Wind Assisted Ship Propulsion "WASP"

WP4. D2.B.
Educational/ Teaching Material

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https://northsearegion.eu/wasp

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Introduction

Key climate and environmental challenges for shipping

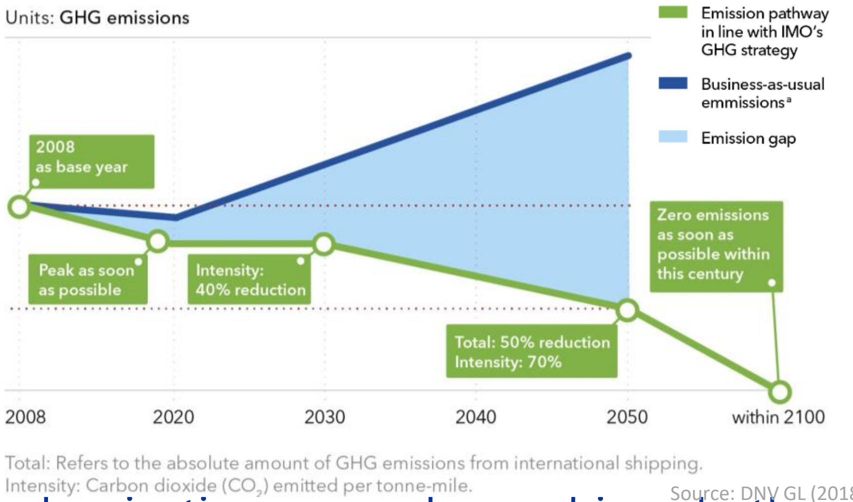
- Projected increase in CO_2 emissions conflicts with all UN climate goals

- Clean fuels increase fuel cost 3-4 times, which will keep ships fossil fueled

- Heavy air pollution contributes significantly to morbidity and mortality

Challenges for shipping

- Strong pressure to reduce GHG emissions from shipping



Source: DNV GL (2018)

- Decarbonization can be achieved through viable options
  - Low carbon fuels and energy sources
  - Technology improvements
  - Operational measures

Wind Propulsion (WP)

Wind-Assisted Motor Vessels

Primarily employing auxiliary-wind propulsion systems retrofitted onto existing vessels. Fuel savings in the 10-30% range, with lower initial retrofit investment costs than new build options. Other benefits: reduced engine and machinery wear and tear, improved stability, reduction in vibration etc.

Hybrid Wind/Motor Vessels

Designs combine fuel and emissions reduction benefits of WP options with capabilities and performance of motor vessels allowing predictable scheduling. In favorable winds savings can be in excess of 60-70%, in less accommodating conditions vessels use a mix of wind/motor propulsion or motor alone. With good weather routing and handling. New build sailing hybrid vessels: fuel savings on an annual basis of over 50%.

Motor vessel

Standard vessels that make up the vast majority of the current world fleet. Improvements in efficiency and savings in fuel costs and emissions: increasing size of vessels, improving hull design, increased engine efficiency, use of renewable energy options. Operational changes: slow steaming, super slow steaming.

Purely Wind Vessel (+Auxiliary Motor)

These vessels can deliver up to 100% savings, with standard maintenance costs etc. however the challenge of maintaining schedules and being susceptible to weather conditions is an important consideration. Some routes will be more favorable to this type of vessel and operation.

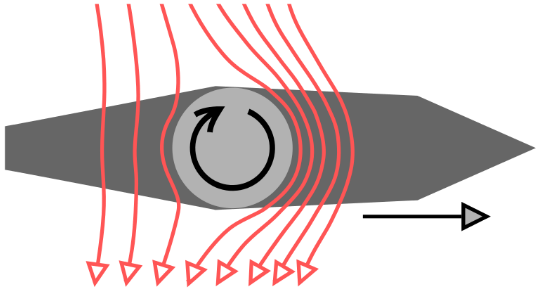
Weather Routing

The development of increasingly reliable weather/wind routing software helps to both predict, plan and operationally adjust sailing routes to maximize the benefits from wind and minimize the disruption from adverse weather conditions

Introduction to WASP

Wind-assisted ship propulsion (WASP)

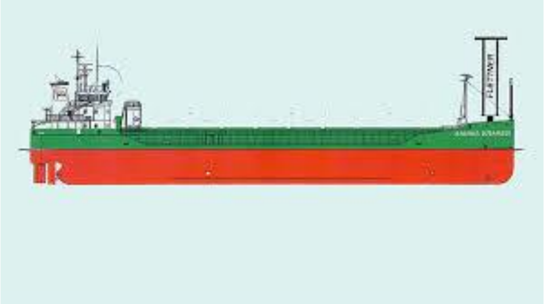
- Short- to mid-term mitigation option
- Can be defined as a group of technologies which harness wind power to thrust a vessel forward, providing auxiliary propulsion to the engine



- Fuel savings vary from 5-25% depending on ship size, type, speed, route, weather conditions etc.
- Can be combined with alternative fuels and other energy saving technologies

Opportunities of WASP

1. Reduce CO_2 emissions and air pollution from existing and future fleet
2. Reducing the price gap between fossil fuelled ships and zero emission shipping
3. Reducing the investments and time needed for full decarbonization of shipping
4. Wind technologies reduce marine fuel use significantly



Applications of WASP in shipping

Types of WASP installations

Rotor

Rotating cylinder installed on deck that generate forward thrust from the Magnus Effect as the cylinders create low and high pressure

Towing kite

They provide thrust to ships with the lift generated by high altitude winds

Suction wing

They are non-rotating wings with vents and internal fans that generate force with boundary layer suction

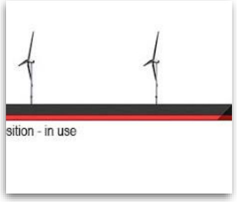
Rigid sail

Foils that could be adjusted to produce aerodynamic forces

Soft sail

These are varied types of traditional sails with modern features

Turbine



Turbines that generate electricity and/or thrust by the blades

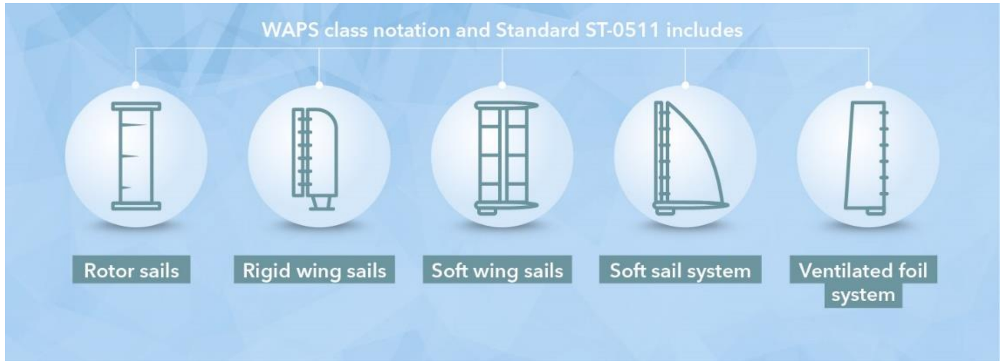
Hull sail

These are hulls that use relative wind with its symmetrical hull foils that generate aerodynamic lifts

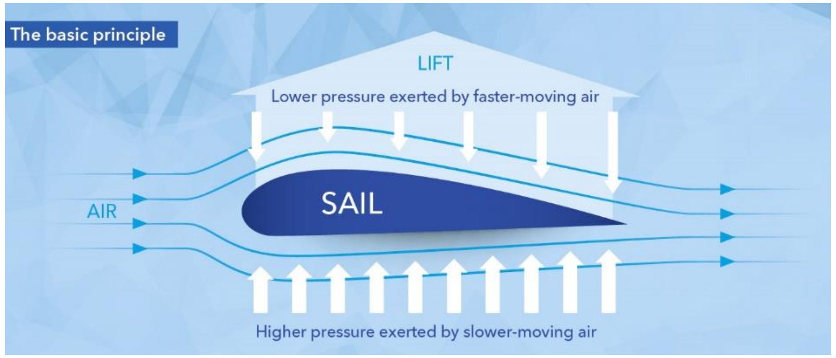
Source: Chou et al. (2021)

WASP Technology

Class notation (DNV GL)

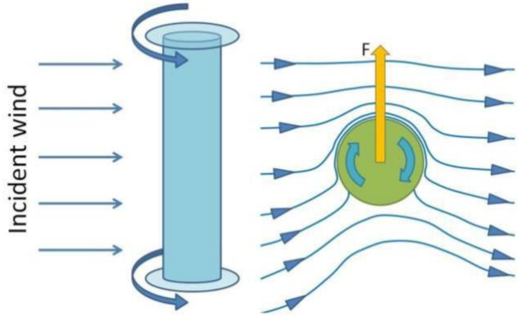


Sail principle and technology



Magnus effect with rotor sail:

- When wind meets the spinning rotor sail, the air flow accelerates on one side of the rotor sail and decelerates on the opposite side of the rotor sail



- The change in the speed of air flow results in a pressure difference, which creates a lift force that is perpendicular to the wind flow direction

Considerations for WASP

Operational factors affecting the performance of WASP technology

- Environme-ntal factors
  - Wind speed
  - Wave height
  - Seasonal pattern
- On-board factors
  - Route optimization
  - Master's decision making
  - Crew training
- Commercial factors
  - Trade pattern
  - Trip duration
  - Trip irregularity
  - Port calls

Operational comparison between Rotors and Kites

	Kites	Flettner Rotors
Absolute Power	Stronger winds at higher altitude	Slower winds at lower altitudes
Volatility of Power	Most effective with wind aligning with navigation direction	Wider range of wind directions
Scalability	Less scalability compared with rotors	Power output increases linearly with number of installations
Wind direction	Most effective with tailwinds	Most effective with winds from side
Compatability with ship operation	Less deck space needed	Fundamental deck construction

WASP adoptions on commercial ships

Ship Name	Ship Type	DWT	Technology Characteristics	Ship Built Year [c]	Installation Year
Flettner-Rotor			**No. of Rotors/Diameter (m)/Height (m)**		
E-Ship 1 [a]	General Cargo/Ro-Lo	10,020	4/4/27	2010	2010
Estraden [a]	Ro-Ro	9700	2/3 [b]/18	1999	2014
Viking Grace [a]	Passenger	6107 [c]	1/4/24	2013	2018
Fehn Pollux [a]	General Cargo	4250	1/3/18	1997	2018
Maersk Pelican [a,b]	Tanker	109,647	2/5/30	2008	2018
Afros [d]	Bulk Carrier	64,000	4/-/-	2018	2018
Copenhagen [e]	Ferry	5088	1/5/30	2012	2020
Annika Braren [f]	General Cargo	5100	1/18/3	2020	Oct 2020 expected
SC Connector [g]	Ro-Ro	8843	2/35/5	1997	Q4 2020 expected
Kite			**Kite's dimension (m^2)**		
Michael A. [h]	General Cargo	4884	160	1994	2008
BBC Skysails [i]	General Cargo	9832	320 [i]	2008	2008 [j]
Theseus [i]	General Cargo	3667	160 [g]	2009	2009 [h]
Aghia Marina [i]	Bulk Carrier	28,522	320 [i]	1994	2012 [j]
Ville de Bordeaux [k,l]	Ro-Ro	5200	500	2004	Nov 2020 expected
TBA [k]	Bulk Carrier	TBA (Capesize)	1000	TBA	2021 expected
Suction Wing			**No. of wings/height (m)**		
Ankie [m]	General Cargo	3600	2/10	2007	2020
Frisian Sea [n]	General Cargo	6477	2/TBA	2013	2020
Rigid sails/wing sails			**No. of foils/height (m)/width (m)**		
MV Tharsis [o]	General Cargo	2364	2/9/3	2012	2021 expected
New Vitality [p,q]	Tanker	306,751	2/32/15	2018	2018
TBA [r]	Tanker	TBA(VLCC)	TBA	2022	2022

Source: Chou et al. (2021)

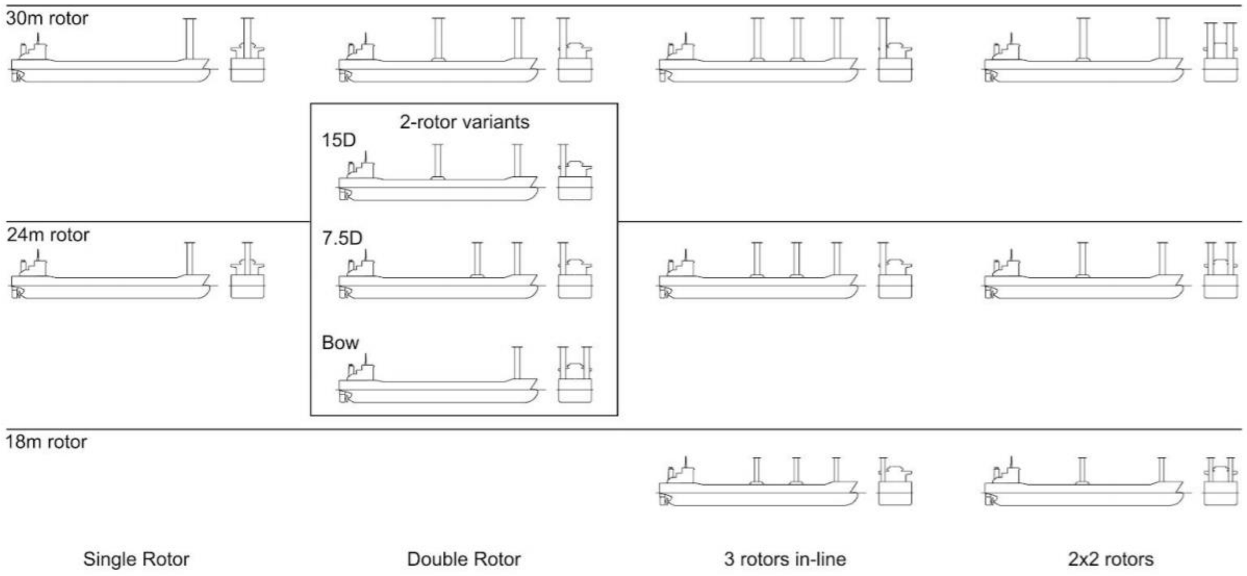
Case study example – Timberwolf (ex Maersk Pelican)

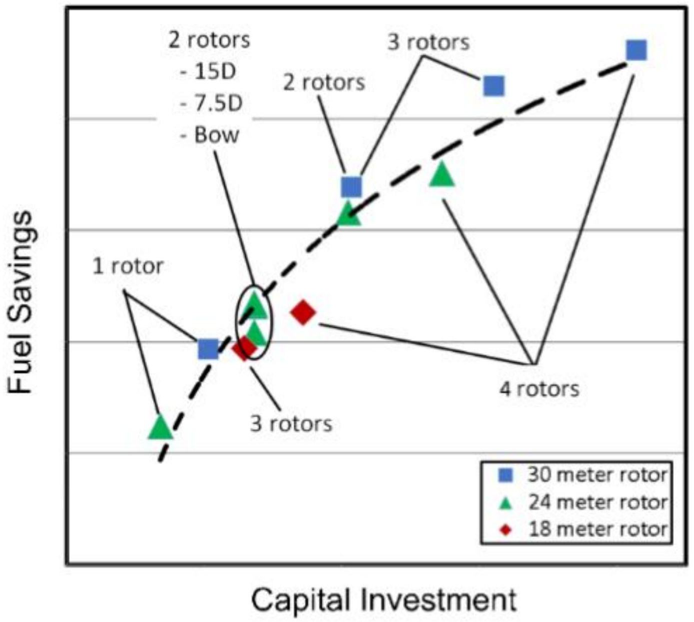
- LR2 Product Tanker 109,647 DWT; LOA: 245m
- 2 x 30m(h) x 5m(w) rotor sails by Norsepower in 2018
- Two Rotor Sails 30x5 are expected to reduce average fuel consumption on typical global shipping routes by 7-10%
- Verified average annual fuel savings: 8.2%
- Equivalent to approx.1,400 tonnes of CO_2
- Norsepower estimates that applying Rotor Sail technology to the entire global tanker fleet would reduce annual CO_2 emissions by more than 30 million metric tonnes, which corresponds to emissions of about 15 million passenger cars.

Case study – Theoretical techno-economic assessment

- Study assesses the installation of three Flettner rotor devices on a 19,500 DWT tanker operating in the North Sea

- Yearly averaged fuel savings: 29.5%
- Annual CO_2 reduction of 3,330 t
- Payback period of 9.7 years





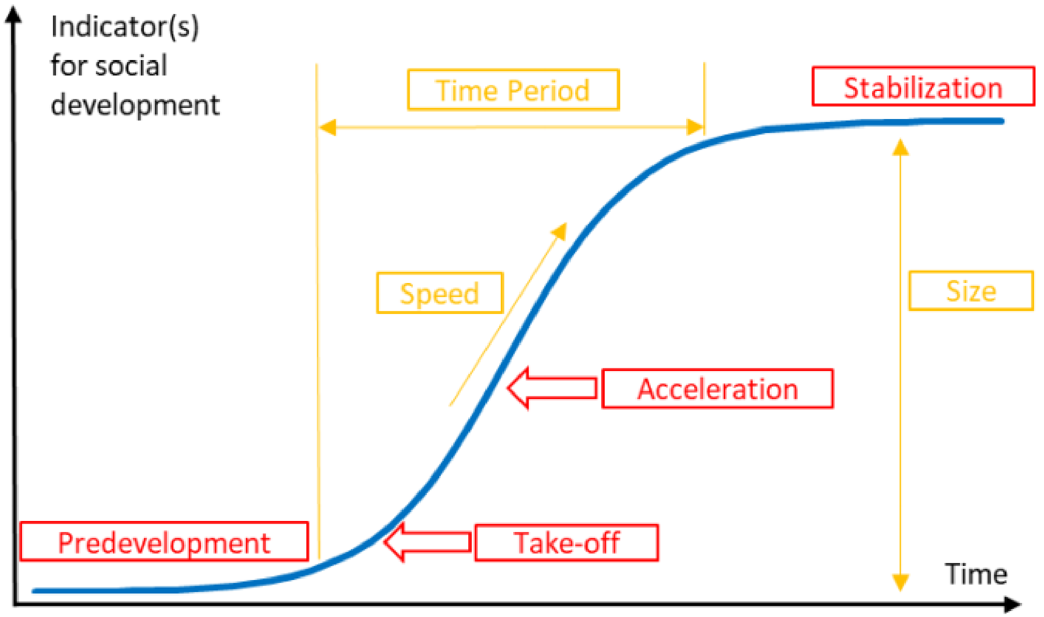
Source: van der Kolk et al (2019)

Green Transition towards decarbonisation in the maritime industry

Dynamic transition

- “a gradual, continuous process of change where the structural character of a society transforms”
- Technological and institutional changes driven by the WASP technology take place at all three levels: socio-technical landscape, regimes, and niche
- With support from regimes and alterations in the regulatory environment, the “WASP industry” will continue to grow and create substantial economic & environmental impact

Transition process by Rotmans et al. (2001)



Barriers for WASP technology

- Uncertainty
  - Fuel prices
  - Shipping market cycle
  - Actual results
- Policy
  - Lack of incentives
  - Lack of guidance
- Different operation profiles
  - Optimal route
  - Time charterer
  - Voyage charterer
- Applicability
  - Safety
  - Reliability
  - Compatibility
- Operational risks
  - Technical uncertainty
  - Counterparts
  - Port operations
- Capital investment
  - Limited access
  - Payback period

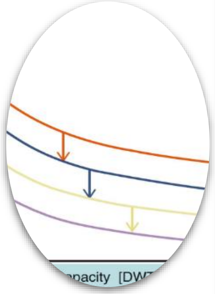
Regulation to promote wind technologies

Introduce a significant **carbon levy**, which is being raised substantially yearly

Introduce a CO_2 dependent **speed limit**/ engine **power limit** at sea

CO_2 reduction aligned with 1.5°C goal of Paris Agreement

More public **R&D** funds for "non-fuel" propulsion technologies



New 1.5°C compatible **EEDI targets** for 2025/30 and beyond

Include shipping in a flag neutral **emission trading system**

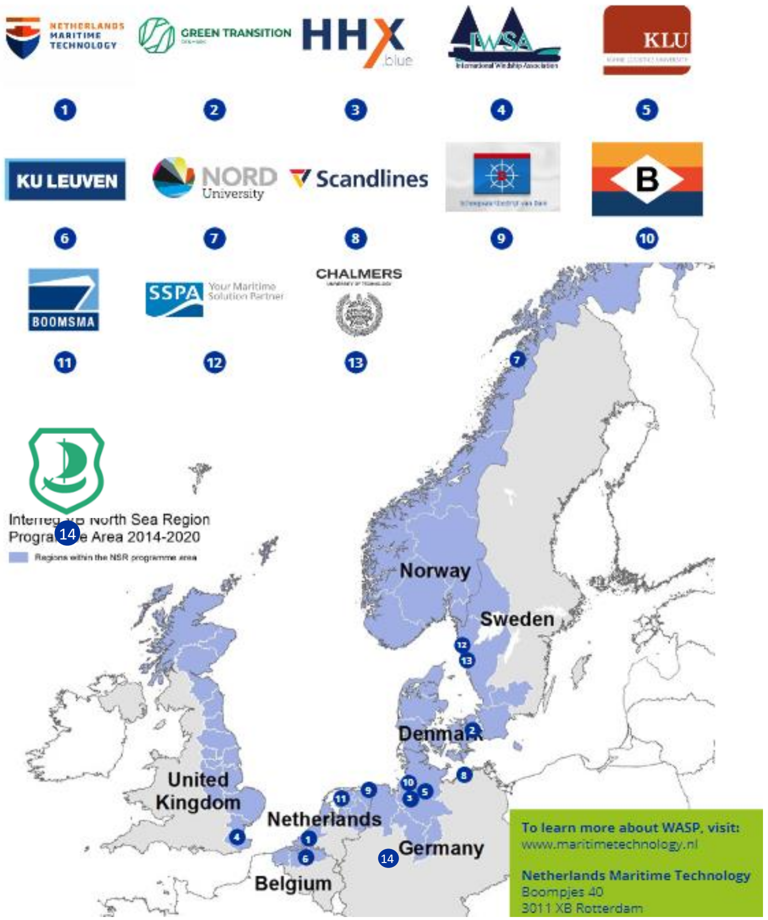
Stricter **regulation** for ship emissions to air and water

New **port fees** based upon emitted CO_2, NOx, SO_2 and particles

Stop public support for **fossil fuels** and their infrastructure

Include **life cycle assessments** when assigning CO_2 savings

WASP Project overview



- WASP Project investigates wind solutions for the North Sea Region
  - Giving the market/policy makers clear indicators on operational parameters, fuel savings, business models and a collection of demonstrator vessels to highlight the wind-assisting propulsion potential
- Financed by Interreg North Sea Region, part of the European Regional Development Fund; Interreg NSR Priority: ‘Eco-innovation: stimulation of the green economy’
- Brings together industry and research institutes to study and validate the performance/commercial viability of wind-assisted propulsion technologies
- Project period: 2019-2023
- 14 partners: Ship owners, wind propulsion technology providers, universities and expert partners are involved
  - Quadruple approach: 1. university; 2. industry 3. government; 4. community
- Transnational & cross-sectoral cooperation
  - worldwide, EU, national, regional, local
- 5 Work Packages: Dynamics, synergy, complementarity within/between cross-cutting themes and WPs
  - Mainstreaming, Engineering, Policy viable business, Operation

Project key objectives & cycle

- **Wind Propulsion Technology proven concepts lead to greening of NSR sea transport**

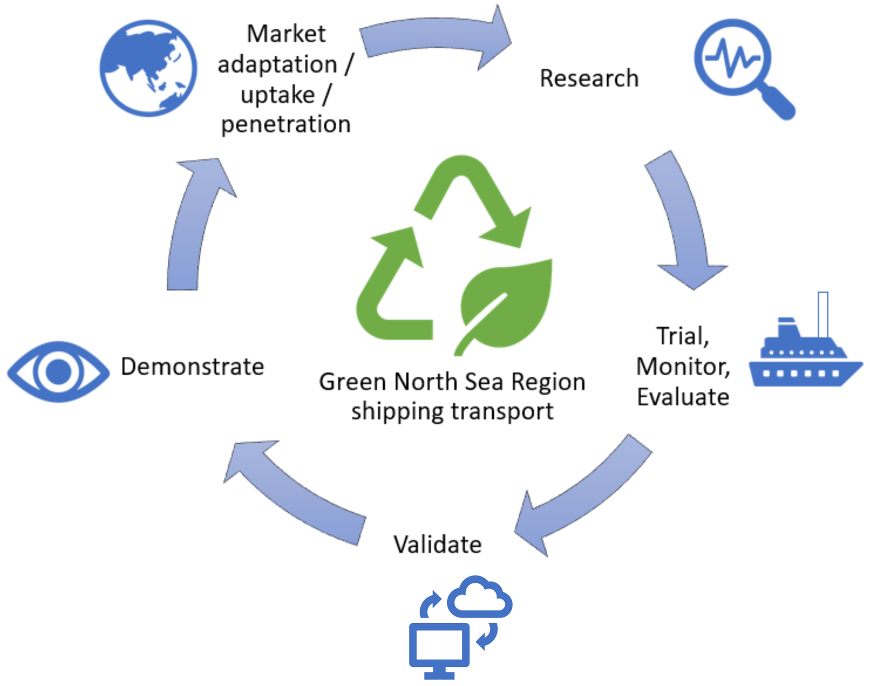
  5 shipowners and charterers implement WPT on their ships, together with engineers and universities they optimize technologies. Based on real-life (operational and capital) performance data on different ship concepts, cargo's and wind conditions will be collected. They harvest WPT savings in the most attractive regional settings during operation.

- **Identify the viable business cases for (hybrid) wind propulsion technologies**

  Third party validated performance indicators will measure WPT performances during real-life trials in different settings. Management data will feed into business models with operational - and capital costs analysis including incentives and investments concepts. A decision support model will support entrepreneurs to deploy WPT economic viable.

- **Facilitate a level playing field for WPT with policy instruments**

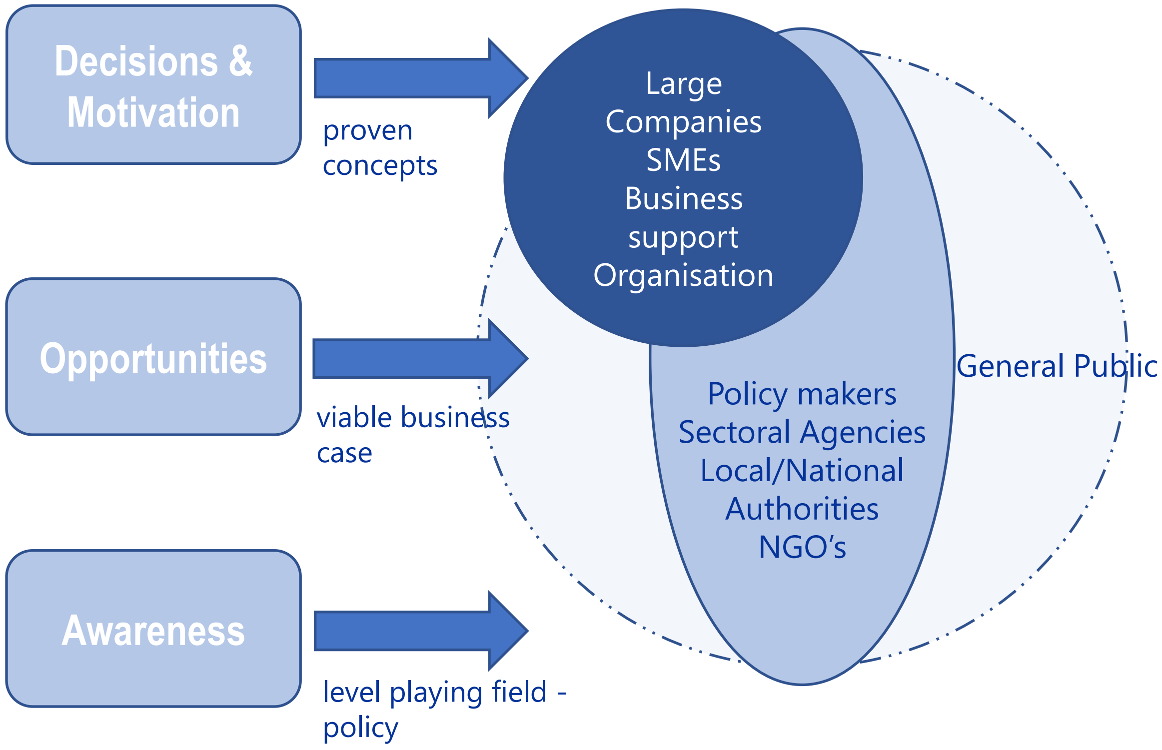
  WASP facilitates inclusion of WPT in legal frameworks like IMO EEDI Energy Efficiency Design Index. With validated performance indicators, calculation of emission and fuel reduction will be quantified. These will help to include WPT in the EEDI and Emission Control Area legal frame works and management of split incentives.



Project structure

WP1: Project Management	Work Package Leader: NMTF
WP2: Communication Activities	Work Package Leader: IWA (NMTF)
WP3: Engineering of Wind Propulsion Technologies	Work Package Leader: KUL
WP4: Policy & viable business	Work Package Leader: KLU
WP5: Operating of WPTy & performance	Work Package Leader: SSPA

WP2: Objectives & Audience



WP3: Engineering of Wind Propulsion Technologies

Ship owners, their installations and (technology providers)

2 Ventifoils (eConowind)

2 Flatrack Ventifoils (eConowind)

Flettner Rotor (Norsepower)

Flettner Rotor (ECO Flettner)

Wing sail (eConowind)

Objectives

- WP3 will prepare ship owners for the installation and operation of WPTs
- Objectives
  - Preparation of WASP participating vessels for operation with WPTs
  - Investigate the implications of using WPTs with simulation studies
  - Use the acquired knowledge to inform ship owners and maximize WPT potential
- WP3 is intended to present ship owners with a sufficient understanding of WPT operation and the possible savings that could be realized

WP4: Overcome business and regulatory barriers

- Economic implications of WASP technologies
- Viable business case
- Socio-economic benefits
- Policy awareness
- Strategies to overcome the barriers
- Innovative financing solutions
- Potential WPT market uptake

Viable business case

Key investment drivers

- Bunker savings
- Brand value enhancement
- Green agenda

Incentivization for WASP investments

- Policy makers
- Customers

Risks

- Technical, operational, financial risks vary according to technology
- Further exploration is required

Other considerations

- Fast & effective decision making process
- Communication between technical experts & top management

Other important stakeholders

- Crew
- Insurance companies
- Classification societies

Ships and installations

Shipowner	Van Dam Shipping	Boomsma Shipping	Scandlines	Rörd Braren	Tharsis Sea-River Shipping
Country	The Netherlands	The Netherlands	Denmark	Germany	The Netherlands
Vessel	Ankie	Frisian Sea	Copenhagen	Annika Braren	Tharsis
Ship type	General cargo	General cargo	RoPax	Minibulker	General cargo
DWT	3,638 t	6,445 t	5,000 t	5,035 t	2,300 t
WPT	2 retrofit front-placed suction wings of 16 m	2 x Flatrack suction wings of 11 m	Flettner rotor	Flettner rotor	2 flexible wing sails
WPT Provider	eConowind	eConowind	Norsepower	ECO Flettner	eConowind
WPT installation	March 2020	January 2021	Sept 2020	April 2021	Q1 2021
Trials planned	Q1 2021	Q1 2021	Q4 2020	2021	2021

Realized Installations

Boomsma Shipping

MV Frisian Sea

Scandlines

MV Copenhagen

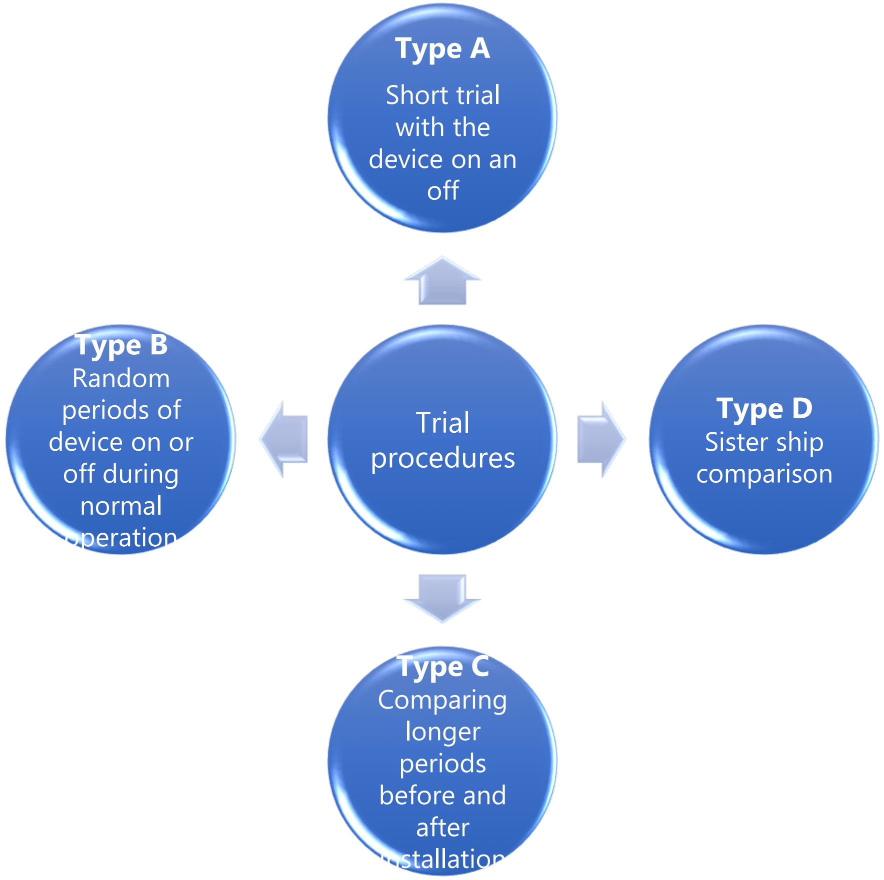
Van Dam Shipping

MV Ankie

Time lapse video of eConowind ventifoil installation: Van Dam Shipping MV Ankie

Time lapse video of eConowind ventifoil installation: Boomsma Shipping MV Frisian Sea

WP5: Operating of WP Technologies and performance



Objectives

- Demonstrate the usability of WPT on vessels
- Develop methods and third-party validated performance indicators for independent evaluation of WPTs in general and assessing the performance of a number of WPTs with these indicators
- The real-life trials will be on existing shipping lanes with ships carrying freight; the only way to really measure cost, fuel and emission reductions
- By testing and assessing several WPTs in real life, on different vessel types and on various routes, knowledge & experience is expected to be gathered from the demonstrations as a base to understand under what conditions and in which circumstances WPT can be beneficial or non-beneficial
- These will provide credible data of WPT performances for new launching customers that will be included in decision support tools

Work Package Results

Predictions

WP 3
Engineering of Wind Propulsion Technologies

WP 4
Policy and viable business

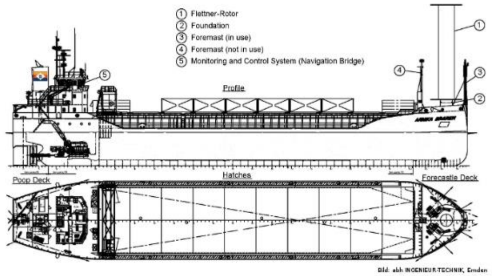
Trials

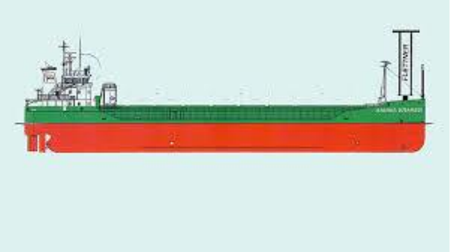
WP 5

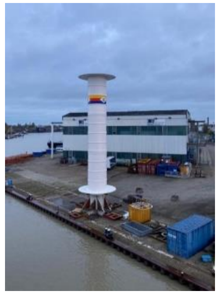
- Trial procedures Type A,B,C,D
- Demonstrate the usability of WPT on 5 vessels
- Validate evaluation tools developed in WP3&4

Support further market uptake

- Develop methods and performance indicators for 3rd party evaluation
- Demonstrate under what conditions WPT can be beneficial







Result Indicators

Result Indicator		Target	Unit	Definition
WPT SAVED 5594 tonnes of heavy fuel oil	HFO Heavy Fuel Oil / Marine Diesel Oil saved with WP Technologies in operation on 1 ferry and 4 freight ships during the project period	5.594	Tonnes	Baseline are the 5 WASP ships sailing without WPT. Measuring starts with WPT in operation. WASP performance indicators will be used. Measuring methods will be aligned with EU Emission Control Area policies & Energy Efficiency Design index.
WPT SAVED 17637 tonnes of CO2 reduction	CO_2 reduction realized during the project period with WPT in operation, on 1 ferry and 4 cargo ships in operation during the project period	17.637	Tonnes	
WPT GENERATED 27634805 KWH generated	KWH generated with WPT's in WASP during the project with WPT in operation, on 1 ferry and 4 cargo ships in operation during the project period	27.634.805	kWh	

Interreg
North Sea Region
WASP
European Regional Development Fund
EUROPEAN UNION
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Wind Assisted Ship Propulsion

Thank you for your attention!

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