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Integrated approach to vessel energy efficiency

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ABSTRACT

Energy efficiency improvements in the shipping industry are being driven by economics, compliance and customer requirements. Whilst various technological and operation improvements are known and available, with many being demonstrated to be cost effective and with savings reported in the industry, their take up in the world fleet remains low. This low take-up can be considered due to many different barriers, as explored in various research studies. However the aim of this paper is first to understand how these barriers are created by considering how ship operations function day-to-day within the context of mainstream business practice. A holistic view of operations is required and is presented in this paper, including consideration of business focus areas in parallel with the functions of technical, operational and commercial stakeholders. With this laid-out, gaps within existing operations are discussed in relation to areas for practical improvements. From here, non-prescriptive mechanisms to enable a desired future are proposed; including the integration of mandates, processes and systems. Case studies are given throughout the paper using hull and propeller maintenance as a recurring example of a typical decision making processes and best practices.

1. Introduction

Energy efficiency, fuel consumption optimization and many other terms have been used synonymously to address issues and initiatives alike. The drivers toward addressing these issues and initiatives can be summarized into three main driver groups: economics, compliance, and customer requirements. Elaborating on these groups, the need to achieve economic voyages is driven by bottom line profit margins. Given the volatility of daily charter rates, shipping demand and bunker prices (UNCTAD, 2014), the objective is to minimize operational costs and to maximize revenue. How this is achieved depends on company organizational structure, ship type and services operated (Stopford, 2008; Poulsen and Johnson, 2015).

The second driver group towards energy efficiency is compliance with regulatory requirements and company adopted standards. On 1st January 2013 the amendments made to the International Convention for the Prevention of Pollution from Ships (MARPOL) 1973/78, Annex VI, entered into force, forming the first regulations related to ship energy efficiency (IMO, 2012a). The regulations require all new build ships to comply with the Energy Efficiency Design Index (EEDI) which targets ship design (IMO, 2014), and all new and existing ships to have a ship specific Ship Energy Efficiency Management Plan (SEEMP), targeting ship operational energy efficiency (IMO, 2012b). Development and enforcement of these regulations by the IMO was in response to the requirement to start taking actions under the Kyoto Protocol (United Nations, 1998): an extension of the United Nations Framework Convention on Climate Change (UNFCCC) treaty (United Nations, 1992), addressing the need to mitigate detrimental climate change via the reduction of anthropogenic carbon dioxide (CO_2) emissions (IPCC, 2014). On average, between 2007 and 2012 it was estimated that the shipping industry emit 3.1% of global CO_2 emission, 2.6% from international shipping alone. If no actions are taken these emissions are expected to increase from the 2012 levels by 50–250% by 2050 (Smith et al., 2014). Therefore significant changes are needed to meet existing (focused within a 2 °C climate change scenario) and future global emission reduction targets (Jordan et al., 2013). It has been identified that enforcement of the EEDI and SEEMP alone is likely to increase awareness and promote energy efficient ship design and operation, resulting in

Abbreviations: AIS, Automatic Identification System; BAU, Business As Usual; CAPEX, Capital Expenditure; CSR, Corporate Social Responsibility; EEDI, Energy Efficiency Design Index; IMO, International Maritime Organization; ISM, International Safety Management Code; ISO, International Organization for Standardization; KPI, Key Performance Indicator; LTIF, Lost Time Injury Frequency; MRV, Monitoring, Reporting and Verification; OPEX, Operational Expenditure; PBCF, Propeller Boss Cap Fin; RCM, Reliability Centered Maintenance; ROB, Remaining On Board; RPM, Revolutions per Minute; SEEMP, Shipboard Energy Efficiency Management Plan; UNFCCC, United Nations Framework Convention on Climate Change; VDR, Voyage Data Recorder

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savings; but not to the magnitude required (Bazari and Longva, 2011). Acknowledging one of the primary weaknesses of the current energy efficiency regulations, the EU adopted a proposal for Monitoring Reporting and Verification (MRV) in April 2015, which will enter into action on the 1st January 2018 (EU, 2014). It is estimated that MRV could contribute a 2% reduction to BAU shipping emissions by 2030 by taking a first step towards reducing market barriers; particularly those related to a lack of reliable and robust information on ship performance (i.e. fuel consumption, and hence predicted emissions) (EU, 2014). However, again there are concerns over the effectiveness of MRV in providing greater transparency. This is because the energy consumption monitoring practices are left to the industry to decide, which will not necessarily address the following four barrier challenges: data collection, misreporting, data analysis and feedback problems (Poulsen and Johnson, 2015). Further, to regulations, International Standards adopted by companies also act as drivers toward implementing ship operational energy efficiency; such as ISO50001 (BS EN ISO, 2011). An advantage of ISO50001 over the SEEMP is that it requires a verification method to be defined for each action (i.e. best practices) (Johnson et al., 2013). Further advantages of the ISO50001, and the codes such as the ISM code, over the SEEMP include: the requirement for mechanisms for reviewing energy demand, setting goals, monitoring performance; encapsulating company management rather than ship specific (Johnson et al., 2013). These are issues that still need addressing in the context of practical ship operations.

The third driver group toward the implementation of energy efficiency is customer requirements. Major organizations, i.e. those mostly listed in stock exchanges, promote the requirement for vessels chartered by them to carry their cargo to follow sustainability initiatives and practices as part of their commitment to Corporate Social Responsibility (CSR). With rising concerns over climate change mitigation, as previously discussed, energy efficiency and low carbon supply chains have become increasingly more important to customers and within CSR (M&S, 2015). There are several industry and working group initiatives and indices to acknowledge energy efficient ships and efforts. Svensson and Andersson (2011) discusses many of these in relation to their intended use, users (e.g. customers), basis and scope.

In light of the described drivers, initiative to increase ship energy efficiency has been extensively explored and researched and discussed in breadth and depth across the maritime industry (LCS (2014), Stulgis et al. (2014), ABS (2013) and Knott and Buckingham (2011) are only a few examples). Many of the initiatives are described in the guidelines for the development of the SEEMP (IMO, 2012b). Focusing on industry reported savings, some of the most commonly implemented initiatives include popular retrofits; such as Propeller Boss Cap Fins (PBCF), Mewis Duct, Stator fins, bulbous bow modifications, propeller change, and de-rating of engines. Armstrong (2013) reported up to a 4% gain in propeller efficiency with the installation of a Propeller Boss Cap Fin (PBCF) and De Kat et al. (2010) reported 1–3 g/kW h were saved after installing injection timing autotuning. Popular operational practices that have been implemented include slow steaming, Just-In-Time (JIT) arrival, weather routing, cargo heating management, and trim optimization. Example savings reported include a validated 1% from trim optimization, and fuel saving of 2.5 MT/day from cargo heating optimization (Armstrong, 2013). Popular maintenance practices include monitoring and timely maintenance of the main engine and onboard equipment, along with the selection of a best-suited hull coating system and hull surface preparation. For example, De Kat et al. (2010) identified a 70–80 kW saving by performing maintenance and optimization of the ventilation system and Armstrong (2013) reported a 2.5 MT/day fleet average fuel saving from a full blast of a hull after drydocking in the 10th year of operation and using a Self-Polishing Copolymer (SPC) coating.

The above demonstrates that savings are achievable in the industry. Marginal Abatement Cost Curve also demonstrates that many measures are considered cost effective (Faber et al., 2011; DNV, 2010; IMO, 2009). However Rehmatulla (2012) describes a survey of primarily ship owners, charters, operators and management companies, that was carried out to assess the barriers to uptake of energy efficiency operational initiatives. The survey results demonstrated that even for the measures considered to have the highest potential for improving energy efficiency; only around 65–85% of the survey respondents had implemented them. 90–100% would be expected for the cost effective measures with easy implementation and short payback periods (Rehmatulla, 2012). An average implementation rate around 50% was observed across all the operational measures included in the survey.

With a low take up of energy efficiency measures in the industry studies have been carried to investigate different types of barriers. From the survey results Rehmatulla (2012) identified the most significant barriers to be the following: lack of reliable information on cost and savings; difficulty in implementing under some types of charter; lack of direct control over operations; materiality of savings. The survey results also revealed that smaller companies cited barriers more frequently than larger companies. Poulsen (2011) discusses and highlights the following as barriers: agency problems (split incentives); inadequate information and transparency for energy efficiency and incentive structures; information uncertainty; high discount rates being applied resulting in decisions made for short-term benefits. Poulsen (2011) also concludes that social science needs to be considered in addressing barrier to energy efficiency improvements, along with attitudes and incentive structures. Considering the perspective of 317 seafarers, survey results revealed the following as barriers to effective change: availability of education; communication between ship and shore, and internal and external stakeholders; transparency of limitations, capabilities, responsibilities and achievements towards energy efficiency improvements (Banks et al., 2014). Furthermore Poulsen and Johnson (2015) discuss the results from 55 interviews with technical and commercial personnel; highlighting data collection, misreporting, analysis problems and feedback as problems for energy consumption monitoring, which is a key barrier toward effective energy management.

In conclusion of the above, it can be considered that despite a body of knowledge, the adoption of best practices, lessons learnt, and new technologies continues to remain a challenge as part of mainstream business practices. Whilst different types of barriers to energy efficiency improvements have been explored it is first necessary to understand how they are created, as discussed in (Poulsen and Johnson, 2015). The aim of this paper is therefore to explore exactly this by taking a closer look at how ship operations function day-to-day within the context of mainstream business practice. This is done by first explicitly laying out the focus areas, stakeholders and functions associated with ship operations in an understandable matrix that can be related to most organizational structures (Section 2). With this laid-out, the type of gaps within existing operations are discussed (Section 3) in relation to practical ship operations. Hull and propeller maintenance is used as a recurring example throughout the paper, although similar principles could be applied to most decision making processes and best practices. A desired future is then proposed in Sections 4 and 5, not stating prescribed outcomes, but suggesting mechanisms to enable recognition of practical improvement areas to allow for improved integration and transparency in ship operations, and hence address several of the barriers to practical implementation.