Green Deal Validatieregeling

Validation programme

Wind propulsion

NETHERLANDS MARITIME TECHNOLOGY
TNO innovation for life
Ministerie van Economische Zaken en Klimaat
Koninklijke Vereniging van Nederlandse Reders
MARIN
Ministerie van Infrastructuur en Waterstaat

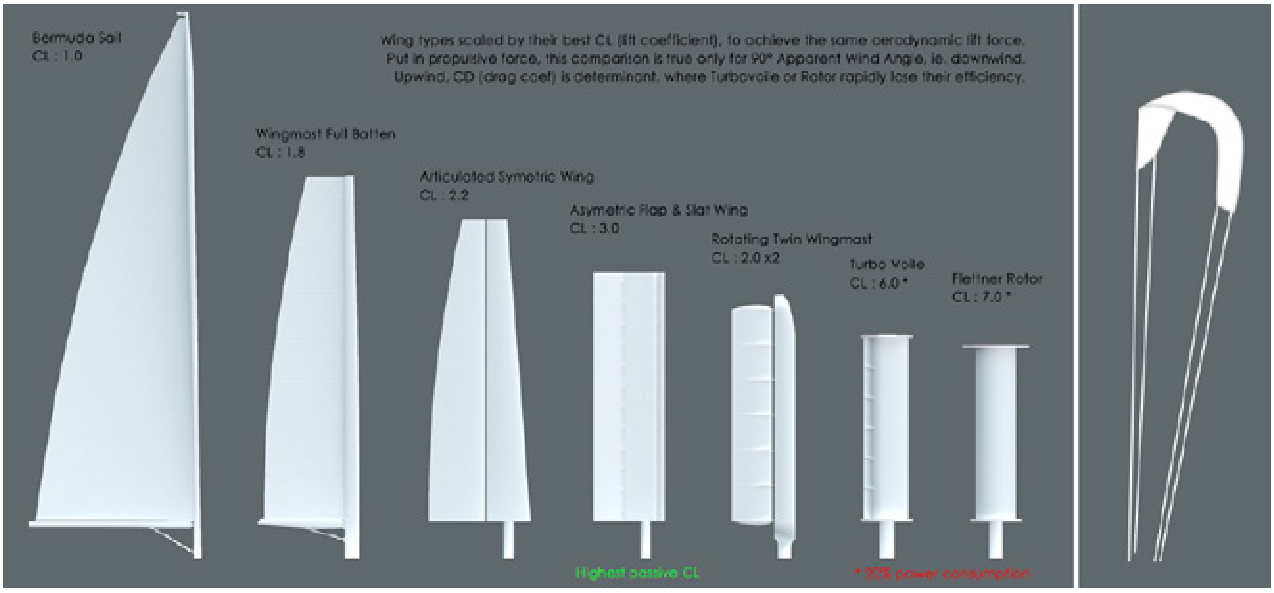
Description

Wind propulsion can be used from modest energy saving of 5%-15% up till providing the majority of propulsion power. The extent to which it can be applied is highly dependent on:

- The wind statistics on the route(s) as used by the vessel.
- The ship speed.
- Geometric and structural constraints considering e.g. proximity to superstructures, cranes, hatch covers.

Contrary to alternative fuels, wind propulsion allows to harvest renewable energy directly at the location of the ship, not requiring any conversions and associated energy losses as required to produce fuels. However, one is of course dependent on the actual wind conditions at the vessel. And, as the energy density in wind is not very high, large savings or propulsion contributions require large devices, which can progressively impact ship operation.

A large number of wind propulsion devices, all scaled such that they develop about the same lift force, is shown below (source: Mathis Ruhl):



Passive: Wind propulsion systems that do not require constant energy input:	**Active:** Wind propulsion systems that require constant energy input for increased forces:
Bermuda sail or wing mast: relatively traditional sail solutions that are simple; when applied at scale they can still yield large contributions. Solid wings (various implementations): elevated lift coefficient, further increased with asymmetric profile or flap. Kite: Large forces because it is operated higher up in more wind. But can further increase forces when flying dynamic patterns in downwind conditions.	Flettner/Magnus rotor: Elevated forces through rotation of the cylinder. Suction (Turbo) sail: Elevated forces through boundary layer suction on the leeward side of the sail.

Although it is clear that Flettner rotors provide the largest lift and thrust (at favourable wind angles) the other characteristics mean that there is not one device that is clearly better than the other ones across the board. At present it appears that all of the devices have a potentially attractive application on specific ship types and operations. For instance, active devices with large lift coefficient allow to use small devices on slower ships. Large passive devices with favourable lift-over-drag ratio are well suited for faster ships (with effectively tighter wind angles) or ships aiming for really large contributions from wind propulsion.

Market readiness & availability

Type	No. of ships	TRL
Solid wing	3	6-8
Kite	1	7
Flettner rotor	11	8-9
Suction sail	4	7-9

The table shows the number of large commercial ships equipped with wind propulsion by the end of 2022 per type as well as the approximate Technology Readiness Level (EU definition). The listing excludes still some research, sail training, traditional vessels as well as large sailing yachts. Predictions by the International WindShip Association (IWSA) indicate that by the end of 2023 there will be at least 50 ships equipped. Generally about 2 to 4 devices are fitted per ship. As can be seen, the Flettner rotor is so far most common. The present suppliers started delivery in 2016 and consequentially the TRL can be considered relatively high. The suction sails follow. For kites there's only one active supplier with a prototype. Solid wings is very much varied. There is one supplier with two installations. But there is also a lot of activity and diversity in this category with multiple suppliers starting delivery of their first devices in the near future.

Applicability on reference ships

For wind propulsion to be useful, the following conditions generally need to be met:

- Reasonable or good wind statistics.
- Not too high ship speed (indicatively <15 kn).
- Space on deck/compatibility with ship/cargo operations.

In addition there are a multitude of other considerations, including economic, that determine which type, number and size may be appropriate.

General cargo	Tug boat	Offshore supply	Crew tender catamaran	Dredger vessel	Super yacht
+	-	-	+	-	+

A tug boat and offshore supply vessel are likely not sailing sufficiently to get a favourable payback time. Also these generally don't have the required free deck area. A dredger may actually be suitable due to its low sailing speed when dredging, however also these ships, with their current designs, don't have an obvious location for installation. A crew tender catamaran may be fitted with wind propulsion. However, ship speed is expected to be high which means that wind speeds should generally be high and/or applicable devices should have a high lift-to-drag ratio.

Installation of wind propulsion does generally require some modifications to the ship, such as:

- Foundation at the location of installation.
- Potential adjustment of ships navigation lights and radar to avoid blind sectors.
- Cabling, control systems/panels and possibly dedicated anemometers.

Emission reduction effectiveness

It is impossible to list generalized saving percentages as performance is completely dependent on types, numbers, (relative) sizing, wind conditions and ship operation. However, reports from the ships presently sailing indicate that annual savings of 5% to 15% on fuel and GHG emissions are generally achievable in reasonable wind with Flettner rotors, suction sails or rigid wings. This is still in a retrofit scenario where, even if the ship is new, the ship design and operation have not been adjusted to maximize savings from wind propulsion. R&D projects are underway with larger devices, adjusted ship design and operations. Research has shown that adjusted routes and speeds over the course of a voyage, while still arriving in time, has large potential for increases in savings, especially on Oceanic crossings.

Operation and safety

Relatively modest application of wind propulsion, with savings between 5% and 15% has shown to be uncomplicated. Devices may need to be moved or tilted for cargo operations or passing under bridges. However, these operations, as well as the control during sailing, is generally automated. No additional crew is required. Some regulatory checks need to be done prior to installation, such as on stability, navigation lights, bridge and radar visibility and a (favourable) adjustment to EEXI. For modest savings these matters are generally not problematic.

However, larger wind propulsion taking a large contribution in the ships propulsion may require more effort. This includes the topics as mentioned above. Additionally it should be expected that redundancy of the wind propulsion itself does become important.

Costs

There is yet little data on cost of wind propulsion. For Flettner rotors, an indicative cost of €30,000 per meter height of Flettner rotor is listed. Indicative cost estimates of suctions sails show a slightly lower price. But there is large uncertainty on this as so far production has been done with small numbers for a large part within research projects. Nevertheless, some case studies suggest that in a business as usual scenario with ships sailing on diesel the payback time may be unattractive. However, as the EU ETS becomes active and as ships start to sail on alternative fuels, the payback time may well become very attractive. Moreover, wind propulsion may be a cost efficient method for ships to become compliant on EEXI and/or CII whit engine power limitation.

Development prospect

Wind propulsion for modest savings is commercially available. However, suppliers and R&D projects are still busy to incrementally increase performance as well as to validate it. About five leading suppliers are known to be busy to arrange their supply lines to scale up to larger numbers, which should also help to reduce cost. Applying wind propulsion with larger contribution is still in R&D stage. First build contracts have been signed (Neolines, OrientExpress, more coming). Validation data should come when these ships start sailing. At the same R&D work is ongoing to see if and how ship design and operations should change in order to support maximum savings from such ships.