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The Logic of Business vs. the Logic of Energy Management Practice: Understanding the Choices and Effects of Energy Consumption Monitoring Systems in Shipping Companies

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Abstract

A major part of the world fleet of more than 47,000 merchant ships operates under conditions that hamper energy efficiency and efforts to cut CO_2 emissions. Valid and reliable data sets on ships' energy consumption are often missing in shipping markets and within shipping organizations, leading to the non-implementation of cost-effective energy efficiency measures. Policy makers are aiming to remedy this, e.g., through the EU Monitoring, Verification and Reporting scheme. In this paper, current practices for energy consumption monitoring in ship operations are explored based on interviews with 55 professionals in 34 shipping organizations in Denmark. Best practices, which require several years to implement, are identified, as are common challenges in implementing such practices—related to data collection, incentives for data misreporting, data analysis problems, as well as feedback and communication problems between ship and shore. This study shows how the logic of good energy consumption monitoring practices conflict with common business practices in shipping companies - e.g., through short-term vessel charters and temporary ship organizations – which in turn can explain the slow adoption of energy efficiency measures in the industry. This study demonstrates a role for policy makers or other third parties in mandating or standardizing good energy consumption monitoring practices beyond the present requirements.

Keywords: Energy efficiency gap; Energy consumption monitoring; Energy management practice; Shipping industry; Barriers; Monitoring, Reporting and Verification (MRV)

Word count: 8766

1 Introduction

Rising fuel prices and an excess supply of ships have driven shipping companies to improve their energy management practices in recent years. Some companies, however, have seen more success than others

(Kühnbaum, 2014; Wang and Lutsey, 2014). Why is this the case? This article argues that prevailing business practices in the shipping industry are incompatible with the logic of effective energy management, leading to excess energy use on many ships.

Assessments have indeed identified an energy efficiency gap (Jaffe and Stavins, 1994) in shipping; a large number of measures that could increase energy efficiency are available at negative net costs (Buhaug et al., 2009; Eide et al., 2011; Faber et al., 2011). These assessments have been carried out to understand the potential for reducing green-house gas (GHG) emissions. Consequently, a part of the rhetoric of policy-making has been that regulations to reduce GHG emissions from shipping will save the industry vast amounts of money (EC, 2013; IMO, 2011). Moreover, a large gap exists between projections of future emissions from the international shipping industry and the industry's own role in mitigating in impact on global climate change (Anderson and Bows, 2012). The industry's share of global emissions are estimated as 2.7% (Smith et al., 2014), but this share may increase up to 8% by 2050 unless further action is taken (Anderson and Bows, 2012).

International shipping was left out of the Kyoto Protocol, partly on the grounds that countries could not agree on how to allocate emissions to individual countries (Oberthür and Ott, 1999). The task of mitigating CO_2 emissions from shipping was passed onto the UN's International Maritime Organization (IMO). In 2011, the International Convention for the Prevention of Pollution from Ships (MARPOL 1973/78) was amended to include two mitigation measures: the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP) (IMO, 2011b). While the EEDI introduced design limits for new ships, the SEEMP aims to improve the day-to-day operations of existing and new ships. A report for the IMO quickly showed that the EEDI and the SEEMP are not expected to reduce total emissions from the sector, only to slow down the growth (Bazari and Longva, 2011; Smith et al., 2014).

Countries have also discussed market-based instruments (MBMs) for shipping in the IMO, but no agreement has been reached (Miola et al., 2011). While technical and management standards for energy efficiency could be agreed upon, the conflict between the concept of Common but Differentiated Responsibilities

(CBDR)—part of the United Nation's Framework Convention on Climate Change (UNFCCC) process—and the IMO principle of giving 'no more favourable treatment' (NMFT) to any ship has hampered further discussions (Gilbert and Bows, 2012; Kågeson, 2011; Lema and Papaioanou, 2013). Either a policy applies to all ships regardless of flag, or it should apply not at all; a policy that would exempt non-Annex I parties to the Kyoto Protocol from, e.g., a fuel tax would easily be avoided through flagging out vessels. Marine fuel is typically not taxed due to the ease of acquiring it in many places. In dissatisfaction with the IMO's progress to regulate GHG emissions, the EU has pushed forward with a regional monitoring, verification and reporting (MRV) scheme. In the longer term, the EC has expressed the intention to combine the scheme with an MBM. The European Commission (EC) expects an improvement in energy efficiency of approximately two percent in the short term, as valid and reliable data sets on ships' energy consumption will become available in shipping markets and within shipping organizations (EC, 2013). Such a system would enable shipping companies to identify fuel saving potential and enable buyers of transportation services to identify the most efficient ships on the market (Maddox Consulting, 2012).

The arguments of the EC are well known from the energy efficiency literature. From the perspective of economics, information asymmetries and imperfections are sources of market failures and as such require policy intervention (Fisher and Rothkopf, 1989; Gillingham et al., 2009; Jaffe and Stavins, 1994; Sanstad and Howarth, 1994; Sutherland, 1991). From a business perspective in many industries, energy consumption monitoring[1] (ECM) is a key aspect of best energy management practice (Bunse et al., 2011; Sivill et al., 2013; Thollander and Ottosson, 2010). Although the monitoring of ships' energy consumption has been observed as crucial for energy efficiency in shipping for decades (Banks et al., 2013; Drinkwater, 1967; Petersen et al., 2011; Sweeney, 1980) the actual monitoring practices employed by the industry remain unexplored. A range of ECM options are available, some more advanced than others (Fischbascher et al., 2012; Faber et al., 2013).

[1] The terms "energy end-use monitoring" and "energy performance monitoring" are also used in the literature somewhat interchangeably.

In this article, ECM practices in ship operations are explored, especially the perceived validity and reliability of data on ship energy consumption available within organizations and markets. Based on a qualitative analysis of interviews with 55 shipping executives and middle managers, the diversity of ECM practices are discussed and best practices are identified. The study shows that best practice in ECM is not compatible with common business practices and ends with a discussion of the academic and wider policy implications.

2 The commercial conditions for ship operations

Shipping accounts for approximately 90 percent of world trade in terms of transport work, and cargoes include important dry commodities (e.g., iron ore and coal), liquid energy (oil and gas) as well as semi-manufactured and consumer goods (Hoffmann and Kumar, 2010). The prices of transportation (freight rates) are negotiated in the freight market between cargo owners and shipping companies. Freight rates are highly volatile and can change overnight. While demand for shipping can shift suddenly (e.g., due to a political crisis or the closure of the highly important Suez Canal), supply can only respond slowly to such changes. It can take up to three years to build a new ship, and ships have a commercial life-length of approximately 25 years. Freight rate volatility cascades into the markets for new buildings and second-hand ships (asset prices), and this provides asset players with business opportunities. Asset players make their main profits from buying and selling ships timely, and in some cases they are willing to accept losses in the freight market while waiting for asset prices to increase (Stopford, 2009).

To understand the nature of ship operations, two issues are key and concern the following:

1. The commercial conditions for ship operations, and
2. The organizational conditions for ship operations.

The commercial conditions are settled in the freight market and written in charter parties. Charterers with a need for transportation are on the demand side, and on the supply side, shipping companies provide the required ships. A charterer can be a cargo-owner as well as a shipping company, which needs additional ships. Charter parties differ in terms of duration and the distribution of risks and ship costs (see Table 1). Ship costs are usually divided between capital costs (investment in the ship itself), operating costs (mainly supplies, maintenance, salaries for crews, and marine insurance) and voyage costs (fuel costs and port and canal dues) (Stopford, 2009). Three types of charters exist: 1) Spot charters (also known as voyage charters), where the ship owner assumes all costs (and risks) and receives payment from the charterer based on the quantity of cargoes carried and the rate per unit cargo. Spot charters concern one voyage. 2) Time charters can have durations from months up to several years. Here, the vessel capital costs and operating costs are paid by the ship owner, and voyage costs including fuel costs, are paid by the charterer. Charterers' payment to ship owners depends on the daily hire rate, duration of contract and vessel off-hire time. 3) Bareboat charters, where the ship owner pays capital costs and leaves all other costs and operational decisions to the charterer. Here, the charterer's payment to the ship owner depends on the daily hire rate and duration of the charter.

The choice of charter party depends on the individual companies' needs and expectations for the future, bearing in mind the high freight market volatility. If a cargo-owner (charterer) has a constant need for transportation services over, e.g., the next five years and anticipates rising spot market rates, a long-term time charter may be preferable to spot charters. In this way, the charterer gains certainty for transport capacity and freight rate. If the charterer has capabilities in commercial and technical ship operations, a bareboat charter may be attractive. A charterer with short-term transportation needs and no such capabilities will prefer a spot charter and leave the ship operation to a shipping company. A company with access to cheap ship financing but lacking the technical and commercial capabilities for ship operations may own large fleets of vessels, which they bareboat-charter to other companies. In this case, the ship owner serves as a tonnage provider for other shipping companies—a practice very common in liner shipping (Cariou and Wolff, 2013).

Estimating the number of ships operating on the various charters at a given point in time is difficult. The fact that a ship on a time or bare-boat charter can be sub-chartered to a third party adds further complexity to the issue. However, it is certain that a very high number of transactions are agreed on every year for the world fleet, which counts more than 47,000 vessels with gross tonnage (GT) above 1,000 (UNCTAD, 2014).[2] For container lines, estimating the size of the chartered fleet is possible because top 20 companies control the market. On average, the container lines own less than 50 percent of their fleets, and charter the rest on a short- or long-term basis from tonnage providers (Alphaliner, 2015; Cariou and Wolff, 2013). This reduces the container line balance sheets in a highly capital intensive industry and adds a desirable flexibility to their fleet deployments. The same applies to dry bulk and tanker shipping companies, which often distinguish between core fleets (of owned vessels) and chartered fleets (vessels on spot, time and bareboat charters). The flexibility of chartering allows shipping companies to take advantage of the volatile freight markets, and it is usually seen as a key part of corporate risk management (Stopford, 2009).

Table 1. Different forms of charter parties, which are used in shipping (Stopford, 2009).

		Who pays for		
Charter type	Duration	Capital costs	Operating costs	Voyage costs
Spot charter	Weeks	Ship owner	Ship owner	Ship owner
Time charter	Months to years	Ship owner	Ship owner	Charterer
Bareboat charter	Months to several years	Ship owner	Charterer	Charterer

Note: Capital costs refer to the ship itself (equity or debt financed); Operating costs refer to crew wages, stores, repair, maintenance and insurance etc.; Voyage costs refer to fuel as well as port and canal dues;

The organizational conditions for ship operations concern the crewing of the ships and the influence of the ship-shore relationship. With current technologies, merchant ships are typically manned by 5 to 30 crew members (depending on vessel size, complexity and cargo), and jobs are divided between engine, deck and navigation departments. The crew makes operational decisions on the specific route and speed, etc. for the ship, and these influence fuel consumption. Moreover, as will be argued below, crews play a key part in ECM. Ship officers frequently receive instructions from ship operators in commercial organizations ashore about issues such as cargoes, arrival and departure times, stores, supplies and ECM. In some cases, the crews are employed by specialized third party management companies (Mitroussi, 2003, 2004; Panayides, 2003;

[2] Gross tonnage (GT) is a measurement of the total volume of enclosed space onboard a ship, measured in cubic metres. Effectively, it is a measurement of ship size.

Panayides and Cullinane, 2002). A shipping company may choose to outsource crewing and technical management to third parties to focus on core commercial capabilities (such as chartering and asset play) or to benefit from economies of scale with third party managers. Cost reduction is a typical argument for outsourcing. Moreover, outsourcing enhances the organizational flexibility of the shipping company, which can quickly respond to changes in the freight and second-hand markets without engaging in major human resource management tasks (crew recruitment and layoffs). This flexibility is highly valued in many shipping companies.

3 Method and choice of sample

The notion of a large cost-effective potential for energy efficiency has been discussed regularly since the oil crises of the 1970s. A comprehensive taxonomy of "barriers" to energy efficiency has been discussed, based on different theoretical frameworks (Cagno et al., 2013; Sorrell et al., 2004; Thollander and Palm, 2012). This approach has also been applied in shipping (Acciaro et al., 2013; Jafarzadeh and Utne, 2014; Johnson and Andersson, 2011). However, there have been calls for alternative approaches. Drawing upon the field of science and technology studies (STS), Shove (1998) criticized the separation of social and technical aspects in the barriers discourse and emphasized understanding the "contexts of action" in which decisions on energy efficiency take place; these will vary with specific organizational practices as well as over time. Shove uses the example of a designer "keen on energy efficiency" working in different organizations: "…the same person with the same psychological propensity for risk taking, and confronting the same decisions … will arrive at different solutions depending upon the organisational environment in which he or she happens to operate." (Shove, 1998, p. 1108).

Shove's argument was repeated and expanded upon by Palm (2009) as well as by Palm and Thollander (2010). The latter repeated Shove's call for applying an STS perspective to gain new perspectives on the barrier discourse. They also emphasized the need to leave the *reductionism* inherent in barriers research, i.e., "the notion that there is a small class of phenomena, objects or events that drive everything else—a suggestion often linked to the belief by the analyst that he or she has understood these root phenomena"

(Law, 1994, p. 12). However, move to where; what would in this case be a fruitful alternative to reductionist explanations?

This paper follows the alternative introduced within STS by Latour (1986), and later applied in organizational studies by, e.g. Czarniawska-Joerges (1993) in the analysis: the move from so-called *ostensive* definitions of phenomena—such as postulated principles, mechanisms, etc.—to *performative*, which start with exploring and capturing practices. The question of *how* is now the focus, rather than *why* (Knorr-Cetina, 1981)—or *why not* as in barrier models. Specifically, the aim of the paper is to describe the diversity of ECM practices that exist in shipping and associated ECM challenges reported by representatives of shipping companies (Section 4). This in turn enables a discussion of the conditions for ECM in the different contexts and an assessment of how business practices influence ECM, thus providing further understanding of the energy efficiency gap (Section 5). The results are discussed in the context of previous research in Section 6. Section 7 concludes the study.

3.1 Selecting the case of ECM practices in the Danish shipping sector

To study ECM practices in shipping and the diverse conditions under which ECM is performed, focus is placed on ECM experiences and perceptions held by shipping executives and middle managers. With one German exception, the focus is on Danish shipping companies, which are highly involved in global liner, tanker and dry bulk shipping as well as multi-purpose shipping (Sornn-Friese and Iversen, 2011). These are the main segments in the world fleet (UNCTAD 2014). These companies have very different answers to the two key issues discussed in Section 2 (the commercial and organizational conditions of ship operations).

Due to the increase in fuel prices in the 2000s and the recent MRV discussions, EPM and its relation to business practices have been seen as sensitive commercial issues. Consequently, executives are unlikely to reveal their experiences in a survey. Instead, a total of 41 confidential, semi-structured interviews (with durations between approximately 50 and 184 minutes) were performed in 25 shipping companies, and 14 additional interviews were performed in classification societies, suppliers of marine equipment, a shipyard, maritime research and education institutions and naval architect consultancies, which also hold valuable experiences with regard to ECM (Table 2). Accounts on four issues were focused on specifically: 1)

Business practices in shipping; 2) Potential for fuel savings in ship operations; 3) How and why ECM is performed; and 4) Validity and reliability of ECM data sets for fuel saving initiatives and ECM best practice (Appendix 1). The interviews were transcribed and coded accordingly (Charmaz, 2006). In preparing the interview guides, publications from leading classification societies, which contain advice for shipping companies on how to improve ECM practices (ABS 2013; Lloyd's Register 2012), were consulted. When the answers received from interviewees differed from those advised by the classification societies, interviewees were confronted with this difference and asked to provide an explanation. This allowed an analysis of the factors that determine current ECM practices as percieved by the interviewees.

Table 2. List of interviewees, who were interviewed for this article.

Viewpoint category	**Respondent's job title**	**Selection**	**Date**	**Format**	**Length**	**Recording**
Shipowners and operators (company level)						
Container shipping	Director (Newbuilding & Engineering)	Snowball	Nov. 30-Dec. 2, 2012	E-mail correspondence		
Container shipping	VP (Sustainability)	Direct contact	May 21, 2014	Semi-structured, face-to-face interview	0:56:34	Tape recorded and transcribed
Container shipping	Environmental Manager/Global Advisor (Sustainability)	Direct contact	Aug. 16, 2012 and May 27, 2014 (2 interviews)	Semi-structured, face-to-face interview	1:38:39	Tape recorded and transcribed
Short-sea liner shipping	Project Manager (Technical Organization)	Direct contact	Oct. 12, 2012	Semi-structured, face-to-face interview		Concurrent notes + Supplementary notes written immediately after interview
Short-sea liner shipping	Naval Architect (Technical Organization)	Showed up unexpectedly	Oct. 12, 2012	Semi-structured, face-to-face interview		Concurrent notes + Supplementary notes written immediately after interview
Short-sea liner shipping	Chief Operating Officer	Direct contact	June 17, 2013	Semi-structured, face-to-face interview	1:09:09	Tape recorded and transcribed
Short-sea liner shipping	Project Manager (Fuel Savings)	Direct contact	Nov. 16, 2012	Semi-structured, face-	1:20:53	Tape recorded and transcribed

				to-face interview		
Gas Tanker Shipping	Vice President (Fleet Management)	Direct contact	June 24, 2013	Semi-structured, face-to-face interview	2:36:19	Tape recorded and transcribed
Gas Tanker Shipping	Chief Technical Officer	Showed up unexpectedly	May 8, 2013	Semi-structured, face-to-face interview	2:20:40	Tape recorded and transcribed
Chemical tanker shipping	General Manager (Marine Projects)	Snow ball	Aug. 17, 2012	Semi-structured, face-to-face interview	1:44:52	Tape recorded and transcribed
Product tanker shipping	Senior Manager (Environmental & Technical Support)	Direct contact	Aug. 21, 2012	Semi-structured, face-to-face interview	1:05:22	Tape recorded and transcribed
Product tanker shipping	Chief Executive Officer	Direct contact	Aug. 24, 2012	Semi-structured, face-to-face interview	1:17:59	Tape recorded and transcribed
Product tanker shipping	Senior General Manager (Technical Support)	Showed up unexpectedly	Aug. 24, 2012	Semi-structured, face-to-face interview	1:17:59	Tape recorded and transcribed
Product tanker shipping	Energy and Performance Specialist (Technical Division)	Snowball	March 8, 2013	Semi-structured, face-to-face interview	1:42:36	Tape recorded and transcribed
Product tanker shipping	Executive Vice President (Tanker Department)	Direct contact	May 3, 2013	Semi-structured, face-to-face interview	1:13:53	Tape recorded and transcribed
Product tanker shipping	Fuel Optimization Manager (Technical Organization)	Direct contact	June 27, 2013	Semi-structured, face-to-face interview	1:33:19	Tape recorded and transcribed
Product tanker shipping	CSR and Sustainability Manager	Snowball	May 28, 2014	Semi-structured, face-to-face interview	1:07:12	Tape recorded and transcribed
Product tanker shipping	Director (Commercial Management)	Direct contact	May 16, 2013	Semi-structured, face-to-face interview	1:46:37	Tape recorded and transcribed
Product tanker shipping	Director (Performance)	Showed up unexpectedly	May 16, 2013	Semi-structured, face-to-face interview	1:46:37	Tape recorded and transcribed
Product tanker shipping	Executive Vice President	Showed up unexpectedly	May 16, 2013	Semi-structured, face-to-face interview	1:46:37	Tape recorded and transcribed
Product tanker	Chief Technical	Direct	May 21,	Semi-	1:15:59	Tape recorded

shipping	Officer	contact	2012	structured, face-to-face interview		and transcribed
Short-sea product tanker shipping	Fleet Manager	Direct contact	May 29, 2013	Semi-structured, face-to-face interview	1:13:14	Tape recorded and transcribed
Dry bulk shipping	Managing Director	Snowball	Nov. 29, 2012	Semi-structured, face-to-face interview	1:37:57	Tape recorded and transcribed
Dry bulk shipping	Director (Operations)	Direct contact	April 15, 2013	Semi-structured, face-to-face interview	2:17:32	Tape recorded and transcribed
Dry bulk shipping	Senior Vice President (Operations)	Direct contact	May 6, 2013	Semi-structured, face-to-face interview	1:40:19	Tape recorded and transcribed
Dry bulk shipping	General Manager (Chartering)	Direct contact	May 8, 2013	Semi-structured, face-to-face interview	2:20:40	Tape recorded and transcribed
Dry bulk shipping	Senior Vice President (Operations)	Showed up unexpectedly	May 8, 2013	Semi-structured, face-to-face interview	2:20:40	Tape recorded and transcribed
Dry bulk shipping	Director (Technical Department)	Direct contact	May 6, 2013	Semi-structured, face-to-face interview	1:29:23	Tape recorded and transcribed
Short-sea dry bulk shipping	Marine Superintendent & Chief Security Officer	Direct contact	May 30, 2013	Semi-structured, face-to-face interview	1:31:49	Tape recorded and transcribed
Special shipping	Ship's Officer (Marine Engineer & Master Mariner)	Snowball	Oct. 31. 2012	Semi-structured, face-to-face interview	1:25:42	Tape recorded and transcribed
Shipowners and operators (corporate level)						
Container & product tanker shipping	VP	Direct contact	Aug. 28, 2012	Semi-structured, face-to-face interview	0:49:40	Tape recorded and transcribed
Product tanker & dry bulk shipping	Director (Corporate Social Responsibility)	Snowball	June 19, 2013	Semi-structured, face-to-face interview	1:41:21	Tape recorded and transcribed
Product tanker & dry bulk shipping	Director (Fuel Efficiency)	Showed up unexpectedly	June 19, 2013	Semi-structured, face-to-face interview	1:41:21	Tape recorded and transcribed
Bulk & multi-purpose shipping	Director (Fleet Management)	Showed up unexpectedly	May 6, 2013	Semi-structured, face-to-face	1:40:19	Tape recorded and transcribed

				interview		
Multi-purpose general cargo & heavy-lift	Chief Financial Officer	Direct contact	Dec. 6, 2012	Semi-structured, face-to-face interview	1:22:36	Tape recorded and transcribed
Multi-purpose general cargo & heavy-lift	Technical Manager	Showed up unexpectedly	Dec. 6, 2012	Semi-structured, face-to-face interview	1:22:36	Tape recorded and transcribed
Ship managers						
Tankers, bulkers and container feeder vessels	Project Coordinator	Snowball	June 26, 2012	Semi-structured, face-to-face interview; followed by e-mail correspondence	0:54:35	Tape recorded and transcribed
Tankers, bulkers and container feeder vessels	Director (Consulting Department)	Showed up unexpectedly	June 26, 2012	Semi-structured, face-to-face interview; followed by e-mail correspondence	0:54:35	Tape recorded and transcribed
Tankers, bulkers and container feeder vessels	Project Coordinator	Showed up unexpectedly	June 26, 2012	Semi-structured, face-to-face interview; followed by e-mail correspondence	0:54:35	Tape recorded and transcribed
Shipbrokers						
Bulk carrier brokerage	Senior Chartering Manager	Direct contact	April 17, 2013	Semi-structured, face-to-face interview	1:18:16	Tape recorded and transcribed
Bulk carrier brokerage	Managing Director & Partner	Direct contact	May 7, 2013	Semi-structured, face-to-face interview	1:16:30	Tape recorded and transcribed
Technical advisors, researchers and teachers						
Technical University	Senior Researcher	Direct contact	June 21, 2012	Semi-structured, face-to-face interview		Concurrent notes + Supplementary notes written immediately after interview
Technical University	PhD Student	Direct contact	Nov. 7, 2012	Semi-structured, face-to-face interview	1:54:57	Tape recorded and transcribed
Maritime Academy	Associate Professor	Snowball	Dec. 5, 2012	Semi-structured, face-to-face	2:05:56	Tape recorded and transcribed

				interview		
Marine consultancy	Owner	Snowball	June 29, 2012	Semi-structured, face-to-face interview	3:04:55	Tape recorded and transcribed
Marine consultancy	Director (Marine Department)	Direct contact	March 7, 2013	Semi-structured, face-to-face interview	0:56:41	Tape recorded and transcribed
Classification	Senior Surveyor	Direct contact	Aug. 2012	E-mail correspondence		
Classification	Environmental and Statutory Advisor	Direct contact	Aug. 8, 2012	Semi-structured, face-to-face interview	1:25:43	Tape recorded and transcribed
Classification	Director (Vessel Performance)	Direct contact	May 27, 2013	Semi-structured, face-to-face interview, not taped		Notes written immediately after interview
Shipbuilders and equipment suppliers						
Diesel engines	Vice President	Direct contact	Nov. 30, 2012	Semi-structured, face-to-face interview	1:00:59	Tape recorded and transcribed
Shipbuilding	General Manager (Ship Design Department)	Snowball	Aug. 20, 2012	Semi-structured, face-to-face interview		Tape recorded
Vessel equipment and marine consultancy	Project Sales Manager	Direct contact	Jan. 16, 2013	Semi-structured, face-to-face interview	1:45:12	Tape recorded and transcribed
Vessel equipment	Product Manager (Marine & Offshore)	Showed up unexpectedly	Apr. 2, 2013	Semi-structured, face-to-face interview	1:45:47	Tape recorded
Vessel equipment	Technical Sales Manager (Marine & Offshore)	Showed up unexpectedly	Apr. 2, 2013	Semi-structured, face-to-face interview	1:45:47	Tape recorded
Vessel equipment	Sales Manager (Energy Solutions)	Direct contact	Apr. 2, 2013	Semi-structured, face-to-face interview	1:45:47	Tape recorded

Individual interviewees were identified using LinkedIn, shipping company home pages and a snowballing approach (Biernacki and Waldorf, 1981).

Danish companies are not representative of the global ship owner community; on average, Danish ships are younger than the world fleet, and Danish ship owners usually prefer to market themselves as ‘quality shipping’ (Danish Shipowners' Association, 2015). Moreover, Danish ship owners differ from the global ship owner community in terms of their environmental policies (Lloyd's List, 2014). Since 2008, the Danish Shipowners’ Association has calculated and published data on CO_2 emissions from Danish shipping (Danish Shipowners' Association, 2015), which are based on ECM data sets. This contrasts with most other national ship owner associations and the International Chamber of Shipping, a global ship owners’ association (ICS, 2015), which do not publish similar data. This fact should be taken into account when generalising the results. Rather than representing global shipping, the sample represents a subgroup where best ECM practices should more easily diffuse. In this sense, ECM practices in Danish shipping can be viewed as a “critical” case (cfr. Flyvbjerg, 2006, p. 230); if ECM practices do not easily diffuse amongst these companies, they probably do not diffuse more easily elsewhere. Finally, interviews were conducted from mid-2012 to early 2014, which coincided with a period of high fuel prices. This fact is also important to keep in mind when interpreting the results. Since mid-2014, oil prices have declined rapidly, which may have reduced economic incentives for ECM in certain parts of the industry.

The interviewees were split almost equally between technical positions (marine engineers, seafarers and naval architects) and commercial positions (ship brokers, charterers, operators, finance experts and top-management). To critically assess the reliability and validity of the information gained from each interviewee, background material from LinkedIn was used. For example, in identifying ECM best practices, the perspectives held by ECM experts with technical insights (as evidenced e.g. by their educational and occupational background information available on their respective LinkedIn profiles), rather than interviewees in commercial positions, received the most attention. On the other hand, the experiences and perspectives held by commercial interviewees with respect to ECM are highly valuable for the assessment of the commercial context under which ECM is performed. This means that both technical and commercial perspectives are valuable for answering the research questions. In Section 4, the types of interviewees upon which the specific analyses were based are discussed in greater detail.

The following scenario exemplifies the method: A shipping company executive with a commercial background argued that the only ECM data his company needed concerned the fuel quantity in the fuel tank at the commencement and completion of a ship voyage. His company rarely operated the same ships for long, so comprehensive ECM was seen as unfeasible. While this practice is not aligned with ECM best practices (as will be shown in Section 3), the interview provided valuable information about the business practices and the reasons for these practices.

To pursue respondent validation of the results, the authors have frequently engaged with the shipping business community in Northern Europe and have participated in numerous 'green' shipping conferences. Moreover, the preliminary results of the research were presented at several such conferences and seven shipping newspaper articles on the research results have been authored (Poulsen, 2012a; 2012b; 2013a; 2013b; 2013c; 2014a; 2014b). At one of the major conferences (Green Ship Technology 2014), the authors organized a 1.5-h panel discussion on ECM and energy efficiency.At the beginning of the panel discussion, the results of this study were presented. Subsequently, each of the six panel members (a nautical school teacher/former seafarer, two shipping company ECM experts, a head of operations and bunkers in a shipping company, a technical expert in a ship owner association, and a maritime administration official) commented upon the findings and thus provided valuable external validation of the results.

4 Assessing ECM practices in the Danish shipping sector

A successful energy management programme identifies and implements cost-effective fuel saving initiatives. In ship operations, valid and reliable ECM data are required for this purpose. All interviewees, regardless of position, education and company, share this perspective. On the basis of valid and reliable ECM data sets, shipping companies can make informed and timely decisions on energy management and implement cost-effective fuel saving initiatives. ECM data are also observed by numerous interviewees as instrumental in raising awareness about energy consumption among all decisions makers at sea and onshore.

On a more basic level, ECM best practices in ship operations require real-time data and extensive sub-metering of energy-consumers throughout a ship. There are numerous energy-consumers on-board a ship (for propulsion, cargo-handling, cargo-cooling, hotel functions, etc.) and disaggregated data sets for each consumer (or at least the main consumers) are necessary for ECM best practices. This will allow onshore fleet managers and crews to immediately identify and realize cost-effective fuel saving initiatives. Ships operate under highly variable conditions (weather, sea, maintenance and loading conditions) and differ fundamentally in terms of designs (size, speed, complexity and cargoes carried). For these reasons, considerable noise in raw ECM data collected on-board the ships is common. A comprehensive data analysis, which neutralizes these effects, is required to provide valid and reliable ECM data. Sophisticated algorithms and long time series are required for this, according to ECM experts, and should be applied by an ECM analysis unit onshore. For the same reason, ECM best practices are time-consuming activities, requiring time series of several years to properly assess the fuel-saving potential. ECM best practices should enable shore and ship organizations to answer the following three questions at any given point in time:

1. What is the energy consumption of the main energy consumers on-board the vessel in real time?
2. How has energy consumption evolved over the last couple of years?
3. What is the potential for implementation of cost-effective fuel-saving initiatives?

The interviewees widely agree that ECM data are important energy management decision support tools for crews and onshore employees. For instance, trim—the difference between a vessel's forward and aft draughts (i.e., the vertical distance between a ship's keel and waterline)—affects fuel consumption. The trim is selected by the crew, who should take into consideration the weather, sea and loading conditions. Using information derived from ECM, the optimal trim can be identified, implemented and subsequently transferred to sister-ships built with the same design. Likewise, ECM can provide data to onshore ship managers about the optimal timing of propeller and hull cleanings. Such cleanings reduce vessel resistance through the water and lower fuel consumption, and detailed, real-time data from ECM will allow ship managers to execute such cleaning whenever necessary.

ECM is also seen by interviewees as instrumental for raising energy efficiency awareness among crews and shore employees. For instance, frequent rudder movements in open sea will cause a vessel's fuel consumption to increase unnecessarily. When valid and reliable ECM data are available in real time, crews will be able to detect this and adjust behaviour accordingly. A few technical interviewees also explain that data from ECM can be used as a basis for vessel fuel-saving competitions. Typically every quarter, the crew on-board the best-performing vessel of the fleet receives a bonus to share for on-board well-fare activities. This is seen as a tool for raising awareness, though only used explicitly in two of the case companies.

4.1 Lack of transparency

Based on the interviews, diverse ECM practices have emerged and the best practice has been discussed with the interviewees. The interviewees, regardless of position and education, agree that a cost-effective potential for fuel saving in ship operations exists, even on-board vessels seen as well operated. Several interviewees also note that fuel saving and ECM were not on the agenda in the 1990s and early 2000s, when fuel prices were significantly below 2004–mid-2014 levels. With very few exceptions, the shipping companies did not have such systems in the 1990s and early 2000s because fuel did not constitute a major cost. Because ships typically have a life-cycle of 25 years, most of the current world fleet originates from that era (UNCTAD, 2014). Among the interviewees, neither the seafarers nor the shore employees who were educated and trained prior to the mid-2000s remember energy efficiency as part of their curriculum.

Following the rise in fuel costs in the mid-2000s and a significant drop in freight markets in 2008, many shipping companies started to set up ECM to reduce fuel costs, but as documented below, ECM practices still differ. In combination with the rising fuel costs, IMO made SEEMPs mandatory from January 1st, 2013. An SEEMP should aim at continuous improvements of energy efficiency and follow four stages (Figure 1). Previous research has compared the SEEMP requirements with various onshore energy management systems and concluded that requirements for the SEEMP are vaguely formulated (Johnson et al., 2013). The interviews confirmed this conclusion: To the extent that the interviewees know about SEEMP, the majority denies that SEEMP requirements have caused any significant changes in ECM practices and see SEEMP mainly as a compliance matter.

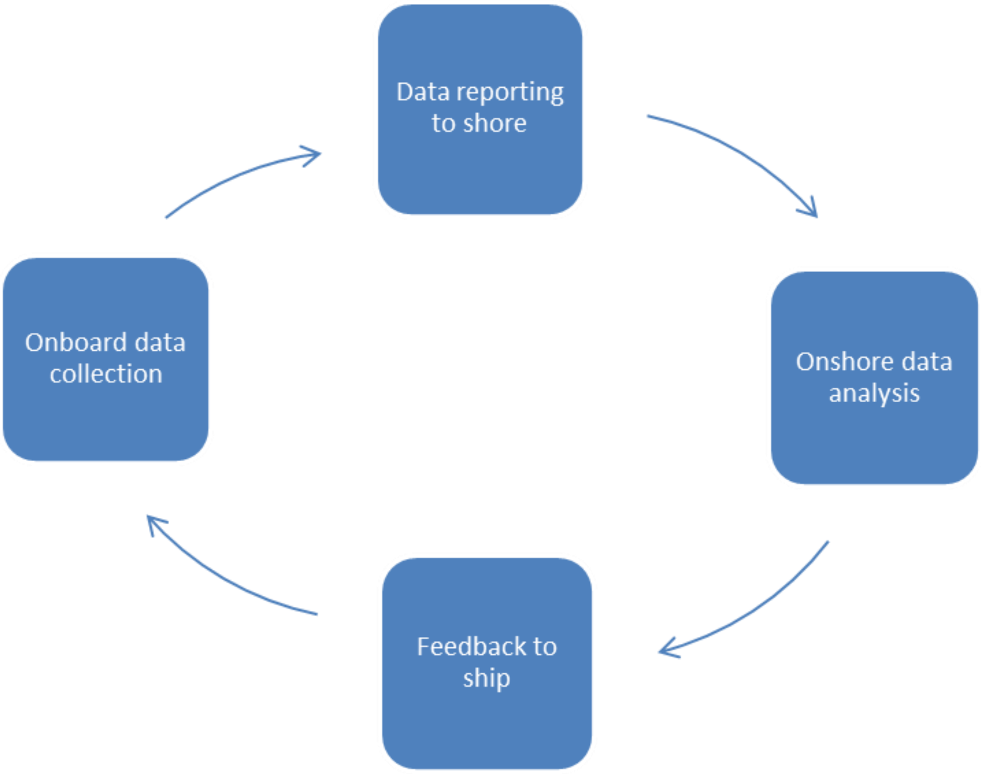

Figure 1. Four, typical stages in ECM in shipping were identified in the interviews.

It is clear from the interviews that ECM best practices are not widely applied in ship operations between 2012 and 2014 despite the high fuel prices. Most shipping companies are unable to answer the above three ECM questions properly for some or all ships. The fundamental problem in ECM practices between 2012 and 2014 has been one of data validity and reliability, and lack of transparency has hampered energy management and fuel-saving efforts (Figure 2). Five problems regarding ECM data sets were evident in the interviews:

- Lack of ECM baselines
- Lack of long ECM time series
- Lack of real-time ECM data sets
- Lack of ECM sub-metering on-board
- Noise in ECM data sets

Due to these lacks, cost-effective fuel-saving initiatives are difficult or impossible to identify, and energy efficiency awareness at sea and onshore suffers accordingly. Decision makers are not able to see the consequences of their actions on energy consumption and lack guidance in all fuel-saving efforts.

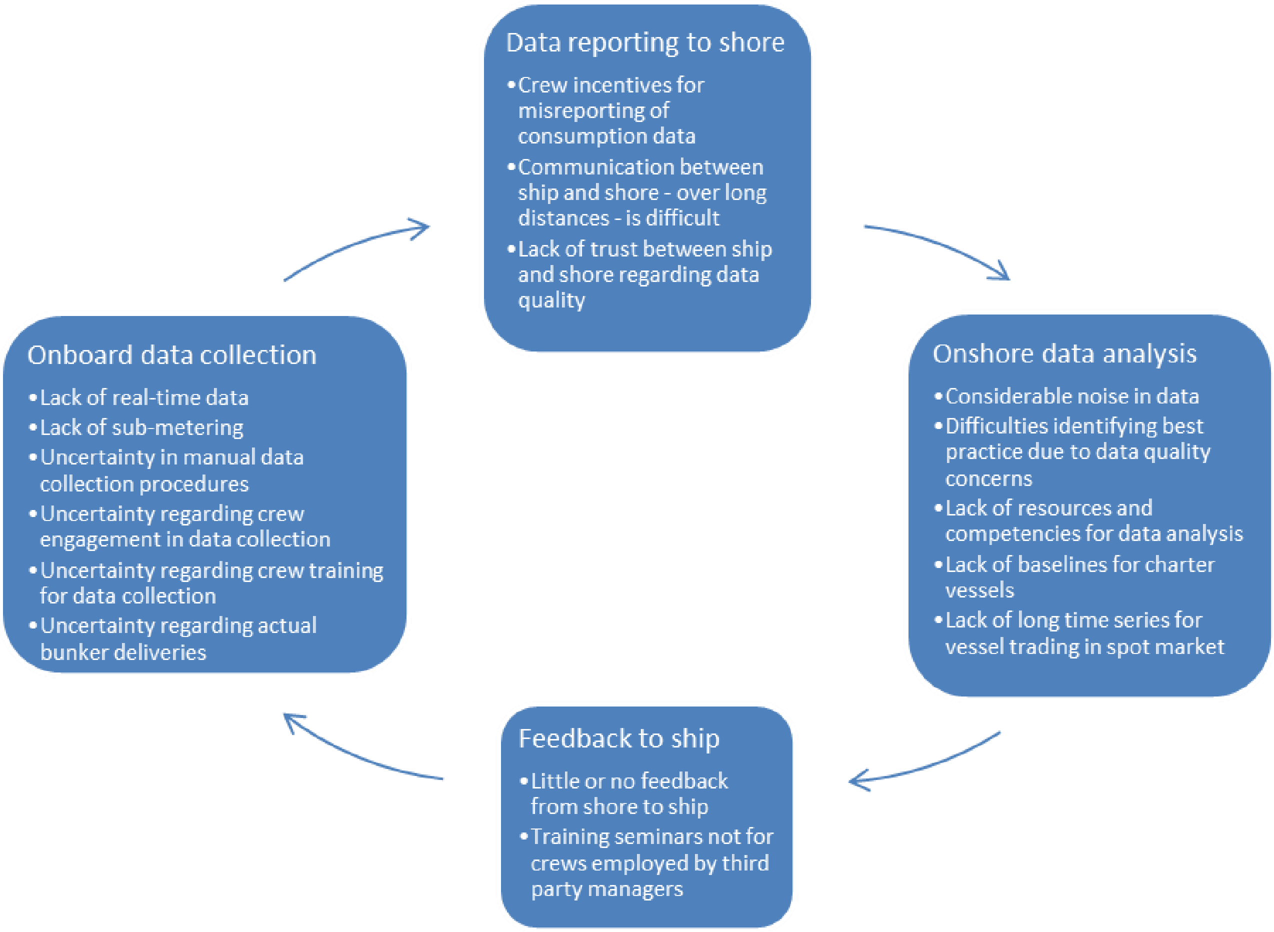

Figure 2. Current problems related to ECM, which were identified in the interviews.

4.2 Data collection challenges

In the interviews, two fundamentally different approaches to ECM were identified: 1) Auto-logging systems with on-board sensors, which require little or no intervention by the crews and 2) Manual logging systems, which require chief officers in the navigation and engine departments to collect data manually. The latter system is commonly referred to as noon reports because data are collected at sea at noon and subsequently sent to shore organizations for analysis. The frequency with which ECM is performed differs between the two systems. In the auto-logging system, continuous monitoring is possible, whereas the manual logging system entails data collection once every 24 hours. A few investigated companies have recently started experiments with auto-logging for selected parts of the ship's equipment, but in all the cases, the noon reports remain key tools for data collection.

Interviewees with seafaring background or in onshore shipping company ECM units or classification society positions agree that lack of real-time data prevents decision makers at sea and onshore from making adequate and prompt changes in ship operations to save fuel. Because ECM is only performed once a day, crews and ship managers cannot immediately see the effects of their decisions and correct for inefficiencies.

While acknowledging the limitations of the manual logging systems, several interviewees with ECM expertise in class societies and ECM data analysis units remain sceptical about auto-logging systems. They fear that crews will lose engagement in energy efficiency if they are detached from data collection. The challenge, as they see it, is to set up systems to engage crews in the collection of high-quality data and this is a time-consuming process, which requires long-term trust building between ship and shore.

Similar problems concern on-board sub-metering. Vessels have numerous energy consumers on-board, and inefficiencies in one consumer may be concealed in aggregated ECM data sets. The technical interviewees clearly state that a large share of the world fleet is still not equipped with sufficient sub-metering equipment to allow for disaggregated ECM.

4.3 Incentives for data misreporting

The interviewees with a technical or seafaring background share a critical perspective on data from noon reports. According to some, crews often deliberately over-report fuel consumption. In this way, they build up a "secret" quantity of fuel to sell on the black market. A lack of appropriate, on-board equipment for ECM, such as flow metres (which measure fuel flows accurately in real time), effectively causes a moral hazard problem. From the interviews, the frequency of such problems cannot be estimated, but the fact that these claims came up in several interviews clearly demonstrates a lack of trust between ship and shore with regard to ECM.

Some interviewees, i.e., those with personal seafaring experience, point to another cause for crews over-reporting daily fuel consumption: insufficient fuel deliveries from fuel suppliers. A large share of the world fleet is not equipped with flow-meters on the fuel delivery line, which would allow crews to exactly measure fuel quantities delivered from suppliers in real time. For that reason, actual fuel deliveries are often claimed to fall short of the quantities specified in supplier contracts (the so-called bunker delivery notes). Crews usually realize deficiencies in fuel deliveries too late (after departure from port), and any legal actions vis-à-vis fuel suppliers are therefore difficult. Instead, crews conceal the problem by over-reporting daily fuel consumption to the shore organization in the shipping company. In this way they try to avoid the risk of legal action in the case of a port state control. As part of port state control procedures[3], vessel fuel tanks and the mandatory on-board fuel reports are often thoroughly controlled and compared. If any discrepancies are identified, crews face serious legal action from port states. In other words, the lack of vessel flow metres often causes two moral hazard problems: insufficient fuel deliveries from suppliers and misreporting of fuel consumption by crews.

An interviewee working in a shipping company ECM unit sees cases where ship operators or fleet managers in shore organizations encourage crews to underreport daily fuel consumption. In time charter parties, maximum daily fuel consumption is specified because charterers pay for fuel. If the limit is exceeded on a single day during the voyage, ship owners' shore operators can discreetly ask crews to underreport consumption on that specific day. This will allow the ship owner to avoid any claims from the charterer, who will not notice the problem as long as the average daily fuel consumption remains below the specified

[3] Port State Control refers to the power that national authorities have to board, inspect and detain vessels under foreign flags calling at their ports. A system of regional Memoranda of Understanding on Port State Control (e.g., Paris MOU) exists, according to which vessels are inspected. The Port State Control officers inspect vessel compliance with IMO standards, including the lack of equipment on board, insufficient maintenance, lack of crew training, etc. In cases of non-compliance, port state control officers have the power to detain vessels until problems have been rectified, thus causing a costly delay for shipping companies. In case of multiple detentions, ships can be banned from calling in any of the MOU ports (DeSombre 2006; Stopford 2009). A list of detentions and bannings under Paris MOU are available at https://www.parismou.org/

maximum over the whole voyage. This is another clear example of moral hazard problems. If reliable and valid ECM data were available in real time for all parties, such practices could not occur.

From the interviews, the frequency of ECM data misreporting cannot be assessed, but the common stories of such practices clearly reveal distrust with respect to the reliability of ECM data available within organizations and in markets. The data concerns hamper fuel saving efforts in international shipping, and ECM best practices remain elusive. Moreover, investment decisions in fuel-saving measures are hampered for the same reason.

4.4 Data analysis problems

The normalization of ECM data collected on the ships remains a challenge today, and several interviewees in ECM analysis positions have shown us data sets that suffer from considerable noise. They struggle with data analyses and lack long time series to identify trends and assess fuel saving initiatives. This is partly due to the relatively short history of ECM practices, most of which were implemented only after 2008. However, the same managers seem confident that time will allow them to improve their analytical results. In other words, the recently started ECM efforts have not made a full effect on energy efficiency in the ship operations. Trim optimization and hull and propeller cleanings are mentioned as some of the most common focus areas in the first phase of ECM, but several ECM managers have more ambitious plans to enhance the details in their systems, i.e., to incorporate more aspects of ship operation in due course.

While the above indicates some improvements in the data quality, this does not cover the whole spectrum of international shipping operations. ECM experts and Chief Technical Officers generally agree most progress is observed for vessels that are operated by the same organization and people for several years. This allows everybody to form a sufficiently long-term perspective of ECM. For vessels on short-term charters, i.e., vessels that do not belong to charterers' "core fleets", major challenges remain. For ECM to work properly, a baseline for each ship (historical data about a ship's energy consumption) is required, and this is very rarely, if ever, available for vessels on short-term charters (spot charters or time charters with a few months duration). Lacking a baseline, charterers cannot benchmark and assess the current performance properly.

While some of the companies have set up shore departments to analyse the ECM data set, recruited new employees for these functions, or engaged with consultants to do the job, not all companies followed this track. In these cases, interviewees refer to company chartering and crewing policy to explain why this is not the case: If ships are chartered for short periods of time (weeks or a few months), efforts to improve ECM and reduce fuel consumption during such short spells are futile. The business practices used in chartering and crewing are not compatible with ECM best practices.

4.5 Feedback problems

Crews and shore employees are far apart, and they meet rarely, if ever. Building trust under such circumstances takes time and effort, according to the interviewees, and this is often a problem. Interviewees see feedback on ECM from shore organizations to crews as an important tool to build trust and support ECM efforts. According to several interviewees with seafaring background, crewmembers feel they receive little or no feedback, and this reduces their awareness of and engagement in ECM.

To improve feedback channels from shore to ship, several companies have recently set up officer training seminars, which focus specifically on fuel saving and ECM. Their aim is to build a common ground for trust and knowledge-sharing among crews and shore employees with regard to ECM and fuel saving. So far, the interviewees, who have been involved in these seminars, assess experiences positively. However, such seminars are typically for a restricted part of the fleets, focusing only on vessels that are operated by the same organization and people for several years. Generally, crews on short-term chartered vessels are not invited to such training seminars because chartering periods tend to be relatively short and because crews are not employed by the charterers. The same applies to ships, which are under third-party ship management, where crew training is the responsibility of the ship manager.

In two company cases, ECM data are used as a regular basis for vessel fuel-saving competitions. ECM data sets for all ships in the fleet are published on-board, and this is seen as a feedback mechanism from shore to ship. The goal is to raise crew awareness of energy efficiency. Given the variable nature of ship operations and weather and sea conditions, the legitimacy of such systems strongly depends on data validity and reliability. Such data are only available for a restricted group of vessels, which operate on the same scheduled liner services year-round. Here, the effect on awareness can be significant, according to technical shipping company interviewees. Interviewees from companies with vessels trading world-wide (mostly tankers, dry bulk and multi-purpose vessels), however, are generally sceptical about incentive programs, arguing that sufficient ECM data are unavailable.

5 How business practices affect ECM and energy efficiency

Conditions for ECM best practices are rarely fulfilled in ship operations. Best practice requires several years to implement, but prevailing business practices in shipping are often based on shorter time perspectives. In other words, the logic of ECM does not correspond to common business practices. Two explanations for the shorter time perspective emerged from the interviews. These explanations are related to the commercial nature of the charter market and the temporary organization of the ship operations.

As described in Section 1.2, a considerable part of the world fleet operates under various types of charters, many of which have durations of weeks or a few months. This conflicts with the logic of ECM best practices, which requires much more time to implement. On short-term charters, ECM is not a priority and other commercial imperatives explain the observed business practice (as described in Section 2). Such charters typically expire long before the effects of fuel-saving initiatives have been properly identified in the ECM data. Under such circumstances, ship fuel-saving competitions aimed at raising awareness, as applied by two liner-shipping companies in the sample, are impossible to implement. This means that crew and shore-staff cannot follow all stages of fuel-saving initiatives nor observe the effects of the initiatives. Time charterers, who pay for fuel, rarely focus on crew energy training because they rarely benefit from such initiatives. By the time these initiatives have a measurable effect, the charter will have expired. The short-term charters also hamper communication, trust building and knowledge sharing between ship and shore, and all parties tend to doubt the reliability and validity of the ECM data.

ECM best practices require continuity in ship and shore organizations and in the relations between the two. Temporary organizations for ship operations, however, are often observed and hamper ECM efforts. Temporary organizations have a short duration of only a few months and are usually caused by high crew turnover and frequent crew changes. If crewmembers do not return to the same ship after onshore leave, the reliability of the ECM data in the noon report may suffer. According to ECM experts, crewmembers tend to apply different data collection procedures for ECM: some are more diligent and interested in ECM than others. Moreover, crewmembers who often move between ships cannot follow all stages of fuel-saving initiatives. Given the inherent difficulties of communication between ship and shore, knowledge sharing and trust building are particularly challenging for temporary organizations. The rollout of best energy management practice (for instance, optimal trim) within a fleet is only possible after best practice has been clearly identified in cooperation between ship and shore organizations. This is incompatible with temporary organizations.

In the sample, a firm financial situation did not explain the success with ECM. The sample included distressed shipping companies, which had recently set up dedicated ECM units and hired ECM experts to reduce vessel fuel consumption. On the other hand, the sample also included examples of profitable shipping companies, which relied fully on chartered vessels, and which did not have dedicated ECM units. The short durations of the charters were referred to by interviewees to explain why the companies did not have dedicated ECM units. Firm size—or more precisely fleet size—could have a positive effect on ECM practices because benchmarking in a large number of vessels is more likely to provide valid and reliable ECM data than benchmarking in small fleets.

In the energy efficiency literature, make-or-buy decisions are often referred to in explaining energy efficiency gaps. Principal-agent problems can occur if a decision maker (agent) does not pay for fuel costs, which are passed onto the principal. Theoretically, such problems occur in ship operations when fuel is paid by a time-charterer (the principal), not the ship owner (the agent). While this does occur in short-term time charters, it is evident from the interviews that fuel-saving initiatives and ECM best practices can also be applied to ships on long-term charters (time and bareboat charters with durations of years). For the two companies in the sample that employ ships on long-term charters and use vessel fuel-saving competitions, several chartered vessels have outperformed the owned vessels in terms of fuel saving. According to interviewees, the ships are chartered for so long that improved ECM practices make commercial sense for the charterer. In other words, it is not a matter of who owns the ship per se, but a matter of how long the party, who pays for fuel, operates and controls the ship.

6 Discussion

The role of information is common in the general energy efficiency literature (see e.g. Sorrell et al., 2004, pp. 33-43) and has also been emphasized in the shipping literature. In a survey of Norwegian ship owners, Acciaro et al. (2013) highlighted the availability of information as a "barrier" to energy efficiency. Agnolucci et al. (2014) concluded in a study of energy efficiency in time charter contracts (where the cargo owner pays the fuel) that only 40% of the fuel savings gained through better energy efficiency accrued to the ship owner, thus reducing incentives for ship owners to address energy efficiency. Based on these findings, they argued for greater transparency on energy consumption between these parties. In a study of five Norwegian ship owners engaged in a collaborative energy efficiency project, (Jafarzadeh and Utne, 2014) found, amongst other aspects, various information-related "barriers" to energy efficiency: inaccuracy of information, the lack of credibility and trust in the source of information, not using information, and not maintaining information. Johnson et al. (2014) performed an action research case study on implementing an energy management system in a short sea shipping company and argued that lack of access to reliable information on energy consumption was a "barrier". This study has contributed to this research stream by describing the wide range of ECM practices employed in shipping, discussing the associated problems, and placing these practices in a commercial context.

The notion that it is necessary to understand practices within and between organizations to explain energy efficiency gaps is not new. "Organizational barriers" are a part of the much developed and explored barrier taxonomy (see Sorrell et al. (2004), Thollander and Palm (2012) or Cagno et al. (2013) for thorough discussions). Further, researchers have drawn upon Prahalad and Hamel (1990) and noted that energy efficiency may be neglected because companies focus on their "core business" and that energy efficiency has a "non-core" character (Cooremans, 2011; Thollander and Ottosson, 2010; Thollander and Ottosson, 2011). The focus on practices rather than mechanisms or principles (e.g., barriers) has enabled this study to delve deeper into this issue through discussing *in which ways* energy efficiency could be said to be "non-core business". After all, "the role of the investigator is not to discover final causes, because there are no final causes. Rather, it is to unearth… schemes and expose their contingency" (Law and Bijker, 1992, p. 292). Of particular importance was the choice not to limit the study to technical experts in energy efficiency ("energy managers", etc.) but to also include CEOs and commercial managers. Accounts of ECM practices that are "wrong" are also important, not only those that are "correct" (see also Bloor, 1976/1991).

On the other hand, refusing to summarize findings in terms of barriers and drivers makes it more difficult to make recommendations to policy-makers or company managers. Which "mechanisms" (see, e.g., Weber (1997)) should now be inhibited, and which should be encouraged? Shove asked similarly: "But if there are no barriers or obstructions to overcome is there then any useful role for social science?" (p. 1109). The argument, however, is not that "there are no barriers to energy efficiency". Rather, it can be argued that if "barriers" are to be mitigated and "drivers" are to be supported through policy, it is necessary to also show *how* these are created and upheld; the barriers themselves still need to be explained (see also Latour, 2005, p. 108). It is doubtful whether summarizing descriptions into physical metaphors such as "barriers" or "drivers" is always the most productive way to make a theoretical contribution. Weber (1997, p. 834), oft quoted in barrier-model studies, argued that

"Barrier models assume that improved efficiency is the result of a particular action (e.g. buying more efficient equipment, retrofitting building shell or decree of an energy tax). Energy conservation, which results from the omission of an action (e.g. not buying a certain machine) or doing something in a different way (e.g., integrated instead of isolated planning), cannot be described by a barrier model. Barrier models are limited insofar as they can only describe energy conservation in the sense of positive actions. Thus, they do not represent the whole range of energy conservation options."

Many of the companies in this study indeed "did something in a different way". It remains to be explored whether new metaphors or something completely different is needed. Czarniawska (2013, p. 106), following Blumer (1954), argued for an alternative—albeit in a different context—that "the aim of theory remains the offering of some kind of understanding of the world, its possibilities for development, and the directions along which it can move. The main concerns of such a theory should be not the highbrow… abstractions, reified into entities, but the on-going construction of the world or certain parts and aspects of it."

The descriptions and discussions of ECM practices in this paper promote a discussion on GHG policy for the shipping sector. In particular, this paper has highlighted the heterogeneity of business practices and their time scales. The market failure argument for policy intervention has not been directly employed in this paper, although the reader would not be at fault for generalizing the arguments along these lines (cf. Greene, 2013; Greening and Jefferson, 2013). It is clear from this study that access to valid and reliable data depends on ECM practices and that best practices are hampered by current business practices.

7 Conclusion and policy implications

A shipping company CEO addressed the issue of global climate change towards the end of one of the interviews:

> As seen from a broader environmental perspective, focused on the best for the world… some practices should be regulated… A schism… exists. For society, the mitigation of a temperature increase and reduction of pollution will be a benefit. However, more narrow economic interests may go in the opposite direction. Regulation is necessary, and it should apply to everyone, to create a level playing field... This is what the IMO does, regulates practices.[4]

Based on 55 interviews, this paper has highlighted four common problem areas within ECM: data collection challenges, incentives for data misreporting, data analysis problems, and feedback problems. "Split incentives", referring to the contractual situation where the charterer and not the shipping company carries the fuel cost, is often quoted as a "barrier" to energy efficiency in shipping. However, this was not seen as a problem per se in this study but rather something that could be solved with longer contractual relationships. Aspects such as size, financial situation, and trade did not explain the success with ECM. The ECM practice

[4] Authors' translation from Danish to English.

was seen as essential for implementing measures that improved energy efficiency, be it better maintenance, better ship operation, or technical improvements to ships.

Shipping company executives, charterers and crews should certainly not be seen as irrational within their respective business contexts, despite the potential for increasing efficiency through cost-effective measures. Rather, the advantages granted by choosing certain business practices, especially the flexibility inherent in short-term charters and temporary organizations, are understandable given the volatility of the industry. Many companies do not have the time or the incentives to implement ECM best practices under such conditions. At present, incentives for the *misreporting* of data even exist. What this study has identified as best practices is more feasible for vessels that are operated and crewed by the same company and people for years. A vast part of the world fleet, however, is not operated under such conditions. In this way, the study contributes to the energy efficiency literature by explaining how and why common business practices lead to energy efficiency gaps in ship operations. It provides new insights into the logic of good energy performance monitoring practices in shipping and provides new evidence as to why common business practices in shipping companies often conflict with this logic.

Previously researchers have argued for urgent changes in business models in the shipping industry as being necessary for reaching reductions in total GHG emissions from the industry. However, what could policy makers possibly do to change successful (albeit not energy efficient) business practices? The study finds a certain paradox in that successful ECM practices are necessary for improving energy efficiency in an organization, but investments in ECM systems may be difficult to motivate without good access to such data. In particular, this applies to the fragmented organization of ship operations, with many parties involved with different business practices and sometimes counteracting incentives. Unfortunately, in the EU MRV framework, choices of ECM practices are left for the industry to decide and the four major problem areas listed above are not taken into account. It is thus doubtful that the MRV will lead to greater transparency. In conclusion and given that

1) Policy makers want to improve the availability of trustworthy information on energy consumption in organizations and markets,

2) Current policy does not mandate best ECM practice that would provide such information, and

3) There may be a lack of commercial incentives to implement best ECM practices in parts of the industry,

there is a role for either policy makers or other third parties in providing governance through mandating or standardizing such best practices. Researchers can play a role in such a process by providing further knowledge of how shipping companies work with ECM in their organizations, and the possibilities for standardizing such practices. Of special interest would be the cases of successful ECM in companies that are expected to have difficulties, i.e., those with short-term vessel charters and temporary organizations. Finally, this study was limited to ECM in a part of the sector that is known for 'quality shipping'. Studies of shipping in other parts of the world would be enlightening to reveal the scope of the problem at hand.

Appendix 1: An example of an interview guide for an ECM expert and an executive in a tanker shipping company

Business practices

- Could you please explain briefly the main activities of your company?
- Do you have long-term relations with cargo-owners or charterers?
    - What expectations do cargo-owners (oil majors) have for your services?
- Do you charter vessels in or out?
    - What types of charters to do you engage in?
    - And with what durations?
    - If you charter in vessels, how do you select them?
    - Do you observe differences between chartered and owned vessels?
    - If yes, which and why?
- How do you crew your vessels?
    - Do you employ your own crews onboard the vessels or use third part ship managers?
    - Why?
    - What are the advantages and disadvantages of using in-house crewing and third party ship management, respectively?
    - How frequently do crews change?
- What are the key sources of corporate competitiveness in tanker shipping?
    - Who pays the fuel costs?

Potential for fuel saving

- In your annual report you provide information on fuel saving initiatives in your company in the last couple of years:
    - What are your experiences in this regard?
    - How did you achieve the savings?
    - What were the major challenges in this regard?
    - Have the initiatives surprised you in any way?
- Have you now realized the full potential for cost effective fuel saving measures?
    - If no, why not?
    - And where does a potential exist?
    - Are you sure such initiatives are cost effective?
    - What is the fuel saving potential with regard to operational measures? Speed reduction, voyage execution, power management, performance monitoring?

How and why ECM is performed

- How do you monitor fuel consumption onboard your fleet?
    - How frequently do you monitor vessel fuel consumption?
    - What are the procedures you employ for monitoring of vessel fuel consumption?
    - For how long have you done so?
    - What is the level of detail in your fuel consumption monitoring? What is monitored?
- How do you analyze the fuel consumption data that you gather?
    - What methods do you employ to analyze data?
- What do you use ECM data for? Why?
    - Did you ever consider implementing fuel saving competitions between your vessels? Why/why not?
    - Do you provide crews with feedback based on the ECM data analysis? Why/why not?
    - In case you provide feedback, how do crews react to this?
- Do you observe any difference in terms of energy efficiency performance within your fleet?
    - If yes, how big are the differences?
        - Are they also observable between sister ships?
    - If yes, which ships are best in class and which are the worst performers?
        - Why?
    - How do you address differences in performance between vessels?
- Do you have a SEEMP?
    - If yes, who formulated it?
    - Why did you establish it?
    - Do your ships have individual SEEMPs or are SEEMPs identical for all vessels?
    - What effects (if any) do the IMO SEEMP requirements have on your business?
- How do you perform in terms of fuel saving and energy efficiency when compared to competing shipping companies?
    - How do you know?
    - In the case of a performance difference, what is the reason for this?

Validity and reliability of ECM data and ECM best practices

- What is the quality of the ECM data you receive from ships?

- Other interviewees have explained that they observe significant noise in ECM data: Is that also the case for you?
- Does ECM data quality vary? If yes, when and why?
- How do you assess the quality of noon reporting systems and auto-logging systems?
  - Which of the systems do you prefer? Why?
- Do you have flow meters installed onboard your vessels?

- What are ECM best practices for you?
- Interviewees in other companies have explained how they experiment with various fuel saving measures, such as the ones mentioned below. Would they be relevant for your?
  - Continuous ECM and auto-logging systems?
  - Vessel fuel saving competitions?
  - Energy efficiency training courses for crews?
  - If no, why not?
- According to your annual report, you energy efficiency initiatives focus on owned vessels, rather than chartered?
  - Is this correct?
  - If yes, why?
  - Can experiences gained on the owned fleet be transferred to chartered vessels? Why/why not?
- Which roles do crews and shore organizations have in regard to fuel saving?
  - How do you engage crews and shore employees in fuel saving efforts?
- What are the ideal conditions for fuel saving?
  - Does outsourcing of ship management influence fuel consumption?

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