

Maritime Summary Note n°242 – June 2022

« Wind propulsion for ships : recent advances and outlook »

Shipping is a highly consolidated sector featuring a restricted number of corporate actors, operating within a global international free-market framework that originally thrived on extremely low-cost, highly polluting, and tax-exempt heavy fuel oil (HFO). The introduction of new binding regulatory mandates by the IMO compels ocean carriers to identify alternative fuels or decarbonized propulsion modes. However, the lack of availability and the volatile pricing of these new fuels serve as primary catalysts to look for alternative solutions. Leveraging the wind to propel the commercial merchant fleet represents a readily available solution to significantly optimize the maritime sector's environmental footprint. A study conducted in 2016–2017 on behalf of the European Commission¹ estimated that if the initial installations of wind-assisted propulsion took place in 2020, between 3,700 and 10,000 vessels would be equipped by 2030, preventing the atmospheric release of 3.5 to 7 Mt of CO₂ while generating 15,000 to 18,000 jobs. This research evaluated only four core technologies. Complementary research² carried out in 2019 estimated that 40% to 45% of the global fleet could be fitted with wind-assisted propulsion systems by 2050.

France possesses a wealth of technological developments and a highly favorable ecosystem that could rapidly transform into a robust domestic industrial manufacturing sector, provided it receives appropriate public and private support. With the global race to decarbonize economies actively underway, numerous stakeholders across Asia and Northern Europe are positioning themselves within the wind-assisted shipping market. The French offering must therefore differentiate itself to drive job creation and contribute significantly to cleaner maritime transport. What milestones and advancements has this sector achieved over the past three years?

Strategic and market overview: Wind-assisted propulsion

Developers and shipowners

For specific vessel segments and trade lanes, wind-assisted propulsion represents a paramount measure to comply with mandatory energy efficiency index thresholds: the EEDI (Energy Efficiency Design Index), which has been mandatory for newbuilds since 2013, the EEXI, which will apply to existing vessels starting in 2023, and the operational carbon intensity index, the CII.

Wind propulsion, when combined with alternative measures (energy efficiency optimizations, vessel operations, and alternative fuel deployment), enables the industry to unlock deep decarbonization levels.

Thus, wind-assisted propulsion can be utilized as a supplemental propulsion aid and retrofitted onto the existing fleet. In this configuration, it reduces fuel consumption and associated GHG and pollutant emissions by 5% to 20%. The potential is significantly higher (exceeding 30%) when deployed on purpose-built newbuild vessels of medium size and displacement. It can even achieve up to an 80% reduction in emissions when acting as the primary mode of propulsion. Currently, around twenty large commercial vessels are already sailing with wind-assisted propulsion technologies. Ranging from 80 to 340 meters in length and from 4,000 to 325,000 gross tonnage, they have been equipped through retrofit operations since 2018—with the notable exception of Enercon's E-Ship 1, constructed in 2010 with 4 Flettner rotor sails.

The development of wind propulsion equipment (categorized into five primary families: suction wings, soft sails, rigid sails, kites, and rotors) is predominantly driven by start-ups. There are approximately

¹ Nelissen D. et al, Study on the analysis of the market potentials and market barriers for wind propulsion technologies, CE Delft, novembre 2016

² The Frontier Economics Report (July 2019), report for the UK Department for Transport.

thirty technology developers worldwide, including about ten located in France. Two dedicated production manufacturing plants are already under construction. In Caen, the AYRO factory will produce Oceanwings—articulated wingsails that have been tested on board the Energy Observer vessel for more than two years. Four of these wingsails will be installed on the Canopée (managed by Zéphyr & Borée and JIFMAR) [INDEX], a 121-meter-long hybrid Ro-Ro vessel currently under construction, designed to transport the Ariane 6 rocket on behalf of ArianeGroup. The vessel is scheduled to be launched in early 2023. AYRO projects the long-term creation of around one hundred regional jobs. Another manufacturing plant is being designed by Airseas, which has anchored itself in Nantes to produce and market traction kites. Its objective is to manufacture 1,000 units across multiple sizes (500, 1,000, and 2,000 m²) by 2030, designed to equip vessels from 100 to 400 meters in length. In total, nearly 200 jobs will be generated by 2025. Airseas installed its 500 m² prototype on board the Ro-Ro vessel Ville de Bordeaux belonging to Louis Dreyfus Armateurs (LDA), which operates transatlantic liner services between Montoir-de-Bretagne and Mobile (USA).

Concurrently, WISAMO's (Michelin) automated, inflatable wing sail mounted on a telescopic, retractable mast is being tested by skipper Michel Desjoyeaux. An automated 100 m² prototype will be fitted onto the Ro-Ro container vessel MN Pélican operated by the Compagnie Maritime Nantaise (CMN) by the end of this year. WISAMO selected Nantes as its strategic home base.

In Saint-Nazaire, Chantiers de l'Atlantique is developing the Silenseas sail-powered cruise ship project, which integrates Solid Sail composite panels onto the Aeol Drive balestron rig. A 40-meter mast and a 500 m² sail are currently undergoing rigorous testing at the Saint-Nazaire shipyard facility, following an initial 50 m² demonstrator set up on the Pornichet port jetty in late 2019. It will not be until the summer of 2022 that the full-scale Solid Sail Aeol Drive solution can be observed in real-world conditions. With a capital cost of €18 million for this future flagship demonstrator, Chantiers de l'Atlantique secured public subsidies covering half of the total sum. These technological breakthroughs are dragging in their wake a dense network of specialized maritime suppliers from the Pays de la Loire and Brittany regions, such as Multiplast, Avel Robotics, and Lancelin. Other specialized equipment is also under development, including ACCWING's thick wingsail, CWS Morel's rigid wingsail, the suction wing system engineered by CRAIN and REEL, Beyond the Sea's traction kite, and ADD Technologie's thick profile sail.

On the shipowners' side, the Nantes-based startup Neoline is working on the construction of a 136-meter cargo Ro-Ro vessel equipped with the Solid Sail rig, boasting a total sail area of 3,000 m². This vessel will operate a pilot liner service linking Saint-Nazaire, Saint-Pierre and Miquelon, Baltimore (USA), and Halifax (Canada). The company is pursuing its capital fundraising rounds and has secured the commercial backing of around fifteen primary shippers, including Renault, Bénéteau, and Manitou, among others. The objective targets the operational commissioning of the first Neoliner by 2024–2025. The specialized operator Zéphyr & Borée and the organic spice importer Arcadie launched Windcoop, a greenfield shipping line structured as a cooperative. The enterprise plans to deploy an initial 85-meter cargo sailing vessel designed by Dykstra and Groot Ship Design to operate a liner trade route linking France, Mayotte, and Madagascar starting in 2025. Concurrently, TOWT (*TransOceanic Wind Transport*) signed a landmark building contract with the Piriou shipyard for the construction of its first 80-meter *Phoenix Class* vessel, utilizing 2,500 m² of sail area as its primary mode of propulsion.

Meanwhile, the company Grain de Sail anticipates the 2023 delivery of its second cargo sailing vessel—a 52-meter unit—by the exact same shipyard, which is also building the 43-meter supply sailing ship *Persévérance* for the *Polar Pod* expedition, scheduled for delivery that same year. At least seven French vessels will be equipped with wind-assisted propulsion systems in 2023, alongside two French vessels fitted with foreign technologies, including Marfret's *Marfret Niolon*, a vessel operated by LDA. Paralleling the intense interest shown by shipowners, a robust demand is emerging from shippers for this type of zero-emission logistical solution; however, the current market supply is not yet sufficient to satisfy it. The transport of high-value-added commodities serves as the primary pioneering engine for this niche sector. Furthermore, performance simulation tools and advanced weather routing software developed by specialized engineering firms such as D-ICE Engineering, CRAIN, Syroco, and BVS M&O act as vital decision-making aids for shipowners. The objective is to forecast a vessel's real-world hydrodynamic and aerodynamic behavior by modeling each of its core components—sails, hull, and auxiliary propulsion systems—while measuring their cross-reactions through structural force analysis. This framework integrates the direct impact of environmental variables (wind, wave friction, and currents) on the global system, optimizing speed, seakeeping, and ship motions. The statistical weather routing offered by selected developers serves to test the vessel's digital twin against historical real-world

navigation data. By executing a high volume of optimal route calculations over past weather cycles, operators can secure highly reliable statistics regarding actual fuel consumption, anticipated sea conditions, and the exact energy savings generated by wind propulsion. Even in the absence of sails, advanced weather routing services enable a reduction in fuel consumption exceeding 5%.

Support activities

Financing

Access to capital represents undoubtedly the primary bottleneck facing the wind-assisted ship propulsion sector, particularly when attempting to cross the bridge from R&D to prototyping. Navigating the learning curve, unlocking economies of scale, and delivering the initial production series remain structurally difficult. Currently, freight rates hover close to 2000s levels while bunker prices have doubled, leaving operators to cope with significantly narrower profit margins. Concurrently, the world's top 40 banks have contracted their lending capacities even as the global fleet expands relentlessly. These factors combine to generate a massive financing deficit. European banks are particularly impacted by this landscape, and the surging capital resources of Asian financial institutions fail to bridge the gap.

Yet, the decarbonization of maritime transport demands heavy capital expenditures, whether for constructing more expensive newbuild vessels or for retrofitting the existing fleet. In this regard, carbon pricing will also exert a major incidence on operational metrics and overall financial results.

The European Parliament's Environment Committee recently reviewed key text files shaping the EU's future climate policy and voted by a large majority in favor of two pivotal measures championed by European shipowners: namely, establishing a clear sharing of liabilities between the shipowner and the operator (the charterer), and mandating the ring-fencing of 75% of revenues generated from carbon allowance sales to fund the breakthrough technologies required for deep decarbonization. This mechanism will provide a powerful boost to transition technologies. The integration of maritime transport into the European carbon market, currently under negotiation within the European Parliament, is set to directly value every single ton of CO₂ emissions saved.

Nevertheless, the pioneering actors within the wind propulsion market are predominantly new entrants into the shipping industry, and sail-equipped commercial vessels have been absent from merchant shipping for a century. Lacking any established track record, these projects struggle to secure bank loans, while the sheer multiplicity of available technological variants deters investors seeking to identify the single most profitable technology. This structural hesitation stalls the arrival of the massive capital inflows required to build genuine industrial-scale production tools, forcing selected shipowners to resort to crowdfunding platforms (such as LITA or WiSEED).

Yet, one fundamental truth remains: the wind is free and will always remain so. Given that fuel expenses account for 20% to 35% of a vessel's operating costs (OPEX), a wind-propelled ship successfully reduces structural dependency on the availability and pricing volatility of future alternative fuels, thereby mitigating global financial risks. For alternative inquiries regarding marine insurance frameworks, see the dedicated white paper published by the Wind Ship Association (<https://www.wind-ship.fr/livre-blanc>).

Regulation and certification frameworks

The adaptation of international regulations (SOLAS, COLREG, MARPOL) to these alternative propulsion modes is occasionally lacking, prompting strong involvement from classification societies and the flag State to assist projects. In France, the DG AMPA (Directorate General for Maritime Affairs, Fisheries and Aquaculture)—alongside its decentralized services including the DIRM (Interregional Directorate for the Sea) and the CSN (Ship Safety Centers)—is responsible for evaluating the compliance of vessels not delegated to classification societies (passenger ships regardless of length, and all vessels under 24 meters in length) and issuing safety and pollution prevention certificates (vessel compliance).

For delegated vessels, the compliance study is performed directly by the classification society ; only exemptions or alternative designs are reviewed and analyzed by the aforementioned administrative services. For all vessels, registration and the issuance of manning licenses (permis d'armement) are handled either by the DDTM (Departmental Directorate for Territories and the Sea) or by the RIF (French International Register) headquartered in Marseille.

The SOLAS Convention mandates that special attention be paid to the reliability of essential propulsion components that are not duplicated, and may require the vessel to possess a separate source of

propulsion power enabling it to maintain sufficient speed for safe navigation, particularly for non-conventional installations. French national regulations even fix this minimum speed at 7 knots. Every wind-propelled vessel must possess a conventional engine to execute port maneuvers or to maintain a baseline speed enabling it to respect schedules.

Wind propulsion equipment positioned on the open deck can at times obstruct visibility from the wheelhouse and the visibility of navigation lights. On newbuilds, this constraint is integrated from the start by naval architects who, in the majority of cases, position the wheelhouse at the bow of the vessel to anticipate the issue. On existing ships, equivalent solutions to the rule are sought by naval architects or engineering offices in partnership with equipment manufacturers (such as remote cameras). The flag State is then petitioned to assess the capacity of the solution to meet the objective of the rule, aiming to issue an exemption certificate or declare a regulatory equivalence.

Whether under the SOLAS Convention, national rules, or European regulations, there are currently no stability criteria specifically tailored for commercial vessels under sail. Consequently, conventional stability criteria for mechanically propelled vessels are applied when the wind propulsion equipment is not deployed. In addition, supplementary stability test cases are applied with the wind propulsion systems fully deployed, ensuring that stability is evaluated under the most unfavorable conditions. There are no insurmountable difficulties, as the administration, backed by the classification society, reviews each vessel and configuration on a case-by-case basis to identify an alternative design that meets regulatory objectives.

In 1987, Bureau Veritas published the Regulatory Note NR 206 entitled "Classification of Wind Propulsion Systems on Board Ships." This technical directive was thoroughly updated in 2020, integrating the latest technological developments in thrusters (traction kites, wingsails), increasingly massive rigging dimensions, alternative advanced materials (composites, synthetic ropes), risk analyses, finite element (FE) calculation methods, automation, and continuous monitoring. It also incorporates updates in safety regulations, stability calculations, and energy efficiency considerations (including the direct impact on EEDI calculations).

Training and crew certification

Finally, the operational management of these innovative systems on board and the implementation of vessel safety protocols during emergencies represent a critical challenge; consequently, marine insurance underwriters demand formal proof of seafarer training in these fields. To address this requirement, the Wind Ship Association, the ENSM (*French National Maritime Academy — École Nationale Supérieure Maritime*), and the engineering firm D-ICE Engineering are actively collaborating on the design of a specialized training framework tailored for the optimized navigation of wind-propelled vessels. Thus, starting in 2023, a continuous professional training module—integrating both theoretical coursework and practical simulation exercises—can be offered to vessel operators and their crews. Marine meteorology, core physical principles of hydrodynamics and aerodynamics, and emergency safety operations stand as the primary topics covered to ensure an optimized and secure navigation. These core subjects will also be audited by the flag State during the vessel's and shipping company's mandatory certification under the international ISM Code (International Safety Management).

Institutional support mechanisms

Institutional backing and financial support operate across multiple governance tiers: European, national, and regional. European Union subsidies are accessible through targeted calls for proposals launched by the European Commission's DG MARE. An illustrative example is the 2021 launch entitled *Blue Economy Window call 2020*. Funded by the European Maritime and Fisheries Fund (EMFF / FEAMP), this call was specifically designed to support innovative SMEs operating within the maritime blue economy. Under this dedicated framework, the startup AYRO secured a €2.36 million financial commitment from the EU to bolster the pre-industrialization, testing, validation, and real-world performance monitoring of its *Oceanwings*. Additionally, two *Horizon Europe* calls for proposals explicitly targeted wind-assisted propulsion systems in 2022.

On a national scale, in France, the 2022 Finance Act (*Loi de Finances 2022*) was welcomed with immense enthusiasm by the shipping industry. It streamlines the adoption of clean alternative energies by introducing an accelerated depreciation tax incentive (*dispositif de suramortissement fiscal*) that is finally applicable to the sector. Commercial vessels flying the flag of an EU Member State or an EEA

country are fully eligible. This framework allows corporations subject to corporate tax or income tax under a real tax regime to deduct from their taxable income sums that vary depending on the nature of the "green" capital equipment acquired (Article 39 decies C of the French General Tax Code / *Code Général des Impôts*).

Low-carbon primary propulsion³ is eligible for a 125% accelerated depreciation tax incentive under the French General Tax Code. It specifies that wind propulsion systems encompass: *"wind equipment: masts, wings, rotors, traction kites and their control systems, sails, ropes, deck hardware, rigging, keels, and leathers or ballasts (installed in addition to the ballasts utilized when the vessel is unladen)."* Until this recent Finance Act, auxiliary wind propulsion equipment only benefited from a 20% depreciation rate on the original asset value. This rate was revised upward to 85%, making the framework significantly more incentive-driven for shipowners. Today, the legal concepts of primary versus auxiliary propulsion remain to be precisely defined, particularly for wind-assisted systems other than conventional sails, as the current definition relies on a historical standard originally designed for conventional rigging.

Notably, this State aid is unique within the EU and is strictly framed by European Union law. Industrial developers of these solutions can apply for various calls for projects launched by Bpifrance, such as the *"Première Usine"* (First Factory) scheme, designed to accelerate the emergence of initial manufacturing milestones by industrial start-ups or innovative SMEs and mid-caps. This mechanism operates under the umbrella of the "France 2030" national investment plan.

At the regional tier, sector backing can manifest through multiple pathways: dedicated budgets allocated as subsidies, loans, loan guarantees, or investment funds. These mechanisms can co-finance corporate support structures such as competitiveness clusters (*pôles de compétitivité*) or fund targeted international events centered on wind propulsion technologies.

The Brittany and Pays de la Loire regions capitalize respectively on decades of technical expertise: ocean racing (*course au large*) for Brittany, and large-scale cruise ship construction for the Nantes Saint-Nazaire hub. Furthermore, both regions benefit from the presence of a dense corporate fabric operating across the shipbuilding and yachting industries. The wind propulsion sector aggregates equipment manufacturers, component suppliers, engineering and numerical modeling services, maintenance operations, shipyards, shipowners, and shippers. This industrial biotope acts as a powerful driver for regional attractiveness and upskilling while generating new employment. This is reflected in a recent study by the BDI agency (*Bretagne Développement Innovation*), which counts 156 companies actively engaged in the sector, with a cumulative turnover for the regional industry estimated at €28 million. The projects developed in Brittany focus on both specific technological building blocks and regular liner trade networks or localized coastal shipping (*cabotage*).

In Pays de la Loire, the Regional Council actively backs various flagship projects, including Airseas' industrial anchorage, Neoline's cargo project, the seafarer training framework managed by Wind Ship, and the development of an innovative performance assessment digital tool engineered by BVSolutions M&O. Reflecting this regional dynamism, Nantes Saint-Nazaire Développement and the Wind Ship Association organized the second edition of the Wind for Goods international summit, which took place on June 1 and 2, 2023, in Saint-Nazaire. This international meeting gathering wind propulsion stakeholders bears clear witness to an industrial sector experiencing a spectacular ascent.

Lise DETRIMONT & Camille VALERO
English translation generated by Gemini AI

³ Decarbonized propulsion' shall be understood to encompass hydrogen, electricity, LNG, LPG, CNG, ammonia, methanol, ethanol, dimethyl ether, as well as wind propulsion.