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Blowin′ in the wind? Drivers and barriers for the uptake of wind propulsion in international shipping

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HIGHLIGHTS

- The overall performance of the technological innovation system for wind propulsion technologies is low.
- Experts acknowledge the importance, but also the lack of fulfillment of theoretically relevant innovation functions.
- Structural barriers for the development of wind propulsion technologies outweigh drivers.
- Drivers for the development of wind propulsion technologies are only emerging while barriers have existed for a long time.
- The IMO can stimulate knowledge development and diffusion as well as the development of market-based instruments.

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ABSTRACT

International shipping transports around 90% of global commerce and is of major importance for the global economy. Whilst it is the most efficient and environmentally friendly mode of transport, CO_2 emissions from shipping activities still account for an estimated 3% of global emissions. One means of significantly reducing fuel consumption and thereby GHG emissions from shipping are wind propulsion technologies (i.e. towing kites, Flettner rotors and sails) – yet current market uptake is very low. Therefore, the aim of this article is to identify the barriers and drivers for the uptake of wind propulsion technologies. To this end, the theoretical approach of technological innovation systems is adopted. This approach combines structural system components with so-called system functions which represent the dynamics underlying structural changes in the system. The fulfillment of these functions is considered important for the development and diffusion of innovations. Based on newspaper and academic articles, online expert interviews and semi-structured interviews, the level of function fulfillment is evaluated, followed by the identification of structural drivers and barriers influencing function fulfillment. Third, the possibilities to influence these drivers and barriers are discussed.

1. Introduction

International shipping transports around 90% of global commerce and is of major importance for global trade and the global economy (United Nations Environment Program (UNEP), 2012). It is unparalleled in terms of its physical capacity and ability to carry freight over long distances and at low costs. Without it, the bulk transportation of raw materials and the import and export of affordable food and goods would simply not be possible (Rodrigue and Browne, 2008; United Nations Environment Program (UNEP), 2012). Even though compared to other transportation modes, shipping is the most environmentally friendly one, the sheer magnitude of shipping operations makes the industry a major emitter of greenhouse gases (GHG) (United Nations Environment Program (UNEP), 2012). In 2007, international shipping is estimated to have emitted 870 million tons or about 2.7% of the global emissions of CO_2 (Buhaug et al., 2009). Scenarios for future emissions of ships predict that emissions of GHG from shipping are likely to increase in the future, mainly due to an anticipated increase in demand for transport services (Buhaug et al., 2009).

One way to cut GHG emissions from shipping is by harnessing wind energy for propulsion purposes. Considering the long history of shipping, the use of fossil fuels in shipping is quite a new development. It was only in the late 18th/early 19th century that steam ships slowly started replacing sailing ships, rendering maritime transportation faster and more reliable as shipping became independent from wind conditions (Geels, 2002). Nowadays, given the looming

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threat of climate change, using wind energy for ship propulsion could become attractive again. There are currently three different technologies by which wind energy can be harnessed for propulsion purposes: towing kites, Flettner rotors and sails. Towing kites are installations attached to the bow of the ship which provide a thrust force directly from the wind (Det Norske Veritas (DNV), 2011). A Flettner rotor is a spinning vertical rotor that converts wind power into propulsive energy (Crist, 2009). For sails, one can distinguish between traditional sails, Dynarigs and wing sails. The Dynarig is a modern square rigger with free-standing and rotating mast whereas wing sails are solid structures resembling aircraft wings (Buhaug et al., 2009; SY Maltese Falcon, 2010). Furthermore, modern technologies can remedy some of the negative factors which led to the transition to steam ships in the past. For example weather routing software can determine optimum routes depending on weather conditions, re-route the vessel if necessary, and calculate approximate arrival times. Mechanical propulsion can be used when wind energy is not sufficient, and the mechanization and automation of sails means that less crew is required (Gendron and Trouvé, 2013; Hamer, 2005).

Despite their potential to reduce fuel consumption and thereby cut GHG emissions from shipping, wind propulsion technologies are either in their early development stages or have only been adopted by a few customers on a very small scale. This is often the case for new technologies as they usually cannot immediately compete on the market against established technologies. While many case studies have been conducted to understand the breakthrough of innovations in different sectors, the field of shipping is still relatively untapped. The research available in this field focuses mainly on mere descriptions of the available (eco-)innovations, assesses their potential in terms of contributing to environmental goals (e.g. GHG abatement potential) and on analyzing their cost-effectiveness (e.g. Buhaug et al., 2009; Det Norske Veritas (DNV), 2010; Eide et al., 2009; O′Rourke, 2006). These reports also include some wind propulsion technologies in their cost-effectiveness analysis. So far, however, no research explicates how to promote and accelerate the uptake of wind propulsion in international shipping. This study aims to close this knowledge gap as it will identify the factors that stimulate or hinder the development and diffusion of wind propulsion technologies and the way they can be influenced.

In the next chapter, we discuss the Technological Innovation Systems (TIS) concept that will be used in our analysis. The performance of the TIS of each of the three innovations we study is first assessed by an event analysis based on a review of about 200 newspaper articles (chapter 3). These articles were identified via the search engine Lexus Nexus as well as via searches on Lloyds List and sustainableshipping.com, two leading maritime news providers. Search parameters included (combinations of) the following: (marine) shipping, propulsion, wind energy, kites, Flettner, sails, dynarigs and wing sails. In addition, each wind propulsion technology provider was researched individually. The articles found ranged from 1983 to 2012. However, where reference was made to events in the past, original newspaper articles dating back to that time were sought. In order to triangulate the results of the event analysis, structured, closed online interviews with nine experts were conducted (chapter 4). Next, we conducted 14 semi-structured interviews with experts from the shipping industry and providers of wind propulsion technologies to get more in-depth insights into the different drivers and barriers influencing the development of wind propulsion. The nine online interviewees were among those 14 experts. The following organizations were interviewed: B9 Shipping; Energy Ship; FutureShip; Global Maritime Investment Group; Greenheart Project; International Association of Ports and Harbors; International Maritime Organization; Maersk; Propelwind; Skysails; Sustainable Shipping Initiative; Transport & Environment; University College London; and Zodiac Maritime Agencies.

The large amounts of data obtained from the interviews were processed and analyzed by using descriptive codes which helped to identify recurring themes, but also contradictory statements. In the analysis itself the identity of the interviewees was disclosed to make sure they could speak openly (chapter 5). In chapter 6 we briefly discuss ways to influence drivers and barriers. We finish the paper with some concluding remarks.

2. Technological innovation systems and their functions

In order to understand the factors that stimulate or hinder the development and diffusion of wind propulsion technologies, the approach of innovation systems is used. The underlying idea behind this theoretical perspective is that innovation and diffusion of technology is both an individual and collective act (Edquist, 2001). This means that the innovation process takes place within a system comprised of different actors who contribute to the overall goal of the innovation system: the development and diffusion of the innovation in question. The relationships between these actors and the institutional infrastructure in which they are embedded form the innovation system (Van Alphen et al., 2010; Bergek et al., 2008; Negro, 2007).

Depending on the unit of analysis, one can distinguish between National, Sectoral and Technological Innovation Systems. Given that in this study, the focus is on specific technologies, the Technological Innovation System (TIS) is the appropriate level of analysis. While TISs may have a geographical dimension, they are often international in nature and may cut across national, regional and sectoral boundaries (Bergek et al., 2008; Hekkert et al., 2007).

A TIS can be defined as

'a network of agents interacting in the economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion, and utilization of technology' (Carlsson and Stankiewicz, 1991, p. 94).

The definition stresses the idea that technological development cannot be understood in isolation, but only when looking at the structural elements surrounding the technology. The key structural elements are actors, networks and institutions. For incumbent technologies, these structures are well developed and provide stability to the system. For emerging technologies, they still need to be built up. This may ultimately lead to a point where the structures supporting an emerging technology challenge and replace those supporting the incumbent one, thus contributing to a technological transition (Geels and Schot, 2007; Suurs, 2009).

Even though the structural analysis of the innovation system can provide us with valuable insights, it is quite static and takes no account of the dynamics that make innovation systems change and evolve over time (Alkemade et al., 2007). Since technological change requires a transformation of the innovation system, an approach which takes these dynamics into account is needed (Hekkert et al., 2007).

In order to address this void, the approach of system functions has been developed in recent years. It focuses on the key activities that take place in innovation systems and result in technological change. These activities contribute to the overall function or goal of the innovation system, i.e. the development and diffusion of innovation, which is why they are called 'functions of innovation systems' or 'system functions' (Hekkert et al., 2007). Seven functions have been identified in the literature on innovation science to represent the dynamics underlying technological change. These are entrepreneurial activities, knowledge development, knowledge exchange, guidance of the search, market formation, resource mobilization, and the creation of legitimacy. It is assumed that in