norsepower™

Experiences of Norsepower Rotor Sails on Board Three Different Ships

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- Visit https://www.youtube.com/watch?v=G-fuPbhtTFo to see the video

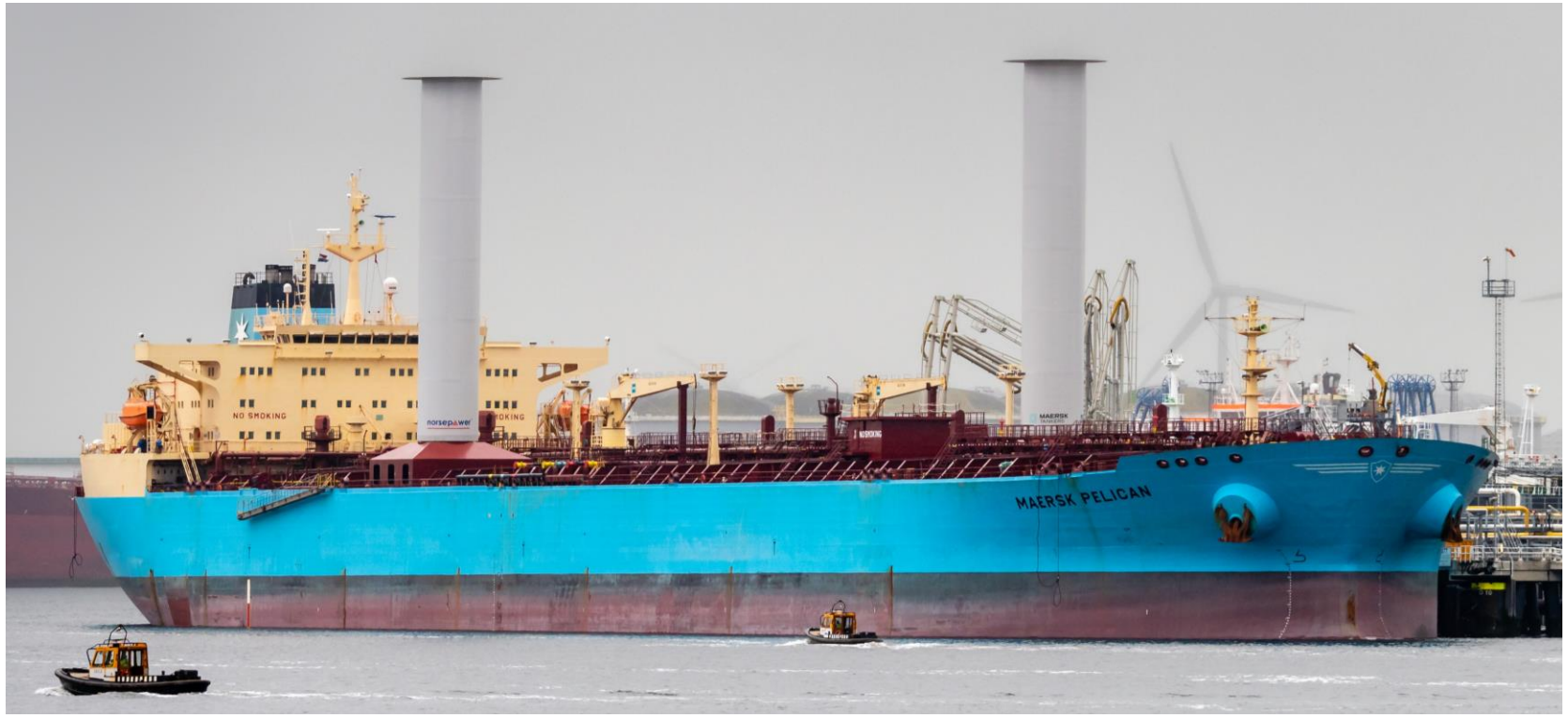
Background and current status

- Norsepower has brought to market the first proven auxiliary wind propulsion system
- The first Rotor Sail was tested on land during 2014
- The first commercial project with two Rotor Sails was delivered 2014-2015 to Bore's M/V Estraden
- Viking Line's cruise ferry Viking Grace started Rotor Sail assisted cruises in April 2018
- Two Rotor Sails were installed on the Maersk Pelican LR2 tanker in the end of August 2018
- Delivery project to Scandlines' hybrid ferry Copenhagen is ongoing
- Over 45 000 hours Rotor Sail operations until today, saving more than 5000 tons of CO2

Modernised wind propulsion

Auxiliary Wind Propulsion

- Norsepower Rotor Sail produces thrust force (it also does not generate electrical power).
- Depending on wind conditions up to 50% of the main propulsion thrust can be replaced by Rotor Sails
  - Average savings depend on configuration and on the wind conditions of the route
- Norsepower's technology is well suited to many ship types:
  - Tankers, Bulk cargo vessels, Ro-Ro, Ropax, Ferries, Cruise ships
- The technology is compatible with all other ways to save fuel



Physics:
Magnus -effect

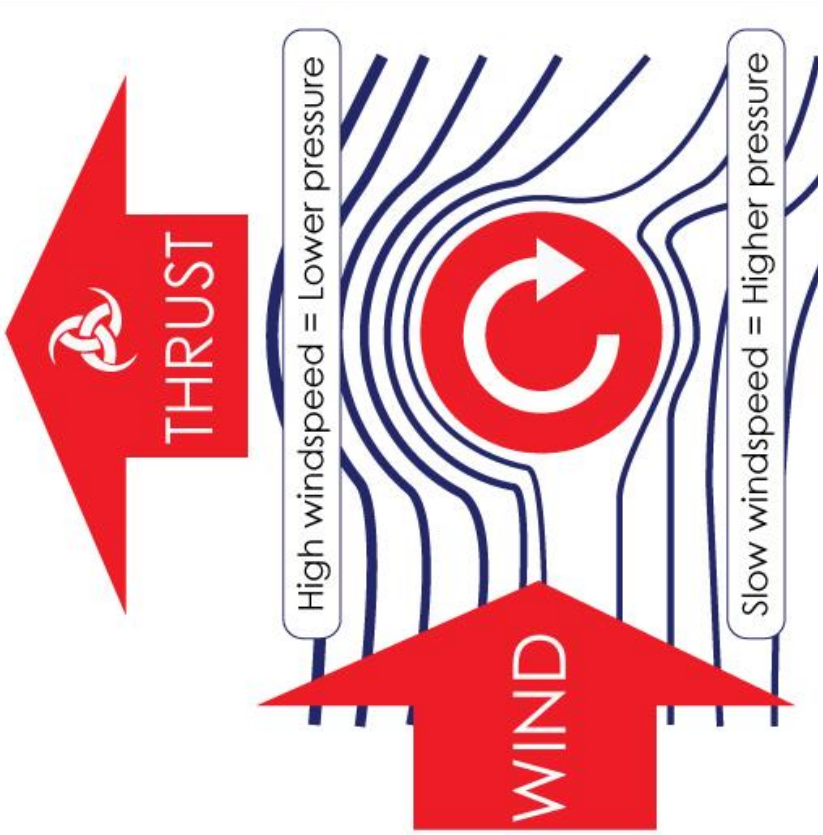
- Visit http://tinyurl.com/nmjyzmo to see the Magnus effect demo video

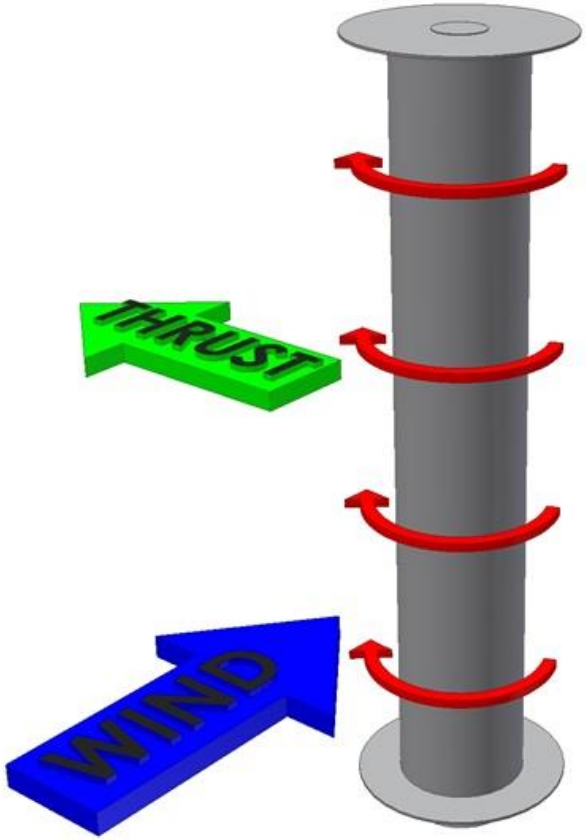
Source: YouTube

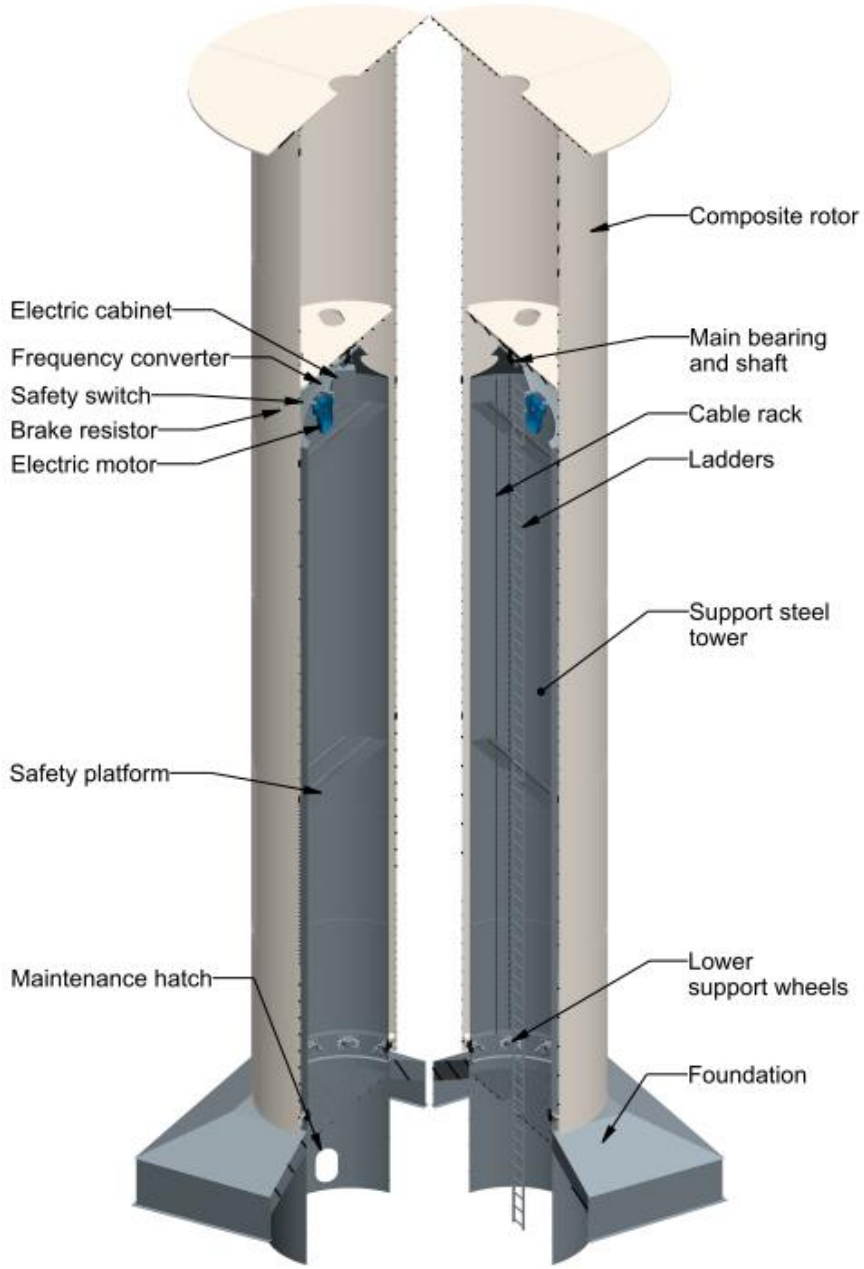
Rotor Sail

Physics of the Rotor Sail: Magnus Effect explained

- When wind meets a spinning object, it results in a high and low pressure differential, which creates thrust at a 90 degree angle to the wind
- Flettner (DE) and Savonius (FI) discovered the fundamentals of a "Flettner rotor" in 1920s
- Norsepower has modernised the technology entirely by introducing high tech materials and automated operation







Norsepower Rotor Sails

- Main components
  - Composite rotor
  - Internal support steel tower
  - Upper support main bearing
  - Motor and drive for rotation
  - Lower support rollers
  - Foundation on ship's deck
- Properties

Model	18 x 3	24 x 4	30 x 5
Rotor height x diameter , m	18 x 3	24 x 4	30 x 5
Weight without foundation, tons	20	27	42
Speed, rpm	0-250	0-225	0-180
Electric motor, kW	55	90	110

#Average el. consumption 15…35kW

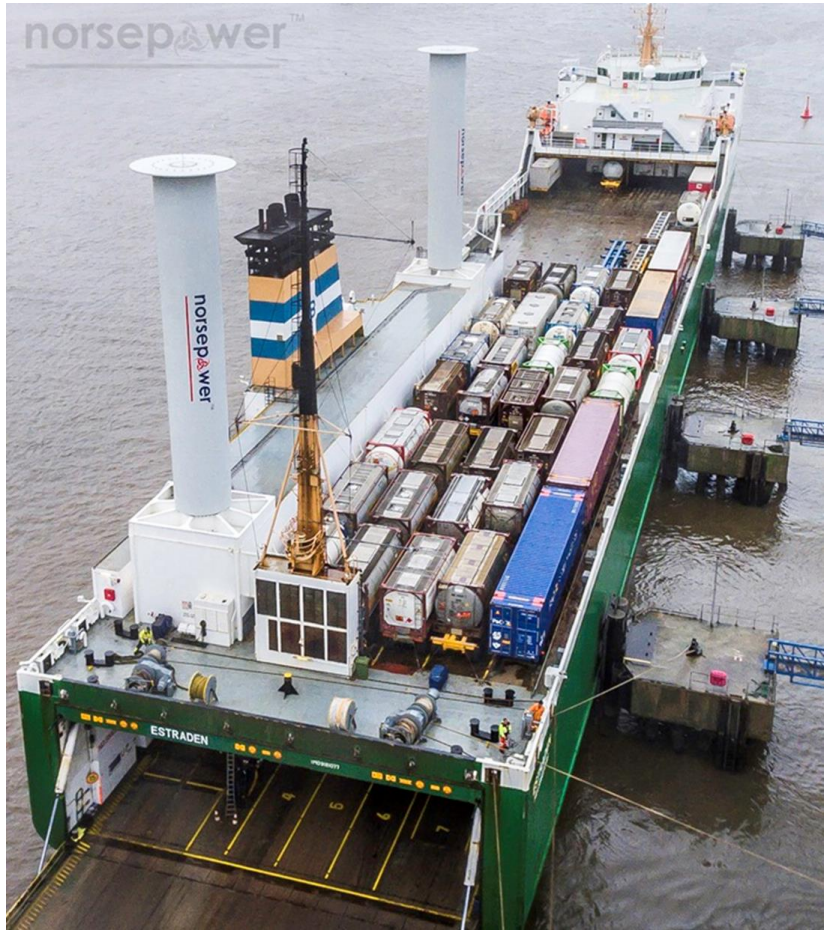
Reference #1: RoRo ship M/V Estraden

Technical performance

- Thrust performance as expected
- System availability exceeds 98%
- Noise and vibrations remain at low levels
- The automation system works as intended

Operator experiences

- The rotor has a stabilising effect on the roll motion of the vessel
- No recognisable effect on rudder angles or leeway
- The system is easy to operate and the crew is able to use it after minimal-training



Average annual net savings:	**6,1% (400 t of fuel and 1200 t of CO2)**
Payback period:	**3 years (MGO, 650 USD/t)**

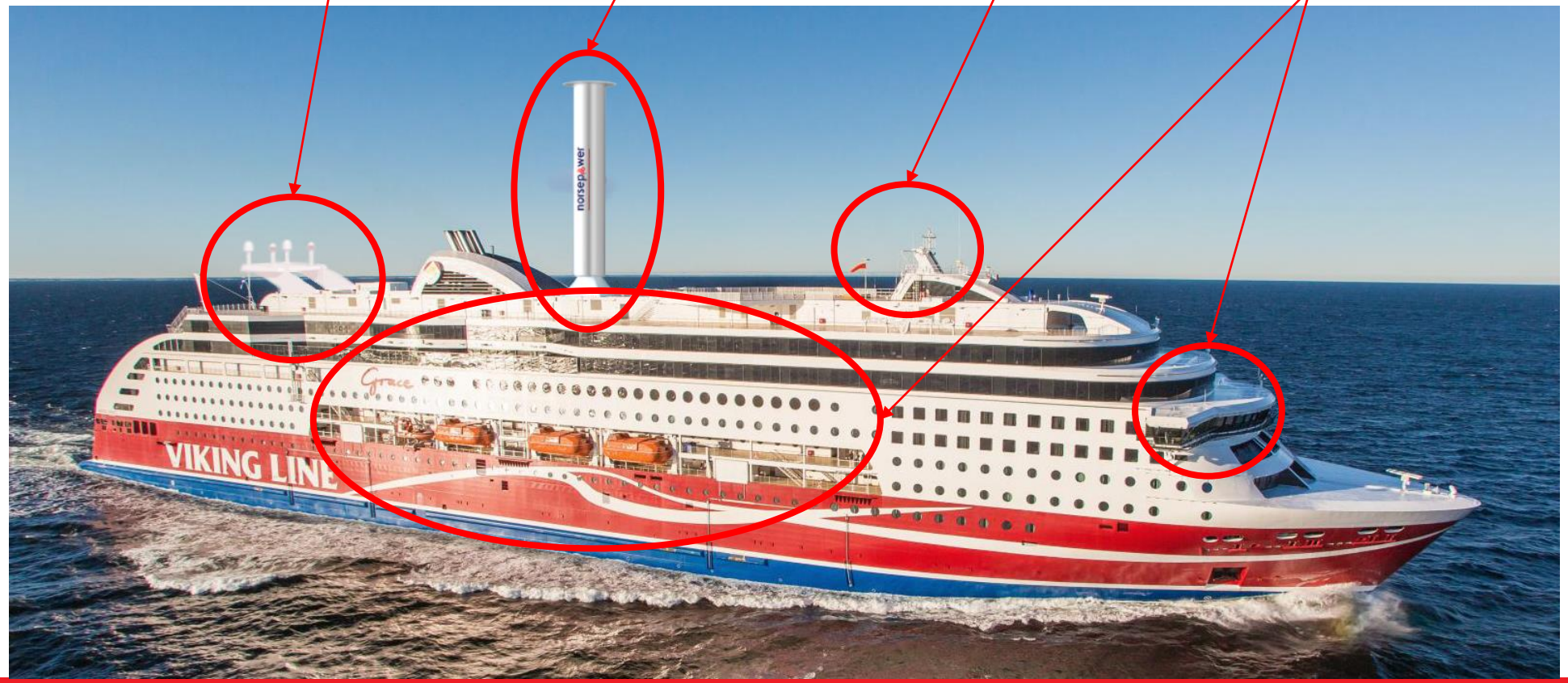
Reference #2: Cruise ferry Viking Grace - Details of installation

Rotor Sail foundation and Rotor Sail

New light mast for masthead lights

New foundation for satellite antennas and relocation of them

Control and automation systems and cabling



Reference #2: Cruise ferry Viking Grace - Results

- Three Rotor Sail performance reports were ordered from independent third parties, and all of them have issued their final reports.
- In addition to this, Norsepower has conducted its own strain gauge analysis. Strain gauges were installed, calibrated and monitored by an external provider.

Source	Net savings [kW]	Per year [MWh]	LNG per year [ton]
ABB analysis	207	1 306	231
NAPA analysis	282	1 779	315
Chalmers university analysis	257	1 621	287
NP Strain gauge analysis	211	1 331	236
Average	**239**	**1 509**	**267**
Original target	**226**	**1425**	**252**

- The long-term annual fuel savings have been verified to be **between 230 and 320 tons**, equaling an average propulsion power **between 210kW and 280kW**.
- CO_2 emissions reduction: up to 900 t/year.

Reference #3: LR2 oil products tanker Maersk Pelican

- Two 30 x 5m Rotor Sails were installed as a retrofit in the end of August 2018
- The estimated average fuel savings on typical global shipping routes are expected to be 7 - 10%.
- Norsepower forecasts that up to 20% average fuel savings are possible on routes with favourable wind conditions
- Extensive LR measurement campaign is ongoing – the results are expected to be released in October 2019

"What we can say is that the rotors have yielded the expected power under favourable wind conditions" - Maersk Tankers.

MAERSK TANKERS norsepower™ energy technologies institute

- Visit https://www.youtube.com/watch?v=7fjS-l-LVoA to see the introductory video

New project: Scandlines hybrid ferry

- One 30 x 5 Rotor Sail will be installed during Q2 2020 as a retrofit on board the M/V Copenhagen, a hybrid passenger ferry.
- The target of the project is to reduce CO_2 emissions on the Rostock-Gedser route by four to five per cent.

Most promising route areas for Rotor Sails

- The technology performs best when the average wind speed is high and typical winds are coming from the beam
- Examples of routes and areas with a high savings potential:
  - Northern Pacific crossing
  - Northern Atlantic crossing
  - North Sea and Baltic Sea areas

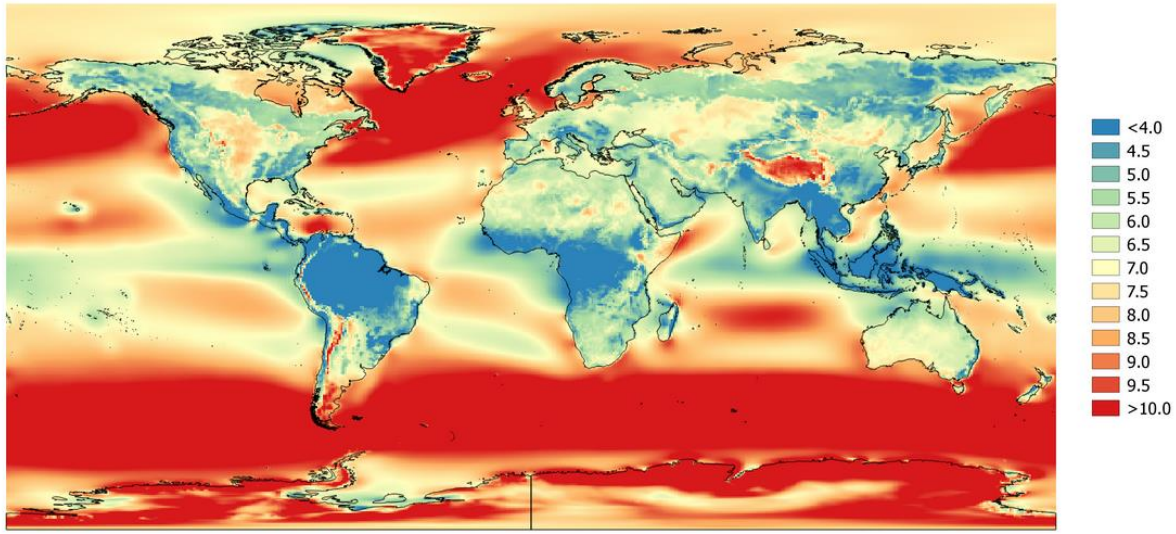


Figure 1
Mean wind speed at 100m from MERRA reanalysis. Period 1979-2013.

MISSION

To reduce the environmental impact of shipping through the commercialisation of innovative and modern sail power

VISION

To set the standard in bringing sails back to ocean transportation, and empower shipping towards reaching the goal of zero carbon emissions

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