– Wind Propulsion –
Meeting the Sustainable Shipping Challenge

Ambitious Decarbonisation Targets

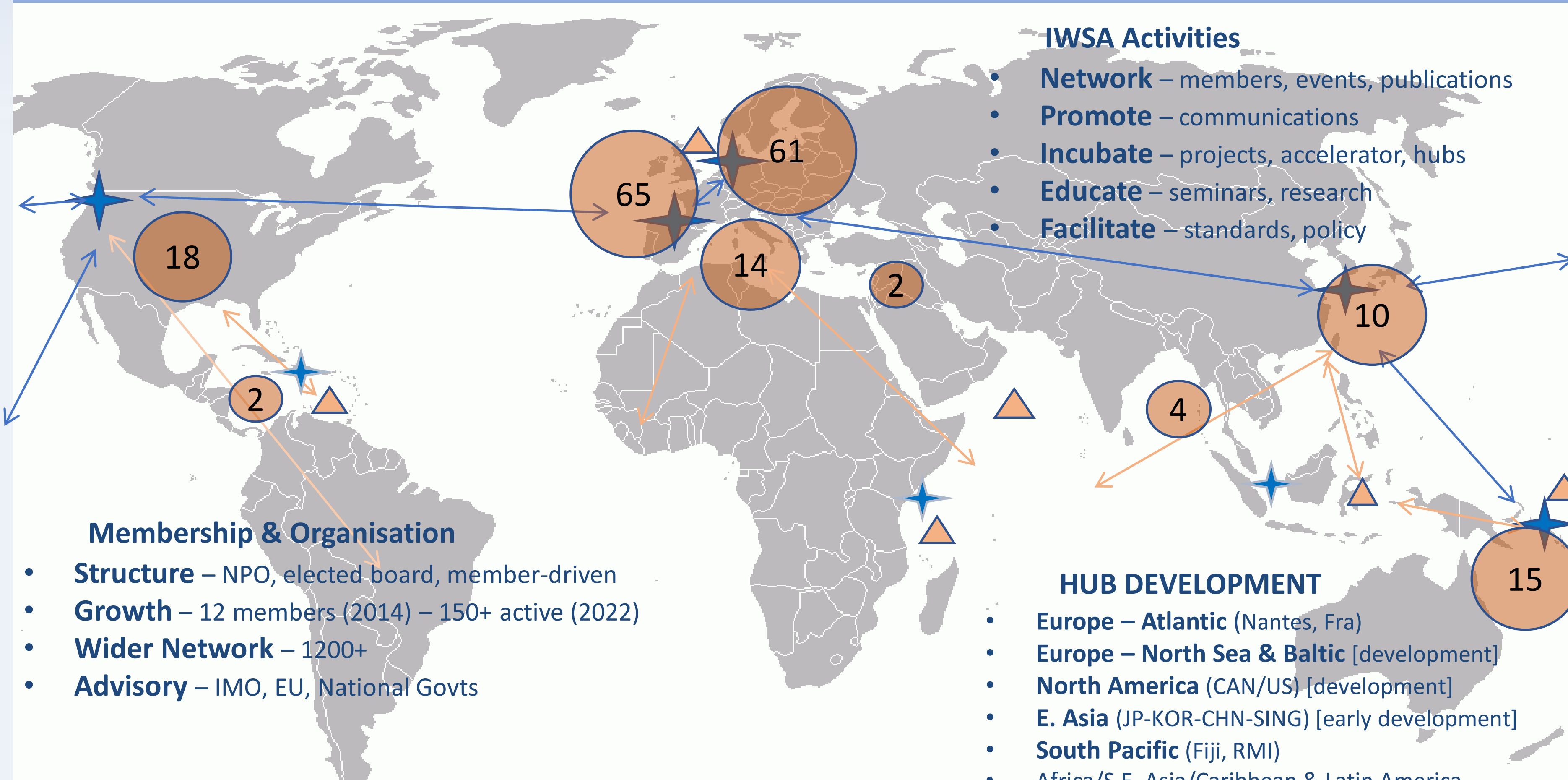
1.5°C

"All ships built today must operate in a net zero emissions world at the end of their service life."

"Carbon budget expended by 2030 if we continue 'Business-as-Usual' approach."

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** – 1200+
- **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)

IWSA International Windship Association

What Wind Power Delivers…

Wind Energy

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

Wind Propulsion Technology

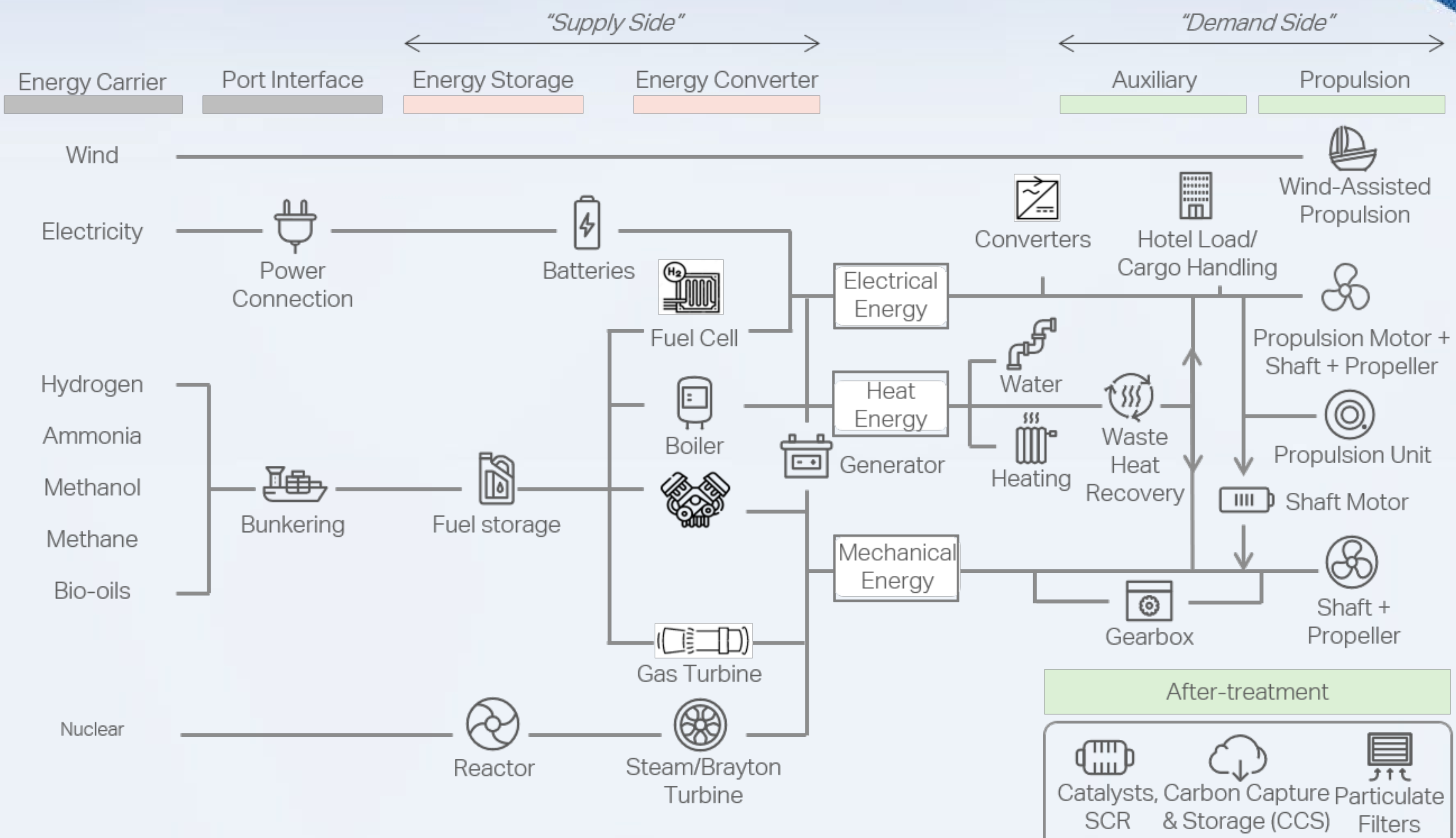
Zero - **Development Time**
Zero - **Compatibility Issues**
Zero - **Additional Crew**
Zero - **CAPEX?**

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

OPTIMISED NEWBUILD
50-80%+ possible with operational changes

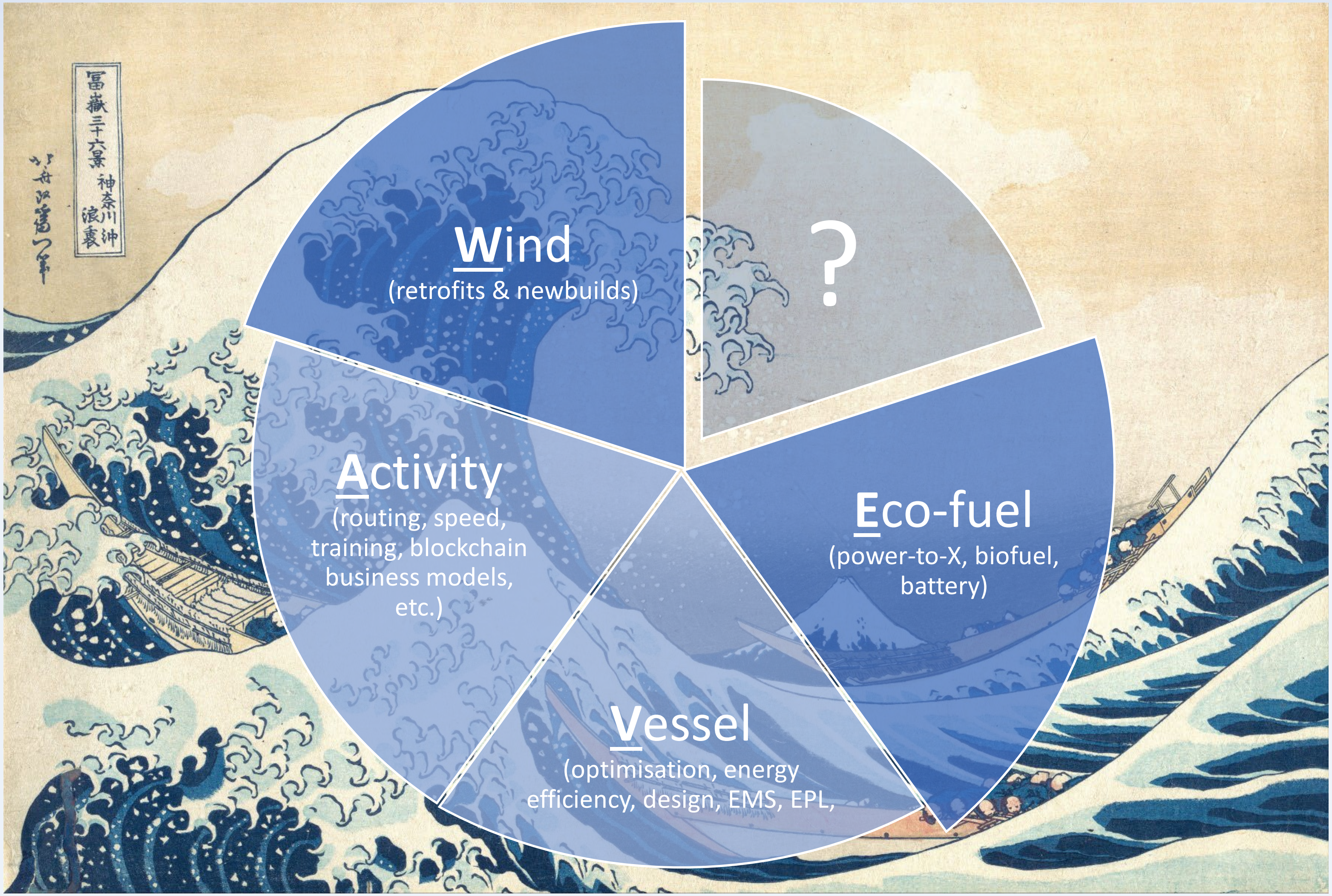
Win-Win-Wind Situation

Wind as a Primary Energy Propulsion Provider



Ref: Industry Transition Report: Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (2021)

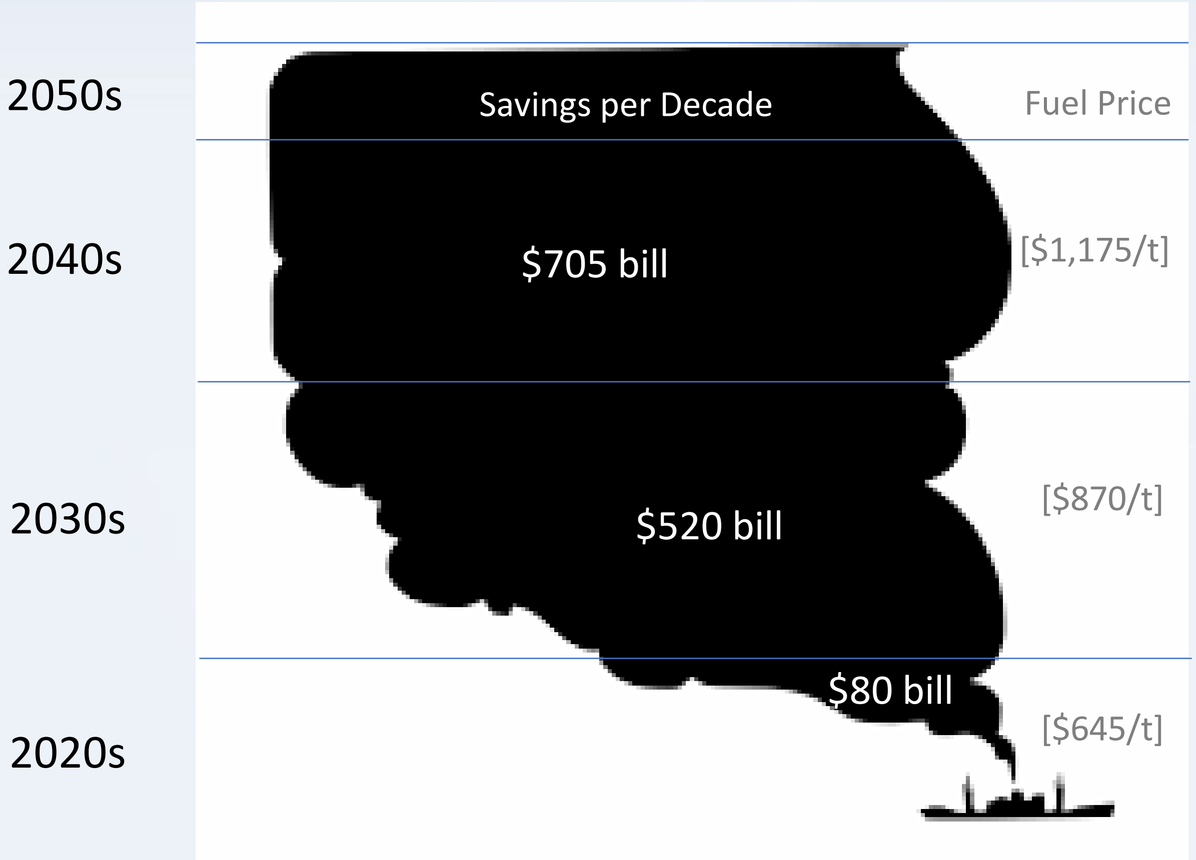
Hybrid W.A.V.E.



冨嶽三十六景
神奈川沖浪裏
Wind
(retrofits & newbuilds)
?
Activity
(routing, speed, training, blockchain business models, etc.)
Eco-fuel
(power-to-X, biofuel, battery)
Vessel
(optimisation, energy efficiency, design, EMS, EPL,

The Shipping Sustainable Shipping Challenge….

Could Wind Propulsion Fund the Sustainable Shipping Transition of the Fleet?



UMAS/ETC Report

IMO2050 (50%) = $1-1.4 trill

100% Sustainable Shipping = <u>$1.4-$1.9 trill</u>

[$1.4 trill = $20+mill per ship]

Ref: UMAS/ETC Report (2020)

Full Wind Propulsion Roll Out in 2020s.

Installation costs = c.**<u>$300 bill</u>**

+ Reduce total cost by 10-20%

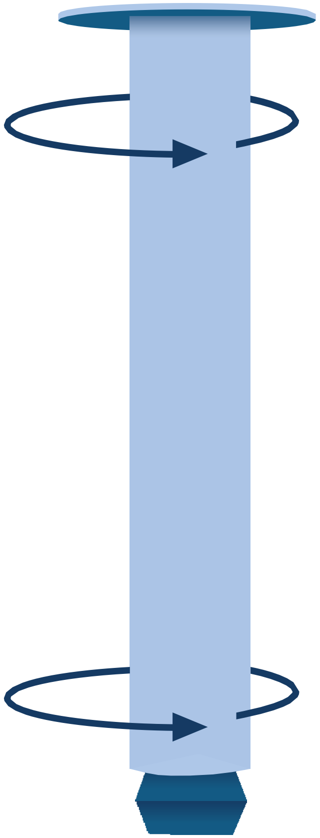
[$200-300 bill = <$5 mill per ship]

- *Static fleet size* : 60,000
- *Fuel:* $300 mill t/yr / *CO2*: 1bill t/yr
- *Price*: $645/t (VLSFO Global Av./02 May'23)
- *Increase*: 35%/decade from 2030s
- *Wind*: 20% power delivery (inc. some operational changes)

NOTE: No IRR/Currency rates etc included

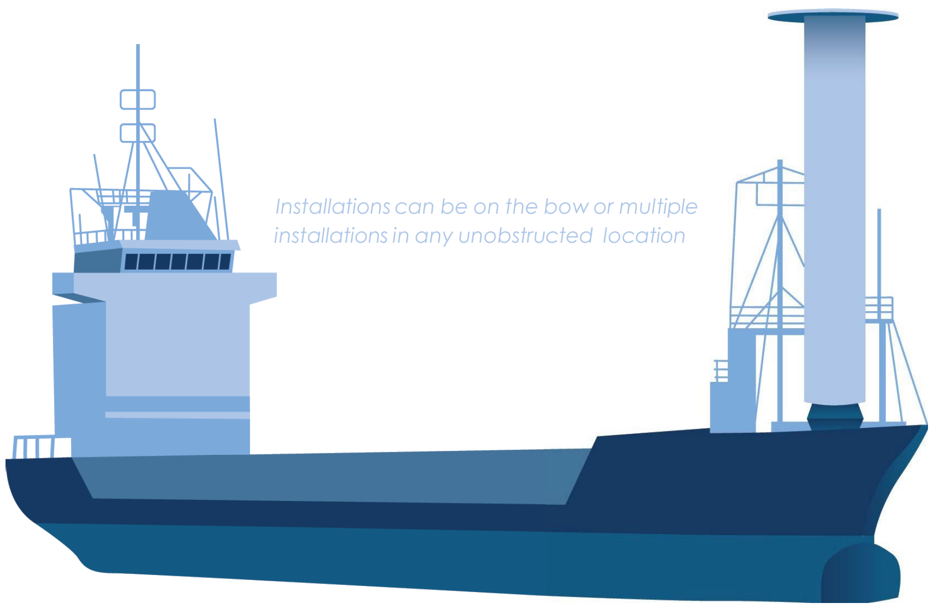
Ref: Updated from IWSA Article (2021)

<u>$1.3 trillion</u>+ savings by 2050 (+ lowers total cost to $1.1-1.7 trill)



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

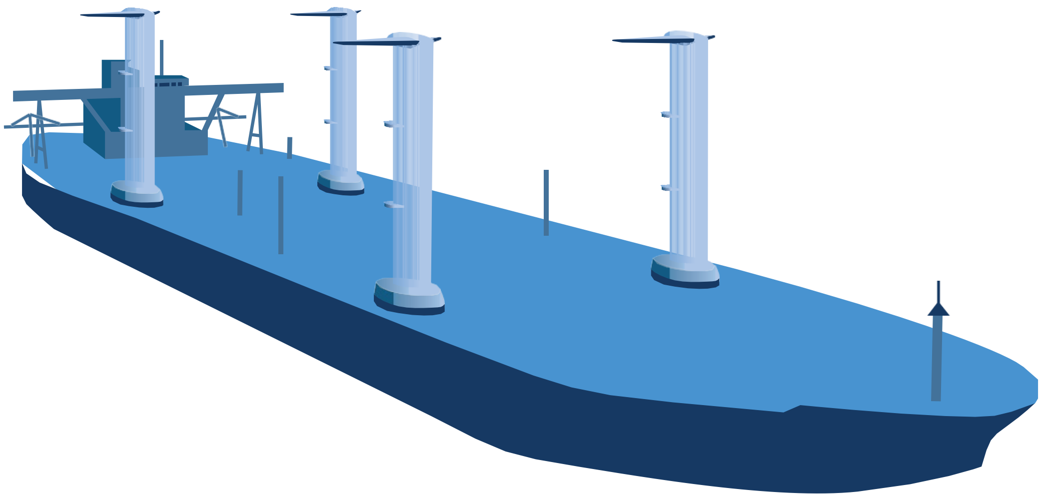
Deck space
Retractability
Navigation/Line of Sight
Beam/Head Wind Performance
Vibration/Motor

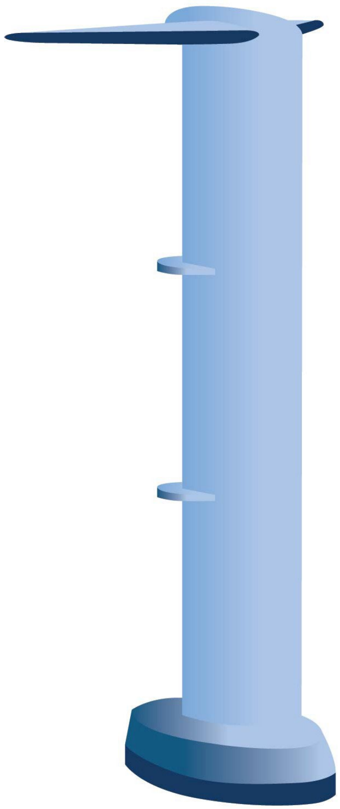
Installed Sizes (to date)
1m x 18m – 5m x 35m

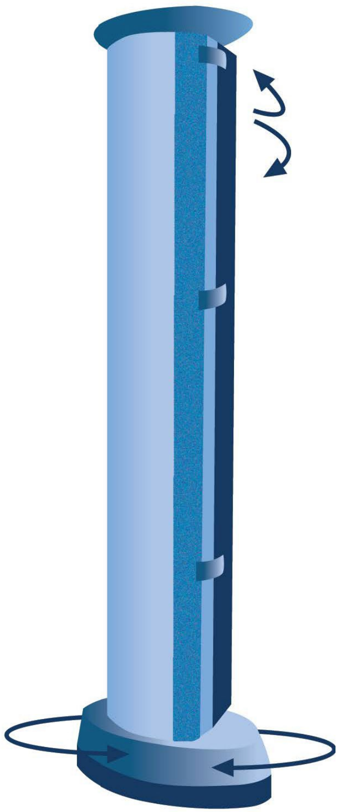
Suction wing

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

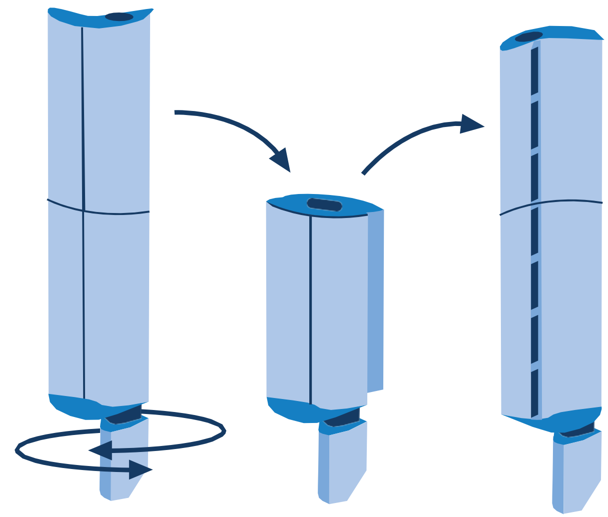
Installed Sizes (to date)
10m-17m

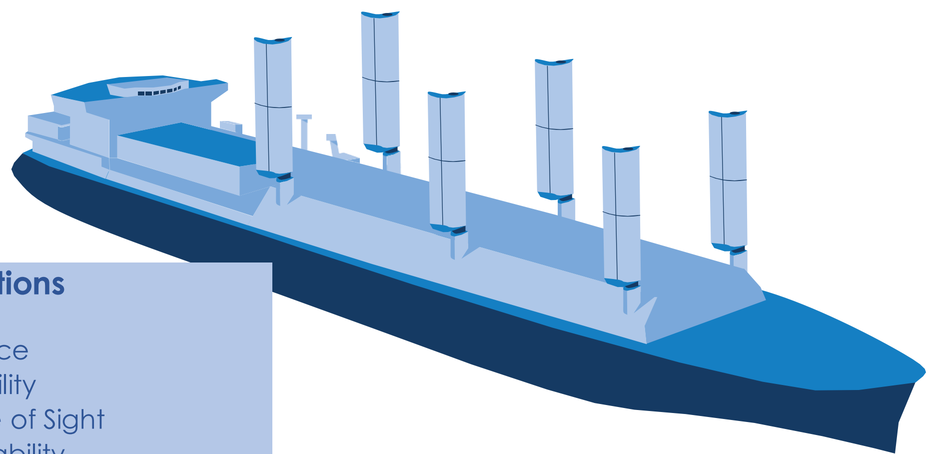
Hard sail

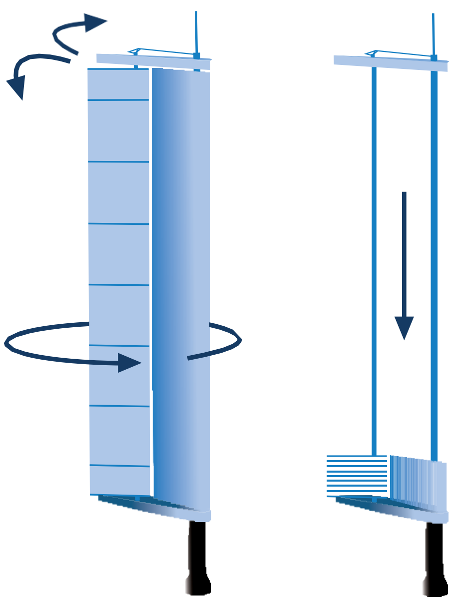
Hard or rigid sails are defined by the use of a rigid materials and design and these types of system have been used extensively in the racing world. There are quite a variety of different systems from wing sails, foils and JAMDA style rigs, some with single or multiple foils, others deploying movable 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





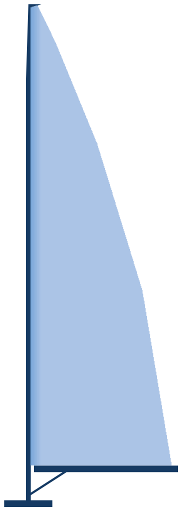


Hybrid wing sail with flap with soft membrane

Considerations

Deck space
Retractability
Navigation/Line of Sight
Windage/Stability

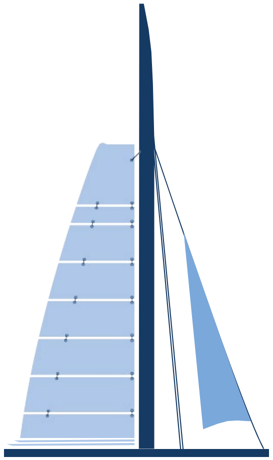
Installed Sizes (to date)
2m x 9m -15m x 35m



Soft sail & Hybrid sail

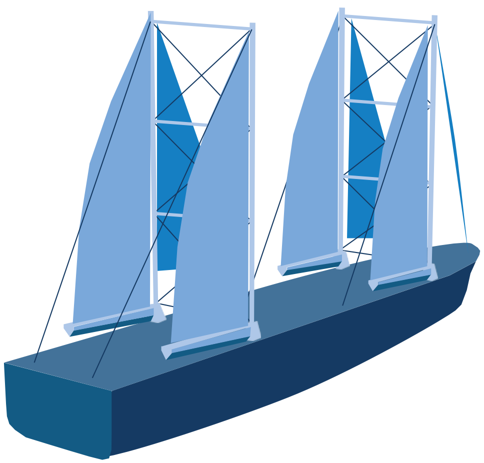
Soft sails come in a wide variety of configurations and these include both traditional sail rigs and new designs such as the dynarig system. Many of these systems are well-tested and their use has been extensive throughout the world both commercially and more prevalently in leisure sailing recently.

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

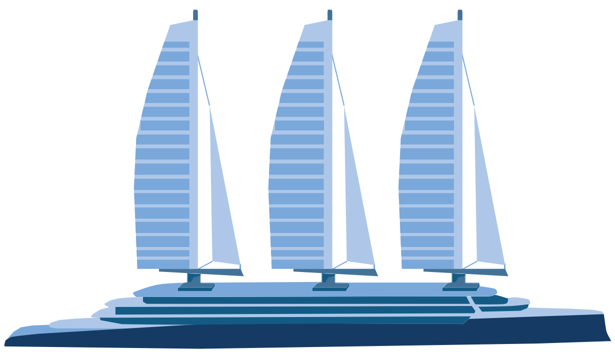
Auto-furling systems are configured for large traditional soft sail installations

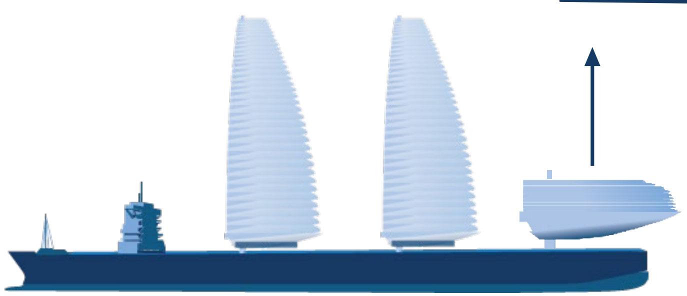


Considerations

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

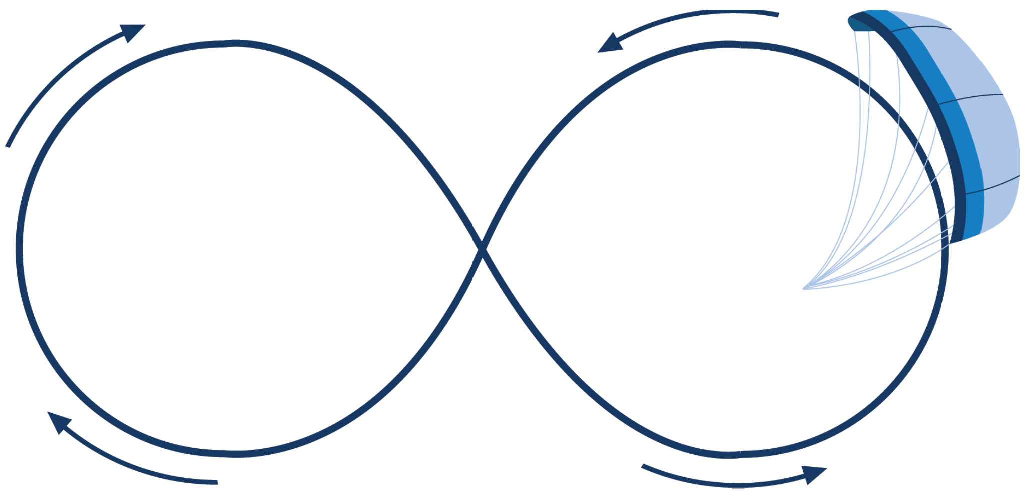
Sizes
highly variable/flexible





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



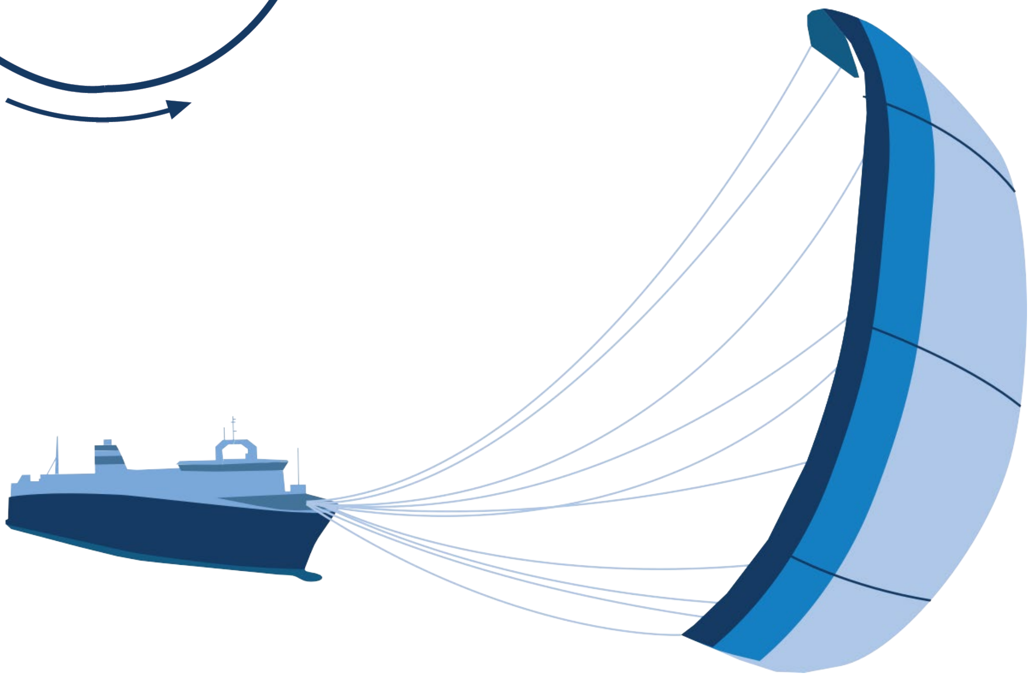
Considerations

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

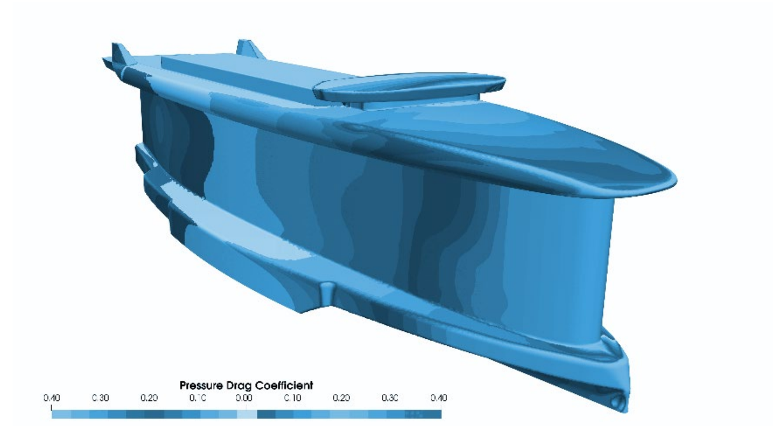
Containerised or Free Standing

Considerations

Stability / Ballast
Extreme Weather Performance
Ship Type / Adaptation

Sizes

Vessel Size

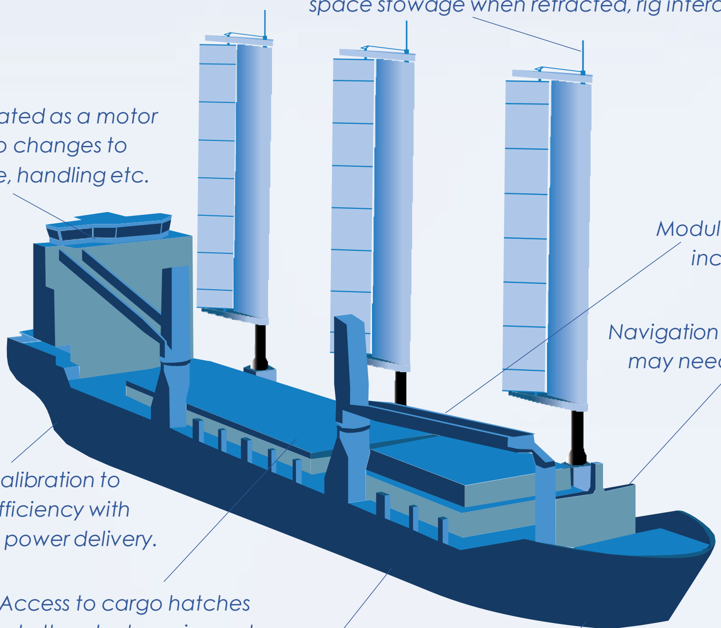


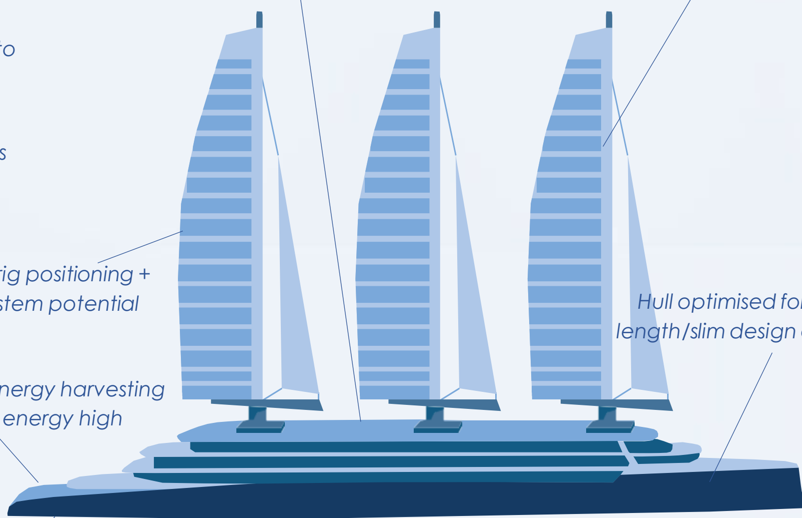
Hull Form

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.

Some Key Considerations Assessing WPT

Wind-Assist





Primary Wind & Newbuild Wind-Assist

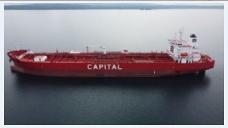
Large Vessel Installations Today…

24 Ocean Going Vessels with Wind-Assist Systems installed by May 2022

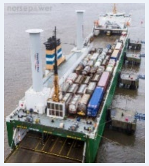
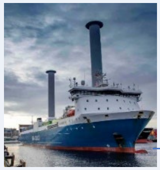
& 9 x Wind-ready + more than 20 small sail cargo, fisheries & cruise vessels in operation

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







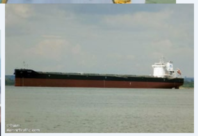





Ship Types
Tankers x 3 (+5) (2 + 1 wind ready order) 2 x VLCC, 1 x LR2 Tanker (+ 5 wind ready)
Bulkers x 4 (+2) (5 x pending + 7 order) 1 x VLOC, 1 x Capesize, 1 x Ultramax, 1 x Kamsarmax (+2 wind ready)
RoRo x 5 (+1) (2 x pending + 1 order) (+ 1 wind ready)
Ferry/Cruise x 3
General Cargo x 7 (4 x pending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







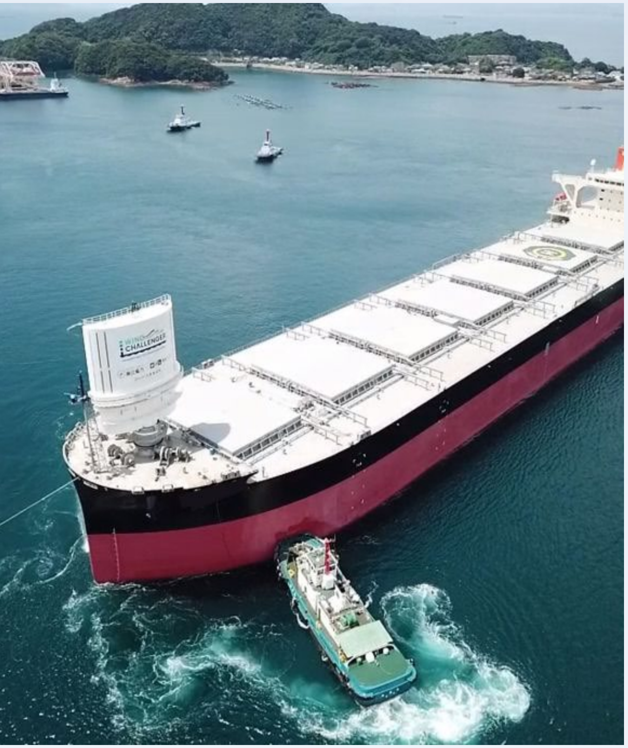


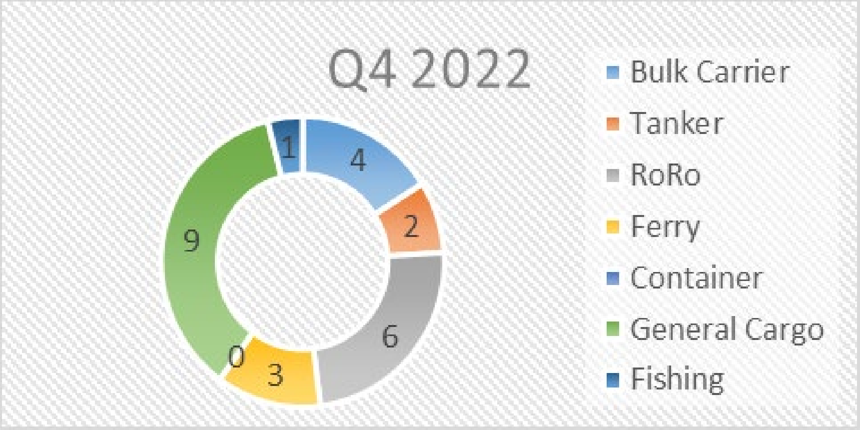





IWSA International Windship Association

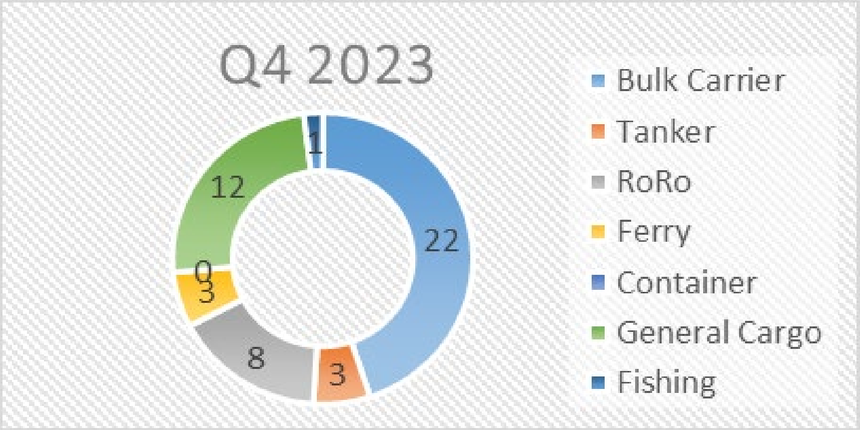
Market Development – 400GT+





24 vessels installed
+ 3 wind-ready

1.5 million dwt



49 vessels installed
+ 7 wind-ready

3.3 million dwt

Large WPT installations by Fleet Category 2022-23

[additional 20+ traditionally rigged cruise and small cargo vessels & sizeable number of small indigenous sailing vessels worldwide.]

Ref: MEPC79/INF.21

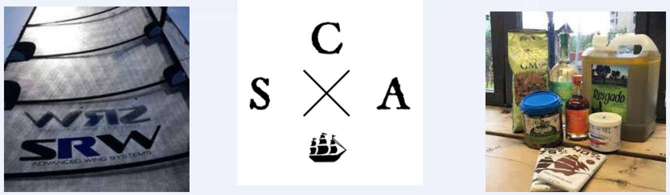
Small Vessel & Traditional Sail Developments

Operations: Cargo

Operations: Fisheries

Operations: Cruise

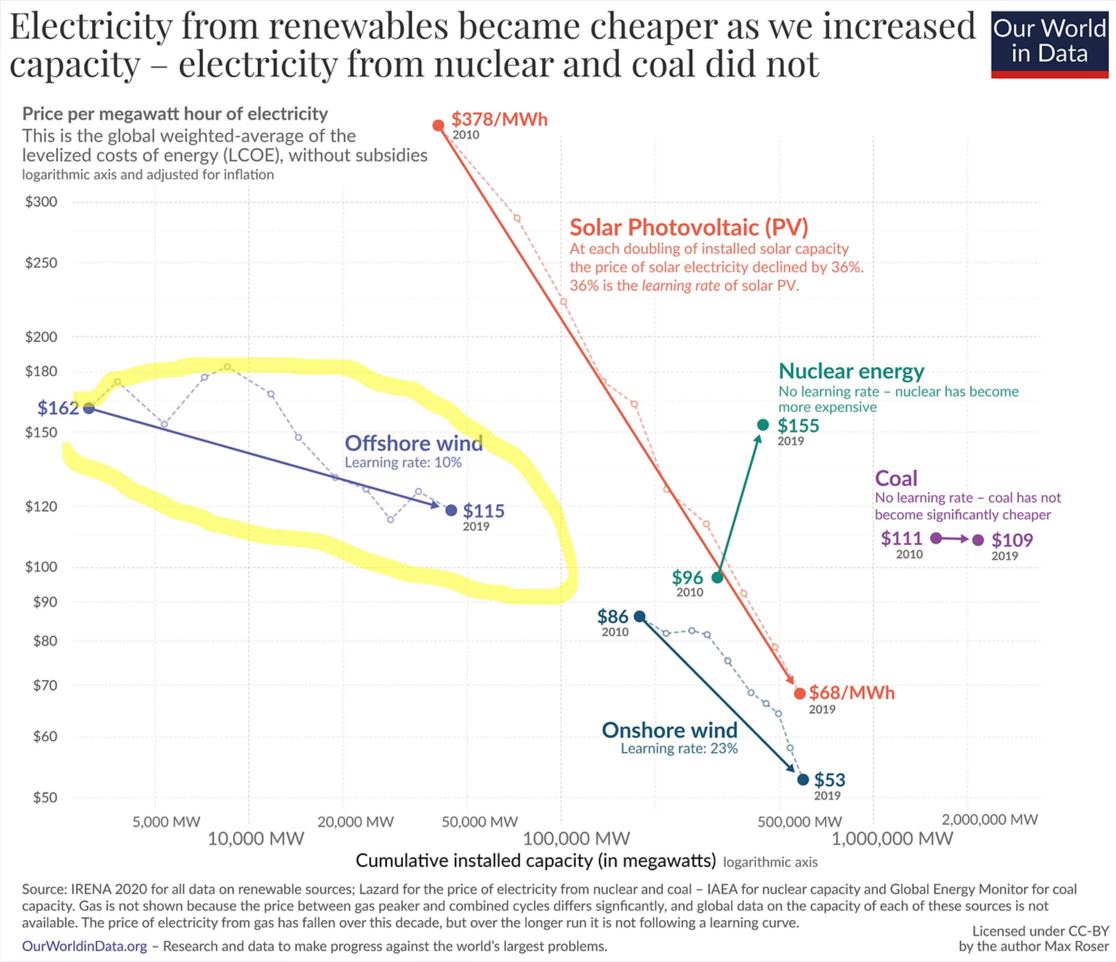
Technology & Networks



Ship Designs

Builds & Retrofits

Wind Propulsion: Learning Curve



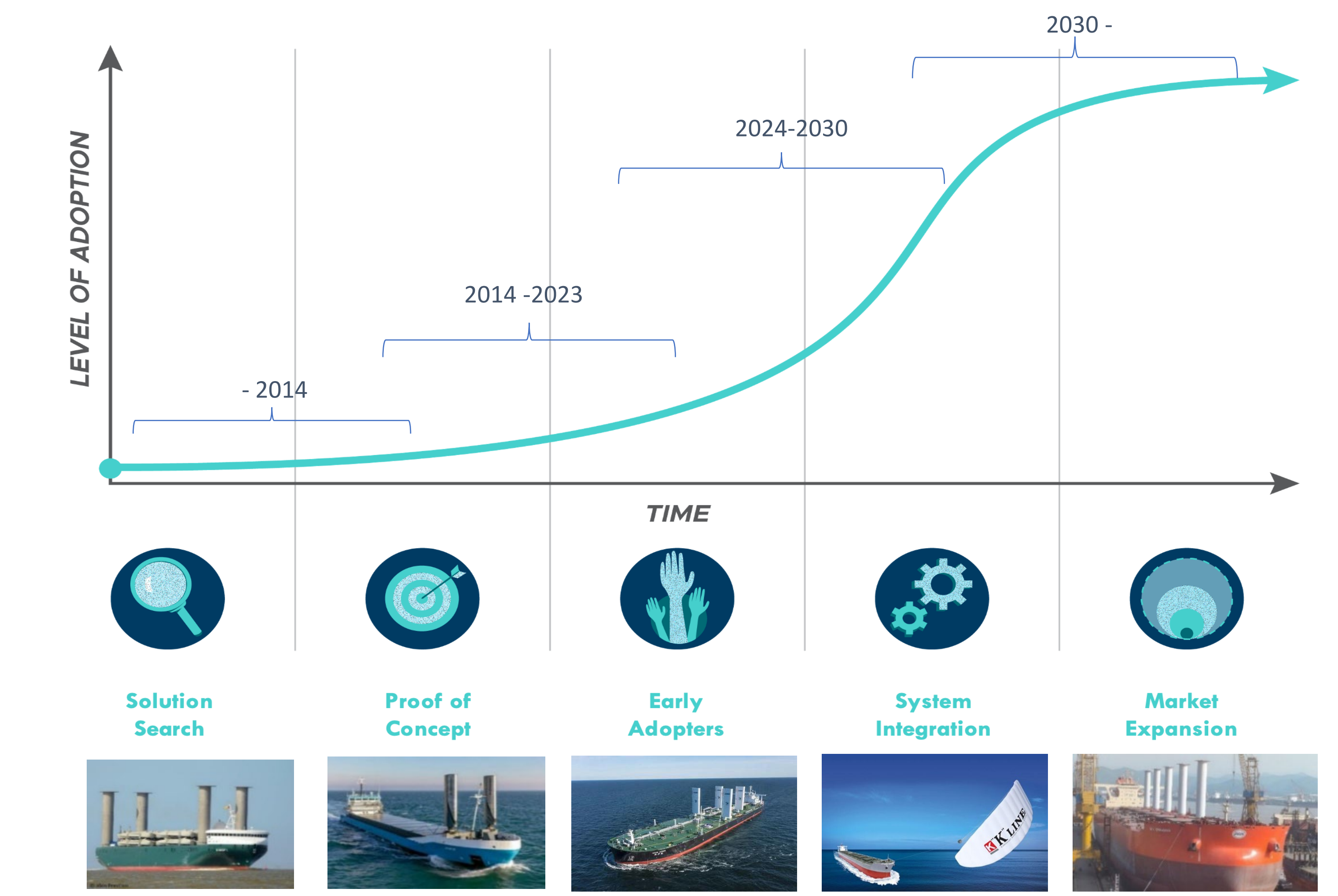
- Est. 10% reduction in cost each time installations double.

Ref: CEDelft report 2016

- ✓ Economies of scale
- ✓ System optimisation/integration
- ✓ Improved materials
- ✓ Installation techniques
- ✓ Relocate production etc.

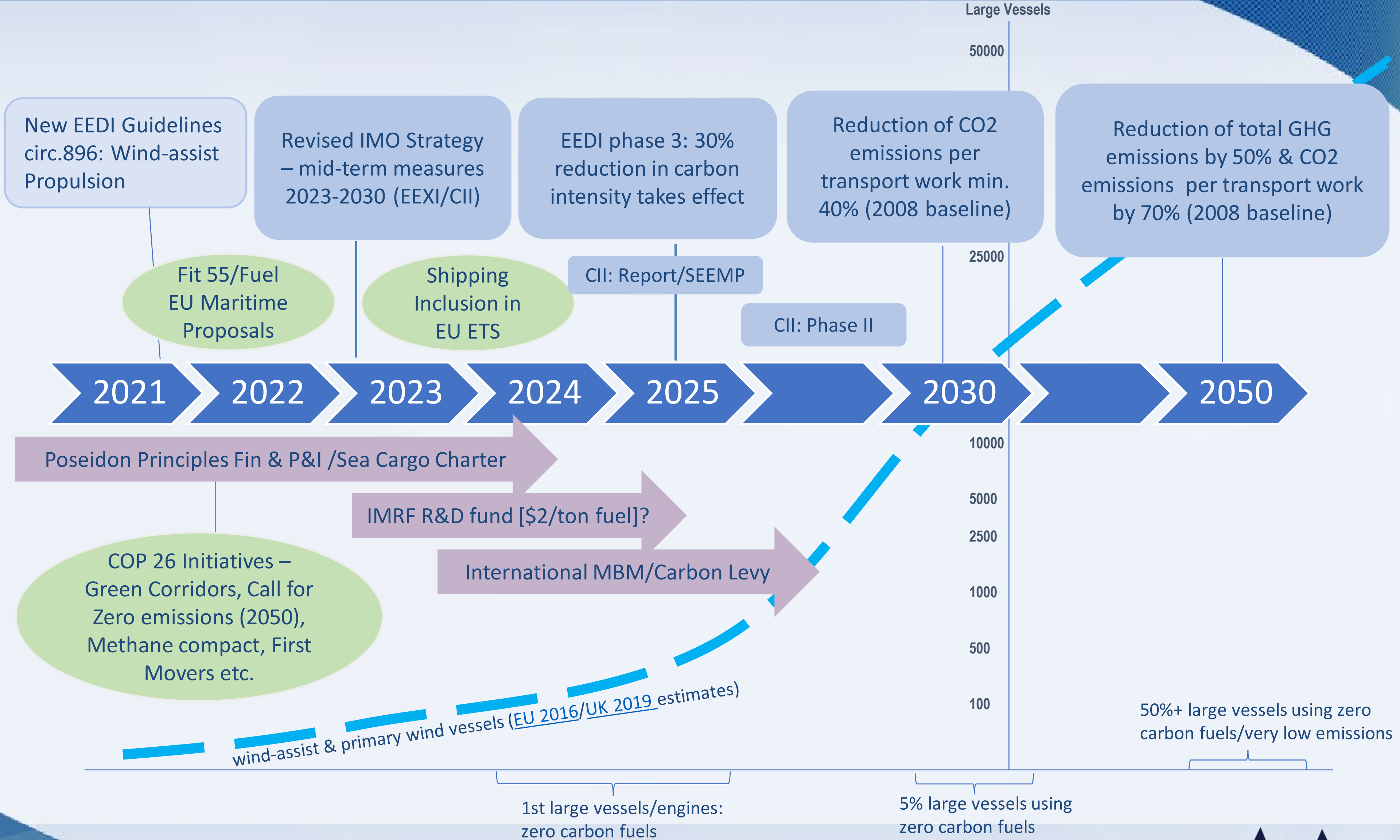
- Similar trajectory to Offshore Wind – largest savings in early deployment phases ('S-Curve').

Wind Propulsion: Innovation Curve



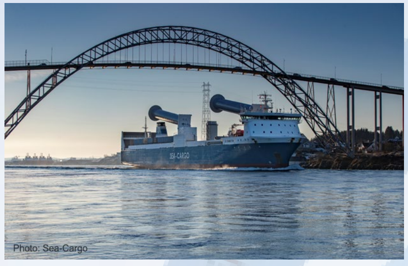
Graphic Template: RMI

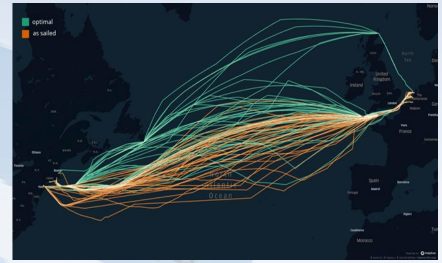
Policy Pipeline & Wind Propulsion



Wind Propulsion: Trends

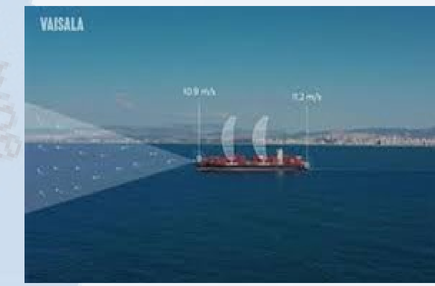
Retractable/Mobile





Wind-Routing

Primary Wind



Optimisation

Energy Harvesting

Modular/Containerised

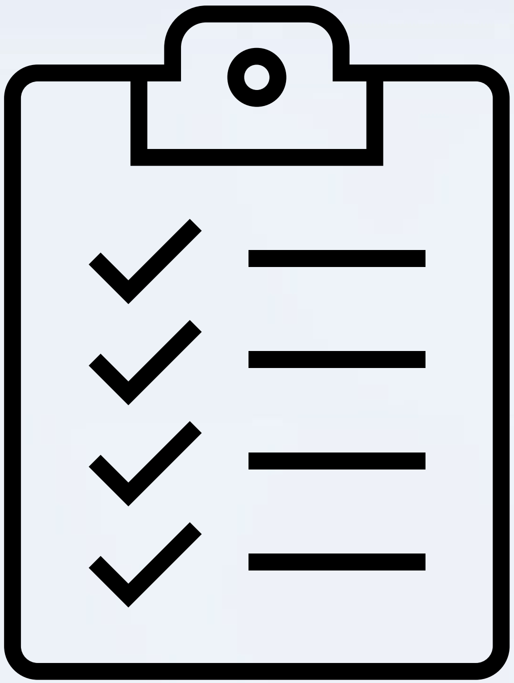
Wind-Ready

Scaling Production

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: Check List



Policy

- ✓ **Ambitious Goals**: GHG reduction ≤50% (2030) + 100% (2050) are achievable/deliverable.
- ✓ **MBM's**: High carbon price & circular levy.

Equity

- ✓ **Level Playing Field**: Include all energy, 20 & 100 year Global Warming Potential (GWP), Well-to-Wake LCA.
- ✓ **Just/Equitable Transition**: LDC/SIDs access new tech/affordable fuels + Co-ownership/Co-design.

Market

- ✓ **Prioritise Zero-Emissions Tech**: Premium for Zero-Emissions (not only GHG) + Guarantee long term charters.
- ✓ **Internalise ALL Costs/Risks**: Stranded Assets, Pollution, Health, Climate, Security etc.

Win-Win-Wind Propulsion….

www.wind-ship.org

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