Cleaner shipping drivers as ecopreneurial opportunities

The case of Frederikshavn


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Trade and maritime transportation growth attract a closer look into the shipping industry environmental performance. The worldwide maritime sector adopts "green shipping" practices. Green shipping has spurred the demand for pollution control technology, cleaner fuels, and best management practices. Other industry sectors adopt sustainability by the interrelation of technology push, regulation push, market pull and business internal drivers. These drivers may create a demand for eco-innovations which will help the industry sector to fulfill its sustainability requirements. Yet, "green" entrepreneurs' role is an attention subject about the technological eco-innovations market introduction. This case study uses qualitative data to explore how the drivers of green shipping are creating incentives to ecopreneurship. The case study focuses on Frederikshavn kommune and counts with two maritime clean tech entrepreneurs as units of analysis. Overall, the case study found that regulations will induce cleaner technology adoption in the maritime industry. Meanwhile, the demand for cleaner technology is likely to create a business opportunity for new entrants (e.g. ecopreneurs). Information intermediaries are important players to inform potential entrepreneurs about these opportunities. Yet, some requirements bound maritime clean tech ecopreneurship. The first requirement is a previous experience in the maritime business. The second is partnership with incumbent firms. These findings suggest that the maritime sector faces technological path dependence. However, a strong regulatory scenario can bridge opportunities for the introduction of eco-innovations. These opportunities may be exploited by new entrants to some degree. The most important barrier being the high technology development costs, and the high risks associated to the clean tech introduction.

To my wife, Catherine Galvez Hooper

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Abbreviations

BWMS	Ballast Water Management System
CSR	Corporate Social Responsibility
ECA	Emission Control Areas
GSF	Green Ship of the Future
HFO	Heavy Fuel Oil
IMO	International Maritime Organization
KASK	Kattegat and Skagerrak
LNG	Liquefied Natural Gas
MARCOD	*Maritimt Center for Optimering og Drift*
MARKIS	Maritime Competence and Innovation Cooperation in the Skagerrak & Kattegat
MARPOL	International Convention for the Prevention of Pollution From Ships
NMVOC	Non-Methane Volatile Organic Compounds
NOx	Nitrogen Oxides
OECD	Organization for Economic Co-operation and Development
SCR	Selective catalytic reduction
SECA	Sulfur Emission Control Area
SME	Small and Medium Enterprise
SOx	Sulfur oxides
TBL	Triple Bottom Line
UNCTAD	United Nations Conference on Trade and Development.

Chapter 1
Introduction

Trade and shipping

Globalization and trade' environmental implications are subject of research interest. One research line focuses on the physical implications of increased trade flows over the last decades. According to Dittrich and Bringezu (2010), trade has dramatically increased between 1962 and 2005 (Figure 1). The data shows how 112 countries traded 5.4 billion tones in 1970 against 10 billion traded by 138 countries in 2005. This implies a factor 3.3 growth during the period.

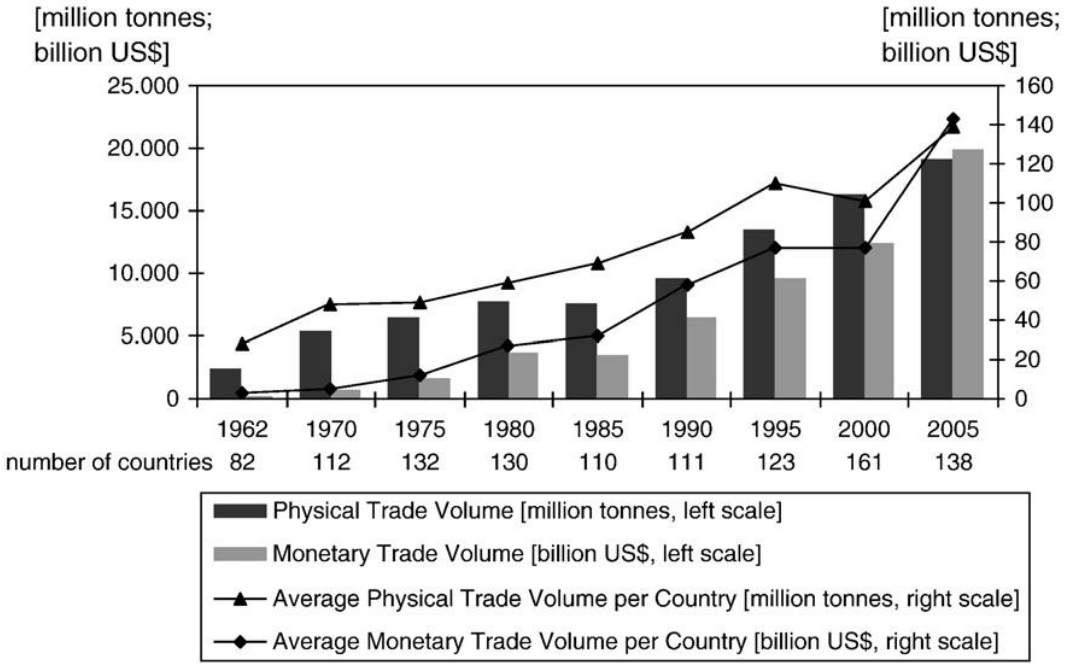

Figure 1- Physical and monetary trade volume between 1962 and 2005. *Source*: Dittrich and Bringezu (2010, Fig. 1).

The goods and resources move from export to import countries as Figure 2 shows. Net importing countries are the members of the European Union (EU), Japan and the United States (USA).

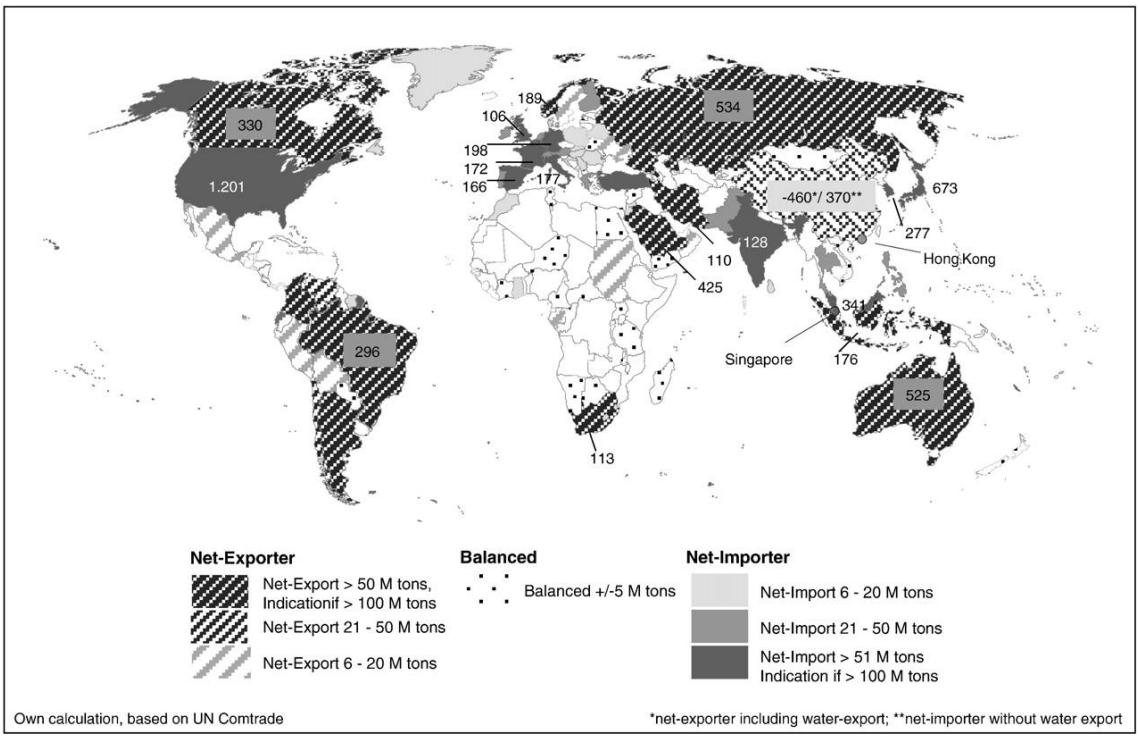

Figure 2- Geographical distribution of net import/ export countries (Year 2005). *Source*: Dittrich and Bringezu (2010, Fig. 8).

Exporting countries specialize in raw material and oil production (Australia, Africa, Persian Gulf countries, South America, Norway, Russia). The geographical scattering requires a reliable transportation system to move goods and merchandises. Seaborne transportation provides this service. As shown in Table 1, each commodity's volume increases over the years for three main shipment categories (oil, main bulks and dry cargo). Between 1970 and 2009 the increase was 5277 million loaded tons.

Table 1- Evolution of seaborne transportation for selected years (millions of tons loaded).

Year	Oil	Main bulks[a]	Other dry cargo	Total (all cargoes)
1970	1 442	448	676	2 566
1980	1 871	796	1 037	3 704
1990	1 755	968	1 285	4 008
2000	2 163	1 288	2 533	5 984
2006	2 698	1 849	3 135	7 682
2007	2 747	1 972	3 265	7 983
2008	2 732	2 079	3 399	8 210
2009[b]	2 649	2 113	3 081	7 843

Source: Compiled by the UNCTAD secretariat on the basis of data supplied by reporting countries as published on the relevant government and port industry websites, and by specialist sources. The data for 2006 onwards have been revised and updated to reflect improved reporting, including more recent figures and better information regarding the breakdown by cargo type.

[a] Iron ore, grain, coal, bauxite/alumina and phosphate. The data for 2006 onwards are based on *Dry Bulk Trade Outlook* produced by Clarkson Research Services Limited.

[b] Preliminary.

Source: UNCTAD (2010, Table 1.3)

Shipping environmental aspects

International shipment entails environmental impacts. According to Hjelle (2010), shipping's environmental impacts —and extensively, other transportation means — can be classified by geographic reach (local, regional or global) and environmental aspects (Table 2).

Table 2- Shipping environmental aspects and associated geographical scale.

Geographical reach	Environmental aspects
Global	• Air pollution (Global warming)

Regional	• Air pollution
	  ▪ SOx, NOx
	• Water pollution
	  ▪ Oil spills
	  ▪ Ballast water
	• Waste products

Local	• Air pollution ▪ NOx, SO_2, Hydrocarbons (HC), non-methane organic compounds and particles. • Water pollution • Routine shipping operations

Source: Own elaboration based on Hjelle (2010)

Air pollution cross cuts the three geographical scales, whereas water pollution is relevant at a regional and local scale. Finally, waste and other aspects are relevant at a local and regional scale respectively.

Ship fossil fuels' combustion generates air pollution. Residual fuels as bunker are still popular on board (by 1997, 70 to 80% of ships). Residual fuels are the remains of the refining process. Bunker has high concentrations of sulfur, ash, asphaltenes and metals. Diesel is also widely used as propulsion fuel on ships (Corbett, and Fischbeck 1997). Table 3 summarizes world ship fleet fuel consumption and pollutants emissions (Eyring et al. 2010).

As shown, CO_2 is the pollutant causing a global scale impact (global warming) and therefore entails media attention. Yet, shipping CO_2 emission is lower than other transportation means (IMO 2009). Shipping releases 931 million CO_2 tones as compared to the aviation 4757 million CO_2 tones contribution. Nitrogenous Oxides (NOx) and Sulfur Oxides (SOx) are regional interest pollutants and their main ecological impact is acidification of the oceans (Doney et al. 2007). Local interest shipping released atmospheric pollutants are Particulate matter (PM), Non-Methane Organic Compounds (NMVOC), Methane (CH_4), Black Carbon (BC), Particulate Organic Matter (POM).

Table 3- Upper and lower bound best estimates for world ship fuel consumption and pollutants release.

Year	Unit	2000 mean[a]	2000 lower bound[b]	2000 upper bound[b]	2005 mean[c]	2005 lower bound[c]	2005 upper bound[c]
Registered fleet fuel use[d]	[Mt]	250	120	370	300	150	450
Registered fleet CO_2	[Tg(CO_2)/a]	780	560	1360	960	450	1660
Registered fleet NO_x	[Tg(N)/a]	5.4	3.0	10.4	6.6	3.7	12.7
Registered fleet SO_x	[Tg(S)/a]	5.5	3.2	9.8	6.7	3.9	12.0
Registered fleet PM	[Tg PM/a]	1.4	0.4	3.4	1.8	0.5	4.1
Registered fleet CO	[Tg PM/a]	1.18	1.06	1.35	1.44	1.30	1.66
NMVOC[e,f]	[Tg NMVOC/a]	1.14	0.37	1.78	1.32	0.46	2.18
CH_4[e,f]	[Tg CH4/a]	0.14	0.05	0.23	0.17	0.06	0.28
BC	[Tg BC/a]	0.13	0.05	0.28	0.16	0.06	0.34
POM	[Tg POM/a]	0.14	0.12	0.82	0.17	0.15	1.00
Refrigerants	[Tg/a]	0.003	0.001	0.016	0.004	0.002	0.020

[a] Fuel consumption and CO_2 are taken from the IMO GHG study (Buhaug et al., 2008). The 2000 mean is derived as mean from Corbett and Köhler (2003), Eyring et al. (2005a) and Endresen et al. (2007) for SO_2 and from the mean of Corbett and Köhler (2003), Eyring et al. (2005a) and Endresen et al. (2003) for all other species except for BC and refrigerants. For consistency, the resulting non-CO_2 emission totals are scaled with the factor 1.04, which is the ratio of the IMO CO_2 value and the mean CO_2 value from Corbett and Köhler (2003), Eyring et al. (2005a) and Endresen et al. (2007). The Corbett and Köhler (2003) and Eyring et al. (2005a) results are for 2001 and have been scaled to 2000 fuel consumption and emissions by using the ratio of the total seaborne trade in 2000 and 2001 from Fearnleys (2007).

[b] Lower and upper bounds are derived from explicit uncertainty analysis for fuel consumption, CO_2, NO_x, SO_x, and PM and from expert judgement for the rest. Uncertainty ranges are taken directly or are derived from the work of Corbett and Köhler (2003, 2004), with extensions for HFCs and cargo methane. Generally, uncertainty ranges are derived using Monte–Carlo simulation by varying each parameter according to distributions on the estimates for fuel consumption and emissions for each pollutant.

[c] To calculate 2005 emissions, the 2000 emissions have been scaled with the ratio of the total seaborne trade (TST) in 2005 (29094) and TST in 2000 (23693) from Fearnleys (2007), see Fig. 4.

[d] Registered fleet includes passenger vessels, fishing vessels plus cargo ships, but not military vessels.

[e] Not including HC emissions from crude oil transport.

[f] NMVOC from crude oil transport (evaporation during loading, transport, and unloading) in 2000 is 1665 Tg and CH_4 is 0.294 Tg from Endresen et al. (2003).

Source: Eyring et al. (2010, Table 3)

Besides atmospheric pollution, water and sediments are polluted by routine shipping operations (ship generated solid and liquid residues). This pollution affects ports and adjacent areas (Darbra et al. 2009). The IMO International Convention for the Prevention of Pollution from Ships (MARPOL) attempted to regulate these pollutants through different conventions. Ng and Song (2010) list these conventions:

- MARPOL Annex I
  - Fuel Oil residues
  - Used engine oil
  - Bilge water
  - Wash water oil
  - Ballast water oil
- MARPOL Annex II/ III
  - Wash water chemical
- MARPOL Annex IV
  - Sewage
- MARPOL Annex V
  - Domestic waste
  - Food waste
  - Plastics
  - Dry cargo residue
  - Maintenance waste
  - Cargo associated waste

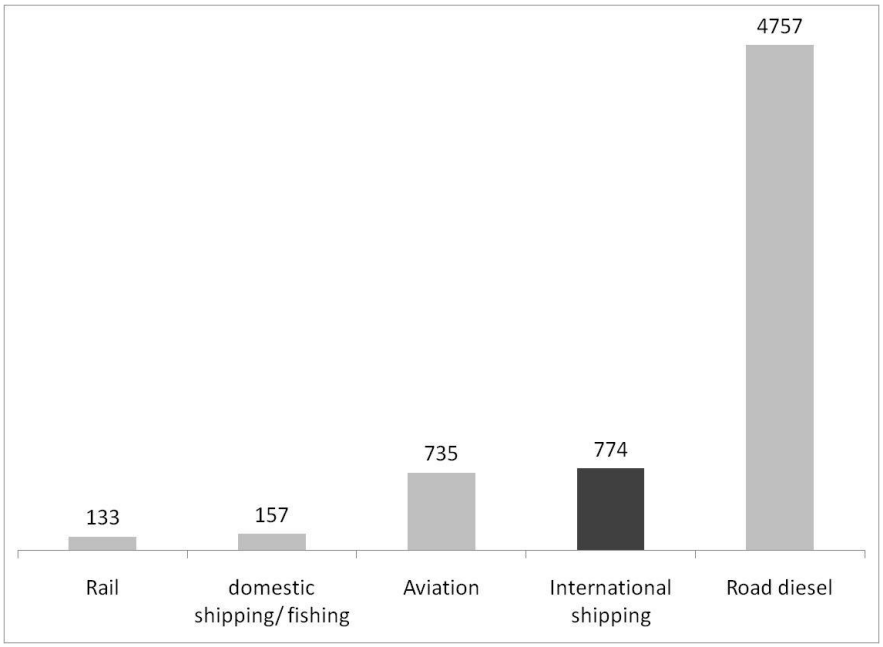

Figure 3- CO_2 emissions by transport mean (million tones, 2005). *Source*: International Maritime Organization (2009, Fig. 9.7)

Industry cleaner technology adoption drivers

Hitherto, the shipping sector addresses its environmental impacts through minimum efforts. Recently, major cargo companies have started to adopt the so called "green shipping practices". Green shipping practices encompass organizational and technological improvements to reduce some of the shipping environmental impacts — company policy procedure, shipping documentation, shipping equipment, shipper cooperation, shipping materials, shipping design and compliance (Lai et al. 2010). In the context of shipping, eco-innovations comprise the technological and non-technological improvements to address shipping related environmental aspects. This section introduces a model of eco-innovation technology change. Eco-innovation refers to:

> The implementation of new, or significantly improved, products (goods and services), processes, marketing methods, organizational structures and institutional arrangements which, with or without intent, lead to environmental improvements compared to relevant alternatives (OECD 2010).

The Push/ Pull innovation model by Rennings (2000) states that the adoption of sustainable technological innovations (eco-innovations) is driven by three factors (Figure 4): technology push, regulatory push and market pull. A fourth driver, "business internal aspects" has been proposed by Rubik (2005). Some authors argue that regulations can be the main eco-innovation driver (Ashford and Hall 2011). However, a case study in the European pump industry by Thiesen and Remmen (2008) avows that technology development can interplay with regulations. The case study showed how a Danish pump producer developed an energy efficient product. Thereafter, the company lobbied with other pump producers to obtain an European pump energy efficiency label.

In this way a market could be create. Therefore, instead of considering the four drivers as separate instances, they can be considered as interrelated components.

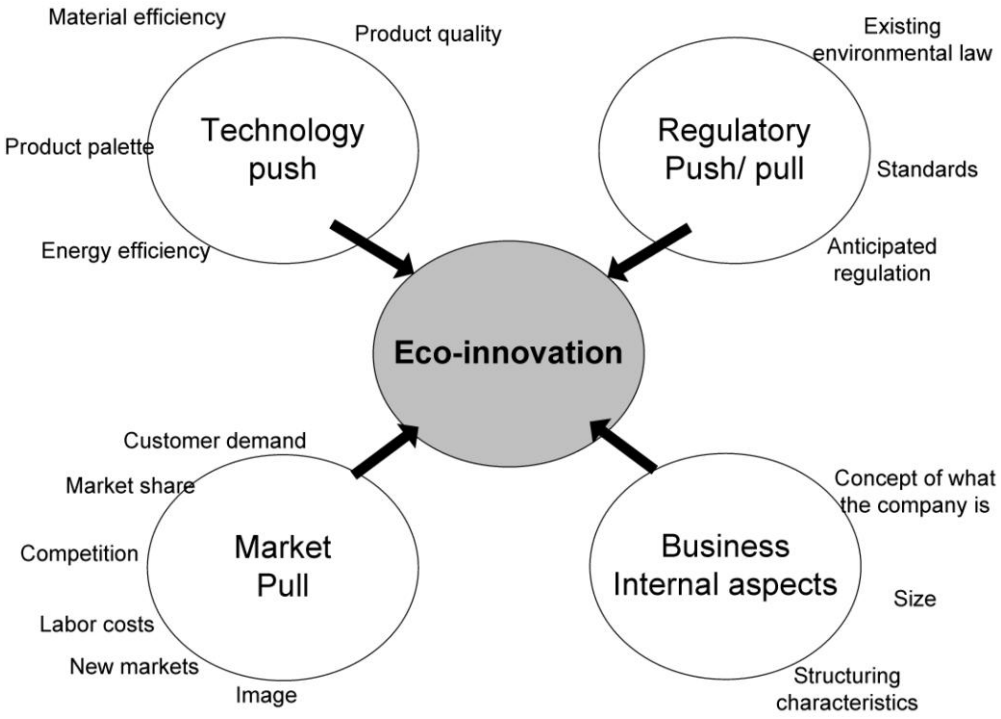

Figure 4- Drivers of eco-innovation. *Source*: Rubik (2005, Fig. 11.1).

Technology push refers to incremental innovations to existing technologies with the aim to save costs. According to Machiba (2010), technology push may imply product and process improvements. Examples of these improvements are pollution control, cleaner production and eco-efficiency. Pollution control has an "end-of pipe" focus when slight modifications after the production process aim to reduce the environmental burden. At product level Life-cycle design strategy (LiDs) is a redesign tool that seeks products with a reduced ecological footprint (Hellström 2007, 151).

Regulatory push, on the other hand, entails existing or forthcoming regulations that will change the "rules of the game" in an existing sector. Sometimes, mandatory pollution reduction legislation has this purpose. Depending on the sector, the coming legislation could be prescriptive (setting the specific kind of technology to reach a given target), or it can be goal based (to gather a certain pollution limit no matter which technology is in place). For some (Ashford and Hall 2011), regulation is the most important industry eco-innovation driver. The "Porter hypothesis" explains how regulation can spur eco-innovation. According to this hypothesis, strict product regulation may influence an incumbent firm interest to create less polluting products through more efficient processes. According to Ashford and Hall (2011), weak and strong regulations influence the likelihood of new entrants participating into the market. Weak regulations are likely to spur responses from the pollution control industry and regulated firm. The kind of response may be pollution control devices, inputs, process change and product

reformulation. Strong regulations are more likely to induce other producers (new entrants) to provide new products, product-services or processes.

Market pull, as a third driver of the model, lifts technological change by different mechanisms. Consumer pressure could be an important factor why firms adopt cleaner technologies. Besides, the firm's improved public image is another green technology adoption incentive.

The fourth driver of this model encompasses business internal aspects as firm's size, self-regulation initiatives and participation in business networks. Machiba (2010) considers these internal aspects to influence the adoption of non-technological eco-innovations (institutions, organizations and marketing methods).

Path dependency

Path dependence implies the adhesion of people to established "institutional path", and the unwillingness to "jump to another path" (Campbell 2004). Path dependence may jeopardize innovation. First, an innovation may encounter resistance if it is introduced radically (radical innovation) as compared as if this innovation was introduced incrementally. For example, in the case of East Germany, attempts to change the energy matrix from a coal dominated grid by including renewable energy sources, derived in fierce opposition by most of the stakeholders who made part of the energy regime in place. Path dependency was evident in this case as workers, laws, and the economy depended on coal energy generation (Hvelplund and Lund 1999).

Another path dependency problem relates to the "first mover" dilemma. A path dependency breaker innovation may gain competitive advantages when it explores another path that was not considered before. Being the first service, product or process are examples of competitive advantages. However, the problem arises when the first mover competitive advantage turns "lock-in". Lock-in implies a stable configuration of what once was an innovation. Lock-in results when other firms or actors create new innovations as a competition for the first-mover (Fagerberg 2006). At this stage, it is possible to escape lock-in by "path creation", which is the "process of de-embedding from the structures that embed economic actors (Schienstock 2005, 99).

Eco-innovations and Ecopreneurship

The diffusion of eco-innovations follows Wüstenhagen et al. (2008) model (Figure 5). The model proposes that consumers and suppliers are both responsible for the diffusion of eco-innovations. On early stages (X axe), some eco-innovations could be introduced by environmental entrepreneurs –startups or spin-offs (A). Later, some incumbent companies could also be interested to supply these innovations as well (B). As long as the eco-innovation has a good reception in the market, the suppliers (incumbents or entrepreneurs) can stabilize.

Meanwhile, the demand side also responds to the eco-innovation offer. Early on time, few companies will adopt eco-innovations. Early adopters may be the "innovators" (C). However, if the technology proves to solve the problem and create competitive advantages, more customers will adopt this technology over time — take-off and

maturity. The inset illustrates the Environmental Policy influence over the consumer side (E) and the investors' influence on the supplier side.

Incumbents, creative destruction, entrepreneurs

The role of "incumbent" players in this regard is questioned by Hockerts and Wüstenhagen (2010). Rather than large companies, it is the endeavor of small start-up firms "greening Davids" to bring radical innovations into the existing markets. This idea is rooted into a line of the business and management disciplines that can be traced back to the concept of "creative destruction", as initially proposed by Schumpeter in 1934 (Schumpeter 1994). Creative destruction implies the radical change of existing production/ organization paradigms by new actors that are able to introduce novelty into the business.

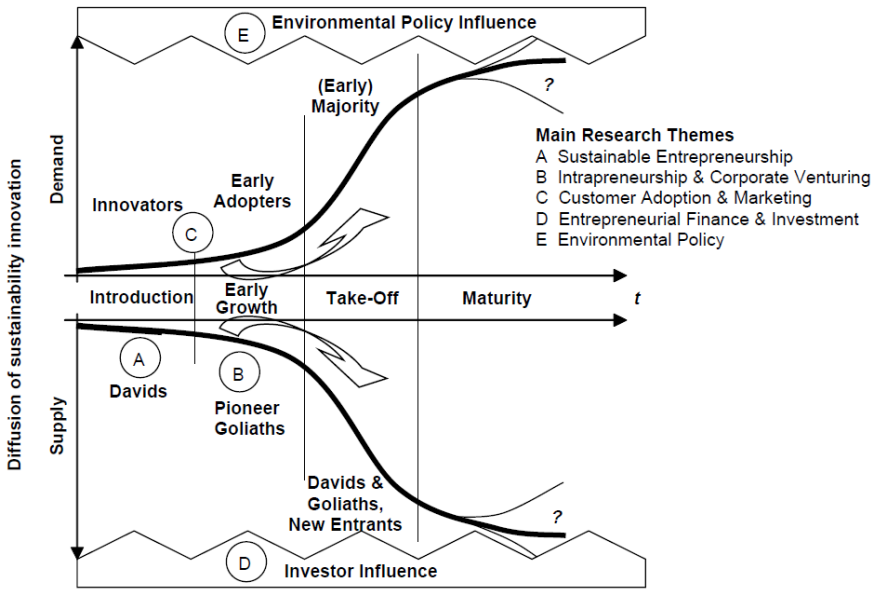

Figure 5- Relation between supply and demand sides on eco-innovation's diffusion. *Source*: Wüstenhagen et al. (2008, Fig. 1.1).

Entrepreneurship unfolds how this "creative destruction" can be promoted or enhanced. Therefore the entrepreneurship concept encompasses different scales and issues: starting a new business from the ground (start-up), expanding a firm or the venturing into new spheres of action (Schaltegger 2002, 48-49). Besides, several scholars foresee entrepreneurship as a social movement, that capable to tackle poverty and environmental degradation at the "bottom of the pyramid" (Hart and Christensen 2002). This paper shares the vision of Larson (2000, 306) by considering entrepreneurship as a task to start a new business venture (start-up), by introducing novelty in products, process, or services.

Entrepreneurs to address market imperfections

Beyond the recent term of "greening Davids", the idea that sustainability can be achieved by entrepreneurs rather than by large incumbent firms is not recent. Hall (2010, 441) refers to this as the "panacea hypothesis" due to the overemphasized

assumption that entrepreneurs could lead the transformation towards a more sustainable society.

The "panacea hypothesis" originated as a possibility to address market imperfections. As Dean and McMullen (2007) point out, a relation exists between the disregard of market imperfections and negative environmental impacts. An actor can exploit a niche market to address specific market imperfections. Therefore, "sustainability entrepreneurs" and the sub-set of "environmental entrepreneurs" are more likely to spot these niches. Path dependence informs why entrepreneurs are better equipped than incumbents to fill in these niches. The more time a given firm has being involved in a certain way of doing things, the harder it is to change cap (Hall, Daneke, and Lenox 2010, 444). Cohen and Winn (2007) classify the market imperfections (that could be a niche for entrepreneurs) as follows: inefficient firms, externalities (i.e. pollution), flawed pricing mechanisms and imperfectly distributed information.

Ecopreneurship defined: Triple bottom line and its relation to entrepreneurship

The triple bottom line (TBL) approach seeks to ground sustainable development into the business daily activities. TBL has been criticized as a way for large corporations to brand themselves and gain more profit (Norman and MacDonald 2004). TBL has also spurred into the entrepreneurship literature and explains why "sustainable" or "environmental" entrepreneurship attract more scholars' attention. TBL claims that accountability can provide major competitive advantages to firms. This accountability should focus in sustainable development dimensions (social, economic and environmental). Therefore, a firm must demonstrate that along being profitable it is also able to increase its entourage social quality and improve the environment (Elkington 1994; Adams, Frost, and Webber 2004).

Figure 6 sketches this relation between TBL and entrepreneurship (Dixon, and Clifford 2007). Conventional entrepreneurs' main interest is the enterprise's economical accountability by ensuring the firm generates enough income to grow. The kind of entrepreneurship related to the "social" strand, creates businesses with their goal to improve the social wellbeing of a given society (Zahra et al. 2009).

Environmental entrepreneurship exploits market imperfections related opportunities (Linnanen 2002, 72). This author classifies these enterprises as: nature-oriented enterprises (e.g. tourism), environmental technology, environmental management services and environmental products.

However, other entrepreneurs combine the two or three sustainability strands. For instance, "Ecopreneurs" combine the environmental and the economic aspects of sustainability. This term has gained large popularity in the literature. Pastakia (1998, 157) defines them as entrepreneurs that bring ecological friendly products or services into the markets. Isaak (2002) enhances this focus on product or service's environmental aspects by considering a "green-green" behavior as the ecopreneurs' marking condition. Environmental protection should be embedded in their products and in the production chain. Moreover, green-green ecopreneurs should be start-ups and not already existing companies. Conversely, Schaltegger (2002) places ecopreneurs as those organizations or individuals that start a business for the mass market, but the environmental performance goals are core part of the business.

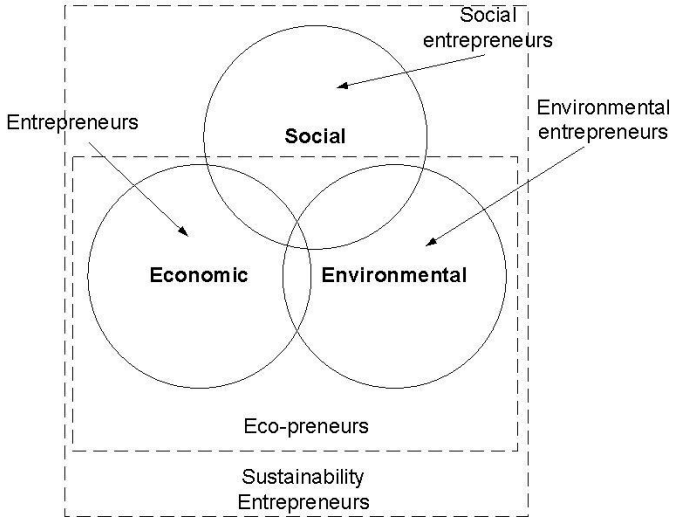

Figure 6- Relation between triple bottom line and entrepreneurship. *Source*: Own elaboration based on Tilley and Young (2009, Fig. 1)

Finally, "sustainability" entrepreneurs integrate the three strands of the TBL into their process of creating a company (Young 2006). Tilley and Young (2009), therefore argue that "sustainable" entrepreneurship goes further than "environmental" or "social" entrepreneurship as it encompasses a more comprehensive range of strands of the TBL model. Case studies on sustainability entrepreneurs have shown the hardship to combine these three elements, even in contexts where a tradition of entrepreneurship and environmentalism could ease things – e.g. case study of a furniture recycling company in the UK (Dixon, and Clifford 2007).

Initiating the study and problem statement

Frederikshavn: is "green shipping" a rescue boat for the local economy?

The "green shipping" movement is particularly intense in Denmark, Norway and Sweden. Denmark hosts the headquarters of some world's largest ship-owners and carriers[1]. Norway recently launched the Norwegian fund, a voluntary program to reduce NOx, and Sweden has a dynamic ship design maritime industry. The maritime sector in the Nordic countries wants to gather "first mover" advantages to develop SOx, NOx abatement technologies, improved propellers and engines. Furthermore, ballast water treatment technologies are increasingly being developed by startups and incumbent firms in the region. In this context, *Maritimt Kluster og Innovationssamarbejde i Skagerrak – Kattegat* (MarKIS)[2] was launched in 2010 as a Norwegian-Swedish-Danish EU financed regional development program. The program is set in a "triple helix" configuration. Universities, industry and government cooperate to put Kattegat and Skagerrak (KASK) in the upfront of the maritime cleantech development (MARKIS 2011).

[1] The following are examples of these firms: Nordic tankers, AP Møller Mærsk, Torm.
[2] Maritime Competence and Innovation Skagerrak & Kattegat (Markis project)]

Frederikshavn is a northern Denmark city and harbor with economic activities dependent on the maritime services sector. Around 7000 persons work in ship maintenance (e.g. retrofitting and engine repair). In recent years, however, shipyards and engineering firms moved from Frederikshavn to Asia and trained staff was left without employment.

The Frederikshavn Business Council (*Erhvervsråd)* and the Frederikshavn *Kommune* face the challenge to keep existing employment and create new. They are both engaged in the MARKIS initiative and expect "green shipping" to bring opportunities to the city. Besides, both institutions got national and regional governments subventions to create a Maritime Competence and Innovation Center (MARCOD). MARCOD has the goal to create 400 jobs in the kommune by creating competences in new maritime technologies, including environmental and climate protection.

Frederikshavn has also a dynamic Small and Medium Enterprises (SMEs) cluster specialized in maritime services. The recent story of the city also shows an entrepreneurial mentality. As large enterprises moved out of town, many trained staff opened their own enterprises and joined into the Frederikshavn Maritime Network. This network "sells" the harbor as a specialized maritime service destination that will build up new competences. With MARKIS and MARCOD, it is expected that Frederikshavn will become more attractive for ship-owners in the Baltic and North Sea Region.

Eco-businesses and the "environmental service/ products industry" is a fertile ground for ecopreneurs. Pollution control technology manufacturing and servicing (installation) is considered as an ecobusiness (OECD 1999). In the context of Frederikshavn, this issue raises particular interest. In the past, large incumbent maritime industries used to provide employment to thousands. Changes in incumbent firms' market priorities obligated them to reduce staff. As a consequence, hitherto unemployed competent staff had no other option than self-employment or working for local SMEs.

Ecopreneurial startups in the maritime field are a fairly disregarded field of study. Moreover, scant literature has analyzed the relation between "ecopreneurs", "opportunity existence, discovery and creation". In a context of evolving maritime market, information flow is highly relevant to discover or create business opportunities (Baron 2010). This research aims to explore:

How are the drivers of green shipping creating incentives to ecopreneurship?

While acknowledging the complexities of the maritime sector, this research will focus on the light blue highlights in Figure 7. The first boundaries are set in the ship's life cycle. A vessel life starts with its design at the engineering design bureau, then it is built, then it operates, and finally needs to be disposed off. The introductory part discussed transport and trade, and therefore this thesis focuses in the operation of the vessel. Thereafter, different environmental aspects were stressed. This thesis emphasizes on air pollution, and more specifically on NOx and SOx maritime regulations and maritime end-of pipe controlling technologies. Eco-innovations concerning fuel change or efficiency improvements are not stressed. Furthermore, other organizational eco-innovations are not analyzed either.

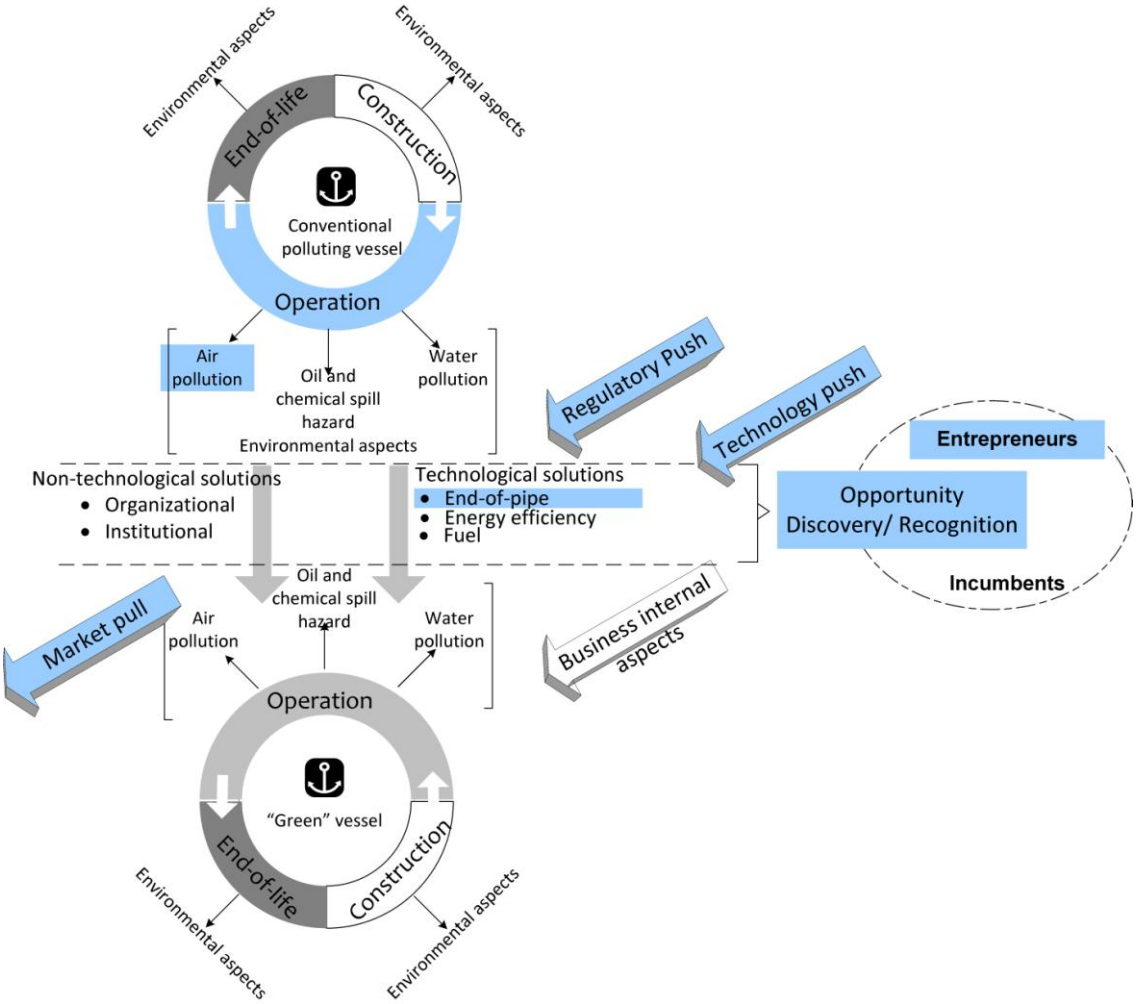

Figure 7- Broad research area and scope of thesis. Subjects covered by thesis are highlighted in light blue.

An important aspect of the thesis comprises the drivers behind the adoption of "green shipping" practices. The introduction presented four of these drivers: technology push, regulation push/ pull, market pull and business internal aspects. The thesis focuses in the first three. The eco-innovation business opportunities are also a subject of study. It is acknowledge that these opportunities can be exploited by incumbent as well as entrepreneurs. The research focuses on entrepreneurs rather than established firms (i.e. Figure 5 "A" component).

Research contributions

The research sheds light on how ecopreneurial opportunities are discovered or recognized in the maritime sector. Key addressed issues are information's role and intermediaries' role in information flow to potential ecopreneurs. By providing empirical evidence from maritime entrepreneurs, the results will contribute to the growing knowledge on ecopreneurial motivations.

While Frederikshavn business councils engage in MARKIS and MARCOD, the research results will provide them with elements to think how to allocate resources for

entrepreneurial promotion through these projects. Even if innovation and competence building are considered part of MARKIS and MARCOD, entrepreneurial promotion is a hitherto disregarded field.

Chapter 2
Research Design

The introduction highlighted the broad research subject, and narrowed it into a research problem. This chapter presents the research design and is structured in two main sections. The first section presents the sub-research questions and introduces the structure of the report in relation with these questions. Subsequently, the Section named Research Methodology discusses the use of qualitative case study as an inquiry strategy and how research methods underpin with this inquiry strategy.

Research questions

The following sub-questions structure the report and serve to answer the main research question:

1- Why and how is the maritime sector adapting "cleaner shipping" practices?
2- What is the current role of intermediaries in facilitating information concerning green shipping practices?
3- Why do ecopreneurs engage into business responses to green shipping practices?
4- How do incumbent maritime technology firms interact with ecopreneurs to deliver air and water pollution control solutions to respond to the demand?
5- How could intermediaries use this knowledge to promote ecopreneurship in the maritime sector?

As presented in Figure 8 two chapters structure the results. Chapter four deals with the case study's contextual conditions, it focuses on the shipping sector. Besides, chapter four addresses sector's ecological modernization adoption drivers. This chapter addresses why the maritime sector has traditionally been resistant to adopt cleaner technologies and why it changes. Therefore, this chapter answers sub-question one.

Chapter five addresses the case study itself. In a first part, the chapter unveils why information management and competence creation is a condition to spot ecopreneurial opportunities in the shipping sector. Sub-question two analyzes the role of intermediaries to convey this information to potential ecopreneurs (new startups or existing firms). Besides, the chapter uncovers sub-questions three and four. Two ecopreneurs' experiences analysis sheds light on what they consider as a "cleaner shipping" opportunity, how they discover or create it. Meanwhile, these ecopreneurs also portray how incumbent firms entangle with new startups at the stages of opportunity discovery/ creation. The recommendations chapter informs on the last sub-question.

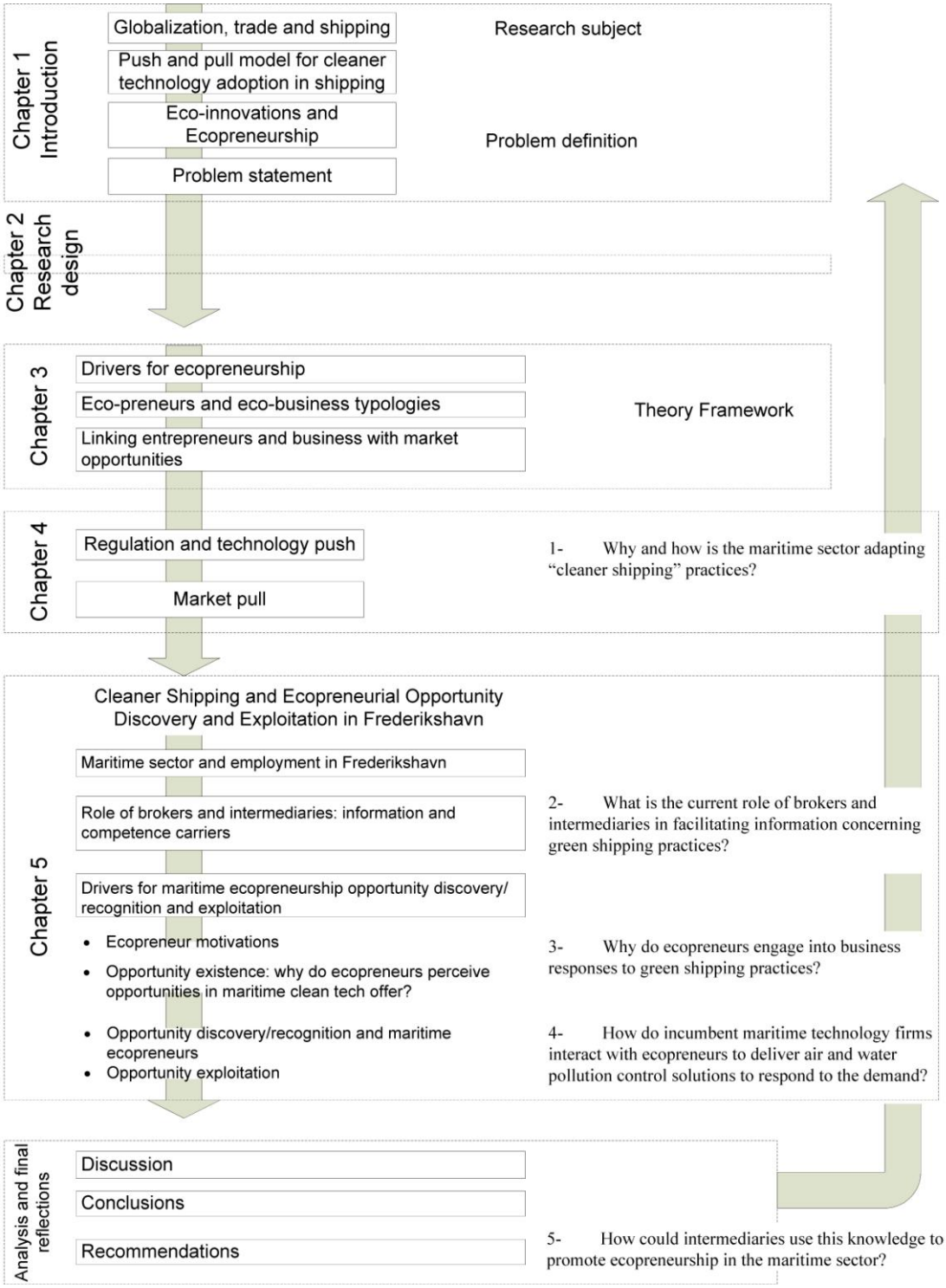

Figure 8- Related research question and chapter in the report

Research methodology

Rationale of constructivism as science position

This research aims to unveil how the shipping sector sustainable practices adoption drivers create entrepreneurial opportunities. Besides, the thesis aims to understand how the supply side may respond to these opportunities. In between these two extremes, it is important to know how information flows (intermediaries' role). Briefly, the previous objectives aim to explore how a phenomenon —in this case, the maritime sector technological change in a given location— affects a set of stakeholders. Actors perceive different phenomenon aspects; this perception depends on the reality embedding the actors. Therefore, it is the research's interest to unfold what are the stakeholders' perceptions and explanations about this phenomenon.

According to Patton (2002, 132), phenomenology cares on "what is the meaning, structure, and essence of the lived experience of this phenomenon for this person or group of people". In management and business science, phenomenology is considered as a research method –i.e. phenomenological interview- closely related to constructivism and opposed to positivism (Hackley 2003, 111-113). It must be acknowledged, however, that phenomenology encompasses a broader set of stages: phenomenology has been mentioned as a philosophy, research paradigm or theoretical tradition (Cope 2005; Creswell 2007; Patton 2002).

The main research's objectives encompass the study of a phenomenon from the participants' perceptions and by triangulating with other qualitative methods (as explained later in this chapter). The phenomenon, which is part of the reality, is understood as the cross- views of the study's participants, the reality is said to be socially constructed. Therefore, constructivism is the science position that back-ups this idea. However, common flaws associated to constructivism are time consuming epistemology due to qualitative data processing and analysis, and lack of credibility from policy makers (Easterby-Smith, Thorpe and Jackson 2008).

Given that constructivism relies mostly in hermeneutical and dialectical methodologies (Guba and Lincoln 2005, 195), qualitative methods shall be used to better understand the phenomenon. Qualitative research is about exploring, describe and explain the complexities of the social world (Denzin and Lincoln 2005, 3). Qualitative research has some advantages over quantitative approaches: a qualitative research conveys a deeper and more detailed analysis. This has to do with the trade-off between generalization (mostly associated to quantitative methods) and in-depth of understanding of a phenomenon (qualitative research). Besides, qualitative approaches imply the inquirer to approach the field with an open mind set to be receptive to the insights from the study participants, without prescribed variables as in quantitative research (Patton 2002, 14). Common flaws associated to qualitative research are subjectivity in data analysis, associated time and financial costs.

Case study: criteria of selection and boundaries

Case study is one among several inquiry strategies associated to social sciences (e.g. experiments, surveys, archival analysis). Researchers rely on case study when interested over ongoing events. Case studies seek to respond why/ how research questions. Why/

how questions pursuit description, explanation or exploration over a bounded system and its relation with the context (Yin 2003, 5-6).

Generalization from single case studies

Case study's validity and generalization is often criticized (Firestone 1993). Qualitative case studies aim to gather in depth information about a phenomenon of study. "Replication logic" in multiple case study designs can yield more significant results by draining results from different contexts. Contrary to quantitative approaches, in which the statistical significance is increased by using larger samples. According to this logic, generalization is achieved by comparing the same issue under different contexts. Because such replication logic lacks in single-case studies, some scholars argue that generalization is less strong and results are bonded to the result's context (Yin 2003).

But in Flyvbjerg's (2006, 228-229) perspective, it is a misconception not to consider generalizations from single case studies. In fact, because the researcher is able to select information-rich cases, more insightful information can be obtained when purposively selecting this kind of cases (Stake 2005, 450). Therefore, it is important to explicitly justify a single-case sampling strategy, which would dramatically make a point of an issue under study, and thus address the generalization appropriately.

Case selection and differentiation with the context

Given that an appropriate case selection is a key condition to enhance the case's validity; this section sets boundaries between the context, the case and the units of analysis. Such clear differentiation between the context and the case is a precondition to use case-study as a research strategy (Creswell 2007). To differentiate the case from the context, this thesis shares the views of Stake (2005, 444) considering the case as a system in which some elements are inside and others are outside a boundary. What remains "outside" is the context.

According to Stake (1995, 3-5), there are two broad categories of case studies: intrinsic and instrumental. The first refers rather to "typical" cases whose selection is by default, and the researcher's interest is to learn the most from that particular case without a generalization purpose. Instrumental cases seek to generalize. A primary purpose of this research is to answer a research question with implications to the stakeholders involved in the case study. From this point of view, the case will be intrinsic. Nevertheless, the research aims to contribute to the theoretical understanding on the maritime eco-innovation and on ecopreneurial business opportunities literature. Therefore, the case selection fits as instrumental case.

Extreme/deviant cases are a kind of instrumental cases. According to Flyvbjerg (2006, 230), extreme/deviant cases seek "to obtain information on unusual cases, which can be especially problematic or especially good in a more closely defined sense'". Therefore, generalization will be better achieved if the case study represents an "extreme/deviant" situation. This idea directs the case study selection in this thesis.

As presented in Figure 9, the case study consists on ecopreneurship and green shipping opportunities in Frederikshavn, Nordjylland Region, Denmark. However, this case is inserted into a larger context: the worldwide, the European and the Danish shipping

sectors. Furthermore, the interaction among KASK region's ports makes this whole region also relevant to the context.

An initial criterion to select an extreme case was to spot where cleaner shipping practices are taking place worldwide. There could be some cases in the world which could imply an interest for this study. In the US, for example, regulations push the harbor/ maritime operations towards stricter air quality controls, as the case in port of Los Angeles (Linder 2010). In European ports as Rotterdam or Gothenburg, shore side "green" power and shore/water/ sediments clean-up plans have become major issues in the harbor/ maritime operations (Darbra et al. 2009, Dutt 2009). Still, there are some reasons why the KASK region context could be considered as an extreme case of green shipping practices and ecopreneurship.

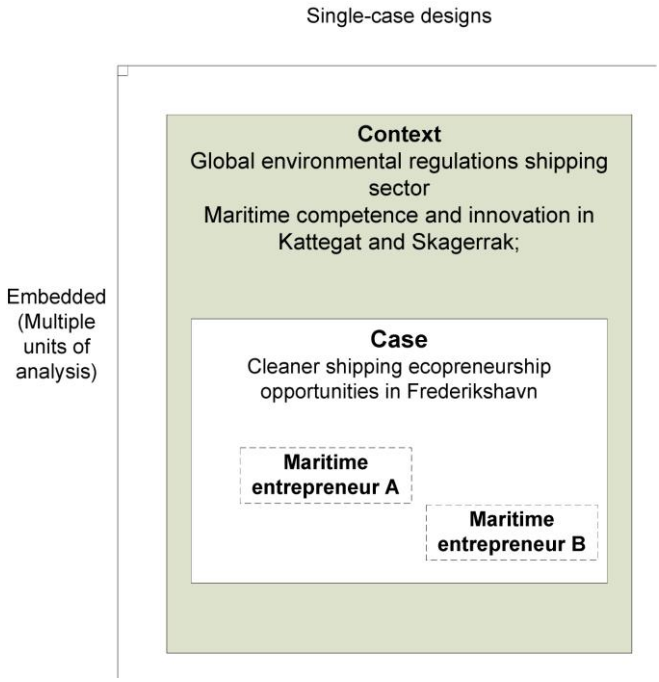

Figure 9- Single case study design with two units of analysis. *Source***:** Own figure with inputs from Yin (2003, Fig. 2.4).

As sketched in Figure 10, the KASK region comprise major Danish ports of Aalborg, Frederikshavn and the Swedish port of Gothenburg, and include several minor harbors in North Denmark, South Norway and West Sweden. This region has a dynamic economy associated with the maritime cluster. Figure 10 highlights number of jobs associated to the shipping business: consulting, forwarders, carriers, classification societies. Furthermore, this region hosts an industry, which has traditionally supplied technology to the shipping sector: ship designers, ship builders, engine manufacturers, pollution control technology manufacturers, etc. (Region Nordjylland 2009).

The region has a history of maritime industry leaking jobs: shipbuilders moved to Asian countries, where operation costs are lower. To avoid losing competition advantages vis-à-vis other leading shipping industry regions, the shipping cluster in this region is taking

first mover steps towards opportunities in the maritime sector. The increased interest of shipping sector on more sustainable practices is regarded as a market niche.

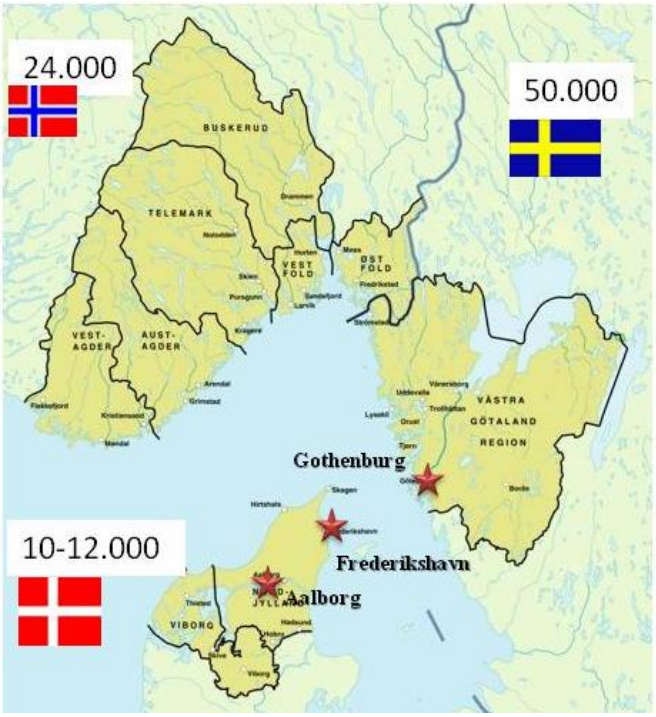

Figure 10- Region Kattegat and Skagerrak (North Denmark, West Sweden and South Norway), number of employments linked to the maritime sector. *Source*: Region Nordjylland (2009).

Selection of units of analysis

Figure 9 also illustrates how the units of analysis are set within the case. According to (Patton 2002), unit of analysis selection steers the research's direction, and multiple selection makes them not mutually exclusive. Further, the units of analysis can consist on different kinds of categories (e.g. people, structures, perspective, geography focused, etc…). Specifically, the two selected units of analysis are considered as intensity cases: "involve information rich cases that manifest the phenomenon intensely, but not extremely" (Marshall and Rossman 2006).

The two units of analysis are maritime cleantech provider entrepreneurs: Desmi Ocean Guard and Canopus Marine Solutions AB. The former is a start-up company specialized in ballast water treatment technologies and located in Aalborg. Despite this firm was not located in Frederikshavn, it could provide important information on the entrepreneurs' motivation to engage into the business, and his strategies to start the firm. Canopus Marine Solutions is a small firm located in Gothenburg. They specialize in NOx and SOx abatement technology design and construction. Similar to Desmi, this firm is not located in Frederikshavn either. It was selected because Frederikshavn did not have any recently created firm specialized in the design, manufacture and installation of NOx/ SOx abatement technology. Canopus' representatives accepted to participate in the

study after having contacted them during the MARKIS event "Business opportunities by Clean Shipping Index".

Selection of interviewees

The case study relies in three qualitative methods: in-depth interviews, document reviews and observation. Qualitative purposively sampling strategies were used to select interviewees according to the classification of Miles and Huberman (1994). As shown in Figure 11, the case study comprised at least one interview for each unit of analysis, as well as interviews with key informants from Frederikshavn and Gothenburg. The interviewee selection out of the units of analysis was based on an "intensity" sampling. As insiders, these interviewees could "manifest the phenomenon intensively" (Miles and Huberman 1994). Insiders in this regard imply that the interviewee's organization works on cleaner shipping or business promotion. "Context" informants were selected in the same way.

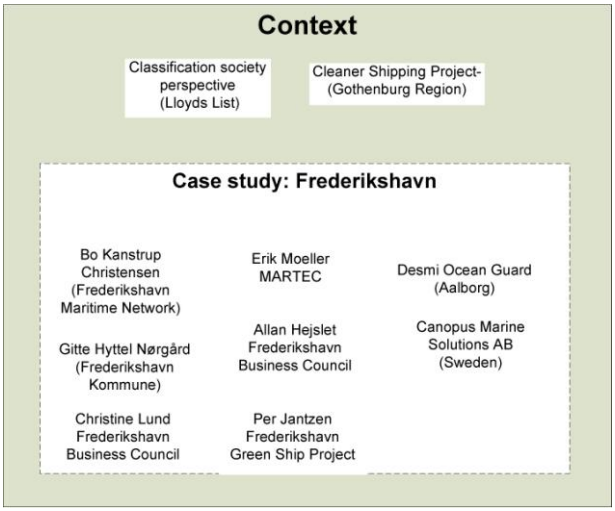

Figure 11- Relation between units of analysis, case context interviews.

Methods of data collection

Validity and reliability in case study research:

Yin (2003) suggests research "quality tests" to strengthen the case study's validity and reliability. Therein, validity aims to tackle such critiques concerning the subjectivity of the research and the extent to which the findings can be generalized. Reliability, informs about the likelihood to find the same results if the procedures are followed when another group wish to undertake the same research. The case study protocol use and the proper control of information sources (database, records and transcripts of documents and interviews) seek to increase the design's reliability. Another test ("internal validity") was not considered appropriate for this design as the research's purpose is not explanatory, but exploratory.

Validity was addressed by using multiple sources of evidence, establishing a chain of evidence and interviewing key informants (Silverman and Marvasti 2008). Triangulation goes along with the integration of multiple sources of evidence. As suggested by Patton (2002), different methods ensure more veridical results than relying on a single method. For this reason, this research protocol integrates three methods: document review, interview and observation. This design relied in two kinds of triangulation: between qualitative methods and between sources. This pursuits consistency cross-check and complement the other method's weak areas. With this in mind, different methods were not expected to come out with the same result. Instead it was expected that some inconsistency could arise if for instance, the interview results yielded with a different perspective as observed.

Document review

As shown in Table 4, the methods were combined in each of the chapters of the report, and ultimately in the research questions. The first of the methods, document review, has several strengths. It allows to document major events, provides context information, the data is easy to manipulate and categorize for analysis. Nonetheless, the method also has a major pitfall: the tendency to get stuck on details (Marshall and Rossman 2006, 107).

Table 4- Information obtained with literature review and interviews as methods.

Chapter in the report	Information obtained with literature review	Interviews	Observation
Chapter 3 Theory	Theoretical propositions about ecopreneurship. Role of brokers and public policies. Trends in global shipping, greening of the transport sector		
Chapter 4 Context	Contextual information: shipping environmental regulations. Market drivers Technology supply	Danish shipping strategy Why to bet for cleaner shipping/ Drivers Role of entrepreneurs Changing of the business/ why to update.	Behavior of stakeholders in cleaner shipping
Chapter 5. Case study	Public-private agreements Economic figures: employment, entrepreneur, Shipping statistics: number of related enterprises / employment/ entrepreneurs/ use of harbor. Company's characteristics Company's size / customers/ partnerships Events/ networks affiliated/ interaction with other actors	Intermediaries' role. Importance of environmental aspects for the harbor, how to turn them into business, regional integration with other ports in KASK Interests to start business Values/ background of the founders Profit generation/ growth of business Triple bottom line	Size of the firm Facilities and technology

Observation

Observation was used as a cross cutting analytical method for all the research questions (Creswell 2007). Observation as an outsider was mainly used during visits to the interviewee's offices. Such issues observed were the firm size, the employees' role and the interviewee's reaction to the questions.

Participant observation took place mainly along the researcher involvement in some events organized by the MARKIS project:

- Seminar "Business opportunities by clean shipping index". This event took place on February 8th, 2011. The author got acquainted with incumbent and startups providing clean technologies to the shipping industry. The participants list allowed screening for potential interviewees and one of the units of analysis was firstly met during this event.
- Seminar "Instruments for the environmental impact of shipping". Held on 4th April 2011.
- Stora Marindagen 2011 [*Swedish Maritime Day*]. This event gathered Swedish ship-builders, ship-owners, education institutions. During the event, it was possible to attend specialized seminars on maritime technology, transport and supply chain optimization and maritime fuels. Besides, the stands provided commercial documentation.

Observation field notes complemented all the interviews transcripts and were subsequently coded as described below.

In-depth interviews

In-depth interviews implied selecting key informants at the units of analysis, at associated organizations in Aalborg, Frederikshavn and Gothenburg (Table 5). Interviewees from Frederikshavn worked for business promotion agencies and a maritime competence center. It is worth highlight that no Frederikshavn entrepreneur was interviewed. Although the Kommune shared a list of maritime service SMEs, none of them fulfilled the requirement of being a startup working on SOx/ NOx/ BWMS technology development or installation. Other interviewees based in the region fulfilled this requirement and were chosen based on intensity sampling –as explained above.

Semi-structured interviews were an appropriate method because they let interviewees respond with open-ended questions. Besides, semi-structured interviews allow respondents to share their reality viewpoint without being predisposed for answers (as in survey questionnaires). Further, interviews facilitated gathering respondents "in vivo" quoting to facilitate a respondents' better perspective on the reality (Patton 2002). As Creswell (2007) suggests, a protocol containing the topics to ask the interviewees, and recording the observations and responses was used. In this case, the protocol was an interview guide. The interview guide contained a brief introductory passage for voluntary participation consent. In most cases was sent beforehand to the interviewee. A different interview guide was prepared for each informant as the purpose was to relate to different research questions. The interview guides are presented in Appendix 1, along

with the questions it is included the coded used for the question[3] and the associated research sub-question.

Table 5 – Case study interviews

Interviewee	Position	Organization	Description
Christian Ingvorsen	CEO	Desmi Ocean Guard	Director of Desmi Ocean Guard, Entrepreneur
Bo Kanstrup Christensen	General Manager, Business development	Frederikshavn Port	Expert in maritime business, responsible person for business opportunities and environmental issues in the Frederikshavn port
Gitte Hyttel Nørgård	Counselor	Erhvervs og direktionssekretariatet [Business promotion] Frederikshavn Kommune	Frederikshavn maritime business expert, with several years of business experience in the maritime business
Christine Lund	Counselor	MARKIS innovation arena Frederikshavn Erhvervsråd	Coordinator MARKIS, Frederikshavn innovation arena
Magnus Gripenwald/ Ralf Bokesjö	Technical managers	Canopus Marine Solutions AB	SOx Pollution control technology

Support interviews' contacts were gathered during an event of the Clean Shipping Index Conference of the MARKIS Project on the 08 February 2011 (Table 6). They were selected based on the criterion of including the perspectives from important stakeholders in the shipping sector -"theory based" sampling strategy (Patton 2002). These interviews proved valuable to assess institutional and business characteristics of shipping, the sector's evolution towards "greener" practices and the linkages between different public/ private actors in KASK.

Table 6 – Conducted support interviews in Gothenburg, Sweden

Interviewee	Position	Organization	Description
Craig Eason	Technical editor and Nordic Correspondent	Lloyd's List	Classification society expert in the maritime sector
Ulf Duus	Spokesperson	Clean Shipping Project	West Sweden Region project that is championing the Gothenburg initiative of cleaner shipping, for instance by creating the cleaner shipping index

Interview transcripts and field notes management

Interviews were audio taped. The files were handled with a PC software (Panasonic Voice Editing Standard ®) for manually transcribing the recordings. Backup files of the recording were kept for easy retrieval. Besides, transcribed files were also stored as text files. A copy of these transcriptions is presented in Appendix 2.

[3] An explanation about the used coding technique is given in a further section of this chapter.

The transcriptions were coded using the software QSR NVivo 7 ®, a Computer-Assisted Qualitative Data Management and Analysis Software (CAQDAS). Two first cycle coding techniques (Saldaña 2009) were used for this raw data: holistic coding and hypothesis coding. In addition, "In vivo" coding was also used as complementary to the other two. "In vivo" coding highlights striking quotes from interviewees to make a dramatic point over an issue. Besides, "attribute coding" was also used to keep track of interviewees' demographics as age, gender, profession, place of work and years of experience in the maritime sector.

Holistic coding groups large portions of the text as a preparation for more detailed content analysis (Saldaña 2009, 118). Holistic codes were generated for each interview question (Appendix 1). The idea of using this kind of coding was to get an appraisal on "what the data tells". Holistic codes were further analyzed by memo writing about the codes. Memos are notes which unfold the reflections of the researcher when creating a code, and further compiling these codes into categories and themes.

Hypothesis coding was the second used code. This coding was an initial step of the research. Literature review generated hypothesis codes. The codes allowed contrasting theoretical propositions with empirical evidence. Appendix 3 presents the "hypothesis" codes and their descriptions.

Holistic and hypothesis codes were grouped by using "Pattern coding", a second cycle coding technique (Miles and Huberman 1994). Pattern coding looks for similar codes and from there on built groups of codes, which jointly rise a common point (categories). These categories can be grouped to form a theme, which in the report take the form of a heading in chapters four and five. Figure 12 sketches how coding techniques were iteratively used until getting obtaining specific chapters in the report.

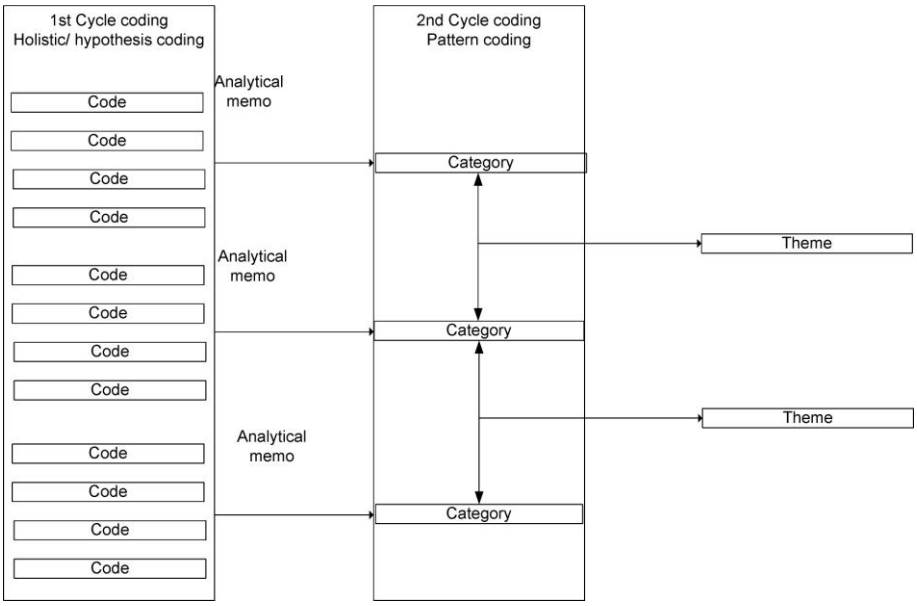

Figure 12- Relation between first and second cycle coding techniques, and generation of themes. *Source*: Own elaboration adapted from Saldaña (2009, Fig. 1.1).

Chapter 3
Theory Framework for Ecopreneurial Opportunities

The theory framework addresses two concepts: The first part defines ecopreneurship and its typologies. The author argues that ecopreneurship is a rising field within mainstream entrepreneurship literature. Entrepreneur's motivations differentiate ecopreneurship from mainstream entrepreneurship. The first part also defines eco-businesses. This part raises the point that ecopreneurs may develop a broad range of activities. Therefore, ecopreneurs are likely to start businesses in the maritime sector as well.

The second part discusses the theory behind business opportunities. Following the mainstream literature on entrepreneurship, opportunities are introduced from a market perspective. This strengthens the argument line that market failures (as environmental impact externalities resulting from foul practices in the shipping sector) are "out there", and it is up to the entrepreneurs to find them. Hence, a section discusses how to find the "opportunities". The theory engages the role of information carriers, and how information becomes critical at the stage of opportunity discovery.

Ecopreneurship drivers

How do ecopreneurs differentiate from conventional entrepreneurs?

Entrepreneurship research is an interdisciplinary field and takes insights from management studies, economics, sociology, psychology and 133 other subfields (Landström and Persson 2010). From a management perspective, ecopreneurs share similarities with conventional entrepreneurs (Linnanen 2002, 72). Both are individuals or organizations that start a firm from scratch. For this sake, they take risks, become community change agents, rise capital and use their networks to start the venture (Schaper 2002, 38). Besides, as Isaak (1998) highlights, they are prone to "free-ride" to reduce costs at the initial stages, by benefiting from channels that can provide them free information, networks access and potential customers.

Despite these similarities, there is little understanding about differences between "ecopreneurship" and "conventional" entrepreneurship (Hall, Daneke, and Lenox 2010, 439). Main differences reside in the initial extra drivers for starting a company. Some studies claim that from the psychological facet, ecopreneurs are "pulled" to enter business with the interest to improve the world. This is what Kirkwood and Walton (2010) consider as "green values". Similarly, Hockerts and Wüstenhaguen (2010, 487) back-up the idea of green values steering the initial steps of "sustainability" start-ups.

A "green" values perspective seems bizarre in a profit making business rationale low operating costs. Ecological minded products and services are considered by business advisers as difficult to enter market and sometimes jeopardize quick return rates (Isaak 1998). For this reason, some ecopreneurs internalize their products and services sustainable aspects. Their selling prices are normally higher and they seek like-minded responsible consumers to pay the difference, as in the agriculture ecological labeled products (Pastakia 1998, 157). Assertions like this are difficult to generalize out of the

food, textile and cosmetic sectors. But evidence shows that within the same economic branch/ industry, entrepreneurs differ on integrating sustainable practices into their businesses. Therefore, ecopreneurs may start businesses in domains not restricted to "soft" sectors as food, cosmetics or clothes. Ecopreneurs may start businesses in more "hardware" minded sectors as carpentry, mechanics, and the like (Schick, Marxen, and Freimann 2002).

Push and pull theory for entrepreneurship motivation

Push and pull entrepreneurship motivation theories (Gilad, and Levine 1986) unfold how "green" values influence entrepreneurs. Push factors have negative connotations as job dissatisfaction, wages concerns and unemployment. As these issues are external to the person, the entrepreneur is pressed for ways out of them, and the rescue boat is to found a new enterprise (Segal, Borgia, and Schoenfeld 2005). Recent research (Schjoedt and Shaver 2007) has criticized the common perception about job dissatisfaction and claims job satisfaction to be what encourages entrepreneurs to start a company.

On the other hand, "pull" factors are intrinsic positive entrepreneur's motivations, which could yield more successful businesses. Examples of "pull" factors are: desire for independence and monetary motivations (Kirkwood 2009). Furthermore, Kirkwood and Walton (2010) suggest that 16 New Zealander ecopreneurs are "pulled" into business rather than pushed. This study accounts the following drivers: ecopreneur's green values, a gap in the market, making a living, being own boss and passion. But, "green values" are the main reasons to set apart ecopreneurs from others.

Keogh (1998, 38-49) proposes three dimensions in which these values interplay. These dimensions imply that "green values" not only play as pull factors, but in some cases also as push factors:

- Affective commitment, involving the individual's emotional attachment to, identification with and involvement in supporting environment concerns.
- Continuance commitment, involving commitment based on the economic and social costs that the individual associates with disregarding environment concerns.
- Normative commitment, involving the individual's sense of obligation to continue supporting environment concerns.

Affective commitment could be portrayed as inherent to the entrepreneur's experiences, trajectories or training. This can be key to open the entrepreneurs' eyes on important environmental issues, which need to be tackled. At least, this is a conclusion reached by Rodgers (2010, 130) when presenting how ecopreneurs turned into business the knowledge acquired through educational and lived experiences. This matches with Linnanen's (2002 76-77) overoptimistic perception that eco-business put their ethical behavior and reasoning above any profit interest. In such kind of enterprises, success is not exclusively measured by economic/ financial thresholds, but also by other parameters (well-being, social impact, environmental contribution).

However, Keogh (1998) suggests that green values are not always resulting from pull. Continuance and normative commitments are rather pushing factors. In these cases, entrepreneurs take environmental considerations into account as obligation. The threat

of not doing so may entail costs and the firm may see its competitive advantages decrease.

Ecopreneurs and eco-businesses' typologies

This section sheds light on which are the market imperfections niches. Eco-businesses address market externalities by providing services and products. After introducing the typologies of ecopreneurs and eco-businesses, a model binds specific kinds of ecopreneurs with their eco-business counterparts.

Ecopreneurs typologies

The previous section highlighted how "green values" are an add-on for ecopreneurs. Yet, mainstream entrepreneurship literature targets this claim. Ecopreneurs should not disregard that economic success is also determinant albeit being committed individuals (Linnanen 2002, 77). Individuals will not start and run with red figures in the account balances.

Ecopreneurs' typologies dimension how the ethical driver interplays with conventional elements of entrepreneurship -profit, market penetration. Further, it addresses the loose utilization of different terminologies (environmental entrepreneurship, sustainable entrepreneurship). A third utility of typologies concerns to better spot which markets externalities fit a particular kind of ecopreneur (Harbi, Anderson, and Ammar 2010, 185).

Table 7 compares different typologies of ecopreneurs. The typologies cast the entrepreneurs' motivations to start a business. As shown, the typologies relate to the push and pull factors introduced beforehand. Besides, the typologies highlight profit making as a guiding driver. Pastakia (1998) sets a single dichotomy: commercial (profit-making) and social (mostly non-profit). This is also present in Schaltegger (2002) taxonomy, but it includes an intermediate group (bioneers). Other classifications propose a quadrant instead of a dichotomy. They combine the interest to make profit, with the interest to improve the world (Linnanen 2002), or include sustainability as a business target (Walley and Taylor 2002).

Table 7- Review of different typologies of ecopreneurs.

			Motivators	
Author	**Categories**	**Criteria**	**Push factors**	**Pull factors**
Pastakia (1998)	• Commercial: Identifies green business opportunities and seeks profit maximization. • Social: Promotion of green products or services which goal is no-profit making.	Green business creation, and profit/ non-for-profit goals	Regulations on products or services.	• Social: Ethical values, interest to improve livelihoods. • Commercial: personal challenges to introduce a "green" service or product.
Linnanen (2002)	• Non-for profit business: Low desire to make money and high desire to change	Desire to make money and change the	Career shift (Schjoedt 2007)	• Green values, interest to increase earnings, social well-

Author	Categories	Criteria	Motivators	
			Push factors	Pull factors
	the world • Self employer: Low desire to make money and low desire to change the world. • Successful idealist: High desire to make money and high desire to change the world. • Opportunist: High desire to make money and low desire to change the world.	world		being.
Schaltegger (2002)	• Alternative actors: Market restricted to alternative "underground" scene • Bioneers: Consumers are mostly located in "eco-niches", medium size markets • Ecopreneurs: Business aimed to reach mass-market	Market characteristics: how much is it influenced by the entrepreneur		• Alternative actors: Autonomy in management without bosses; time appropriation; cooperation and non-for profit goals • Bioneers: Desire to access more market than alternative scenes • Ecopreneurs: Bring their green innovations into mass market, profit increased
Walley and Taylor (2002)	• Innovative opportunist: Largely driven by external influences (e.g. regulations) but also economically oriented • Visionary champions: Although driven by external influence, their orientation is mainly sustainability. • Ethical maverick Business aimed to pursue sustainability goals but at the same time, not much influenced by the external factors. • Ad hoc enviropreneur: Path dependence economic oriented, with soft influences from the context		Innovative opportunists and "ad-hoc enviropreneurs".	Visionary champions and mavericks are normally motivated by the desire to change the world. Values drive their business orientation and interest to start the firm.

Source: Own elaboration based on Pastakia (1998), Linnanen (2002), Schaltegger (2002), Walley and Taylor (2002), Harbi, Anderson and Ammar (2010).

Major push factors are regulations, career shift and path dependence in the different typologies. The first creates a specific demand for a product or service. The

entrepreneurs are obligated by law to adopt new requirements and therefore it is an external driver that makes him/her act as an ecopreneur. This can be the case for commercial and social ecopreneurs.

Similarly, career shift is usually considered as a negative factor (Gilad and Levine 1986). This factor could be present in the self-employer category of Linnanen (2002). Ad-hoc enviropreneurs follow the same business inherited by relatives or start a business as a continuation of learnt competences in a former employment. There is room to debate whether this can have negative (push factor) or positive implications (pull factor).

Concerning pull factors, "green-values" are a cross-cutting characteristic of ecopreneurs who set a low interest to earn money and a high motivation to improve the world (e.g. those categories of non-for profit, alternative actors, mavericks). However, green values also interplay with profit as pull factors. This is the case of hybrid typologies (e.g. visionary champions, bioneers, ecopreneurs, successful idealists). Entrepreneurs belonging to "opportunists" group are pragmatic; they are neither pulled by values but only for profit making (Linnanen 2002).

As shown below, Figure 13 combines the previous push and pull factors with the typologies discussed so far. Most of the ecopreneurs typologies are in the "pulled" divide of the diagram. Whether ecopreneurs are pulled for profit objectives is not totally true: half of the categories fall in the non-for profit quadrant. Interestingly, the figure also show few typologies included in the "pushed" section. A consequence of this configuration is that ecopreneurs being pulled have higher probabilities to keep their business on float.

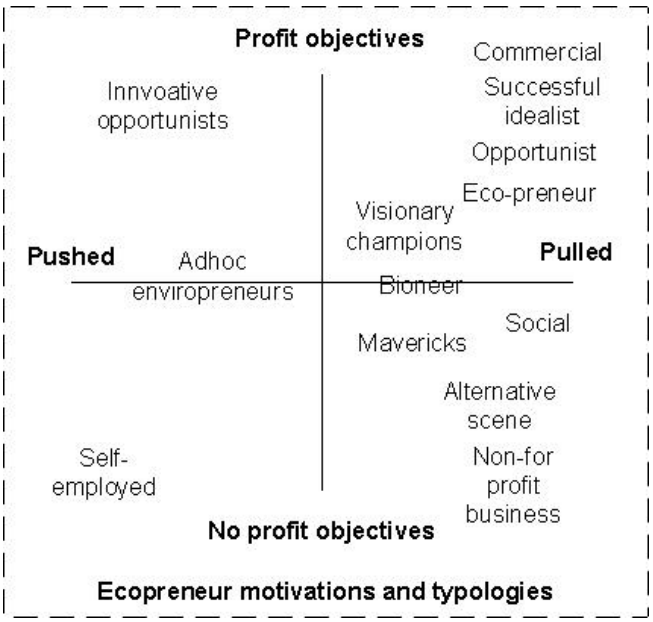

Figure 13- Ecopreneur typologies and relation to push/pull factors

Eco-business typologies

OECD (1999) defines the "environmental services industry" a sector grouping pollution control, cleaner technologies and resource management. According to this categorization, pollution control firms offer technology and services in any of the following domains:

- Air pollution control
- Wastewater management
- Solid waste management
- Remediation/ clean up of soil and water
- Noise/ vibration abatement
- Monitoring, analysis, assessment

Besides, the category "cleaner technologies" imply equipment and technology production or service provision for:

- Cleaner/resource technologies and process
- Cleaner/ resource efficient products

Finally, the "resource management" is a broad group which encompasses several activities:

- Indoor air pollution control
- Water supply
- Recycling of materials
- Renewable energy
- Heat/ energy saving and management
- Sustainable agriculture and fisheries
- Sustainable forestry
- Natural risk management
- Eco-tourism

The first group scopes end-of-pipe solutions: technologies and services targeting pollutants control. The second category covers in-factory production and processes improvement, and the third sets out factory and business in different economic segments (from tourism to agriculture and forestry).

In 2001, OECD quantified the contribution of the "environmental industry" towards the worldwide economy. The task proved challenging due to the sector's broadness (OECD 2001). Therefore, based on the OECD classification, Eastwood et al (2001) developed a shorter classification to study the "environmental industry" segment in Northern Ireland. Figure 14 highlights how some domains within market represent opportunities for environmental industry. Opportunities existence is debriefed into the categories of eco-businesses most likely to be forged (thick arrow). Figure 14 makes the point that for all these kinds of eco-businesses, the entrepreneurs may have different motivations to start that business (profit and no-profit), being pushed or pulled.

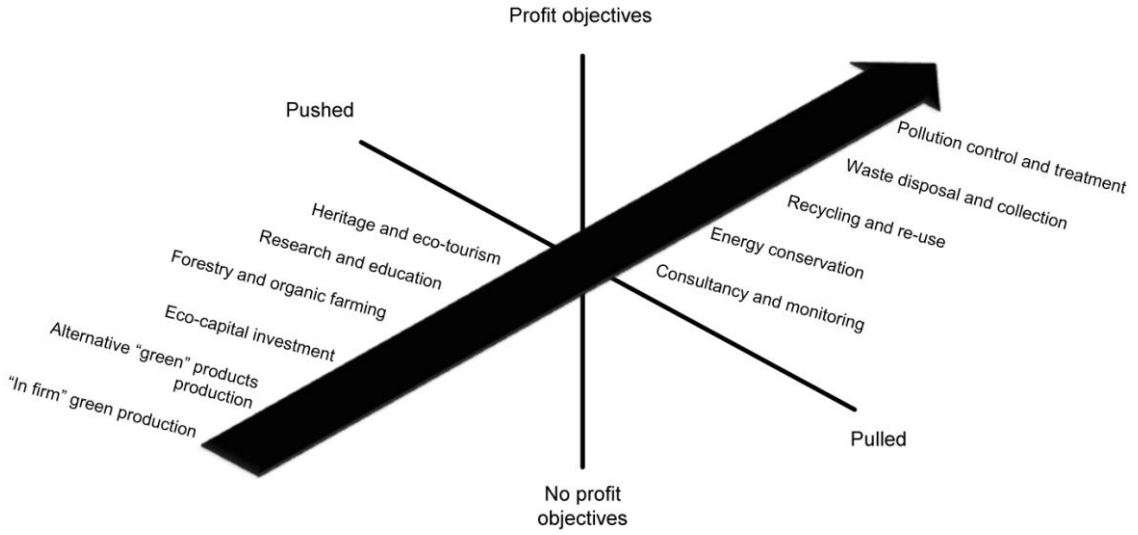

Figure 14- Eco-business and ecopreneur motivation to start business.

Linking entrepreneurs and business with market opportunities: Role of intermediaries

Ecopreneurs' categories stressed their relation with certain types of eco-business. Profit and non-profit objectives may lead the push and pull factors that motivate ecopreneurs. Motivation explains the ecopreneurs' likelihood to start a business in a particular domain. The theory of business opportunity portrays what a market-niche mean, how can it be discovered, exploited or created. In other words, what the "direction" of the entrepreneurial process is.

What is "opportunity"

Defining entrepreneurial opportunity

Opportunity is a *sine qua non* precondition for entrepreneurship. Opportunity follows the inquiry line on "alertness", or how entrepreneurs respond to market signals and are able to spot niches for their development (Foss and Klein 2010). In this paper, opportunity is defined as:

> Those situations in which new goods, services, raw materials and organizing methods can be introduced and sold at greater than their cost of production (Shane 2000a, 220).

Therefore, the above market situations examples of can be filled by the entrepreneur's actions undertaken by entrepreneurs. For this reason, Eckhardt (2010, 49), considers

that entrepreneurial existence follows three stages: existence of opportunity, opportunity identification and opportunity exploitation.

Types of opportunities

Entrepreneurial opportunities are classified by Eckhardt and Shane (2010) by where the market changes take place (locus of changes), sources of opportunity and who initiates the change.

The locus of changes refers to the evolving state of a dynamic market economy and its associated sectoral market chain. Relying on the works of Schumpeter (2003), changes are foreseen in five entities of the value chain: creation of new products or services, discovery of new geographical markets, discovery of new materials of production, improvements of methods of production and changes of organization.

Similarly, different actors can encourage entrepreneurial ventures. Klevorick et al. (1995) highlight how specific changes in certain industry sectors (influenced by technological change) influence the likelihood to become "entrepreneurial" niches.

The role of information

Information management and availability serves the entrepreneurs to get closer to the different kinds of opportunities mentioned. For example, information indicates where the loci of market changes are and what is needed to access. Thus, who has information also has "first mover" power. Baron (2010, 125) indicates two conditions to better use first-mover advantages: firstly, a greater access to information and secondly a superior utilization of that information. The access to information is facilitated by the entrepreneur's social network, previous experience and overall knowledge of the sector.

Access of information can be either active or passive. Active information involves facilitation actors to close gaps between the entrepreneur and the lying opportunities. A passive information search implies a cognitive asset of the entrepreneur to determine where the opportunities lie. This asset is reinforced by the entrepreneur's previous experience on the domain. Passive information search also requires capabilities to have a better utilization of the available information. Cognitive potentialities are besides intelligence, creativity and improved means to link different kinds of information.

Opportunity identification

Opportunity recognition, discovery and creation

Some issues are not covered by the opportunity definition presented above. For instance, demand and offer side information availability. Sarasvathy et al (2010) have enlarged the previous definition by splitting it in three views: allocative, discovery and creative. From the "allocative" perspective, both sides (demand and offer) have complete information about the market characteristics. The opportunity is mainly seen

as how both demand and supply match their compatibilities. In this case it is claimed that opportunities are "recognized".

The "discovery" view encompasses complete information from either the demand or supply side, not both. Therefore, opportunity is mainly discovered, and the purpose is to correct market imperfections by conveying a better offer or better demand. Shane (2000) proposes the following supply conditions for the discovery of opportunities:

- Discovery of opportunities is closely linked to the individual assets to spot them
- Passive searching can also led to opportunity discovery
- Entrepreneur background knowledge about the market can increase his/her awareness about which market to enter
- Entrepreneur background knowledge about how to serve market help the entrepreneur to offer a suitable technology to exploit that market
- Entrepreneur background information about the customers within a specific market helps to offer a suitable technology.

The previous conditions give the entrepreneur higher responsibility share to "discover" opportunities. Entrepreneur's assets and experience drive such responsibility while encompassing a high degree of knowledge and information conveyance.

Finally, a "creation" view claims that information is not fully available for the demand or the supply side. The "creation" of opportunities is opposed to the "recognition" or "discovery" of such opportunities. In this regard, opportunities cannot be discovered or recognized if they do not exist. Instead, opportunities are standby ideas, innovations and mental subjective schemes in within each individual entrepreneur. These "constructions" unfold in the right time and context to become objective issues (Kariv 2011).

Chapter 4
Push and Pull Drivers for Cleaner Shipping

This chapter contextualizes the case study. The constructivist character of the research envisions high relevance to the views of stakeholders. This is one reason why the chapter focuses in the most relevant maritime cleaner practices adoption drivers in Frederikshavn and the Baltic Sea. Another reason for this focus is to avoid an overwhelming listing of environmental maritime regulation (Danish and International). The first part explores the regulatory driver behind adoption of cleaner practices in the shipping sector. The second part explores the market driver.

Regulation and technology push

Air pollution regulation: SOx and NOx

Sulfur Oxides (SOx) and Nitrogenous oxides (NOx) vessel exhaust gas control is the foreseen business opportunity for Frederikshavn maritime stakeholders (Chapter 5). This part discusses why and how these two gases are internationally regulated, and what are the regulatory specificities in the Baltic Sea.

As discussed in the introductory chapter, health and environmental protection foster SOx and NOx control by regulation. Specific ruling appears at a local level. For example, in the USA, the San Pedro Bay Ports Clean Air Action Plan (CAAP) attempts to control emissions from sources at the port –not only ships but also related port machinery. Targets include 45% NOx reduction and 52% SOx emissions reduction by January 2012 (Knatz 2009).

However, shipping international character hinders local initiatives. Usually, the vessels' country of registration and origin differs from the landing port. Ships are commonly third country assets and little enforcement can be expected from local ports (Frémont 2009). The International Maritime Organization (IMO)[4] has the responsibility to set the worldwide parameters for maritime protection. IMO members agree on these parameters and take the form of conventions, protocols and technical norms. In 1973 IMO members endorsed the International Convention for the Prevention of Pollution from Ships (MARPOL). At the outset of MARPOL, the pollution prevention was restricted to oil, harmful substances, sewage and garbage. MARPOL convention Annexes contain each one of these environmental aspects. In 1997 Annex VI adopted air pollution prevention as a further area of environmental protection (Mensah 2007). As sketched in Figure 15, MARPOL Annex VI entries into force since July 1st 2010. Given the critical characteristics of some regions, the emission limits are set to lower limits in the Emission Control Areas (ECAs).

[4] The IMO is a 169 Nation-States members and United Nations body responsible for Maritime affairs – launched in 1948. Its headquarters are based in London. Since its origins it has issued around 1000 maritime safety codes and around 50 conventions, including some of environmental protection. (International Maritime Organization 2009).

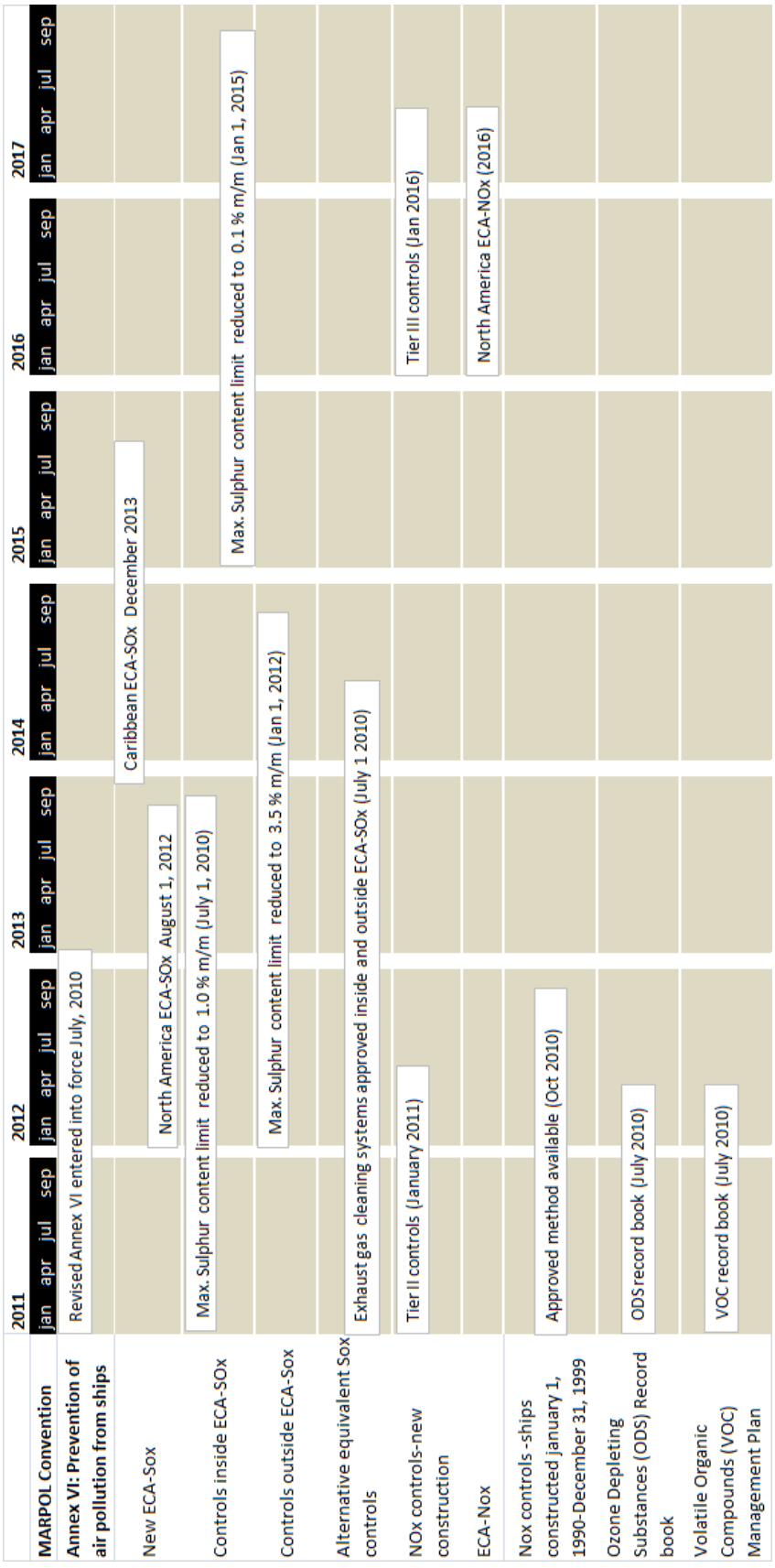

Figure 15- MARPOL convention Annex VI. In place and expected regulations for pollutants SOx, NOx, ODS and VOC. *Source:* Adapted from Lloyds Register (2011, 18-19).

Emission limits control SOx and NOx emission with different times and values for ECA and non-ECA. In the case of SOx, two ECAs are already in place: the North Sea and the Baltic Sea. North America expects to impose an ECA in August 1, 2012 and the US Caribbean in December 2013 (Figure 16).

Inside ECAs, maximum fuel Sulfur content limit is 1.00% by mass since July 1st 2010. This minimum will be decreased to 0.10% on January 1st 2015. Outside ECAs, the minimum is increased to 4.50% until January 1st 2012, 3.5% until January 1st 2015 and below 0.50% after 2020 (International Maritime Organization 2009; Lloyds Register 2011). Although these regulations stress the fuel characteristics, there are technological alternatives to reduce SOx emissions (as further discussed).

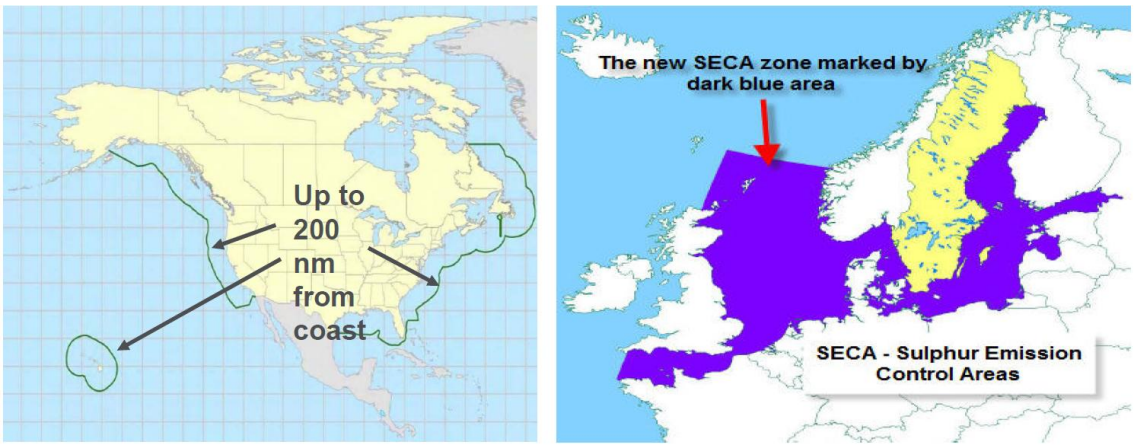

Figure 16- SOx ECA areas. At the right, the North American ECA (200 nautical miles from coast), not already in place. At the left, the existing North Sea-Baltic Sea ECA. *Source*: Rydbergh (2010).

NOx are subjected to a Tier approach (Stipa et al 2007). Tier I rules ships built before and after 1st January 2000. The NOx limits set a maximum of 17g/Kwh when the Diesel engine runs at less than 130 rpm. The limit is set with the equation: $45*n^{-0.2}$ g/Kwh when the speed (n) is set in between 130-1999 rpm. Finally, 9.8 g/Kwh when the speed is more than 2000 rpm.

Tier II applies for ships built after January 1st 2011. The NOx limits set a maximum of 14.4g/Kwh when the engine runs at less than 130 rpm. Speed comprised between 130-1999 rpm must not release more than $44*n^{-0.2}$ g/Kwh. With a speed above 2000 rpm the maximum NOx emission should be 7.7g/Kwh.

Tier III NOx limits are 3.4 g/Kwh for an engine speed less than 130 rpm. 3.4 g/Kwh NOx with a speed below 130 rpm; $9*n^{-0.2}$ g/Kwh for speeds between 130 and 1999 rpm; 2.0 g/Kwh.

Technological options for SOx and NOx control

Three broad technical options are available to reduce ship's SOx and NOx emissions and accomplish the new IMO regulations: low sulfur content heavy fuel oil (HFO) to reduce SOx, end-of-the pipe technologies (e.g. scrubbers or SCR) and alternate fuel utilization (Liquefied Natural Gas-LNG). Engine and propulsion fixes are a fourth category.

The IMO regulation suggests HFO's reduced sulfur content as the best mean to achieve SOx emissions decrease by shipping operations. Hitherto, ships rely on residual fuel with sulfur content ranging between 3.5-0.5. Low sulfur content HFO is not so easy available (Eason 2011). For Lykkegaard (2011), from Danish Maritime[5], doubts flag the maritime industry on low sulfur fuels availability. In this situation, distilled fuels are an alternative to non available low sulfured HFO. Yet, given the high prices of distilled fuel, end of pipe technologies seem to be preferred by ship-owners (Eason 2011).

Exhaust gas SOx cleaning is the increasingly used technology to comply with legislation. Aalborg industries, a Green Ship of the Future (GSF) partner, tests scrubbers as part of the SOx abatement devices (GSF 2011). The system can work under a wet or a dry mode. In the wet mode, the SOx exhaust gas contained particles are absorbed by a liquid. This liquid can be sea water or a mixture composed by NaOH –as sketched in Figure 17. The wastewater can be alternatively stored or release into the sea. Dry scrubbing uses a solid absorbent in the chimney (Andreasen and Mayer 2007).

From a ship-owner perspective, the regulatory playground and technological update seems confusing. Feeding the Lloyd's list[6] with reports about technology updates and meeting regularly with shipping stakeholders, Craig Eason (2011) considers that "…the optimum is to use a scrubber, and the owners invest in scrubbers, some say yes, some say no, some say they don't know. But they have to do something by 2015, if they are in an emission control area".

Yet, the shipbuilding industry and land-based technology developers are aware of the ship owners' compliance needs. There are SOx regulation awareness and technology promotion initiatives targeting ship-owners and shipbuilders. In Sweden, Norway and Denmark several industry initiatives seem to encourage ship-owners technology adoption. To cite a few: the aforementioned Danish GSF has a Swedish counterpart with the Effship (Efficient Shipping with low emissions). Effship seeks to "improve the efficiency of the ship machinery, introducing alternative marine fuels, using wind energy as a complementary propulsion force and developing applicable technology for reducing the emissions of CO2, NOx, SOx and Particulate Matter". As Danish counterpart, incumbent land and maritime technology developers seek to combine all these technologies in a single vessel.

[5] Danske Maritime is a prívate association –founded 1919- of 22 incumbent Danish firms with stakes in the shipping business. Its purpose is "to bring together the leading Danish-based companies in maritime production, development and service in order to safeguard the common interests of the industry" (Danske Maritime 2011).

[6] Lloyd's List

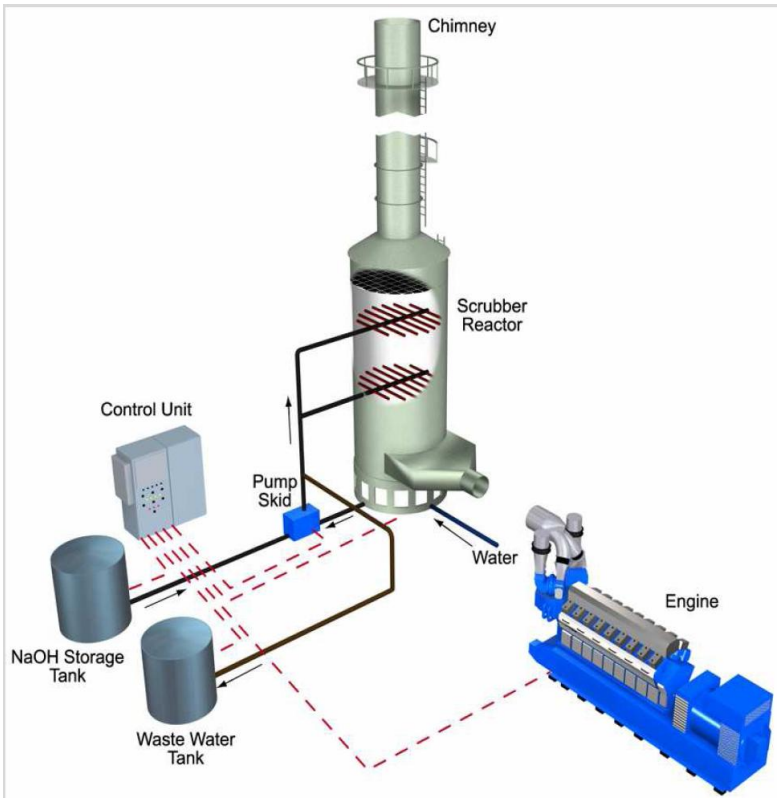

Figure 17- Sketch of a "wet" exhaust gas emission control system. The engines' exhaust gas is expelled by the chimney. *Source*: Heim (2008).

NOx control technical options

NOx control measures respond to ECAs Tier II measures in place since the 1st January 2011 and the tightened Tier III regime starting in 2016. Scrubbers cannot be used on NOx abetment. Feasible alternatives are Exhaust Gas Recirculation (EGR) and Selective Catalyst Reduction (SCR). STT Emtec AB is a Swedish EGR manufacturer. Its DNOx Marine ® is a filter based EGR that can be implemented in new or retrofitted ships to achieve Tier II regulations. The commercial brochure claims a NOx reduction between 35-45% from original levels (STT Emtec n.d.).

Canopus Marine Solutions AB is a Gothenburg-based SCR system developer. Their CaNOx® uses urea, ammonia as reductive agent. The NOx particles are reduced to N_2 and water. The commercial brochure claims compliance of this system with stricter Tier III requirements (Canopus n.d.). This company was visited during the fieldwork. The three maritime engineer employees know the shipping interests and demands. Canopus considers that there is no-one size fits all technical solutions for vessels, customers demand's differ and is key to adapt each technological solution to each vessel context (Bokesjö and Gripenwald 2011).

Liquefied Natural Gas (LNG)

LNG as fuel source can address NOx and SOx emissions, SOx is present at neglected levels and NOx is presented at low levels when burning. A ferry in Norway already uses

LNG as an alternative to HFO. This experiment gives some lessons to replicate LNG propulsion at a larger scale: the whole ships needs reconfigured reconfiguration to set space for the LNG storage tanks. Further, the experiment raised the need of LNG refueling stations. Despite, Einang (2007) acknowledges that NOx and SOx MARPOL Annex VI regulations will make LNG technology competitive as compared to low sulfured HFO.

Frederikshavn maritime stakeholders view LNG technology with reservation. Bo Kanstrup Christensen, from the Maritime Network, considers that ship-owners will likely invest on LNG. In case this investment focuses on retrofitting old ships to adapt the LNG systems, then ship service cities as Frederikshavn will likely see LNG technology as a business opportunity. However, he points that LNG fueling stations continue to be a pitfall for LNG. Contrasting with HFO, it is not easy to refuel a LNG vessel. Construction of refueling stations needs large investments. These stations could be another business opportunity at Frederikshavn. When a ship enters harbor for refueling, Christensen (2011) lists these complementary services: crew change, servicing, certifications. A challenge is however, the promotion of the "service station": how to attract customers.

Critical perspectives on regulation

MARPOL Annex VI updated regulations are seen with good eyes by the emissions control technology providers. For an entrepreneur, the ratified regulation will force ship-owners to install the technology on their vessels (Ingvorsen 2011). But, other stakeholders are more critical to upcoming SOx/ NOx regulations.

A first critique arises from the nature of IMO. As an UN organization, it works under consensual agreements. Frederikshavn local business promoters fear the tare of regulation to be lowered and some countries will contribute more than others. Not surprisingly, the first ECA was established in the North and Baltic Seas. Countries in the area have political agendas with environmental priorities on top. In contrast no ECAs are currently approved for Southeast Asia (Figure 18).In the maritime business, South east Asia becomes the top world region in largest ports and container terminals, hosting many of the cargo carriers, largest construction shipyards and some of the most transited seas (Frémont 2007; Rodrigue and Browne 2008, Lun, Lai and Cheng 2010).

A concern for Baltic maritime stakeholders —e.g. ship-owners—is the unfair competition from third countries registered ships. Unlike a Norwegian or Swedish ship, an Asian –or any third country registered- ship may sail over the Baltic without the same emission control technology. Conversely, Scandinavian ship-owners may invest on retrofitting or in new complying vessels. The maritime legislative framework gives a high priority to flag states (the country where the ship is initially registered). A snapshot to the registration flag of the world fleet provides an explanation to this concern.

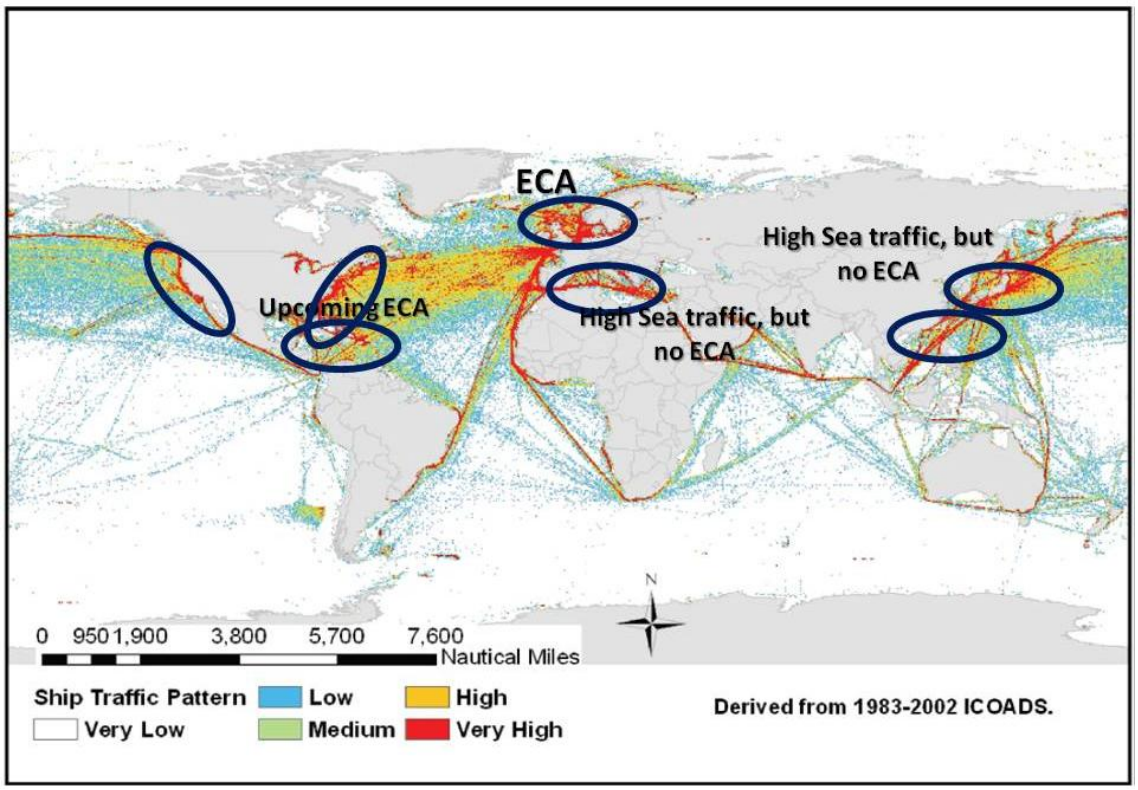

Figure 18- SOx Emission Control Area (ECA) and maritime traffic density. *Source*: International Maritime Organization (2009, Fig. 2.4)**.**

Table 8 presents the first ten deadweight tonnage flag of registration countries. These countries not necessarily own the fleet, but provide registration facilities to third country ship-owners. Endured by more flexible fiscal and regulatory scenarios, flag registry countries are headed by Asian and developing countries (UNCTAD 2010).

A problem would be third country registered ships entering into ECAs without the SOx or NOx reduction technical requirements. In Christensen's (2011) opinion, this discourages ship-owners to be first movers and carry with the costs when others are not doing so:

> Why should I be so environmentally conscious when everyone else is not. But I have to pay extra for it, what would I do if it were not my choice. I doubt. Shipping wants to be clean as everyone else, everybody wants to, but again. If you take in Denmark, you have to adjust to Danish regulation. But if you take ships is a world field and you have to compete with whoever is the cheapest

For this sake, ship designers want the Baltic Sea countries' national legislation to give maritime clean technology adoption incentives to local ship-owners. One way to achieve so would be to penalize third country vessels entering into the ECA without the SOx abatement devices or exceeding the minimum emissions levels:

> …sometimes you have an old vessels and a new vessel. This new is very clean but... that is something that Helcom [Helsinki Commission for the Baltic Sea protection] is intending to have a clean are up here. Suddenly an old vessel will come up here, and get more dirt, so that is why introduce one... could be a backlash to get dirty…when the

vessel comes from outside the (...) if you don't want to have a vessel up here as like the new vessels, the rules have to be written, forbidden old vessels. In that way the ship-owner likes it, but if the rule if like "new vessels will be punished" by not... they are on the same level (Bokesjö and Gripenwald 2011).

Table 8- First ten Deadweight tonnage flag of registration countries.

Flag of registration	Number of vessels	Share of world total, vessels	Deadweight tonnage, 1 000 dwt	Share of world total, dwt
Panama	8 100	7.93	288 758	22.63
Liberia	2 456	2.40	142 121	11.14
Marshall Islands	1 376	1.35	77 827	6.10
China, Hong Kong	1 529	1.50	74 513	5.84
Greece	1 517	1.48	67 629	5.30
Bahamas	1 426	1.40	64 109	5.02
Singapore	2 563	2.51	61 660	4.83
Malta	1 613	1.58	56 156	4.40
China	4 064	3.98	45 157	3.54
Cyprus	1 026	1.00	31 305	2.45
Republic of Korea	3 009	2.94	20 819	1.63
Norway (NIS)	560	0.55	18 648	1.46

Source: Adapted from UNCTAD (2010, Table 2.7).

As Figure 19 sketches, the stakeholder involvement in maritime legislation is broad. Given the internationalization of ships, nation-states and local ports are in a weak position to enforce a specific technical requirement in a given vessel. Instead, the responsibility to do so falls under the flag states. As shown before, these flags states are sometimes those where environmental requirements are weaker.

Classification societies: police of the maritime world?

As Figure 19 illustrates, classification societies are delegated by flag states to survey ship-owners compliance on maritime rules. Basedow and Wurmnest (2005) name classification societies "police of the maritime world". Classification societies are an important player in the maritime sector to get on-board technology. Few interviewees considered classification societies could play a role to enforce third country vessels to acquire SOx, NOx abatement equipment or ballast water management systems. Classification societies' primary goal is to "classify" vessels and the navigation equipment (including all auxiliary devices as engines, electrical systems, etc…) based on their own safety rules. Vessels are required to receive a class certificate by these societies –which need to be renewed after a period of time- (Basedow and Wurmnest 2005). According to the Lloyd's List technical adviser, Craig Eason, classification societies are neutral, but their activities go beyond "classifying" and issuing safety

certificates. For instance, classification societies engage in consultancy nowadays[7]. In a nutshell, the role of classification is a blurry line between strict risks assessments, classifying the ships and the consultancy services.

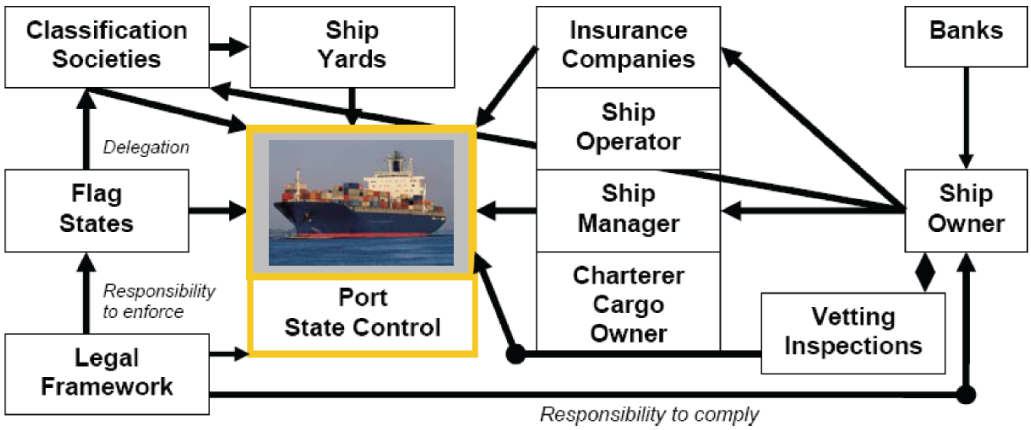

Figure 19- Maritime legislation enforcement stakeholders. *Source*: International Maritime Organization 2009, Fig. 2.12.

Given the broad role of classification societies, there are implications for air and water pollution equipment (e.g. SOx scrubbers, NOx SCR or ballast water management systems). During the field-work, interviewees stated that this kind of equipment must meet IMO requirements to be commercialized. Yet, IMO does not do any inspections, but sets standards that the equipment on board must meet. Meanwhile, national authorities adapt these standards. Classification societies verify IMO and national standards compliance.

Market pull

Regulations are the main cleaner practices adoption driver for a conservative maritime sector. Despite the Baltic Sea becomes an ECA, it was shown the difficulties to ensure all the ships sailing there control their emissions. Therefore, regulation alone could not ensure shipping companies compliance with SOx/ NOx. Besides regulatory push, adoption of SOx and NOx controlling technology can be explained by a cost reduction, regulation incentives and corporate social responsibility (CSR) combination.

New restrictions are seen as opportunity to reduced fuel associated costs. Some incumbent players expect to spend less in HFO by retrofitting vessels and constructing new ships with improved engines and propellers. Therefore, when large incumbents as

[7] Some of the most important classification societies are competent in some maritime areas albeit they provide services in all maritime matters. Det Norske Veritas (DNV) is a Norwegian Classification society focusing on LNG (liquefied natural gas) fuel development. Germanisher Lloyd is competent in containers classification. Another major classification society is the 1760 London based Lloyds Register (Branch 2007; Eason 2011)

AP Møller invests in maritime clean tech ventures, their interest is to get access to low energy consumption and high efficient technology (Ingvorsen 2011).

Maritime clean tech demand: bounded on time?

Path dependence can explain why shipping companies, ship builders and ship owners resist the adoption of environmental friendly practices. An interviewee mentioned that major stakeholders in the shipping business "want more of the same". Ship-owners and service provision technical staff foresee in new technologies a barrier to their business-as-usual practices. In general, shipping industry sticks to the strictly necessary "what they have to do", but leaving room to slight self-initiatives spurring from major commercial clients -what will later be exposed as market-driven interests (Bokesjö and Gripenwald 2011).

Besides path dependence, the ship-owner associates maritime clean technology update[8] with risks. According to Craig Eason, ship-owners consider risky to invest on non-conventional technology whose life-time is dubious. Furthermore, the whole legislation nature is filled with uncertainties regarding evolution overtime. An example of these uncertainties is how to combine MARPOL Annex VI complying technology. As Figure 15 sketches, SOx and NOx regulations often overlaps, and also ship-owners are confused on how to install SOx and NOx abatement technology. NOx SCR needs high exhaust temperature and scrubbers reduce exhaust temperature, therefore scrubbers should be installed after SCRs (Bokesjö and Gripenwald 2011).

Christian Ingvorsen from the start-up Desmi Ocean guard considers that market for ballast water management systems (BWMS) is restricted to a specific time frame (2014-2019) because IMO Ballast Water convention is expected to enter into force in 2012 (Figure 20). During that time frame a minimum of 15 000 to 20 000 systems will be retrofitted per year. But beyond that time, the retrofit market is over.

National governments and local ports initiatives seek to encourage SOx and NOx technology adoption in the Baltic Sea. The empirical evidence did not assessed to what extent ship-owners see in these initiatives a main driver to adopt gas emission controlling technology. However, two incentives exemplify which "carrots" could promote new technologies in ECAs.

[8] Including SOx scrubbers, NOx SCR and Ballast water management systems (BWMS).

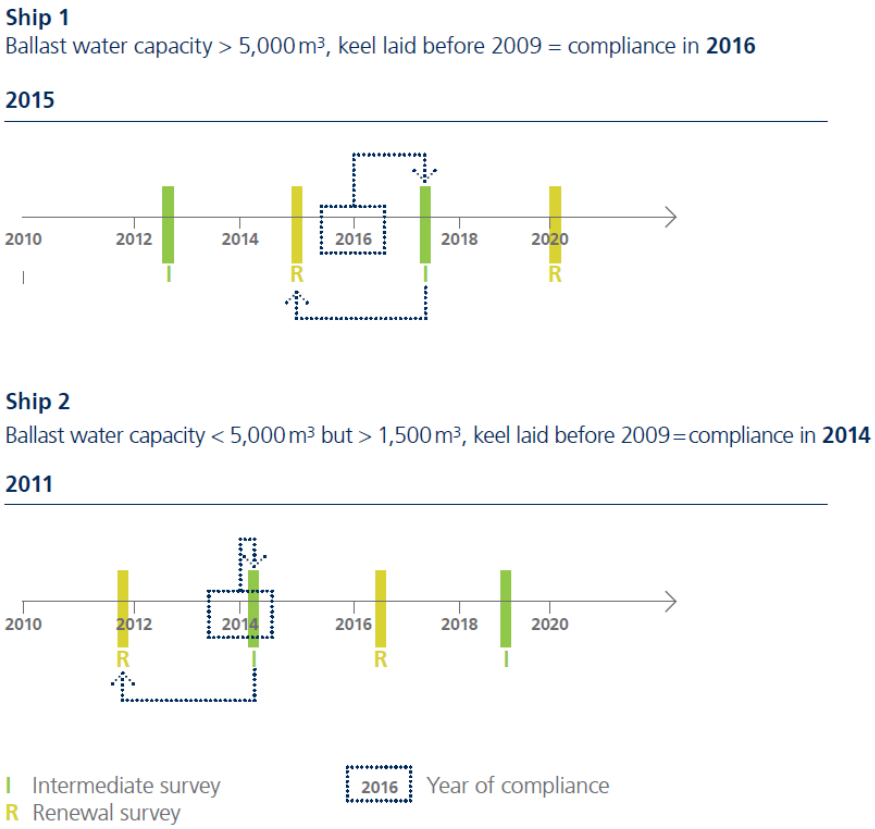

Figure 20- Time line on Ballast water convention compliance. *Source*: Lloyd's Register (2011).

Incentives: Norwegian NOx fund and Gothenburg Clean Shipping Index

The Norwegian NOx fund is a voluntary program between 14 business organizations and the Ministry of Environment. Since it became applicable (1st January 2008) it seeks to reduce annual NOx emission to the threshold value of 98000 ton by the end of 2011. The agreement was extended until 2017. The fund finances enterprises wishing to update NOx controlling technology. Besides, the enterprises joining NOx fund have a 16.43 Norwegian Kroner/Kg NOx tax exemption (Næringslivets Hovedorganisasjon 2011). Hitherto, the major impact of fund has been a 23000 ton NOx reduction between 2008 and 2011 with 530 supported or verified projects (Høibye 2011).

Clean Shipping Project is a Region Västra Götland (Gothenburg) funded initiative. It launched a web-based interactive index and database (CSI). Current members are large cargo-owners who can fill in 20 questions on 10 ship categories' criteria as SOx/NOx emissions, waste water, bilge water, antifouling. A third party (Classification society) should verify the information and the owner should register at least 20% of the fleet. The database is then shared with carrier or trading companies. The information serves as a decision-making tool, to choose the vessel with the lowest transport environmental impact (Duus 2011a). The tool can also serve to shipping authorities to reward best performing vessels. Forwarders and classification societies also benefit from the collected information (Duus 2011b).

CSI illustrates that some shipping companies invest in SOx/ NOx abatement equipment as part of their self-regulation interests. Rederi AB Transatlantic is a Swedish ship-owner with NOx/ SOx compliant vessels. The company owns 30 vessels and the fleet's environmental performance information was filled in the CSI database. From a market point of view, Transatlantic AB expects to "be a part of the increasing of green shipping, it is a win-win situation for all members and they can reach new customers globally" (Rusth Jensen 2011).

The case of Transatlantic illustrates how besides command-and-control regulation, market based instruments and information release may serve similar purposes. . From a ship-owner perspective, CSI is an instrument to improve image in order to attract customers (carriers and trading companies). AB Lindex is a Swedish fashion retail company with stores in Sweden and online shopping. Their clothes are manufactured in Asia and transported to Europe. As part of their CSR, Lindex committed to reduce the environmental footprint associated with transport. CSI helped Lindex to find a carrier with the best environmental performing vessels (Albinson 2011).

However, tools as CSI may also serve as incentive. Gothenburg Port proposes differentiated harbor fees based on a vessel CSI NOx, SOx and antifouling rating. The 600 000 Swedish Krone incentive is retroactive and rates the first 20 registered vessels. In synthesis, voluntary instruments as CSI may pull ship-owners to install SOx and NOx controlling technology. The threat of having a bad image works as an incentive (especially in the container share). Moreover CSR serve as a CSR promotion tool.

Cargo owners' logistic chain improvement can be another driver for the adoption of NOx and SOx controlling technology. Some Swedish paper producing companies export by sea to Europe. This part of the transport cycle implies a great SOx contribution. To address this issue, the paper company requires the sea transporter to reduce its SOx emissions. If the ship-owner cannot fulfill this requirement, the paper company will likely choose another carrier. In the production of paper, the company releases NOx as well. NOx emissions are more regulated on land than over sea. As sea NOx emissions add the larger part of the overall NOx emissions (including land-based), the paper producer tackles the share of maritime transportation (Bokesjö and Gripenwald 2011).

Chapter 5
Cleaner Shipping Ecopreneurship in Frederikshavn: Opportunity Discovery and Exploitation

Chapter four provided a contextual perspective for the case study. Maritime clean tech updating is mainly driven by stricter maritime air pollution control regulations and by self-regulation and market-based factors. The case study is also bounded by a region: the North Sea and the Baltic Sea. This region is the first ECA currently enforcing SOx control regulations.

This chapter presents empirical evidence to build the case study and answer three research sub-questions. Three main Sections compose the chapter:

- The first section is named "Maritime sector and employment in Frederikshavn" and introduces the case study.
- "Intermediaries' role: information and competence carriers" addresses the third research sub-question, and explores the role of intermediaries in the business opportunities discovery/ recognition process. The results in this section will be later contrasted with the business opportunity discovery theory introduced in chapter 3.
- The last section is named "Drivers for maritime ecopreneurship opportunity discovery/ recognition and exploitation". This section explores how maritime ecopreneurs discover/ recognize shipping clean technology associated business opportunities. The empirical evidence builds on entrepreneurial motivation propositions presented in chapter 3.

Maritime sector and employment in Frederikshavn

Frederikshavn follows a similar employment leak pattern as other kommunes facing de-industrialization. The leak of jobs has grown in Frederikshavn with the closure of shipyards: 1500 lost jobs with Dan Yard's departure in 1999, 800 people unemployed in 2002 Ørskov Christensen's departure, 500 jobs lost in 2004 with the MAN Diesel motor production facility transfer to Asia (Frederikshavn Erhversvråd 2011). The maritime sector was "smashed" according to Christensen (2011). The red dotted line in Figure 21 contrasts these marking events with maritime service SMEs' foundation years.

The previous marking events entailed unemployment among maritime highly qualified staff. The authorities needed a solution (Therkildsen, Hansen and Lorentzen 2007). Without a yard to work and with high qualifications, many of the technicians began their own business to apply their abilities in practice. Perhaps, this explain the blossom of maritime service SMEs in the last two decades (Figure 21).For Christensen (2011) many of these startups had problems to keep their business floating : "when you are an engineer, marketing is something you don't consider".

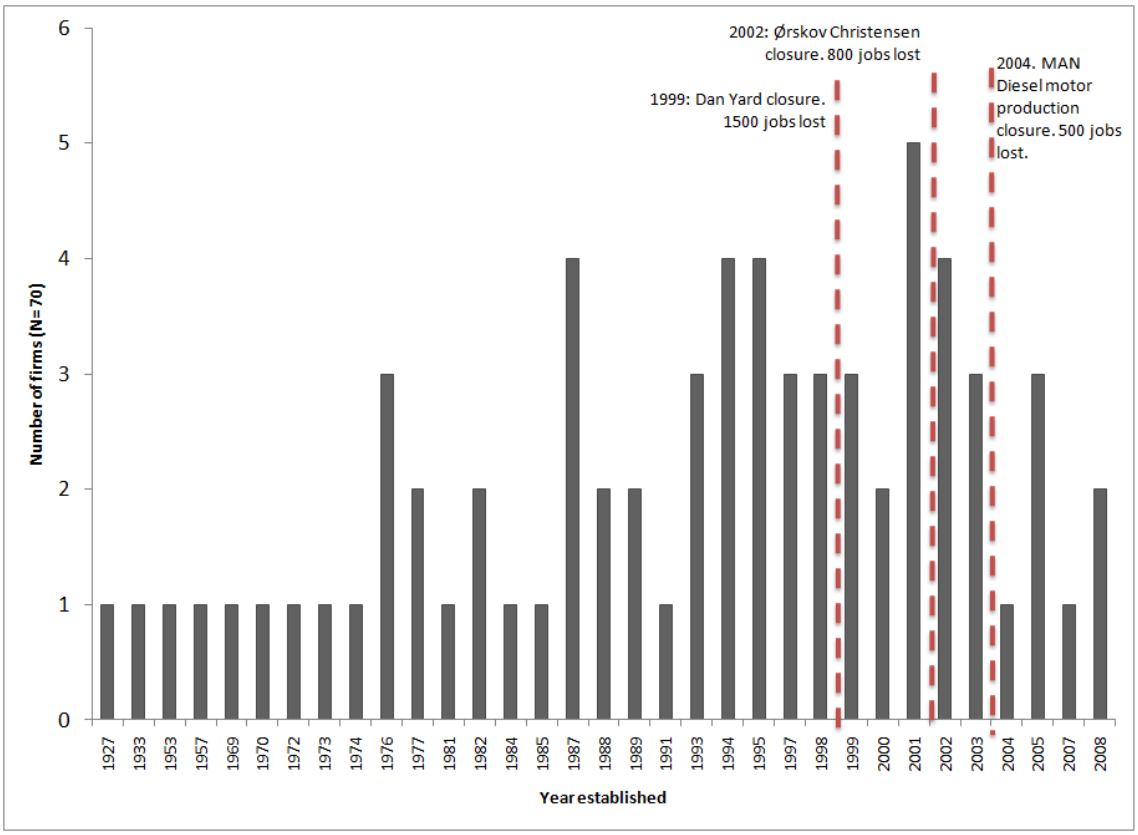

Figure 21- Existing Frederikshavn, Skagen and Sæby (Frederikshavn Kommune) maritime firms' foundation year and important shipyard employment milestones. *Source*: Gitte Hyttel Nørgård, March 17, 2011, Database supplied to author).

By 2009, most of the companies providing maritime services[9] were small and medium enterprises (SMEs). Figure 22 compares firm's activity and size (number of employees). The four categories respond to the definition of maritime services given by Danske Havne (2010). This definition groups maritime services in the following activities:

- Repairs and manufacturing
  - Repair, refurbishing and building of ships and offshore installations – e.g. Industry and Handicrafts in electronics, hydraulics and machinery.
- Diverse
  - Industrial service - e.g. processing of fish.
  - Logistics, pilotage, towage, etc.
  - Supply and waste disposal.
  - Catering - ferry
  - Training, recruiting, etc.
- Trader
  - Ship brokers and consultants.
  - Bunkering and ship trade.

[9] The maritime services derives from the broad Maritime sector. The maritime sector encompasses all activities associated to transport by ships. This includes: shipping industry, shipbuilding and repair, maritime equipment manufacturing, maritime service and offshore, off-shore and gas extraction (Region Nordjylland 2009).

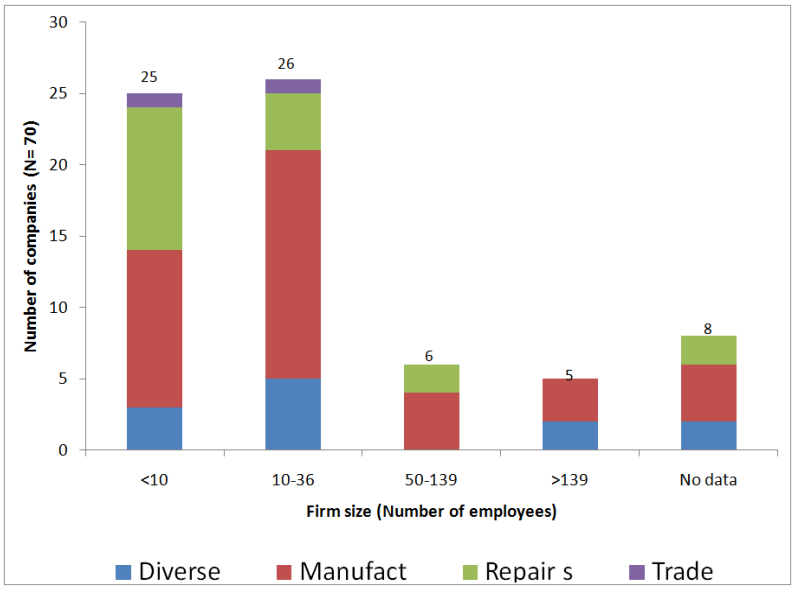

Figure 22- Comparison between firm size and activities. Frederikshavn Kommune. *Source:* Gitte Hyttel Nørgård, March 17, 2011, Database supplied to author).

According to Danske Havne (2010), Skagen and Frederikshavn harbors generate 6919 direct and indirect jobs. Skagen harbor generates 2342 jobs, Frederikshavn commercial harbor generates 2501 and Frederikshavn Navy base generates 2076. Intermediaries help new business to start-up, keep competitive on market and growth.

Incumbent and entrepreneurs relation in Frederikshavn

As sketched in Figure 22, companies with less than 26 employees amount more than 60% of firms in the kommune. Nevertheless, the role of firms employing more than 50 employees cannot be disregarded: 2009 data shows that they create 5218 jobs, which implies 90% of the total maritime sectors jobs in the kommune

Table 9- Large size Frederikshavn Kommune maritime service firms and number of employees.

Firm	Number of employees
Mekanord A/S	50
SenCON A/S	50
Furuno Danmark A/S	53
Vestergaard Marine Service	60
Danish Yacht A/S	69
Roblon A/S	139
Stena Line Denmark A/S	155
Scanel International A/S	199
Karstensens Skibsværft	200
Flådestationen	1800
Man B&W Diesel A/S	2443
Total firms (≥50 employees)	5218
Total combined SME (≤36 employees)	601

Source: Gitte Hyttel Nørgård, March 17, 2011, Database supplied to author).

For Frederikshavn Kommune business promoters, the importance of large firms goes beyond merely job creation. Large firms can attract more clientele because these firms

have a name on the market. Therefore, with larger assignments they can generate contracts for smaller companies. SMEs can fill some of the competences and deliver minor assignments to the bigger companies.

An example of the previous is MAN B&W Diesel. Although the manufacturing branch closed down operations in 2004, its Primeserve branch still generated circa 2500 jobs in 2009. An interviewee in Frederikshavn admitted: "It is good signs for Frederikshavn that this firm stays in the harbor and is currently expanding its facilities".

Other stakeholders consider that more incumbent companies (e.g. Aalborg Industries), could partner Frederikshavn SMEs to install SOx scrubbers. In this way, Aalborg industries could benefit from a more convenient placement vis-à-vis Aalborg for vessel retrofit. In fact, MARTEC[10] recently installed scrubbers in its own laboratories for training purposes.

Maritime network: incumbent and entrepreneur interaction

Frederikshavn's Maritime Network is a rather new initiative launched in late 2009 by the Business Councils in order to promote business growth. Frederikshavn harbor also supports the network, as the harbor considers the network's promotion activities can increase some vessels docking (Christensen 2011).

Around 40 firms compose this network that sells Frederikshavn's assets in the following domains (Frederikshavn Maritime Network 2011):

- Ship repair service
- Marine transport and logistics
- Marine fuel and provisions
- Shipping and consultancy service
- Marine waste solutions
- Crew management service
- Passage service

The network comprises 31 active members, 30 of them are shipping related firms and one is a shipping line (Stena Line). The remaining nine members have a passive and supporting role (banks and lawyer firms). The network originated with the goal that SMEs attracted more customers on the yard. Ship-owners prefer one single servicing stop (as those listed above). As Erik Møller states:

> The idea was that there are many small companies that work as single companies. But most of them have a common customer, ship-owners for instance (…) then they are dealing with the ship-owner, they do what they can do. If they hear about other things, they say... that is not our business and they do not do more. So the idea is when a person from these companies are visiting customers, he has 40 companies in his back pocket, when he's on port with the ship he always ask if there is something else he can do.

The network's first task is promotion: Frederikshavn network's affiliated SMEs have participated at international maritime business events (e.g. in Hamburg and Gothenburg). Besides, a webpage and printed documentation promotes the network's

[10] MARTEC is a maritime school located in Frederikshavn. The role of this school is explained further on.

service offer. In Møller's opinion, joint promotion fosters cooperation among hitherto competing firms:

> That is quite... for some of them it is quite systematically they work together, one take the electrical part, one take the mechanical part. In the eyes of the ship-owner they are one big company. This kind of cooperation is growing (…) because if they are single they are very small. But if they go together they have more capacity.

Intermediaries' role: information and competence carriers

Information carriers to promote business growth and employment

Information flows from sources (at the left of the figure) to the end-users (at the right) is illustrated in Figure 23. This information concerns maritime cleantech business opportunities. Intermediaries help spot and share information with end-users. Information rich contexts are major shipping events or shipping associations where ship-owners discuss sector's current and future trends. Intermediaries are business promotion agencies (Frederikshavn *Kommune* and Frederikshavn Business council (*Erhvervsråd*). Final users are the firms requesting the services of the business promotion agencies (including the maritime network).

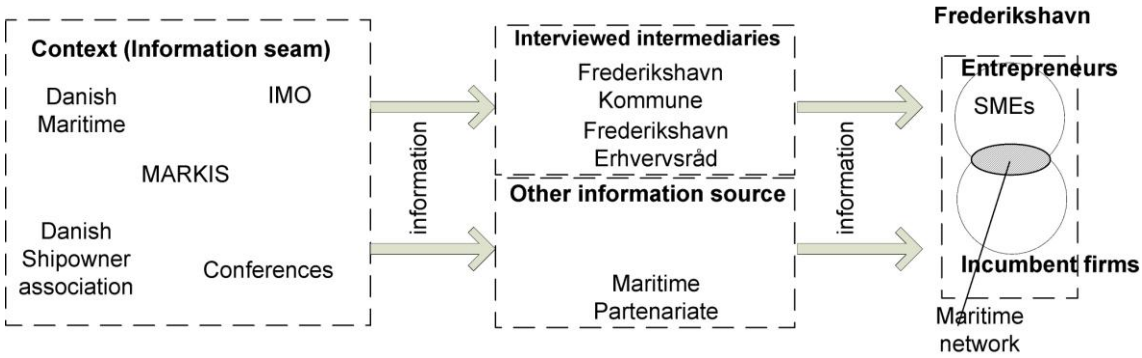

Figure 23- Intermediaries' role on information sharing

Frederikshavn *Kommune* and Frederikshavn Business council (*Erhvervsråd*) are the two major intermediaries helping information flow. Indirect information sources are specialized maritime events (e.g. Maritime Partenariate) setting stage so the demand side meets the suppliers. The need to secure employment may explain Frederikshavn *Kommune* and Frederikshavn *Erhvervsråd* involvement. Both organizations perceive business creation and growth as a mean to achieve this goal.

The role of Business Councils fits Frederikshavn's situation. Business councils were initiatives launched in the mid- 1980s in Denmark. They represent a particular third way to promote local development. In the 1970s, the development strategy consisted in the manufacturing capacity promotion of local hinterland kommunes. Afterwards, the industry moved from Danish hinterland to lower costs countries. Thereafter, local government's development targeted outsider investors to create enterprises locally. Each kommune exploited its assets and offered incentives to investors. The business councils resulted in an alternative to these two previous ideas of local development. Largely subsidized by kommunes, but also with private involvement, business councils are not

exclusively focused in manufacturing, but, exploit broader kommune's assets: including services (Snell 1988).

In line with the previous, Frederikshavn Kommune launched a Business development strategy (*Ehrvervsudviklingsstrategi*) in 2008. This strategy is a participatory initiative by local businesses and council representatives. The final document encompasses the local stakeholders' needs related to future challenges. The strategy's argument focuses in four domains: labor, competences, experience economy and "world as commercial center". Labor implies creating incentives to retain the workforce in the area. Competence refers to the promotion of workforce's new economic domain skills. Tourism is another core economic municipality's domain. "Experience economy" seeks to promote tourism all year around by "selling" the municipality's assets in its historic and cultural richness. The final domain encompasses trade and globalization related business opportunities. Knowledge-based and service based economy could have implications and set opportunities for places as Frederikshavn (Frederikshavn Kommune 2008).

Frederikshavn's Kommune Business Support department (*Erhvervs og direktionssekretariaet*) is the local promoter of the Business development strategy. This organization is independent from Frederikshavn *Erhvervsråd*, but, they work closely together. They are located in separate buildings, have different personnel and differ in their tasks. The Kommune's Business department has a more distant relation with entrepreneurs but conveys more strategic information (e.g. how to create synergies and funding for concretize the business development strategy's targets). Concretely, the Business support department emphasizes the sector of energy, maritime, retail sale and fishing. An interviewee from the department considers that climate and environmental change scenarios match with the energy and maritime sectors. Therefore, business opportunities could be locally promoted in these domains - e.g. renewable energies (Nørgård 2011).

Entrepreneurs in need of information and advice may approach the Kommune, but Frederikshavn *Erhvervsråd's* answer entrepreneurs' concerns on business set-up, operation and opportunities. This Council gets kommune funding and therefore, supports any business in Sæby, Frederikshavn and Skagen. The counseling is diverse for entrepreneurs willing to start a new firm. The advice may go on financial related issues (e.g. how to draft a budget, how many employees to hire, how much to invest in the venture). Although the *Erhvervsråd* does not finance ventures, it gives advice on potential financing sources. Another information way is to match the entrepreneur in need of knowledge with the appropriate training organization.

MARKIS involvement

The *Kommune*'s Business support department also interacts with the Business council in scouting innovation and competence projects for the city. MARKIS and MARCOD (Maritim Center for Optimering og Drift)[11] are two examples of this interaction. While the first (MARKIS) is a KASK regional project, the second (MARCOD) is a Danish initiative.

[11] Martime Center for Optimization and Operation.

MARKIS's involvement seeks to bridge business opportunities for Frederikshavn's maritime service companies. An interviewed business counselor acknowledged MARKIS information and contact gathering as the primary goal. Yet, the interviewee grants that environmental protection drives the needs of shipping companies: "…we help to look after the companies, it would be very relevant for them to find a small niche, a small thing where you can actually care about these environmental solutions in the shipping industry" (Hejslet 2011).

In practice, both business support organizations can foster networking between entrepreneurs and potential clean technology customers in the maritime sector. Joint projects promotion is one way to achieve this networking. In MARKIS, however, joint projects must be presented between at least two different partner organizations located in different countries. Lunde-Christensen (2011) cites the example of a Skagen based initiative to develop an energy efficient ship of light materials. Funding these projects is not a task of Frederikshavn business support organizations, instead they suggest and connect project developers with potential funding sources.

Another interaction between business promotion organizations is the maritime competence center (MARCOD)[12]. As further developed below, the two local business promotion agencies' role was to link different people, and raise funds for the project. The Frederikshavn Kommune business support department emphasizes MARCOD's social goal:

> We are in the development area, so we are not going to be part of everything which is already in place. Because then we'll be everywhere. Of course we are following it close, it is very important for us, that this is going to accomplish the goals: 100 jobs in three years, and about 400 hundreds in five years. That is what is important for the municipality… get this investment back in jobs (Nørgård 2011).

Competence creation for green shipping in Frederikshavn

Information gathering and sharing regarding new developments in maritime technology can help identify what are trends in the shipping industry and what could be businesses' niches of Frederikshavn.

Intermediaries' second endeavor is to match potential entrepreneurs or current SMEs with competence providing organizations (Figure 24). Stakeholders in Frederikshavn maritime sector consider that technological changes will require new competences to exploit the potentials of new technologies. This section presents how the Frederikshavn Maritime School (MARTEC) deals with new competences. Besides, the section discusses how Frederikshavn business intermediary agencies promote new competences (MARCOD and Green ship project).

[12] A more expanded explanation on this project is given in the "competence" heading below.

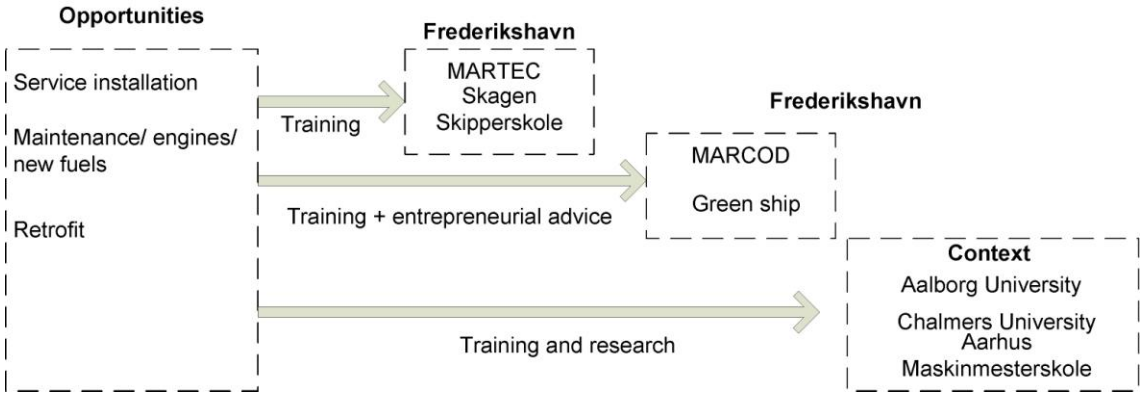

Figure 24- Relation between business Cleaner Maritime Technology opportunities and competences in Frederikshavn. *Source*: own elaboration.

New competences are needed to respond to maritime clean technology

Most of Frederikshavn's maritime service companies employ trained staff who can render an efficient service. However, SMEs in Frederikshavn are locked-in with traditional technologies. These SMEs lack the time to get acquainted with new technological developments and changing regulations. According to Bo Christensen, the Maritime Network's head, it is his responsibility to deserve time to oversee the changes facing the sector. In his opinion, the information and opportunities are out there, and initiatives as MARKIS can help to identify these opportunities and inform other members of the Maritime-Network.

Erik Møller, MARTEC's director, pin-points competence needs in the following domains:

- Ship catalyst systems' installation, this may happen with SOx abatement scrubbers, NOx SCR technologies and alternate fuels burners (e.g. LNG).
- Rebuilding of existing ships, this service is in connection with a focus on energy optimization. However, this opportunity will depend on the legislation

For Christensen, Frederikshavn maritime service staff will face challenges within the next years. By then, new technologies will be widely used on board and Frederikshavn's staff may not be competent to service these vessels. The main issue relates to timing: if service competences are acquired on the run (e.g. at the same time as the technologies appear), then the harbor's businesses will lose competitive advantage vis-à-vis other regions that may already have the competences. However, Christensen claims that networks as MARKIS and its affiliated research and education centers (e.g. Aalborg University, Chalmers Technical University) may shed light on what are the necessary competences to focus on the future.

Current competence creation: MARTEC

Despite concerns regarding competences related to future maritime technologies, Frederikshavn's maritime education center is the one working in close contact to the maritime stakeholders and their current competence needs.

MARTEC is a Frederikshavn based training center. The school generates competences through formal and tailored-made short industrial training courses. The school offers

around 20 different training lines. Formal education includes the three to four years maritime engineer formation (MARTEC 2011). Each year around 600 students and trainees attend short courses, and circa 280 students are enrolled full time.

MARTEC´s maritime engineers exemplify how conventional ship technologies competences will gradually evolve into cleaner technologies associated competences. According to Erik Møller, maritime engineers acquire electrical-mechanical operation and system optimization skills. These competences involve conventional ship devices' control (e.g. engines, boilers) and electrician's tasks on board. After this basic training, the engineers can choose four areas of specialization in the last year: power and automation, energy and environment, management and shipping. The employment of MARTEC alumni reflects preferences for land based-industries. According to Erik Møller, 80% of the students "end on shore", employed in power stations, waste handling facilities, hospitals, electrical installation firms, mechanical firms, control industries, food processing industries. The land-based employment bias is not a drawback for future maritime industries. Maritime competences can be applied to land-based technologies and vice-versa. As an example, in the last years, from 140 MARTEC student projects, 70 to 80% focused on energy and maintenance automation (land-based or sea-based).

Beyond conventional competences, MARTEC considers looking to the future. The School receives insights from Frederikshavn Maritime Network on new competence arenas. This may result in new courses or new laboratories to get students acquainted with new technologies. A visit to the lab helped the author to understand the evolution of MARTEC. The electricity and engine laboratories were reorganized to familiarize students with fuel cells, gas turbines, wind turbines, boilers and automated control systems.

In addition, the new maritime ECA regulations have awaken interest to develop competences in NOx and SOx controlling technologies. A first example is a computerized fuel injection simulator, which controls the emission of NOx, depending on the region's NOx emission limits. A second example concerns scrubbers. MARTEC has a vivid interest to install experimental scrubbers. In this way, students will be able to operate SOx emission abatement scrubbers.

Competence creation in Frederikshavn: MARCOD

MARCOD is a three years 15 million Danish Krone (DKK) project focused on the creation of 500 jobs in Frederikshavn Kommune. Despite an employment creation focus, MARCOD is not restricted to Kommune's partners. Instead, the project promotes partnership from companies based all around Denmark in a triple helix (University-Industry and Education centers) configuration[13]. MARCOD complements MARTEC

[13] While writing this thesis, MARCOD was still managed by Frederikshavn Erhvervsråd. Although an "official" list of partners was not available, information from Frederikshavn Erhvervsråd shows that industry, Government and education centers are involved in MARCOD. This is the list of members : Dansk Rederiforening, Dansk Eksportforening, Danske Maritime, DTU, EBST, EMUC; FME, FORCE Technology, Frederikshavn Erhvervsråd, Frederikshavn Havn, Frederikshavn Kommune, Incentive Partners, Maritime Network, MARTEC, MSR-Consult, NAVCON, Region Nordjylland, Serviceteam

competence tasks. While MARTEC is an education center, MARCOD is a business promotion oriented initiative.

The aforementioned employment problems pushed Frederikshavn Business Council and Frederikshavn Kommune to do something for the maritime sector. These two organizations drafted an initial "Maritime Knowledge and Innovation Center" project. Subsequently, the local maritime business community welcomed this idea in November 2009. The project got a 9.5 million DKK in funding from *Fornyelsesfonden*[14] and 3.2 million DKK from *Vækstforum* Nordjylland [Growth Forum Nordjylland] (Frederikshavn Erhversvråd 2011).

The main idea behind MARCOD is to support local businesses (particularly SMEs) to be ahead of the Maritime technology developments. This "front-runner" objective can only be reached by adapting the existing education according to needs of the maritime sector. In particular, MARCOD will allow Frederikshavn businesses to respond to ship owners' demands in retrofitting, scrubber installation and improving engine energy efficiency (Lunde-Christensen 2011).

Green ship: a promotion project

Currently MARCOD has one running project: "*Det Grønne Skib*" [The Green ship]. It consists of installation of air pollution prevention technology on the ferry Læsø-Frederikshavn. The "Green ship" is a partnership between 18 Danish maritime organizations (including ship builders, yards, navigation equipment providers, education centers and local business promotion agencies)[15]. In some aspects, the Green Ship emulates the larger Danish project "The Green Ship of the Future" (GSF 2011). Nevertheless, both projects have differences on scale, the stakeholders and where the technology is installed (e.g. each GSF participating ship has a different demonstration technology on board; conversely, the green ship has all technologies on a same ship).

The Green Ship project has two major goals: first, it aims to promote Frederikshavn as a maritime retrofit and service station for air pollution control technology. Second, in the light of the previous, it promotes synergies between SMEs and incumbent firms.

The Maritime Network also promotes Frederikshavn as an air pollution control retrofit and service station. According to Christensen (2011), it is important to let ship operators and managers know that Frederikshavn provides several services. Part of the promotion strategy should emphasize Frederikshavn's assets: besides a fast and reliable service, there is an airport and road transport (to change crew), and training schools.

Skagen Havn, Skagen Skipperskole, Søfartsstyrelsen, Væksthus Nordjylland (Frederikshavn Erhvervsråd 2011a).

[14] The Innovation Fund is a 2009 initiative of the Danish Ministry of Economic and Business Affairs (Fornyelsesfonden 2011)

[15] Green Ship member organizations range from local SMEs to incumbent international firms, they have in common their links to Frederikshavn: RM Staal A/S, Orskov Yard A/S, Soft & Teknik A/S, Scanel International A/S, Elektromarine A/S, Denrex Aps, Clean Marine Exhaust A/S, Skagen Skipperskole, Force: Green Ship of The future, Norisol A/S, Thorøs Industri & Skadeservice, Silentor A/S, MAN Diesel & Turbo, Brancheforeningen Danske Maritime, Færgeselskabet Læsø, Frederikshavn Kommune, Frederikshavn Erhvervsråd (Frederikshavn Erhvervsråd 2011a).

Previous experiences in Frederikshavn inspire the types of synergies forged through Green ship. In fact, the "Green house" looked for a similar objective: creation of an infrastructure with a low environmental footprint (especially in energy consumption). Several local firms worked together and made different installations, so the potential customers could see what each one had to offer. Besides, media promoted the "Green House", and therefore the Kommune was known for the project.

Afterwards, the idea of the "Green house" was proposed to the "Green Ship". The ship could be a "floating exhibition". Customers may sail on it, and see the different devices in action: insulation, electricity saving system, NOx emission control equipment. Besides, the engine will have gas and fuel measurement devices to track fuel consumption and gas emissions (Hejslet 2011).

Drivers for maritime ecopreneurship opportunity discovery/ recognition and exploitation

This section is based on two maritime entrepreneurs' in-depth interviews and associated document review (Figure 25). The first part explores entrepreneur's motivations to start and run their firms. The second part presents the entrepreneurs' perspectives on opportunity existence. The third part discusses how these opportunities are discovered and explored.

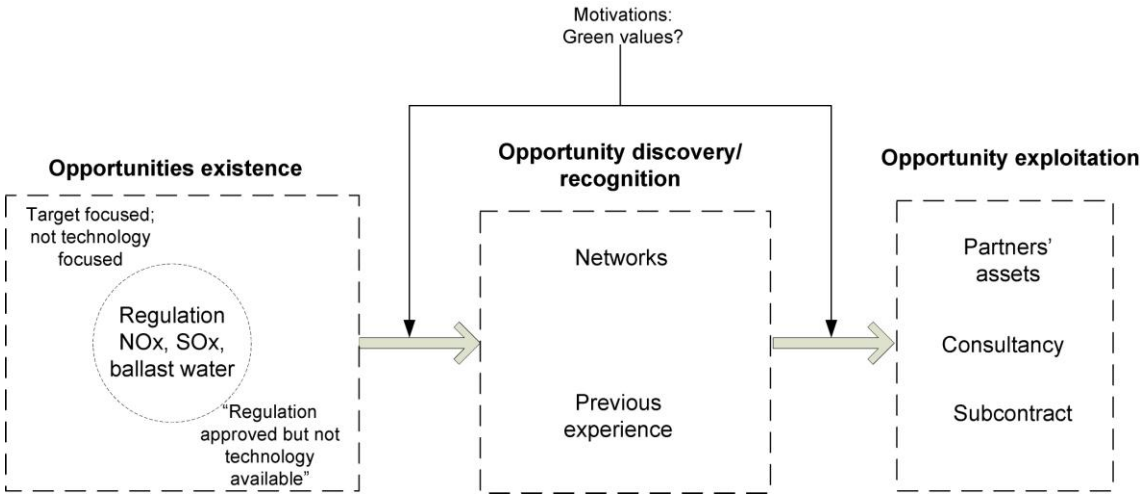

Figure 25- Relation entrepreneur and opportunity existence, discovery/ recognition and exploitation.

Ecopreneurs motivations

Introducing two maritime ecopreneurs

Two representatives from maritime startup firms agreed to participate in this research: Desmi Ocean Guard A/S and Canopus Marine Solutions AB. These two companies differ in technology offer, location and time of foundation.

Desmi Ocean Guard A/S is a ballast water management system (BWMS) Danish developer based in Nørresundby. It is a joint venture by AP Møller Maersk, The Desmi Group and Ultraaqua. The small firm involves ten persons: two full time (besides the entrepreneur Christian Ingvorsen one extra person), and eight part time partner companies' collaborators. Christian Ingvorsen proposed the initial idea to create this venture in 2006, after a life-long professional experience in a water oil-spill control technology provider.

Canopus Marine Solutions AB (CMS) is a Swedish maritime industry air emission control technology developer. Two naval architects and marine engineers founded the company last year. CMS' specialization is the development of NOx control exhaust gas control systems (e.g. Selective Catalytic Reduction –SCR-. Yet, CMS offers a wide array of consulting services on propelling and water treatment[16].

Ecopreneurial start: Do "green values matter?

Both entrepreneurs acknowledged that their businesses did not respond to "green" values as exclusive driver. In fact, improving environmental quality and the world was a secondary – if not a third driver for starting their business. Some of the entrepreneurs' personal motivations to start and keep their firms operating are presented here.

For Christian Ingvorsen, the main motivation to start Desmi Ocean Guard was the venture associated technical challenge. Besides, he grants importance to his past experience as a salesman and promoter of oil spill control technology. By then, he was focused to sell the best performing equipment, rather than focused on political discussion on how to solve the same problem. In the present, his personal challenge is to obtain the BWMS' permissions. For this purpose, he keeps a practical approach by issuing appropriate information to the three shareholders. In this way he keeps expectations at a realistic level:

> If I'm too negative, from the very beginning, then they can say... I don't want to join into this (…) if I'm too optimistic, they will hit me in the neck when I've problems, it is the challenge to find this area where you can work with being optimistic at a realistic level.

He does not consider that his endeavor is driven by a world improvement value. In fact, profit making interests pulled him to start the company:

> …why did you start the company? The reason is simple: we can make money on this, we going to save the world, or make it a better place. We have to make money for the shareholders. Keep it

[16] Water cleaning services: Development of bilge and mud water cleaning systems and Mud water cleaning systems. Propulsion consulting: Propeller and hull resistance calculations; Development of propeller pod systems; Commissioning of propulsion systems offshore installations and high speed vessels; Marine market researches, classification and rules (Canopus 2011).

> very simple and honest this is it. If we didn't know there was profit in this market, we will never join this…

Ralf Bokesjö and Magnus Gripenwald, used to work together in a previous company until the last year before founding Canopus Marine Solutions. Presumably, the reason why they founded a company has to do with improving their earnings. This experience linked them with knowledge about the maritime business. The knowledge helps them to access more easily to tenders.

Canopus' environmental values are not explicit through an environmental policy statement, but these values are implicit in the firm's delivered products and services:

> In itself the nature of our business is very promoting greener environment, greener marine environment, so I think that is to some extent that is sufficient. Maybe in the future we should put something in writing, formulating a vision for company procedures. We have not though that yet.

Bokesjö and Gripenwald argue that it is part of CMS' internal routines to be green. If CMS sells NOx/ SOx abatement technology, CMS should be consequent with its business' goals. As example, CMS' production contractors have ISO 14000 certification. Perhaps CMS' entrepreneurs have more evident values considerations to develop a green technology than the other interviewed entrepreneur. CMS' entrepreneurs consider that much more could be done to reduce NOx or SOx emissions. But the problem strives in the demand side: customer's willingness to pay is very low.

Opportunity existence: why do ecopreneurs perceive opportunities in maritime clean tech offer?

Maritime ecopreneurs consider that NOx, SOx and ballast water IMO regulations imply business opportunities. On one hand, these regulations were created "without the technology on the market". On the other hand, the regulations are "open ended", they set targets and it's up to the ship-owners to reach them. Both reasons leave open room for entrepreneurs – or incumbent maritime firms, who wish to fulfill the market. Yet, entrepreneurs are cautious on future scenarios.

Regulation uncertainty is a concern. As previously introduced, both entrepreneurs develop SOx, NOx or ballast IMO conventions technology. Although some of these regulations have recently entered into force (e.g. SOx ECA), Ballast water convention still waits to be ratified and IMO member states to adopt them into their own legislation. According to both entrepreneurs and to Craig Eason, these three IMO regulations were created without an appropriate technology on the market. At least this was the case for the ballast water convention. For SOx and NOx, a technology existed for land-based emission sources. Ship-owners fostered the demands on technology and services to update their vessels. This is the reason why ventures formed –in the case of Desmi Ocean Guard to develop a ballast water treatment system, in the case of Canopus to adapt land-based SOx control technologies to a sea-based market.

Besides, maritime stakeholders consider that any technology could be developed if it fulfills IMO requirements. This is seen as an opportunity not only by ecopreneurs but also by maritime protection index developers. Ulf Duus, from the Gothenburg Clean Shipping Index (CSI), considers that ship-owners would acquire any technology that

proves legal compliance. In fact, CSI does not evaluate a particular technology, but it centers on whether the ship complies with a certain regulation (e.g. ballast water pollutant limits, or NOx, SOx emissions limits):

> If it is only ballast water treatment, to get full score you have to have a final (...) it has to be tested and accepted by IMO, (…) final acceptance. Of course it should be methods that do not use toxic substance or have a release of toxic substance or make a threat for people who work (...) so, it's a big problem but there are many actors on that now. Trying to find "final approval" is the name… IMO final approval, if you have that for ballast water system, you get the highest point in our system. That is on shore and on the vessel that this actually works. You don't have a dangerous solution for the environment.

Despite this perception to acquire water and air protection equipment, entrepreneurs are cautious on the consumer side willingness to pay. Canopus' managers consider that ship owners are currently waiting and reflect this on scant NOx/ SOx abatement equipment and installation purchases.

Opportunity discovery/recognition and maritime ecopreneurs

Canopus and Desmi Ocean Guard cases shed light on how information availability supports discovering and recognizing ecopreneurial business opportunities. In these two firms, entrepreneur's networks and previous experience facilitated information.

Maritime ecopreneurs should count with network or intermediate available information. For Christian Ingvorsen, "network" comprises the shareholders' specialists and not other business/ maritime networks. In his opinion, shareholders' networks are enough to discover market trends and regulations surrounding technology approval.

In particular, one new technology developer's challenge is getting IMO approval for certain technology on board. This approval is required if the technology aims to be commercialized[17]. Ingvorsen saves time and resources while accessing Maersk's maritime technology regulations specialists. He mentions that a bottle neck became the approval of land-based site for performing part of the BWMS approval tests[18]. Initially, land-based site tests were planned in a Norwegian or Dutch facility. However, the entrepreneur feared its technology to be exposed to foreigner competitors. This pushed the entrepreneur to look for a Danish testing facility. An alternative was the Danish

[17] Desmi Ocean Guard develops a BWTS. The demand for BWTS results from the come into force of the Ballast Water Performance Standard (IMO regulation D-2)in between 2009 and 2016. D-2 is part of the "International Convention for the Control and Management of Ships' Ballast Water and Sediments" which was adopted in 2004. The convention will entry into force 12 months after the approval of at least 30 IMO member states (Gollasch et al. 2007). According to the IMO (2011), 27 member states have ratified the convention.

[18] To get approval for their BWMS, companies as Desmi Ocean Guard must adhere to the Guidelines for the approval of ballast water management systems (G8) and Procedures for Approval of BWMS that use active substances (G9). G8 and G9 were adopted by the IMO Marine Environmental Committee 58 (MEPC) in July 2005. As Gollasch (2007) states, these guidelines include land-based tests and ship board tests. Land-based test, have however become a bottle-neck for companies seeking the IMO approval of the technology. This has to do with installations availability to perform the test. G8 and G9 were revised after the 55 MEPC meeting. As result, some member states have granted manufacturers with flexibilities to open their own test facilities.

Hydrological Institute, but the installations were not BMWS tests approved by authorities. During spring 2010, Lloyds Register approved the testing facility in behalf of the Danish Maritime Authority.

Both interviewees mentioned previous professional experience as the main reason to start a venture. Canopus' founders were co-workers[19] in a similar firm and after some years planning decided to start a new company. From this previous experience, they managed to keep the contacts. These contacts provide information on the market's changing trends:

> We have personal contacts here with Chalmers. We know, as it is relatively small institution. But they have large competences on maritime technical. We meet them from time to time.

Canopus managers value networking beyond their former contacts, but are continuously looking for new information through maritime networks:

> We started considering going to a network called, SMTF Swedish Marine Technology Forum. That is a very good network. Then, of course we are part of the informal network from our.. We have our huge network from our past contacts that we are of course (…) tell them we start, here a project with SOx emission. Reduce their emissions.... I think we have a pretty strong network. We are working on it.

Similarly, Christian Ingvorsen's previous professional experience gave him insights on the changing scenarios in the maritime sector. While he worked as a commercial person within an oil spill control company (in the late 90s) he got acquainted with IMO environmental regulations. At that time, Christian considered that his former employer should get involved in BWMS development. However, the employer considered premature to venture on the ballast water domain. Despite employer's rejection on his plan to enter into BWMS business, Christian's position facilitated links with some BWMS developers.

Professional experience also plays in behalf to match common interests between different shareholders. This was the experience in Christian Ingvorsen's Desmi Ocean Guard. As ecopreneur, he exploited the connections and information he conveyed from his years in the maritime business. With this information, he could link three different interests' companies to work together in a joint venture.

Opportunity exploitation

Desmi Ocean Guard's experience also shows that financial back-up is important to venture in the maritime technology development. Canopus experience is different the company works on demand rather than mass-producing a device. Besides financial matters, the interviewees considered that technical and customer focused flexibility is key to stay on business.

According to Craig Eason[20], maritime entrepreneurship is special. It requires larger financial investments as compared to other domains – e.g. IT. Besides, maritime entrepreneurship is not something that can be started from the conventional university

[19] In fact, they have an education background as naval architects and marine engineers.
[20] Lloyd's List technology specialist

entrepreneurship course as IT entrepreneurs do. Ingvorsen's experience reflects the venture's strong financial back-up need. In his opinion, the technology development related expenses for a ballast water treatment system sum up til five million US Dollars; associated costs include also the lengthy and financial resource consuming approval process. Without financial backup, he considers there is no possibility for small firms to survive out of the incubation. He considers this is a drawback to university student's creative ideas.

To solve the financing challenge, Desmi Ocean Guard's entrepreneur relied on networking. As mentioned previously, three major shareholders provided in-kind and financial contributions to the venture. Desmi, a medium size firm (ca. 500 employees) manufactures ballast pumps and has installed capacity. Desmi wishes to produce the BWMS at a large scale and sell it to the ship-owners. Ultraaqua's involvement is rather for the technical challenge. As a small company, it specializes on fish farming water purification, and his owners perceive the BWMS development as a technical challenge. Finally, the biggest partner, Maersk, is a leading world class ship liner and carrier with several autonomous divisions (e.g. bulk carriers, container cargo, etc…). Maersk also has an innovation department, looking for challenges (like CO2 reduction, SOx, NOx, ballast water) and looking for partnerships with third parties to develop technical solutions to these challenges.

Having a ship-owner as shareholder differentiates Desmi-Ocean Guard from the competitors. Christian Ingvorsen noticed that early ballast water treatment systems performed poor on board. The reason was that few developers had access to vessels to try the system on board:

> What I could see from the other companies being ahead of us. Their systems seemed sometimes to be... from an engineering point of view, quite good systems, but not really fit to be on board vessels. My idea was that one important player in this partnership should be a ship-owner from the beginning. So we had to contact the ship-owner. The other companies had problems in finding a vessel, where you could do your vessel system, also your vessel should be in an area where you have water [...], species plants, etc... So it was important for me, to find a ship owner.

BWMS approval is in the practice performed by classification societies. Here resides another barrier for entrepreneurs without strong financial backup. The cost for getting a classification society approval is elevated. In Ingvorsen's experience it raises up to 100 thousand USD. In addition, Ingvorsen claimed, Desmi Ocean Guard needs an approval from other major classification societies at a cost of 100 000 USD each time. Classification society rules, according to Ingvorsen, require BWMS to be certified by the ship's original classification society:

> But we will not allow to sail with this system unless we have checked this system and we give you the allowance to sail. So you have to contact the eleven classification societies, they are members of this Association of this group, of big companies, classification societies, and then of course (…) I was a little surprised.... if I'm allowed by one of the classification societies, one of the big ones, then you have to accept... but they say... "No, no" ballast water is not part of this big cooperation. So may end up to be forced to have approval from all the classification societies. This is of course costly... again costly, it my cost 100 000 USD for each of these certificates.

However, if the information availability and funding barriers are passed, the entrepreneur still needs to face another challenge: the particularities to operate a business in the maritime sector. Canopus' managers are aware of this situation; they

have witnessed how many land-based companies broke into the maritime sector. These ventures stay in business a certain period of time, but then fail. The reason respond to unawareness on how behaves the maritime demand. On land based technology, business operates under the premise "one-size-fits-all". In the maritime sector, however, each vessel has particularities, and requires an in-depth study if a given device will fit this vessel. Customers require the equipment to fit the vessel and not vice-versa. Besides, a ship-owner requires his vessel to remain little time on yard. Therefore, entrepreneurs must be available full time, be flexible to the ship-owners requirements and render a service on time.

Chapter 6
Discussion

This single case study explored how cleaner shipping drivers could create incentives and entrepreneurial business opportunities in Frederikshavn. It was hoped that a better understanding of these drivers, the role of information and competences, would provide insights on how to foster maritime entrepreneurial ventures in Frederikshavn.

This research positions in the constructivism tradition and therefore collected qualitative data by in-depth interviews, observation and document review. Participants in the study included six maritime business and competence advisors in Frederikshavn, two maritime entrepreneurs, one maritime technology specialist and one cleaner shipping promoter in Gothenburg region. As explained in the research design, the data was coded, analyzed and organized first by research question. Five research sub-questions steered this study.

Chapters four and five's findings respond the first four research questions. The last question encompasses the previous fourth insights and is responded in the recommendations chapter. The general finding of this study unveiled how MARPOL Annex VI SOx / NOx became an ECA's shipping industry incentive. This incentive matches with Frederikshavn assets to supply shipping industry with regulation compliance services: easy harbor access in the Baltic Sea and a competent maritime cluster. Maritime service entrepreneurship, viewed as the process of starting-up a SME firm is a way to counteract the effects of unemployment in Frederikshavn. However, entrepreneurship in the shipping sector clean technology provision is bounded with challenges: large amounts of financial resources requirements, networks, competences and low clean technology adoption willingness from the consumer-side (ship-owners).

This chapter discusses these findings and is organized in the following analytical categories:

1- Push and pull drivers influences on maritime clean technology adoption (Research Question 1)
2- Ecopreneurial opportunity discovery and exploitation (Research Question 2, 3, 4).

The previous two chapters merged the coded categories and subcategories into a narrative, which became the different sections of these chapters. The purpose therein was to provide empirical evidence that supports an in-depth discussion in the present chapter. This in-depth discussion bridges the empirical evidence with the literature on environmental innovation (presented in the introduction), and with the literature on ecopreneurship presented in chapter three. Through this discussion it is possible to have a better appraisal on how the results expand, contradict or complement the already existing knowledge on eco-innovation, ecopreneurship and maritime cleaner practices adoption. The chapter concludes with the author's reflections on research assumptions at the outset of the thesis and with a critical revision on the research's generalization issues.

Analytical category 1: Push and pull drivers influences on maritime clean technology adoption

The first research question examined why and how the maritime sector is adopting cleaner shipping practices. At the outset of the study, four main factors were considered: market pull, regulation push/pull, technology push and business internal aspects. The introduction explained these drivers and Figure 4 sketched them. The findings corroborated that drivers motivate environmental innovations in the shipping sector. Figure 26 adapts and revises these drivers to the case study's findings.

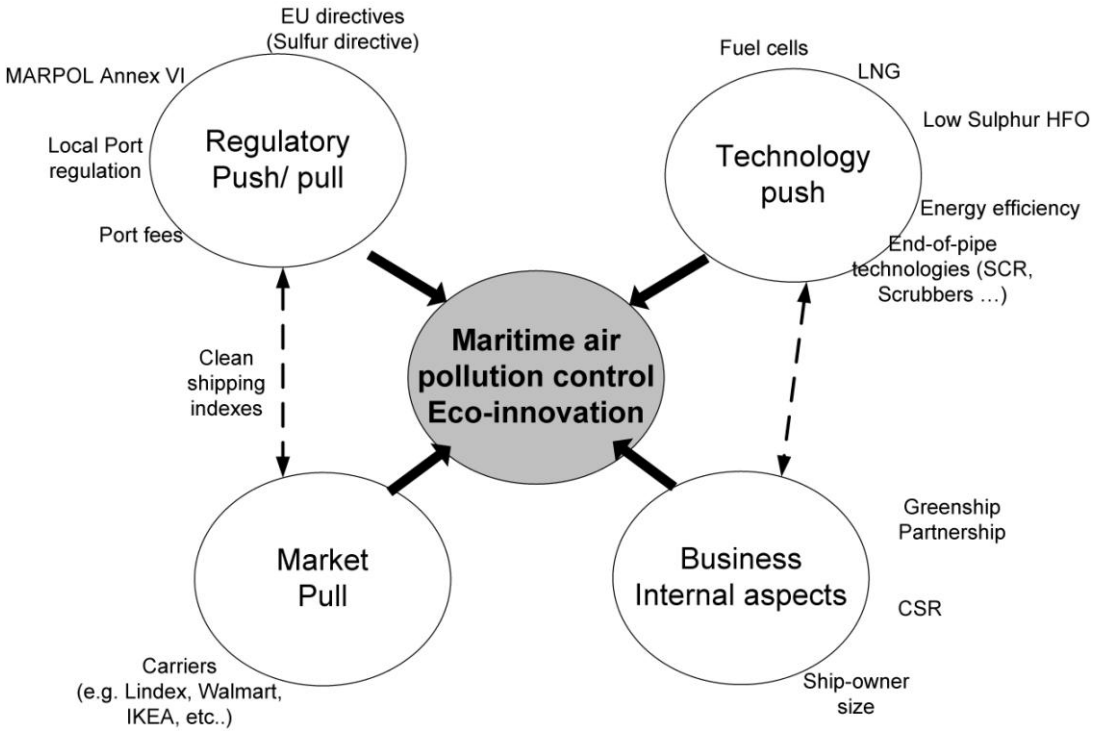

Figure 26- Push and pull factors for maritime air pollution control eco-innovation revisited. *Source*: Adapted from Rubik (2005, Fig. 11.1).

This research unveiled how international IMO regulations (MARPOL VI) are tightening control over ship's SOx and NOx emissions. This perception was shared among interviewees and between specialized documentation from the research area. Eco-innovation and technological change research has continuously pointed out how regulations entail the adoption of environmentally friendly practices among industries (Carrión-Flores and Innes 2010). Regulation groups changes in environmental laws, standards and future regulation (Rennings 2000; Rubik 2005). These standards can foster eco-innovation according to the "Porter hypothesis". The hypothesis claims that when a firm faces a new environmental regulation, it will be forced to seek for a solution to comply with that legislation. This may happen if the firm has the willingness, the opportunities and capacities. The company will unfold its creativity and innovation while looking for a solution (Ashford and Hall 2011, 277).

The shipping sector evidences path dependency and a lock-in regime. The Porter hypothesis can explain clean technology adoption. Analogous to the aircraft flight example presented by Leydesdorff (2000, 244), the maritime shipping industry could be

considered as a regime at the confluence of technological trajectories, responding to specific market demands and embedded into an institutional context. These trajectories set a system that creates stability and standards for the industry –i.e. lock-in. Therefore, the introduction of air or water pollution control technologies will face challenges by the system.

Probably, a first challenge is the way regulations are to be implemented. In fact, interviewees had doubts on whether MARPOL Annex VI air quality and ballast water protection regulations will be equally enforced to all vessels entering into the ECAs. The reason resides in the maritime sector's third country flag registry to reduce fleet costs. This lack of trust in the regulatory set-up has similarities to free-riding patterns in other domains -e.g. voluntary programs, natural resource management- (Sterner 2003, 112). Free-riding in the maritime sector context may be explained by highly scattered regulation enforcement responsibilities.

However, the case highlights how regulation may lock-out a hitherto path dependent sector that resisted to incorporate sustainable practices. This is probably one contribution of this case to the growing literature on the subject of legislation induced sustainable innovation. As mentioned in the introduction, path-dependency implies routines to avoid incremental or radical changes in a given organization –or sector– production (Campbell 2004).

Likely, two types of voluntary initiatives influence the adoption of air and water pollution prevention technology in the maritime industry: corporate social responsibility (CSR) and voluntary approaches. As mentioned in the introduction, Lai et al. (2010) name these practices "Green shipping practices (GSP)" and exemplify the MAERSK case. GSPs can be considered as CSR because GSPs or similar activities go beyond the prescribed by law, but also because several public and private organizations joint efforts for a common goal or project. Albareda (2008, 434) points out three ways that CSR initiatives can become practical: voluntary initiatives adopted unilaterally by one firm; voluntary initiatives adopted between a group of firms; voluntary initiatives adopted jointly by firms and public organizations and NGOs. The findings suggest that MARPOL Annex VI and ballast water convention technology adoption is spurred not only by GSP but also by voluntary demonstrator projects as Green Ship of the Future (GSF) (in Denmark), or Effship (in Sweden). Initiatives as GSF and Effship could be considered as CSR strategies. Both GSF and Effship are formed by large Danish or Swedish ship-owners, engine technology developers and pollution control technology developers.

Voluntary agreements appear as other kinds of self-regulation that locks out the shipping sector from path dependency. The NOx fund in Norway exemplified how this may happen. According to Delmas and Terlaak (2001), voluntary agreements may take two forms: a) negotiated agreements between regulators and business boards, or b) public programs that firms may join in exchange of an incentive. NOx fund is an example of the second category and participating firms receive economic support to adapt NOx abatement technology.

The findings suggest that technological solutions are developed and supplied to the shipping industry for regulation compliance. However, these technologies are adapted

to sea-based users, from land-based technologies as result of the regulation. It is likely that energy efficiency becomes a common characteristic of improved engines and new ship fuels. The results showed how technology suppliers offer low Sulfur content HFO and LNG vessel engines. Although the findings did not assess ship-owner adoption rates, the researcher participated in several events (as described in the methods), and interacted with technology suppliers. These Swedish events showed how propulsion and LNG technology suppliers are promoting energy efficient technologies. Besides CSR and voluntary agreements, technology push is probably a pressure factor for the lock-out of conventional polluting practices. However, it is not assessed to what extent propeller or LNG manufacturers are lobbying for future maritime shipping regulation. Energy efficiency lobbying has been described in other industry domains as the pump manufacturing. Even if pump energy efficiency was hitherto a disregarded field, the European commission adopted the EU Energy Classification Scheme under the influence of the European Association of pump manufacturers (Thiesen and Remmen 2008).

Analytical category 2: Ecopreneurial opportunity discovery and exploitation

The perception that regulation will spur the ship retrofit demand in the KASK region, may explain why Frederikshavn Kommune has considered this as an employment generation opportunity. In line with Therkildsen, Hansen and Lorentzen (2009), this case study highlights how Frederikshavn has steadily recovered from the ship-industry crack-down in the early 2000s. The economy's transformation from an industrial city into an experience-oriented and maritime service center is mainly the result of actions promoted by the Kommune and the business council. According to Lorentzen (2008), Frederikshavn is an example of a post-industrial location seeking innovative ways to foster local economy. Experience-oriented economy encompasses offering the historical, touristic and social assets of a location by providing an unique visit/ anecdote to the visitor. Concerning maritime services, the case findings suggest that offering Frederikshavn as a maritime service destination goes in line with already existing competences and workforce. The findings revealed that intermediaries (Frederikshavn Kommune and Frederikshavn *Erhvervsråd*) contribute to information flow, between information rich domains (maritime associations, conferences, etc) to end users. "Information" in the Frederikshavn's context implies: new shipping environmental regulations, air and water pollution control technology specifications. Besides, information encompasses maritime staff competences how to service new air emission control technology (e.g. scrubbers, SCR, etc...), as well as alternative energy sources engines (e.g. LNG, hydrogen fuel cells).

The case may provide insights on how ecopreneurial opportunities are recognized with intermediaries' support. According to Baron (2010, 124) a key question in entrepreneurial recognition is "Why are some people and not others able to discover specific opportunities?" This author considers that an answer to this question resides in access to and best use of information. Furthermore, access to information can result from active search, alertness to opportunities, and entrepreneur's previous experience. The Frederikshavn case study may add a fourth element: access to information can result from the facilitation provided by intermediaries.

Better use of accessed information also explains why some entrepreneurs could better spot business opportunities. The findings suggest that competences are mostly perceived as preparation for future maritime trends. Intermediaries try to bridge gaps between potential entrepreneurs and agencies working in competences provision (e.g. MARTEC or the project MARCOD). Competences are also a way to integrate information into a pragmatic way to change lock-in and path dependence.

The third thesis' research question dealt with entrepreneurs' motivations to start and keep a business in the maritime clean tech domain. Previous research emphasized push and pull factors role on entrepreneurs' drivers to start and keep a business (Gilad and Levine 1986). The knowledge on entrepreneur's motivation to start and keep a business has implications for venture capitalists or other decisions makers willing to support entrepreneurs. Business start-up motivations inform on the business survival and growth likelihood (Amit and Muller 1995). Kirkwood and Walton (2010) concluded that push and pull factors intertwine in ecopreneurial ventures and what differentiates ecopreneurs from conventional entrepreneurs are "green" values.

The case study's findings however, do not support Kirkwood and Walton's claim that green values differentiate ecopreneurs from conventional entrepreneurs. The case study highlighted two maritime entrepreneurs' motivations and business characteristics. Although the entrepreneurs have differences (i.e. location and technology), they share some similarities. Both entrepreneurs head recently founded small firms (less than five years and less than 10 employees) whose business respond to a market demand on cleaner shipping technologies (ballast water treatment and air pollution control equipment, respectively).

The findings suggest that these entrepreneurs could be pulled or pushed to enter business. Pull factors comprise technical challenge. Push factors comprise interest to increase profit or continue working in what they have always done. None of the entrepreneurs considered "change the world" when entering into business –this claim is often associated to "green values". Using Figure 13 (page 29) on ecopreneurial typologies, both ecopreneurs could be classified in the upper and left quadrant (profit driven). This quadrant implies ecopreneurs who are less likely to start a business because of "green values". For instance, both entrepreneurs may be "adhoc enviropreneurs". This category implies an entrepreneur who starts an own business as a continuation of his/her previous competences.

The case study provides a contribution to the understanding on ecopreneurial opportunity discovery. It was previously highlighted that information access and use had consequences on opportunity discovery and exploitation. The findings suggest that maritime entrepreneurs may recognize business opportunities through their professional networks and previous work experience. Eckhardt and Shane (2010) highlight that social ties and prior knowledge are likely to contribute to information access. Linnanen (2002) explained ecopreneur's previous professional experiences to understand what could be unexploited market niches. The current case study expands Linnanen's perspective by giving hints on how previous experience often overlaps with current enterprise endeavors. These overlaps are addressed below, in the intertwined character of startups and incumbent firms.

The fourth research question addressed the interaction between incumbent maritime technology firms and ecopreneurs. This question responds to a research demand on how the interactions between "sustainability" startups and "greening" incumbent firms path the way towards a more environmentally sound market (Hockerts and Wüstenhagen 2010). According to the Hockerts and Wüstenhagen's propositions, startups are more likely to behave under triple bottom line accountability operations. Green startups are more likely to provide products and services while creating profit, improving social conditions and protecting the environment. Given this endeavor's inspirational capacity, industrial incumbents will likely follow this example and also include triple bottom line. The interaction between incumbents and entrepreneurs takes place while the first move towards more sustainable practices and the second towards a larger market share.

The findings from one unit of analysis (Desmi Ocean Guard) contribute to the knowledge on startups and incumbents interaction. The data from the second unit of analysis (Canopus Marine Solutions) does not allow stating any interaction with incumbent firms. Desmi Ocean Guard was founded as a joint venture between two incumbents and a small size firm. One of the partners is a worldwide leader in container and bulk shipping (Maersk line). The other incumbent is Desmi, a medium size firm specialized in maritime pumps. The third founder is Ultraaqua, a small company specialized in wastewater treatment. In the strictest sense of the term, Desmi Ocean Guard is not an "emerging David" –triple bottom line startup- as Hockerts and Wüstenhagen would propose. Instead, the three players at Desmi Ocean Guard's origins have specific commercial interests to develop a product through an adhoc enterprise. This interaction takes place at the firm's origin, early growth and take-off (Figure 27). It is an author's supposition that incumbents' main influence is in the early adoption of the developed technologies (Figure 27). Maersk involvement in Desmi Ocean Guard ensures that at least one major company will adopt the BWMS once they get the approvals. Desmi Ocean Guard's director acknowledged that there was no certainty a market existed after 2020 (when most of existing ships should have adopted ballast water treatment systems).

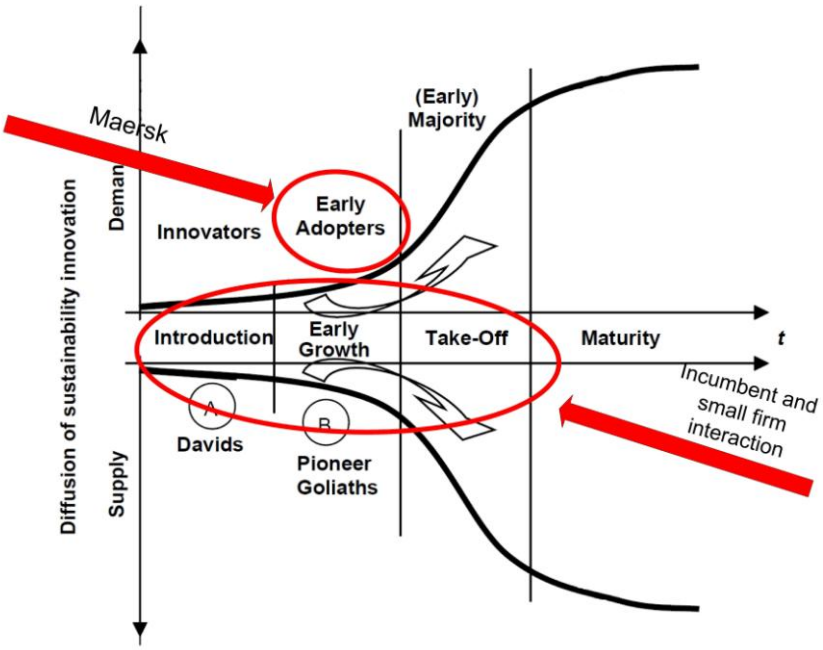

Figure 27- Interactions between incumbents and startups within eco-innovations' diffusion. *Source*: Wüstenhagen et al. (2008, Fig. 1.1).

Revisiting initial assumptions, case study generalization and research's limitations

The researcher presented assumptions at the inception of this study. These assumptions were based on the researcher's literature review, previous experience and knowledge of the problem. The assumptions are contrasted against the findings discussed above. Meanwhile, by revising the assumptions it is also possible to discuss to what extent the results could be generalized.

The first assumption underlying the research was that four drivers may influence maritime clean technology adoption. This assumption held partially true according to the findings discussed in the first analytical category. The maritime stakeholders' perception in the KASK region held that changing international regulations are the main reason for this change. Market pull, business internal aspects and technology push are secondary drivers.

A second assumption was presented in chapter three. The assumption implied that "green" business opportunities could be discovered/ recognized through information access. Information could be accessed through entrepreneur's alertness, past experience or professional networks. The findings discussed in the second analytical category improved this assumption. It was found that information access and use improved entrepreneurs' chances to get acquainted with maritime clean tech business opportunities. Intermediaries and competences would likely provide support in this regard.

The third assumption was that ecopreneurs holding "green" values were more likely to discover and exploit maritime cleaner technology adoption. This assumption did not

hold true because the maritime entrepreneurs considered opportunities others factors to start business: technical challenge and profit generation.

A final assumption was that maritime air/water pollution control technologies were mostly supplied by entrepreneurs who could develop eco-innovations in this market niche. This assumption did not hold true either: whenever entrepreneurs initiated startups to exploit opportunities, the venture was supported by large and medium size maritime incumbent firms.

The author acknowledged that theory contribution was an objective of this case study when referring to the case selection as "instrumental". The findings and revisited assumptions may contribute to the theory if some methodological issues are considered. As acknowledged in the research design section, case study as inquiry strategy is usually subjected to generalization criticism (Flyvbjerg 2006; Stake 2005). Besides, Firestone (1993) points out that qualitative research is also subjected to the same generalization criticism.

The findings and revisited assumptions can be generalized with the following conditions. The first condition is the context in which the case study is embedded. It was highlighted that the case study represented an "extreme/deviant" case study. According to Flyvbjerg (2006) this selection aims "To obtain information on unusual cases, which can be especially problematic or especially good in a more closely defined sense". A findings' revision indicates that the case will be rather classified as a "paradigmatic" case instead of "extreme/deviant". According to Flyvbjerg, a paradigmatic case's purpose is "to develop a metaphor or establish a school for the domain that the case concerns".

The case study creates a standard on how the maritime cleantech could develop in the future. The case is embedded into institutional and geographical contexts. In case of generalization, it is easier to generalize in similar contexts. The institutional context refers to an EU, Danish and Baltic Sea maritime sector. This sector is subject to common regulations. The geographic context of the case is the Baltic and North Sea, which is the first ECA. Therefore, an area where ship-owners are more pressed to adopt technology to comply with NOx and SOx regulations. It is difficult to assess whether the case can be generalized to other institutional and geographic context –e.g. Southeast Asia, Yellow Sea; where different regulatory maritime regimes apply and it is not an ECA. However, the case illustrates how a paradigm can be change and gives insights on what challenges will face next ECAs (Asia, Africa or USA).

The second condition for generalization relies on what Firestone (2003) names "case-to-case" transfer. If this research's insights are transferred other cases, the case study contains thick information to help the reader assess the suitability of such result's transfer. The information user has therefore responsibility to assess whether this case study's result may apply to another case study.

Chapter 7
Conclusions and Recommendations

Conclusions

The objective of this case study was to explore how the drivers of cleaner shipping create incentives and business opportunities for entrepreneurs in Frederikshavn. This section presents the conclusions drawn from the research questions, findings and its related analysis. In consequence, the following analytical categories are used: (a) Push and pull drivers influences on maritime clean technology adoption and, (b) Ecopreneurial opportunity discovery and exploitation. These conclusions are followed by recommendations.

Push and pull drivers influences on maritime clean technology adoption

The first major finding of this study is that regulations are a push factor for shipping industries. This research unveiled how international IMO regulations (MARPOL VI) are tightening control over SOx and NOx emissions in the Baltic and North Seas' ECA. A second major finding is that maritime stakeholders (particularly ship-owners in the Baltic and North Sea) fear free-riding in MARPOL Annex VI adoption when third country registered vessels enter into an ECA. A third major finding is that voluntary initiatives (CSR and voluntary agreements) become a practical way for ship-owners to take first-mover advantages while adopting cleaner technologies.

A conclusion to be drawn from these findings is that maritime air pollution control technologies face a lock-out scenario facilitated primarily by regulation. In a second level, the adoption of air pollution control technologies is encouraged by market pull, business' own characteristics and to less extend by the promotion of technologies by suppliers. In line with research in other path-dependent sectors, regulation proves to be the major driver for the adoption of cleaner technologies. However, voluntary initiatives become the most important conveyor of the diffusion of air pollution control technologies in the shipping sector. This has implications for the exploitation of business opportunities related to this sector's technological change. While incumbents firms may find useful to supply ship-owners with air emission control technologies, alliances and joint ventures are possible with startups.

Ecopreneurial opportunity discovery and exploitation

The previous analytical category unveiled how the maritime sector faces a gradual evolution towards environmentally protecting practices. The second research question dealt with intermediaries' role as information channels for potential maritime entrepreneurs. A related finding for this research question is that Frederikshavn business council and Frederikshavn Kommune act as maritime business facilitators. Both organizations share information through the business and the maritime network. Besides, competence creation is considered as a way to improve the information use. It is expected that acquired competences will get the maritime players ready for future opportunities.

A conclusion to be drawn from this finding is that information availability, facilitated by public and private networks is a requirement for potential maritime clean tech entrepreneurship. Competence creation organizations improve this information usage. Information provision, access and use should be variables to take into account to measure business promotion cause-consequence relations–e.g. quantify employments generated through quantitative methods.

The third research question aimed to understand why entrepreneurs engage into business responsive to cleaner shipping practices. By closely analyzing two maritime clean tech entrepreneurs' experience, it was found that a combination of push and pull factors motivated them to enter business. Pull factors comprised technical challenge and the interest to increase profit. None of the entrepreneurs considered "green values" as a reason to start the firm. Instead, both entrepreneurs could be considered as "adhoc enviropreneurs" given that their previous professional experience and network influence their opportunity discovery and creation.

It can be concluded that maritime clean tech entrepreneurs will only start a venture if they had a previous professional experience in the domain (therefore the venture is an extension of that experience).

The fourth research question explored the relation between startups and incumbent firms. The results indicated that one of the entrepreneurs could start its business by having a financial and technical back-up from medium and large size maritime incumbents. The other entrepreneur did not require this support. It can be concluded that large maritime incumbents (technology developers or other larger shipping firms) need to be engaged in the phases of introduction, early growth and take-off. The participation of incumbents reduces risks associated with the technology adoption by ship-owners.

Recommendations

The following recommendations are based on the findings, analysis and conclusions. Besides, this section has the purpose to answer the fifth and final research question: How could intermediaries use this knowledge to promote ecopreneurship in the maritime sector? The recommendations that follow are therefore directed to (a) Frederikshavn business promotion agencies (b) Competence creation organizations (c) Further research.

Recommendations for Frederikshavn business promotion agencies

Frederikshavn Kommune and Frederikshavn *Erhvervsråd* should be clear that although regulation is promoting the adoption of cleaner technology, opportunities will be bounded during a period of time. The findings suggest that most of the business in SOx/ NOx control technology upgrade and retrofit will take place at least until 2020. Afterwards, the sector will mostly incorporate the technology in the new buildings at construction shipyards. The larger market for Frederikshavn as a retrofit and upgrade station is therefore bounded from now until 2020. After 2020, Frederikshavn may focus in maintenance of the new systems.

Although stakeholders at Frederikshavn are not totally unaware of the previous, the interviews highlighted only broad comments on market potential. The focus of the responses was mainly on "opportunities" without underlying what was the market all about. It was good sign that Frederikshavn harbor's business promoter at has quantified the vessels passing by the strait. These figures could be a good basis for further market quantitative calculations on market potential. Such quantitative assessment should include:

- Total number of vessels using the strait that will likely use Frederikshavn for NOx/ SOx control retrofitting purposes.

- Self regulation and energy saving initiatives may imply that LNG will also become a trend; the creation of a LNG station has some advantages, as this may also help diversify income and services provided in town. Therefore, a complementary study may address what is the market potential for creation of a LNG station at Frederikshavn.

The previous assessment will allow planning in advance future requirements, budgeting for competence creation and promotion activities. Frederikshavn Kommune and Frederikshavn *Erhvervsråd* may collaborate with Frederikshavn Maritime Network to undertake the assessment.

Recommendations for competence creation organizations

Employment generation is a main intermediaries' concern. The findings in this report suggest that it is unlikely that new startups will emerge from Frederikshavn only because of a potential market in vessel clean technology retrofit. The current focus of Frederikshavn Kommune and Frederikshavn *Erhvervsråd* on strengthening existing SMEs is likely a good strategy for the future. The findings also suggest that maritime entrepreneurs are pushed to enter business. Push factors commonly consist in the entrepreneur's interest to improve his/her earnings or technical challenges to start a new business. Therefore, it is possible that some of the current SMEs or large Frederikshavn based firms will originate spin-offs (i.e. some of the employees will continue their own business in the better opportunities' pursuit).

Intermediaries could support spin-offs with the following:

- It is difficult to determine how many spin-offs are likely to emerge, and how many employments will generate. MARCOD may however include entrepreneurship modules along with the technical competences. It is possible that the inclusion of a maritime incubator will allow concretizing such idea. Business incubators are commonly use practice in university and science parks. Given the MARCOD focus on innovation and competence creation, this will be a good way to put innovation into practice.

MARTEC is an important competence creation center in Frederikshavn. The findings highlighted how land-based companies employ most alumni and only a minority starts their own business. MARTEC has launched some initiatives to promote

entrepreneurship among students. Yet, the initiatives could be improved by approaching students to maritime entrepreneurs. Currently, the Nordjylland entrepreneur's network support MARTEC with guest speakers and contacts. MARTEC could take advantage of this connection to improve understanding on how maritime entrepreneurs start and keep their business.

Recommendations for further research

The explorative character of this case study sets some insights on further research areas. Concerning the case study uncovered research, it will be useful to carry quantitative analysis to unveil the maritime entrepreneurial potential in Frederikshavn. An research question example is "How many new firms could be generated as result of the changing trends in the Maritime sector?". The results discussed so far, provide insights on the kinds of variables that such study could contain.

From a theoretical stance, this research followed the line of inquiry on entrepreneurial alertness, ecopreneurial opportunities discovery and exploitation. The results suggested that maritime incumbent firms play a role in venture capital provision and in cleaner technology adoption. Given the explorative character of this case study, two entrepreneurs volunteered for the study with insights in this regard. However, it will be useful to have a larger sample of maritime ecopreneurs in other domains. A maximum variation sampling strategy will allow to better understand this relationship between incumbent firms and entrepreneurs at early stages of the startup process.

Finally, this case study did not uncover the perspectives of the demand side from first hand sources. Instead, the case relied on secondary sources for this purpose. Little research has systematically explaining why ship-owners do engage into cleaner shipping practices. Phenomenological studies with a small sample of the most important maritime ship-owners stakeholders will shed light on this.

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Appendices

Appendix: 1 Semi-structured interview guides

The brackets following the interview questions present the associated holistic codes and the associated chapter of the report.

Presentation and voluntary participation consent letter

Dear interviewee,

This research study is to be submitted for the fulfillment of requirements for the degree of Master of Science in Environmental Studies, at Aalborg University. The results of the study will be published as a thesis. In addition, information may be used for educational purposes in professional presentation(s) and/or academic journal publication(s).

Your participation in this study requires an interview during which you will be asked questions about your experience, opinions about the changing trends in the shipping business, and the environmental requirements driving the sector. The duration of the interview will be approximately 45 minutes. With your permission, the interview will be audio taped and transcribed, the purpose thereof being to capture and maintain an accurate record of the discussion. Before using your inputs in the research you will be sent the text to allow corrections or further elaborations.

Interview guide Frederikshavn Kommune

1. What is your work about? (current_work, Demographics)
2. What is the relation of the Frederikshavn Kommune with regards to the shipping sector? (Kommune_shipping, Problem definition)
3. How do you relate with Frederikshavn Erhvervsråd? (Kommune_erhvervsraad, 3-Brokers/ intermediaries)
4. How does the kommune supports ventures/ start-ups/ existing companies in the maritime sector? (Kommune_shipping, Problem definition)
5. Do you have some statistics or figures that can help me understand this support? (Kommune_shipping, Problem definition)
6. How does your office promote opportunities in the shipping sector? (Kommune_shipping, Problem definition)
7. Which kind of support do you provide to existing or new companies who want to enter business? (Kommune_shipping, Problem definition)
8. Do you know of a company that started as result of the existing companies in cleaner shipping? (snowball_startup)
9. Which assets has Frederikshavn to develop maritime related business? How do you exploit these assets? (assets_Frederikshavn, Problem definition)

Interview guide Frederikshavn Erhvervsråd

1. What is the relation of your current/ past work and shipping? (current_work, Demographics)
2. MARKIS: Why this project started and who takes the lead? (Region_perspective, 1-characteristics green shipping)
3. What is the weight/ importance of the maritime sector in the region of Skagerrak and Kattegat? (Region_perspective, 1-characteristics green shipping)
4. How has the main characteristics of the sector in the region evolved over time? (Region_perspective, 1-characteristics green shipping)
5. How does this region (northern Denmark and Gothenburg) differs from other leading shipping/ maritime hotspots in Europe/ world? (Region_perspective, 1-characteristics green shipping)

6. Which are the IMO regulations/ EU directives/ National legislation that pushes the shipping sector to stick to more environmental friendly practices? (regulation_influence, 1- why clean shipping)
7. What comprises the Maritime sector in Frederikshavn? (assets_Frederikshavn, Problem definition)
8. Which are the most important stakeholders of the maritime sector in Frederikshavn? (stakeholders_Frederikshavn, 4- incumbent/ ecopreneurs)
9. From these stakeholders which are "new" entrants and which are long-lasting firms? (stakeholders_Frederikshavn, 4- incumbent/ ecopreneurs)
10. How many jobs (directly and indirectly) do relate to shipping from the total share? Do you have official statistics? (employment_Frederikshavn, 3-reasons ecopreneurs)
11. What kind of support do you provide to the maritime business sector in Frederikshavn? (erhvervsraad_support, 2- Brokers/ intermediaries)
    a. In terms of Knowledge
    b. In term of Competences (competences_support, 2- Brokers/ intermediaries)
    c. In terms of networks (network_support, 2- Brokers/ intermediaries)
12. What stakeholders are most likely to benefit from your services? (stakeholders_Frederikshavn 4- incumbent/ ecopreneurs)
13. Do you think there are opportunities in "green shipping" for new entrepreneurs? (opportunities_Frederikshavn, 3-reasons ecopreneurs)
14. What do you think is necessary for these new entrants? (opportunities_Frederikshavn, 3-reasons ecopreneurs)

Interview guide Frederikshavn Havn

1. What has been your experience in the maritime sector? (current_work, Demographics)
2. Why do you think the maritime sector is changing towards greener practices? (regulation_influence, 1- why clean shipping)
3. How is Frederikshavn port managed/ organized? (harbor_organization, Problem definition)
    a. Is there a role for the municipality
    b. For the government?
4. Which assets have the Frederikshavn harbor to develop business in green shipping? (assets_Frederikshavn, Problem definition)
5. Do you have statistics (Harbor use)/ ships using the strait? (opportunity_statistics, Problem definition)
6. How are the MARPOL regulations put into practice? (regulation_influence, 1- why clean shipping)
7. How is it applied to the Danish context? (regulation_influence, 1- why clean shipping)
8. Which particular environmental regulations do you have at the Harbor/ municipality? (regulation_influence, 1- why clean shipping)
9. How is the MARPOL waste and other environmental issues managed at the harbor? (regulation_influence, 1- why clean shipping)
10. Are third parties involved in environmental management activities to the vessels? (harbor_environmental_services, 1- characteristics green shipping)
11. How is the Harbor involved in this project? (Green_ship_Frederikshavn, 2- Brokers/ intermediaries)
12. What kind of relation does the Harbor has with Frederikshavn Erhvervsråd with regards to this project? (Green_ship_Frederikshavn, 2- Brokers/ intermediaries)

Interview guide entrepreneur in Aalborg

1. Could you tell me about how it started your company?

    a. When it started? (opportunity_entrepreneur, 3-reasons ecopreneurs)
2. How many employees do you have? (entrepreneur_firm, 3-reasons ecopreneurs)
3. Why did the three major shareholders decided to found a new company (opportunity_entrepreneur, 4- incumbent/ ecopreneurs)
4. How did regulations influence the start of companies as yours? (entrepreneur_regulations, 3-reasons ecopreneurs)
5. Is it possible for new entrants to enter the shipping business and respond to the needs of the sector in waste treatment technologies/ services? (entrepreneur_characteristics, 3-reasons ecopreneurs)
6. How do maritime leading companies collaborate with public agencies to promote business responsive to their needs? (incumbents_public, 3- incumbent/ ecopreneurs)
7. Is you company part of a particular network? What are the characteristics of that network? (entrepreneur_network, 2- Brokers/ intermediaries)
8. What kind of collaboration you receive from universities? Or from government agencies? (entrepreneur_universities, 2- Brokers/ intermediaries)
9. What is your organization major goals? (entrepreneur_goals, 3-reasons ecopreneurs)
10. Have your goals evolve over time? (entrepreneur_goals, 3-reasons ecopreneurs)
11. Why did you started a company? (opportunity_entrepreneur, 3-reasons ecopreneurs)
12. How do you measure performance? (entrepreneur_goals, 3-reasons ecopreneurs)

Interview guide Maritime School Frederikshavn

1. Could you please tell me how did you get involved in the maritime sector? (current_work, Demographics)
    a. What is your work about?
2. What contribution brings MARTEC to the Kommune/ region? (competences_support, 2- Brokers/ intermediaries)
3. How many students do you train for the region? (competences_support, 2- Brokers/ intermediaries)
    a. Do you have some statistics?
4. Which competences are required for these students? (competences_support, 2- Brokers/ intermediaries)
5. Which competences do you think will be needed in the future? (competences_greenship, 1- characteristics green shipping)
6. What do students do after graduation? (entrepreneur_competences, 3-reasons ecopreneurs)
7. Do you have statistics about how many of them open their own firms? (entrepreneurs_school, 3-reasons ecopreneurs)
    a. Can you recall on some of them? Do these firms relate to ship retrofitting?
8. What competences do you provide students to become entrepreneurs? (entrepreneur_competences, 3-reasons ecopreneurs)
9. What do you think will be required competences for new technologies in ships? (competences_greenship, 1- characteristics green shipping)
    a. E.g. ballast water, NOx, SOx scrubbers, exhaustion systems.
10. How is MARTEC participating in local initiatives as Green shipping and MARCOD? (Green_ship_Frederikshavn, 2- Brokers/ intermediaries)
11. How is the industry/ state influencing these initiatives/ local industry? (drivers_local industry, 1- why clean shipping)
12. What is the Nordjylland entrepreneurs network? (entrepreneur_network, 2- Brokers/ intermediaries)

Interview guide entrepreneur Gothenburg

1. What are your firm's areas of expertice? (entrepreneur_characteristics, 3-reasons ecopreneurs)
2. Could you tell me about how your firm started? (opportunity_entrepreneur, 3-reasons ecopreneurs)
    a. When did it start?
3. Is it a spin-off of major company or a venture by an entrepreneur? (entrepreneur_characteristics, 3-reasons ecopreneurs)
4. Does your company have an environmental policy/ vision? (env_policy_entrepreneur, 3-reasons ecopreneurs)
5. To what extent non monetary values influenced the start of your firm? (opportunity_entrepreneur, 3-reasons ecopreneurs)
6. How many employees do you have? (entrepreneur_firm, 3-reasons ecopreneurs)
7. How do regulations influence the start of companies as yours? (regulation_entrepreneur, 1-characteristics green shipping)
8. Are there other reasons that contribute to the raise of maritime cleantech providers as yours? (opportunity_reasons, 1- characteristics green shipping)
9. How is it possible for new entrants to enter the shipping business and respond to the needs of the sector in cleaner technologies? (entrepreneur_characteristics, 4- incumbent/ ecopreneurs)
10. How do maritime leading companies collaborate with public agencies to promote business responsive to their needs? (incumbents_public, 4- incumbent/ ecopreneurs)
11. How did your company manage to spot business opportunities in relation with cleaner shipping practices? (opportunity_recognition, 3-reasons ecopreneurs)
12. Is you company part of a particular network? What are the characteristics of that network? (entrepreneur_network, 2- Brokers/ intermediaries)
13. What kind of collaboration do you engage in with universities? Or with government agencies? (entrepreneur_network, 2- Brokers/ intermediaries)
14. How do regulations hinder the introduction of "green" maritime technologies? (entrepreneur_regulations, 1- characteristics green shipping)
15. What is the role of classification societies in the approval of your services/ products? (entrepreneur_regulations, 1- characteristics green shipping)

Interview guide Scandinavia and Technology specialist Lloyd's List reporter

1. What is your work about? (current_work, Demographics)
2. What is your experience in the shipping sector? (current_work, Demographics)
3. To what extent do the Maritime authorities encourage/ discourage innovations in the design/ adoption of cleaner technologies on vessels? (regulation_influence, 1- characteristics green shipping)
4. In the case of an improved technology (ballast water treatment for example) that aims to be sold on market: should classification societies endorse it? Validate? (regulation_cleantech, 1-characteristics green shipping)
5. What is a normal "path" for these kinds of technologies since they're designed in a lab until release to the market? (regulation_cleantech, 1- characteristics green shipping)
6. How do you think the market (shipowners) will respond to the offer of new technologies (i.e. ballast water treatment/ scrubbers/LPG/ improved engines)? (demand_cleantech, 1-characteristics green shipping)
7. Will the retrofit be a good business? Which are the main areas/ port where this service is available? (opportunity_retrofitting, 1- characteristics green shipping)
8. Which are the main events/ milestones for the adoption of cleaner shipping discourse by the sector? (regulation_influence, 1- why clean shipping)

9. Which initiatives do you know that relate to "green" shipping? (green_ship_initiatives, 1- characteristics green shipping)
10. To what extent do local port / specific regions (i.e. Baltic) regulations influence shipping companies to retrofit their fleet? (regulation_influence, 1- why clean shipping)

Interview guide Cleaner Shipping Project, Gothenburg

1. How was the CSP started? (Clean_shipping_origins, 1- characteristics green shipping)
2. Does CSP restrict itself to the development and promotion of the Clean shipping index? What other activities do you carry? (Clean_shipping_origins, 1- characteristics green shipping)
3. How many participants do you have? How many do you expect to enroll? (clean_shipping_participants, 1- characteristics green shipping)
4. What are major initiatives of the shipping sector with regards to embracing cleaner practices? (drivers_shipping_sector, 1- characteristics green shipping)
5. Are there similar indexes to the CSI? How do you differentiate to them? (CSI_similar, 1- characteristics green shipping)
6. How do regulations and voluntary initiatives influence the CSP? (drivers_shipping_sector, 1- why clean shipping)
    a. To what extent the market influence the participation of companies in the CSI
    b. To what extent the regulations do this?
7. What do new entrants (startups) need for entering into the business of green shipping clean tech for bilge water/ exhaust gas scrubbers, ballast water? (entrepreneur_characteristics, 3. reasons ecopreneurs)
8. What is your perception about a "front-runner" region in terms of cleaner shipping: is it the aim of the Gothenburg authorities/ business community? (Region_perspective, 1- characteristics green shipping)
9. Does regulation hinder or promote the development of maritime clean technologies? (regulation_influence, 1- why clean shipping)
10. Being a global business and sector: to what extent is it possible that IMO regulations have an influence on a "greening" of the shipping sector? (regulation_influence, 1- why clean shipping)

Appendix 2: Interview transcripts

Original transcriptions are available in the attached CD-ROM.

Appendix 3: Hypothesis coding

Code	Description	Related research question
Regulatory_push	Regulatory push, on the other hand, has to do with those policies that encourage innovations to accomplish with regulations.	1- why clean shipping
market_pull	Market pull, is at the other side of the model, lifting innovation by a steadily complex environmental governance in which firms perform their activities. Jänicke (2006, 561) considers that the pressure from stakeholders may come from the grassroots (NGOs and consumers) or from the top (governments, man communal organizations as the EU, etc.).	1- why clean shipping

techno_push	Technology push refers to does incremental innovations that add to the current existing technologies and made them more efficient to save costs.	1- why clean shipping
type_opportunity	Relates to opportunity: locus of change, source of opportunity and who initiates the change.	1- why clean shipping
opportunity_recoginition	complete information for offer and demand.	1- why clean shipping
opportunity_discovery	Incomplete information for any the offer or demand size	1- why clean shipping
Public_agency	Role of public agencies in support of the shipping sector	2- Brokers/ intermediaries
Broker	Explain what is the role of brokers of some public and private organizations	2- Brokers/ intermediaries
push_entrepreneur	Factor that "push" entrepreneurs to enter business, rather negative connotation (regulations, career shift and path dependence)	3-reasons ecopreneurs
pull_entrepreneur	Factor "pulling" entrepreneurs to enter business, mostly positive facet (i.e. personal challenge, increase earnings…)	3-reasons ecopreneurs
commercial_entrepreneur	Category of ecopreneur, personal challenges to introduce a “green” service or product.	3-reasons ecopreneurs
bioneers_ecopreneurs	Category of ecopreneur, Desire to access more market than alternative scenes.	3-reasons ecopreneurs
innovative_opportunist_ecopreneur	Category of ecopreneur, largely driven by external influences (e.g. regulations) but also economically oriented.	3-reasons ecopreneurs