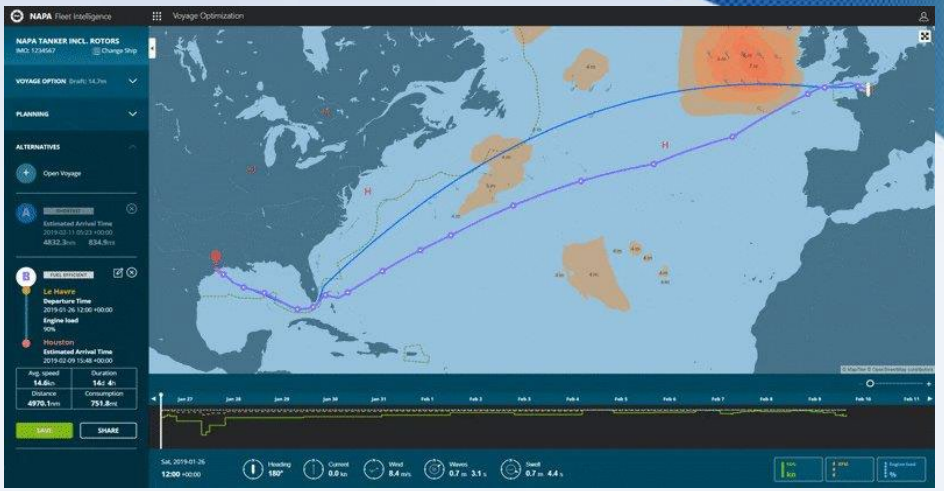


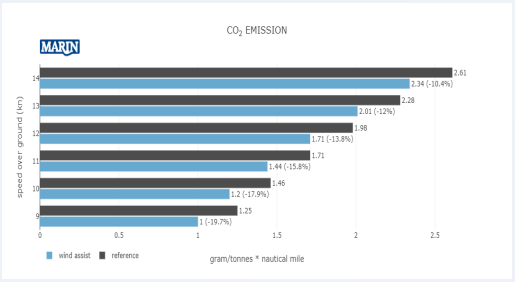
Hull Form

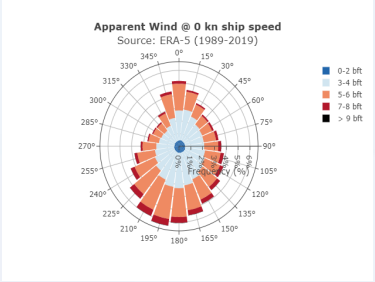
Hull Form designs take the whole of the vessel and adapt the ship's hull itself so that it functions as a large 'sail', capturing the power of the wind to generate thrust. Applicable primarily to newbuilds.

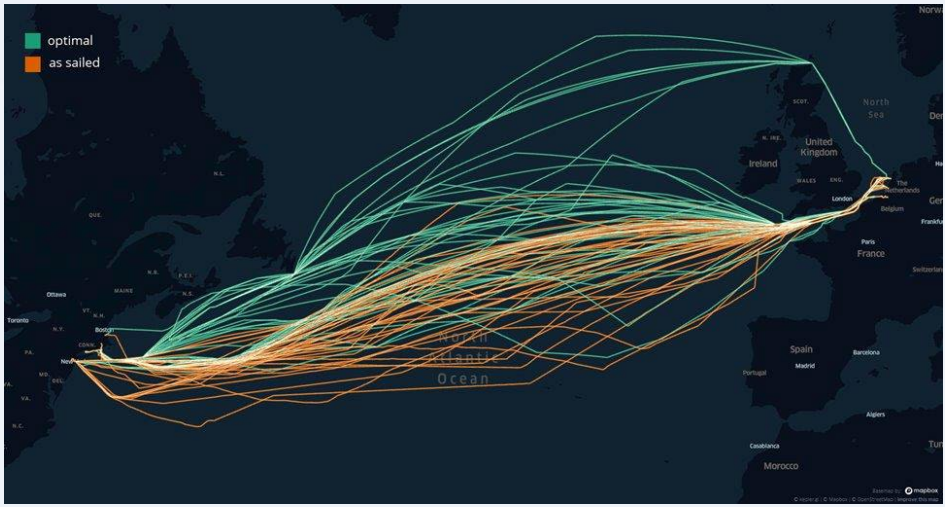
Optimisation: Weather Routing











Example: Direct Course Only
Singapore – Los Angeles
Capesize bulker (loaded)
4 Flettner rotors

(Capesize = approx. 70t fuel/day)

Source: MARIN Blue Route (WiSP JIP)

Source: NAPA

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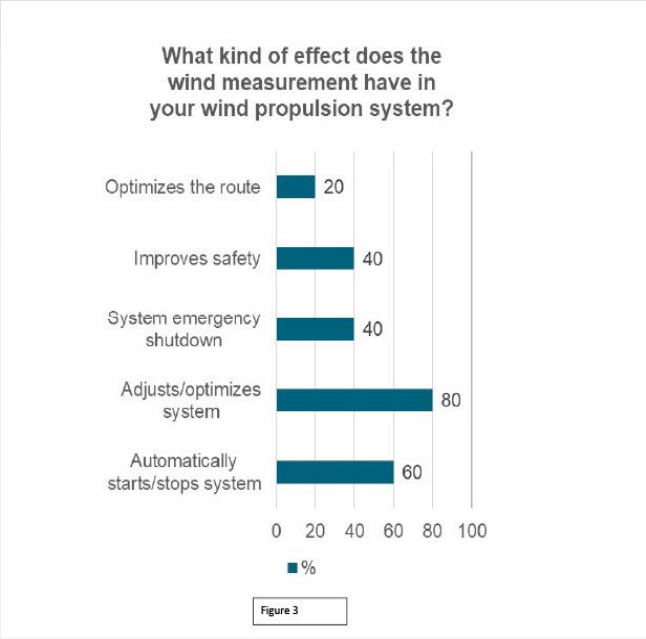
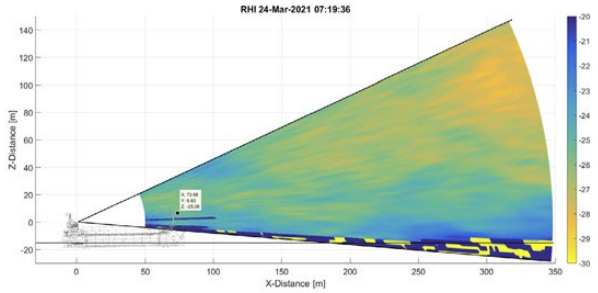
Optimisation: Wind Sensors & LiDAR

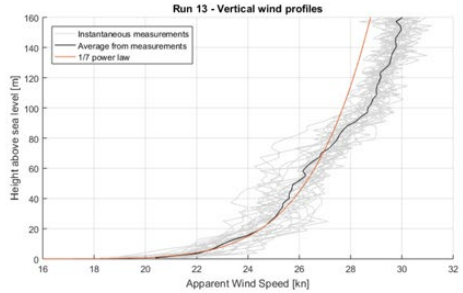


Wind Measurement & Sensor Survey
May 2022 (Vaisala & IWSA Members)

LiDAR Testing on Vessels
(Digital Twin & Operations)



RHI scan example along the anemometers in the forward mast. Image courtesy @MARIN.



Measured instantaneous vertical wind profiles over run 13 (grey lines) and 1/7 power law fitted to 10 m reference value (red)

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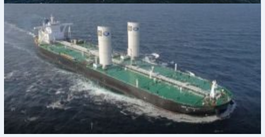
Large Vessel Installations Today…

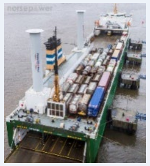
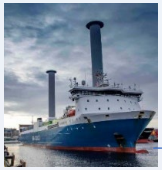
23 Ocean Going Vessels with Wind-Assist Systems installed by Jan 2022

& 4 x Wind-ready + more than 20 small sail cargo, fisheries & cruise vessels in operation

NOTE: *More large WPT vessels in operation than all new alternative fuelled ships combined (excluding tankers & LNG/LPG)*









Ship Types
Tankers x 3 (+1) (2 order) 2 x VLCC, 1 x LR2 Tanker
Bulkers x 4 (+2) (5 x pending + 7 order) 1 x VLOC, 1 x Capesize, 1 x Ultramax, 1 x Kamsarmax (+2 wind ready)
RoRo x 5 (+1) (2 x pending + 1 order)
Ferry/Cruise x 3
General Cargo x 7 (4 x pending + 3 order) Various sizes: 2–12,000dwt
Large Fishing Vessel x 1











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Small Vessel & Traditional Sail Developments

Operations: Cargo





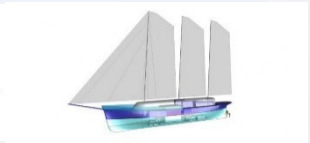

Operations: Fisheries


Operations: Cruise



Technology & Networks



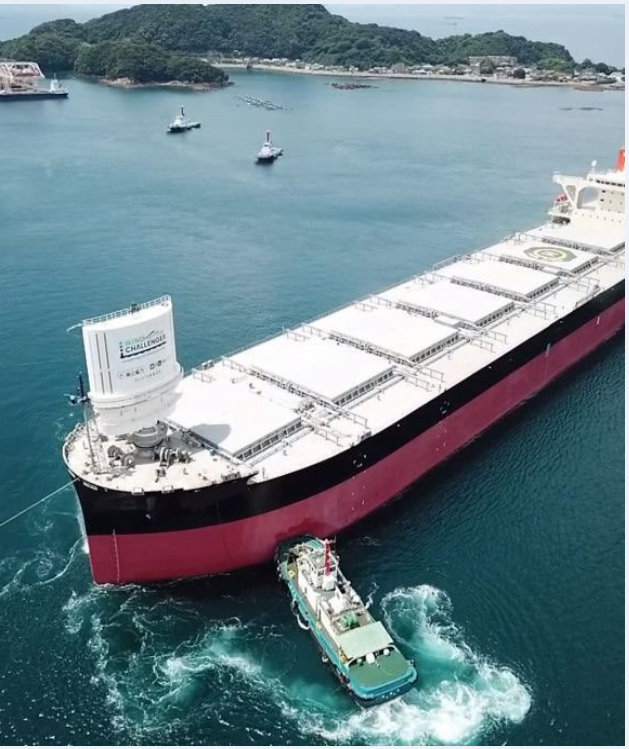


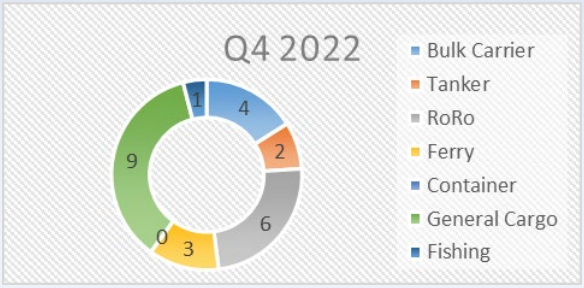

Ship Designs

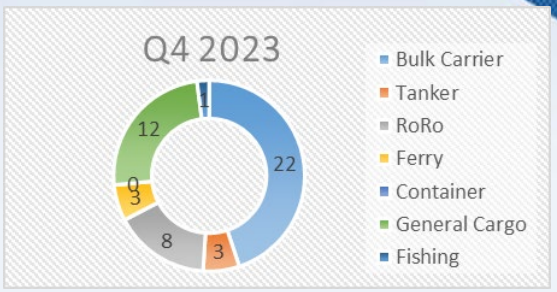


Builds & Retrofits

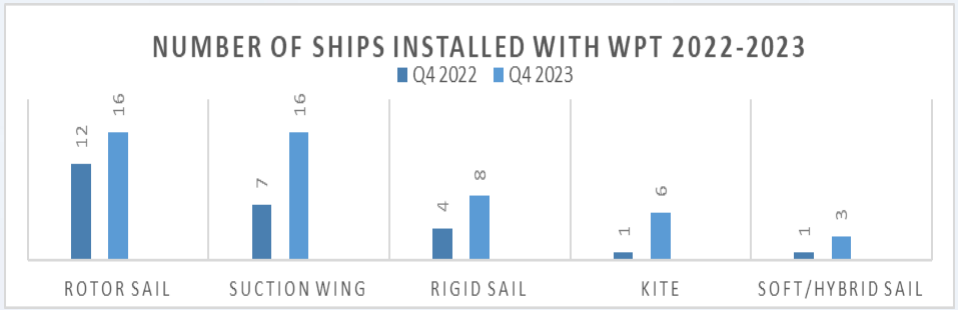
Market Development



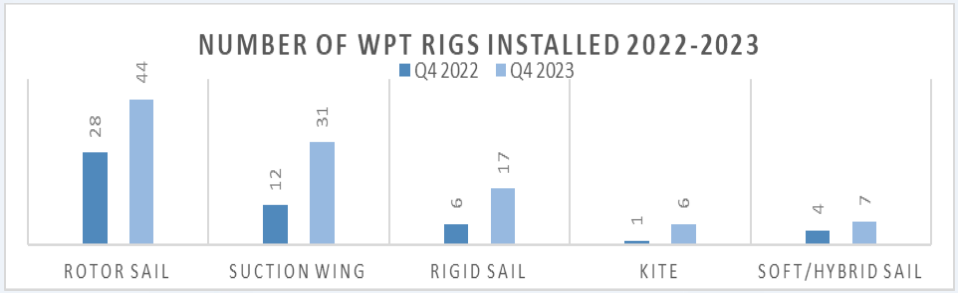




WPT installations by fleet category 2022-23



Ships installed by WPT category 2022-23



Rigs installed by WPT category 2022-23

Ref: IWSA Members Survey (May 2022)

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Signs of Scaling & Maturity in the Market?

Technology

R&D

Container vessel AiP

Turbines, Hull forms, Primary Wind
Drone/autonomous
Lidar / Harvesting

Market Availability

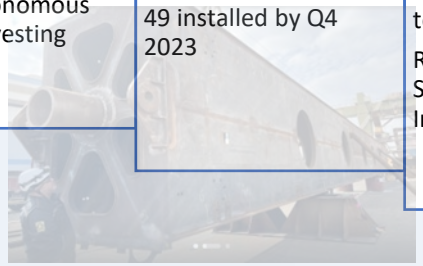
23 Vessels + 4 Wind-ready - 12+ OEMs

49 installed by Q4 2023

Size, Variants etc.

Size, power, additional tech (flaps, fans etc.)

Routing/software
Sensors/Remote
Integration



Production & Partnerships

Standardisation

Sizes, Materials, Operating Systems, Fleet Installations
Moulds
Standard Yard Lists

Scaling & Geography

Manuf. Lines – Asia

Fleet Installations
Industry Partners
Demonstrators
Long-term contracts

Hybrid Systems

Wind + Zero-emissions/air lubrication
Wind + Harvesting Energy Integration

Verification

Technology Validation

Increased datasets
Evaluation tools
Third party verif.

Standard Approaches

Fuel/Power calc.
Sea Trialling
EEDI/EEXI Calc.
Safety/COLREGs

Classification

Comprehensive – class guidelines + increase focus on primary wind.

Finance

Economies of Scale

Lowering costs – manuf./installation/ integration, learning curve, collaborations
JIP/A&M

De-risking & Investment

Leasing
Pay as you use
OPEX shift

Larger stakeholders
Service agreements

Wind as a Service

Tech agents/Third party , hands-off, vessel as market place etc.

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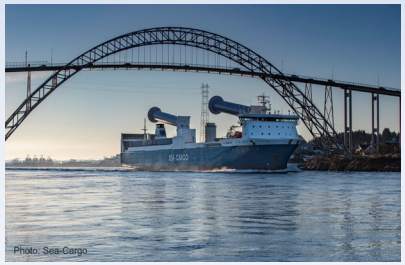
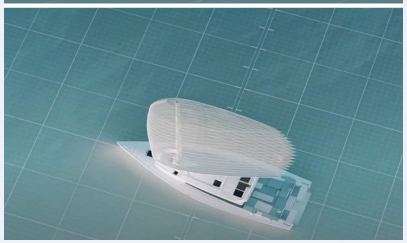
Example: Primary Wind: Larger Vessels

Name	Neoliner	Silenseas 210	Oceanbird	Wind Hunter
Size	136m x 24m 11,000GT/5,000dwt	190m x 25m 300pax 23,000GT	200m x 45m 7,000 car capacity	Not currently specified
Type	RoRo	Expedition Cruise	Car Carrier	Tanker
Wind System	Soft Sail	SolidSail: reefable rigid sail system	Rigid Wingsail: retractable	Rigid 'Windchallenger' Sails: retractable
Performance	Upto 80% wind power 11kn sail, 14kn engine	Upto 70% wind power. Max speed under sail 17kn	Upto 90% wind power at 10kn	100%+: capture excess wind energy – H2 fuel
Build/ Operation	2023/24 // 2025	Build ready – full scale rig testing 2022/23 – first 2 x Orient Express Ships 2026/27	Design 2023, first operations 2025	Initial system testing 2021/2, 60m test vessel 2024, full-size by 2030
Route	Initial: North Atlantic	Various	Initial: North Atlantic	Pacific+

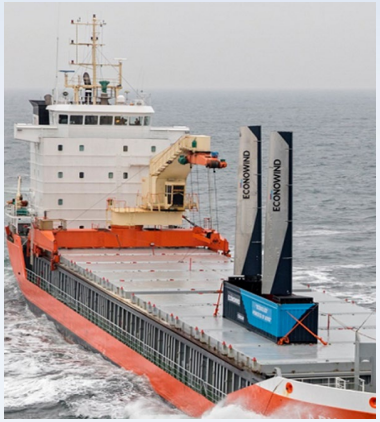
Wind Propulsion: Trends & Approaches





Retractable, Stowable, Mobile

Modular & Containerised



Energy Harvesting & Wind Ready

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Win-Win-Wind Propulsion….

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