Project acronym:	WASP (Wind Assisted Ship Propulsion)
Project full title:	Run Wind Propulsion Technology real life trials on sea going ships in operation>showcase proven concepts>market adoption>green sea transport
Project No.	38-2-6-19
Coordinator:	Netherlands Maritime Technology Foundation

D 5.B.2
Report

Barriers and overcoming strategies for accelerating the uptake of WASP

Deliverable data

Deliverable No	5.B.2	
Deliverable Title	Barriers and overcoming strategies for accelerating the uptake of WASP	
Work Package no: title	WP4: Policy and viable business	
Deliverable type	Report/strategy	
Lead beneficiary	Kühne Logistics University	
Responsible author	Lara Pomaska	
Co-authors	Zhanita Rafaelova, Vasileios Kosmas, Michele Acciaro	
Date of delivery	30-12-2021	
Approved	**Name**	**Date**
Peer reviewer 1	Jacqueline Brouwer	12-11-2021
Peer reviewer 2	Roberto Rivas Hermann	23-11-2021
Peer reviewer 3	Ning Lin	23-11-2021

Document history

Version	Date	Description
1	11-11-2021	First draft
2	30-12-2021	Final version

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List of symbols and abbreviations

Capex	Capital Expenditure
CO_2	Carbon Dioxide
DCS	Data Collection System
EEDI	Energy Efficiency Design Index
ESG	Environmental, Social, and Governance
EU	European Union
GHG	Greenhouse Gas Emissions
IMO	International Maritime Organization
IP	Intellectual Property
IT	Information Technology
MBM	Market-Based Measures
MRV	Monitoring, Reporting & Verification
NO_x	Nitrogen Oxides
OI	Open Innovation
Opex	Operating Expenses
PES	Proactive Environmental Strategy
SME	Small and Medium Enterprises
SO_x	Sulphur Oxides
WASP	Wind Assisted Ship Propulsion

Executive Summary

Purpose of Report

As a result of the decarbonization efforts of the maritime industry, various options of greener technologies are currently investigated. Wind Assisted Ship Propulsion (WASP) is seen as a potential solution to the environmental challenges of the maritime industry, still broader uptake is limited by barriers that hinder its adoption, implementation and upscaling.

The purposes of this report are as follows:

- Identify overcoming strategies to accelerate the uptake of WASP.
- Create a framework that shipowners can consult or adapt to their specific needs in order to evaluate strategies for investments in CO_2 abatement technologies.
- Create a foundation of suggestions for WASP technology providers that can be adapted internally to overcome certain market barriers.
- Provide a basis for policymakers with respect to regulation and incentives that can be provided to accelerate the uptake of WASP technologies.
- Provide managerial and policy insights for all stakeholders that are involved in the process, mainly WASP technology providers, shipowners and policymakers.

Methods Used

This report assesses the implementation barriers that are preventing the uptake of WASP technologies and proposes strategies that are found outside of the maritime literature that have been developed and applied for the implementation of greening innovations. The strategies are put into maritime context, specifically to the case of WASP. The methodological approach of critical analysis to find key barriers and a systematic literature review to examine potential strategies in implementing technological innovations were followed. A total of 53 papers were reviewed and analyzed in the process.

Findings and Conclusion

The report stresses the need of prerequisites for implementing core principles suggested by open innovation (OI) strategy to overcome key barriers of cost and access to capital, split incentives and trusted information. In particular, proactive environmental strategy, cooperation strategy, innovation orientation, financing and policymakers were found to be vital key concepts for the implementation of new innovation technologies. The literature further suggests that introducing and applying OI strategies in the commercialization phase of SME leads to valuable results, which could hold for WASP providers.

The results of the study found that open innovation strategies are potentially beneficial to implement in the adoption, implementation and upscaling of WASP technologies.

Recommendations for Industry and Policy Stakeholders

Suggestions to accelerate the uptake of WASP include:

- Implementing economic incentives through program-based crediting mechanisms, investment schemes and tax-breaking for research activities
- Establishing funds and international financing for wind propulsion projects
- Forming partnerships between public and private sector to leverage interests for both parties
- Implementing knowledge sharing platforms organized by impartial organizations and implementing new policies focusing on knowledge diffusion to overcome trusted information barrier
- Starting close collaboration between technology providers by forming alliances on market level
- Enhancing IT infrastructure, environmental management systems, IP management and supporting IP competencies to protect assets of technology providers.

1. Introduction

The global shipping industry carries approximately 90% of world trade by weight, accounting for nearly 2.89% of anthropogenic carbon dioxide (CO_2) emissions (IMO, 2020). If left to business as usual, Nelissen et al. (2016) report that greenhouse gas (GHG) emissions in the industry are expected to increase by 50-250% by 2050 compared to the emissions level in 2012. Alongside this, the shipping industry is responsible for around 13% and 15% of the global sulphur oxides (SO_x) and nitrogen oxides (NO_x) emissions respectively due to human activities, significantly impacting human health (Smith et al., 2015).

The maritime industry is under pressure to mitigate its environmental impact and deliver changes in line with the limits laid out in the Paris Climate Agreement (UNFCCC.INT, 2015) by implementing strict emission regulations. Full decarbonization of international shipping is necessary and highlights the importance of short- to medium-term emission reduction measures to meet this goal (Traut et al., 2014). As a result of the decarbonization efforts, various options and the uptake of greener technologies are currently investigated. Although existing research has mostly focused on cleaner alternative fuels and primarily on Liquefied Natural gas (LNG), it has also highlighted the promising role of renewable energy sources (e.g. wind power) in reducing CO_2 emissions (Ampah et al., 2021).

Given the necessity for finding viable options for the decarbonization of the shipping sector, the Interreg North Sea Region Programme, part of the European Regional Development Fund (ERDF), funded the Wind Assisted Ship Propulsion (WASP) project that was launched in 2019. The four-year project brings together industry and research organizations to investigate and validate the performance and commercial viability of wind assisted propulsion technologies on five vessels. The goal is set to enable wind propulsion technology market penetration and to contribute to a greener North Sea transport system through harvesting the regions wind potential (Interreg North Sea Region, 2021). WASP technologies are seen as an effective and innovative option that can benefit shipowners and society through fuel consumption reduction, energy efficiency improvement and emissions reduction (Chou et al., 2021).

Despite the growing attention and interest of key industry stakeholders due its promising fuel savings and environmental benefits, WASP technologies have not yet reached market maturity (Nelissen et al., 2016). The uptake of WASP technologies is observed to be rather slow and is largely limited to small-scale uptakes within the industry. While many studies have investigated advantages and benefits of WASP technologies (Smith et al., 2016; Bouman et al., 2017) there is no specific study that has identified strategies for overcoming barriers and hence accelerating WASP adaption, implementation and upscaling. This report therefore addresses this gap through an assessment of barriers that are preventing the uptake of WASP technologies and proposing strategies found outside of the maritime literature that have been developed and applied for the implementation of greening innovations. In this context, it is important to investigate following research question: *Which strategies can be applied from industries outside shipping for overcoming the WASP implementation barriers?*

In order to answer the research question, a systematic literature review approach is followed. This report identifies strategies that can be adapted in order to overcome the preventing factors. The purpose of this report is to create a framework that shipowners can consult or adapt to their specific needs in order to evaluate strategies for investments in CO_2 abatement technologies. It creates a foundation of suggestions for WASP technology providers that can be adapted internally to overcome certain market barriers. It also provides a basis for policymakers with respect to regulation and incentives that can be provided to accelerate the uptake of WASP technologies.

The remainder of the report proceeds with the following structure. Section 2 presents the theoretical framework of this paper and the methods used within this study namely systematic literature approach. Section 3 highlights the existing barriers that prevent the uptake of WASP in the shipping industry. Section 4 presents key strategies from the literature review that are applied for implementing technological innovation in other industries. The strategies are then put into a WASP context. Section 5 concludes, identifies limitations and provides recommendations for future research.

This is a revised and redacted version of research that has appeared in Rafaelova (2021) as well as work carried out in the context of the Interreg North Sea Region WASP project. This report serves as a deliverable in WP4 "Policy and Viable Business", activity 5b: Economic impact of WPT, 3: Strategies to overcome barriers.

2. Methodological approach

For the purpose of investigating and presenting potential strategies in implementing technological innovations, a critical analysis and systematic literature review were conducted. These methods are concisely presented in the following section.

2.1 Critical analysis

Critical analysis is a method that focuses on examining main concepts, ideas, and relationships that are presented by the literature (Nakano & Muniz, 2018). This method was used in observing and deriving the *Barriers of the uptake of WASP* section of this report, in order to provide a state-of-art knowledge and analytical framework for the existing barriers for the implementation of WASP technologies. Four fundamental principles were followed, namely the exploration of sources, sample selection, interpretation and presentation of results. The goal here is to provide industry-relevant materials to discuss important topics and solutions focusing on specific industry needs. Barriers have been extensively discussed in the literature (Acciaro et al., 2013; Nelissen et al., 2016) and multiple literature reviews have been conducted on the topic (Rojon & Dieperink, 2014; Rehmatulla et al., 2017).

2.2 Systematic literature review

Systematic literature review is described as a comprehensive, thorough and transparent analysis of existing academic work to provide an evidence-based guideline for researchers and practitioners (Nakano & Muniz, 2018). Thus, this approach was applied to allow for using a large and diverse set of paper.

For the collection of relevant materials for revision, Web of Science Core Collection was used, as it is ranked as one of the most widespread literature databases (Guz & Rushchitsky, 2009) and allows for a focused search of papers (Easterby-Smith et al., 2012). Figure 1 displays the searching and the selecting process that was performed. The systematic literature review is guided by following research question throughout this whole process: "which strategies can be applied from industries outside shipping for overcoming the WASP implementation barriers?".

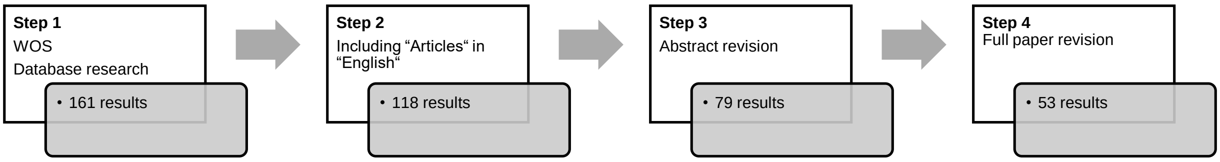

Figure 1: Searching and selecting process

As a first step, key search terms were identified, following the example by Pittaway et al. (2004), using a brainstorming technique. This activity resulted in identifying strategies, technologies, innovation, and barriers as leading topics to be searched for. Based on these terms, a search string was defined as an AND function, consisting of the combination of strateg*, technolog*, innov*, barrier* terms. This type of search insures the relevance of the results and inclusion of only relevant materials. The search was narrowed down to title and abstract to ensure that those terms are included in the main topic of the paper. The trend of articles in this topic as increased immensely in the last fifteen years, therefore the timeframe from 2005 until now was applied to include all relevant material. This resulted in 161 possible papers. To narrow down the results within following Step 2 until the last Step 4, a selection process was performed using following inclusion and exclusion criteria displayed in Table 1.

Table 1: Criteria for systematic literature review

		Inclusion Criteria	Exclusion Criteria
Step 2	Web of Science	Journal-published articles, Articles in English, Paper should be published between 2005-2021.	Papers that are not published in journals, such as proceeding papers, editorial material and notes.
Step 3	Abstract Revision	Main objective of the article to present strategies and provide context-relevant insights.	Papers that are out of the scope of this research.
Step 4	Full Paper Review	Main objective of the article to present strategies and provide context-relevant insights.	Papers that are out of the scope of this research.

After the second step, 118 articles were obtained but they needed to be analyzed more precisely. A revision process was conducted to ensure quality assessment of the results. First, the obtained articles were reviewed by title and abstract. As a result, 39 articles were excluded. The most common exclusion reason was based on the fact that articles have presented strong characteristics of industries such as business to consumer or service-related context which are not relevant to the context of WASP. The obtained 79 articles went through full text revision as a final step. The papers that did not provide context-relevant insights or did not present any strategies were excluded. The final result contains 53 papers.

3. Barriers of the uptake of WASP

According to the literature (Smith et al., 2016; Bouman et al., 2017; Balcombe et al., 2019; Chou et al., 2021) the installation of wind technologies on ships provides numerous benefits, for instance lower carbon emissions and reduction of the exposure to the price volatility of fossil fuels (Snyder & Kaiser, 2009). Still, there are factors that are preventing the adoption of WASP technologies. There is a number of studies that have been conducted in order to identify these barriers. An overview of different classifications by these studies is provided in Table 2.

Table 2: Classification of barriers

Source	Barriers influencing the implementation of WASP technologies		
Nelissen et al. (2016)	**Cost and access to capital**	**Split incentives**	**Trusted information**
Acciaro et al. (2013)	Financial and economic constraints	Market constraints	Safety and reliability, technical uncertainty, behavioral barriers and complexity
Rehmatulla et al. (2017)	Non-market failures	Market failures	-
Rojon & Dieperink (2014)	External factors, hard institutions, interactions	-	Soft institutions, knowledge infrastructure

Nelissen et al. (2016) classified barriers that are hindering the uptake of WASP into three key subjects, namely the access to capital for the development of WASP, incentives to improve the energy efficiency and simultaneously reduce emissions of ships. The third key subject is classified as trusted information on several factors that influence for instance the applicability, safety, risks and economic implications of WASP. Acciaro et al. (2013) provided industry insights covering the topics of financial, economic and market constraints for example split incentives, economic viability and investment costs that are hindering the uptake of the technology. This includes the technical uncertainty and complexity of the technology, risks associated with the implementation affecting the crew, vessel or operations and behavioral barriers related to the availability of interorganizational information.

Furthermore, Rehmatulla et al. (2017) presented insights into organizational, behavioral and economic barriers that linked to market failures (split incentives, asymmetric and imperfect information) and non-market failures (market heterogeneity, hidden costs, access to capital and risk). Rojon and Dieperink (2014) differentiate between hard (e.g. lack of policies, financial incentives) and soft institutions (e.g.

lack of trust, conservative industry). Other barriers are described as knowledge infrastructure, interaction such as collaboration between stakeholders and external factors.

For the following section and the overall report, we used the key classifications provided by Nelissen et al. (2016), namely cost and access to capital, incentives and trusted information. This study, which was commissioned by the European Commission and particularly DG Climate Action, has attracted the attention of industry stakeholders. For instance, the classification provided in Nelissen et al. (2016) was used in the recent "Wind Propulsion Strategy Workshop"—one of the authors of the present report participated in the workshop—organized by the International Windship Association that discussed potential strategies toward accelerating the uptake of WASP technologies (International Windship Association, 2021).

3.1 Cost and access to capital

There is an existing financial burden in access to capital for WASP providers, due to the small size of the market (Nelissen et al., 2016). On the demand side, it is problematic for shipowners to install WASP technologies caused by the large initial investment, lack of funding for conducting trials and overall lack of liquidity in the sector. The conventional financing schemes appear to be reluctant to providing financial support, owing to the inability for shipowners to fulfil their contribution, as the payback period of these technologies is not fixed (Nelissen et al., 2016). Subsequently, access to capital is described as a company's hurdle of accessing internal or external capital due to their budgeting process, investment appraisals and biased management.

Hidden costs are described as non-market failures which occur after the implementation of the technology namely maintenance and costs of spare parts and operation. Additionally, access to capital can be hindered by other hidden costs namely the transaction costs that relate to the costs associated with obtaining accurate information, screening, supervision and opportunity costs. Furthermore, hidden costs can refer to overhead costs, loss of benefits costs and identification costs that have not been included in the cost-effective analysis for evaluating an investment project. These hidden costs display economic constraints in the investment decision making as the investment's efficiency can be overestimated (O'Malley et al., 2003).

The more complex the technology is, the less attractive it is for the shipowners, due to the risks of increasing the burden on the crew (Acciaro et al., 2013). Other risks include the fleet, market, and operational heterogeneity of the shipping industry (Rehmatulla et al., 2017). WASP technologies are proven to be cost-effective on average, but there are not many evidences on all specific cases of WASP performance, as it varies based on ship sizes, type and route (Pirrong, 1993). For instance, the technology's payback period could be lengthened if operated in non-favorable, less windy regions (Rehmatulla et al., 2017). Subsequently, fuel prices are observed as a structural driver of the economic barrier as the uncertain future oil price affects the investment's payback period and hence the willingness to invest.

Other factors are the role of institutions and interaction among technology providers. Rojon and Diepernick (2014) argue that some of the barriers in accessing capital are created by the lack of policies in promoting wind propulsion, public finance of R&D activities, start-up finance, weak compliance and enforcement mechanisms. Furthermore, the lack of knowledge exchange incentives and platforms among technology providers is preventing from lobbying activities that can influence policymakers (Rojon & Dieperink, 2014).

3.2 Split incentives

The legal setup of the shipping industry is one aspect that creates split incentives for implementing wind technologies (Nelissen et al., 2016). According to Acciaro et al. (2013), charterers are perceived as a bigger barrier to the implementation of new technologies in general, outweighing the role of regulations. Depending on the type of agreement, charterers are profiting from fuel expenditure savings most of the time, which creates no motivation for shipowners to take the risk of retrofits (Nelissen et al., 2016).

Additional barriers are the commercial agreements, as changes in routing or speed for the optimization of the WASP technology on board might not be allowed (Rehmatulla et al., 2017). When examining the WASP target market in the face of dry bulk, it can be observed that 60% is under charter contracts. The duration of 90% of those contracts is less than two years, which is less than the payback period of the WASP technology (Rojon & Dieperink, 2014).

Furthermore, split incentives not only exist between the companies investing in a new technology and the companies obtaining the benefits of the investment, but also between different departments within a company. This can be observed when the accountability of energy costs does not align with the accountability of energy management. Bounded rationality is the situation when investors make suboptimal decisions in energy-efficiency investment with available information and incentives under the constraint of time, attention, and resources that often lead companies to routines, inertia, and status-quo bias.

Another aspect relates to competing projects once the shipowner has internal capital to deploy, thus energy efficiency projects might not always be highest priority. Hence, small projects tend to have higher hurdle rates and a lower priority (Rehmatulla et al., 2017). Other areas might require more attention in case of low fuel prices and therefore the cost-efficiency of WASP technologies might be outperformed by simple cost-efficient solutions causing greater cost savings (Nelissen et al., 2016).

3.3 Trusted information

One of the most prominent concerns of shipowners is related to the overall operability of WASP. For this reason, stakeholders require detailed, trusted information on their specific case, that include all aspects such as setup, maintenance, opportunity costs, compatibility with other technologies and infrastructural limitations (Nelissen et al., 2016). Hence, imperfect information and asymmetric distribution of information refer to the lack of information about investment opportunities and their costs and performances leading to decisions made by the rule of thumb to achieve satisfying results. The lack of information and transparency is a substantial barrier that hinders the uptake of energy-efficient technologies.

However, availability is not enough as the source of information plays a crucial role and data from technology providers is generally perceived as biased and therefore not trusted (Rojon & Dieperink, 2014). Hence, lack of trust among actors and the overall conservative and risk-averse character of the industry are preventing the exchange of information, especially among technology providers due to the fear of losing competitive advantage on the market (Rojon & Dieperink, 2014). Therefore, little collaboration and knowledge exchange as well as weak networks between stakeholders are barriers that need to be addressed.

Another obstacle is derived from the variability of performance as savings from specific cases cannot be generalized. It is necessary to factor in operating conditions such as wind speed, wave height, seasonal patterns, route, crew training, trade patterns, trip duration, trip irregularity and port calls (Chou et al., 2021). Subsequently, stakeholders should be provided with case specific parameters of a ship and its routings. This faces another hurdle since there is no standardized way of collecting this data. Currently, the available information is based on a small-scale theoretical tests, due to the limited number of funds. Another reason is the skepticism on the side of shipowners, that are usually opposed to the idea to participate in trials, due to the lack of legal protection from arising risks (Nelissen et al., 2016).

4. Strategies for implementing technological innovations

After identifying the barriers that are hindering the uptake of WASP technologies, we continued with the systematic literature review presented in the second section in order to find strategies for overcoming those barriers.

Open innovation (OI), which is described as the way to use knowledge inflows to accelerate internal innovation and knowledge outflows to stimulate external use of innovation and market growth (Chesbrough & Crowther, 2006), was fully or partially present in all articles from the systematic literature review. Currently, firms pursue a more closed approach to innovation (Lichtenthaler, 2008), while OI is driven by pioneering companies that tend to approach the innovation process systematically and dedicate a corporate venturing unit for external technology exploitation activities (Crupi et al., 2021).

In the near future, external technology acquisition and exploitation will be a necessity rather than an option, implying that a closed innovation approach has negative effects on the long-term performance of the company. Thus, proactive openness to innovation holds competitive advantages for innovators, independent from the industry context (Lichtenthaler, 2008). Proactive environmental strategy (PES), cooperation strategy, innovation activities, financing and policymakers' role are crucial topics in examining this strategy, which will be described further. The key concepts and respective sources can be found in following Table 3.

Table 3: Key concepts of strategies

Strategy	Key concepts	Source
Proactive environmental strategy (PES)	The importance of PES	Ryszko (2016), Bhupendra & Sangle (2015), Bhatia (2021)
	Knowledge sharing	Ryszko (2016), Crupi et al. (2020), Páez-Avilés et al. (2018), Köhler & Som (2014), Gupta et al. (2020), S. Y. Kim & Kim (2018), J. Zhao & de Pablos (2010), M. Zhao & Li (2014), Q. Zhou et al. (2014), Edsand (2017), Zarzewska-Bielawska (2012), Guo et al. (2019), Deng et al. (2019), Vasudeva (2009), Hervás Soriano & Mulatero (2011)
	Internationalization	Kyläheiko et al. (2011), Mueller-Using et al. (2020), H. Liao et al. (2020)
	Overcoming communication barriers	S. H. Kim & Huarng (2011), Cui et al. (2015), Chatterjee et al. (2015)

Cooperation Strategy	The importance of cooperation strategy	Crupi et al. (2020), Henttonen & Lehtimäki (2017), Wonglimpiyarat (2016), Yu & Hang (2011), Christensen & Raynor (2003), Zeleny (2012), Antonioli et al. (2017), Frank et al. (2016), Gupta et al. (2020), S. Y. Kim & Kim (2018), Caloghirou et al. (2003)
	Licensing and Patenting Strategy:	Holgersson & Granstrand (2017), K. Kim (2017), Suzuki (2015)
	Role of the management:	Ho (2011), Hughes et al. (2021), Musaad et al. (2020), Crupi et al. (2020), S. Y. Kim & Kim (2018), Xu et al. (2014), Gupta et al. (2020), Zarzewska-Bielawska (2012)
Innovation orientation	The importance of innovation orientation	Long et al. (2016), Frank et al. (2016), X. Liu & Wu (2011), Park et al. (2012)
	Technology acquisition:	Park et al. (2012), K. Z. Zhou & Wu (2010), Edgett & Cooper (2010), Verbano & Crema (2016), Wang et al. (2021), J. Liu & Baskaran (2009), S. Liao et al. (2020)
	Market orientation:	Park et al. (2012), Frank et al. (2016), Knockaert et al. (2013), Hsieh & Tsai (2007) , Gupta et al. (2020), Knockaert et al. (2013), Henttonen & Lehtimäki (2017)
Financing	The importance of financing	Knockaert et al. (2013), Miller & Hope (1992), Wu et al. (2016), Zeleny (2012)
Policymakers' role	The importance of policymakers' role	Borrás (2004), Suzuki (2015), Frank et al. (2016), J. Zhao & de Pablos (2010), Yang et al. (2017), Suzuki (2015), Gupta et al. (2020), Balachandra et al. (2010), Edsand (2017)

4.1 Proactive environmental strategy

Proactive environmental strategy (PES) has a significant mediating role in the relationships between interorganizational cooperation, knowledge sharing, and technological eco-innovation. PES constitutes a unique organizational capability that affects the company's environmental and economic performance through improved transformation of knowledge.

In essence, PES is in place, when companies not only take actions just enough to meet the minimum requirements by the regulators, but voluntarily engage in activities to reduce their environmental impact (Ryszko, 2016). The success of PES lies in the introduction of coherent activities across multiple departments of the company (Bhatia, 2021). Additionally, improved transformation of knowledge is crucial (Ryszko, 2016), thus creating a knowledge sharing setup shows the stimulation of the overall innovation ecosystem and individual actor's performance (Crupi et al, 2021).

4.1.1 Knowledge sharing

In general, knowledge sharing can be internal or external. The company can import external knowledge from broad networks, rather than focusing on protecting their own knowledge. One aspect of external knowledge sharing is forming alliances (Zhao & de Pablos, 2010) as it holds benefits such as stable cooperation between collaborative agents (Zhao & Li, 2014). The sharing of information, technology and know-how is perceived as a tool for overcoming economical barriers through the reduction of the large investments in resources (Gupta et al., 2020). The establishment of perfect information sharing mechanism, to develop a variety of open communication channels is suggested in order to accelerate co-contribution and keeping conflicts within alliances on a moderate level (Zhou & Wu, 2010). The role of governmental policies needs to be highlighted, due to their role as arbiter, when conflicts regarding resource acquisition arise.

The lack of internal knowledge, on the other side, can limit the information flow within the organization. Strategies that can stimulate the internal knowledge sharing mechanism lies in the implementation of educational and vocational programs that support human resources training (Edsand, 2017). Other measures are described as sustainable proficiencies and skill development strategies as it aims at creating an environment for developing competences, skills and know-how across employees to stimulate green innovation ideas. These strategies aim at overcoming the conservativeness of different industries by creating demand for new alternatives, rather than referring to traditional practices (Gupta et al., 2020).

However, barriers in implementing either internal or external knowledge strategies exist in the face of insufficient knowledge base and political support in implementing innovation technologies, as well as lacking dissemination between research institutes, governments, and the industry. In this case, policies that add support on expanding research activities on new innovation technologies in universities and the development of long-term plans to support such activities can be established (Edsand, 2017). Promoting this cooperation among organizations to prevent the waste of resources and to establish an information exchange network is an important activity that governments can support (Guo et al., 2019).

4.1.2 Internationalization

Another aspect of PES and the knowledge sharing concept is internationalization and therefore establishing international relationships for a company. International support programs are perceived as a key to establishing innovativeness and competitiveness in the case of small and medium enterprises (SMEs) targeting international markets. Another success factor is the establishment of an internationalization process that underlies the knowledge network position and builds trust, typical for process innovation. For companies that are focusing primarily on domestic markets, support on client's acquisition is prevailing (Mueller-Using et al., 2020).

Intellectual property (IP) should be protected in either way in order to keep the company's competitive advantage. Furthermore, the import of technological innovations from abroad can stimulate local activities. By shifting the focus to secondary (already existing but modified) innovation, existing local technologies can be aligned with technology and knowledge from abroad to optimize the industrial structure (H. Liao et al., 2020).

4.1.3 Communication strategy

A significant part of knowledge sharing is the communication between actors for the success of industrial technological innovation, which can be observed in three different aspects, namely on institutional, market and company level (Cui et al., 2015).

On industrial level, deeper exchange and cooperation among firms should be carried. One strategy is the improvement of top-level design of companies allowing for openness for cooperation to establish appropriate industrial agglomeration areas (Kim & Kim, 2018). However, physical proximity is currently questioned as an approach for innovation, as cognitive proximity appears to be increasingly important depending on the company's characteristics (Steinmo & Rasmussen, 2016).

On market level, there are three major directions for improvement, namely market-oriented development and resource allocation, increasing applied research to stimulate innovative research and lastly, having scientific research institutions as supervisors. First, the promotion of market-oriented development and market resource allocation facilitates cooperation among organizations and prevents malignant competition (Kim & Huarng, 2011). Secondly, an increase of applied research stimulates the number of innovation research projects and closes the gap between different levels of scientific research in several countries. Finally, new scientific research institutions as supervisors and verifiers for certain achievements should be appointed in high-tech markets to improve the testing of innovative achievements by a company. This high technology diffusion can also be achieved through information and communication strategies (Kim & Huarng, 2011).

On a company level, communication barriers can be approached through information technology (IT) improvements (Cui et al., 2015). An example of the role of IT is enhancing firm's knowledge sharing and collaboration activities with external partners, while organization should not focus only establishing, but also effectively harnessing their IT infrastructure. IT integration facilitates the quick economical adaptation and knowledge sharing, while IT flexibility emphasizes on internal knowledge sharing and contributes to structures established by the company. This can be achieved through strategic IT alignment, that is defined as the fit between technology and business strategy (Cui et al., 2015).

4.2 Cooperation strategy

The implementation of cooperative strategies is suggested for smaller sized markets with fewer competitors (Crupi et al., 2021). SME's can successfully collaborate with external firms, by using a blend of strategies on multi-firm collaboration modes in the commercialization phase, namely networks with a lead partner, equal partnerships, and partnership for external technology commercialization (Henttonen & Lehtimäki, 2017). Companies interact and exchange good practices and knowledge with partners in the face of research centers and universities within a co-creation process (Zeleny, 2012). Alongside this, cooperation with researchers can contribute to the development of theoretical understanding of applicable strategies (Crupi et al., 2021). The product and process quality can potentially be improved due to industry independent opinions of scholars and researchers.

Networking strategy is another tool for building collaborative capabilities within the organization and between external partners (Gupta et al., 2020). Especially external cooperation is considered vital due to enhanced IP management capabilities with various external sources (Kim & Kim, 2018). Furthermore, partnerships with complementary products are beneficial and a stepwise diffusion strategy suggests starting a pilot test of both technologies and business models in one country only. This mitigates risks and helps better understand complications related to technical and marketing problems.

Additionally, a more consumer centric approach is suggested where customers are involved in the early stage of the product development process to understand customer needs (Frank et al., 2016). Moreover, product and process quality can be improved by cooperating with external researchers that have industry independent judgements. For instance, university business incubators (UBI) aim at stimulating the formation of new ventures by providing mentoring and administrative support for firms (Crupi et al., 2021). Enabling factors in the context of UBI are financial and market assistance, mentoring programs, all tailored to the specific needs of the product and target market, as well as reliability and credibility of the incubator.

Another aspect is the sourcing of simplified high-end technologies through research institutions or universities by using inputs from SME to capture market needs (Yu & Hang, 2011). The simplification strategy is in line with the trend of OI and can be achieved on technical as well as on market level through the value proposition that the product holds (Christensen & Raynor, 2003).

4.2.1 Licensing and patenting strategy

The protection of product technology is crucial whereas licensing is considered as an effective way for technology acquisition and utilization in innovation technology industries (Holgersson & Granstrand, 2017). Other motives for applying for a patent lies in R&D collaborations, cross-licensing and external financing. Hence, licensing is considered as an effective way for technology acquisition and utilization in innovation communication technology industries.

Thus, licensing can be an efficient strategy as it can decrease the direct costs by avoiding the payment of royalties to the licensor (K. Kim, 2017). However, licensing can also hold a discouragement for the private sector due to the participation in the innovation diffusion process (Suzuki, 2015).

4.2.2 Management's role

The role of management in small technological companies plays a significant role as the focus should be set on exploitation (incremental innovation), rather than exploration (disruptive innovation) activities to meet profitability goals (Hughes et al., 2021). Additionally, developing environmental management systems help resolve the managerial barriers in implementing green products.

Middle management plays the leading role in knowledge sharing processes. Hence, dynamic managerial capabilities such as the ability to transform the resource base in order to keep the company's competitive position, are needed to overcome knowledge recognition and transfer barriers (Crupi et al., 2021). In addition, human resource management influences IO performance, therefore, internal training has a positive effect on innovation. For instance, companies can persuade their sustainability goals through internal stimulus for employees without the contribution of policymakers (Gupta et al., 2020).

4.3 Innovation orientation

Strategic orientations are defined as a tool for achieving competitive advantage, based on the specific firm's context (Day, 1994; Hunt & Robert, 1995). There are two major differentiation strategies namely market orientation and technology orientation (Frank et al., 2016), where the former type is based on sustaining product innovation, and the latter type stresses market and product image management (Liu & Wu, 2011).

Market-oriented companies have relatively higher sales performances, whereas technology-oriented score better in company value. However, the combination of both does not bring outstanding results, thus, in order to achieve the desired outcomes in context of innovative companies, managers should set their focus on one prevailing orientation only (Park et al., 2012). An understanding of their innovation activity, which is described as innovation input versus innovation output, is needed to achieve the desired innovation effect (Frank et al., 2016).

4.3.1 Technology acquisition (technology push)

In terms of technology orientation, long-term growth can be achieved through the created high value among innovative firms (Park et al., 2012), where technological capabilities foster innovation exploitation at an accelerated rate and strategic flexibility strengthens the positive effect (Zhou & Wu, 2010). It is suggested to develop market entry strategies and to define a strategic roadmap with goals, objectives and the focus of R&D areas (Edgett & Cooper, 2010).

Moreover, the implementation of technology acquisition strategy has an influence on technology innovation performance, along with the combination of technology innovation strategy (TIS) and Intellectual Capital (IC) development (Verbano & Crema, 2016). The combination of internal R&D and acquisition of capital with embodied technologies provides advantages for companies focusing on either product or process innovation. In particular, the effects for product innovation companies are in the face of higher novelty of their goods and significant cost reduction for the case of science-based technologies (Verbano & Crema, 2016).

The complementary relationship between internal and external innovation, which in combination with internal and external knowledge strategy creates innovation activity, has a positive effect on marginal return on all individual activities (Wang et al., 2021). Subsequently, attention should be paid equally to organizational, technical and innovation resources in order to build strategic capabilities (Liu et al., 2009).

Technology-capable companies should create strategic flexibility in their resource allocation and coordination, such as self-organizing teams, development of flexible manufacturing processes and maintenance of organizational culture that facilitates the rapid deployment of resources. This leverages the exploration for new opportunities and helps dealing with environmental changes (K. Z. Zhou & Wu, 2010).

4.3.2 Market orientation (market pull)

On the contrary, market orientation strategy shows a positive effect on innovation results by focusing on commercialization activities and the combination of both internal and external R&D activities (Frank et al., 2016). Considering the level of market orientation and customer prioritization, where pilot production and demonstration activities are prevalent, those projects tend to have a positive effect on creating enhanced products and services by importing and mixing ideas from different places, markets or people (Frank et al., 2016).

Marketing strategy innovativeness (MSI) refers to the degree of differentiation between the marketing strategy for a particular product, compared to the convectional strategies applied for this case. It should be bundled with external managerial relationships and market dynamism through new distribution channels, media content or payment methods. The role of MSI is classified as capability, as it expresses the specialized knowledge and unique understanding of the environment of the company (Frank et al., 2016).

It is essential for companies to keep their launch approaches flexible to align with the continuous market demand (Hsieh & Tsai, 2007). Furthermore, marketing promotion strategy that emphasizes on promoting benefits of sustainable production combined with the launching strategy stimulates the demand across customers (Gupta et al., 2020). Thus, OI strategies are efficiently applied only if introduced in the commercialization phase, rather than the research and development phase (Knockaert et al., 2013).

4.4 Financing activities

Finance-related services are vital for new technology-based firms to persuade a technology strategy (Knockaert et al., 2013). One strategy is to incorporate environmental costs in the planning and investment incentives in combination with delayed implementation. Miller and Hope (2000) suggest the establishment of proper feed-in tariffs and geographical diversification of installation and capacity building in commercial banks.

Another alternative is the introduction of a subsidy system of high-tech guarantee loss compensation (Wu et al., 2016). Furthermore, product as a service is a viable strategy, where companies can monitor, measure, customize and bill for assets use in a great detail. This allows for purchasing units of a product and accounting for them as a variable cost, rather than capital investment. Finally, the exploitation of public funds is suggested as a way to prove higher standards of the offered product (Zeleny, 2012).

4.5 Policymakers' role

The role of institutions is crucial for companies when trying to overcome industry-related barriers as they have control over knowledge production and diffusion, alignment of actors, reduction of uncertainty (by including risk reduction) and control over knowledge usage (Borrás, 2004). However, the impact of policymaker's influence differs, depending on the different stages of technological innovation. Thus, early-stage involvement is essential for instance, to provide empowerment of research groups that demonstrate and deploy the technologies (Suzuki, 2015).

Policymakers can further be involved by introducing tax-braking for research activities in order to positively influence return on investments (Frank et al., 2016). Technology sourcing is defined as a set of policies, information, consulting service system and bilateral investment protection agreements which can be stimulated by above mentioned activities of policymakers as well (Zhao & de Pablos, 2010).

Moreover, knowledge sharing, innovation performance improvement and financial support at different diffusion stages enhances the enabling environment of innovation technology industries (Suzuki, 2015). Economic incentives should be provided to ensure participation of various actors in the technology diffusion stage (Balachandra et al., 2010). For creating incentives, the importance of regulatory push is needed for preventing the double market failure effect, that emerges in a more advanced stage of innovation.

Investment schemes such as co-investment, loans or risk-guarantees and partnerships between public and private sector for leveraging the interest for both parties are instruments of those incentives (Edsand, 2017). Additionally, international financing through funds, grants and international funding projects can be eligible. Another tool for policymakers is lobbying, which can be differentiated into two levels, namely formal and informal lobbying. (Edsand, 2017). While formal lobbying can be supported through workshops sponsored by the local government to reduce the knowledge gap among stakeholders such as governmental departments, experts and incumbent actors, informal lobbying can be enhanced through campaigns for the public. In addition, forums can be established consisting of environmental, research and business groups to unify and to enable the exchange of information (Edsand, 2017).

Furthermore, governments can take decisions toward specific goals on technology acquisition, development and deployment to improve the domestic technology with a technology leading approach, which is called government technology policy (Yang et al., 2017). Enterprise technology strategy formulates the execution plan for exploiting technological resources and for achieving improved performance (Yang et al., 2017). The goal is not just committed to keeping up with advanced technologies, but rather to foresee developing domestic markets in the corresponding country.

Finally, regulatory and environmental strategy is a tool for the formulation of policies to promote sustainability practices in the context of manufacturing organizations' ecosystem, for instance, the support for developing IP competences for green products and process innovation (Gupta et al., 2020).

5. Proposed strategies for accelerating the uptake of WASP

Potential strategies that are suggested from the managerial literature are now put into maritime context in order to overcome implementation barriers for WASP technologies. OI plays a central role in strategies for technological innovation uptake and can be adopted by shipowners and technology providers in the context of WASP (Lichtenthaler, 2008). Various suggestions for policymakers are provided to stimulate the process of OI between the different actors on the market and to provide a better setting for accomplishing sustainability-oriented goals. Table 4 summarizes the key findings.

Table 4: Strategies for overcoming WASP barriers

Barrier	Level of implementation	Strategy
Cost and Access to capital	Market	○ Internationalization ○ Collaboration for WASP providers ○ Delayed implementation ○ Product as a Service ○ Technology-orientation ○ Co-creation ○ Pilot production ○ Demonstration activities
	Government	○ Tax-breaking for research activities ○ Enhanced political competition to increase optimal level of green technology innovation ○ New policies, focusing on knowledge diffusion
Split incentives	Government	○ Governmental policies to support IP competences development
Trusted Information	Market	○ Alignment of launch strategy and marketing strategy ○ Environmental management system for monitoring WASP providers' performance ○ Collaboration of WASP providers ○ IP management strategy ○ Simplification strategy ○ Improvement of IT infrastructure on the market

		○ Internal approach when analyzing external information for WASP providers
	Government	○ Establishment of funds for international financing for WASP projects ○ Knowledge-sharing platform, organized by international organizations

5.1 Strategies for cost and access to capital barrier

The cost and access to capital barrier consists of large initial investment costs for shipowners, long payback periods, hidden implementation costs for the technology, absence of capital for full-scale demonstrations and the lack of financial schemes from the governmental level.

On the supply side, stimulation of innovation activities for technology providers leads to company growth and strengthens the industry. Through the means of internationalization, technology providers develop their own capacities and enhance their competitive advantages. The supply to shipowners is improved by enhancing competition within technology providers' markets which results in overall market growth due to the attractiveness and potential for new entrepreneurs. This leads to enhanced investment opportunities due to the enlarging size of the market and allows for significant portfolios of the technology performance use cases.

Another way for technology providers to ensure the coverage of more use cases is cooperation between one another by applying multi-firm collaboration modes in the commercialization phase, namely networks with a lead partner, equal partnerships, and partnership for external technology commercialization. Public-private partnerships are needed to lower R&D costs in joint efforts, which is especially beneficial for SMEs due to lower investment risks and the enhancement of progressive results.

A clear governmental policy and delayed implementation strategy are beneficial to overcome high initial investment cost of WASP technologies and the lack of assurance in supply. Public support for R&D activities can be made available by governments through public programs and funding and other stakeholders such as financial institutions can lower the entry bar by allowing for instance lower interest rates. Alternative financial and business models reveal great potential in the shipping industry, as large initial investment costs (Capex) can be transferred to an operating expenses (Opex) model, for instance pay-as-you-save model (Schinas & Metzger, 2019). Additionally, product-as-a-service strategy enables technology providers an innovative way of selling products by charging for maintenance or specific parts only. Hence, shipowners have the opportunity to account for them as variable costs, rather than capital investments. Alternative leasing approaches and accelerator programs initiate lower Capex and R&D

costs and support early market adoptions that can be supported through public-private funding for early installations.

Governmental support in terms of economic incentives can be provided through program-based crediting mechanisms, investment schemes, loans or risk-guarantees and partnership between public and private sectors for leveraging interest for both parties. For overcoming long return on investment barriers, policymakers support with incentives for instance tax-breaking for research activities. Furthermore, specific funds for financing wind propulsion projects, that are supervised by qualified personnel for effective distribution, are essential. At the EU level, there are already several projects in place, such as Horizon Europe calls and the Interreg program. These programs focus on research and innovation in combination with SME, sustainability and a low carbon economy. Finally, there are also support programs at a country level available, where national authorities can for instance grant tax benefits to investors.

5.2 Strategies for split incentive barrier

The barrier of split incentives relates to the overall incentives to improve the energy efficiency and simultaneously reduce emissions of ships that can be hindered by different commercial agreements in place.

The role of policymakers is crucial to overcome split incentive barriers, thus it is vital to promote sustainability practices in WASP development ecosystems with the means of regulatory and environmental strategies. An example of such strategy is the support for developing IP competences for green and sustainable products and process innovations. The strategy is proposed as a potential solution for overcoming institutional barriers, where monetary benefits are not provided by policymakers. Economic and incentive-based strategy helps stimulating a mechanism for creating an incentive to implement WASP technologies by allocating separate funds for greening innovations.

Companies trying to improve their environmental, social and governance (ESG) agendas and the increased pressure on shipowners to invest in green technologies through the Poseidon Principles[1] creates market-based incentives to invest in WASP (Poseidon Principles, 2021). This beneficial cycle can be further pushed through the promotion of benefits of WASP related to triple bottom line, which is a sustainability framework where companies commit to focusing on environmental and social matters in addition to their financial performance.

In terms of split incentives created by shipowners carrying the initial investment costs and charterers reaping the benefits from fuel savings, current agreements should be reviewed and revised on the

[1] *According to Poseidon Principles (2021) "The Poseidon Principles are a framework for assessing the climate alignment of ship finance portfolios". This assessment is a requirement for the Signatories to the Poseidon Principles on a yearly basis (Poseidon Principles, 2021).*

criteria necessary for WASP considerations. Additionally, insurance liability issues need to be assessed and clarified in order for shipowners to invest and deploy such technology.

Market-based-measures (MBM) are other instruments designed to address the environmental impact of an industry. MBMs provide an economic incentive to shipowners in particular to reduce emissions of ships by reducing fuel consumption and operating in a more energy-efficient way. The uptake of WASP technologies will be enhanced by adopting MBMs due to their ability of bridging fossil fuels and sustainable alternatives and compatibility with all options. Furthermore, a carbon levy has an upward pressure on fuel prices and hence favors an investment in energy-efficient alternatives. On the policy side, WASP needs to be included in regulations, for instance adjusting exiting environmental regulatory measures and incentive schemes would have a positive effect. Hence, stricter Energy Efficiency Design Index (EEDI) requirements and inclusion in the reporting of the EU Monitoring, Reporting & Verification (MRV) and the IMO Data Collection System (DCS) could incentivize the uptake of WASP technologies. Finally, a coherent framework should be provided by policymakers and institutions.

5.3 Strategies for trusted information barrier

The lack of transparent information on several factors such as applicability, safety, risks and economic implications of WASP hinders the uptake this technology.

Hsieh and Tsai (2007) suggested the launch strategy, which needs to be consistent with the marketing promotion strategy in promoting benefits of sustainable products and practices. This helps creating trust among shipowners and investors and stimulates the demand for WASP. Shipowners heavily rely on quantitative methods for evaluating new opportunities, therefore information about the technology requires to be presented in transparent way by introducing environmental management systems for monitoring processes in the technology provider's company.

There is the need for further diffusion of engineering and technical know-how which relates to the classifications guidelines of WASP and the further need to increase R&D efforts. Publicly funded projects such as WASP and WiSP[2] projects can help reduce this gap by providing accessible and trusted information regarding the benefits and operations of WASP technologies. This includes the standardization of data such as routes, technologies, vessel types, operation profiles and segment. Standard metrics including rating systems with parameters for each technology type can be developed to assist the decision making.

[2] *This Joint Industry Project (JIP), launched July 2019, led by ABS and MARIN has the objective to overcome barriers to the uptake of WPT, specifically to improve methods for transparent performance prediction, use these improved methods to provide ship owners/operators with fast low-cost predictions for their fleet and to review the regulatory perspective including status of rules and regulations, identify gaps and make recommendations, and provide examples on establishing compliance (MARIN, 2021)*

The provision of funded research vessels by national and regional government is another solution for extending the collection and distribution of data to standardize databases and datasets. Thus, shipowners can adapt these datasets to their specific needs when making the investment decision. Therefore, the number of demonstrator vessels and trials requires to increase in order to provide data for each segment and vessel type.

Moreover, the inclusion of independent partners in the development phase ensures a better trusted quality and objective demonstration of the technology’s usability. Subsequently, WASP providers can increase their competitive advantage through public programs participation as their performance will be compliant with certain standards and thus, more trustworthy. Another approach is the inclusion of research institutions within the use of the simplification strategy where WASP are simplified by using inputs from shipowners in order to capture better market needs.

Furthermore, firm’s cooperation through market-oriented development is advantageous for all stakeholders on the market and prevents competition among WASP providers. For high-tech markets such as the WASP, it is suggested to continuously improve testing of innovative achievements by shipowners with the supervision of scientific research institutions as verifiers since they can ensure credibility and non-biased datasets.

Additionally, knowledge sharing platforms for the interaction between market actors should be implemented. This helps in changing the shipowners passive role to an active role and therefore stimulates innovation. Knowledge sharing platforms in the case of WASP should be organized and managed by external organizations, for instance the EU, IMO or independent institutions. These public databases could consist of global wind protocols, wind data for routing to access the technology’s performance worldwide and technology measurement tools for each individual WASP technology.

Lastly, governments can increase the pressure on shipowners to implement innovative technologies and at the same time improve functions with focus on knowledge diffusion, guidance of the search and market formation support.

Policy makers and regulators at the national, European and global levels have yet to improve existing policies to incentivize wind propulsion, for instance information campaigns, providing public funding to support research and development, as well as testing and pilot programs in energy efficiency measures.

6. Conclusion

In the introduction of this report, the need for full decarbonization of the shipping sector through more sustainable technologies has been determined. WASP has been identified as an option to meet emission reduction targets, yet managerial and policy guidance for overcoming implementation barriers for this particular technology have not been researched in sufficient detail. The contribution of this report is to address this gap by investigating strategies outside of shipping that have been suggested for the implementation of greening innovations in various industries. The approach of a systematic literature review is required in order to incorporate a significant and diverse set of papers and to present the literature in an integrated way.

The report stresses the need of prerequisites for implementing core principles suggested by OI strategy to overcome key barriers of cost and access to capital, split incentives and trusted information. In particular, PES, cooperation strategy, innovation orientation, financing and policymakers were found to be vital key concepts for the implementation of new innovation technologies. The literature further suggests that introducing and applying OI strategies in the commercialization phase of SME leads to valuable results, which holds for WASP providers.

The study found that it is advisable for policymakers to implement economic incentives through program-based crediting mechanisms, investment schemes and tax-breaking for research activities. The establishment of funds and international financing for wind propulsion projects help further accelerating the uptake of WASP. Partnerships between public and private sector leverages interests for both parties and enhanced political competition increases the optimal level of green technology innovation. Governmental policies should be developed to support IP competencies and therefore protect assets of technology providers. Furthermore, new policies should be implemented focusing on knowledge diffusion. This helps overcoming the information trust barrier by implementing knowledge sharing platforms that are organized by impartial international organizations.

On market level, a first strategy implies close collaboration between WASP companies by forming alliances as it holds benefits of stable cooperation on both sides of the partnership. Environmental management systems for monitoring technology provider's performances is an effective tool to create trust for shipowners. Other strategies such as IP management, improvement of IT infrastructure on the market and simplification strategies tend to generate a positive effect for WASP providers in terms of perceived impact of innovation.

Shipowners should identify the variety of WASP technology and select the technology that is best suited for their vessel type, route and other technical factors. An investment decision should be made based on standardized datasets provided by research organizations that can be adapted for their specific needs. Current charter agreements and insurance liabilities should be reviewed and revised on the criteria necessary for investments and deployments of WASP technologies. Additionally, shipowners have the possibility to participate in alternative leasing approaches and accelerator programs with specific funds for financing wind propulsion projects that initiate lower Capex and R&D costs. Knowledge sharing platforms helps changing the shipowners passive role to an active role and stimulates innovation. In general, open innovation strategies are beneficial to implement in the adoption, implementation and upscaling of WASP technologies.

The study is limited to the selection of articles used within the systematic literature review based on the authors' definition of inclusion and exclusion criteria. Additionally, papers have been extracted from one database of high quality, however, other databases can complement this extracted foundation in future studies. Lastly, the suggested strategies could be tested through the means of surveys or interviews with industry experts, including stakeholders from the maritime industry for validation to further accelerate the uptake of WASP.

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