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ORIGINAL ARTICLE

Potential for, and drivers of, private voluntary initiatives for the decarbonisation of short sea shipping: evidence from a Swedish ferry line

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Abstract

The aim of this paper is to analyse shipping firms' reactions to environmental challenges and identify how significant reductions in energy consumption and air emissions can come about by implementing a variety of voluntary initiatives. The paper focuses on the various sustainability initiatives implemented by the Swedish short sea shipping operator, Stena Line, either on a purely voluntary basis as part of their corporate social responsibility (CSR) strategy or as their chosen route for compliance with regulations. A conceptual model is developed based on stakeholder theory, the theory of planned behaviour and resource dependence theory to understand the main drivers of the firm's adoption of sustainability initiatives and the factors affecting the integration of CSR in maritime companies. According to our findings, the company operates within a strongly enforced regulatory environmental framework and needs to exceed this framework to differentiate its service and strengthen its relationships with its customers by addressing their social and environmental concerns. As the firm's competitive strategy focuses on service differentiation, a large pool of complementary resources is available for CSR and the implementation of sustainability practices. The results of this paper bring new insights to the potential of local private voluntary initiatives for the reduction of maritime air emissions. These include the provision of onshore power supply, the conversion of vessels to use methanol, ferry electrification, the construction of larger RoPax vessels and the implementation of an energy-saving program that focuses on crew involvement and continuous training. The environmental outcomes derived from a combination of local operational and technical energy efficiency measures are found to be significant and can contribute to the efforts for the achievement of sustainable maritime transport undertaken by international and regional organisations. The main barriers for the adoption of voluntary sustainability initiatives in the maritime sector are economic and technological. To encourage the wider adoption of these initiatives, the provision of economic incentives at national or regional level is crucial, as such initiatives usually imply high initial installation costs that should be somehow compensated for both vessels and terminals.

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Keywords Decarbonisation · Maritime transport · Air pollution · Short sea shipping · Sustainable development · Stena Line

1 Introduction

Although global trade is heavily dependent on the maritime sector, air emissions from maritime operations contribute significantly to climate change and have negative effects upon human health (Corbett et al. 2007; Cullinane and Cullinane 2013). According to Smith et al. (2014), shipping is responsible for 2.2% of global carbon dioxide (CO_2) emissions. Although this percentage is relatively low compared with other transport modes, the amount of total CO_2 emissions is quite significant, accounting for 938 million tonnes (Smith et al. 2014). The share of local air pollutants from shipping, though, is larger, accounting for the global emission of about 7% of sulphur oxides (SO_x) and 15% of nitrogen oxides (NO_x) (Zis et al. 2016). Moreover, compared with other sources, maritime CO_2 emissions are forecast to rise significantly in the coming years as a result of increasing demand for maritime services. Despite acknowledging that maritime trade has lost momentum in the past 3 years with a slowness in its growth rate, the United Nations Conference on Trade and Development (UNCTAD, 2016) has predicted a higher annual average growth rate of 3.4 % for the period 2019–2024.

Finally, a binding agreement for combating maritime CO_2 emissions has only recently been adopted by the International Maritime Organization (IMO)'s Marine Environment Protection Committee (MEPC). Two regulations on maritime energy management—the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP)—came into force in 2013, and an initial strategy for the reduction of greenhouse gas (GHG) emissions was adopted in 2018. This initial strategy emphasises a need for immediate actions that will lead to a minimum 50% reduction of the maritime GHG emissions by 2050 compared with 2008, with the ultimate target of phasing them out entirely (IMO 2018).

In this context, during the last decades, various diverse initiatives have been undertaken by a wide range of maritime actors for the abatement of shipping emissions. In addition to the regulatory work of the IMO regulating the maritime industry at international level, the European Union (EU) has adopted some directives for the reduction of maritime air emissions within its boundaries, and some governments have launched national strategies. Additionally, some private maritime actors have developed initiatives for the abatement of their air emissions on a voluntary basis.

Although the existing green-shipping literature has analysed the potential of international and regional policies for the reduction of shipping emissions to air, the environmental outcomes derived from local private voluntary initiatives that have been implemented by individual shipping companies have not received the same attention in the academic literature. These private voluntary initiatives vary widely and include but are not limited to the use of alternative fuels, the electrification of vessels on short distance routes, the construction of larger vessels where emissions would be reduced due to economies of scale and slow steaming.

Recent academic articles have focused on the potential for implementing a combination of measures and policies to achieve emissions reductions in shipping, as no single measure could achieve meaningful environmental outcomes (Christodoulou et al. 2019). Among these articles, though, only a limited number of case studies show how emissions reductions from these combinations of measures could be achieved in practice (Johnson et al. 2014). Case studies are beneficial in this field due to the collection of detailed data that go under an in-depth analysis compared with other research designs and can offer valuable lessons on the potential implications of implementing combined energy efficiency and other emissions reduction measures (Ridder 2017). Our study aims to fill this gap in respect to the short sea shipping sector. We attempt to offer a comprehensive understanding of the initiatives implemented by a significant actor within the sector: i.e. the need to consider a combination of initiatives in parallel and research their potential to increase energy efficiency and reduce air emissions from short sea shipping.

The aim of this paper is to investigate the responses of shipping firms to environmental challenges and to identify how significant improvements in energy performance can come about by introducing a variety of voluntary initiatives. As a result of the advanced maritime regulatory framework and the need for maritime companies to respond to their corporate social responsibilities, green shipping practices have become integrated into the corporate actions of maritime companies at the level of the individual firm, mainly aiming at improving their energy performance and reducing associated air emissions (Dummett 2006; Yliskylä-Peuralahti and Gritsenko 2014; Lee et al. 2012; Lai and Fryxell 2004; Yang et al. 2010). Through the application of stakeholder theory, Wong et al. (2009) explained the impact of institutional pressures on the adoption of sustainable practices and the motivation of firms towards integrating sustainability into their operations. Nevertheless, according to Lai et al. (2011), green shipping practices can also be motivated by their alignment with the firm's competitive strategies that fundamentally rely upon subjective norms focusing either on reducing their production costs or differentiating their services. The conceptual framework developed by Lai et al. supplemented by the findings of Yuen et al. (2017) on integrating corporate social responsibility in maritime companies is used herein for the creation of a conceptual model relevant to our study.

This research offers generalisable lessons on the issue of emissions reductions in short sea shipping and contributes to the formalisation of the problem and to its better understanding. More specifically, this paper investigates the case of a Swedish ferry line that has succeeded in significantly reducing its energy consumption and emissions since 2011 by combining a number of diverse initiatives and attempts to give some insight into the practical implementation of these combined initiatives. Some of the company's sustainability initiatives have been implemented before the relevant regulations came into force, and others were based on voluntary action (e.g. vessel electrification). The special characteristics of short sea shipping are taken into account in this study, which represents a novel approach as this sector has been strongly questioned over its energy-efficiency performance (Lopez-Navarro 2014; Hjelle 2010; Christodoulou et al. 2019; Christodoulou and Woxenius 2019; Konstantinus et al. 2019). In contrast to ocean shipping, which takes advantage of economies of scale and has low emissions per unit of transport work, some short sea shipping segments (e.g. RoRo/RoPax) have a low load factor and operate at high speeds, thus undermining any inherent energy efficiency advantages through higher energy consumption and related emissions.

The remainder of this manuscript is organized as follows. Section 2 reviews the regulatory environment that provides the context for the abatement of emissions to air implemented by the shipping company of our case. In so doing, relevant literature relating to the regulatory context of the adopted initiatives is also reviewed. A combination of theories that together provide the theoretical underpinnings of sustainable maritime practices are discussed in Sect. 3. Section 4 presents the case study methodology used in the analysis, while the environmental and financial outcomes from the combined application of the various initiatives are analysed in Sect. 5. The major findings of the paper in relation to the existing literature are discussed in Sect. 6, and the main conclusions are drawn in Sect. 7.

2 The regulatory context

The reduction of shipping emissions to air is mainly undertaken by the IMO, the UN agency that regulates international shipping. Over the years, the IMO has adopted various regulatory measures for the abatement of maritime air pollution; For example, the designation of Sulphur Emission Control Areas (SECAs) in 2008 through a revised International Convention for the Prevention of Pollution from Ships (marine pollution: MARPOL) Annex VI requires vessels to use fuel oil with limited sulphur content when operating in these areas. A more recent example is the decision to set a global sulphur limit, which was eventually implemented at the start of 2020 (IMO 2008). As these sulphur limits became stricter over the years both inside and outside SECAs, the issue of complying with these mandatory environmental regulations has become a major concern for the maritime industry as a whole. As a consequence, environmental management emerged and then became widespread as an integral element of maritime operations. This is most clearly evident for maritime operations that take place inside SECAs, where the sulphur limits are stricter and the shipping companies had to take earlier and more drastic measures to comply with them. The abatement costs of and environmental benefits from the use of low-sulphur fuel or the installation of scrubbers have been largely investigated in literature (Cainelli and Mazzanti 2013; Cullinane and Bergqvist 2014). Since the designation of SECAs and, more latterly, the imposition of the global sulphur cap, the employment of low-sulphur fuels and the investment in scrubbers have proliferated. Although these routes to compliance have significant positive outcomes for the abatement of SO_x and particulate matter (PM), their reduction potential for CO_2 emissions is quite limited (Brynolf et al. 2014; Bengtsson et al. 2012). The response of the IMO to the need for the abatement of maritime GHG emissions is greatly complicated by the existing contradiction between the IMO's fundamental principle of 'equal treatment' for all nations and one of the underlying principles of the United Nations Framework Convention for Climate Change (UNFCCC) that there are 'common, but differentiated responsibilities' among nations (UNFCCC 2005). The issue is fully discussed in Kågeson (2011). In 2003, the abatement of maritime GHG emissions was included in the official agenda of the IMO for the first time (IMO 2003), while 10 years later, in January 2013, two mandatory regulations came into force: the EEDI, which sets specific design energy-efficiency limits for vessels built after 2012, and the SEEMP, which aims to enhance the operational energy efficiency of a ship (IMO 2012). Vessel speed reductions and better fleet planning are some of the operational measures included in the SEEMP guidelines. The significant potential of operational measures to achieve GHG emissions reductions has been highlighted by several authors (Winnes et al. 2015; Kontovas and Psaraftis 2011; Cullinane 2012). Another approach aiming to enhance the operational energy efficiency of vessels very relevant to this paper is related to the economies of scale achieved from utilising the largest size of vessels possible (Cullinane and Khanna 1999).

Besides the initiatives undertaken by the IMO, the EU recently announced the 'European Green Deal'; a new growth strategy that aims to 'transform EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy' that will become climate neutral by 2050 (European Commission 2019). Moreover, the EU White Paper on Transport (2011) also specified a 60% reduction of transport-related GHG emissions by 2050. In this direction, the EU has adopted a number of directives for the reduction of GHG shipping emissions to air within its boundaries. Ahead of the IMO's decision to introduce a global sulphur cap of 0.5% sulphur content as from January 2020, the EU imposed a sulphur limit of 0.5% in the fuel content for vessels operating within its boundaries as from January 2020 and an even stricter sulphur limit of 0.1% in fuel content for vessels berthing in EU ports (European Union 2012) as from January 2012.

The later Directive 2014/94/EU promotes the use of liquified natural gas (LNG) through the building of LNG refuelling points in member states' core ports and enforces the installation of onshore power supply (OPS) at the same ports by the end of 2025 (European Union 2014). Although a shift to LNG eliminates SO_x and PM emissions and substantially reduces NO_x emissions, its use as marine fuel does not necessarily lowers total CO_2 emissions due to methane slip through the combustion process (Bengtsson et al. 2012). Nevertheless, the use of LNG is particularly beneficial for ferry and passenger segments as these vessels typically berth near urban centres, thus the emissions reductions of air pollutants from their operations would impact directly on the nearby populations. Installation of OPS in ports enables vessels to use electric power generated ashore during their berthing time and could result in significant emissions reductions at ports (Acciaro et al. 2014; Ballini and Bozzo 2015; Innes and Monios 2018; Christodoulou and Cullinane 2019). According to Winkel et al. (2016), OPS installation in all European ports could result in a reduction of 800,000 tons of CO_2 emissions, while Zis et al. (2014) and Vaishnav et al. (2016) also acknowledge the potential of OPS to significantly reduce ship emissions in and near ports. Given the significant capital outlays involved, however, all these previous studies point to the importance of financial stimuli so that investment costs in OPS are somehow compensated for both vessels and ports.

The provision of OPS in ports is directly related to the electrification of vessels and a shift to cleaner energy sources. This represents another means by which significant emissions reductions can be achieved, primarily over shorter distances, with most real-world applications of battery technology currently deployed within the

North and Baltic Seas. The current focus of research in this field lies with improving battery capacity to enable vessels to cover longer distances without the need to recharge batteries (Bakirtzoglou 2017). The current state-of-the-art, however, means that the electrification of vessels could provide an answer to the criticism levelled against the energy efficiency performance of short sea shipping (SSS) that sits in counterpoint to the widely accepted sustainability advantages of deep-sea shipping. In comparison with land-based modes of transport, SSS presents significant environmental benefits that derive from its better fuel performance and lower associated emissions from its operations, as asserted by Medda and Trujillo (2010). This is verified by recent European transport statistics, indicating that the energy consumption and emissions of SSS account for only 1% and 12.1% of all transport modes in Europe, respectively, despite carrying 32% of the cargo volume moved (Eurostat 2018). Despite this, the sustainability performance of SSS has been strongly questioned by Hjelle (2010) and Lopez-Navarro (2014). The authors, ultimately, provide support for the proposition that certain conditions do exist under which the environmental benefits of SSS can be retained. This depends largely on the employment of low-sulphur fuel and the speed reduction of vessels, as well as on them being as fully loaded as possible.

3 Theoretical background and contextual framework

As a consequence of developments in the maritime regulatory framework and the need for maritime companies to respond to their corporate social responsibilities, green shipping practices have evolved to become an integral element in the corporate behaviour of many maritime companies (Parviainen et al. 2018; Yliskylä-Peuralahti and Gritsenko 2014). Yuen and Lim (2016) examined the challenges shipping companies face when implementing strategic CSR and identified the barriers to the implementation of strategic CSR in shipping related to a lack of resources, strategic vision, a measurement system, and high regulatory standards, and to a low willingness to pay for CSR.

To identify the main drivers behind green shipping practices, different theories are analysed below in relation to the initiatives implemented by the Swedish case study company. The motivation of companies to address sustainability issues due to institutional pressures is highlighted in stakeholder theory (Freeman 2010). The shipping industry is heavily impacted by international and regional institutions that affect the actions and decisions of companies and could provide an explanation as to what motivates a firm towards sustainable practices (Meixell and Luoma 2015). Additionally, Yliskylä-Peuralahti and Gritsenko (2014) suggest that CSR can complement command-and-control regulations in a co-governance system to increase transparency and improve quality in shipping and that collaboration between these two forms of regulation is essential for effective maritime governance.

Quite apart from the presence of institutional pressures, the theory of planned behaviour (Hardeman et al. 2002; Ajzen 2011) suggests that shipping firms may adopt sustainability initiatives if they believe that such initiatives are aligned with their competitive strategies (Wolf 2014). Another perspective is the one proposed in resource-dependence theory, whereby companies need to collect and retain from their external environment the essential resources for their activities to ensure their survival and improve their strategic position (Pfeffer and Salancik 1978; Drees and Heugens 2013). Lun et al. (2016), for example, characterise sustainable shipping practices as effective tools for strengthening relationships with stakeholders, thereby ensuring access to vital resources.

According to Lai et al. (2011), the three above-mentioned theories are complementary to each other and together form the foundation for the adoption of sustainable shipping initiatives. On the basis of this logic, Lai et al. (2011) developed a conceptual framework to identify the drivers for and potential from the implementation of sustainable initiatives within the maritime sector. As described in the ensuing section, the framework they developed, supplemented by the findings of Yuen et al. (2017) on the integration of corporate social responsibility in maritime companies, served as a guide to the semi-structured interviews undertaken for the collection of primary data within our work.

4 Methodology

The potential of the various possible technical and operational initiatives for the reduction of maritime emissions to air has been highlighted by several authors (Bouman et al. 2017; Miola et al. 2011; Kontovas and Psaraftis 2011; Johnson et al. 2013; Goulielmos et al. 2011; Shi 2016a, b; Wan et al. 2018); For example, Smith et al. (2014) pointed out that maritime CO_2 emissions could be reduced by 40–60% simply by expediting energy-efficiency measures. These measures were clustered by Bouman et al. (2017) in six main groups related to (i) hull design, (ii) economies of scale, (iii) power and propulsion, (iv) speed, (v) fuels and alternative energy sources and (vi) weather routing and scheduling. Additionally, the authors underlined the potential for the combined implementation of these initiatives, suggesting that these could result in GHG emissions reductions of more than 75% by 2050. However, only a limited number of case studies show how emissions reductions from the implementation of combined initiatives could be achieved in practice (Styhre et al. 2017; Searcy 2017; Baldi et al. 2015; Johnson et al. 2013).

The present study applies a case study approach to the investigation of real-life instances where energy performance of shipping has been effectively improved, with the consequence of reduced maritime air emissions (Voss et al. 2002; Yin 2009). Our paper is based on an in-depth case study that underlines the emissions reduction potential of combined measures and policies in pursuit of achieving the objective of sustainable maritime development. We focus on the diverse sustainability initiatives that have been implemented by a Swedish SSS operator, i.e. Stena Line, either on a purely voluntary basis as part of their CSR strategy or as their chosen route for compliance with regulations. The range of initiatives implemented resulted in substantial reductions in the company's energy consumption and air emissions compared with the base year of 2011. Stena Line was selected because sustainability is among its core values and is successfully integrated into its operations. Voluntary green policy practices adopted by Stena Line are considered 'benchmarks' for the global maritime industry, as exemplified by its role as a pioneer in the installation of OPS infrastructure on board its vessels and at its terminals.

The company's website, sustainability reports and newsletters provided valuable information on the sustainability initiatives adopted by the shipping company on a voluntary basis but did not provide a full answer to the question of how these policies were implemented in practice. Primary data for our study were compiled through semi-structured interviews with persons responsible for the environmental and sustainability policies of the company who could shed light on this issue. As the initiatives varied widely, it was necessary to identify and interview respondents with deep knowledge of the various technical and operational sustainability initiatives of the company (Voss et al. 2002). Thus, to overcome potential subjectivity and/or bias, two semi-structured interviews were conducted. The first interview was with the environmental manager of the shipping line in October 2017 and focused on the sustainability policy of the company and its corporate values. The second interview took place one year later, in October 2018, with both the environmental and the technical managers of the shipping line, so that valuable data on specific technical issues could be obtained. These concerned the provision of OPS in Stena Line's vessels and terminals, the methanol conversion of vessels, ferry electrification and the construction of larger RoPax vessels.

To understand the main drivers of the firm's adoption of sustainability initiatives and to highlight the factors that are essential for their successful implementation, a conceptual model based on the findings of Lai et al. (2011) and Yuen et al. (2017) was developed on the drivers for and potential from the implementation of sustainable initiatives within the maritime sector and the parameters that affect the integration of corporate social responsibility in maritime companies. The use of this model facilitates the analysis of the drivers that motivate the adoption of green shipping practices, including the impact of both institutional pressures and subjective attitudes towards a firm's sustainability practices and was utilised as a guide to the design of the semi-structured interviews. The model is depicted in Fig. 1.

5 Results

5.1 Case study company: Stena Line

Stena Line is one of the largest ferry companies worldwide, carrying more than 7.6 million passengers, 1.7 million cars and 2.1 million freight units every year. The company has more than 5600 employees, comprising over 40 nationalities, and in 2018, it posted a turnover of USD 1.4 billion. The company owns and operates 38 vessels on 20 ferry routes between 10 countries in Northern Europe. Its route network covers Scandinavia, the Baltic Sea and the North and Irish Seas (Fig. 1). The fleet consists of RoPax ships, combi ferries and RoRo vessels that travel between specific ports under a precise weekly schedule. In addition, the company owns and operates 30 terminals in 10 countries (Table 1). As can be seen in Fig. 2, a large part of Stena Line's vessel operations take place in the North and Baltic Seas, which are designated as SECAs by the IMO. The vessels operating in these areas, therefore,

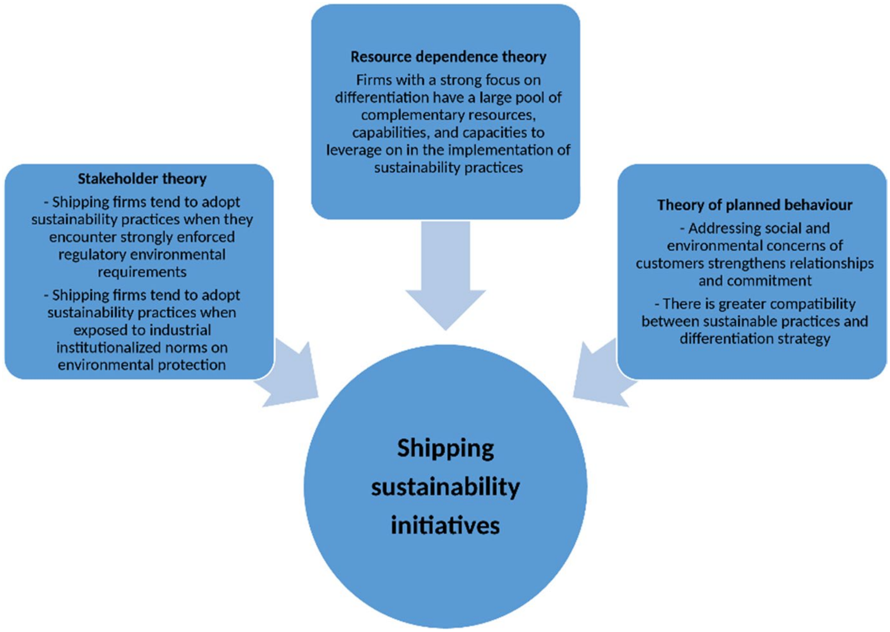

Fig. 1 Conceptual model. Source: Own elaboration based on the findings of Lai et al. (2011) and Yuen et al. (2017)

Table 1 Terminals owned and operated by Stena Line. Source: Stena Line (2020)

Country	Terminal			
Sweden	Gothenburg Karlskrona	Trelleborg	Varbery	Nynashamn
Norway	Oslo			
Denmark	Frederikshavn		Grenaa	
Germany	Kiel	Travemunde	Rostock	Sassnitz
UK	Immingham	Killingholme	Harwich	Liverpool
	Holyhead	Fishguard	Heyham	Cairnryan
The Netherlands	Hoek van Holland	Rotterdam		
Ireland	Belfast	Dublin	Rosslare	
Latvia	Ventspils	Liepaja		
Poland	Gdynia			
France	Cherbourg			

have been running on low-sulphur fuel (0.1%) since 2015, with eight of these vessels having also installed scrubbers for the further reduction of their SO_x emissions.

Stena Line considers sustainable growth as the only acceptable business model, and equally, its operations are consistently monitored for social, environmental and economic aspects. The market structure of the RoPax segment—in which Stena Line

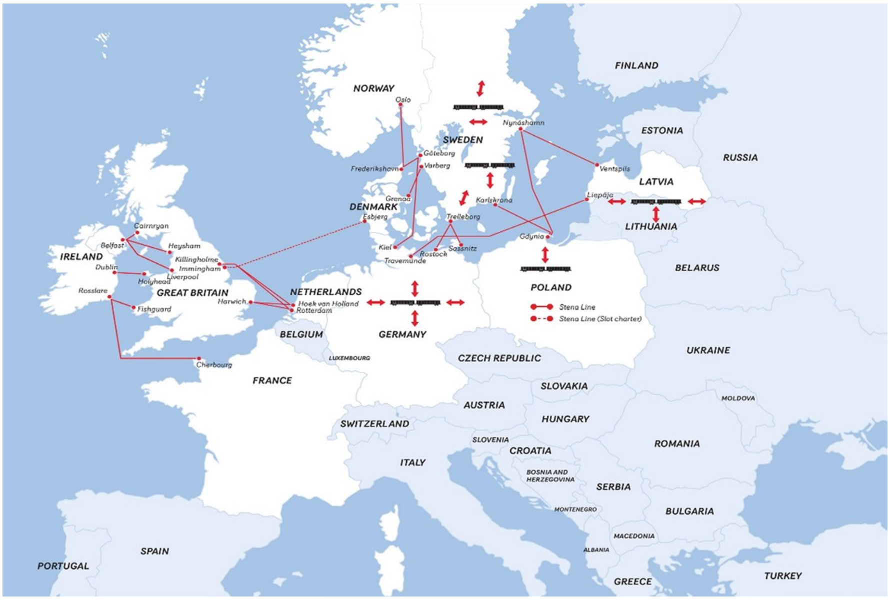

Fig. 2 Stena Line route network. Source: Stena Line Interview

operates—is described by a high elasticity of demand compared with other maritime segments due to strong competition from land-based modes of transport. RoPax companies tend to differentiate their services as a response to the increased competition coupled with the need to maintain high-capacity utilisation and high frequency of departures for the passengers (Styhre 2009).

The primary competitive strategy of the company focuses on service differentiation and the creation of commitment and strong relationships with its customers. In this sense, addressing the environmental and social concerns of its customers is tightly aligned with the company's competitive advantage. Social concerns of passengers include responsible consumption by continuously reducing waste and increasing recycling, as well as gender equality. Stena Line has managed to address such concerns by reducing the number of single-use plastic products by 90% in the North Sea and Irish Sea and increasing the share of material recycled waste to 33%. Coming to gender equality, the company embraces diversity and inclusion and targets to improve the ratio of female leaders to a minimum of 30%.

The company's strategic vision is to become a leader in sustainable shipping, and in this direction, it has adopted a number of measures targeting the reduction of its energy consumption and related emissions that have been applied either on board the vessels or at the company's terminals. These measures include the provision of OPS in Stena Line's vessels and terminals, the methanol conversion of a vessel, ferry electrification, the construction of larger RoPax vessels and the implementation of an energy-saving program that focuses on crew involvement and continuous training. In the subsections below, the challenges of and the benefits from the application of these measures are identified and analysed not only to provide some valuable lessons from the practical implementation of these policies but also to highlight aspects that may constitute the main barriers to their wider adoption.

5.2 Stena Line sustainability initiatives

Before going into detail concerning the different sustainability initiatives that the company has adopted, the environmental manager of Stena Line provided some data on the criteria that play the most important role in the identification and selection of energy-efficiency measures, assigning points to the various criteria on a scale of 1–5 in relation to the strategic priorities of the company as operationalised by the environmental management team. According to the respondent, the fulfilment of diverse criteria must be accomplished to proceed with the adoption of energy-efficiency measures. Specifically, five points were assigned to the implementation cost of the various initiatives, underlying the high investment cost and the risk undertaken by adopting a new energy-efficiency measure that has not been previously tested for its environmental outcomes. The potential environmental benefits from the implementation of the measures were assigned four points, as the reduction of air emissions is the main focus of these measures and the raison d'être underpinning their adoption. The ease of implementation (existence of technological or operational barriers) and the funding opportunities available (probability of financing opportunities) for the various measures were also ranked quite high (three points). The latter highlights the potential need for the provision of financial incentives from national authorities for the stimulation and further employment of these initiatives. Grant or subsidies (e.g. EU funding) could incentivise the further adoption of measures, and in a similar way, reductions in port fees based on better-than-average environmental performance could free up resources that could be used in the same direction.

5.2.1 Provision of OPS

As referred to in Sect. 2, the installation of OPS in ports could result in significant emissions reductions at ports. First of all, the technology has been promoted by the EU Directive 2014/94/EU that imposes the investment in OPS infrastructure in all member states' core ports by the end of 2025 (European Union 2014). As Stena Line operates within the territorial waters of the EU, sooner or later, it would need to install this technology in its terminals and on board its vessels.

In 2018, the company made OPS available in seven of its terminals, connecting 13 of its vessels to OPS while at berth and saving 3800 tons of oil, 12,340 tons of CO_2 and 8 tons of SO_x per year. These large emissions reductions verify the previous findings of Zis et al. (2014) and Vaishnav et al. (2016), both of which acknowledge the potential of OPS for the abatement of maritime emissions at and near ports, also verifying the conclusions of Winkel et al. (2016) that OPS installation in all European ports could result in the reduction of 800,000 tons of CO_2 emissions.

Installation and operational costs for the provision of OPS, though, are quite high. The cost for the onboard installation for vessels to be able to connect to OPS at ports is approximately USD 500,000. The relevant technology mainly includes a socket on board that connects the cables from the shoreside sub-station at the port terminal with the vessel and a step-down transformer that converts the high voltage from these cables to the level required on board the vessel. The required investment cost at the company's terminals averaged USD 850,000.

What was strongly emphasised during the interviews is the fact that the grid fee (the fee required for the port terminal to have access to the electricity grid that provides shoreside electricity) is quite high and exerts a highly negative impact on the business. When docking at Swedish ports, however, the company enjoys the generally available energy tax reduction on shoreside electricity, such that it pays only USD 0.05 per kWh. This turns the implementation of OPS technology into a more attractive and feasible option, especially since the company may also receive reductions in port fees (or rebates) due to their reduced emissions to air as a result of utilising OPS.

The provision of these national financial incentives is mainly relevant to the voluntary implementation of OPS until the end of 2025, when the installation of OPS at EU member states' core ports will become compulsory. Its adoption will be mandated following the EU 'polluter-pays' principle and needs to be harmonised and incentivised at regional level (O'Connor 1997). The importance of financial stimuli for the investment in OPS infrastructure is mentioned by Winkel et al. (2016), Vaishnav et al. (2016) and Innes and Monios (2018), as the installation and operational costs of OPS are high and should be counterbalanced, at least partially, for both vessels and ports.

5.2.2 Methanol conversion of vessel

Apart from running its vessels on low-sulphur fuel, in 2017, Stena Line completed the methanol conversion of Stena Germanica, which is the pioneer vessel worldwide to operate on both methanol and diesel. Stena Germanica is a ferry operating on the Gothenburg–Kiel route, with a carrying capacity of 1300 passengers, 300 cars and 3800 lane metres of freight cargo. Its gross tonnage is 51,837 tons, and its sailing speed is 21.5 knots. The use of conventional methanol results in a reduction of SO_x and PM of almost 100%, a reduction in NO_x emissions of 60% and CO_2 emissions that are equivalent to the use of normal bunker fuel. These large emissions reductions from the use of methanol are supported by Brynolf et al. (2014), who suggest that, although the use of methanol can substantially reduce overall maritime emissions, only a switch to liquefied biogas and bio-methanol can have an impact on GHG emissions.

According to the interviewees, the price for methanol (early 2018) was very high compared with bunker fuel and its use was bound to have a sizable impact on costs. The price of methanol, though, has constantly declined since the beginning of 2019 and, according to Hansson et al. (2019), is predicted to reach 12$/GJ by 2030, compared with an anticipated price of heavy fuel oil (HFO) of 10$/GJ. The cost implications from the use of bio-methanol, which has a high performance in relation to CO_2, are significant, expected to be double the price of conventional methanol, at 24$/GJ in 2030.

In the current case, the use of conventional methanol produced from natural gas is not expected to reduce CO_2 emissions as ‘well-to-tank’ emissions in the life cycle of methanol are quite high (Corbett and Winebrake 2018). These emissions are encompassing the extraction of the raw materials as well as the processing, storage and distribution of the fuel from the refinery to the vessel. CO_2 emissions from the use of conventional methanol account for 90 g/MJ and equal emissions from bunker fuel (Hansson et al. 2019). The best ‘well-to-tank’ performance, with regard to CO_2 emissions, is achieved when methanol is produced from biomass, generating 20 g/MJ of fuel used. In the long term, though, the interviewees pointed out that methanol represents one way of decreasing shipping’s dependence on fossil fuel, in particular if larger volumes of renewable methanol can be developed; all kinds of sources that contain carbon can become methanol, for example wood and forest products.

Regarding the technical challenges for the methanol conversion of the vessel, this took several months, and the company needed the IMO to make regulatory changes so that methanol became approved as a fuel in the International Gas Carrier (IGC) code for ships. Despite the various technical, operational and regulatory barriers, the ship is now constantly running one engine on methanol to gain experience of this new marine fuel.

5.2.3 Ferry electrification

Electrification represents an alternative energy source for shipping that could lead to significant emissions reductions over shorter-distance routes (Bakirtzoglou 2017). Stena Line is running a pilot project on ferry electrification, having installed a 1000-kWh battery pack on board its RoPax, Stena Jutlandica, for the manoeuvring of the ship in port. Stena Jutlandica is a ferry operating on the Gothenburg–Frederikshavn route, with a carrying capacity of 1500 passengers, 550 cars and 2100 lane metres of freight cargo. Its gross tonnage is 29,691 tons, and its sailing speed is 21.5 knots. The next step is the installation of battery power on the main engine propellers so that the vessel runs on electricity for approximately 50 nautical miles, i.e. the distance between Gothenburg and Frederikshavn.

The electrification project of the Stena Jutlandica involves the following steps:

- Step 1 Switching to electrical operation with the installation of a 1000-kWh battery pack on board to replace diesel generators for manoeuvring operations in port.
- Step 2 Two of the four primary engines switching to electrical operation to enable the ship to operate on electrical power inside the Gothenburg archipelago.
- Step 3 Switching to electrical power for all four primary engines so that the vessel can cover the 50 nautical miles between Sweden and Denmark without using diesel generators.

For the moment, the first step has been successfully implemented, leading to substantial environmental benefits due to the battery hybrid operations. Before the battery installation, there was a need for three auxiliary engines to run during the trip, while now, only one is always running in a more optimal mode. The switch to electrical operation for the manoeuvring in port has resulted in the reduction of about 500 tons of fuel and 1500 tons of CO_2, equivalent to the emissions from about 600 cars per year.

The interviewees highlighted the potential of electric and hybrid solutions in the future for sustainable SSS operations, especially if ports offer OPS. In the case of the Stena Jutlandica, the vessel operates between Gothenburg and Frederikshavn and does not face any electricity supply shortages, as both terminals are owned and operated by Stena Line itself. The need for electricity supply agreements in other locations may pose difficulties on different routes. The challenges associated with the need for port terminals to deliver high power rates from the local grid to charge the vessels' batteries during short port stays is highlighted by Gagatsi et al. (2016). This technical difficulty can be supplemented by the need for electrical infrastructure investments on land when OPS is not already offered in the terminals.

Although the implementation of the first step was not technically that challenging and the battery installation was not that difficult, challenges are expected to be larger in the second step, with the installation of battery power for propulsion. The larger dimensions of the battery, which will occupy 10–15 times more space, will have an effect on ship stability, cargo space, fire safety and, of course, cost; not only due to the reduction of bunker fuel but also to the increased need for shoreside electricity. Nevertheless, current developments related to the size and cost of batteries turn battery hybrid operations into a more realistic alternative in SSS (Stena Line 2019).

5.2.4 Construction of larger RoPax vessels: economies of scale

Another initiative for the enhancement of the energy performance of Stena Line's fleet is the construction of a new series of RoPax vessels with dimensions much larger than the existing ones (around 50% larger). The vessels carry the class notation 'gas ready' in preparation for conversion to LNG or for catalytic converter installation for operation on methanol. LNG in particular is actively promoted by the recent European Council (EC) Directive 2014/94/EU, with the consequent improvement of overall environmental impact (Brynolf et al. 2014). According to the interviewees, the construction of these ferries represents a huge investment. The new ships will be among the most fuel-efficient per unit of transport working in this maritime segment. The environmental outcome from the employment of larger vessels is consistent with the findings of Cullinane and Khanna (1999) that the operational efficiency of shipping can be improved by the maximisation of the size of the vessels due to economies of scale, assuming their full loading.

5.2.5 Implementation of an energy-saving program, crew involvement and continuous training

Since 2011, Stena Line has implemented more than 300 initiatives under the framework of its energy-saving project (ESP) and, as a result, has managed to reduce its bunker consumption by 15% (2011–2016). The list of these initiatives is long, including changes in the size of propeller used, changed bulbs, frequency-controlled pumps and fans, eco-driving and education of captains, optimised weather routing, streams, wind, solar films on cabin windows, light-emitting diode (LED) lighting, route scheduling and punctuality. The company has invested approximately USD 4.5 million per year in the adoption of these various measures to reduce energy consumption.

Over 3000 employees have completed the e-learning SAVE program, focusing on saving energy. The interviewees mentioned that the staff and crew involvement in continuous training for the achievement of energy-efficiency goals is very important and that it would be a good idea to link SAVE with the implementation of the SEEMP, where vessel speed reduction, high punctuality performance of vessels in port and better fleet planning are some of the operational measures already included in the SEEMP guidelines (MEPC 58/INF.7 2008).

- Close collaboration between shore and sea operations: freight and passengers can be loaded/embarked quickly, and the vessel can often leave port before the scheduled departure time and thus reduce speed.
- Careful planning of each route, taking into consideration weather and wind, so that the vessel can arrive at its destination safely, on time and using as little fuel as possible.

The sustainability initiatives adopted by Stena Line are summarised in Fig. 3, while Table 2 provides an overview of the energy-efficiency initiatives adopted by the company, the emissions reductions accomplished and the implementation costs.

6 Discussion

The sustainability practices implemented by Stena Line highlight the company's commitment to implementing various environmental initiatives. Adopting these measures, the company has managed to comply with the existing international and regional regulations and even proactively anticipate the upcoming regulations that will come into force in the near future. In particular, it has already invested in scrubbers and engine retrofitting to meet the 2020 global sulphur regulation and has

Table 2 Energy efficiency initiatives, emissions reductions and associated costs. Source: Own elaboration based on data from the interviews

Initiative	Emissions reductions (tons)			Reduction in fuel consumption (tons)	Implementation costs (USD)
	SO_x	NO_x	CO_2		
OPS	8		12,340	3800	On board: 500,000 Terminals: 850,000
Methanol conversion	100%	60%			15 million, whereof 50% funding
Battery hybrid vessel			1500	500	27 million, whereof 50% funding
ESP				15%	4.5 million

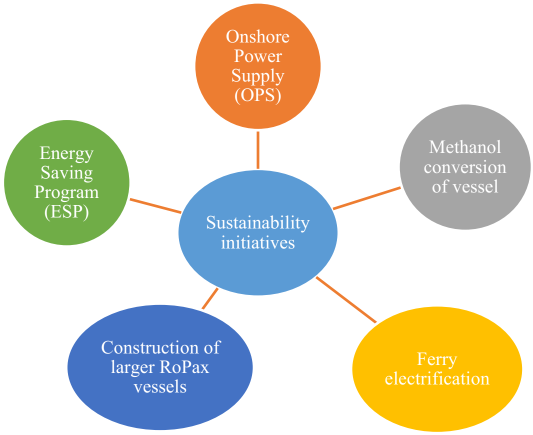

Fig. 3 Sustainability initiatives of Stena Line Source: Own elaboration based on data from the interviews

introduced the use of OPS and LNG fuel to comply, in its role as a terminal operator, with the upcoming EU Directive 2014/94/EU.

Using the terminology employed in Yuen et al. (2017), this shipping company is following a proactive rather than a reactive strategy, regarding its meeting the existing regulatory framework. Some of the company's sustainability initiatives were implemented before the relevant regulations came into force, and others were based on voluntary action (e.g. vessel electrification). The adoption of sustainability practices within Stena Line goes beyond the mandatory requirements of the relevant legislative authorities. The interrelationship between the implementation of these practices and the firm's approach and beliefs towards the outcomes from these initiatives is supported by the theory of planned behaviour (Wolf 2014).

Yuen et al. (2017) proposed the adoption of an organisational attitude towards sustainability and the perspective that integrating this concept into the company's operations is more likely to provide a better solution to achieving sustainability rather than a must-do mentality and the trade-offs associated with it. The values and attitudes within Stena Line support this view, since the company has clearly positioned itself in the centre of responsibility for enhancing sustainability in shipping, considering sustainable growth as the only acceptable business model. The company's operations are constantly monitored in terms of social, environmental and economic aspects, and its strategic vision is to become an acknowledged leader in sustainable shipping. As a leading ferry line, Stena Line is investing heavily in OPS and the electrification of ferries, which together could lead to significant emissions reductions, especially in SSS operations. The awareness and continuous training of managers and staff on sustainability matters as well as the integration of energy management in the company's activities are of critical importance, with the company having invested USD 4.5 million in its ESP. The engagement of management and staff in the company's energy-management plan has the perceived advantage of reducing the risk of it being undermined by staff or management resistance.

The large investments in LNG/methanol conversion of vessels and the electrification of ferries confirm the existence of a positive organisational approach towards sustainability practices that lies behind the encouragement of the aforementioned alternative strategies (Staats 2013; Chaiklin 2011). In accord with resource dependence theory, to survive and prosper, companies need to collect and retain the essential resources for their activities from their external environment (Hillman et al. 2009). Knowledge and skills represent two of the resources that are derived from the external environment, which in combination with the required finance, facilitate the development of innovative investments in the sustainability prerogative. The adoption of sustainable shipping initiatives, therefore, could be the outcome of a positive behavioural shift attributable to the acquisition of new knowledge with respect to the effectiveness of different sustainability measures (Vogel and Wanke 2016). Stena Line's promotion of LNG and methanol as alternative fuels and the electrification of ferries, in addition to its investments in OPS, are perceived by the company to be correlated to positive business performance.

A further interesting finding of this study has to do with the interrelation between using OPS for both port power and battery charging, with the same company operating both terminals and ships. The use of shoreside electrical power in this type of vertically integrated and closed network can result in substantial environmental benefits. It is necessary, though, to take into account the fact that ferries constitute a rather specific maritime segment and their operations are not very generalisable to other sectors. They operate on relatively short distances and make regular calls at the same ports, which make them much more suitable than most sectors for options such as electric batteries and OPS. This advantage is increased if the company owns the terminals too.

The findings of the case study suggest that the drivers underpinning the sustainable shipping practices adopted by Stena Line vary from meeting the existing regulatory framework to sustainable development and social responsibility that are of crucial importance to the company. The company operates within a strongly enforced regulatory environmental framework and needs to exceed this framework to differentiate its service and strengthen its relationships with its customers by addressing their social and environmental concerns. As the firm's competitive strategy focuses on service differentiation, a large pool of complementary resources is available for CSR and the implementation of sustainability practices. Two major barriers which constrain the expansion of the various sustainability initiatives were underlined by the interviewees. One has to do with the implementation costs of each proposed measure and the costs or the risks of investing in energy-efficiency measures not previously tested for their environmental outcomes. The second is related to technological or operational barriers that make the implementation of the measures difficult.

7 Conclusions and policy implications

This work investigates the potential of a mix of private voluntary initiatives undertaken by individual SSS companies for the abatement of shipping emissions. Although the impact of international and regional policies on the reduction of shipping emissions has been investigated extensively in literature (Lai et al. 2011; Shi et al. 2018), limited focus has been given to the environmental outcomes to be derived from local private voluntary initiatives undertaken by SSS companies. Recent works have focused on the potential of a combination of measures and policies for a significant reduction of maritime air emissions, as no single measure could achieve meaningful environmental outcomes (Bouman et al. 2017). Nevertheless, only a limited number of case studies show how these combined emissions reductions could be achieved in practice. This study seeks to address exactly this—i.e. the need to consider a combination of initiatives in parallel and research their potential to improve the environmental performance of SSS.

Through an in-depth case study of a leading industry actor (Stena Line) in the SSS sector, this paper explores the implementation of various private voluntary initiatives—the provision of OPS, the use of alternative fuels, the electrification of vessels over short distances, the construction of larger vessels where emissions would be reduced due to economies of scale, timetable optimisation with shorter port stays and longer cross-overs and other operational energy-efficiency measures. The results emerging from the case study bring new insights into the potential offered by private voluntary initiatives undertaken by individual shipping companies for the reduction of shipping emissions.

Apart from the implementation of the mandatory measures imposed by international and regional regulations, green shipping practices can also be motivated by their alignment with the firm's competitive strategies and rely on the subjective norms of individuals and the corporate culture of the firm, as supported by Yuen et al. (2017). The environmental outcomes derived from a combination of operational and technical energy-efficiency measures are significant and can supplement the efforts of international and regional authorities seeking to achieve sustainable maritime transport.

Based on the findings of this paper, the main barriers for the adoption and implementation of voluntary sustainability initiatives in the maritime sector are economic and technological. To encourage the wider adoption of these initiatives, external funding and provision of economic incentives at national or regional level are crucial, since voluntary environmental investments usually imply high initial installation costs that should somehow be compensated for both vessels and terminals. Technological innovations in the maritime industry should also be encouraged by all stakeholders and integrated into upcoming regulations, as sustainability initiatives depend heavily on technological improvements, besides regulations and policies.

This case study of sustainability initiatives undertaken by Stena Line is not representative of maritime sustainability practices in general, and in this respect, the findings of this research cannot be thoughtlessly generalised. Nevertheless, the sustainability initiatives of Stena Line and their environmental outcomes are worthy of investigation, not only because of the valuable practical input they offer but also because of their potential to stand as benchmarks of best practice.

Further research can be initiated based on the outcomes of this study. Case studies on voluntary sustainability initiatives undertaken by shipping lines around the globe could be developed, highlighting potential technical and operational energy-efficiency measures and/or analysing different maritime segments. In addition, quantitative studies, such as cost–benefit analysis for example, could further explore the environmental outcomes from the implementation of the various energy-efficiency measures.

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