# Demonstration projects as drivers of maritime energy renovation technologies

## Abstract

This article presents a multiple case study of demonstration projects addressing technologies for energy efficient retrofit solutions for the maritime sector. Demonstration projects have the purpose to test a given technology and its ability to enter the market to support the diffusion of technologies. The analysis shows that the projects do not merely address technology diffusion but are innovation processes with ongoing development and implementation of the technologies.

In the projects, numerous actors are involved including actors with experience in retrofit technologies from other sectors. The duration of the projects is 2-5 years and several technologies are discussed. Some of the technologies that are introduced are new to this sector and the demonstration projects both challenge the mindset of how to perceive energy on board ships and lead to changes in practices among the users of the technologies.

The demonstration projects are therefore an opportunity to facilitate green retrofits in a somehow resistant maritime sector, as they serve as a platform for both the development and the implementation of cleaner technologies.

## 1. Introduction

Climate issues and energy consumption are central topics in both research and practice (Brewer, 2003; Dovì et al., 2009). One of the major contributors of greenhouse gasses is transport, and in 2010, the contribution to the total greenhouse gas emissions from transport was estimated at 14% (Love et al., 2010). While decreasing for other sectors, greenhouse gas emissions continue to increase for transport (Harvey, 2013; Love et al., 2010). Cars, trucks and trains have been in focus in terms of reducing the greenhouse gas emissions of transport in Europe and there has been a technological focus on effective engines and weight reductions (Harvey, 2013). Maritime transport, however, has a low level of greenhouse gas emissions per freight weight compared to other forms of transport (Buhaug et al., 2009). To meet sustainability objectives, the EU has the goal reducing $CO_2$ emissions from shipping by a minimum of 40% by 2050 compared to 2005 levels (EC European Commission, 2011). Increased energy efficiency - defined as energy use per transport work - through better operational practices and new technologies are key elements in the effort to meet the emission targets (EC European Commission, 2011).

Maritime transport represents 3.3% of the world's total $CO_2$ emissions and it is forecasted to increase by 150%-250% by 2050, mainly due to increased freight volumes (Buhaug et al., 2009). Within the maritime sector, the reduction efforts have focused on large vessels; their speed, freight volumes, and reduction in fuel consumption by improved operation. The International Maritime Organization (IMO) emphasizes technical, operational and market-based measures of reducing greenhouse gas emissions from maritime transport (Buhaug et al., 2009). Cleaner technologies and energy efficiency become still more important to the sector both due to the increased focus on maritime transport in environmental legislation (EC European Commission, 2011) and due to increasing fuel prices (Corbett et al., 2009).

The diffusion of clean technology is governed by endogenous mechanisms or socio-economic factors, such as costs, research and design activities, learning and increment in the invention of new technologies, and by exogenous mechanisms, such as legislative activities and market structure (Kemp and Volpi, 2008). While policies are important to the diffusion of clean technology, other factors like the characteristics of the clean technology and the absorptive capacities of potential adopters are also important. Companies select between an end-of-pipe solution, a process change (adaptation), and a change of their process (substitution) (Kemp and Volpi, 2008). When selecting between these different types of solutions, certain technologies may be totally overlooked, especially if they are traditionally applied to other sectors (Mosgaard et al., 2014b).

Innovation and use of cleaner technology in the maritime industry require the involvement of a number of stakeholders to achieve the desired output (Mosgaard et al., 2014b). The introduction of cleaner technologies in the maritime sector can be complex and history shows that it may carry difficulties. Within the maritime sector, greenhouse gas reduction efforts have been focused on large vessels in terms of speed, freight volumes, and reduction in fuel consumption by improved operation (Buhaug et al., 2009; Lindstad et al., 2011). Improved operation can include changes in both practices and technologies. Studies suggest different barriers such as the non-existence of a binding international regulation and technical standards; uncertainty about the reliability and efficiency of the equipment; high development and installment costs; and inadequate technical expertise in developing and supervising the installation processes (King et al., 2012). An analysis of Buhaug *et al*. shows that a 25-75% increase in $CO_2$ efficiency in shipping is reachable with known measures mainly directed towards energy efficiency (Buhaug et al., 2009). Reductions of more than 33% could be achievable by 2030 at a negative or zero marginal cost (Eide et al., 2009).

Marine vessels generally have a long lifetime. As an example, the world's cargo carrying fleet in 2011 is 55,138 ships with an average age of 19 years (International Maritime Organisation (IMO), 2012). An average age of 19 years indicates that the expected lifetime of a vessel is more than 30 years, and this means that the reduction of the environmental impacts from maritime transport cannot only happen through the development of cleaner technologies in new vessels, but also involves retrofitting existing vessels due to the environmental impacts of operating these vessels.

However, there seems to be inertia towards implementing cleaner technologies in vessels even when economic and environmental arguments are favorable (Corbett and Fischbeck, 2002; Eide et al., 2009; Hermann and Köhler, 2012; Lyridis et al., 2005). This also means that changes only happen slowly. Studies have, however, shown that, e.g., demonstration projects facilitate energy efficient shipping practices (Krozer et al., 2003).

Testing technologies in demonstration projects is a measure for showing the feasibility of the technology, but also a way to develop the technology further and thereby facilitate innovations that meet the demands from the stakeholders (Harborne and Hendry, 2009). The financial risk involved when investing in new technology may delay the implementation, and the perceived and real financial risks are a major barrier to the adoption of energy efficiency measures in shipping (Faber et al., 2011). The financial risk is only a part of the perceived risk; changes in the energy system of the ships also mean changes in the operating practices of the ships and these constitute an endogenous risk as well(Mosgaard et al., 2014a).

Demonstration projects play an important role in technological development as they bridge a gap between technological breakthroughs, industrial application and commercial adoption (Frishammar et al., 2014). Several papers analyze the role and theorization of demonstration projects (Frishammar et al., 2014; Klitkou et al., 2013; Krozer et al., 2003), but related to the maritime sector, the discussion of the actors' reasons for entering the projects and the outcome of these projects are not thoroughly described.

The aim of this article is to analyze the potentials in demonstration projects; can they facilitate the implementation of energy efficient technologies in the maritime sector?

Demonstration projects are defined in various ways, but in a Danish context, they include several actors that jointly test a given technology and its potentials to enter the market. Thereby, the projects do not involve the development of new technologies, but the diffusion and test of a given technology in a (new) market relevant context. The projects have the purpose to ease the pathway for new technologies to enter the market.

The literature points towards a number of factors that may influence the success rate of demonstration projects, such as user involvement and alignment with existing institutions. These factors are difficult to address in practice as the actors involved may have divergent views on, e.g., how to distribute knowledge and secure knowledge rights (Frishammar et al., 2014). Government funding of these projects may also lack coherent and well-defined objectives (Harborne and Hendry, 2009). Another uncertainty is related to how to effectively manage and organize demonstration projects in the individual firm (Frishammar et al., 2014). The projects may generate knowledge spillovers that benefit other firms at the expense of those involved in the projects. Even though this may be beneficial to society at large, it may delimit the incentives for firms to contribute to the development of the projects (Mowery et al., 2010). There is a need for understanding the actor networks surrounding the projects and this requires research that analyzes demonstration projects in relation to innovation management (Frishammar et al., 2014).

The demonstration projects described in this article are economically supported by governmental funds. As the newest initiative in a number of subsidies, it was decided in 2013 to support 6 projects with a total cost of 20 mill. DKK. The six projects are expected to contribute to more green and energy efficient shipping. Previously, similar initiatives have been implemented and especially energy retrofitting related to shipping has been in focus. Only two of the projects involved in this analysis are supported by the funds from 2013; the others are supported by funds for the development of green maritime products.

## 2. Method

Demonstration projects involve a collaboration process that happens in a multi-party network "in the making". This means that the networks are developed and revised during the projects. In order to analyze these processes, multiple case studies are chosen with the aim to gain as much information as possible about the process in demonstration projects.

We have chosen to focus on the process by analyzing the actors and their practices and perceptions rather than that the technologies involved. We analyze how the process influences the practices of the involved actors. To identify practices and collaboration, a qualitative research design is chosen.

The empirical basis is a case study of maritime actors involved in demonstration projects. The cases are selected from a network of actors that collaborate on different platforms in the maritime sector. The authors have themselves been involved in projects in the maritime sector. This background knowledge is important when analyzing the interviews, as it provides the basis for a comprehensive understanding of the processes.

Many research methods and techniques are available within the field of qualitative research, and the task is to make these appropriate for the specific research design (Norman K. Denzin and Yvonna S. Lincoln, 2005). In case studies, it is of importance to supplement with different sources of evidence in order to validate the data (Yin, 2009). Supplementary data sources are document reviews, such as email communications, meeting minutes, a catalogue of products and services, excel list of firms with interest in the project, power point presentations, technical and financial quotes, and formal contracts. These additional data sources have provided insight into how the actors were involved and their official agenda when participating in the projects, but these sources have also enabled the authors to analyze the complex interactions around demonstration projects.

The data collection includes interviews with a number of actors that have been involved in demonstration projects. Five projects have been selected for the analysis, as they involve different actors and technologies and thereby represent diversity in the demonstration project processes. The respondents are industrial actors, supplying energy efficient technologies, as well as coordinating actors.

| **Focus of demonstration project** | **The main actors involved** |
|---|---|
| Air conditioning (improving energy efficiency) | Suppliers, business consultants, knowledge institutions |
| Energy management and control, information screens with suggestions for changed practices | Suppliers, Technological institute, customers |
| Heating by applying heat pumps and changing operational practices. | Suppliers, business consultants, ferry operator |
| Ventilation with improved energy efficiency | Suppliers, users, business consultants |
| LED-lighting to reduce energy consumption | Suppliers, ferry operator, business consultant |

Table 1: Overview of projects included in the analysis

We performed 12 semi-structured interviews addressing the experience with energy renovation projects, internal processes in the organization, external actors, collaboration process, and the roles in the project. The interviews had a mean length of 90 minutes. The respondents were selected using a combination of informed and snowball sampling (Biernacki and Waldorf, 1981). The respondents include 3 coordinating actors that are involved in running projects as well as 6 suppliers of technologies and one person working on vessels, representing the users of the technologies. The technological institutions are not represented in the interviews.

## 3. Analytical framework

In this article, we discuss eco-innovation in demonstration projects with a focus on energy retrofits in the maritime sector. Eco-innovations are measures which contribute to a reduction of environmental burdens, introduced by actors through the development of new ideas, behavior, products or processes (Rennings, 2000).

Incremental and radical innovations are terms that are often applied in the understanding of the potential environmental improvements created by innovations. The distinction between incremental and radical innovations relates to the level of change involved. Incremental innovations reduce the environmental impact, based on the existing knowledge, technology, behavior, and organizational framework (Conway and Steward, 2007). Radical innovations are based on the application of new knowledge, new technology, and a new organizational framework in a way that interrupts the existing practices in the sector (Conway and Steward, 2007). However, it may be difficult to distinguish between radical and incremental innovations. A new combination of existing knowledge, and thereby existing technologies, can constitute a radical innovation as it, e.g., influences the practices in the sector (Hargadon and Sutton, 1997; Hargadon and Douglas, 2001).

The demonstration projects are analyzed as innovation processes that have the purpose to ease the pathway for new technologies to enter the market. This means that we do not look at innovations as an outcome, but as a process; innovation journeys of complex activities in action can be divided into three periods: an initiation period, a developmental period, and implementation or termination (Van de Ven et al., 1999).

An innovation process may be followed by invention through the development and implementation of ideas (Garud et al., 2013). Innovation processes unfold at different levels such as within firms, across multi-party networks and within communities. In the following, the three stages (invention, development and implementation) are described for multi-party networks (Garud et al., 2013). Multi party networks are constellations in the making of firms that interact to invent, develop and implement innovations. The demonstration projects that are analyzed in this article occur in multi-party networks.

The underlying key mechanism for invention is the recombination of ideas and artifacts across different domains of knowledge (Van de Ven et al., 1999). The connection between the firms can be based on weak ties that can facilitate the flow of ideas between distant domains (As opposed to strong contractual links). The ability of the firm to absorb knowledge is based on its prior knowledge; if there is a lack of absorptive capacity it hinders a recombination of knowledge and the inventions may not occur (Garud et al., 2013). As the firms share knowledge, fast-learning firms may gain a competitive advantage in the multi-party networks (Garud et al., 2013).

Development is the process which takes place between the invention and the finished concept that can offer value when used. Transformation is an underlying mechanism as both actors and artifacts are transformed in the development process. Important activities, such as the proof of concepts in prototyping, demonstrate through tests the feasibility of the technology (Garud et al., 2013). Prototyping tests the technical specifications, but the prototypes also work as boundary objects that create a common understanding among the various actors involved in the innovation process. In this process, the involved actors may change as the idea is developed. The development is dependent on the distribution of resources and assets across members of the network. In the development process, the actors change their roles and collaboration patterns, and new artifacts and resources come into play (Garud et al., 2013).

Implementation can also be called institutionalization. It refers to the part of the innovation process in which the innovation has proved to be viable and it is implemented in the institutional logic of production, use and regulation (Garud et al., 2013). Diffusion is a key mechanism for driving implementation. Rogers describes how institutionalization involves reinvention (Rogers and Shoemaker, 1983), meaning that adopters modify an innovation to fit local circumstances.

Fleck addresses this as well in the concept of innofusion, describing that the diffusion of technologies holds some of the same characteristics as innovation processes (Fleck, 1993). The steps in the innovation process are not continuous but are interlinked in an iterative process. The cooperation between various actors to develop eco-innovations is an inter-organizational innovation process. Ring and Van de Ven (Ring and Van de Ven, Andrew H, 1994) describe a three-stage model of inter-organizational cooperation. The first stage is *negotiations* where organizations discuss the possible terms and procedures of a potential relationship. The second stage is *commitments* where they reach an agreement on the obligations and rules of the cooperation. Finally, the third stage, *execution*, is where they carry out the agreements (Ring and Van de Ven, Andrew H, 1994). In the innovation process, the practices of the involved actors are important to the way in which the innovation is continued.

The processes are cyclic as organizations completing the execution stage often enter the negotiation stage for a new process; in other words, the collaboration processes are dynamic. The actors assess the efficiency, and equity, of the processes and this assessment determines their willingness to participate in new cooperation (Ring and Van de Ven, Andrew H, 1994).

This cyclic approach is interesting, as the maritime actors have collaborated in various ways and their collaboration is dynamic. We therefore use this cyclic approach to discuss how actors become involved in the projects.

Eco-innovations in the maritime sector have previously been analyzed in relation to the importance of trust and experience from previous collaborations (Mosgaard et al., 2014a; Mosgaard et al., 2014b). The analysis in this article involves demonstration projects between known actors and in new constellations. When the actors do not know each other in advance, there may be other challenges in the collaboration, but they also have the potential for contributing with new knowledge in the network. In the analysis, demonstration projects are seen as innovation processes.

## 4. Analysis and results

In this analysis, we look into five demonstration projects to identify both how different actors are involved in the innovation processes and which potential these projects have. This analysis does not only relate to energy efficient renovation as such, but does also look into the mechanisms within the projects; how do the actors collaborate and innovate and which potentials does that collaboration release. The analysis deals with the making of networks of actors and the innovation process in which these are involved; the networks are not established in advance but are created for the individual projects. The demonstration projects involve the following energy efficiency technologies; Air conditioning, energy management and control, heating, ventilation, and LED lighting, see Table 1.

By analyzing the 12 interviews, five main topics showed to be of importance. First, demonstration projects can change the mindset of how to handle energy management on board ships. The actors are aware that new initiatives are developed, but they also perceive these as very expensive and as an investment that involves a high risk. Secondly, demonstration projects provide access to technologies from other sectors and through subsidizing they reduce the potential risk of testing new technologies. Thirdly, an obstacle to the projects is identified, namely that the demonstration projects create an uneven risk among the participating actors. As a fourth topic of importance, both the development and the implementation of technologies occur in this collaboration, even though demonstration projects are meant to facilitate only the implementation. Finally, the projects create a platform for actors to collaborate, also actors that under normal circumstances do not collaborate. These five issues are analyzed in the following.

## 4.1 Changing the mindset of how to handle energy in ships

The actors in the maritime sector are resistant to addressing energy management, and this counteracts the possibilities for energy retrofits. In recent years, the maritime actors have had an increased focus on energy renovations, but it is not a sector that implements changes rapidly. As one of the suppliers says:

"*The shipping companies are very conservative; they do not change anything if they are in doubt of the outcome."* (Supplier C, 2014)

Several of the respondents explain the way in which the actors on board the ships counteract energy saving measures and simple retrofit solutions due to their routines and habits. A simple example shows this:

*"We have examples of captains that leaves the heating on and opens the windows on the bridge.. also during the summer..In total it is 6kWh of heating"  (Business consultant A for a maritime center for operations, 2014)*

One of the other business consultants explains the same challenge in more general terms:

*"It is hard to save energy in a ferry. The officers on board the vessel are not ready; they don't have the spirit to save energy" (Business consultant B for a maritime center for operations, 2014)*

One of the examples is that if a ship has two auxiliary engines on board, one can be running at 85%, and this is less energy consuming than having two engines running at 40%. There is, however, a practice of always having two engines running in case one of them fails.  A supplier also addresses this barrier which is related to the existing practices of running the ships:

"*We make an energy management system (..) We want to make them aware of how they use the energy, for them to optimize the way they run the ship (..) It seems that they are not really interested in changing anything that involves themselves*." (Supplier B, 2014)

One of the suppliers that traditionally have supplied technologies onshore has a similar experience:

"*I think that our technology can only be applied on board ships if we can change the mindset of the involved actors; they have a totally different mindset of energy management than what we are used to from private households but also industry."* (Supplier A, 2014)

Another supplier has an idea of how to use the heat from the engines for other functions in the vessel and thereby save electricity, but the users are resistant to this type of change:

*"I asked them – Why are you doing this? They answered; we have always done this. This is motors, and we use them for some things and the boilers for others"* (Supplier E, 2015)

Several of the involved actors explain how demonstration projects thereby challenge the mindset of how to handle energy on board ships, but it is done through interaction and communication about the challenges that they face.

One of the barriers to the energy efficient retrofits on board the ships is a general perception that the ships have excess electricity:

"*A common misunderstanding in the maritime business is that we have power for free (…) That makes them less interested in energy savings."* (Supplier E, 2015)

This means that the actors involved are unwilling to participate in the implementation of new technologies, especially if they are unsure of the feasibility of the investment. If they do not believe that saving electricity actually results in reduced costs, it is very hard to get the technologies implemented:

*"Sometimes we can't even sell a retrofit solution with a pay-back time of less than two years. If it is a technology or investment that the owners are not used to thinking about; it gets even worse if it is a technology that is not tested (..) that's why we need the demonstration projects" (*Supplier C, 2014)

As this supplier points out, the demonstration projects constitute a potential for reducing the previewed risk of a technology.

These quotes show that some maritime actors do not support the energy retrofits, and this can be explained by the practices in shipping in relation to acquiring new knowledge of new technologies. The actors do not make investments, even with short pay-back times, if they are in doubt of either the outcome of the technology or the future of the vessel that they operate. They are, however, open to the idea that the projects can reduce the uncertainties of their investments. Thus, the demonstration project is a method for testing the technologies and make the actors feel less insecure about the investments. Thereby, demonstration projects play an important role in getting the new retrofit technologies on the agenda in the sector. Existing knowledge is combined in new ways and thereby constitutes a radical innovation as it influences the practices in the sector even if the technology is not radically new in itself.

## 4.2 Demonstration projects provide access to technologies from other sectors

Demonstration projects are an opportunity for suppliers to gain access to the maritime sector and to develop and match their inventions to a maritime environment. This is both due to the funds in the projects, but also because the projects provide access to the actors in the maritime sector.

However, the way in which the funding works in practice is a barrier, as it is difficult to include a test of already developed onshore technologies in the projects:

*"It is difficult to find funding if it is not new technologies; it is just incremental innovation in those companies. Witch fund would support that with money?"* (Business consultant B for a maritime center for operations, 2014)

This also shows the institutional logic of those actors, as a combination of existing technologies is seen as an incremental innovation, and thereby not as something that can be supported by demonstration projects, at least the business consultant does not think so. But there is an interest in testing onshore technologies:

*"Heating and ventilation are interesting, if they can put heat pumps instead of pressure heating and conditioning system, and it involves other kind of industries. Onshore you can see those kinds of solutions, but not on ships"* (Business consultant B for a maritime center for operations, 2014)

Related to a discussion of what a new technology is, the consultant adds:

*"it can be a discussion of what is new? It can be new for the maritime sector but not for the world. The maritime sector is very conservative"* (Business consultant B for a maritime center for operations, 2014)

The suppliers see some of the same challenges:

*"It is a challenge to get technologies from other areas into the maritime sector; they are quite conservative"* (Supplier D, 2014)

One of main actors in two of the demonstration projects is a key actor in introducing onshore technologies:

*"I have a background from airplanes and racing cars (..) I have a lot of knowledge about heat pumps for industrial use on shore. I was thinking, why don't we use heat pumps on the vessels?"* (Supplier E, 2014)

This quote shows how new knowledge from other sectors is actually brought into the projects, and several of the actors describe the creation of a platform where technologies can be both developed and implemented to be ready for the market. But the demonstration projects also serve another purpose as they create know-how that the suppliers can bring home:

*"We use this project to test the technology and make it ready to sell, but mainly we want to get know-how for other projects."* (Supplier B, 2014)

Demonstration projects have the purpose to test technologies and make them ready to enter the market, but in reality the projects have a role in bringing in, testing and developing technologies from other sectors and thereby facilitating eco-innovations in a sector in which retrofits challenge the current mindset and practices. Thereby, the demonstration projects lead to actual innovation processes. The suppliers are the main actors in providing the technological inputs, but they need a platform for testing these and that is what the demonstration projects can provide.

## 4.3 Demonstration projects with uneven risks

Testing green technologies in shipping is quite expensive. In case of demonstration projects, some suppliers are willing to sell technologies at a low price, but installing these can be quite expensive and difficult to finance:

*"Most of the demonstration projects will fund everything else but the salary for installment" (Business consultant for a maritime center for operations, 2014)*

This means that for retrofit projects, the companies operating the ship both need to have the funding and the will to prioritize the cost of the installment. This creates an uneven balance between the actors involved in the development of the demonstration project, as some (the suppliers) get their costs financed, except from maybe the salaries for the time they spend on project meetings, but the users that need to get the technology installed on the ship have to cover the installation costs.

You could argue that the users also get the economic benefits from the new technology, but the technologies need to be adjusted and tested and the uncertainties about the investment still exist. For the suppliers, this has been one of the main motivation factors for entering demonstration projects:

*"We get a real world test of the technology, and can use that in our advertisement material in the sector"* (Supplier A, 2014)

There are funds that are more favorable in other Scandinavian countries that finance 80% of the costs of the installment:

*"They had plenty of work to do on the Norwegian Ferries for instance, and then they can use that in their advertisement material" (Business consultant for a maritime center for operations, 2014)*

There are examples of suppliers that withdraw from Danish demonstration projects, especially those that have technologies that are close to being ready to enter the market and do not need further development. The main suppliers involved in the projects are those that need to develop their technologies.

The uneven balance between the economic risks among the actors counteracts the potentials of the projects. Collaboration in which some runs a bigger risk than others can lead to a lack of involvement, and in practice, this has prolonged the projects. One example of this is a ferry that wishes to use its own crew to implement sensors as the basis for an energy management system on board the ferry. Using its own crew reduces the expenses of the ferry, but the supplier of the technology is not satisfied with the quality of the work and has to be involved in the process of the installment much more than expected.

## 4.4 Development in parallel with implementation

Demonstration projects have the purpose to test a given technology and its potentials to enter the market. In reality, technologies are both developed and implemented in the projects, since an ongoing learning process occurs and the technology is continuously modified. Two technology suppliers describe this in different ways:

"*We use the demonstration projects as a sailing exhibition, some of the equipment we have on board is just to be able to show how much energy you can save*." (Supplier D, 2014)

"*We do not use the ferries as guinea pigs, we use products that are very well known and proven, but we combine it in a new way (..) we are not certain on the results, if the reductions could be positive*." (Supplier C, 2014)

The demonstration projects can be described as a cyclic learning process in which technologies are tested, experiences gained, and the technologies are modified or the actors change their practices to fit the new technologies. The uncertainty is dependent on two main factors: how the technology performs technically in a maritime environment and how the maritime actors apply the technology in a given situation. The suppliers adjust their technologies to fit the needs of the maritime actors and continue to develop the technologies throughout the projects.

One of the central suppliers handles energy management on board the ships. He explains the role of the suppliers in the following way:

"*We do not develop new products; we put them together, based on calculations made in a program that we have developed*" (Supplier C, 2014)

And this collection of information and assessment of technologies are almost impossible if the suppliers are not willing to collaborate and share information early in the projects. The suppliers agree to this and find that it is essential to have a coordinator:

"*We need a coordinator that runs the project and secures the information we need for collaboration but also makes it clear who is responsible for providing what and when*" (Supplier A, 2014)

This coordinator can facilitate the collaboration, but also the development and implementation of the technologies. The coordinator facilitates the cyclic features of the multi-party network collaboration as the actors collaborate in later projects as well.

Even when the technologies that are involved in the demonstration projects are well known to the suppliers it is important to implement these in a real context, where the technologies are tested with the actual practices on board the ships. This is a two-way development, as the maritime actors also need to adjust their practices according to the new technologies. Therefore, it is also important for the suppliers to consider which knowledge the demonstration projects should generate in order to make the technology attractive in the future. The suppliers that are interested in demonstration projects are those that actually need to develop their products further, for instance if their technology has been applied to the energy management of houses, but needs to be developed to work on board a ship.

## 4.5 Demonstration projects create a platform for collaboration

In the maritime sector, there are constellations of actors that have a tradition for collaborating and some of the business network initiatives have originally been established as local initiatives. It is a challenge that the involved actors have diverse understandings of how demonstration projects work:

*"All the industrial actors and the ferry expected that they could participate for free, but demonstration projects do not work like that, and we did not communicate that well enough." (business consultant C for a maritime center for operations, 2014)*

It is important to the development of the projects that one person is responsible for keeping the process running and getting the actors to collaborate. The suppliers of technologies and the users find it difficult to agree on the processes and therefore an external facilitator is important:

*"All the different actors involved have different agendas, even when we think that we have a common goal there are different ways to get there, and the suppliers like to get their competitors out of the projects" (Previous business consultant for a maritime center for operations, 2014)*

There is a practice of inviting several suppliers to participate in the projects and then select partners among those that provide the most appropriate solutions for the given project. In this process, the coordinators also play an essential role:

"*The competitors don't want to show their product details to each other, so in the beginning of a project it is important that someone else can facilitate the discussions and select suppliers.*" (Supplier D, 2014)

Another barrier to achieving the best available solutions is that competing companies are involved, and they are resistant to providing specifications of their technologies:

"*The shipping industry is very competitive; it is hard to run a project where no one is willing to be the ones that first show their solutions to the others*" (Supplier C, 2014)

Another technology supplier adds to this discussion, as he finds it difficult to handle the lack of collaboration between the suppliers in the projects:

"*We thought that it was a part of a corporation but in reality we did not talk to any of the other suppliers, just the users and the coordinators*." (Supplier B, 2014)

Several of the business consultants explain how this structural barrier to getting actors to collaborate prolongs the retrofits and makes it difficult to get technologies tested and implemented as a part of the projects. The suppliers are more willing to collaborate with other actors that they know from previous projects and they do to some extent collaborate in inter-organizational innovation projects in a cyclic approach, where new projects are negotiated while they execute the former project. This approach makes the actors less open towards collaboration with new actors.  There are, however, examples of demonstration projects with specific goals which have initiated this process with "new" suppliers. Thereby they serve as a platform for new collaboration between various actors.

## 5. Discussion

Demonstration projects in the maritime sector contribute to much more than just testing energy efficient technologies' readiness for the market. Through the case studies of the demonstration projects, it is found that they are innovation processes as described by Van De Ven (1999). Although the energy retrofits in the maritime sector are based on existing technologies, they represent more than just a diffusion process;

1) The technologies are developed and tested in parallel in the specific setting. In other words, a re-innovation of the technologies occurs that goes beyond traditionally testing, but especially there is a change in the practices of the involved actors.

2) The process can be long lasting; some projects have lasted more than three years, and the innovations do not occur in a linear manner.

3) Numerous actors are involved in multi-party networks and their benefits from the projects are not equal.

4) The actors have different motives for entering the projects, but they also hold different risks both economically and technologically.

5) Demonstration projects change the way in which actors perceive energy management on board ships and influence their current practices. Therefore, the projects constitute radical innovation for the involved actors.

6) The lack of support for energy retrofits in the maritime sector slows down the retrofit processes.

Therefore, the demonstration projects are innovation processes and not just simple technology diffusion. The multi-party networks operate in a cyclic manner where the termination of one project often leads to the initiation of another. This involves not only demonstration projects but also other technological development projects.

It is difficult for the maritime actors to get funding for demonstration projects that address new combinations of existing technologies; especially the business consultants explain that there needs to be something “really new” to test. Thereby, the funds do not support the combination of existing technologies, even though the diffusion of existing technologies and especially the process of involving suppliers from other sectors can be just as difficult as the development of new technologies (Fleck, 1993).

Energy efficient technologies from other sectors that might be of relevance to the maritime industry are not considered, if they are not coherent with the existing practices in the sector. This means that innovations of a more radical nature than the ongoing incremental innovations that fit the current practices are hard to implement (Mosgaard et al., 2014a). Invention happens in a recombination of ideas and artifacts across different domains of knowledge. Demonstration projects can be a method for overcoming this barrier by supporting the collaboration between actors that can implement the new technology and thereby give an example of its possible feasibility. The demonstration projects serve as a driver to break the established understanding of how to handle energy management in the daily practice on ships, as they bring the actors together with a common agenda, namely to develop and test new solutions for energy efficient retrofits.

Frishammer (2014) has shown that demonstration projects play an important role in technological development as they bridge a gap between technological breakthroughs and industrial application and commercial adoption. The projects in this analysis both involve the development and implementation stages of the innovation process, as they facilitate the transfer of technologies from other sectors as well as the test and implementation of these. The demonstration projects thereby facilitate the introduction of changed practices by letting “non maritime” suppliers and “maritime actors” collaborate in a project with the goal of testing and developing a new technology, not just demonstrating existing technologies. Through the tests, the technology becomes more feasible to other maritime users as well. Thereby, the tests facilitate what has been set as the Danish goals for maritime demonstration projects, namely the test of a given technology’s ability to enter the market.

Kemp and Volpi (2008) have shown that the diffusion of clean technology is influenced by exogenous mechanisms such as legislative activities and market structure (Kemp and Volpi, 2008). The market structure means that there are retrofit solutions to which the actors in the maritime sector do not gain access, as the suppliers from other sectors find it hard to enter the maritime sector. Demonstration projects are therefore a potential for suppliers for testing and introducing well known technologies from other sectors and thereby reducing the barriers caused by the practices of the maritime actors to energy efficient retrofits.

Kemp and Volpi (2008) have also identified a number of endogenous mechanisms or socio-economic factors that influence the diffusion of green technologies such as costs, research and design activities, and learning and increment in the invention of new technologies.  Through the demonstration projects, several of these factors are involved. The costs of implementing the technology are reduced, an ongoing development process takes place during the projects, and the suppliers have the potential for learning about the practices of the users in the maritime sector. In order for the suppliers to gain from the process, they need to consider which type of learning and knowledge they can facilitate. This can, e.g., be technical specifications or a more social understanding of the technology and the actual practices in which it needs to operate. The special conditions on board ships mean that demonstration projects are important to get the technologies from other sectors tested. By understanding the practices of the users, it is easier to make the technology attractive on the market.

There is inertia towards implementing cleaner technologies in vessels even when economic and environmental arguments are favorable (Corbett and Fischbeck, 2002; Eide et al., 2009; Hermann and Köhler, 2012; Lyridis et al., 2005). The industrial actors do not have a tradition for collaboration to build on; they need someone else to facilitate the process. Therefore, external business consultants have been managing the demonstration projects and have involved a number of actors. The involvement of multi-party networks is important to facilitate the implementation of cleaner technologies in the maritime sector (Mosgaard et al., 2014b).Having an external consultant managing the projects and having progression as a primary focus facilitate the inter-organizational collaboration, challenge the current practices, and thereby facilitate the implementation of greener technologies.

## 6. Conclusion

Which are the potentials in demonstration projects? Can they facilitate the implementation of energy efficient technologies in the maritime sector?

The demonstration projects presented are very different as some of them constitute more radical technological innovations than others and some involve actors from different sectors that do not have a tradition for collaboration. Thereby, the demonstration projects are multi-party networks and the actors involved are not predefined, but are selected among those actors that can contribute to a solution of the problems in the individual project. A cyclic process occurs as actors with previous experiences from collaboration tend to enter new innovation projects together.

Demonstration projects in the maritime sector can be seen as a success in more than one way; they do fulfill the “traditional” goal by facilitating the entrance of technologies into the market, but they also lead to an improvement in the technology as well as changed practices among the actors involved. The projects become a success because they are more than a simple technology diffusion; they lead to a process that have similarities to innovation projects by leading to changes in technologies.

The innovations are not incremental but radical in the sense that they challenge the mindset and current practices in the maritime sector, even though they are well known in other sectors. The innovations happen in multi-party networks and lead to new combinations of technologies. Besides the changes in practices, the demonstration projects also change the mindset of how to handle energy in ships. The perception is moved from a focus on mainly fuel and engine efficiency to considering energy management on the entire ship.

What is initiated as a “simple” diffusion of a technology therefore ends up as an actual innovation process in which technologies are developed and tested in parallel and a re-innovation of the technologies occurs. Actors are involved in multi-party networks “in the making”, including actors from different sectors. The actors hold different risks both economically and technologically. But most of all, demonstration projects change the way in which actors perceive energy management on board ships and influence their current practices.

In order to gain the relevant knowledge from these demonstration projects, it is important that the projects also have funds for dissemination that can facilitate the distribution of the knowledge gained about changes in practices as well as the application of technologies. Likewise, it could be interesting to do a more systematic evaluation of the actual outcome of the demonstration projects in general.

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