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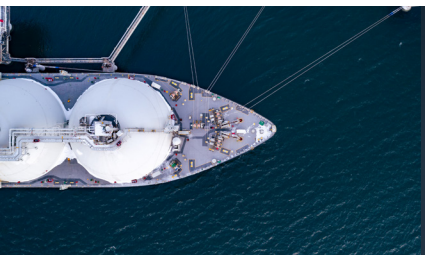


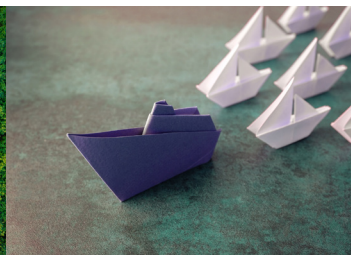

A prestudy carried out within the Swedish Transport Administration's industry program Sustainable Shipping, operated by Lighthouse, published in November 2025

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HÅLLBAR SJÖFART

Social relations influence over choices of alternative marine fuels

An exploration of bounded rational aspects in the decision processes

Authors
Hanna Varvne, RISE Research Institutes of Sweden
Selma Brynolf, Chalmers

In cooperation with
Terntank
Stena Teknik

A prestudy carried out within the Swedish Transport Administration's industry program Sustainable Shipping, operated by Lighthouse

Summary

This prestudy explores how social relations influence the choice of alternative marine fuels among Swedish shipowners. Adopting a cognitive perspective on decision-making, the study challenges rational models and instead highlights the role of networks, symbolic tools, and organizational dynamics. Based on twelve interviews with industry stakeholders, including operative staff from the two contributing companies Terntank and Stena Teknik and two additional Swedish shipowners, three key themes emerge: the role of networks, the temporal structure of decisions, and the symbolic use of decision-support tools.

This prestudy conclude that the process of choosing alternative marine fuels among shipowners is not linear nor isolated; rather, it reflects a complex interplay of actors, tools, timings, and symbolic meaning. Within this realm different decision support tools were identified such as:

- Life Cycle Assessment (LCA)
- Indicators
- Economic evaluations
- Backcasting

These are used not only to support decisions but also to signal rationality and responsibility. Hence tools carry both symbolic and instrumental value. The prestudy also identified challenges of future research, particularly the difficulty of accessing the organizational spaces where decisions are made. This makes it necessary to thoroughly consider both the design of studies and how industry stakeholders can contribute to overcome obstacles with access.

In sum shipowners operate in a context of uncertainty regarding future regulations, fuel prices, and technological developments. Decisions about alternative fuels are intertwined with broader strategic and operational choices, influenced by fuel availability, technology maturity, and external demands from customers, financiers, and regulators. The study reveals that decisions are shaped within networks involving researchers, suppliers, and industry associations, where technological artifacts also act as agents in the decision-making process.

Sammanfattning

Denna förstudie utforskar hur sociala relationer påverkar val av alternativa marina bränslen bland svenska redare. Studien utgår från ett kognitivt perspektiv på beslutsfattande, där val inte ses som strikt rationella utan snarare som resultat av komplexa nätverk, symbolik och organisatoriska processer. Genom tolv intervjuer med personer inom branschen, inklusive operativ personal från de två medverkande företagen Terntank och Stena Teknik samt två ytterligare svenska rederier, identifieras tre centrala teman: nätverkens roll, beslutens tidsmässiga ordning och användningen av beslutsstöd som symboliska verktyg.

Förstudien drar slutsatsen att processen att välja alternativa marina bränslen bland rederier varken är linjär eller isolerad; snarare speglar den ett komplext samspel mellan aktörer, verktyg, tidpunkter och symbolisk mening. Inom detta sammanhang identifierades olika beslutsstöd såsom:

- Livscykelanalys (LCA)
- Indikatorer
- Ekonomiska utvärderingar
- Backcasting

Dessa används inte bara för att stödja beslut utan också för att signalera rationalitet och ansvarstagande. Verktygen har därmed både symboliskt och instrumentellt värde. Förstudien identifierade även utmaningar för framtida forskning, särskilt svårigheten att få tillgång till de organisatoriska rum där besluten fattas. Det gör det nödvändigt att noggrant överväga både studiers utformning och hur branschaktörer kan skapa tillgång till organisatoriska rum där beslut fattas.

Sammanfattningsvis navigerar rederier i en kontext av osäkerhet kring framtida regleringar, bränslepriser och teknikutveckling. Beslut om alternativa bränslen är sammanlänkade med strategiska och operativa val, påverkade av bränsletillgång, teknikens mognad och externa krav från kunder, finansiärer och myndigheter. Studien visar att besluten formas inom nätverk som involverar forskare, leverantörer och branschorganisationer, där teknologiska artefakter också fungerar som aktörer i beslutsprocessen.

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1 Introduction

Shipping accounts for approximately 3% of global greenhouse gas (GHG) emissions, (Faber et al., 2021). Shipping is also responsible for emissions of air pollutants and discharges to the sea (Andersson, et al. 2016). To mitigate these emissions, efforts include but are not limited to hull optimization, sailing techniques, digital tools for route planning and performance monitoring, and a broad spectrum of alternative fuels, including biodiesel, ammonia, hydrogen, liquefied natural gas (LNG), liquefied biogas (LBG), and nuclear power (e.g. Bouman et al., 2017; Gaul & Rutkowski, 2025). Considerable research is underway to identify propulsion systems for the next generation of ships with low environmental impacts (e.g. Malmgren, et al. 2023; Parsmo, et al. 2024; Flodén, et al. 2024; Lunde Hermansson, et al. 2024; Kanchiralla, et al. 2025). Emission-reduction technologies, such as onboard carbon capture and storage (CCS), are also being explored (Wang et al., 2017).

Shipowners, shipyards, and investors now face the complex challenge of evaluating and adopting technologies to reduce emissions to remain compliant with evolving regulatory frameworks and maintaining economic competitiveness. Many existing studies rely on rational decision-making models to support fuel and technology selection (e.g. Ölçer & Ballini, 2015; Trivyza et al., 2022). However, this rationalistic approach may underestimate the discrepancy between idealized decision processes and the actual practices within organizations. At the same time recent research has further highlighted the complexity of the shipping sector, emphasizing how the network of actors involved in ship operations including owners, charterers, port authorities, and classification societies can hamper operational change (Poulsen & Johnson, 2016; Poulsen et al., 2022; Varvne, 2024). These findings point to the need for new perspectives and frameworks to understand and facilitate operational and organizational changes in support of emissions reductions.

There is limited empirical evidence to what extent these decision-support models are applied in real-world contexts, or how they shape organizational behavior. Therefore, the aim of this prestudy is to explore how theories form organization studies, particularly those addressing bounded rationality, can be applied to the decision processes of alternative fuels among shipowners. This was done through twelve interviews with shipowners' personnel, showing the process of choosing alternative marine fuels among shipowners including the network of decision their temporal aspects and the role of decision support tools.

2 Choice processes and their relations to decisions

One foundational idea in modern economics and social sciences is that human actions are driven by human choices. In standard theories of choice view decision-making as intentional and consequential, it is assumed that all alternatives, their consequences, and their subjective values are known, and the choice is made by selecting the alternative with the highest expected value (March, 1991). This has resulted in the development of two major strings of research within decision theory. One is described as mathematical

rational models or game theory models. This perspective has previously been explored in relation to the decision support methods of sustainable ship energy systems (Trivyza et al., 2022) and cleaner seaborne transport in relation to international regulation (Ölçer & Ballini, 2015). The second string of research in decision theory is cognitive models describing what happens in practice. Some recent studies with empirical cases investigating these cognitive models covers the decision processes of investing in new sea locks (Pot et al., 2018), the interactions between policy and market practices in public purchase with aim of reduced climate impact (Mattsson & Junker, 2023), and attention allocation in software projects (Tonellato et al., 2024). This prestudy has explored the choices and decision processes of alternative fuels among Swedish shipowners and their technical departments from the cognitive perspective. To the best of our knowledge this has not been thoroughly explored in any previous studies[1].

The heritage of cognitive research on decision processes has its foundation in the studies by Simon (1959) who introduced the importance of behavioral science to understand decision making. Simon acknowledged that decisions are not completely rational since humans cannot process the complexity of the entire world, hence decisions can at best be satisfying. This was the foundation of the concept bounded rationality[2].

The concept of bounded rationality has been continuously developed and resulted in numerous advancements in decision theory focusing on the behavioral aspects of decision processes. Among these developments is the "*Garbage Can Model of Organizational Choice*" (Cohen et al., 1972). The model explores decision-making in organized anarchies, characterized by problematic preferences, unclear technology, and fluid participation. The model views organizations as collections of choices, problems, solutions, and decision-makers. Key components include:

- Problem – such as the need for new services, products, or organizational change. In relation to choices of alternative fuels this can be understood as the strive to reduce one's emissions, hence negative impact on earth's systems.
- Solutions – to address the aforementioned problems, the identified solutions investigated in this prestudy relate to using alternative fuels to propel the ship and thereby reduce emissions. There could be other solutions to the problem such as ship size or route optimization which are not explored here.
- Participants – who are involved in the process of identifying problems and solutions. For this prestudy the focus has been on shipowners' shore personnel.
- Choice opportunities – when are decisions expected to be made? These occasions are regular in the organization. Examples presented (but not observed) in this

[1] There has been studies indirectly exploring the decision processes among Swedish shipowners from a more cognitive perspective, Forsberg, P. (2001). *Berättelser och omdömen i en redares vardag* Diss. Göteborg : Univ., 2002]. Göteborg. being one example, but the extensive development of alternative fuels which has followed the years of its publication makes it impossible to draw any clear parallels.

[2] The concept of bounded rationality has also resulted in research on decision processes on an individual level where Kahneman, D. (2013). *Thinking, fast and slow* (1st pbk. ed.). New York : Farrar, Straus and Giroux. has been most influential. Both Simon and Kahneman has won The Nobel Memorial Prize in Economic Sciences for their respective advances to decision theories on individual and organizational level.

prestudy is board meetings, covering strategic decisions for newbuild and retrofits.

The garbage can model highlights the complexity and interrelatedness of organizational phenomena and offers insights into decision-making processes. Cohen et al. (1972) conclude among other things that:

> *It is clear that the garbage can process does not resolve problems well. But it does enable choices to be made and problems resolved, even when the organization is plagued with goal ambiguity and conflict, with poorly understood problems that wander in and out of the system, with a variable environment, and with decision makers who may have other things on their minds. (Cohen et al., 1972, p. 16)*

This reality as described by Cohen et al. (1972) with ambiguity and conflict seems to resemble well with the reality faced by shipowners trying to assess which alternative fuel has lowest environmental impact at the same time as it has a competitive price. At the same time shipowners need to adhere to the daily organizational needs of operating ships while strategic decisions need to be considered. Overall, this situation makes it reasonable to assume that the garbage can model is likely to resemble the choice situation of alternative fuels.

Related to these ideas are the later developments by March (1978) where he explores how traditional models of rational choice based on stable, well-defined preferences and perfect information fail to capture the complexity of real human and organizational decision-making. March argued that decision-making involves two uncertain guesses: future outcomes and future preferences. In relation to choice of alternative fuels this reflects in at least two uncertainties, that of the regulatory framework which shapes both outcome and preference but also the future cost of the fuel and potential technological issues or advancements are likely to add to these uncertainties.

While bounded rationality has been widely accepted as a realistic and normatively useful adjustment to the first guess, (March, 1978) emphasizes the underexplored ambiguity in the second, how preferences are formed, evolve, and influence choices. He critiques the assumption that preferences are stable, consistent, and exogenous, showing instead that they are often constructed, strategic, and even contradictory. March proposes that ambiguity in preferences, like bounded rationality, may be a form of intelligence rather than a flaw, and calls for a richer, more nuanced theory of choice that incorporates insights from ethics, aesthetics, and human experience.

In his later essay in 1991 March continues to explore different aspects of choice and decision, taking a starting point in the already discussed bounded rationality, he developed the perspective further by describing decisions as rule-based actions. This perspective shares many resemblances with the developments of institutional theory (DiMaggio & Powell, 1983; Greenwood et al., 2017) and particularly its view on legitimacy in organization (Deephouse & Suchman, 2008) where actions are taken based on what is expected rather than most effective, called the logic of appropriateness. This is followed by an elaboration of decision as artefacts, a notion that has greatly influenced this prestudy and freely interpreted, underpins the continued disposition of the prestudy.

The elaboration includes the Centrality of choice (elaborated in this section), Networks (described next), Temporal order, Symbols and the construction of meaning.

2.1 Networks and action-nets in decisions

Organizations are often described as hierarchical, but in practice, they function more like complex networks of relationships. It is argued that hierarchical models persist because they reflect and reinforce a worldview centered on domination and subordination. While network analysis tools have advanced our understanding of organizational decision-making, they also reveal that decisions emerge from intricate, context-dependent interactions, challenging simple rational explanations (March, 1991).

Following this notion of the importance of networks as described by March this prestudy embraces the concept of networks as further developed by Czarniawska and Sevón (1996) into action nets. The concept of the *action net* refers to how collective actions, such as producing, selling, or buying, are interconnected in institutionalized patterns (DiMaggio & Powell, 1983) across various organizations or groups, not necessarily within a single formal organization. These connections can be formal (e.g. contracts) or informal and may evolve, break, or be newly formed in innovative ways. Unlike traditional organizational concepts, action nets emphasize dynamic, socially constructed linkages between actions rather than fixed entities (Lindberg & Czarniawska, 2006).

Attention to action nets is important since it can provide a more detailed account for an event or action in relation to decisions. Or as formulated by Nilsson-Lindén et al. (2021, p. 103) "Is it a company's vision or strategic plan that has afforded an actor a central position? Or, could it be that a personal contact, an unforeseen event or a routine act is responsible?" In other words, an understanding of the implication of action nets is essential to grasp the structures of a choice or decision process regarding an alternative fuel and whom might be involved in such process.

2.2 Temporal order of decisions

The choice of alternative fuels among shipowners does not take place in a vacuum. Rather it is a process which happens among other operational and strategic choices in the daily life of the organizations. In theories on choice and decisions this was described by March:

> *In particular, it is argued that any decision process involves a collection of individuals and groups that is simultaneously involved in other things. Understanding decisions in one arena requires an understanding how those decisions fit into the lives of participants.*
> *(March, 1991, p. 109)*

More recent studies show that theories by March and colleagues on decision making and particularly in relation to attention, timing and importance still hold (Tonellato et al., 2024). From a shipping perspective the dimensions of attention and timing have been covered on several occasions from different angles, often described as the inherent conflict between business and other actions improving environmental performance. where the party bearing the cost of the efficiency measure is not always the one who benefits from the resulting cost savings (Poulsen & Johnson, 2016; Poulsen et al., 2022).

Even if these studies have not focused on the choice of alternative fuels they have in common that they capture the reality of shipping companies where the work with improving environmental performance needs to coexist with the daily task of the shipowner and in coordination with commercial activities. Highlighting the complexity of the decision situation and variety of attention demanding tasks faced by the shipowners.

2.3 Decision support tools as symbols and construction of meaning

One important part of decision making is its symbolic action and how it develops joy and interpretation of life (March, 1991). One aspect of this symbolism is the information that is gathered. Feldman and March (1981) discussed how organizations gather more information than they use and continue to request more. Their study suggested that this behavior is due to the symbolic and ritualistic value of information in organizations. Information gathering and use are seen as representations of competence and reaffirmations of social virtue. One example from the choice processes of alternative fuels in shipping is the study by Malmgren et al. (2023) where people continuously requested more information.

Feldman and March (1981) also explored the strategic misrepresentation of information, and the symbolic significance of information used in decision-making. For this prestudy one of their mentioned perspectives is particularly important, that is their examination of the symbolic significance of information use, suggesting that simple decision-theory perspectives do not align with organizational practices. Rather than a stable separation of symbolic and instrumental actions, organizations demonstrate a dynamic interplay between these aspects. Interpreting life influences life, making symbolic investments in information likely to transform into instrumental ones, which may be a strategic approach to uncovering information's decision value.

Interpreted to this prestudy this means that the information gathered to choose alternative fuels is likely to indicate which information is important which in turn will shape the decision. So even with a symbolic view on information in choice and decision processes the preferred tool or method and its outcome is likely to have both symbolic and real meaning. As described by March (1991, p. 111) "…life is not primarily a choice; it is interpretation Outcomes are generally less significant – both behaviorally and ethically – than process." This makes it relevant to delve deeper into the processes which are used to aid choices of alternative fuels. There are different methods and tools used to gather and structure information about marine fuels, some of these are illustrated in figure 1. The figure is adapted from Andersson et al (2016), the tools emphasized in this report are highlighted, and described in further detail below.

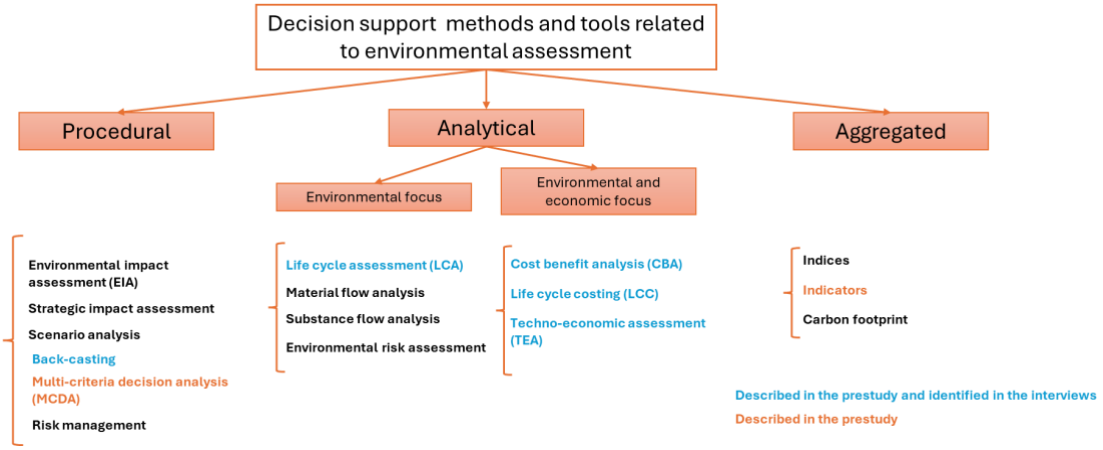

Figure 1: Overview of decisions support methods and tools related to environmental assessment of marine fuels

2.3.1 LCA

Life Cycle Assessment (LCA) can be a powerful decision-support tool and is used to evaluate the environmental impacts of a product, process, or service throughout its entire life cycle, from raw material extraction to disposal or recycling (Baumann and Tillman, 2004). Its use has grown over the last decades, and it is used both as a decision support tool within industry, for example in product development, but also in regulations and policy.

LCA is for example the basis for the calculation rules in different low carbon fuel standards: the Renewable Energy Directive (RED), the United Kingdom's Renewable Transport Fuel Obligation (RTFO), the California Low Carbon Fuel Standard (LCFS) the United States' Renewable Fuel Standard (RFS), the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), British Columbia's Low Carbon Fuel Standard (BC-LCFS), Canadian Clean Fuel Regulation (CFR) and the Brazilian National Biofuels Policy (RenovaBio) (Mandegari et al., 2023; Roux et al., 2024).

IMO adopted specific LCA guidelines for marine fuels in March 2024 in resolution MEPC/81/16. The scope of IMO LCA guideline includes well-to-tank (WtT) and tank-to-wake (TtW) to assess well-to-wake (WTW) GHG intensity and the functional unit is 1 MJ of fuel. The guideline uses the attributional approach expressing the global warming potential over a 100-year time horizon (GWP100) as given in the fifth IPCC assessment report. LCA has also been used extensively in academic literature (Kanchiralla, 2025; Roux et al., 2025). The use of LCA as a decision support tool within shipping companies and other maritime industrial actors is less well known. However, from interviews with stakeholders the need for knowledge about the climate performance of marine fuels has been raised (Malmgren et al, 2023). Industrial initiatives on LCA of marine fuels can for example be seen by the Maersk Mc-Kinnely Möller Center for Zero Carbon Shipping which have developed their own LCA methodology (MMMCZCS, 2023).

2.3.2 Economic assessments

There are different types of methods available to assess the economic viability of marine fuels using a systematic approach. These include life cycle costing (LCC), techno-economic assessment (TEA) and total cost of ownership (TCO) (Ellram Lisa, 1993;

Ferrin and Plank, 2002; Hunkeler et al., 2008; Rödger et al., 2018; Thomassen et al., 2019; Wunderlich et al., 2021). LCC can also be called life cycle cost analysis and refers to a variety of methods used in different contexts and are commonly divided in three types: conventional LCC, societal LCC and environmental LCC (Rödger et al., 2018). It is important to note that there are multiple different forms of these methods. Conventional LCC, also called financial LCC, is similar to TCO and sometime used identically. It typically considers only the pure economic evaluation of a product or service. To address the costs at different points in time, conventional LCC typically involves discounted costs, with the discount rate selected by the decision-maker (Hunkeler et al., 2008). Maersk Mc-Kinnely Möller Center for Zero Carbon Shipping have for example developed a TCO model for ships in the form of an Excel spreadsheet (MMMCZCS, 2021).

Environmental LCC is developed to be harmonized with environmental life cycle assessment (LCA) in terms of system boundaries, functional unit and methodological steps (Heijungs et al., 2013; Rödger et al., 2018). It is typically used when an environmental LCA is also carried out comparing both environmental and cost performance. Extensive work on assessing marine fuels economic and environmental performance using the same system boundaries have been done by Fayas Malik Kanchiralla (Kanchiralla et al., 2022, 2023, Kanchiralla (2025)). The focus of environmental LCC is on internal cost borne by the actors in the life cycle to avoid double counting with LCA. TEA is a framework to assess the technical and economic performance of a process, product and service and is in a way another term for LCC. TEA has typically a deeper focus on assessing the technology than LCC. An example of a TEA assessments of marine fuels is Korberg et al. (2023).

2.3.3 Indicators

To monitor complex systems effectively, information must often be simplified into clear, communicable formats. Indicators and indices distill complex data into understandable measures—typically quantitative—that reflect environmental, social, or economic conditions in a specific area (Andersson et al., 2016).

Indicators are used in everyday contexts, often expressed as a number with or without a unit. Examples include scorecards, grades or body temperature. Two examples of indicators used in shipping are the Energy Efficiency Design Index (EEDI) and the Carbon Intensity Indicator. EEDI is a metric developed by the IMO to quantify a ship's CO_2 emissions per transport work (g CO_2/ton*nautical mile) under standardized design conditions, promoting the use of energy-efficient technologies in new ships. It sets mandatory efficiency targets that progressively tighten over time. The CII is also a metric implemented by the IMO. CII aims to monitor and reduce the operational carbon emissions of ships by calculating how efficiently a ship transports goods or passengers in terms of CO_2 emitted. The resulting value is graded from A (best) to E (worst).

2.3.4 Multi-criteria decision analysis

Multi-criteria decision analysis (MCDA) is a structured method for decision support in cases involving complex criteria. It is a procedural tool as it follows several steps, (i)

problems identification, (ii) defining alternatives and criteria, (iii) model building, (iv) model application, and (v) planning and extension (Andersson et al., 2016). In model building, the alternatives are scored against the criteria. Before reaching a decision, the criteria are weighted against one another. There are several methods of weighting alternatives against the set of criteria selected and each other. One such common method is the analytic hierarchy process (AHP) developed by Thomas L. Saaty in the 1970s.

MCDA is used in various scientific contexts, and its use in shipping has grown significantly during the last decade. Hansson et al. (2019) used MCDA and specifically the AHP to rank seven alternative fuels for the shipping sector in 2030. The criteria included were grouped into economic, environmental, technical, and social aspects. The preference of different stakeholder groups was investigated. For ship-owners, fuel producers, and engine manufacturers, they ranked the economic criteria, and in particular the fuel price, as the most important. With the ranking of criteria set by these three stakeholder groups, liquid natural gas and heavy fuel oils were the fuels that ranked the highest. Another stakeholder group considered was Swedish government authorities they instead prioritized environmental criteria highest, specifically GHG emissions, and social criteria, specifically the potential to meet regulations. This resulted in ranking renewable hydrogen as the highest of all alternatives, followed by renewable methanol. A follow up study was done in 2020 including also ammonia as an option (Hansson et al., 2020). These studies are some years old, and the landscape has changed and most likely also how different stakeholders rank different types of criteria.

2.3.5 Backcasting and other ways to look forward

One tool which can be used to guide decision-making under ambiguity is Backcasting. Backcasting is considered a useful tool in situations where there is a complex problem, when trends are a part of the problem and there are uncertainties (Holmberg & Robert, 2000). Backcasting combines some methodological and philosophical underpinnings of March's perspective on choice and decisions withing the realms of organizational learning, especially in the early and conceptual work such as Dreborg (1996) and Vergragt and Quist (2011).

Backcasting as a tool or method was further instrumentalized and used in a Swedish context including cases of companies like IKEA, Electrolux, and Scandic Hotels (Holmberg, 1998; Holmberg & Robert, 2000) and to evaluate the Swedish energy mix (Thollander et al., 2013). Holmberg emphasized the importance of upstream thinking and systems perspectives, arguing that Backcasting is particularly effective for complex, long-term issues like sustainable development. Backcasting should thereby enable organizations to align short-term actions with long-term sustainability goals, identifying investments that are both flexible and economically viable (Holmberg & Robert, 2000).

In Backcasting the first step is to define the framework with criteria for a sustainable future, these criteria are constantly developed (Holmberg, 1998). Within the Backcasting tool the definition for a society to be sustainable, the functions and diversity of nature must be preserved. This means avoiding the systematic buildup of substances extracted from the Earth's crust, limiting the accumulation of man-made substances, and preventing the degradation of ecosystems through over-harvesting or other disruptive

practices. Furthermore, resources must be used efficiently and distributed fairly to ensure that basic human needs are met globally. The second step is to describe the current situation. This should include descriptions of competences and activities and can be drawn from other tools such as LCA. The third step combines the insights from the first and second, where the framework created in the first step together with the knowledge of the current situation from the second step is used to create possible future solutions. However, the future solution should not be too specific, and a broader perspective might create new business ideas. In the fourth step the strategies to move from the current situation to the desired future are created (Holmberg, 1998). In the fourth part in the Backcasting model it is enlightened that it is important to create a strategy that is viable in the future and gives short term gains as well (lowest hanging fruit) (Holmberg & Robert, 2000). All these steps are visualized in figure 2.

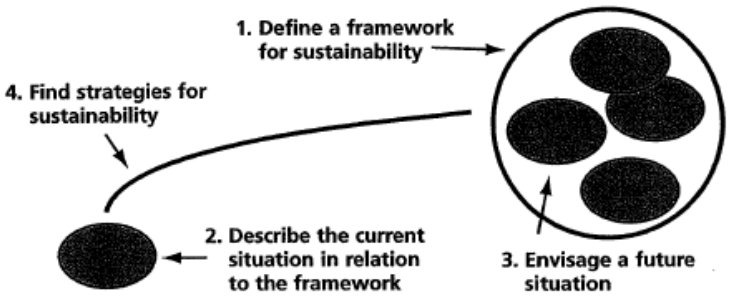

Figure 2: Backcasting (Holmberg, 1998, p. 33)

Other ways to work actively with forward looking predictions as part of decision processes are presented by Pot et al. (2018) who investigated forward looking decision processes in maritime context. Pot et al. (2018) focused on the uncertainties related to climate change and uncertain technology development (more specifically in relation to infrastructure). Their study introduced a structured framework to define and evaluate what makes long-term infrastructure investment decisions forward looking, emphasizing three core criteria. First, a forward-looking decision must include a problem definition that explicitly considers future developments and adopts a time horizon of at least ten years. Second, the chosen solution should be either robust—able to perform effectively under a range of future scenarios—or flexible—adaptable to changing conditions through monitoring and iterative decision-making. Third, the justification for the decision must be grounded in long-term goals or visions and/or supported by the use of multiple future scenarios that explore diverse developments such as economic trends, climate change, and technological shifts. These criteria help distinguish genuinely forward-looking decisions from those that are merely reactive or short-sighted, offering a practical tool for assessing and improving public investment planning.

3 Method

Studies of choice and decisions can be designed in many ways. Many of the classical conceptual studies such as the one by Cohen et al. (1972) and Feldman and March (1981)

draw on a number of case studies of decision opportunities to come to their conclusions. This highlights the importance of studying decision processes close to where they actually happen. More recent studies on the decision and choices come with a variety of methods, for example Guercini et al. (2022) choose a conceptual approach whereas (Pot et al., 2018) used interviews and documents to build up their case of decision regarding sea locks. There are also examples where cases have been created from the digital logs created in software which has enabled studies of statistical nature to attention spans of choice (Tonellato et al., 2024). This prestudy follows the tradition of studying people close to the decision process. It builds on the tradition of combining Actor-Network Theory (ANT) with institutional theory, particularly the translation model of organizational change (Czarniawska & Sevón, 1996). While often associated with theory, ANT is better understood as a methodological lens that offers new ways of seeing rather than explaining (Latour, 1999; Kjellberg & Sjögren, 2020). For this study the use of ANT means that both humans and non-humans have been explored as potential actants in the analysis, an actant means any entity which has the capacity to shape actions and decisions. ANT allows for an open-ended exploration of the influence network has on how choices and decisions regarding fuels on ships are shaped and the primary material collected in this prestudy has been interviews.

3.1 Interviews

The field material includes 12 interviews conducted with 10 people for between 30 and 120 minutes. The interviewees had different roles within their organizations, including CEOs, technical managers and sustainability coordinators. A list of interviews is shown in table 1. The interviews were conducted in a dialogic form, which led to adaptations of questions based on each organization and prior insights (Kvale, 2006). For some of the interviews joint mind maps were used to aid the common understanding of the decision process as discussed. The questions were revised before each interview and tailored to the specific organization and interviewee's position. The interview questions were related to choices of alternative fuels as well as other techniques for reducing emissions. Including questions regarding the decision process, who were involved in this process, the time spans for retrofit and newbuilds, and identification of key factors for the organization in these choices. The interviewees were primarily the ones involved in the prestudy, and the selection was expanded based on their recommendation.

3.1.1 Ethics and anonymity

One central ethical dilemma in research is how to treat the identity of people and places (Göransson, 2019). In the work with this prestudy, all interviewed participants were given the opportunity to review the text beforehand and share their wishes regarding how they would like to be portrayed and give feedback if their quotes were misunderstood or poorly translated. While some participants felt comfortable with their names and roles being visible, others expressed a preference for greater anonymity. In line with the principle of responsibility and decency emphasized in previous research (Scheper-Hughes, 2000), their views were carefully considered to avoid causing harm or discomfort. This consultation ensured that each participant could influence the way they were represented.

Given these different preferences, we decided to follow the wishes of those who wanted to remain more anonymous. This meant using generic descriptions and neutral titles, even in cases where full disclosure had been approved, as full identification of some could compromise the sense of security for others. This included adjusted titles when necessary to make them less specific and reduce the risk of recognition within the industry. Even though we acknowledge that this is hard particularly due to the display of participating companies on title page and project contracts. Even if complete anonymity cannot be guaranteed, these measures aimed at upholding the researcher's obligation to not do harm to informants (Scheper-Hughes, 2000). By prioritizing anonymity for all, we sought to balance transparency with ethical responsibility, as far as possible ensuring respect for participants' individual wishes to remain anonymous.

Table 1: Interviews

#	Organization	Persons involved	Date	Duration /record type
1	Shipowner B	Energy specialist	2024-11-12	Teams, notes
2	Shipowner B	Energy specialist	2025-02-04	Teams, transcribed + notes 00:43
3	Shipowner A	Sustainability specialist	2024-10-18	Teams, notes
4	Shipowner A	CEO	2025-01-24	In person, notes, approx. 1 hr.
5	Shipowner A	Board member	2025-01-24	In person, notes, approx. 1 hr.
6	Shipowner A	Fleet manager	2025-01-24	In person, notes, approx. 1 hr.
7	Shipowner A	Technical manager	2025-01-24	In person, notes, approx. 1 hr.
8	Shipowner A	Tech superintendent	2025-01-24	In person, notes, approx. 1 hr.
9	Shipowner A	Sustainability specialist	2025-01-24	In person, notes, approx. 2 hr.
10	Shipowner C	Naval architect	2025-05-27	Teams, transcript
11	Shipowner C	COO	2025-05-27	Teams, transcript, approx. 1 hour
12	Shipowner D	Naval architect	2025-06-10	Teams, transcript, approx. 1 hour

3.2 Analyzing the material

The analysis method embraced in this prestudy has been an iterative process inspired by Czarniawska (2014) and her description of collecting qualitative research material as well as the dialogic form of interviews applied. As described in figure 3, the process started at the desk browsing for literature, from this stage the researcher presented an initial thought in the form of a mind map and an open interview with the project partners. The input from the project partners was then brought back to the desk and refined in relation to relevant literature. After a second round of interviews with feedback and input from the project partners it was decided to invite other shipowners to enrich the material and broaden the perspective.

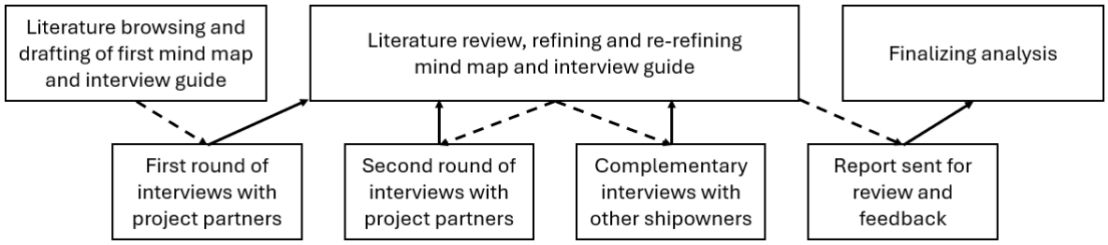

Figure 3: Analysis method of this prestudy

To analyze the interviews in this prestudy an initial examination of interview notes and the transcriptions of audio recordings was conducted. The material was then coded for themes in the software NVivo, the coding approach was in accordance with grounded theory as outlined by Glaser and Strauss (1967). This initial coding was then groped into themes as presented in figure 4. These themes were later related to the theoretical framework which guided the presentation of the result and analysis. In this phase the coding was used in reverse while identifying suitable quotes to exemplify the detected patterns. Finaly this version of the analysis was sent to the interviewees for a final opportunity for input.

4 Results and analysis

The most commonly mentioned themes which emerged from the interviews is *energy sources* (alternative fuels) and *decision factors* (choice), the frequent mentioning of these themes clearly mirror the focus of the prestudy (figure 4). Exploring the themes further exposes a few different patterns of discussion in relation to the theoretical framework of this prestudy.

One of these patterns revolves around the process of how the decisions are organized within the organizations coded to the theme *decision levels* in figure 2. This includes aspects such as who is involved, at what level decisions are processed, for example at management level or at different companies within a group of companies. In the analysis of the material this has been considered to relate to the networks of decision making as well as the insights on design of future studies. To capture the non-dualistic view of action nets where the intention is to not separate the social aspects from the technical, the interviewees thoughts related to the technical aspects of the choice process such as ship specifics and type of propulsion/fuel have also been included in the network discussion. This includes the changing relation to alternative fuels in the purchasing process of fuel where increased focus will be on securing availability of chosen fuel and potential partnerships.

Another pattern is an elaboration on the temporal order of decisions, *time frames*, the timelines these incorporate, this includes aspects such as what type of decisions are made, there can be decisions of a principled character, who can be seen as guiding the direction of the organization. There are also decisions of a more action-based nature, such as decisions of investment, and other more precise decisions aimed at guiding action in a more direct way.

The identified pattern of *requirements* was in relation to the choice process of alternative fuels identified to be threefold, based on customers, financiers and regulatory demands. These requirements do of course come with different weighting and varying aspects but in common there is the outside pressure to engage in some sort of change. One decision support tool which can capture the trade-off between different types of requirements is multi-criteria decision analysis. The theme of requirements is fundamental to the decision support tools as they shape and are shaped by information within these. However, these requirements are also part of the network as quasi objects. Another theme which includes both quasi objects in relation to networks and decision support tools is the theme decision factors. These factors are guided by the decision support tools but they are also directing the information requested in the decision support tools.

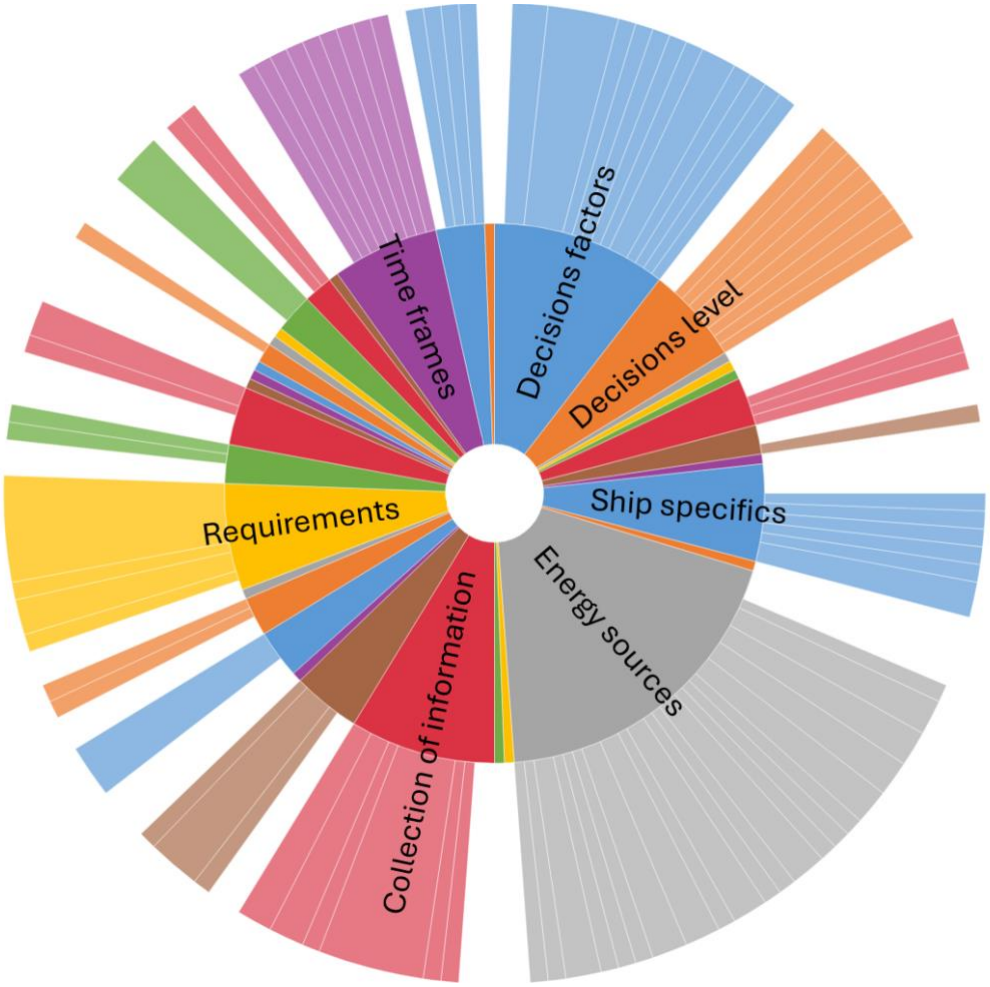

Figure 4: Overview of most discussed topics during interviews

4.1 Networks in decisions on alternative fuels among shipowners

By exploring the networks surrounding choices of alternative fuels reveal the role of external collaboration and contextual awareness. From the interviews it becomes clear how people engaged in these organizations view themselves as parts of interconnected networks where decisions are influenced by the actions, knowledge, and strategies of

others rather than being operated in isolation. It became clear that companies rely heavily on external sources of knowledge and collaboration to navigate the complexity of the transition to alternative fuels. For instance, a naval architect #10 emphasized the value of staying connected to a wide range of external actors:

> *We talk to suppliers and engine manufacturers. …we talk to our commercial partners, from these partnerships we collect a lot of information which is widely shared amongst us. …Business associations, media and news coverage.*

This quote highlights the importance of active information gathering from multiple sources, including industry partners and public media, which combined creates a network of relationships and interactions. Such interactions allow companies to monitor trends in technological developments and market signals. Between the interviews there is a differentiation of these interactions and their focus on geographical proximity, where the local, regional or global level seems related to the specific trade of the shipowner.

These informal and formal networks appear to serve as central nodes for knowledge diffusion. This was further elaborated by the COO #11 from the same company who highlighted that they connect with knowledgeable people in the field such as researcher and they "…are often involved in research projects, sometimes as part of a reference group or similar". In addition to this, they are also deliberate in their recruitment processes and hire well informed people to build up internal know-how. This reflects an understanding that tackling the challenges posed by alternative fuel choices requires not only technical solutions but also sustained intellectual partnerships. From the discussions with the energy specialist #2 it became clear that the build-up of own knowledge is an important part of the network creation, as well as testing out new technologies on their own ships and participation in industry projects (also described by, CEO #4 and sustainability coordinator #9, COO#11 and naval architect #10). These projects often result in continuous collaborations. From an action net perspective this makes it possible to assume that the technological artefact becomes important actants in the shaping of both collaborative efforts as knowledge development.

The perceived networks span beyond the organizations own partners and industry. A broader contextual awareness was reflected in the way companies perceive their role in the wider sustainability transition to alternative fuels as part as a global energy transition. As stated by Interviewee #2:

> *We try to understand this transition in a wider context. Sometimes we view ourselves as some sort of isolated industry which can make its own decisions, but we are only one part of the puzzle… What choices aviation makes, what choices heavy industry makes, what choices road transport makes, and so on.*

From this perspective it is possible to see that companies are aware of systemic interdependencies and recognize that their own decisions will both affect and be affected by developments in other sectors. This awareness reinforces the need for communication and collaboration across different industry sectors. Sometimes beyond what is common today.

Finally, the increased attention to collaboration was described not only as a necessity but also as a prerequisite for innovation in an increasingly complex and differentiated technological landscape. Naval architect #12 explained:

> *We are heading towards a differentiated world where we are looking for non-trivial complex solutions. This is the reality we are heading towards. And that requires collaboration in consortiums, and I believe that is the key to future success.*

This quote illustrates the shift in mindset from competition to co-creation, where complexity is not something to be solved individually but collectively, through shared efforts.

4.1.1 Creating your fuel supply network

Expressed in the interviews is a shifting sense of responsibility in securing future fuel supply. This signals a potential redefinition of institutionalized roles within the action net, particularly regarding responsibility for fuel sourcing, development, and infrastructure. Through the interviews, it became apparent that companies are experiencing a growing tension between their historical role as fuel consumers and an emerging necessity to become more actively involved in securing future fuel supply the COO #11 expressed it in the following way:

> *In a way, you have to see your own knowledge and understand your limitations so that when we look at these types of questions, you would rather be a demander and say that yes, but this is what we need… But we have no intention of becoming a fuel supplier. … It is probably not a desirable path to take, but maybe you will be forced to do it.*

This quote illustrates an underlying reluctance to assume roles related to fuel production, traditionally held by others. Simultaneously acknowledging that the uncertainties and gaps in the current supply chain of alternative fuels may compel organizations to reconsider these boundaries. A similar view was echoed by the energy specialist #2 "We have not yet made any decisions to invest in factories, and I am uncertain if we will do so. But we will need to take greater responsibility for our own supply compared to the past." Reinforcing the idea that while full integration into fuel production remains uncertain and perhaps undesirable, there is a clear acknowledgment that passive purchase is no longer sufficient. Instead, organizations anticipate having to influence or stabilize their supply chains more proactively in order to meet future energy demands and climate targets.

For some shipowners the choice to become more actively engaged has gone further as expressed by a naval architect #12:

> *We have stepped in and taken responsibility for a more active role in our own fuel supply. As we have had the opportunity to do.*

This quote points to an example where opportunity and necessity aligned, allowing for a more engaged stance. It also suggests that such involvement may not be universally applicable, but context-specific—dependent on resources, local partnerships, and strategic timing.

The tendency to share risk and engage in greater collaborations seems to be apparent everywhere clearly indicating the importance of the networks surrounding the choices of alternative fuels, if a ship owner is to invest in a more expensive drivetrain, they wish to know that there is fuel supply for that ship. This requires an extended network with engine suppliers, fuel suppliers and down the line a customer who is engaged as well. Throughout his collaboration there will also be plenty of technology and contractual agreement making up the actants in the net.

4.2 Temporal aspects of choosing alternative fuels

One aspect to explore in order to increase understanding of the temporal order in relation to choice of alternative fuels is the timelines of these processes. This is important since it provides an indication of the timeframes during which the attention for these decisions need to be shared with other daily tasks of the participants. Through the interviews it became clear that there are several different timelines which happen in parallel in relation to the choice of alternative fuels, this includes the strategic decisions and vision timeline, as well as the timelines for maintenance, docking and newbuild cycles of ships to mention some. The lengthiest parallel in relation to the vision work which was brought up during the interviews was presented by COO #11:

> *"We started this journey quite early, at the end of the nineties. When we realized that the heavy fuel oil we used in shipping at that time had unacceptably high sulfur levels in it... We had a vision of emission-free shipping as early as 2004. Since then, we have tweaked the wording from emission-free shipping to being truly sustainable shipping, but the idea has been the same since 2004."*

This quote shows that for those involved in the decision processes of alternative fuels they engage in these concepts on a strategic level over a rather long timeframe. Relating this to March's argumentation about uncertain guesses of future outcomes and consequences makes it clear that these uncertainties must be substantial if the timeframe considered is 30 years. Even if this example broadcasts one of the more extreme timeframes other interviewees have made similar remarks such as "… strategics choices made for the fleet might influence the resistance in these decision processes" #12 referring to the fact that change can take time. The quote also links the two types of timelines, that of strategic nature towards the more operational one consisting of timeframes for docking and maintenance of ship as well as the newbuilding cycles.

This aspect was further elaborated on in the discussions with an energy specialist who described the temporal order of a potential retrofit: "There needs to be a principal decision in place and an upgrade package available from the technology suppliers." #2. This explains how the strategic, visionary or principal decisions translates into decisions of a more action-based nature. However, due to the timing of these processes it could be argued that there is an amount of coincidence involved in this choice process based on what is available and possible to "…time with scheduled maintenance" #2. Aligning the timing of availability of products and the ships maintenance cycle thereby creates an environment which resembles with the reflections of (March, 1991) that decisions sometimes "happens" rather than are purely intentional.

For some of the interviewees the same principle of being able to apply available technology at a certain time was also apparent in the new build cycles. These new build cycles lasted a variety of years depending on trade and could be influenced by commercial demands and public procurement processes. For example, the sustainability coordinator #9 described that their new build cycles were 20 years and that within those years they had a 6-year design cycle. So, a temporal opportunity of what technology is available at a certain time is likely to be influential in both retrofit and new build processes of ships. Another dimension to the dynamic of temporality in choice of technology relates to other surrounding factors such as market and political situation. Included in this is the current situation of fuel cost for different alternatives and forecasts. Although, as recent development in the world has shown these forecasts are volatile and with an increase in unexpected events such as invasion, tolls and other political events the uncertainty is likely to be high for a foreseeable future.

One way for companies to tackle all the uncertainties involved in the choice of fuel is to avoid the decision by flexibility or multifuel use. This was brought up in all interviews and one example is the COO #11, "When we build our ships today… it's to build them for a multifuel solution to bring in as many options as possible." This approach reflects how flexibility becomes an asset. Rather than committing early to a single fuel path, organizations make a deliberate effort to maintain flexibility in an uncertain technological and regulatory landscape. However, choices cannot be always avoided, Naval architect #12 reflected on the need for deliberate decision-making in an increasingly complex fuel landscape:

> *"It's so easy to talk about alternative fuels, but it's a decision to make regardless [including continuing with conventional fossil fuels]. Making compromises means opting out and ultimately, it's about making conscious decisions, I would say, informed and conscious decisions."*

This pinpoints one of the key aspects of fuel choice today. Even staying put and continue using oil comes at a cost. One of these costs is likely the risk of missing out on the technological development and being left behind. At the same time the interviewees are also open to that there are costs related to avoiding the choice by using multifuel as well. Both in terms of purchasing the engines to the ship adapted for multiple fuels as well as reduced efficiency within these engines which might increase the operational cost and fuel consumption.

4.3 How decision support tools act as symbols and construction of meaning

The complexity of fuel choices makes the symbolism in the information collected valuable to those working with it. One example is the assessment of environmental impact intended to choose the alternative fuel with least impact on earth resources. This was described by naval architect #12, who noted that evaluations and assessments is indeed taking place, "but not necessarily in the format of LCA." This suggests that while life cycle thinking may inform decisions, it is not always formalized, and other comparative frameworks may be in use. It can also be noted that LCA has been incorporated into the regulations of alternatives marine fuels in both IMO and EU.

A recurring theme is the balancing act between compliance and ambition. As noted by the energy specialist #2, "For most of us it will all come down to being compliant to the lowest possible cost." This pragmatic stance reflects a baseline orientation toward regulatory adherence. It also makes economic assessments crucial to anchor both economic and environmental benefits to the business. At the same time, it is clear that shipping companies are willing to invest in greener solutions, the energy specialist #2 noted "The lower the climate impact, the higher the prices we will be prepared to pay. We often make these kinds of calculations…" This illustrates how economic rationality and environmental ambition are negotiated through internal assessments and comparative evaluations. Which should preferably be done in a structured manner (tool) which is broadly accepted to be rational both with the organization but also by society at large.

The decision support tools used in choices of alternative fuels are not only reflecting the evaluation of specific fuels, they are also closely linked to the strategic work performed in the organizations. Further evidence of strategic orientation was presented by COO #11, who described the planning model guiding their work:

> *"This project is based on the Backcasting model where we have created our ultimate vision of the future. That is what we will reach at some point. In that way we know roughly what steps we need to take to get there, and it is based very clearly on the fact that we must not take the options that we know will not lead there."*

This illustrates a goal-driven approach that constrains choices in the present based on a clear vision of the desired future. It reflects an effort to navigate uncertainty not just reactively but through structured foresight, excluding pathways incompatible with long-term goals.

4.4 Insights on design for future studies

One of the extended outcomes of this prestudy was to conduct an "analysis of possibilities and risks with access in an extended project (commercial secrecy etc.)". In relation to this, the indication from the prestudy is that future studies of the decision process of alternative fuels will suffer a high risk of lack of access to the organizational space where decisions on this take place. One of the most telling examples of this was expressed by a naval architect #12:

> *I actually don't know how much I can say about it. I'm a bit unsure about that. It's related to decision-making authority and the financial approval of investments, and it can vary. I don't know if it's a company secret, so I'm not sure if I can talk about it. If I had known, I wouldn't have had any problem sharing it…*

This quote clearly summarizes the problematization of access which has been experienced throughout the prestudy and through the other interviews similar patterns emerge where the decisions are described to take place elsewhere, often in boardrooms or they are scattered through other parts of the organization. The problematization of access to the organizational spaces of decisions were exaggerated further due to the prerequisites of this prestudy with the limitations of time and resources. This has made alternative methods such as observations in organizations impossible to conduct and the

results are there for relying on interviews which provide valuable insights, but merely account for how people in retrospect make sense of their situation and decisions (Czarniawska, 2014; Weick, 1995)

To bring in the processual bounded rational view of decisions as elaborated by (March, 1991) and social network perspectives (Lindberg & Czarniawska, 2006) of alternative fuels, our belief is that observations within the organizations would be a necessity. However, this structure of studies requires a wide scope in time and resources to be able to conduct them in a sufficient way. To increase the likeliness of successful material collection it is also essential that the participating organization(s) are open for a long-term commitment for hosting a scholar as observer and allowing them into management meetings as well as accepting their participation in non-official decision arenas such as office gossip (March, 1991; Nilsson-Lindén et al., 2021). One way to accomplish this in future studies could be to engage the observed organization either as co-founder of an industrial PhD student or post-Doc or in other way ensure commitment. Although even with formal agreement to conduct a study most previous research show that the process of access and acceptance of observers is time and energy consuming (Göransson, 2019; Wax, 1985). The richness of material collected from such study would also require quite some time to analyze and we predict that a 3–5-year project would be necessary to gain any further insight into these processes.

Depending on what type of technology is being discussed, the outcome of such a project would have varying scientific contributions. Considerable problems with access are likely for projects exploring decision processes of alternative fuels which are close to market entrance or already available, due to their impact on competitive advantage. The contribution of such a project would likely be to the domain of business administration and economic theories rather than technology development. This could provide great contributions to theories on choice in organization during uncertain circumstances. However, we are uncertain of the possibilities to provide theoretical contributions which would aid the implementation of alternative fuels. For studies of less mature technologies, access might be easier due to the integration of research contributions and less focus on market sensitive topics.

5 Concluding discussion

Taken together, the result from this prestudy suggest that the decision-making process regarding alternative fuels is not solely an internal, technical matter. It is deeply embedded in a broader social, industrial context and the ability to engage and associate within dynamic action nets of internal and external stakeholders.

Decisions on alternative fuels are not always made by clearly defined actors at clearly defined moments. Insights from this prestudy show that who is involved and when, reflects previous research such as the garbage can model of decision-making. Temporal aspects further complicate the decision landscape. The timing of commercial timelines and technical development phases, often create a tension between strategic vision and operational feasibility. Decisions may be shaped by maintenance schedules, newbuild cycles, or market fluctuations, making timing a critical factor. This underscores the

importance lengthy timeframes in both discussions and vision work among shipowners, integrating both short-term actions and long-term ambitions.

It is important to keep in mind that there are parallel processes where mature and novel technologies are developed side by side. This parallelism influences not only the timing of decisions but also the type of information required and the sources from which it is drawn. Depending on the maturity of technologies related to the preferred alternative fuel, the need for structured, comparative information shifts, and so does the reliance on external expertise and collaborative networks, or market surveillance.

In the strive to balance between compliance and ambition in the choice of alternative fuels decision support tools such as Life Cycle Assessment (LCA), multi-criteria decision analysis, and Backcasting aid in different ways. On one hand, they serve as symbolic markers of rationality, signalling structured and informed decision-making. It is crucial for acceptance of the choice that economic and environmental considerations are weighed within a framework that is both internally accepted and externally credible. At the same time these tools are integrated in the shaping of regulations which form an essential part of the action net surrounding shipowners and thereby secondary influencing their decision processes.

Finally, the prestudy highlights a significant challenge in accessing the organizational spaces where decisions are made. This limitation suggests that future studies must consider alternative methods, such as long-term observational research, to gain deeper insights. The role of research in this process also warrants reflection. While academia often operates on longer timelines, with slower publication cycles, it brings a necessary long-term perspective to the sustainability transition. However, this creates tension with the faster-paced decision-making of shipowners and investors. Designing effective research-based decision-support tools requires acknowledging this mismatch and finding ways to bridge it, ensuring relevance without sacrificing scientific rigour.

In sum, the process of choosing alternative marine fuels among shipowners is not linear nor isolated; rather, it reflects a complex interplay of actors, tools, timings, and symbolic meaning.

6 References

Andersson, K., Brynolf, S., Landquist, H., Svensson, E. (2016). Methods and Tools for Environmental Assessment. In: Andersson, K., Brynolf, S., Lindgren, J., Wilewska-Bien, M. (eds) Shipping and the Environment . Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-49045-7_9

Baumann, H., Tillman, A.-M., (2004). *The hitchhiker's guide to LCA : an orientation in life cycle assessment methodology and application*. Studentlitteratur, Lund.

Bouman, E. A., Lindstad, E., Rialland, A. I., & Strømman, A. H. (2017). State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping – A review. *Transportation research. Part D, Transport and environment*, *52*, 408-421. https://doi.org/10.1016/j.trd.2017.03.022

Cohen, M. D., March, J. G., & Olsen, J. P. (1972). A Garbage Can Model of Organizational Choice. *Administrative Science Quarterly*, *17*(1), 1-25. https://doi.org/10.2307/2392088

Czarniawska, B. (2014). *Social Science Research: From Field to Desk* (First Edition ed.). London: SAGE Publications, Limited. https://doi.org/10.4135/9781529799613

Czarniawska, B., & Sevón, G. (1996). *Translating organizational change*. Berlin : de Gruyter.

Deephouse, D. L., & Suchman, M. (2008). Legitimacy in Organizational Institutionalism. In R. Suddaby, R. Greenwood, K. Sahlin, & C. Oliver (Eds.), (pp. 49-77). London: SAGE Publications Ltd. https://doi.org/10.4135/9781849200387.n2

DiMaggio, P. J., & Powell, W. W. (1983). The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields. *American sociological review*, *48*(2), 147-160. https://doi.org/10.2307/2095101.

Dreborg, K. H. (1996). Essence of backcasting. *Futures : the journal of policy, planning and futures studies*, *28*(9), 813-828. https://doi.org/10.1016/S0016-3287(96)00044-4

Ellram Lisa, M., (1993). A Framework for Total Cost of Ownership. *The International Journal of Logistics Management* 4, 49-60.

Feldman, M. S., & March, J. G. (1981). Information in Organizations as Signal and Symbol. *Administrative Science Quarterly*, *26*(2), 171-186. https://doi.org/10.2307/2392467

Ferrin, B.G., Plank, R.E., (2002). Total Cost of Ownership Models: An Exploratory Study. *Journal of Supply Chain Management* 38, 18-29.

Forsberg, P. (2001). *Berättelser och omdömen i en redares vardag* Diss. Göteborg : Univ., 2002]. Göteborg.

Gaul, K., & Rutkowski, G. (2025). Harnessing the Wind: The Rise of Wind-Assisted Ship Propulsion (WASP) in the Transformation of Maritime Transport. *TransNav: International Journal on Marine Navigation and Safety of Sea Transportation*, *19*.

Göransson, K. (2019). *Etnografi : sjösätt, navigera och ro i land ditt projekt* (Upplaga 1 ed.). Lund : Studentlitteratur.

Greenwood, R., Oliver, C., Lawrence, T. B., Meyer, R. E., & Sage, e. (2017). *The SAGE handbook of organizational institutionalism* (Second edition. ed.). Los Angeles : SAGE Reference.

Guercini, S., La Rocca, A., & Snehota, I. (2022). Decisions when interacting in customer-supplier relationships. *Industrial Marketing Management*, *105*, 380-387. https://doi.org/https://doi.org/10.1016/j.indmarman.2022.06.019

Hansson, J., et al. (2019). "Alternative marine fuels: Prospects based on multi-criteria decision analysis involving Swedish stakeholders." *Biomass and Bioenergy* 126: 159-173.

Hansson, J., Brynolf, S., Fridell, E., & Lehtveer, M. (2020). The Potential Role of Ammonia as Marine Fuel—Based on Energy Systems Modeling and Multi-Criteria Decision Analysis. *Sustainability*, 12(8), 3265. https://doi.org/10.3390/su12083265

Holmberg, J. (1998). Backcasting: A Natural Step in Operationalising Sustainable Development. *Greener management international*, *23*(23), 30-51.

Holmberg, J., & Robert, K. H. (2000). Backcasting - a framework for strategic planning. *International journal of sustainable development and world ecology*, *7*(4), 291-308. https://doi.org/10.1080/13504500009470049

Hunkeler, D., Lichtenvort, K., Rebitzer, G., Ciroth, A., Huppes, G., Klöpffer, W., Rüdenauer, I., Swarr, T., (2008). *Environmental life cycle costing*. CRC Press, Pensacola, Florida.

Kahneman, D. (2013). *Thinking, fast and slow* (1st pbk. ed.). New York : Farrar, Straus and Giroux.

Kanchiralla F. M., Brynolf S., Malmgren E., Hansson J., & Grahn M. (2022). "Life-Cycle Assessment and Costing of Fuels and Propulsion Systems in Future Fossil-Free Shipping." *Environmental Science & Technology*, 10.1021/acs.est.2c03016. https://doi.org/10.1021/acs.est.2c03016

Kanchiralla F. M., Brynolf S., Olsson T., Ellis J., Hansson J., & Grahn M. (2023). "How do variations in ship operation impact the techno-economic feasibility and environmental performance of fossil-free fuels? A life cycle study." *Applied Energy* 2023 Vol. 350 DOI: 10.1016/j.apenergy.2023.121773

Kanchiralla, F. M., et al. (2024). "Role of biofuels, electro-fuels, and blue fuels for shipping: environmental and economic life cycle considerations." *Energy & Environmental Science*.

Kanchiralla, F.M., (2025). *Energy Transition towards Sustainable Shipping: Environmental and Economic Life Cycle Considerations, Mechanics and Maritime Sciences*. Chalmers University of Technology, Göteborg

Korberg A D, Brynolf S, Grahn M and Skov I R (2021). Techno-economic assessment of advanced fuels and propulsion systems in future fossil-free ships *Renew. Sustain. Energy Rev.* 142 110861

Lindberg, K., & Czarniawska, B. (2006). Knotting the net of action, or organizing between organizations. *Scandinavian journal of management*, *22*.

Malmgren, E., et al. (2023). "Navigating unchartered waters: Overcoming barriers to low-emission fuels in Swedish maritime cargo transport." *Energy Research & Social Science* 106: 103321.

Mandegari, M., Ebadian, M., Saddler, J., (2023). The need for effective life cycle assessment (LCA) to enhance the effectiveness of policies such as low carbon fuel standards (LCFS's). *Energy Policy* 181, 113723.

March, J. G. (1978). Bounded Rationality, Ambiguity, and the Engineering of Choice. *Bell Journal of Economics*, *9*(2), 587-608. https://doi.org/10.2307/3003600

March, J. G. (1991). How Decisions Happen in Organizations. *Human-computer interaction*, *6*(2), 95-117. https://doi.org/10.1207/s15327051hci0602_1

Mattsson, L.-G., & Junker, S.-O. (2023). Market shaping for a fossil-free economy: Institutional work to change market practices of public procurement. *Industrial Marketing Management*, *108*, 23-34. https://doi.org/https://doi.org/10.1016/j.indmarman.2022.10.015

MMMCZCS, (2021). *The 'Total Cost of Ownership' model is a first generation excel tool from the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping that allows the user to create simple, bespoke vessel comparisons.*. Mærsk Mc-Kinney Møller Center for Zero Carbon

Shipping, Retrived from: https://www.zerocarbonshipping.com/publications/calculate-total-cost-of-ownership-tco-for-decarbonization-of-vessels; 2025-08-25
MMMCZCS, (2023). *MMMCZCS LCA Methodology for Calculating the GHG Intensity of Marine fuels*. Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, Retrived from: https://www.zerocarbonshipping.com/publications/mmmczcs-lca-methodology-for-calculating-the-ghg-intensity-of-maritime-fuels; 2025-08-25
Nilsson-Lindén, H., Diedrich, A., & Baumann, H. (2021). Life Cycle Work: A Process Study of the Emergence and Performance of Life Cycle Practice. *Organization & Environment*, *34*(1), 99-122. https://doi.org/10.1177/1086026619893971
Pot, W. D., Dewulf, A., Biesbroek, G. R., Vlist, M. J. v. d., & Termeer, C. J. A. M. (2018). What makes long-term investment decisions forward looking: A framework applied to the case of Amsterdam's new sea lock. *Technological Forecasting and Social Change*, *132*, 174-190. https://doi.org/https://doi.org/10.1016/j.techfore.2018.01.031
Poulsen, R. T., & Johnson, H. (2016). The logic of business vs. the logic of energy management practice: understanding the choices and effects of energy consumption monitoring systems in shipping companies. *Journal of Cleaner Production*, *112*, 3785-3797. https://doi.org/https://doi.org/10.1016/j.jclepro.2015.08.032
Poulsen, R. T., Viktorelius, M., Varvne, H., Rasmussen, H. B., & von Knorring, H. (2022). Energy efficiency in ship operations-exploring voyage decisions and decision-makers. *Transportation Research Part D: Transport and Environment*, *102*, 103120.
Roux, M., Ekvall, T., Schmidt, J., Croxatto Vega, G., (2024). Which rules to follow? how differences in renewable fuel standards obscure the potential climate impact of transportation fuels. *Frontiers in Energy Research* Volume 12 - 2024.
Roux, M. (2025). Environmental Life Cycle Assessment of Alternative Maritime Fuels. Technical University of Denmark.
Rödger, J.-M., Kjær, L.L., Pagoropoulos, A., 2018. Life Cycle Costing: An Introduction, in: Hauschild, M.Z., Rosenbaum, R.K., Olsen, S.I. (Eds.), *Life Cycle Assessment: Theory and Practice*. Springer International Publishing, Cham, pp. 373-399.
Scheper-Hughes, Nancy (2000). Ire in Ireland. *Ethnography*, 1(1), 117–140. https://doi.org/10.1177/14661380022230660
Simon, H. A. (1959). Theories of Decision-Making in Economics and Behavioral Science. *American Economic Review*, *49*(3), 253. https://research.ebsco.com/linkprocessor/plink?id=0b700230-0888-36dc-bde7-8cde1008cc1f
Thollander, P., Rohdin, P., Moshfegh, B., Karlsson, M., Söderström, M., & Trygg, L. (2013). Energy in Swedish industry 2020–current status, policy instruments, and policy implications. *Journal of Cleaner Production*, *51*, 109-117.
Thomassen, G., Van Dael, M., Van Passel, S., You, F., (2019). How to assess the potential of emerging green technologies? Towards a prospective environmental and techno-economic assessment framework. *Green Chemistry* 21, 4868-4886.
Tonellato, M., Tasselli, S., Conaldi, G., Lerner, J., & Lomi, A. (2024). A Microstructural Approach to Self-Organizing: The Emergence of Attention Networks. *Organization Science*, *35*(2), 496-524. https://doi.org/10.1287/orsc.2023.1674
Trivyza, N. L., Rentizelas, A., Theotokatos, G., & Boulougouris, E. (2022). Decision support methods for sustainable ship energy systems: A state-of-the-art review.

Energy, *239*, 122288. https://doi.org/https://doi.org/10.1016/j.energy.2021.122288

Varvne, H. (2024). Anchoring current arrival practices in rhetoric: A study of just-in-time arrival of tanker ships. *Cleaner Logistics and Supply Chain*, 100197. https://doi.org/https://doi.org/10.1016/j.clscn.2024.100197

Vergragt, P. J., & Quist, J. (2011). Backcasting for sustainability: Introduction to the special issue. *Technological forecasting & social change*, *78*(5), 747-755. https://doi.org/10.1016/j.techfore.2011.03.010

Wang, H., Zhou, P., & Wang, Z. (2017). Reviews on current carbon emission reduction technologies and projects and their feasibilities on ships. *Journal of Marine Science and Application*, *16*(2), 129-136.

Wax, R. H. (1985). *Doing fieldwork : warnings and advice*. Chicago : University of Chicago Press.

Weick, K. E. (1995). *Sensemaking in organizations*. Thousand Oaks, Calif. Sage.

Wunderlich, J., Armstrong, K., Buchner, G.A., Styring, P., Schomäcker, R., (2021). Integration of techno-economic and life cycle assessment: Defining and applying integration types for chemical technology development. *Journal of Cleaner Production* 287, 125021.

Ölçer, A., & Ballini, F. (2015). The development of a decision making framework for evaluating the trade-off solutions of cleaner seaborne transportation. *Transportation research. Part D, Transport and environment*, *37*, 150-170. https://doi.org/10.1016/j.trd.2015.04.023