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Electric & hybrid vessels – a secret safety risk?

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ABSTRACT

Each year there are built more and more hybrid or electric vessels worldwide. These ships range from cruise ships accommodating thousands of passengers to offshore support vessels. These ships increasingly rely on lithium batteries for energy storage. This technology has proven itself to be useful and reliable, but as this is relatively new technology there is still a lack of track-record and performance history.

Maritime safety requires the competency from the crewmembers. There most of the crew do not always possess the right skills simply because they are not exposed to the training processes that are geared towards boosting their knowledge and technical skills. Most of the crew members cite a lack of skill and experience in the operational processes. In other words, they do not have the right skills and experience in undertaking the operational processes that are mostly concerned with the technical aspects. Research on Electric and Hybrid vessels entails several criteria on different variables such as competence of the crew, requirements for the crew, requirements for a hybrid or electric vessel and real safety needs of the ships. Various specialists have different views about each phenomenon under the theory chapters, and these theoretical arguments give information on critical requirements for safety and competence of personnel in the ordinary way of carrying out activities.

The thesis findings are based on several interviews, theoretical research and the analysis of requirements. The concept of competence occupies a key position in the informant’s perception, and lack of competence was a source of insecurity in regard to electric and hybrid vessels. Findings indicate is that the current requirements for vessel and crew competence fall short of matching the real safety needs on board.

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LIST OF ABBREVIATION

AB – Able Seaman

EMS – Energy management system

ETO – Electro Technical officer

ETR – Ship Electrician

FAFO – Norwegian Institute for Applied International Studies

FtF – Face to face

HSC – High Speed Craft

LFF – Low flashpoint fuel

LNG – Liquid natural gas

ILO –International Labor organization

IMO – International Maritime Organization

ISM – International Safety Management

MV – Motor Vessel

NIS – Norwegian International Ship Register

NOR – Norwegian Ordinary Ship Register

NMA – Norwegian Maritime Authority

NSD – Norwegian Centre for Research data

NOKUT - Norwegian Agency for Quality Assurance in Education

OS – Ordinary Seaman

OSV – Offshore Support Vessel

PV – Passenger vessel

PMS – Power management system

SOLAS – Safety of life at sea

STCW - Standards of Training, Certification, and Watchkeeping for Seafarers

DEFINITION OF TERMS:

Competence - a cluster of knowledge, skills, and capabilities to perform a diverse range of tasks, solve critical arising issues and perform analysis and ethical decision making on crucial aspects in the workplace. More specifically, competence refers to the collection of more demonstrable skills that enhances and improves the efficiency of the workforce or particular people in a given task. The term first appeared in the article by R.W White in the year 1959 to express a perception of performance motivation.

Intelligence – the ability to acquire and apply knowledge and skills, and the ability to deal with new situations.

Safety - this is the ability to be free from danger or risks as a result of certain events that occur in the everyday life. In the maritime industry or operations, safety is considered to embrace important factors that ensure efficiency and quality in the entire operational process. In most cases, competency is brought about by a competent workforce that has elaborate training from both the technical and normal operational processes.

Knowledge - a set of information or data relating to a subject or science. Also, knowledge may refer to the practical or theoretical understanding in a given subject. People acquire knowledge through education and experience. Developing competency is based on improving knowledge and experience required in performing different tasks. The development of knowledge requires continuous training on various technological innovations.

Real safety needs - A individuals needs for safety is a subjective matter. The real safety needs is the perceived requirements for security an individual has. Perceived or subjective safety refers to the individuals evaluation of comfort and perception of risk, without consideration of standards/requirements or safety empiricism.

Resilience - Resilience is a psychological concept of the ability to cope with stress and uncontrollable events. People with good resilience are able to handle crises and strains in a positive way. Southwick, Bonanno, Masten, Panter-Brick and Yehuda (2014) defines resilience as the ability to adapt well when subjected to trauma, difficulties, adversity, tragedy, threats or a significant source of stress

1. Introduction

Few industries are equally exposed to competition and changes in market conditions such as shipping. At the same time, there are few industries that offer equal opportunities for those who succeed. It is the ability to stay ahead of developments that have made Norwegian shipping and the rest of the maritime industry succeed over generations, and today it is larger than in a long time. According to the Norwegian Shipowners' Business Report for 2019, the total turnover in Norwegian shipping companies increased from NOK 206 billion in 2017 to NOK 229 billion in 2018, and the shipping company says that 2019 appears to be a year of further growth to NOK 240 billion. The need for innovation is greater than ever. New maritime solutions must be developed to meet a growing need for transport and energy recovery, efficiency- and environmental requirements. In April 2018, the International Maritime Organization (IMO) decided to cut shipping emissions by 40 per cent by 2030 and halve them by 2050, this compared with 2008. The above scenario must happen at the same time as the world’s transport needs and shipping fleet increases. The decision also requires each ship to use its energy more efficiently, and that total transport efficiency for the entire sector should be improved by at least 40 per cent by 2030 and 70 per cent by 2050. Additionally, the Norwegian Parliament decided in April 2018 that cruise ships and ferries will have to sail emission-free in Norwegian world heritage fjords within 2026 and all Norwegian fjords within 2030.

Through the development of larger and more efficient vessels, there has been a formidable increase in shipping efficiency over the last few decades. This development is likely to continue. High climate ambitions mean that shipping is challenged by demands for efficiency and low environmental footprint. At the same time, the requirements for environmental improvements are greater than ever, both by regulatory and market requirements. These challenges represent great opportunities for players capable of developing new solutions. While ships are moving into greener and often high-tech energy systems, it is a question whether the education and competency demands of seafarers are evolving accordingly.

While this technological transition brings opportunities, it also brings challenges. During the finishing phase of this study project the hybrid ferry MF Ytterøyningen caught fire due to a malfunctioning battery package, leading to an explosion on board in October 2019. This incident is highly relevant for the current thesis and will be included.

This thesis will assess the regulations, requirements and, demands imposed by the authorities concerning safe manning of Norwegian vessels, and inquire whether the qualifications of the crew are perceived as relevant, given the recent development of marine technology. The focus will be on emerging technology, mainly electric and hybrid propulsion, seen from the operational and safety perspective.

1.1 Presentation of the Research Question

As the marine fleet is changing at a fast pace, the qualifications of the crew and manning on board should adapt correspondingly. It is important that the requirements for qualified personnel and safe manning onboard are relevant and suited for the vessel's technology at any time. This study explores how the crew's competency requirements and experience contribute to the safe operation of electric and hybrid vessels concerning the coexistence and relation to the crew and the three variables; 1) the competence needed to work as an officer on board; 2) the governmental requirements for the vessel; 3)and the real safety needs experienced by the crew onboard. Based on this, the research question for this thesis is:

How do the requirements to the crew's competence and ship regulations – accommodate the experienced safety needs of an electric or hybrid vessel?

1.2 Research Approach

This study takes several variables into consideration, of importance being the subject matter and the proceeding operational requirements. The primary purpose revolves around the insights on the best information about the safety risks and new vessels comparison with electric and hybrid vessels. The resultant crew competence at work, as well as the requirements, is of equal importance. Research on electric and hybrid vessels entails several criteria on different variables such as competence of the crew, regulatory, formal and semi-formal requirements, as well as real the safety needs of the ship.

As further addressed in the theory chapter, different disciplinary knowledge as well as theoretical perspectives are engaged to forge critical requirements for safety and competence of personnel in their day-to-day activities.

According to Hollnagel (2009), safety and safety awareness are essential in determining the various causes of operational defects. Hollnagel's approach may arguably be used to illuminate risk, incidents and malfunction in the case of electric and hybrid vessels. Because of practical considerations, and the fact that the ships are in actual operations at the time of this study, the crew competence cannot be addressed by systematic observation. The main approach to data acquisition in this qualitative study is based on interviews.

2. Theory and background

2.1 Bourdieu's Socioeconomic Theory

The current study is of explorative and qualitative nature. The theoretical approach is grounded in sociological concepts and inspired by the conflict theory promoted by Pierre Bordieu.

According to Power (1999), Bourdieu's theory is a concept of action surrounded by the idea of the environment where people thrive. By the logic of his argument, social and economic agents develop elements that are adapted to the needs of the world around them. In the context of this study, the economic and social aspects of maritime operations demand adjustments of the industry and its constituents according to the technological and education changes. Therefore, if Norwegian Seafarers do not adjust their level of education, consciousness on safety, competence, and resilience, they may not survive in the new socioeconomic maritime environment that has adapted to the age of information and disruptive innovations.

Disruptive Innovation is a concept that explains the sudden change of operational model, creating a new operational methodology (Yu & Hang, 2010). In the context of the shipping industry, disruptive technology involves the use of electric-powered engines which are replacing fuel-powered engines to reduce emissions.

Dromundo (2007) agrees with Power (1999) in that integration into a new socioeconomic environment requires the subject to undergo gradual change through the concepts of field, cultural capital, and habitus. In the context of this study, the field is the maritime industry, while cultural capital may embrace competence, resilience, accountability, knowledge, professionalism, and safety consciousness. The habitus is the vessels such as the ferries and ships where the operations take place.

Bourdieu's theory is also more inclined to personal and individual economic power as opposed to the usual analysis of socioeconomic concepts through a group (or class) perspective.

Power (1999) indicates that Bourdieu believed that an individual's cultural capital is depending on the person's institutionalized, embodied and objectified assets plus their economic wealth and social class. Such aspects apply to the Norwegian seafarers because, besides the experience needed to work in the maritime industry, the new developments in the industry require a different level of knowledge and competence for the individual to have the befitting cultural capital.

2.2 Resilience

Resistance to difficulties is mostly associated with pushing through misfortune and overcoming challenging situations without necessarily surrendering. However, Southwick, Bonanno, Masten, Panter-Brick and Yehuda (2014) defines resilience as the ability to adapt well when subjected to trauma, difficulties, adversity, tragedy, threats or a significant source of stress. Hatler and Sturgeon (2013) had a study with employees from a memorial hospital to determine the role of resilience in developing the theories of competence and professionalism. Results indicated that while some people thrive when subjected to changes and hard economic times, others do not possess the physical and mental capacity to adjust and accommodate the changes adequately. For instance, when maritime fleet changes on a fast pace, the resilient crew members may view the development as an opportunity for advancing their academic qualification while others may perceive the same conditions as a chance for turnover and layoffs from the job.

Hatler and Sturgeon (2013) suggest that psychological resilience is an aspect of competence and leadership, and it is necessary to counteract burnout, improve overall well-being and reduce stress. Therefore, although the changes in the Norwegian maritime industry may seem unwarranted and unfavorable among the seafarers, the alterations will arguably introduce mental toughness, resilience and improve competence in the job.

The fundamental question, then, is how competency relates to Bourdieu’s theory of socioeconomic theory. The changes imparted by the Norwegian maritime authorities represent shifts in the habitat of Norwegian seafarers, while resilience may be tied to the cultural capital needed to enhance the working environment in ships and fleets (Power, 1999). Therefore, it can be argued that while the current conditions of Norwegian seafarers are not entirely vulnerable, there is a need to improve regarding resilience for the sake of the current and future economic and technological changes. The change factor in Bourdieu’s theory is critical to foster resilience. Marthers (2017) validated the position of Hatler & Sturgeon

(2013), and Power (1999) in that changes and new methods of conducting business are necessary catalysts for developing a psychological element of resilience among employees in any field. For example, while new technology improves resilience among Norwegian seafarers, Marthers (2017) contends that campuses have designed intentional initiatives that shift the attitudes and behavior of students that promote success even amid adversity. By the logic of Bourdieu's theory, the social factors of education, knowledge improvement and resilience affected the economic aspects of job retention and the possibility of career progression as a result of adjusting to changes. As the ships move to greener and high-tech energy systems, the resilience of Norwegian seafarers will determine their career progression and socioeconomic power henceforth. In other words, the management through senior officers needs to ensure that everything is operational to avoid accidents that result from negligence. Closely related to resilience is the level of competence of the employees, as discussed below.

2.3 Competence

One of the most critical factors to clarify is whether the Norwegian seafarers are competent or not. Competence can be defined as a cluster of knowledge, skills, and capabilities to perform a diverse range of tasks, solve critical arising issues and perform analysis and ethical decision making on crucial aspects in the workplace. Mani (2013 page 69) defines competence as "a unique set of technical as well as behavioral skills and abilities which are required for achieving the desired level of performance". The study submits that under Bourdieu's theory of socioeconomic change, the workers cannot be termed as incompetent but rather have the necessary skills that require revision due to changes in the industry. The realization that the current dispensation of workers and working conditions do not complement the changes in the industry is as a result of competency mapping. According to Sanghi (2016), competency mapping refers to a process of determining essential capabilities for an institution, an industry, or a job and incorporating those competencies throughout the various methods such as training, recruitment, and job evaluation. Therefore, as the habitat of seafarers is changing, the crew are bound to adjust and shift their level of competency to collaborate the industry requirements. In the context of the Norwegian seafarers, the proposed qualitative study will undertake individual interviews with the primary aim of evaluating the experienced safety needs of officers working with new technology and innovative vessels.

The Norwegian seafarers can raise their levels of competence by learning about the new technology from an operational and safety perspective. For example, if electric and hybrid propulsion is a vital technique for the current maritime operations, then according to Power (1999), Bourdieu's theory demands an improvement of cultural capital and economic power to cater for changes in the socioeconomic habitat.

Hansen (2016) contends that achieving competency requires the professional modelling of the discipline according to the specifics of the particular industry. In his analysis, Hansen (2016) determined that firefighter companies undertake a regular evaluation to identify the competency gaps in the workforce, and implement an open learner model that improves decision-making, and quick response to emergencies within the bounds of safety.

Evaluating competence is a way of measuring the skills and capabilities of employees in a work station. Competence can be assessed by developing assessment methodologies such as work observation, structured interviews, and simulation exercises. These assessment methodologies aids in measuring the capabilities of different individuals in the diverse range of assigned tasks. Operating the new electric and hybrid propulsion requires the evaluation of the level of competency and then implementing a strategy of learning for the current and subsequently new employees to follow.

2.4 Safety

One of the prominent definition of safety is termed as a state whereby individuals has the freedom to be safe from activities or occurrences that poses as an imminent danger, risks or threats of harm and loss of human resources and belongings either due to accident or deliberate situations (Hollnagel, 2013). Maurice et al. (2001) define safety as a state in which hazards and conditions leading to physical, psychological or property harm are controlled to promote the wellbeing and health of individuals and the community at large. According to Hollnagel (2013), the main point of concern when it comes to safety is either under the incidences, real or possible and diverse adverse outcomes due to exposure to risks, hazards and dangers or accidents. Safety can, therefore, be understood as explained in the following statements;

1. *When something goes wrong, then there is no safety.*
2. *Safety happens when nothing goes wrong, and everything happens the way it should.*

3. *The methodical research of safety ought to put their centre of attention on circumstances whereby nothing goes wrong.*

Hollnagel (2013) in *a description of two safeties*, established that when systems and employee's competence is high, the management tends to trade their diligence for efficiency. Consequently, the proficiency of some workers may vary, the capability of employees may differ, and procedures used for dependable operating maybe limited. The author regards humans under these circumstances as a valuable asset instead of a liability and the way they adjust to these circumstances depends mainly on their strength somewhat instead of threats.

2.5 Current empirical literature relevant to research questions

In Hollnagel's (2013) *the tale of the two safeties*, he establishes that factors such as safe and efficient functioning of multiple systems influence the existence of modern societies. The above case is because these factors are often much related and when it comes to safety; safety cannot be successfully controlled by focusing only on activities that go wrong and coming up with solutions only when something goes wrong. It further stipulates that for the management to prevent the occurrence of these situations, the safety management team must focus on future activities to avoid activities going under the wrong directions but also to ensure that these activities go in the right perspective. Practical safety administration ought to put their center of attention on how daily activities normally happens the right way instead of focusing on how and why these activities intermittently go wrong, and the safety management must come up with initiatives try to improve the performances that go wrong instead of preventing the latter.

In today's environment, competence among different sets of variables and their safety preparations requires unique methodologies to counter the consequences for certain decisions made (Sarkar, 2013). Competence among crew members is identified according to academic knowledge based on education to different levels and career that establish the level of experience. For one to be competent in the ordinary way of life, he or she must have clear information and skills about what they are doing to minimize costs and work efficiently.

Modern safety techniques involve taking individual initiatives among electric and hybrid vessels management. Such practices include taking insurance of the assets, safety drills, and frequent maintenance. Safe manning regulations require ship-owners to ensure that the crew is capable of carrying out the tasks and responsibilities required for the safe operation of the vessel. The ZZZs In Zeebruge case is a report on when the passenger vessel Herald of Free Enterprise capsized on its first voyage and 188 people lost there lives. The maritime accident that occurred was partly a result of negligence from the crew. Also, the blame was partly on the manufacturers who failed to install the necessary safety indicators that could guide the captain and other members of the team. Specifically, the accident was attributed to the assistant Boatswain Mark Stanley who failed to close the bow doors as the ship was leaving the port. Besides, the accident is attributed to Captain David Lewry, who left the port without ensuring that the bow doors were closed. In most cases, it is the responsibility of the crew undertaking different roles to ensure that everything is in order before the ship leaves the port. Failure to close the boor lead to the entry of ocean water into different decks causing the ship to capsize. In other words, the accident was not caused by the system failure but by the negligence on the side of the crew. However, the accident can also be blamed on the side of management as the crew lacked enough capacity to monitor and control all the systems due to lack of indicators.

The third concept of consideration under the safety theory in the maritime industry is safety awareness. According to Hollnagel (2015), safety has often been mistaken as the absence of danger and accidents, which equally disenfranchises industries as they attempt to foster safe work environments. The current habitat on fleets and ships consists of high-powered machinery whose efficiency also means a high probability of danger. Therefore, Hollnagel (2015) asserts that the recognition of risk and the reasons why accidents can occur is the first step of raising safety awareness among employees, a concept known as safety-I. The knowledge about technology, green energy, and hybrid propulsion are issues that need to be addressed incompetency of the crew and represent the factors of study in safety-I training. Sarkar (2013) insists that competency-based training is the most advantageous way or building resilience and cultural capital among employees. Therefore, when the training of maritime employees considers safety-I as a priority, the levels of awareness increase and they can succeed in the new environment.

Safety-II involves understanding how a system responds to varying conditions. For a leader, safety is not the absence of danger, but it is the presence of personnel’s adaptive capacity (Hollnagel, 2015). According to Hollnagels theory of the tale of two safeties the competence of individuals depend on their ability to adjust on different changes on their workplace and the ability to recognize and devise the flaws and practical differences to help them in fixing and identifying their demands to improve their competences in the workplace.

With the Safety-II approach, it not only about avoiding errors but also to manage the consequence of those errors ensuring the systems continue performing. Therefore, it can be argued that while Safety-I seeks to understand the mistakes with an operation, safety-II is more inclined to elaborating the correctness of processes as the basis for recognizing when errors occur. For instance, if a maritime employee can focus on being competent on understanding the process of hybrid propulsion, then the employee has a higher level of safety awareness than the one who only knows the possible dangers of operating the machinery. By the logic of Bourdieu's theory, the current habitat requires the employee's cultural capital to include knowledge of both safe and unsafe operations and processes (Power, 1999).

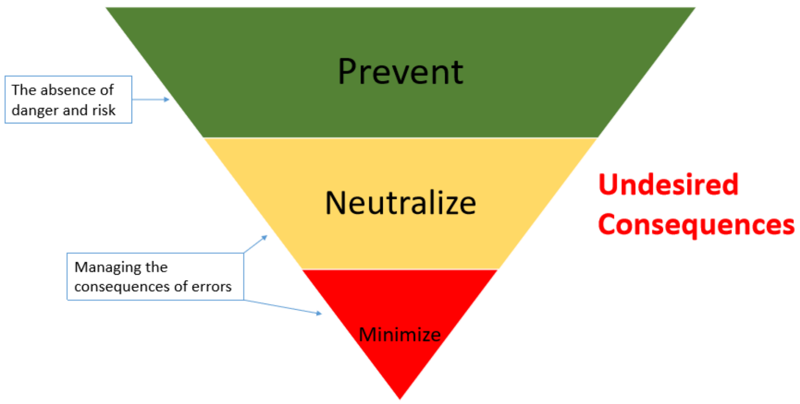

Figure 1: Hollnagels Theory Model (author's contribution)

The logical connections among critical elements of theories or phenomena of interest lie in Hollnagels *Third age of human factors* (2012). The above scenario individually and specifically narrates the human factors and effects on different phenomena, for instance, the Third age of social factors establishes that human factors are widely accepted as essential parts of industries in practically every domain. Human has developed in different ages, each with different consequences namely first, second, and third ages of which human intelligence and way of thinking or rather innovation takes place.

3. Competence and technical ship requirements

There are a number of laws and regulations, both national and international, that together set requirements for the competence crew and technical requirements of vessels. The Norwegian Maritime Directorate (NMA) shall supervise the construction and operation of vessels with Norwegian flag and their shipping companies, as well as supervise foreign vessels in Norwegian ports.

3.1 The Norwegian Ship Safety Act

The Norwegian Ship Safety Act (2007) applies to all Norwegian ships wherever they are located, except vessels less than 24 meters in length and used outside commercial activities. Through Section 9 (Technical safety), the Ministry of Trade and Fisheries may issue regulations on how ships should be designed, built and equipped to meet the requirements of the first paragraph, including:

(a) hull strength and waterproof integrity;
(b) stability and flowability;
c) machinery and electrical installations;
(d) fire protection;
e) navigation equipment,
f) communications equipment;
(g) life-saving appliances

The Norwegian Maritime Directorate (NMA) is thus an administrative body subject to the Ministry of Trade and Fisheries and the Ministry of Climate and Environment. It is also the administrative and supervisory authority for the work on safety of life, health, environment and material values on vessels with Norwegian flag and foreign vessels in Norwegian waters. NMA is also responsible for ensuring legal protection for Norwegian registered ships and their rights. Its' activities are determined by national and international regulations, agreements and political decisions (NMA website).

3.2 Requirements when building a electric or hybrid ship

When building Norwegian flagged vessels the standard is mainly based on the *Regulations on shipbuilding*, this regulation refers to §3, §4 or §5 (depending on the vessel in question) to either Safety of Life at Sea resolution (SOLAS), recognized the classification society's requirements or "Nordic Boat Standard 1990". Also other regulations affect to various degrees, the *Regulations for maritime electrical installations* is worth mentioning, especially for hybrid and electric ships. However, none of the current regulations, SOLAS nor "Nordic Boat Standard 1990" include battery systems as a power source, but the NMA has issued a guide on chemical storage for energy (RSV 12 - 2016). In this connection, this usually results in the use of battery installation rules from a recognized classification society in combination with the guide on chemical storage for energy (Juell 2019). It is then a condition that the recognized classification society's battery system rules are accepted by the NMA. Alternatively, one would have to follow the work process described in MSC.1 / Circ.1455 "Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various IMO Instruments". It is important to understand that the recognized classification society's rules will only apply through reference in regulations. To sum up, the rules and regulations for building Norwegian vessels are illustrated in Figure 2.

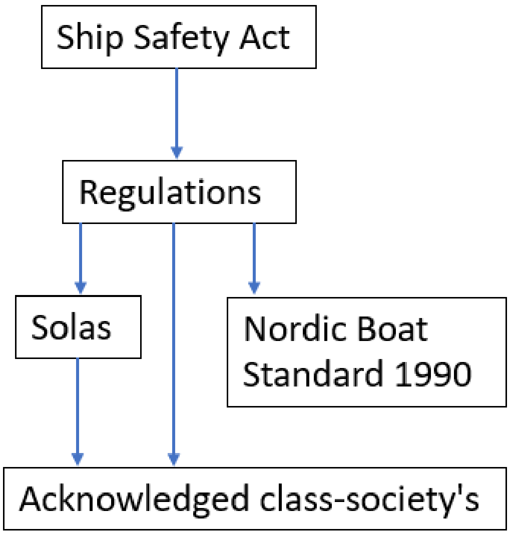

Figure 2: Rules and regulations for building Norwegian vessels (author's contribution)

3.3 Supervision and inspections of Norwegian Vessels

The NMA is a delegated supervisory authority under the *Ship Safety Act, Ship Work Act, the Product Control Act and the Leisure and the Small Craft Act.* Their audit involves certification, document control, inspection and auditing to ensure compliance with the regulations, which helps to create good attitudes to health, the environment and safety (NMA webpage: audits). The audit process depends on what flag-register the Norwegian vessel is registered, a Norwegian vessel is either flagged in the Norwegian Ordinary Ship Register (NOR) or in the Norwegian International Ship Register (NIS).

Depending on the chosen flag (NOR / NIS) and any voluntary delegation regarding the NOR flag, the supervision and follow-up will be different in terms of who does what. For NOR flags, vessel certificates will be issued and audits performed by the Norwegian Maritime Directorate, while at NIS flags or some voluntarily delegated NOR flags, this will be delegated to a recognized classification society which will then perform tasks on behalf of the Maritime Directorate (NMA website). These will then be tasks in addition to their own tasks as a classification society. The supervision of Norwegian vessels, related to the ship registers, is illustrated in figure 3.

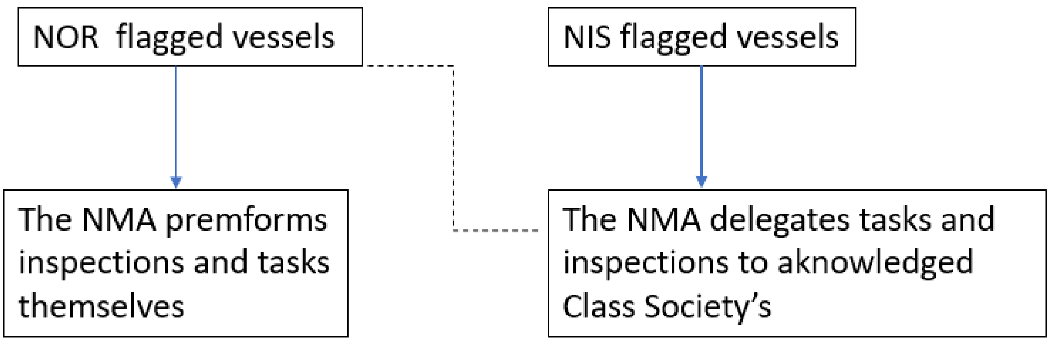

Figure 3: Supervision of Norwegian vessels (author's contribution)

A recognized classification society's rules can therefore not be equated with regulatory requirements. Regulatory requirements are verified in Norwegian law, while the recognized classification society's rules may be regarded as a building standard. There are several different recognized classification society rules with some common features, but still there are distinctive regulatory requirements. The difference between a classed vessel and unclassified vessel will be the shipowner's duties - the responsibility remains with the shipowner, but for a classed vessel the shipowner will thus be able to avoid having to carry out the follow-up recognized classification company on his behalf (Maritime Connector 2019). In many cases the charterer may demand that a vessel is using a class society.

3.4 Education of seafarers

Competence is the ability to fulfil some task or function**.** Education plays a vital role in developing the skills and ability to conduct maritime operations**.** Education training provides the ability to put into practice the theories and mental concepts that have been acquired, while competence joins and coordinates the knowledge, attitudes, and skills. It is the International Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) and national regulations that regulate the requirements for the seafarers. In Norway, the "*Regulations on qualifications and certificates for seafarers*" regulate the requirements for the ship's officer training. For deck officers, the STCW regulations section II/1-2, sections A-II/1-2, as well as the associated tables A-II/1-2, apply. For the ship engineers it is similar, but with section, III/1-2 instead of II. Besides, education is subject to the requirements of the Norwegian Agency for Quality Assurance in Education (NOKUT). The above case does not regulate the content of the education, but more framework and level. The level shall be by the National Qualifications Framework. All maritime universities / colleges and vocational schools must adhere to the contents of the STCW tables in relation to education. In the approval processes that are settled with NOKUT the NMA is included in the process.

In Regulation on qualifications and certificates for seafarers (2011) §14 states that educational institutions and training institutions must have a quality system approved by the Norwegian Maritime Directorate and be certified according to a recognized standard. NMA also approves and certifies the educational institutions periodically and has a follow-up reviewed every 5 years. This is based on requirements in the STCW 1978 Convention, Rule I / 8 on quality standards and Rule I / 6 on competence, and in the Qualifications Regulations.

The NMA also participates in groups in the International Maritime Organization (IMO), and participates in various groups and influences and contributes to develop the STCW convention (NMA webpage).

3.5 IMO & STCW requirements

International regulations form the basis for Norwegian regulations. "*Regulations on qualifications and certificates for seafarers*" could be compared to be the Norwegian translation of the International Standards of Training, Certification, and Watchkeeping for Seafarers (STCW), but it lacks some important definitions and correct translations. Among other things, the definition of qualification and level of competence for the different levels on board (Management level, Operational level, and Support level), which is crucial for staffing with the right competence is lacking.

The STCW is an IMO convention that offers training and exposure to valuable skills for making the mariner more skilled and flexible aboard the ship. It’s role is to ensure ship-owners, seafarers, training centers, and national maritime administrations follow the standards required to keep the shipping industry safe and protect the oceans from pollution. It also requires that the training and assessment of seafarers before the issuance of a certificate is administered, supervised and monitored by the provisions of the STCW Code. Also, the convention requires that trainers and competence assessors are appropriately qualified by the provisions of the Code. The training is a requirement of IMO to standardize the basic skills required to safely crew aboard a large vessel outside of the areas where domestic rules apply.

STCW defines crew on board into three categories in Chapter I, Section A-I / 1: Management, operational and support level. *Management level* means the level of responsibility associated with serving as a master, chief officer, chief engineer or first engineer on board a seagoing ship and ensuring that all functions within the specified area of responsibility are properly performed. *Operational level* means the level of responsibility associated with serving as an on-duty officer on duty on the bridge or as an on-duty officer on duty in a engine room or as a radio operator on board a seagoing ship, and having direct control over the care of all functions within the designated area of responsibility in accordance with proper procedures and under the direction of a person serving at the management level for the same area of responsibility. *Support level* means the level of responsibility associated with performing assigned tasks and duties or safeguarding responsibilities on board a seagoing ship under the direction of a person serving at the operational or management level.

3.6 Qualification requirements for crew

The International Safety Management Code (ISM-code) is a regulation adopted by IMO with general rules for the safe operation of ships. All vessels of a certain size must comply with the ISM Code by having a valid safety management certificate. The ISM-code chapter 9 sets requirements for personnel and resources. These requirements are ratified into Norwegian legislation through the *Regulations on safety management on Norwegian ships* and applies to all Norwegian vessels in commercial operation. *Paragraph 6 Resources and personnel* states the following:

6.1 The company shall ensure that the master is:
- duly qualified to have the command,
- fully familiar with the company's security management system, and
- provided the necessary support so that their tasks can be performed in a proper manner.
6.2 The company shall ensure that each ship is: staffed by qualified, certified and medically fit seafarers, in accordance with national and international requirements, and appropriately staffed so that all aspects of safe operation on board are taken care of.
6.3 The company shall introduce procedures to ensure that new personnel and personnel transferred to new tasks in the field of safety and environmental protection are made aware of their tasks in a satisfactory manner. Instructions that must be given before departure must be identified, documented and given..

3.7 Positions on board that require a certificate of competence

The function as watchkeeping navigator, marine engineer and ship electrician require a certificate of competence, given that they have that position on board in the safe manning. The requirements are stated in the Regulations for qualifications and certificates for seafarers:

§ 3. Positions that require a certificate of competence
(1) The master, chief officer and officer in charge of the deck shall have a relevant certificate of competence for the deck officer at
a) passenger ships of any size and speed,
b) cargo vessels with a maximum length of 15 meters or more, irrespective of the area of speed,
c) fishing vessels with a maximum length of 10,67 meters or more,
d) barge.
(2) The chief engineer, first engineer and marine engineer in charge in the machine must have a certificate of competence for engine officers on ships with propulsion power of 750 kW or more.

(3) An electrician officer shall have a certificate of competence for an electrician officer on ships with propulsion power of 750 kW or more.

The requirements for a ship electrician will be discussed later in this chapter, however its important to point out that there are no specific requirements for when a ship electrician is necessary on board. However, if a ship electrician is part of the safe manning on board and the vessel has a propulsion power of over 750 Kw, the ship electrician needs a competence certificate as a ship electro technical officer (ETO).

3.8 Safe manning

All Norwegian passenger vessels of any size, Norwegian cargo vessels with a gross tonnage of 50 or more and Norwegian fishing vessels of length (L) 24 meters or more, unless otherwise stated in the individual provisions, are required to have a safe manning certificate. The safety manning is determined in accordance with the Regulation on the crewing of Norwegian ships. This is based on IMO resolution A.1047. In addition to these regulations, there are also the *Watchkeeping Regulations, Work and Rest Time Regulations, the Qualifications Regulations* and the *Ship Safety Act* in use during the determination of security staffing. This is assessed every time a vessel applies for a crew certificate. In accordance to *Regulations on crewing of Norwegian ships*, when minor changes are made such as change of name or home port, small correction of gross tonnage so that the tonnage corresponds to the measurement letter and minor changes in qualification requirements, it will not require a complete application. However, all other changes to a vessel will require a complete application. The ship owner is obliged to apply for a manning certificate in the case of a rebuild, flagship and newbuilding.

It is important to distinguish between security staffing, or minimum safe manning, and necessary operations/ operations staffing. The NMA determines so-called security staffing on application by the ship operator. This is done by *Regulations on crewing of Norwegian ships*, which in turn is based on IMO resolution A.1047 (27) “principles of safe manning” and ILO Convention 188 on working conditions in the fisheries sector (ILO 188) Articles 13 and 14. The proposed safe manning shall cover all relevant operations, tasks, and functions for the safe operation of the ship. In the application, the company must prove that the crew proposed as security staff can fulfil these tasks. The safe manning is the smallest allowable crew a vessel can have during operation. The Directorate's decision on safe manning does not function as a decision on what is correct staffing in all situations. The actual workload on the vessel can vary greatly depending on the type of vessel, market segment, route, traffic congestion, etc.

Furthermore, the shipping company has full freedom to impose on the crew tasks that go beyond the tasks of the minimum safe manning. These tasks should not go beyond or at the expense of the security-related tasks. Examples of such tasks may be restaurant operation, ticketing, not safety-critical maintenance. In all relevant operations, tasks, functions, areas of operation, and levels of safety, in collaboration with the ship management, a risk analysis shall ensure that qualified seafarers operate the ship. The above case is in line with national and international requirements so that each ship is suitable manned and all aspects of safe operation on board are taken care of, to safeguard the safety of the ship and those on board, as well as prevent pollution of the marine environment. The shipping company, therefore, has to continuously assess the need for operating the vessel. This duty arises from the crewing regulations and safety management regulations, and the company must ensure that the operation of the vessel is carried out within limits provided by the regulations.

The *Regulation on crewing of Norwegian ships* (crewing regulations) mentions the need for additional manning in paragraph 12 and states that to ensure proper manning, the company and the master shall perform their duties under the Ship Safety Act and the provisions of the regulations here, including assessing whether additional manning is necessary. Additional staffing is the additional staffing company in collaboration with the master finds it necessary to have onboard to be able to carry out operations that cannot be taken care of by the security crew alone without reducing the safety level of the ship and those on board.

3.9 Qualification requirements when using Low-flashpoint Fuels

In January 2017, the International Code of Safety for Ships using Gases or other Low flashpoint Fuels (IGF Code) entered into force for ships using low-flash fuel. In Norway, it became statutory through "*Regulations on qualifications and certificates for seafarers*". From July 1, 2018, anyone who has duties and responsibilities related to fuel handling and use, or who is in charge of such operations on board this type of ship, must have a low-flashpoint fuel proficiency certificate (NMA article 2017).

This certificate requirement was introduced in the wake of the International Code of Safety for Ships using Gases or other Low Flashpoint Fuels crew on ships with flash point below 60 degrees centigrade (LFF ship). In general, this means that everyone serving onboard gas-powered vessels, or vessels using fuel with a flashpoint below 60 degrees Celsius, must have an IGF course and certificate. An officer needs IGF basics to fulfil certain duties and responsibilities related to the handling and use of fuel onboard ships using fuel with a flashpoint below 60 ° C; or who in an emergency situation must perform duties relating to such fuel. Further on, the officer needs IGF advanced if you are a master, engine officer or other personnel who is directly responsible for the handling and use of fuel and fuel systems on ships that use fuel with a flashpoint below 60 ° C. The certificate requirement is also applicable to vessels with LFF built before 1.1.2017. This means that crews on ships built before 1.1.2017 must also solve the skill certificate for LFF.

3.10 Requirements for electrical competence

In Norwegian legislation, and not in the STCW-code for that matter, there is no direct requirements for having a ship electrician on board. More specific, the regulation on crewing of Norwegian ships 2009 does not have direct requirements for having a ship electrician on board vessels. According to crewing regulations and *Regulations on the Safety Management System for Norwegian ships and floating facilities*, and the ISM code 6.2., it's the shipping company's responsibility to consider which competence and crew is necessary in addition to the chief engineer. With ships without electricians, the marine engineers is the electrical expertise on board. Marine engineers shall in accordance to STCW A-III/1 and A-III/2 operate electrical and electronic systems and control systems and to a certain degree do maintenance and repair of electrical and electronic equipment.

Ship electricians is categorized into two groups: Ship electrician (ETR) and ship electro technical officer (ETO). Minimum standards for competence for ETR and ETO are specified in the *regulations for competence and qualifications*. The main difference is that the ETO can operate at an operational level, while the ETR is at the support level. The ETR is then equated to a motor man or an able seaman and the ETO is equated with a marine engineer.

On September 30.09.2019 the NMA issued a Guidance for ETR and ETO in certificate of manning. The following it stated:

- ETO can serve on board or in addition to engine officers at the operational level if the company considers this to be appropriate based on the monitoring, operation and maintenance tasks to be performed on board.
- In conventional machinery, ETO cannot replace a watch-keeping machine officer, ref. Regulations on guarding on passenger and cargo ships of 27.04.1999 no. 537, but can take part in the machine watch.
- For vessels in which all or part of the propulsion is electric, the NMA will, on application, consider an exemption from the current requirements to allow ETO to act as on-duty engine officer.
- The ETR may be taken on board as a replacement for or in addition to support staff at the support level if the shipping company considers this appropriate on the basis of the monitoring, operation and maintenance tasks to be performed on board.
- According to The Ship Safety Act of 16.02.2007 No. 9 §16 (the Ship Safety Act), the person having his work on board shall have the qualifications and any certificates required for the position or work to be performed.

ETO can thus, as the education is today, not replace engine officers whatever level the machine officer has. A marine electrician education has a basis of electro competence from high school level, followed by an apprentice and learning period. However, marine engineer at the chief and first engineer level have enough competence to lead the work of an ETO, but not the competence to perform it. The ETR can thus be replaced by the requirements of STCW - Table A-III / 7 by machine officers at management level, in other word marine engineers with certificate of competence as chief or first engineer (according to STCW Table A-III / 2).

Especially interesting is point number 3 in the guidance above, where the NMA will consider allowing the ETO to function as the duty-officer on fully electric vessels. This has not been possible before. However, according NMA (Phone call in November 2019) there has per date been no applicants for having an ETO as a duty-officer.

3.11 Thermal runaway and fire with batteries

One of the biggest risks for high energy batteries is not just a conventional fire but also thermal management and thermal runaway. A thermal runaway is an often uncontrollable process where an increase in temperature causes a further increase in temperature, that may again lead to destructive outcome. In other words, a thermal runaway can be described as a process which is accelerated by an increase in temperature, that in turn releases energy that further increases the temperature, as illustrated in figure 4 below. The thermal runaway follows a mechanism of chain reactions, during which the decomposition reaction of the battery component materials occurs one after another. A review of typical accidents show that a thermal runaway is often a result for some sort of abuse. The conditions may be mechanical, electrical or thermal abuse (Xuning, Minggao, Xiang, Languang, Yong, Xiangming 2018). In situations of abuse, heat may be generated within the lithium cells, which may in turn increase to a point whereby it melts the separators inside the cells. This creates a reaction between the cathode and electrolytes, which again results in to that the temperature increases further, until the battery produces combustible and lethal gasses and may ignite. If the gases ignite, this can start an aggressive fire which again can be extremely challenging to extinguish. If the gases are in large enough concentrations in an area, a powerful explosion can occur (Jindal, Bhattacharya 2019).

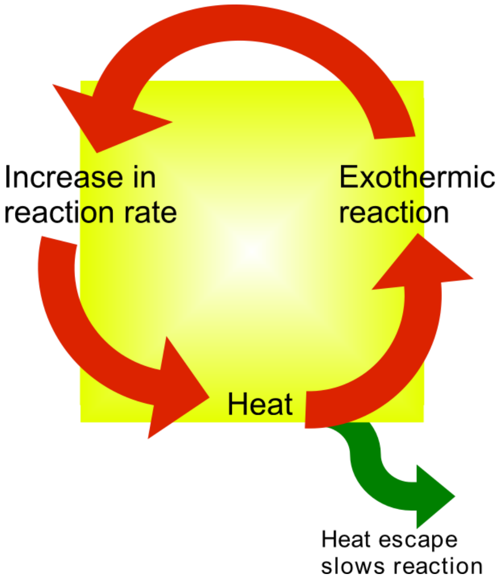

Figure 4: Thermal Runaway (Source: Wikipedia)

3.12 Testing and certification of batteries

Because battery and storage of electrical energy are not regulated directly in Norwegian legislation, NMA published the circular “Guidelines for chemical energy storage – maritime battery systems” in July 2016. These guidelines applies for all Norwegian vessels with an installed battery systems based on Li-ion or similar technology. However, rules on battery systems from a recognized classification society, for example DNV, may be used in combination to the guidelines. These class-society rules must be acknowledged by the NMA.

The battery system itself has to be certified by a recognized classification society. The minimum requirement for Norwegian vessels batteries is the Propagation Test Type 1. In order to receive a certification, this test must be conducted three times. The intention of the test is to prove resistance of propagation of the thermal runaway process from one battery test to another. Simply explained, if a thermal runaway and ignition happens in one battery cell, the fire may consume that cell, but will not spread to nearby battery cells in the same module. The battery system as a whole therefore remains secure. Further on, the ship owner has to describe the design and position of the batteries, solutions for explosions and ventilation, and fire-extinguishing based on the specific battery. Also, a gas analysis that identify the maximum gas generation and the gas composition for one cell should be carried out.

The Norwegian certification scheme has recently been criticized from experts in the field of maritime batteries, especially from Perry and Brown (2019) in their article “Safety Concerns for hybrid & electric Ships” published in gCaptain october 23, 2019. Both authors work for Sterling PBES Energy Solutions, specializing in marine battery and hybrid installations. In the article they identified some potential problems with the Propagation test 1:

Isolating a thermal event to one cell makes sense but reliance on this standard on its own creates potential problems:

- *The gasses that escape from even one cell are very flammable and are dangerous in an enclosed space. Proof of management of dangerous gases is required.*

- *What occurs when more than one cell is involved right from the beginning of the event?*

- *What happens when a module full of cells fail or even an entire system*

- *How can software help to predict and prevent a physical incident?*

Testing to validate the design of batteries needs to expand to incorporate the risks we identify above. (Perry & Brown, 2019, p. 4)

3.13 Concluding the theoretical framework

As illustrated in the conceptual framework (figure 5), this study aims to exploit three variables; 1) the competence needed to work as a ship officer on a electric / hybrid vessel; 2) the governmental requirements for the vessel; which will be compared with 3) the real safety needs experienced on board.

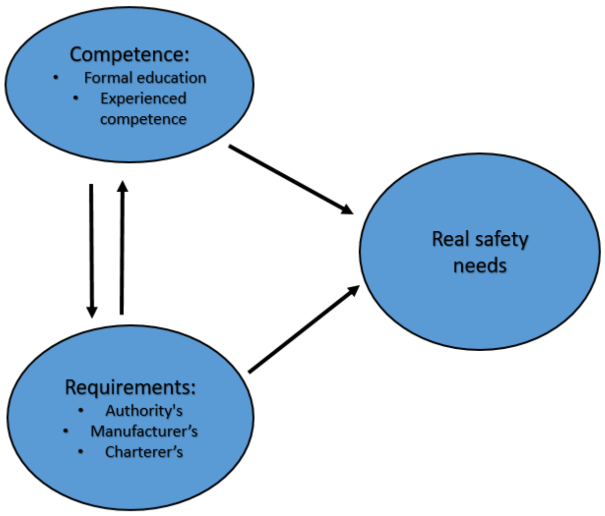

Figure 5. The conceptual framework for the study (Authors contribution)

There is a co-dependency of the factors that generate the performance of Norwegian seafarers and other employees in an organization. Although the research discusses resilience, competence, and safety separately, the three concepts must be applied together for the full realization of the intended level of professionalism. Sarkar (2013) adds that knowledge, aptitude, skill, ability, and attitude determine the competence of an employee. Further, the level of talent defines how the individual behaves within and outside the work environment. For instance, when the employees in a fleet have the technological and technical competence to operate hybrid propulsion machinery, they have high resilience, and they behave differently from those who can only manage the fossil fuel machinery. The level of competency is arguably the most critical determinant of the performance and survival of an individual in a habitat. The socioeconomic theory by Bourdieu does not discriminate or map competency while considering all the necessary variables, in this case, safety, resilience, and technological knowledge. Both Power (1999) and Sarkar (2013) agree with Hollnagel (2015) on the need to prioritize the safety of the various elements in organizations. If the Norwegian ship owners do not retrain their employees by the new technological environment, then they are culpable for any dangers on the employees.

In conclusion, Bourdieu’s socio-economic theory is fundamental to the understanding of the seafarer's role and competence in developing a wholesome working habitat for Norwegian seafarers. According to Hollnagel, safety is not absence of something; it is the presence of people's adaptive capacity.

4. The explosion on board MV Ytterøyningen

As the explosion on board MV Ytterøyningen is highly relevant to the thesis topic and several of the subjects interviewed could relate to the incident it will be described in this chapter. All information is retrieved from various newspapers listed in the references.

4.1 Chain of events

Around 1840 on October 10, 2019, the ferry MV Ytterøyningen reported a fire in a battery rom below the main deck. MV Ytterøyningen, was recently refitted with a lithium-battery hybrid drive. The batteries onboard was the Orca ESS with water cooling. They were type-approved by DNV GL earlier this year. The battery packs on board MV Ytterøyningen were disconnected when the fire started. The fire was presumably extinguished, and the local fire department reported at one time that the fire was under control. However, firefighters were unable to enter the battery room because of high temperature and harmful gases. The temperature outside the battery room was at one point measured to 60 degrees Celsius. The next morning, October 11, an explosion rocked the ferry while dockside in Sydnes, Norway. The explosion, which occurred in the battery compartment, came from a build-up of explosive and flammable gasses below deck and caused significant damage to the vessel structure. Thankfully the ferry was evacuated when the explosion occurred, and only crew and personnel from the fire department was on board. Fifteen persons was admitted to the hospital after the fire, but none were badly injured.

The reason for the fire is yet to be announced. In operation that night the MV Ytterøyningen had its diesel engines running and had disconnected the battery pack. Without the battery pack connected, the bridge might have missed important error messages, according to the battery manufacturer Corvus. Even though the fire seemed to be under control, the battery was most likely in a thermal runaway, which explains the production of flammable gases.

After the fire and explosion MV Ytterøyningen was towed to Westcon Yard, it took a few days before technicians were able to enter the battery room to start investigating and then dismantling. The reason for the delay was that the owner Norled had to make the necessary risk assessments, including being sure that the temperature and heat in the fire-ravaged was no longer a risk, and that hazardous substances and gases from the fire had been evacuated.

The battery pack that was then disassembled and they burned parts were taken of the vessel. The battery type that was installed in the MF Ytterøyningen is unlike the battery types that Norled has on other ferries. Investigators conducted conversations with various parties and mapped the course of events. Since the fire is the first of its kind in Norway, the case has gained a lot attention both at home and abroad.

4.2 Vessel data

MV Ytterøyningen, callsign LNXL, is a 48 meters ferry build in 2006 at Fiskerstrand dockyard in Norway. The ferry is owned and operated by the Stavanger based shipping company Norled. The vessel is equipped 4 Nogva Scania DI 16 43 M diesel engines, each with a output of 441 kW, a total of 1764 kW and is connected to 2 Schottel STP 330 propulsion systems propulsion, later converted to hybrid operation on diesel and battery, with a battery pack of 1998kw/h.

The minimum safe manning on board is a crew of 4 stated in the vessels manning certificate from 15.12.15; Captain (D3 certificate), motor man (able bodied seaman engine), able bodied seaman and ordinary seaman. As the vessel was refitted with a battery unit the total kW effect of the vessel increased to over 750 kW, which then again triggered requirements for a certified marine engineer given in *Regulation on qualifications and certificates for seafarers*. Norled then applied for a reduction in the safe manning requirements, in order to continue sailing with a motor man (Notice of Concern Ferries with battery power 2019).

4.3 Reactions

On October 14th 2019, the NMA issued a preliminary safety report in consultation with the battery manufacturer Corvus. The report points out that all battery installations on ships must be connected to the power management system (PMS) at all times to ensure access to alarm systems and fault sources. The safety report also recommends that ship owners take a new risk assessment related to the dangers of possible gas evolution in the event of a fire / incident with the battery installations.

Some few weeks later, on November 6th 2019, the Norwegian Union of Marine Engineers (DNMF) issued a notice of concern regarding MV Ytterøyningen, see appendix 9. This notice of concern points out that the vessel was operating with only a motor man onboard, despite that the total kW of the vessel is over 750 kW, which regarding the regulation on qualifications and certificates for seafarers, requires a certified marine engineer. DNMF also points out that the Norwegian Ship Safety act requires that those who have their work on board shall possess the qualifications required for the work in question to be performed on board.

When evaluating the safe manning onboard the notice of concern concludes with *"Dnmf cannot see that a Motor Man meets these requirements for expertise in service, hazards, risk and handling of batteries."* Further on DNMF points out that there is no requirement from the shipowner for watchkeeping on board the ferries during the period between the end of the route and the start of the route next day. Potentially, this means that all crew can leave the ferry and it is then without watchkeeping on board. Should an incident or warning occur during this period, there will be no crew on board to notify or start necessary actions. This contradicts the § 8. Proposal for security staffing in the *Regulation on crewing of Norwegian ships*, that says: *"The proposed security crew shall cover all relevant operations, tasks and functions for the safe operation of the ship, including a) guarding both at sea and* ***on land****, as well as safety and emergency preparedness exercises."*

5. Methodology

The methodology is vital for allowing the reader to evaluate the overall validity and reliability of the study. The study applies a qualitative explorative method with primary and secondary data. The section will present the procedures and techniques used to identify, select, process, and analyze the data. The main areas of concern of this research entail the methodologies to be used in analyzing the crew's competence and its comparison to new vessels.

The collection of primary data was based on individual semi-structured interviews. The vessels selected for the study represent two different aspects of Norwegian shipping, including both passenger- and offshore support vessels. The informants were recruited from several ships that all agreed to participate in the current project; the resulting group of informants totaling four ships with two officers from each, as shown by Table 1. On each ship, a navigator and a leading crewmember from the engine department were interviewed. In addtion, representatives from the Norwegian Maritime Authorities and the Norwegian Union of Marine Engineers (DNMF) were contacted for questions via telephone and email. This in order to provide another point of view on the subject and provide additional relevant information.

Table 1 – Overview of vessels and subjects participating in the study

Interview	Type of vessel	Subjects interviewed
1A & 1B	Offshore supply vessel, dual fuel with battery energy storage.	Chief officer & chief engineer
2A & 2B	Passenger vessel, electric ferry.	Captain & chief engineer
3A & 3B	Passenger vessel / high speed craft, hybrid / battery propulsion.	Captain & motor man
4A & 4B	Offshore supply vessel, diesel electric with battery energy storage.	Chief officer & first engineer

The study aspires to focus on leading officers onboard i.e. under-navigators and engineers. The inclusion criteria required the vessels to be innovative ship and represent both passengers and offshore support vessels.

In addition to the primary data, government regulatory requirements and educational requirements evaluated constitute the secondary data. The results were added to the database.

5.1 Justification of methodology

Being exploratory with a focus on novel and potentially disruptive technology, a qualitative approach is well positioned to establish a conceptual framework conducive to further investigation and research, the interview process was designed to allow an inductive analysis to elicit the basis of a conceptual understanding. In addition, elements of theoretical results were adopted from the literature, allowing well established concepts – e.g. Hollnagel's theory - be exploited through a deductive process.

The study opts for a qualitative research approach with analysis of various sources that provide information on changing economic and social aspects of maritime authority and the prevailing circumstances of the employees in the Norwegian vessels. The analysis enables the researcher to identify research gaps and commonalities to show the underlying theoretical framework of safety, competence, and resilience in the Norwegian maritime industry. Without first analyzing the theoretical and conceptual framework, the study may encounter difficulties with identifying the variables of investigation to include in the interview and data collection process. Semi-structured face to face (FtF) interviews may be necessary to present the research with the observational advantages to recorded interviews. The inductive analysis is justified by the need to create a conceptual framework and improve the already existing themes of competence, safety, and resilience among seafarers in Norwegian maritime operations. The methods of research design, data collection, and analysis are in the context of the explorative study.

5.2 Research design

The study employs a combination of qualitative and explorative research designs. The qualitative approach occurs through the analysis of theoretical and conceptual views on the competency of seafarers in the Norwegian maritime industry while considering the introduction of new technology and systems of operation. This approach helps to know in detail the object of study, allowing understanding the experiences, perceptions, and valuations of the subjects investigated to achieve the objectives set. According to Miles, Huberman, and Saldana (2014), the variables of study in qualitative research can vary depending on the concept of study in question, and in this case, they can be the level of competence, accountability, qualifications, education, resilience, and understanding of the new systems.

5.3 Research Approach

The explorative research will seek to interview officers on Norwegian ships that have agreed to collaborate with the study in a bid to understand the current safety and resilience concerns given new technology. According to Berg (2007), interviews are essential instruments for observation and have the advantages of building a holistic snapshot, giving a detailed view of vessels crews and word analysis but also allows interviewees to "*speak in their voice and express their thoughts and feelings*." (2007 page 96). The data then guides the researcher in the abductive reasoning approach that seeks to make inferences from the collected data and explain a phenomenon, in this case the competency and resilience of seafarers in the context of new technology.

5.4 Data collection

Interviews can take different forms, and this study will use face to face (FtF) semi-structured interview, which is characterized by synchronous communication in place and time (Opdenakker, 2006) for collection of primary data. Based on the research question, a semi-structured interview guide, as described below (chapter 2.12), was developed to ensure that certain key issues were addressed. The informants were asked, specially selected questions that address the safety and competence concerns of the electric and hybrid technology of Norwegian Vessels. The FtF data collection mode enables the interviewer to get extra information from the tone and style of verbal answers and through the reading of the social cues. The interviews took 45-60 minutes each.

Essentially, data collection for the study involved individual interviews in the various vessels combined with some textual research. In qualitative research, the choice of data collection method is dependent on the variables that should be measured and the available sources of information. There are different methods of data collection; therefore, it is upon the researcher to determine the best approach that can suit studies that need to be conducted to answer the research question.

5.5 Sample questions and analysis

The study recommends interview questions that focus on resilience, adaptiveness and competence for Norwegian seafarers. Given that resilience and competence are interrelated concepts in the maritime industry, the questions on resilience are likely to offer a projection on how the worker answers the competence queries. An alternative argument that if an individual cannot fair adequately on resilience-related issues, they are likely to fail on those dealing with competence and ability to adjust to the new environment. The Free Management Ebooks (2018) contends that the evaluation factors for employees are usually codependent, and each phase of assessment shows an employee’s level of ability beyond the most basic knowledge and skills. The study recommends that the questions should be framed to provide both data and additional information to assist in the analysis of the answers.

The study submits that the interview questions are not based on any model but are solely administered on a f2f interview with the Norwegian seafarers. Given that testing knowledge and skills do not require any interactive operations, the above questions are consistent with the proposed approaches to research design and the method of data collection. Notably, the interviewer will not test any competence because such an evaluation would involve going beyond the scope of research design and methodology.

The analysis of interview data requires the use of the written answers or transcribed interviews, the observed attitudes and reactions of people to the various questions and topics of discussion. For instance, although the knowledge on competence and resilience seems the most essential, the basic skills question shows the general orientation of workers to the new environment and the likelihood of adjusting depending on the level of know-how. The following steps are necessary for a proper analysis of the entire evaluation exercise.

1. Familiarize with the data and thoroughly understand the recorded, written, and observed data before the start of the analysis.
2. Make the analytical method focused. In this case, the study recommends an diagram that arranges the questions according to the desired order and classes (Devault, 2018).

3. Categorize data and create a framework that organizes the information compiled during the interview (Devault, 2018). Interview answers will involve categories such as safety, competence, and vessel requirements.
4. Identify patterns and connect the data based on different categories to form inferences.
5. Interoperate the data and explanation of findings overall. The final stage involves the collective analysis of the employees' competence based on the measured levels of safety awareness, knowledge, and accountability as well as the other variables.

In conclusion, the qualitative approach is vital for this study in understanding the correlation between competence and safety needs of Norwegian seafarers. The variables of consideration are discussed on the theoretical framework and may be subject to changes in the future depending on the changes in the industry.

5.6 Interview Guide

The literature provides a little background for the detailed design of the interview guide. The interview process entails an endeavor to capture the informant's perceptions in a structured way. The interview guide is instrumental in preserving this structure. As a starting point, however, the interview guide is frequently described as a semi-formal document, compiled to ensure that the interview process visits the main themes of the study. These themes must be tentatively determined before the interviews but may be modified or amended as the study progresses. In compliance with the sociological approach of this study, the interview guide should remind the interviewer to attend to the key notions at micro, meso and macroscale.

Moreover, as the guide can arguably be a source of bias used as an instrument to influence the informants, the couching of the informants should be a gentle process and avoid conferring the notions of the interviewer to the informants and ensuing analysis.

The interview guide applied in the current study was designed to include the following elements:

- Capture the relevant demographics, such as age, gender, employment

- Perceptions of safe operations

- Perceptions of new technology challenge, especially electric and hybrid vessels

- Perceptions of roles and responsibilities

- Governance, rules, and regulations

- Technical and non-technical skills, resilience

- Training and competence

The interview guide template is listed under in table 2. The interview was conducted in English or Norwegian. When the interview was conducted in Norwegian, the summary was translated into English.

Table 2 – Interview guide template

Interview guide template
1. Demographic data: a. Age b. Education c. Position on board d. Years on the job e. Previous work experience
2. Experience: a. What characterizes your job? b. What tasks do you have? c. How do you perceive your own competence in the job? d. On a scale of 1 to 10, how adaptable are you to new technology in the maritime industry? Do you want to explain your choice?
3**. Competence and education**: a. How do you perceive your education? b. How do you perceive your competence including training and courses given to you as an employee? c. How do you perceive your overall competence including experience (in addition to education, training and courses)? d. What do you perceive as your "weakest sides" or lack of expertise? e. How can a shipping company best meet and apply new technology in relation to employee competence? Are courses or new hires the best for example?

4. Vessel: a. What do you think works well on board with new hybrid / electrical technology? b. What do you think is challenging on board with new hybrid / electrical technology? c. How has the crew adapted to the new hybrid / electrical technology? d. What do you wish was different? e. Suggestions for improvement?
5. Safety: a. What is your experience with safety work on board? b. What security challenges do you experience? safety aspects of hybrid / electric propulsion technology? c. Is there anything you are afraid of here? d. Have you experienced any incidents or near accidents related to this? e. How is your safety staffing function affected by new technologies such as electric and hybrid propulsion? f. What requirements for crew expertise do you find most demanding? Including requirements from authorities, shipping companies or manufacturers.
6. Crew & Safe Manning: a. On board your vessel, is there enough expertise within the regular crew when it comes to operating the ship and with a particular focus on the propulsion system? b. Do you experience any shortages of key positions / personnel when it comes to ship manning?

5.7 Analysis

The study employs directed content analysis to form theories and develop themes from the data collected from the semi-structured interview, while abductive reasoning will aid in making new inferences (Hsien & Shannon, 2005). According to Worster (2013), the data obtained from the FtF interview enable the researcher to develop new knowledge and insights on safety and competency in maritime operation through the abductive reasoning approach. Worster (2013) contend that the use of both deductive and inductive analysis helps to develop new approaches as improvements to old themes using newly collected data and information.

The data was transcribed and coded and re-coded to identify categories (Miles, Huberman, and Saldana, 2014). The process was continued until saturation, i.e. no new categories were added. The categories were named “vessel comparison”, ”subject findings concerning competence” and “subject findings concerning safety needs”.

5.8 Ethical Considerations

The primary ethical issue is whether the researcher is allowed to interview during the time of maritime operations. The study acknowledges the possibility of rules and regulations prohibiting outsiders from accessing sensitive information and processes as well as engaging informants during work time. The lack of consideration of safety concerns is both ethical and ironic, especially given that the research explores the effects of new technology on the safety and wellbeing of seafarers in Norway. Due to the sensitivity and nature of the study questions, the principles of confidentiality, privacy and anonymity were considered to protect the informants. All informants received and signed an informed consent prior to the interview. The Norwegian Centre for Research Data (NSD) was informed of the study in advance through the standardized notification form. In the process of data collection, there is always the consent that will enable the study participants to accept to participate in the study.

5.9 Research quality and limitations

Every method of research, including qualitative methods, have limitations and methodological disadvantages. According to Anderson & Pharm (2010), all methods of research, including a qualitative study has limitations that could lead to the implementation of faulty policies and legislation based on the findings of research and experiments (Devault, 2018). In qualitative methods, limitations may be amplified by the fact that a sharp distinction between the researcher and the field of study – a demarcation sought in quantitative studies – is elusive in most cases (Lincoln & Guba, 1985). Hence, sources of bias may arise not only from the field of research, but also from the habitus of the researchers and the informants.

To mitigate the above, qualitative research marshals an impressive array of methodological tools and concepts particular to the qualitative process. For example, the concept of verification is largely replaced by a requirement of trustworthiness and credibility (Lincoln & Guba, 1985). Positioned against this backdrop, this paragraph undertakes to summarize the main limitations of this study.

5.9.1 Reliability and validity

Reliability and validity are key concepts in qualitative research. Reliability is the degree of consistency which a method or instrument measures an attribute. Validity is referring to the degree to which inferences made in a study are accurate and well-founded. In conjunction with measurement, the validity expresses how well an instrument measures what it is intended to measure. Hence; validity is about asking relevant questions (Lincoln & Guba, 1985).

Given that the study seeks to develop new themes and highlight data based on some degree on inductive reasoning, a limitation is due to the possibility of establishing a fallacious argument due to false data. False data may result from bias or misinformation from the crew members, especially if they realize that a lack of proper knowledge and education could impact their career and professional progress (Devault, 2018). Also, inductive reasoning is often weak and incomplete since the researcher can get the correct data but make incorrect conclusions due to faulty data analysis. Such limitations coupled with the failure to address the ethical issues mentioned above can lead to the questioning of the reliability and validity of the research.

5.9.2 Preconceived notions

Preconceived notions adopted from established theoretical approaches - e.g. functionalism, Marxism - impose constrains on conceptual understanding, and is particularly detrimental to deductive reasoning. This constitute a very significant argument for inductive research where the effect of preconceived notions is minimized. In the current study, the use of regulatory guidelines may introduce preconceived notions, as may the use of Hollnagel's theory. In addition, the unavoidable selection of certain theoretical positions, implies that other concepts will likely be neglected, e.g. learning theory may be discarded in favor of a more sociological framework. The current study, however, is fortified by the inductive approach used to develop the conceptual framework, and the effect of preconceived notions is therefore reduced.

5.9.3 Selection of informants

The informants' personal characteristics such as age, gender, location and sociological habitus may not exhibit sufficient variation, resulting in data that fail to be very representative for the broader group of players in the field. For example, in this study no women participated; a fact that warrants some reflection. Although the study is qualitative, a narrow selection of informants may impair the generalization of the results (Miles and Huberman, 2014) and effectively collapse the study to a case study.

5.9.4 The role of the researcher

The researcher conducting the interviews has many pathways to influence the informants (Morgan, 1997). His or her phrasing and selection of topics to be included in the interview may change the informants understanding and attitude. The researcher is also the one that determines when the dialogue and/or interview has reached saturation and can be terminated.

These potential sources of bias were curbed by requiring the researcher to allow the informants to steer the interviews as much as possible, limiting the interviewer's role to gently ensure that the interview guide was followed up.

5.9.5 The Hawthorne effect

The Hawthorne effect is known in many situations to influence the informants to react overly favorably to novel ideas, interventions, training, procedures and arrangements– due to the awareness of being observed (Parson, 1974). After the observation is terminated, the Hawthorne effect loses its grip and the informants may be assumed to give a more balanced account of their perceptions. In the current study, the inductive analysis was tuned to downplay statements that might be seen as too optimistic as a result of the Hawthorne effect.

5.9.6 The fundamental bias of psychology

This source of bias - which is also termed *the fundamental attribution error* – is due to the psychological tendency (Ross, 1977) of an informant to perceive any successful outcome of an action, intervention or decision - as a result of the informants own qualities and agency – in contrast to faulty outcomes that are understood as caused by circumstances. This particular bias might lead to false assumptions concerning the relation between agency and structure, suggesting the first is of primary importance for positioning in the field. In this study, the fundamental bias was to some degree counteracted by the inductive part of the investigation.

5.9.7 Confirmation bias

Confirmation bias (Plous, 1993) refers to a tendency to interpret data in a manner that strengthens a hypothesis favored – or held in advance - by the researcher. Confirmation bias may also influence the statements and reasoning of the informants. The bias may be amplified in analysis based on preconceived notions. In this study, the inductive approach and strict coding procedure are assumed to help controlling a potential confirmation bias.

5.9.8 Lack of triangulation

Social research often seeks to bolster results by analyzing the same data with different and independent methods, a process referred to as triangulation (Lincoln and Guba, 1985). However, the scope and practical arrangements of this study could not be extended to include triangulation, the remedy for which is strict adherence to good qualitative research practice.

6. Findings and discussion

First, the key findings are presented. A table summary of each interview is presented as attachments. The summary's provides comparable data, potential findings and quotations of special interests. Potential findings are divided into findings relevant for the vessels and findings relevant to each crew member. Then the key findings are illustrated with quotations and discussed according to the literature.

6.1 Presentation of data comparing vessels

Table 3 – Comparison of vessels

Vessel comparison					
	Finding / claim	**Vessel 1 – OSV**	**Vessel 2 – PV**	**Vessel 3 – PV HSC**	**Vessel 4 – OSV**
Crew on board	Certified Engineer required				
	Ship electrician in safe manning (ETO/ETR)				
	Crew is concerned about low minimum safe manning				
	Extra crew compared to minimum safe manning				
	Client / charterer requires extra crew on board				
Vessel requirements	Battery unit integrated as vessel was built.				
	Interviewed crew concerned about the actual position of the batteries				
	Charterer payed for upgrades of the vessel				
	Vessel is followed up by class society's				
	Vessel can sail with both fuel and electric power in comb. Mode.				
	Vessel is often dependent on external help with hybrid power				

The potential findings for the vessels as a category is presented in the table above. A color code represents a answer to a finding or claim. The color green represents positive, yellow represents neutral and red represents negative. The claims and findings are then categorized into the two groups crew on board and the vessel requirements.

6.1.1 Key data with the vessel comparison

When analyzing the data regarding vessel comparison it will be natural to divide between offshore and passenger vessels. However, all vessels are concerned with to low sage manning requirements. For the offshore vessels the charterer / client sets requirements for extra crew compared to minimum safe manning, the charterer has also payed for the installation of battery packages on both vessels. Besides extra crew both offshore vessels have an electrician in their safety manning requirements, while the passenger vessels do not. However, All vessels are often dependent on external expertise and assistance with the battery and hybrid solutions. In regards to audits both the offshore vessels are using a class-society (DNV) while the passenger ships are followed up by the NMA.

The passenger vessels are built with battery solutions, on the offshore vessels they are installed afterwards. The offshore vessels can sail in a combination mode of engines and battery power, while passenger vessel can't combine two energy sources for propulsion. As the offshore vessels are refitted to hybrid and electric power, a battery container is installed on board. Both offshore vessels the crew are concerned with the position of the battery container in regards to fire and gas leakage, especially in case of an evacuation.

It's worth noticing that vessel number 3 is not required to have a licensed marine engineer onboard as it is a high speed craft (HSC) with less than 1500 kw in effect. The vessel then sails with a motor man instead.

6.2 Presentation on data from interviewed informants

The potential findings for subjects as a category is presented in the following table. Here the same color code as in the vessel comparison is used. The color green represents positive, yellow represents neutral and red represents negative. The claims and findings are then categorized into the two groups perception of competence and experienced safety needs.

6.2.1 Key data concerning competence in the subject findings

Table 4 – Presentation of data concerning competence

Presentation of informant findings concerning competence									
	Claim / finding	1A – Nav.	1B - Eng.	2A - Nav.	2B - Eng.	3A - Nav.	3B - Eng.	4A - Nav.	4B - Eng.
Perception of competence	Considers himself competent in current role on board								
	Considers himself competent with hybrid/electro competence on board								
	Is positive to hybrid / electro technology on board								
	Adapts easily with new technology								
	Has a university or college education								
	Considers education still relevant in regards to hybrid / electro								
	Relies on and highly values previous experience								
	Had an introduction with installation of hybrid / electro equipment or as new build								
	Has received training or courses after installation or newbuild.								
	Would like more electro competence.								
	Would like more technical training.								
	Would like more knowledge about fire safety.								
	Would like more software and computer training or support.								
	Would like more safety training in general, firefighting, first aid, rescue means.								

A majority of the officers, both marine engineers and navigator, interviewed are insecure when it comes to the operation and especially maintenance of electrical propulsion systems. If we focus on deck officers, none of the navigators are competent within hybrid and electric technology on board and several of them pointed out that the expertise is supposed to be in the engine department. However, all the marine engineers would like electro competence and technical training and considers their education not relevant for hybrid/electric propulsion. That being sayd, all of the navigators would also like more electro competence and technical training. Further on, none of the subjects have had any external training or courses on the subject, besides the 5 that had an introduction with installment or when the vessel was new build. As the power management system (PMS) of a electric/hybrid vessel are often advanced software half of the subjects expresses the need for computer and data training or support.

A subject all of the informants especially focused on was fire safety. All of the subjects interviewed would like more education and courses on the subjects of fire safety. This specifically towards hybrid/electric propulsion and ship batteries.

It's important to mention that all the interviewed subjects are positive to hybrid and electric power systems, but all informants rely on and highly value previous experience. It's also worth noticing Subject 3B doesn't have a higher education as it is not required on a HSC. Further on, 3B does not feel competent with hybrid and electro technology and would like more training and education on hybrid- and electro technology. 3B also has the need for advanced safety training.

6.2.2 Key data concerning safety in the subject findings

Table 5 – Presentation of data concerning experienced safety needs

Presentation of informant findings concerning experienced safety needs									
	Claim / finding	**1A – Nav.**	**1B - Eng.**	**2A - Nav.**	**2B - Eng.**	**3A - Nav.**	**3B - Eng.**	**4A - Nav.**	**4B - Eng.**
Experienced safety needs	Concerned about fire safety with hybrid and electric technology.	(green)	(green)	(green)	(green)	(green)	(green)	(green)	(green)
	Concerned about the position of the battery unit.	(green)	(green)	(red)	(red)	(red)	(red)	(green)	(green)
	Concerned about black out.	(red)	(red)	(green)	(green)	(green)	(green)	(yellow)	(red)
	Considers the minimum safe manning requirements as enough for all operations.	(green)	(red)	(red)	(red)	(red)	(red)	(red)	(red)
	Needs more crew on board.	(red)	(red)	(green)	(green)	(green)	(green)	(red)	(red)
	Has difficulties understanding alarms.	(green)	(green)	(green)	(green)	(green)	(green)	(green)	(green)
	Considers the total competence for the entire crew as sufficient for all operations.	(green)	(green)	(red)	(red)	(red)	(red)	(green)	(yellow)
	Considers that it's enough electro competence within the organization.	(green)	(red)	(red)	(red)	(red)	(red)	(green)	(red)

A common concern for all informant's interview is fire safety with battery power. Several actually mentioned the ferry MF Ytterøyningen as an example, but also those interviewed before the ferry explosion mentioned fire safety as a concern. Other concerns are more divided as all informants from the offshore support vessels (OSV) are concerned of the position of the battery unit, while all the subjects from the passenger vessels are concerned about a potential black-out.

As to safe manning, a clear majority of the subjects, 7 out of 8, considers the minimum safe manning requirements as to low for all operations, here under if there was an emergency. It's especially visible on the passenger vessels where all the informants would say that the vessel needs more crew on board. Also, none of the subjects from passenger vessels consider the total competence on board as good enough for all operations, here under an emergency situation.

Only 2 out of 8 subjects considers that there is enough electro competence within the organization, both are navigators on offshore vessels. However, all subjects often experiences not understanding alarms from the battery's PMS.

6.3 Key data combining vessel comparison and subject findings

When comparing key data from both vessels and informants one can further analyze the data. As the fear of a black out is only present on passenger vessels, it might be in relation to that these vessels can't go in combination mode and will have a weaker redundancy in their primary energy source for propulsion. The vessels with combination mode are then built for fossil-energy propulsion and refitted with battery units later. Only the vessels where the battery package was installed as an upgrade, the offshore vessels, are the crew concerned about the position and storage of the batteries.

When comparing crewing, the passenger vessel are operating without any extra crew compared to minimum safe manning requirements and all informants on these vessels state they need more crew on board. Only the offshore vessels with extra crew and a ship electrician consider that the total competence of the crew is good enough for all operations.

6.4 Discussion

In the electric and hybrid vessels, the competency of the crew members is one of the essential factors that the management needs to look at. With the advanced controlled techniques and the numerous requirements while controlling the vessel, a lot of experience and in-depth training of the crew members is a requirement. In addition to competency, there is also an important factor that the crew members need to possess intelligence. Technical skills and ability to undertake different tasks in an emergency are part of the competency that is required when it comes to the management of electric vessels. There are always safety needs that every crew member must possess to ensure a more safe and secure electric vessel. The competency requirements for the crew members in the electric and hybrid vessels vary significantly, and it depends on the roles that are played by different members. However, competency is always the key in as far as the job requirements are concerned. Competency is defined as the ability to be able to apply the skills, knowledge, and experience to undertake different tasks at different conditions. It is also of importance to highlight the need for competence in digitalization as the power managements system of a vessel are advanced software, and as both supplying equipment as well as operating and updating equipment after delivery often plays a different role today compare to past operating systems (FAFO report, 2019:19). These required competences require a high standard on the part of the educational institutions.

The study has observed that the safety requirements of electric and hybrid vessels rely on the competence and individual intelligence of the crew. Also some of the informants stated out that as personal motivation was necessary for being able to cope with new technology on board, one of them stated that

"In general I think the company should retrain and educate existing crew. But I think the company has to look at what the employee wants, the shipping owner can't force people on courses just because you're on a specific boat with new tech. Then they will learn nothing. You have to look at personal characteristics, who wants to learn and who wants to think new. So, if it means that the shipping company has to go out in the market to get motivated people, then so be it. But they must also be trained in the normal ship work" (1A). I followed up by: *"Yes, but in a way you have to be motivated to learn something new to be on this type of boat?"* and he answered *"Yes, certainly, there is no sense in expecting that understanding of new systems will come by itself, so you have to be a little proactive and motivated"* (1A).

As elaborated in the Hollnagel theory, human factors contribute to the high demand of social and technological developments. The performance variability of humans between the first and third ages have major differences which show inequality in the mode of performance and hence subsequently affecting the level of competence among different variables.

However, in some cases, workers or crew members may possess the above characteristics but still find themselves in a situation where they cannot work effectively and efficiently. From the process of data collection, the majority of the people interviewed, though possess a high level of competency, and often feel insecure when it comes to some operational activities such as the maintenance of electrical propulsion systems. As an example on the question 'What do you find challenging on board with new hybrid / electrical technology?' another informant answered "*Well, it would the be a lack of training and competence*" (4B). I then replied 'So there is a lack of understanding?' and he continued "*Yes, we have the basics, but I think in particular about technical maintenance and insight in the systems*". Yet another informant told that "*There are many critical components attached to this, but I should have had more understanding on this either from courses or re-training. After all, I operate the system all day and then maybe without knowing I'm stressing the system"* (2A).

Going by the Bourdieu's theory, there is need to incorporate the social factors of education, knowledge improvement and resilience affected the economic aspects of job retention and the possibility of career progression as a result of adjusting to changes. As the ships move to more green and high tech energy systems, the resilience of Norwegian seafarers will determine their career progression and socioeconomic power henceforth.

On the other hand, from the process of interview, it is evident that the majority of the people or the workforce in the maritime industry have very little education concerning the hybrid and electric propulsion. Therefore, there is always the need to increase training processes to enhance competency among the workers, especially those involved in the technical works. From the interview processes, majority of the informants believe that their education is outdated. One informant went as far as to predict a radical change in the marine eningeers future competence needs*: "I think, an engineer today can do a bit about a lot. Very superficial. In the future, I think electricians will take over for engineers. But not just ordinary electricians. They should be trained as automation engineers. It will be the best. An automation engineer that has had some mechanical education in addition, that would be very good. If they can do a little mechanical work"* (1B).

From the above situation, even though there is a requirement of high competency, especially when it comes to the electric or hybrid vessel, the seafarers believe that they do not possess the right skills and experience required as their education system was not related to the field. As none of the informants felt that their education was up-to-date, the combination with that none of the informants had had any specific external training or courses on new electro- and hybrid technology, one can assume they do not have updated skills in the same field. As one informant told: *"I's a bit strange. On this type of vessel there is no other formal requirements than on a conventional boat. You can go straight in from a pile rust from the 70's and step on board here without any specific training requirements. Especially considering this type of energy source" (2A).*

To ensure efficiency in the maritime industry, there is the need to improve training for all the workers, especially those who work in the hybrid and electrical systems. More specifically, all the maritime engineers need to update their skills and competency, and this is only possible through the management. Both the STCW table A-III/1-2 and A-II/1-2 sets requirements to that the crew has to be competent enough to protect the passengers and goods on transit. The competency should involve developing experience and equipping the workers with the necessary materials that are required in the process of undertaking different roles. The electric and hybrid vessels have unique features that require a lot of attention and concentration on the side of crew. Magnetism and electricity form the basis of demonstration of the underlying electromagnetic forces in electric and hybrid vessels. Electromagnetism is a concept in physical science that explains the interaction between magnetic fields and electric fields. The movement of current creates the magnetic field and consequently, magnetic fields can also induce electric current through the flow of charges. The interaction between the two forces is significant as the idea can be applied in various applications. Even though from the research, many crew members do not have the necessary skills or required training programs, there is the need for the management of maritime industry to consider imposing more education programs to develop competency and the contemporary skills that are required to manage electric and hybrid vessels. All eight informants in this study would like to have more technical training and education regarding electro competence and battery power. One Chief Engineer argued that "*I would like more education with battery and electrical power. Now there will soon be batteries on most ships in the company"* (2B).

An interesting comparison is the competence requirements for working on a vessel using LNG gas. The two LFF courses are mandatory for all officers on management level on Norwegian ships. As informant 1A pointed out that in regards to LNG gas as fuel he had two mandatory courses in a total of four days, but no courses at all in regards to battery power. On the question ‘On board your vessel, is there enough expertise within the regular crew when it comes to operating the ship and with a particular focus on the propulsion system?’ one informant answered *“Well, it is the same as mentioned before. When it comes to gas it is good. But with the battery it’s too low. Marine engineers and electricians have some expertise, but they are for example not smoker-divers”* (1A).

The resultant crew competence at work, as well as the requirements, is of equal importance. Research on electric and hybrid vessels entails several criteria on different variables such as competence of the crew, requirements for the crew, and real safety needs of the ships. Various specialists have different views about each phenomenon under the theory chapters, and these theoretical arguments give information on critical requirements for safety and competence of personnel in the ordinary way of carrying out activities. The performance variability of humans between the first and third ages in their work environment often have major differences which show inequality in the mode of performance and hence subsequently affecting the level of competence among different variables.

A majority of the maritime crew interviewed does not feel secure, and they are specifically focused on the safety with regards to fire on board. Specifically, they remain insecure in battery power systems. On the question ‘So lack of technical insight and being able to do maintenance is challenging?’ one informant answered *“Yes, and especially when you think about if something goes wrong. After all, I don’t think we know enough about fire safety. We have CO2 and can fill the container with water, so it should be taken care of. But if the battery-cells burn, we can't extinguish them, and if gas is formed over time and spreads. I don't quite know. It may help to fill water”* (4B). I followed up by asking ‘It should cool down to some degree and keep a pressure?’ and he continued *“Hehe, I guess it gets so hot that the whole container will boil.”* (4B).

With the lack of competency, dynamic learning and training processes, the maritime crew and engineers cannot operate some of the electrical systems and alarm panels; they cite technicality and advanced operational processes in an attempt to secure them. When asking about what kind of alarms they have, one informant told that *“There is a bit of everything, often temperatures, battery capacity and a lot of error messages we don't always know what is.....Off, there are often just a lot of numbers and codes. You have to have the design system to know what it is. If it gets too bad we just switch to clean diesel operation (3A)”*

On the questions about having control of all the alarms and what all the beeps means, one informant told that he had no clue (1A), and this conversation went on when I asked if there was a lot of unknown alarms. Then he answered *"it is battery-related stuff, we don't know enough. You just get a number, and what the hell do you get out of that? It's like just tags, it doesn't have any plain text. So we're not quite where we should be, I don't think it's finished"* (1A).

The above scenario reveals that most of the crewmembers do not fully understand the alarm systems, and especially the electrical sources. The management should, therefore, consider training the personnel available or recruit already trained individuals who are well compliant with the electrical systems and engineering in the maritime sector. In most cases, the requirements for crew on offshore vessels are more demanding compared to those in the passenger's vessels. The offshore vessels normally have more crew, and they are usually applying the class authority scheme. This of course has to be seen in light of what flag and audit scheme the vessel sails under, crew from the offshore vessels pointed out that it was the client/charterer who demanded extra crew, as well as payed for the refitted battery-packages. This may tell us that the clients set the highest standard. One informant highlighted that *"There is not really pressure from authorities or ship owner. That's more minimum requirements. The clients tend to be better at demanding different skills and training, and without the clients' demands we would have been without both battery-package and extra crew (4B)"*

The requirements for an electrician onboard are vague, and up to the ship owner to consider together with the NMA, also there have been recent changes in the newly published *"Guidelines on Ship Electrician and Ship Electro Officer in safe manning certificate"*. However, the requirements today allow vessels with advanced electric energy to sail without any appreciable electro competence, given that a marine engineer at management level has the necessary electro competence. For example, both passenger vessels in this study is without a electrician on board, and all 4 of the interviewed informants would like more electro competence for themselves and would like a ship electrician on board or closer in the organization. Regarding the informants experience of shortages of key positions / personnel when it comes to safe manning one said that *"It is a little strange that a fully electric boat has no requirements for a ship electrician or more electrical training on the crew. You should have personnel with some insight and greater understanding of data and the electrical* *processes. One should have a dedicated person to rely on in these things" (2A).* Further the informant argued that this was "*because they do not have an electrician in a crew and it certainly should have been. For the systems are just getting more and more advanced and everything is linked together." (2A).*

On the vessels that don't have a ship electrician one can assume that the marine engineers has the necessary competence according to STCW A-III/1 and /2. A marine engineer at management level can according to regulations replace an ETR and lead the work of a ETO. However, as none of the marine engineers interviewed in this study felt competent with battery and electro work one can assume that the training and competence is not sufficient. This again might also be the assumption of the manufacturers as several informants reported that service and analysis to the system was remotely operated and that the crew on board did not have the necessary rights to change settings. After the introduction course informant 3A summarized "*It was just one message, keep your fingers away"*.

The leeway a ship owner has in regards to electric competence is especially alarming on High Speed Crafts (HSC). On a HSC there are a dispensation for having a certified marine engineer on board as long as the total effect of propulsion does not extend 1500 kW and there are two separate engine rooms. This dispensation given in Regulation on crewing of Norwegian Ships, paragraph 9 Minimum requirements for safe manning and is a unique Norwegian directive aberrated to the STCW-code. This means that the HSC can operate with a motor man instead of a marine engineer in Norwegian waters if it fits the requirements in paragraph 9. The interview informant 3A and 3B both indicated that the electro competence on board was lacking and the biggest safety concern on board was to few crew. This is supported by report "Safety on high speed crafts" (Fenstad J., Kongsvik T., Størkersen K.V. 2012). In this study different aspects of staffing were the most frequently mentioned safety challenge in free text responses. The top safety concerns mentioned was number of crew members, lack of experience, weaknesses in training.

As this study points out that the electro competence of marine engineers can be questioned, a particular concern should be the electro competence on board vessels crewed with a motorman and using hybrid power. This was the case on board MV Ytterøyningen as it exploded. The Union of Marine Engineers (DNMF) has several times sent concern complaint, as seen at the bottom of appendix 9 *"With this, DNMF will strongly urge the Norwegian*

Maritime Directorate to require that all ferries with a battery pack be manned in accordance with Art. the regulations with certified engine officers, with the necessary additional expertise, even on ferries with propulsion below 750kw so that the safety of ships, passengers, crew and the external environment is safeguarded."

MV Ytterøyningen is at the same time interesting as the total effect of the vessel was over 750 kW and then should require a certified engineer. However, the NMA can give a dispensations to reducing the requirements for safe manning in accordance to paragraph 3 in Regulation on crewing of Norwegian ships. This reduction of safe manning requirements has to be applied for by the ship owner. On October 22. 2019 the NMA published a news article on their website titled *"More recommendations after ferry review"*. A review of the safe manning requirements shows that the ship owner gets his will more often compared to the captain or staff. Of the 232 cases that are reviewed, the parties agreed on solution in 28 percent of cases. In 22 percent of the cases the shipowners point of view was legislated, in 5,6 per cent of the cases the captain heard, while it in almost 16 per cent of cases no feedback from employees has been registered regarding staffing application. One example relevant for the study is the fully electric ferry Ampere, built in 2014. Ampere is operated and owned by Norled. In 2014 Norled applied for a reduction in safe manning, for then being able to sail with a motor man instead of marine engineer. In November 2014 the DNMF sent an official complaint to the application and the reduction in safe manning was denied, see appendix 10.

There seems to be a difference between the perception of safe manning between the crew, authorities and the ship owning companies. The safe manning seems low, and the offshore vessels have extra personnel on board as the charterer demands it. In the maritime industry, there is a need for management to ensure that there is competency among the workers. However, with the advancement in technology, there are some people who are always left behind. In other words, there is always the need to ensure continuous learning and technical ability of the entire workforce, especially the engineers who deal with the technical aspect of the systems.

In the Electric and Hybrid vessels, there is always the application of electricity and magnetism, a section that requires a high level of safety among the crew. Almost all machinery run on motors, and this leads to a wide application of the concept of electromagnetism. The modern scientist has persistently come up with new technologies that make use of electricity and magnetic effects. The concept of electronics involves the behaviors of positive and negative charges in the nucleus, and it is this idea that leads to more inventions in the modern world of physics and engineering. The interaction between magnetic and electric fields is of great significance as it is applicable in motors that sustain the operations of different machines. Power generation stations employ turbines which makes use of the motor system to function. As modern technology innovates the shipping industry competence of crew and regulations for ships mist follow up. The technical requirements for ships using battery's are vaguely regulated through a guidance for storage in combination with class-society rules for building. However, the requirements for battery testing raises awareness as the propagation test 1 does not focus on gas development and ventilation. In the NMA's Guidance on chemical storage for energy – marine batter systems it's described*: The company will describe philosophy related to the design and placement of battery compartments, as well as solutions for explosion relief, ventilation and fire extinguishing based on the chosen specific battery solution. The battery solution must be tested in accordance with this circular*. It's uncertain what Norled's philosophy was on board MV Ytternøyningen, but it might be safe to say that an explosion was not part of it. In general, testing to validate the design of batteries needs to expand to incorporate the risks identified.

From the theoretical perspectives, there is a co-dependency of the factors that generate the performance of seafarers and other employees in the maritime industry. Although there is the adoption of resilience, competency as well as safety, there are a few concepts that must be applied together for the full realization of the intended level of professionalism. Knowledge, aptitude, skill, ability, and attitude determine the competence of an employee. Further, the level of talent defines how the individual behaves within and outside the work environment. For instance, when the employees in a fleet have the technological and technical competence to operate hybrid propulsion machinery, they have high resilience, and they behave differently from those who can only manage the old vessels. The level of competency is arguably the most critical determinant of the performance and survival of an individual in a habitat. The development of competency requires constant education and training approaches that improve skills. Dynamic learning also increases the adoption of new technology and new work procedures, a scenario that increases efficiency in handling new equipment in the maritime industry. Historically, there were times when workers were fully under the control of their employers, specifically when it comes to benefits and safety measures. Also, the employers had the full responsibility for initiating promotions as well as hiring processes. On the other hand the process of recruitment should involve testing or examination of the worker's competency, abilities, and skills. Competency in the work environment requires individual effort and personal decisions. In most cases, the work environment consists of different people with different skill. Among the crew members, there is a need for the management to encourage association between members to ensure continuous acquisition of knowledge and skills. Since most of the workers interviewed believed that they lack the necessary skills, both social and technical there is the need for the industry or the organization to consider training programs that will best impact knowledge and competency among the workforce.

Secondly, on the safety and safety awareness based on the tale of the two safeties of Hollnagel (2013), safety is described as freedom from unacceptable risk. In regards to individual actions, it is essential to focus on circumstances whereby activities go wrong because these activities happen unexpectedly, and they may lead to physical or emotional harm, loss of possessions, and properties. Safety and safety awareness can be promoted by not only focusing on what goes wrong but also emphasizing on what is right and developing strategies that can help in rectifying the activities that are considered as wrong to promote safety. With the lack of competency on the side of crew members, specifically on the technical issues, accidents arise. In some cases, there are accidents that occur and follow Frank Bird's Domino Model, which states that some accidents occur as a result of the lack of control from the management. In other words, the effective management of ships requires that they are equipped with enough safety measures or equipment that can guide the captain and other crew members about the impending danger. In most cases, it is the responsibility of the government and the ship owner to ensure that there is competency among the crew member especially through establishing training programs that suit the current operational processes. This is plainly regulated in *Regulations on safety management for Norwegian Vessels* paragraph 6.2:

The company shall ensure that each ship is:

.1 staffed by qualified, certified and medically fit seafarers, in accordance with national and international requirements, and

.2 appropriately staffed so that all aspects of safe operation on board are taken care of.

In the accident of the MV Herald of free Enterprise, the ship management was unable to ensure that everything is in order before the ship's departure. In other words, there was a lack of safety measures such as indicators that would ensure that the bow doors are closed for safety purposes. The accident was caused by the lack of ship management oversight and assumed the risk. The same aspect can be fitted to the MV Ytterøyningen explosion. The vessels management had switched of the batteries EMS and was not able to monitor the temperatures in the battery cells. These accidents can be attributed to the Heinrich theory, whereby human negligence and stubbornness can lead to a serious accident. In the Herald of Free Enterprise, a crew with experience in sailing understand that sailing with the bow door open poses a risk to the ship; however, they left these doors open for the vehicle's exhaust to be released.

Additionally, the ship required indicators that could show that everything was in order or under control before the ship left. Equal the Ytternøyningen lacked indicator of that the battery was under control as the system was switched of. The competency relates to Bourdieu's theory of socioeconomic theory. The ruling regulations and changes imparted by the NMA represent the shifts in the habitat of Norwegian seafarers, while resilience is the cultural capital needed to enhance the working environment in ships and fleets. Therefore, it can be argued that while the current conditions of Norwegian seafarers are not entirely vulnerable, they need to improve regarding resilience for the sake of the current and future economic and technological changes. The improvement and changes need to be in line with the safety measures in the maritime industry. The level of competency is arguably the most critical determinant of the performance and survival of an individual in a habitat. The socioeconomic theory by Bourdieu does not discriminate or map competency while considering all the necessary variables, in this case, safety, resilience, and technological knowledge.

The third age of social factors establishes that human factors are widely accepted as essential parts of industries in practically every domain. Human has developed in different ages each with different consequences namely first, second, and third ages of which human intelligence and way of thinking or rather innovation takes place. Therefore, for one to develop competency in the work processes, there is the need to adhere to the social factors that may enable them to learn various social and technical skills. The acquisition of knowledge and skills often requires associating with more people and acquiring different skills and capabilities. According to Bourdieu's Theory Model, prevention and neutralization are some of the approaches that can enhance the acquisition of different knowledge and skills.

There is always the need for all officers at management level to hold a practicing license for them to be able to carry out competent works and operations. On the other hand, there is a need for them to engage in continuous or dynamic training programs that can boost their knowledge and especially technical competence. In addition to having a license, there is always the need for renewal to keep up with the increasing demands of the industry. In electronics, there is a need for one to understand the idea of electricity and magnetism. Also, there is a need for social skills and work ethics that will enable an individual to operate collaboratively to ensure safety. Hetherington, Flin and Means (2006) concluded in their literature review article about safety in shipping and the human element that the three safety key arena; common themes of accidents, the influence of human error and interventions to make shipping safer could contribute to maritime safety performance. The review illustrated that human factors as stress, fatigue, situation awareness, teamwork, decision making etc. are present in incidents.

As hybrid and electric vessels are still new in the shipping world, there are still relatively few vessels who are fitted for this study's scope. The study's use of a small sample of informants and vessels prevent these findings from providing an accurate representation of the general Norwegian ship tonnage. The study represents the seafarer's perceptions of real safety needs, and no ship owners were included. As a result, the applicable of its findings might be limited. For a future research it would be interesting also to include ship owners to evaluate their view of current regulations, competence of crew and safety on board with hybrid and electric vessels. Another area for future research would be to expand this study in an international setting. To verify findings, it would be interesting to conduct a competence mapping of the crew and compare the safety record of ships with extra training and education on hybrid and electric power.

7. Conclusion

Introduction of electric and hybrid vessels is ongoing and in a few years such ships may be ubiquitous, raising questions regarding the competence needed for safe operations of such ships. The current study was guided by the following research question:

"How do the requirements to the crew's competence and ship regulations – accommodate the experienced safety needs of an electric or hybrid vessel?"

The study was qualitative and explorative, based on data acquired by interviews. A recent incident – the explosion onboard the hybrid ferry MV Ytterøyningen was included in the study, serving mainly as background for the discussion of the results. While the analysis was mainly inductive based on content analysis, a literature study of the regulatory framework enforced by the naval authorities was included in the data accumulated. The discussion of the finding was informed by the theory of Hollnagel, and more generally inspired by the sociological work of Pierre Bourdieu.

The coding and analysis of interview data allowed establishing the conceptual framework illustrated by Fig. 5 below:

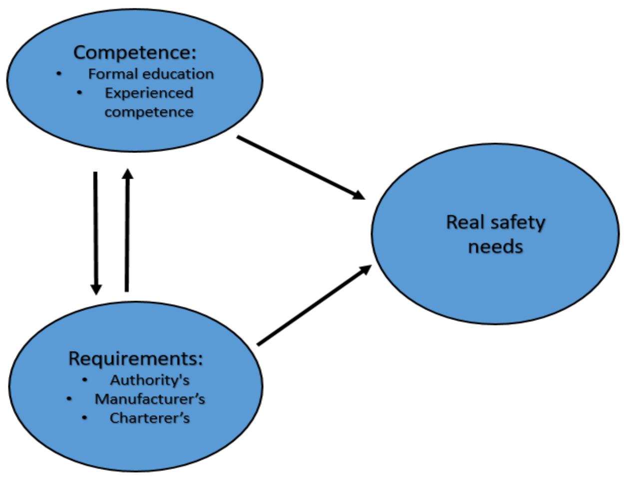

Figure 5. The conceptual framework for the study (Authors contribution)

The main conclusion emerging from the interviews and the analysis of requirements is that the current vessel regulations and competence requirements fall short of matching the real safety needs on board. The concept of competence occupies a central position in the informant's perception, and lack of competence was a source of insecurity in regard to electric and hybrid vessels.

According to the informants, building competence would improve both the safety of operations, but also would potentially improve work efficiency. As shown by Fig 5, the manufacturers are attempting to enforce their own requirements. Interesting, these were in some cases too ambitious as compared with the crew members' competency.

The operational requirements for a vessel were perceived by the informants as comprehensive, but somewhat vague with regards to electric and hybrid ships. The guidelines in some cases reflect a lack of regulations by naval and state agencies. As an example; the requirements for electro competence are unspecific, with the result that several vessels rely on the marine engineer to replace the electrician. However, the electro competence of marine engineers was perceived by the informants as too basic for being in charge of electric and hybrid systems. Several informants expressed concern regarding fire hazard and the position of energy concentrations on board. The theoretical study indicated that a specific operation, the testing of batteries, is seen as a potential hazard.

This study has implications to the literature, practice and policy. The implications to the literature is primarily a number of findings that can be published. This embraces a conceptual framework for further investigation of variables linked to safe operations of electric and hybrid vessels.

The implications to practice are recommendations on crew competence necessary for safe operations and for complying with authority regulations regarding crew qualifications and safe manning of vessels and also improve the procedures of battery testing.

The implications to policy are embedded in recommendations for manning and operations electric and hybrid vessels. The result of this project may be used to improve guidelines and regulations for operating electric and hybrid vessels including manning and competency requirements.

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9. Appendix

9.1 Appendix 1 – Interview 1A summary

Interview 1A Summary.
Demographic data:
Type of vessel: Hybrid offshore supply vessel, dual fuel with LNG gas and diesel, with battery package. **Age and gender:** 32 year old male **Title:** Chief officer **Experience:** 1 year on current vessel, 5 years on other vessels, 1 year as a marine superintendent
Experience & current work:
Responsibilities and tasks: Current job involves being in charge of maintenance, operation of the vessel, safety, navigation on fire/emergency drills. **Competence:** Considers his own competence in the job as good, value 8 out of 10. **Adaptiveness to new technology:** 9 out of 10. Finds new technology and innovation exiting. ***Quotation 1.*** *1A: I find it exciting with new technology, so I consider myself very adaptable. I think it is important that the company tries to find new solutions, someone must first be with the different solutions that come out in the market. Although many of the solutions become more gimmick than the desired effect of it ..*
Competence & education:
Education: Considers his own education as mediocre, a bit outdated, but OK. Would say that he learned the most of his knowledge in the cadet-period. The education had very little focus on offshore-industry and hybrid/gas propulsion. **Training & courses**: Points out that in regards to LNG gas as fuel he had 2 mandatory courses, but no courses at all in regards to battery power. 1A would like more education on battery and electric propulsion, especially with regards to fire safety. Considers his own competence with battery power as to thin. **Future competence needs:** The company should train and educate their existing crew. However, employees needs to be motivated to meet new tech, if there is no existing motivated employees then the company must hire someone new. As a employee you need to be motivated to work on an innovative vessel.

Quotation 2. *1A: I think cadet time is the most important thing. If you did something about it you would have had more cadet time in school. In relation to the boat I am on today, we had nothing about gas, dual fuel, or battery at school. We were well on some business visits where it was mentioned, but can't remember we had anything special about it at school.* *Re: Yes, I guess the development has gone fast, but gas was used a lot when you went to school?* *1A: Yes, gas was big. The first offshore vessels came with gas for over 15years ago. So it's a long time ago.* ***Quotation 3.*** *1A: Well, on this boat we also have battery systems for propulsion. I have very little knowledge of that. So with the storage of such large amounts of energy, I think most of the things that can go to hell, and with the extinguishing of this. There is not so much to do as I understand, since there is so much energy stored in this stuff .. So on that battery bit, my knowledge is a bit thin.* ***Quotation 4.*** *Re: To meet future competence needs, do you think the company mainly should train existing crew or hire new personnel?* *1A: In general I think the company should retrain and educate existing crew. But I think the company has to look at what the employee wants, the shipping owner can't force people on courses just because you're on a specific boat with new tech. Then they will learn nothing. You have to look at personal characteristics, who wants to learn and who wants to think new. So, if it means that the shipping company has to go out in the market to get motivated people, then so be it. But they must also be trained in the normal ship work.* *Q: Yes, but in a way you have to be motivated to learn something new to be on this type of boat?* *1A: Yes, certainly, there is no sense in expecting that understanding of new systems will come by itself, so you have to be a little proactive and motivated.*
Vessel:
Positive to: - Running on dual-fuel in transit and battery combined with one engine in DP-mode works fine. Running on battery power saves fuel and hours on the engine. **Negative to:** - Using battery in "peak shaving mode" in transit. To much power is lost and the fuel consumption increases compared to normal dual-fuel mode.

- Also negative to the shore-based electricity. The normal shore-based electricity system in Norway is not dimensioned for a offshore vessel, which results in that the battery must be used and then charged again. This again results in that the total electricity consumption is high.

Challenges on board:

- The battery requires a lot of energy to stay “toped of”. When using the battery and one engine there are to many alarms.
- Many of the alarms are unknown. Points out that there is to little training on the DP and battery alarm system.
- The battery package is to close to living quarters and the LNG tank. 1A would like the battery-cotainer to be placed on the aft end of the ship.
- Fire and emergency preparedness. Would like more knowledge on fire extinguishing in regards to battery and electric fire.
- Data-competence is reliant on one person.

Quotation 5. *Re: ..do you have control of all the alarms then? What do they mean when everything beeps?*

1A: No, I have no clue.

Re: There is a lot unknown?

1A: Well, it’s battery-related stuff, we don’t know enough. You just get a number, and what the hell do you get out of that? It's like just tags, it doesn't have any plain text. So we're not quite where we should be, I don't think it's finished.”

Quotation 6*. 1A: Well it is this with a fire on board, here the battery pack is placed somewhat silly. The battery container is 5 meters from the LNG tank and right outside where we sleep. The LNG tank is protected by air locks and rooms on rooms. But anyway, if that battery pack fails and catches fire.. Then it gets extremely hot.*

Safety:

Own experience: Experienced within safety work as chief officer. Considers his safety competence as good.

Safety challenges:

- Little knowledge about fire extinguishing in electrical components, such as ship-batteries.

- The actual position of the battery container in regards to a collision, fire and evacuation. Also considers the battery container in a vulnerable position out on deck, especially compared to he LNG tank. - In an emergency there is more energy sources to consider. Combined with little knowledge it creates uncertainty. - The ship class society requires the ship to be I excellent condition, but they are no experts on battery-power. - The producers of the battery are most competent. ***Quotation 7.*** *1A: I would say that the manufacturer is the most competent, so they know what it is all about .. So I feel they have down to earth requirements for this. They have the requirement that this must be done. But the most demanding is probably class society and what out clients' demand from us. The only reason we have some extra people on board is probably because those who hire us demand it. The class companies require that the boat is in top condition, so it would have been easier if the boat had not been under a class society. But the class-society has a job to do, they must probably attend the same courses of equipment we should have had.*
Crew & Safe Manning:
Key points: - Safe manning requirements is OK for normal operations, but the vessel sails with 3 extra. As the client demands it. - Competence on gas is OK, but not OK on battery power. - Smokedivers have no competence on battery-units. ***Quotation 8.*** *Re: On board your vessel, is there enough expertise within the regular crew when it comes to operating the ship and with a particular focus on the propulsion system? 1A: Well, it is the same as mentioned before. When it comes to gas it is good. But with the battery it's too low. Marine engineers and electricians have some expertise, but they are not smoker-divers.*
Commentary:

9.2 Appendix 2 – Interview 1B Summary

Interview 1 B Summary
Demographic data:
Type of vessel: Hybrid offshore supply vessel, dual fuel with LNG gas and diesel, with battery package. **Age and gender:** 54 year old male **Title:** Chief engineer **Experience**: 5 years on current vessel, 20 years on other vessels.
Experience & current work:
Responsibilities and tasks: Current job involves being in charge of the engine and propulsion, leading the engine department, instructor for new crew. **Competence:** Considers his own competence as good and has a lot of experience. **Adaptiveness to new technology**: 8 out of 10. Interested, but it's a lot to learn and takes a lot of time.
Competence and education:
Education: Considers his own education as out-dated and sees the importance of retraining and courses. Used to be an electrician before started sailing. **Training & courses:** The initial courses when the battery was installed was very good. After installing there has been no courses or re-training. Courses when it comes to gas and LFF is good. Evaluation of competence: Considers his own competence as good, but sees the value of being an electrician. Acknowledges that an engineer today can't have in depth knowledge on everything on board and point out that they are dependent on specialist from land. **Future competence needs:** The company should train and educate their existing crew. **Quotation 1.** *Re: ..so you have to rely on the land apparatus for expertise? Is it then the ship owner or the producers?* *1B: Yes it is the producers.. and sometimes also the shipping company, but as a general rule the producers. You are dependent on good access to the supplier and experts. Because there is so much data and more of the components are arranged so that we can not do anything about on settings.* **Quotation 2.** *Re: So data and new technology require more specialist expertise?* *1B: Yes, I can say one more thing as well. The engineers work today is very much where*

you are an operator, much more than a repairman. When I was young and started as an engineer I was a lot of repairman as well. That's not it anymore, now I am more operator..

Quotation 3. *Re: In the future, do you think the marine engineers education needs to be adapted?*

1B: Yes, I think, a engineer today can do a bit about a lot. Very superficial. In the future, I think electricians will take over for engineers. But not just ordinary electricians. They should be trained as automation engineers. It will be the best. An automation engineer that has had some mechanical education in addition, that would be very good. If they can do a little mechanical work.

Vessel:

Positive to:

- Running on dual-fuel. The system functions very good. Cost saving.
- The battery makes a lot of energy available at all times. It increases safety in regards to prevent black-out.
- Using the battery and running on one engine saves fuel and maintenance.
- Crew not being able to change settings in propulsion systems.

Negative to:

- Would like a bigger engine, so that the battery combination would run more optimal. Points out that when the ship was built it was never adapted to battery power.
- The position of the battery-container. It should have been more aft.
- The normal shore-based electricity system in Norway is not dimensioned for offshore vessels.

Challenges on board:

- Training new crew. Its done internal.
- Knowing the processes in the ships systems.

Quotation 4. *1B: When new marine engineers come on board, we train them in our systems our selves. I think they should training with suppliers as we got when it was new. At least those who will be on board for a long time. With the boat itself I can only say that if you had known that you would get batteries when you built this boat then you would have put slightly larger motors in it. So that the engine matches better operation when running on a machine. So we could go 12 knots on one machine and not just 10. It is designed to*

always run with 2 engines. But they didn't know that when the boat was built, the technology goes so fast that they had no idea.
Safety:
Own experience: Considers the safety standard on board as high. Safety is a priority. The standard is much higher on current vessel compared to other types of vessels 1B has worked on before. **Safety challenges:** - If you follow the instructions from producers its mostly ok. On the bridge is human erros causing problems. - The position of the battery container is not optimal, it should have been further aft. - Has had previous problems with the cooling system for the battery container. Its now closely monitored. - The most challenging for the crew is to stay updated on new equipment and systems. - Spends the most time on requirements from the class-society. **Quotation 5.** *1B: I really think it's safe here. The gas is well shielded and it takes a lot before it is affected. The battery is close to the tank, and I don't think it would have been placed that way if the boat were to be built today. But trying to extinguish and the fire fighting with burning batteries it is not good. Here the container stands out on deck thankfully. What you have to do is to close the container and use foam. We have foam systems that are mounted, it comes from the engine room. And then we have to cool with sea water from the outside. There is nothing else we can do. If it burns, we can't turn it off inside. There is tremendous energy that short-circuit burns and it takes time.*
Crew & Safe Manning:
Key points: - Competence in the crew is good enough for normal operation. If something out of the ordinary happens with equipment they are dependent on help from land. - The manning of the vessel is good, but the minimum safe manning is to low. They have 3 extra to the minimum safe manning requirements. - The ship has an electrician as part of the safe manning minimum. The electrician has the lead on issues considering the battery.. **- Quotation 6.** *Re: "Do you experience any shortages of key positions / personnel when it comes to crewing the ship?"*

1B: "No it's very good here I think. We have 3 engineers and 1 ship electro officer, plus apprentices in the machine" *Re: "You probably have some extra personnel on board besides minimum safe manning?"* *1B: "Yes we always sail with 3 men extra. In the engine department we have an extra engineer and then we have apprentices. There is very good help in an apprenitice. If we are kind with them then they join and it will be good.* ***Quotation 7.*** *"Re: You have, as you mentioned, a ship electrician on board. Has he been given a bigger role after the battery pack was installed?* *1B: Oh yes yes, he's got more to do now. He has put in a lot of hours. It is often he who talks to the suppliers when there is something about settings and set points. But it is always the supplier that changes the parameter. They fix it directly. There is usually a specialist from the office who fixes it online.*
Commentary:

9.3 Appendix 3 – Interview 2A Summary

Interview 2 A Summary
Demographic data:
Type of vessel: Electric passenger vessel – ferry **Age and gender:** 36 year old male **Title:** Captain/chief officer **Experience:** 3 years on current vessel, 13 years on other vessels.
Experience & current work:
Responsibilities and tasks: Current job involves routine work, bridge duty, administration, training of crew, overseeing maintenance, overlooking budget, safety work. **Competence:** Considers his own competence as good. 8 out of 10. Based on experience. **Adaptiveness to new technology**: 8 out of 10. Personally interested in new tech. ***Quotation 1**. 2A: ..I have to say that I feel a little lucky because I belong to the generation that had a home computer and I got to play with it a little. So I've got a basic introduction to data systems growing up.. and systems on board today are more and more computer screens and less manual switches. When you board an older vessels there are a lot of turn-overs switches and buttons.. while there are now many more screens and it requires an understanding of how that technology is put together. So I feel pretty competent, and I'm actually genuinely interested in technological advancements. So for self-interest I find it nice to get into systems.*
Competence and education:
Education: Considers his own education as to theoretical and out-dated. Glad for his cadet period. **Training & courses:** Has not received any courses or specific training when it comes to battery and electric propulsion. **Evaluation of total education:** Considers his own competence as good, but would like more education and training on the propulsion systems and firefighting in regards to battery power. **Future needs:** Prefers training and educating existing crew. Would like re-training with producer with all new crew.. ***Quotation 2.** 2A: And then its what we talked about, the schoolwork today is focused on traditional shipping.. and traditional propulsion and energy sources. Now, there are*

electrical solutions on the way in from all directions, which is something we have seen in recent years. But there was nothing, for example, about gas or batteries in my textbooks, and I hear that new crew and graduates also know little about it. Now there are boats that have only the electrical energy to run absolutely everything on board. And then I feel that those who come out of school have the wrong idea, when you have read that you should be able to troubleshoot the big things like oil pressure, too little cooling .. but here on board it may be enough to reset wifi. And there you have a big transition and you can feel very outdated. So you have to be forward-looking and realize that what you learn at school may not be what you encounter in reality. Especially this is with electrification and gas operation. Right.

Quotation 3. *2A: So for a navigator operating a fully electric vessel it is quite similar, the only problem is usually this with alarms. Alarm log. It is often referred to as battery cells and quite technical components that no other vessels have. And something you've never heard of. On traditional vessels, it is normal for alarms to related to temperatures and things like that. Here there are more earth faults and voltage and stuff. So you might have trouble locating and actually understanding the very problem of an alarm.*

Re: Does that mean that you do not have the same understanding?

2A: Yes quite right, you do not have the same understanding of what the alarm entails and you are more uncertain then. And in essence, the education we have on board does not consist of courses and training. It is based more on experience transfer from shift to shift. We have not received any courses either internally or externally. The crew who took out the boat got a review with the yard, and afterwards they have communicated it to us. Afterwards the shipping company has tried to spread experienced crew on the various shifts.

Quotation 4. *Re: Is there anything you could wish for more expertise on. Are there any "weaker sides" or lack of expertise?*

2A: Yes, a lot more about engine learning, especially with this kind of propulsion, to increase the safety and understanding of the system. Maybe a slightly larger introduction to electrical energy to get a better understanding of how this works. Both with resistance, temperatures and risks.

Re: Do you think of any dangers that may arise?

2A: Yes, as responsible for the safety of the ship, I think its necessary with a greater understanding of how the electrical works and its limitations. For example, this with the backup and how it inserts ..will the battery pack and the backup battery will have the capacity to prevent dead ships over a longer period? Of course it should, but we do not know until we have tried. There are many critical components attached to this, but I should have had more understanding on this either from courses or re-training. After all, I operate the system all day and then maybe without knowing I'm stressing the system.
Vessel:
Positive to: - Low emissions and impact on the environment. - Less noise and more comfortable for passengers and crew. - Ship maneuvers and responds easily and fast. - Dangers associated with conventional propulsions, like fuel leakage, temperature, moving machinery is removed. **Negative to:** - The lack of competence and understanding of the propulsion system and energy source. - Unknown alarms and to technical alarm texts. - The land-based charging is not effective enough. **Challenges on board:** - Charging enough power and sticking to route. - Troubleshooting faults. - Competence among the crew. Would like an electrician on board. - Often dependent on land expertise, but this is expensive. ***Quotation** 5. 2A: ..the entire vessels end up as a large fuse box and a bit more like a floating computer. And then you have to think a little differently, because it's not like we can do it on the old method of just pressing the button and turning off the computer to restart. There are many components with consequential errors.*
Safety:
Own experience: Considers his own experience as good. Worked a lot with the ISM-systems and safety related work. Is also an instructor in offshore and marine safety courses. **Safety challenges:** - A lot of new crew with little competence on electric propulsion.

- Competence with firefighting and electrical energy.

- Unknown alarms.

- Getting power back with a potential black-out.

Quotation 6. *2A: Let's take a special thing we discussed, consider if you get something called too high temp in the battery. If they actually catch fire. We have discussed this with manufacturers and others .. but have not come up with a good solution due to the content of the battery in such a type of fire will only.. that is, the temperature is so high that if you keep cooling with water, the water will evaporate and boil the whole vessel. So for extinguishing the battery fire I'm not sure. Then there is this with blackout, it sounds a bit strange that an electric boat gets blackout, but we have the system in the ship that distributes the energy around the boat, and if these systems should fail we will get a classic black-out. And then the procedure is a little more extensive than starting a new machine and go on. So there we have more to consider, well, because that kind of thing might take a lot more time to fix*

Quotation 7. *2A: ... and then we have this with the alarms. As a navigator, it is not easy to misunderstand "Battery Pack 4HA6". There may be a contact at the back where some warmth is in, I don't know..*

Re: Do I understand it correctly in that there can be uncertainty associated with the types of alarms that go?

2A: Yes, especially for new personnel on board, it can be very challenging. It a mostly for engineers. For those of us who have worked here for a while you get used to the most common alarms that come, we have a 6-7 alarms that come and go. But sometimes it comes a brand new and then there is a little extra pressure. You can also get the problem that there is an alarm, but you hardly bother to see because it is probably the alarm that has gone 18 times so far .. but then suddenly there is another type.

Re: Well then you can make mistakes quickly. Especially if you do not fully understand what the alarm applies.

2A: Yes and here it is special for the alarm setup is made for electro engineers on land.

Quotation 8. *2A: I's a bit strange. On this type of vessel there is no other formal requirements than on a conventional boat. You can go straight in from a pile rust from the 70's and step on board here without any specific training requirements. Especially considering this type of energy source.*

Re: Yeah, you mean it's a little weird?

2A: Yes, it's a bit strange, because it's a big transition. I expect that we have come where the technology is ahead of the regulations, but I think there will be changes to this eventually.

Quotation 9. *2A: sometimes we have to call the ship builder or other producers for guidance, and then they often use remote control simply. It is often done. But we have also had situations where the manufacturer is simply stuck. Where they had representatives on board to troubleshoot. This one time the ship was completely stopped and taken out of route. Then the supplier of the propulsion system came on board, because the vessel simply did not start. We went through the system, but we just didn't get it. And then it was by chance that this one guy logged on to a hard drive, this was the alarm log hard drive, and on the disk there should have been a script that deletes the oldest alarms. This script missing and when the hard drive was full the whole system collapsed. So what they did was pull out a plug, put in a new hard drive and then the ship started. So with these types of things you can't use remote control, and you have to know how the system is designed just to be able to consider that hard drive. So we're dependent on the manufacturers. The problem is that service people often have to be sent from long distances, often from abroad, and it becomes a very costly affair.*

Crew & Safe Manning:

Key points:

- Competence in the crew is OK for normal operation. To few in an emergency.
- There is a need for a ship electrician.

Quotation 10. *2A: When it comes to the crew we meed someone with a more expertise in the electrical field. We sail without a ship-electrician. I think specifically that a ship-electrician would have been nice to have. But again, I want to be clear that a electrician should not replace a chief or first engineer. It should be a supplement. Not a replacement.*

Quotation 11. *Re: Next question. Suggestions for improvement?*

2A: I mentioned this with an electrical expertise, and also more data expertise. Maybe not stationed on board at all time, but a dedicated person who could follow up all the data systems. Also, it is the case that crews should be more involved in the process of development and installation. It would give more understanding. It might also have led to more thoughtful solutions. More specifically, one should take hold of experienced *personnel, including me, who have not been on installation and given the more courses and training.*

Quotation 12. *Re: Do you experience any shortages of key positions / personnel when it comes to safe manning?*

2A: It is a little strange that a fully electric boat has no requirements for a ship electrician or more electrical training on the crew. You should have personnel with some insight and greater understanding of data and the electrical processes. One should have a dedicated person to rely on in these things.

Re: Yes, just because you do not have a electrician in a crew?

2A: No, and it certainly should have been. For the systems are just getting more and more advanced ... and everything is linked together.

Commentary:

The vessel was build after a DNV standard, but does not follow the classification society inspections, but follow normal external reviews from the Norwegian Maritime Directorate.

Quotation 13. *Re: You talked about regulations. Are class companies in any way involved in operating this ferry?*

2A: No, we don't see much to them. Not since the ship was built.. It's not like on offshore boats where they have DNV hanging over their shoulders. Our charterer, The Norwegian Public Road Administration,, do not demant class approval requirements on ferries, so we rstick to regular ship control.

Re: Yes exactly, do you think class requirements would have been demanding?

2A: Yes, they often have more specific requirements, so I'm glad we can avoid it."

9.4 Appendix 4 – Interview 2B summary

Interview 2B Summary
Demographic data:
Type of vessel: Electric passenger vessel – ferry **Age and gender:** 37 year old male **Title:** Chief engineer **Experience:** 1 years on current vessel, 20 years on other vessels.
Experience & current work:
Responsibilities and tasks: Maintenance, responsibility for propulsion system, operating the engine. **Competence:** Considers his own competence as good. 8 out of 10. **Adaptiveness to new technology**: 6 out of 10. ***Quotation 1***. *Re: In regards to new technology and electric propulsion, and when you started on this vessel, did you have to adapt in the role as chief engineer?* *2B: It was a little different, a lot of electronics and stuff.* *Q: Did you have to study or update your knowledge?* *2B: Yes, it was. A lot of new systems and differences.* *Q: Did you feel that you adapted well?* *2B: Well, I do the best I can.*
Competence and education:
Education: Considers his own education as to theoretical and out-dated, but points out his schooling was a long time ago. **Training & courses:** Has not received any courses or external training on battery or electric propulsion. Has had internal training on board. **Evaluation of total education:** Considers his own competence as chief as good, but on an electric vessel he's "not on top". **Future needs:** Prefers training and educating existing crew. Would like re-training with producer with all new crew.. ***Quotation 2*** *Re: How do you perceive your competence as chief engineer on board, this in regards to education, training and courses.* *2B: Well, it's OK, but I don't really feel I'm on top.* *Re: Why not?*

2B: Well I'm quite new here, but it is very technical systems with these batteries. If something should fall out and the control system fails, its are not exactly like my old ship which I could knew better. *Re: You don't have the same understanding, is that right to say?* *2B: That might be right to say.* ***Quotation 3.** 2B: I would like more education with battery and electrical power. Now there will soon be batteries on most ships in the company.*
Vessel:
Positive to: - The ship itself is good in operation. In general there has been few problems with it. - Little noise. - Ship maneuvers and responds easily and fast. **Negative to:** - Shore based charging is not effective enough and to vulnerable for a drop in voltage. Which results in that the ferry has to skip one or two departures a day. - Would like to be able to use the emergency generator to charge the batteries. **Challenges on board:** - Uncertainty related to starting up again of the battery fails to deliver power. - Understanding alarms. ***Quotation 5**. Re: Do you become uncertain when an alarm goes off?* *2B: No, it's usually okay. But many times you do not know exactly what it is about, its explained by some numbers.* ***Quotation 6**. Re: Do you often have to call the ship builder or manufacturers for assistance?* *2B: Yes, we do. If the other shifts they do not know what it is, then we have to call the producer. Last time I called a manufacturer it was when there was a problem on land with the charging unit, and then they had to come on board. But we try to avoid calling the manufacturer because it quickly becomes very expensive.*
Safety:
Own experience: Considers his own experience as good and has worked a lot with increasing safety as chief engineer. **Safety challenges:**

- Fire in the battery's, but trusts the stationary extinguishing equipment. - Unknown alarms. ***Quotation 7.*** *2B: Of course, if a fire starts it could be quite serious. But we have good fire extinguishing systems and routines for evacuating.* *Re: So you thrust the systems?* *2B: Well, we have to. I don't worry much about that. But clearly, should a fire happen in the battery compartment then it can be disastrous.* *Re: Hard to extinguish?* *2B: Yes, but there are extinguishing systems so we have to rely on them and evacuate as soon as possible.*
Crew & Safe Manning:
Key Points: - Competence in the crew is OK for normal operation. To few in an emergency. - Considers there is not good enough reason to have a electrician on board all the time, but would like a dedicated electrician in the company to call when needed. - Would like an extra crewmember in general. Especially on deck. **Quotation 8** *2B: It would have been very good to have a dedicated ship electrician in the company that we could call. One who knew the boat, but I don't think we could argue for have one on board all the time.* *Q: No you don't think so?* *2B: No, an extra man costs a lot of money. I don't think there would have been so much to do either during a normal day. But of course in an emergency it would have been very good to have one.*
Commentary:
The vessel was build after a DNV standard, but does not follow the classification society inspections, but follow normal external reviews from the Norwegian Maritime Directorate. ***Quotation 13.*** *Re: When it comes to requirements for competence, there are several organizations that sets standards from the crew and ship. This might be authorities, the shipping company, manufacturers or class companies. Are some of the ones you find more demanding than others, something you spend more time and energy on?* *2B: No. It's a mix of all. But we do not use a class-society company.*

9.5 Appendix 5 – Interview 3A summary

Interview 3A Summary
Demographic data:
Type of vessel: Hybrid passenger vessel – high speed craft **Age and gender:** 45 year old male **Title:** Captain – D4 certificate **Experience:** 2 years on current vessel, 25 years on other vessels.
Experience & current work:
Responsibilities and tasks: Paper work, administration, operation of vessel, contact with the office. **Competence:** Considers his own competence as good. 8 out of 10. Extensive experience. **Adaptiveness to new technology**: 6 out of 10. Needs time and training with new systems. **Quotation 1**. *2A: I learn quite fast, but not as fast as my younger crew. I spend a good deal of time getting to know new systems, it doesn't just help with an instruction manual or a PowerPoint presentation. I have to use the equipment.*
Competence and education:
Education: Considers his own education as a good introduction, but a lot of the study was unnecessary. Would wish his education was more practical. **Training & courses:** Had a introduction with ship builder and battery producers, other than that no courses or training in regards to hybrid propulsion. **Evaluation of total education:** Considers his competence as good in general. Own experience is the most important. **Future needs:** Prefers training and educating existing crew. Company should hire dedicated personnel with IT and electro competence. ***Quotation 2.*** *3A: If I hadn't used the free time to read for yourself, I would never get the hang off it... There is not much training or courses we have been given. We got a good introduction with the manufacturer of the batteries, but it stopped there. All these regular safety courses are OK, although the level of the different course-centers are somewhat variable. But in general, my competence is pretty good, but there's always something to learn.* ***Quotation 3.*** *3A: We're so few people here, we are only 3 crew and I really doubt that we will get a fourth position on board. There's no economy for it. So the training of existing*

crews will probably be the only thing possible, but the shipping company should have more dedicated staff that we could relate to. For example, an electrical and data engineer who was responsible for the battery packs being placed around, one who could be a specialist in this. Same with the data items. We should have a youth who could come on board every other week and make sure everything went well. *Re: Yes, because rely on help from land?* *3A: Yes, or we rely heavily on manufacturers and others who have some bearing. On simple wifi and pc stuff we can talk to the shipping company, but as soon as there are management systems or the battery pack we have to talk to the supplier. We do that all the time.* ***Quotation 4**. 3A: After that fire you wonder a little about gas development and extinguishing. So I would wish for more training in fire extinguishing on specific plants and components. What we have on the normal safety training is very basic.*
Vessel:
Positive to: - Low emissions and impact on the environment. - The redundancy in easily switching from battery to engine power. - New vessel in general. - Running on battery in sheltered waters. - Charging battery on two locations. **Negative to:** - To many alarms in challenging weather. - Unknown alarms when regarding battery. - Maximum speed to low. - Would like the possibility to charge the battery using engine. **Challenges on board:** - Battery-power will not suffice in strong wind. - Troubleshooting faults. - Competence among the crew. - Few crewmembers. ***Quotation 5**. Re: Yeah sure, what kind of alarms are they?* *3A: There is a bit of everything, often temperatures, battery capacity and a lot of error*

messages we don't always know what is.

Re: Hehe yes there is some technical maybe?

3A: Off there are often just a lot of numbers and codes. You have to have the design system to know what it is.. If it gets too bad we just switch to clean diesel operation..

Quotation 6. *Re: What do you find challenging on board with new hybrid / electrical technology?*

3A: No, it's when things are unknown. Alarms and messages. And there is this with fire, as it just burned in Ytterøyningen.

Safety:

Own experience: Considers his own experience as good. The captain handles most of the administration and QHSE management on board.

Safety challenges:

- Few crewmembers.
- New equipment.
- High speed and challenging waters.
- Only captain with advanced safety and medical training.

Quotation 7 *Re: Does the risk of blackout apply when you are running on battery or machines?*

3A: Yes both, the most critical is when we have to switch between power sources. Fortunately, we have the engines running for a few minutes in case we need to switch back from battery power. On battery we go at max 10 knots, but it is fast in narrow waters.

Re: Have you experienced any incidents or near accidents related to this? Fire or stop?

3A: We had some black-outs in the beginning, it's better now .. What they fix I don't quite know. Fortunately we have not had fire .. but it is clear if we get something like Ytterøy we are in deep shit. The batteries are much smaller, but so is the boat and .. And we have a lot of people on board.

Quotation 8. *Re: What requirements for crew expertise do you find most demanding? Including requirements from authorities, class societies, shipping companies or manufacturers..*

3A: Well government requirement is what it is.. But it may have become a bit much, if you as an individual have to pay for the courses you have to sell your house. The ship owning company largely complies with government requirements, so if it is the case that there is no

requirement for extra training or equipment we rarely get it in this industry. It is not like in the oil industry that we can afford extra people and new equipment all the time.
Safe Manning:
Evaluation of the safe manning: - Competence in the crew is OK for normal operation. - The crew is only 3 persons. Possibly to few in an emergency. ***Quotation 9**. Re: On board your vessel, is there enough expertise within the regular crew when it comes to operating the ship and with a particular focus on the propulsion system?* *3A: In normal operation yes, but we are few people on board .. That is the big challenge on this type of boat. We are a crew of 3, where the other two crewmembers can potentially have very little expertise. As a ordinary seaman, you need virtually nothing, and as a motor man there is also little requirements. But since we are few people often have to figure things out for our selves. It's good that we are in a city a lot then, it's easy to get hold of experts and gear. As I said before, I would like someone who could follow up the ships systems from the company. Like software and stuff like that.* *Re: But you can also sail with 2 crew or? I thought i read that somewhere..* *3A: Yes, if we are little passengers we can go differential or what it is called. Then we go with a motor man and ordinary seaman in a combination role.* *Re: It may not be desirable?* *3A: No, here we have to keep the few persons we are.* *Re: But is the expertise good enough in emergencies?* *3A: Well, we could have needed a fourth man with evacuation and certainly more competence if there will be troubleshooting and difficulties with propulsion and steering systems. Optimally, I should have had a navigator and a certified engineer, but there is no requirements for that. But you know I'm the only one with IMO 80 on board. And in transit I can't leave the bridge, so if something happens then maybe we have to take the patient up on bridge?*
Commentary:
The normal crew is of tree persons, however with few passengers the vessel is allowed to sail with a crew of 2 persons. As a high speed craft the vessel is allowed to sail with a motor man instead of a engineer. This as long as the effect does not extent 1500 KW.

Quotation 10. *Re:..do you experience any other shortages of key positions / personnel when it comes to crewing the ship?*

3A: We could always have use for an extra person .. But we should have easier access to an expert or specialist. We also sail without a engineer, and it's a bit strange in these waters. After all, its not sheltered water.

Q: Yes this is perhaps certified for sailing are zone 4?

3A: Yes, she's actually approved for 5 then.

Q: Yes, exactly, so you think it might have been wise to have a certified engineer on board?

3A: Well, the motor man we have is very good, so no problem there. But if we had got a new one I would probably prefer a engineer with more education. We have a lot of passengers on board, and advanced equipment. Modern engines and batteries also require some insight into automation.

Q: Yes, you don't have a machinist since it is under 750 kw per machine?

3A: Yes the machine is de-rated to 749 kw each, and then we have 2 separate engine rooms.

Q: Okay, but with this type of boat with 2 machines and battery operation you might want to have had a machinist?

3A: Yes, you at least depend on good electrical and engine knowledge.

9.6 Appendix 6 – Interview 3B summary

Interview 3B Summary
Demographic data:
Type of vessel: Hybrid passenger vessel – high speed craft **Age and gender:** 44 year old male **Title:** Motor Man – certificate of apprenticeship. **Experience:** 2 years on current vessel, 20 years on other vessels.
Experience & current work:
Responsibilities and tasks: Routines, passenger handling, mooring and lookout on bridge. **Competence:** Considers his own competence as good enough. 7 out of 10. Several years of experience. **Adaptiveness to new technology**: 6 out of 10. Needs time and is not personally interested in new development. But handles it OK. ***Quatation 1**. Re: On a scale of 1 to 10, how adaptable are you to new technology in the maritime industry? Do you want to explain your choice?* *3B: No, it's average. There's a lot to get into, and I'm not particularly interested in new tech. Of course, things go slow sometimes, but it's usually okay.*
Competence and education:
Education: Considers himself as a "lightweight" in regards to education. Has no higher education, but high school and a certificate of apprenticeship as a motor man. Considers his competence is from experience. **Training & courses:** Only required safety courses, has no specific courses or education on electric propulsion. **Evaluation of total education:** Considers his competence as good, much based on experience. Would prefer more training in troubleshooting and education on equipment and propulsion. Would also like more advanced safety courses. Hereunder IMO 80. **Future needs:** With current regulations the company should train and educate existing crew. ***Quotation 2.** Re: Well with the package you have now then, education, training and courses. Is it good or lacking in relation to the job you have?*

3B: The boat is getting more advanced, so I might want some troubleshooting courses from those who make the equipment. I don't always manage just with scrolling through a manual.

Re: So in relation to your job, how do you value your expertise?

3B: In normal operations, things go well, but sometimes I do get stuck.

Re: Anything in particular you would like more training on?

3B: No, it may be computer systems or just this with the passengers. I only have regular safety training courses as a motor man.

RE: Yes, you could think of more first aid and stuff?

3B: Yeah, that's just something we've talked about. Here it is only the skipper who has advanced safety training, and he can't leave the bridge. In basic safety training you learn the most necessary, but you also learn more with rescue equipment and stuff in IMO 80.

Re: Yes, it is probably a more comprehensive course. How do you perceive your overall competence including experience, that is, in addition to education, training and courses?

3B: It's pretty good, its my experience I rely on. There hasn't been much education in the past 20 years.

Quotation 3. Re: How can a company best meet and apply new technology in relation to employee competence? Are courses or new hires the best for example?

3B: The shipping company must adhere to rules, but it will not surprise me if there will come more strict requirements for certificates on board these vessels in the future. A engineer or an extra navigator for example, and if that is the case you have to hire someone.

F: But considering how the regulations are today. Is it best to train or hire new ones?

3B: The shipping company always follows minimum requirements, its all about money, so maybe they should train us more.

Vessel:

Positive to:

- Low emissions and impact on the environment.
- New vessel in general.
- Running on battery in sheltered waters.
- Redundancy in being able to switch of electric propulsion.

Negative to:

- Electric capacity in challenging weather.

- Unknown alarms when regarding battery.

Challenges on board:

- Uncertainty with unknown alarms.

- Battery capacity in strong wind and challenging weather.

Quotation 4*. Re: What do you find challenging on board with new hybrid / electrical technology?*

3B: No, it is understand all the systems and often error messages.

Re: Are there a lot of alarms and messages?

3B: Well, there are some from battery, but then it is reassuring to be able to switch to the engines. Also, there are common alarms.

Re: Do you have control of all the alarms then?

3B: No, I don't always have it. I often wonder a lot. Often you understand what it is about, but what to do next is worse. If there is too much alarms with the battery and PMS system, we disconnect it. But in general the system functions fine.

Safety:

Own experience: Considers his own experience as average. The ship owners are the most demanding of the crew in regards to safety for ship and crew, often on behalf of the Norwegian Maritime authorities. Vessel is not inspected or followed up by class-societies.

Safety challenges:

- Potential black-out, especially with high speed and coastal navigation.

- Lack of understanding of ship systems.

- Few crew.

- When doing bridge look out duty, 3B is often not allowed to leave the bridge.

Quotation 5 *Re: Do you experience any safety challenges with the aspects of hybrid / electric propulsion technology?*

3B: It's keeping the systems up and running. If there is a downtime or black-out, things can quickly go wrong.

Re: Is it more challenging in hybrid and electric, do you think?

3B: I do not know, but you do not have the same understanding of electronics as with the engines.

Re: Yes, you do not have the same expertise in those fields?

3B: Yes you can say that. Fortunately, there's not much to do with the batteries, but that's if things go wrong. Then we just have to plug in the machines. *Re: Is there anything you are afraid of here?* *3B: It must be that the batteries fail and it takes time to get the engines up and running. Or if it will be black-out in narrow waters..*
Crew & Safe Manning:
Key points: - Competence in the crew is OK for normal operation, in an emergency there is a shortage in technical knowledge of engines, battery and power systems. - To few crewmembers. Only 3 persons. ***Quotation 6****. Re: With safe manning on board your vessel, is there enough crew and competence within when it comes to operating the ship and with a particular focus on the propulsion system?* *3B: Well on the propulsion system it is mostly me, as we have one motor man. I have to be honest to say I can feel a little light at times. I do not know if a engieer straight from school could have done better, it might not be necessary with a certified engineer, but I have little technical knowledge about power systems and battery operation.* *Re: Do you experience any shortages of key positions / personnel when it comes to ship manning?* *3B: We usually go with a crew of 3, me, the skipper and a ordinary seaman. Actually, we should always be 2 on bridge as a high speed craft. We can have 60 - 70 - 80 passengers on board, so if something goes really wrong we are far too few people.* *Re: Yes you are thinking of a emergency?* *3B: Yes, fire or if we go aground. At least if we have to evacuate and stuff..* *Re: Yes, fire and gas development are a bit in the wind after Ytterøyningen.* *3B: Yes, that was terrible stuff. If there is a fire in the batteries here we just have to evacuate.* *Re: Yeah, you have then thought about it?* *3B: I would like more training on troubleshooting and follow-up of the systems. And more knowledge about fire extinguishing and the gas produced..*
Commentary:

The normal crew is of tree persons, however with few passengers the vessel is allowed to sail with a crew of 2 persons. As a high speed craft the vessel is allowed to sail with a motor man instead of a engineer. This as long as the effect does not extent 1500 KW.

Quotation 7. *Re: ..But you always sail with 3 persons?*

3B: Yes, we are actually allowed to go without the deck-hand, then the motor man can function in a combination role. But then we have to take less passengers.

Re: But since you are already too few people, I guess this is not desirable?

3B: No, that would be crazy. You should always be 2 on the bridge I demanding waters, so it will not be possible.

9.7 Appendix 7 – Interview 4A summary

Interview 4A Summary
Demographic data:
Type of vessel: Hybrid offshore vessel, diesel electric with battery package **Age and gender:** 34 year old male **Title:** Chief officer – D1 license. **Experience:** 1 years on current vessel, 13 years on other vessels.
Experience & current work:
Responsibilities and tasks: Management of deck operations and safety on board. **Competence:** Considers his own competence as good. 8 out of 10. **Adaptiveness to new technology**: 8 out of 10. Takes things easily. ***Quotation 1****. Re: On a scale of 1 - 10, how adaptable are you to new technology in the maritime industry, when new technology is introduced?* *A4: For my part it is quite high, but it varies, it is very person dependent. Of course, we are of the younger generation, so we have an easier time getting into thing. But for the older crew it is perhaps more difficult. For my part it is around an 8.*
Competence and education:
Education: Considers his education as good, but out-dated. **Training & courses:** No extra education or training with battery and hybrid propulsion. **Evaluation of total education:** Considers his average in regards to hybrid propultion, 6-7 out of 10. Dependent on other crewmembers with technical questions. **Future needs:** The ship owner company should train and educate existing crew. ***Quotation 2.*** *Re: But education in terms of relevance to hybrid operation and battery pack?* *4A: Well its been a while since I went to school. So all this is new, it's only 3-4 years since they started building hybrid packages, at least for offshore vessels. When I went to school, it was not like how it is today.* *Re: So I guess you didn't have that much about it?* *4A: No, we had regular engine learning. How the engines are built.* *Re: Have you received much training on hybrid energy in hindsight?* *4A: No, I haven't got it yet.* *Re: Would you like more?* *4A: Maybe about what to do and what goes on if there is a fire in it.*

Vessel:
Positive to: - Having the battery as a back up if the engines fail. A extra safety when under the platform. - Saves fuel and money. - Less running hours and maintenance on engines. - The crews competence. **Negative to:** - Battery containers location. **Challenges on board:** - A lot of new systems to learn. ***Quotation 3****. Re: What do you find challenging on board with new hybrid / electrical technology?* *4A: Nothing special. Of course there are things, there are, after all, electrical components. But as I said, I haven't studied this very much, so it's a bit difficult to answer exactly what. But there is data and electrical components, and all data is critical components, no matter what we are doing.* ***Quotation 4:*** *Re: So it requires that you study the systems by yourself?* *4A: Yes, that's necessary with and without battery. You have to know how things work anyway, because no ships are the same.* ***Quotation 5.*** *4A: With the battery its really like we have a fifth engine..*
Safety:
Safety evaluation: Safety on board and in the offshore industry is very good. **Safety challenges:** - Black out, especially under rig operations. ***Quotation 6.*** *Re: Are you experiencing any safety challenges in regards to hybrid and electric propulsion technology?* *4A: Not what I know of. The engine department may have more info there, but for my part I have neither heard nor experienced myself.* *Re: Is there anything you are afraid of here?* *4A: No, it's not. Not that I feel anyway.* *Re: Anything you focus extra on then?*

4A: We have trained and discussed a fire in the battery-container. We have stationary systems that will help, but they have to be activated early in the process. Especially after that ferry had an explosion. ***Quotation 7.*** *Re: What is the most demanding for crew and ship requirements? Including requirements from authorities, class society's, ship owner or manufacturers.* *4A: It is general mix, there is nothing specific to each one. Can't say it's anything challenging. Not as I've noticed, but I don't have much experience outside of this industry here. Then I don't have much to compare with. But, it is class companies that mainly follow up the ship.* ***Quotation 8****: Re: So you in offshore have security conscious clients?* *4A: Yes, the offshore industry is on top when it comes to safety, and its the first priority. We always keep that in mind when we perform jobs.*
Crew & Safe Manning:
Key points: - Competence in the crew is good and access to expertise is easy. - Good to have extra crew. ***Quotation 9.*** *Re: Do you experience any shortages of key positions / personnel when it comes to ship manning?* *4A: For our part, we have more people on board than the minimum safe manning says we should have. We have an extra mate on board, then we have an extra navigator and an extra engineer. So we are actually more people than we need given what the safe manning list indicates.* *Re: Is it a client's wish, or something the ship owner demands for himself?* *4A: It is basically set up so that we always have to be two men on the bridge when we are under the rig and there should be two men on the deck, there are client requirements. So the staffing is basically a mix between what the company wants and what the clients say.* ***Quotation 10****. Re: I was just wondering if you guys follow the current crew number all the time? Or if you ever head to sea with a man short..* *4A: No, I've never experienced it. Then they may have to ask for approval to go out without an extra man.* *Re: You are three extra men then, so you want to say you are well covered? Would you feel that you were not covered so well if you had just gone out with the minimum safe manning?*

4A: You manage to sit up on bridge alone, but at the same time it is something to be two because then you have that backup. You the have more eyes and two heads to observe if something happens. So you have a good backup in the guy you are sitting with. You feel more confident with having that extra man with you.
Commentary:
The battery unit was payed for by the charterer. **Quotation 8.** *Re: ..But the ship owner didn't pay anything. It was the charterer that payed the whole bill.*

9.8 Appendix 8 – Interview 4B Summary

Interview 4B Summary
Demographic data:
Type of vessel: Hybrid offshore vessel, diesel electric with battery package **Age and gender:** 32 year old male **Title:** First engineer – M1 license. **Experience:** 2 years on current vessel, 9 years on other vessels.
Experience & current work:
Responsibilities and tasks: Maintenance and monitoring power/propulsion systems. **Competence:** Considers his own competence as good. 7 out of 10. **Adaptiveness to new technology**: 7 out of 10. It may take some time, but figures it out eventually. ***Quotation 1****. Re: On a scale of 1 to 10, how adaptable are you to new technology in the maritime industry?* *4B: Maybe a 7er, I usually get it. But it does take some time.*
Competence and education:
Education: Considers his education as good, but outdated. Competence gained with experience. **Training & courses:** No extra education or training with battery and hybrid propulsion. Except high-voltage certificate. **Evaluation of total education:** Considers his average in regards to hybrid propulsion, 6 out of 10. Would like more courses and education. **Future needs:** With current regulations the company should train and educate existing crew. ***Quotation 2.*** *Re: How do you perceive your overall competence including experience, in addition to education, training and courses?* *4B: With hybrid propulsion? Average maybe, 6 out of 10.* *Re: What do you perceive as your "weakest pages" or lack of expertise?* *4B: Well, what should I say. The lack of training and competence development in general.* *RE: What would you like more of then?* *4B: More technical focus on battery packs and control system.* *Re: I guess you got an introduction with the installation of the battery pack?*

4B: Didn't seem like they knew much the guys that installed it either. The project was inadequately managed. This was one of the first ships that the yard rebuilt for battery energy, so it was a little try and fail. *RE: Have others on board been given any courses or specific training?* *4B: No. The chief and the electrician had a tour at the shipyard.* *RE: But they got an instruction?* *4B: Those who installed had one, but it was very basic. I didn't get that much out of it.* *Re: Why?* *4B: It was just one message, keep your fingers away. But it is not much maintenance that is required. It is a separate powerboard and the whole system is separated.*
Vessel:
Positive to: - Low emissions and impact on the environment. - Saves fuel and money. - Less running hours and maintenance on engines. **Negative to:** - Lack of training and education. - Unknown alarms when regarding battery. - The alarm panel for battery unit is not in the engine control rom. - The battery containers position on board. **Challenges on board:** - Uncertainty with fire extinguishing systems. ***Quotation 3****. Re: What do you find challenging on board with new hybrid / electrical technology?* *4B: Well, it would the be a lack of training and competence.* *re: So there is a lack of understanding?* *4B: Yes, we have the basics, but I think in particular about technical maintenance and insight in the systems.* *Re: So lack of technical insight and being able to do maintenance is challenging?* *4B: Yes, and especially when you think about if something goes wrong. After all, I don’t think we know enough about fire safety. We have CO2 and can fill the container with water, so it should be taken care of. But if the batterycells burn, we can't extinguish them, and if*

gas is formed over time and spreads.. I don't quite know. It may help to fill water. *Re: It should cool down to some degree and keep a pressure ?* *4B: Hehe, I guess it gets so hot that the whole container will boil.*
Safety:
Safety evaluation: Considers his own experience as good, safety is considered in all actions on board.. In regards to safety demands the clients are most demanding. **Safety challenges:** - Uncertainty with a potential fire. - Position of battery container in a potential fire. Close to living quarters and close to evacuation platform. - Potential black-out. - When doing bridge look out duty, 3B is often not allowed to leave the bridge. ***Quotation 4.*** *Re: Are you experiencing any safety challenges in regards to hybrid and electric propulsion technology?* *4B: Well, if its a fire. How it behaves. We do not know. You know, chlorine gas is formed.* *Q: So, do you think of gas formation that can lead to explosions?* *4B: Yes, it can happen. Just look at the ferry that exploded. And our battery is located just below the living quarters. So it is too close.* *F: Yes, that's not ideal?* *4B: No, and in addition it stands in the middle of the fleet stations. So if we have to evacuate because of it, we will probably come to close. It should have been more screened more and located further aft.* ***Quotation 5****. Re: What requirements for crew expertise and the ship do you find most demanding? Including requirements from authorities, class-society's, ship owner or manufacturers.* *4B: No, there is not really pressure from authorities or ship owner. That's more minimum requirements. The clients tend to be better at demanding different skills and training.* *Q: Yes the clients set a higher standard?* *4B: Well without the clients' demands we would have been without both battery-package and extra crew.*
Crew & Safe Manning:
Evaluation:

- Competence in the crew is good in normal operations, but the engineers lack competence and training in regards to battery and electrical power. The electrician on board has gotten more to do after the battery was installed.

- Considers the safe manning to low. Values having extra crewmembers on board.

Quotation 6. *Re: Do you experience any shortages of key positions / personnel when it comes to the ship manning?*

4B: Not so much in the gang we actually have on board. But the minimum safe manning is damn low. It is a crew of 6-7, but we are 13 on board now. Over twice the required, and everyone has something to do.

Re: So you mean the safe manning requirement is too lov? Would it be possible to sail the vessel with 7 persons?

4B: Well .. You could move from A to B, but if something happens there is not much you can do. In case of fire with only the minimum safe manning, it is propably best just to evacuate.

Re: I guess there might not be a lot of smoke divers available. Is an electrician part of the safety staff?

4B: Yes, he's part of the safe manning. We cannot sail without him, but there are similar vessels without electricians in the safe manning.

Re: So a modern vessel of this type depends on having a electrician?

4B: Yes absolutely, although there is not always a requirement for it. For example, I have a friend who is chief on board a cargo vessel that is chartered by a petroleum service company.. It is an older vessel that was rebuilt, now with battery and gas propulsion.

Re: That sounds expensive.

4B: Yes, of course. But there they would not update the safe manning requirements and the ship owners wanted to sail without a electrician. So there were a lot of problems at first, but then my friend refused to continue without one. So after some pressure they hired a one.

Quotation 7. *Re: How has the crew adapted to the new hybrid / electrical technology?*

4B: Not that much, but there was a lot to study and get into. However, it involved a lot more for the ship electrician to follow up. For us engineers it is not that much. The battery-unit behaves much like a generator, it is controlled by PMS. So it's easy to operate.

Re: But the electrician has got a lot more to follow up?

4B: Yes, the electrician has had a lot more to do, but there isn't that much work with it. There is a lot of surveillance on it then, as if something goes wrong, the electrician often takes it with the producer.
Commentary:
The battery unit was payed for by the charterer.

9.9 Appendix 9 – Notice of concern regarding MV Ytterøyningen from DNMF

Sjøfartsdirektoratet

post@sdir.no

06.11.19

BEKYMRINGSMELDING FERJER MED BATTERIDRIFT

MF «Ytterøyningen» har 4 Nogva Scania DI 16 43 M dieselmotorer som hver har en ytelse på 441 kW, totalt 1764 kW og er koblet til 2 Schottel STP 330 propellanlegg fremdrift, senere ombygd til hybrid drift på diesel og batteri, med en batteripakke på 1998kw/h.

Etter Dnmf sine opplysninger har MF «Ytterøyningen» et bemanningssertifikat som kun krever Maskinpasser.

Den 10. oktober 2019 var fergen MF «Ytterøyningen» utsatt for brann med dertil eksplosjon i batteripakken om bord. Skadene er omfattende og slukkearbeidet for brann og rednings etat var krevende med evakuering både av ferjemannskap og beboere i området rundt.

Det er sterkt bekymringsverdig at kvalifikasjons krav på MF «Ytterøyningen» er maskinpasser når samlet kW er over 750 Kw, etter DNMF sin oppfatning i strid med regelverket;

Forskrift om kvalifikasjoner og sertifikater for sjøfolk § 80.Motormann som ikke skal ha ferdighetssertifikat og maskinpasser

Motormann som ikke skal ha ferdighetssertifikat motormann og som ikke har fagbrev, samt maskinpasser, skal ha minst seks måneders tjenestetid i maskin og 30 måneders tjenestetid som nevnt i § 77.

Lov om skipssikkerhet § 16 fastslås det at de som har sitt arbeid om bord skal inneha de kvalifikasjoner som kreves for det aktuelle arbeidet som skal utføres om bord.

I bemanningsforskriften § 9 pkt. 2 fastslås det videre at Sjøfartsdirektoratet kan i det enkelte tilfelle kreve sertifikat for å gjøre tjeneste som maskinoffiser på skip med mindre fremdriftsmaskineri enn nevnt i første punktum, dersom skipets type, virksomhet, type maskineri, dets tekniske utstyr, fartsområde, operasjonsområde eller andre spesielle sikkerhetsmessige forhold gjør det nødvendig.

Dnmf kan ikke se at en Maskinpasser oppfyller disse kravene til kompetanse om tjeneste, farer, risiko og behandling av batterier.

Det vises også til Sjøfartsdirektoratet sikkerhetsmeldingen av 14. oktober 2019:

Alle rederier som bruker batterisystemer, bør foreta en risikovurdering basert på rådene i den oppdaterte sikkerhetsmeldingen.

Risikovurderingen bør identifisere mulige nødssituasjoner om bord, f.eks. brann, vannfylling, kollisjon osv.deretter innføre prosedyrer for reaksjoner i nødssituasjoner samt opplærings- og øvelsesprogrammer for å håndtere slike situasjoner.

DNMF vil påpeke at det fra rederiets side ikke er kav til vakthold om bord i ferjene i perioden mellom ruteslutt og rutestart. I praksis betyr dette at alt mannskap kan forlate ferjen og den ligger da uten vakthold. Dersom det skulle oppstå en hendelse eller forvarsel i denne perioden så vil det ikke være mannskap om bord til å varsle eller starte bekjempelse. Dette strider etter Dnmf sin oppfatning mot Forskrift om bemanning av norske skip

§ 8.Forslag til sikkerhetsbemanning

(3) Den sikkerhetsbemanning som foreslås skal dekke alle aktuelle operasjoner, oppgaver og funksjoner for sikker operasjon av skipet, herunder

a) vakthold både på sjøen og ved ***landligge****, samt sikkerhets- og beredskapsøvelser*

DNMF vil med dette sterkt anmode Sjøfartsdirektoratet til å kreve at alle ferger med batteripakke bemannes iht. regelverket med sertifiserte maskinoffiserer med nødvendig tilleggs kompetanse, selv på ferger med fremdrift under 750kw slik at sikkerheten for skip, passasjerer, mannskap og ytre miljø ivaretas.

9.10 Appendix 10 – DNMF complaint regarding MV Ampere

Sjøfartsdirektoratet
Norwegian Maritime Authority

Vår dato	Vår referanse	Vår saksbehandler
07.09.2015	2014/62594-4	Inger Staveland
Deres referanse	Arkivkode	Direkte telefon
	57/027647	52 74 52 41

Nærings- og fiskeridepartementet
Postboks 8090 Dep.
0032 OSLO

AMPERE LFEA - Bemanning - Klage

Sjøfartsdirektoratet viser til klage og utfyllende klage av 19. og 24 november 2014 fra Det norske maskinistforbund (heretter Dnmf eller klager) (vedlegg 1) over Sjøfartsdirektoratets vedtak om sikkerhetsbemanning for Ampere LFEA av 18. november 2014 (vedlegg 2).

Etter forvaltningsloven[1] § 28 kan et enkeltvedtak påklages av en part eller en annen med rettslig klageinteresse. Dnmf representerer de ansatte om bord og har rettslig klageinteresse. Fristen for å klage er tre uker fra parten har fått melding om vedtaket. Vedtaket ble sendt til parten med kopi til klager den 18. november 2014 og klagen ble sendt dagen etter den 19. november 2014. Klagen er fremsatt i tide.[2]

Konklusjon
Sjøfartsdirektoratet opprettholder vedtak av 18. november 2014 om sikkerhetsbemanning på Ampere LFEA. Saken oversendes Nærings- og fiskeridepartementet for endelig avgjørelse, jf. forvaltningsloven § 33 fjerde ledd.

Sjøfartsdirektoratet beklager at det har gått lang tid fra klagen ble mottatt til saken er ferdig behandlet her hos oss. Vi har hatt dialog med klager om status i klagesaken.

Sakens bakgrunn
Rederiet Norled AS søkte den 10. oktober 2014 om vedtak om sikkerhetsbemanning for Ampere LFEA. Passasjerskipet var ferdigstilt i 2014. Rederiet søkte først om sikkerhetsbemanning med én fører, én overstyrmann, én maskinpasser, én matros og én lettmatros (vedlegg 3). Den 14. oktober sendte Norled en revidert søknad hvor det ble opplyst at de hadde glemt å søke om differensiert bemanning i den opprinnelige søknaden. Rederiet sendte derfor inn ny søknad hvor det var inntatt at lettmatros kan sløyfes når passasjerantallet er 149 eller mindre (vedlegg 4).

Den 5. november 2014 sendte rederiet uttalelse signert de tillitsvalgte fra Det norske maskinistforbund, Norsk Sjøoffisersforbund og Norsk Sjømannsforbund (vedlegg 5). De tillitsvalgte ga i sin uttalelse uttrykk for at det var nødvendig med maskinoffiser med minimum kompetansesertifikat klasse to om bord på Ampere LFEA. Skipsfører uttalte seg om den omsøkte bemanningen i sin kommentar av 7. oktober 2014 som var vedlagt søknaden av 10. oktober 2014. Også skipsfører anførte at det burde være maskinoffiser i bemanningen.

[1] lov om behandlingsmåten i forvaltningssaker av 10. februar 1967
[2] Jf. forvaltningsloven §§ 29 og 30

NIS//NOR

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Tlf: 52 74 50 00
Faks: 52 74 50 01
Organisasjonsnr: NO 974 761 262 MVA
Besøksadr.: Smedasundet 50 A N-5528 HAUGESUND
E-post: post@sdir.no
Internett: www.sjofartsdir.no

Sjøfartsdirektoratet hadde deretter muntlig korrespondanse med rederiet med bakgrunn i dissensen mellom rederiet og skipsfører og de tillitsvalgte. Fremdriftsmaskineriet på Ampere LFEA var opprinnelig 900 kW, men maskineriet var ved levering redusert til 749 kW. Det fremgår av søknaden fra rederiet og på side 36 i rapporten fra Siemens i søknadens vedlegg.

Rederiet imøtegikk skipsfører og delvis organisasjonenes innspill. Opprinnelig effekt for fremdriftsmaskineriet på 900 kW ble derfor tatt i sikkerhetsbemanningen med tilhørende krav om maskinoffiser med minimum kompetansesertifikat klasse tre.

Sjøfartsdirektoratet fattet vedtak den 18. november 2014. Sikkerhetsbemanningen ble satt til én fører D3, én overstyrmann D3, én maskinsjef M3, én matros og én lettmatros som kan utelates når passasjerantallet ikke overstiger 149.

Den 19. november 2014 mottok Sjøfartsdirektoratet klage over vedtaket fra Dnmf. Klagen ble begrunnet i e-post av 23. november 2014.

Klagers kommentarer
Dnmf mener at Sjøfartsdirektoratets vedtak om sikkerhetsbemanning av 18. november 2014 må oppheves.

Klager mener at rederiets søknad er mangelfull. Det vises til at rederiets søknad om å bemanne skipet med maskinpasser ikke respekterer regelverket. Dnmf anfører at skip med likestrøm, uansett volt, skal bemannes med elektriker eller minst en maskinoffiser med klasse M2 for at det skal være tilstrekkelig kompetanse om bord. Klager er videre av den oppfatning at rederiet ikke har fylt ut kontrollskjema KS0308-1 B på riktig måte. Til slutt peker klager på at rederiets begjæring om differensiert bemanning ettersendes i en e-post.

Sjøfartsdirektoratets vurdering
Etter skipssikkerhetsloven[3] § 15 skal et skip være bemannet på en sikkerhetsmessig forsvarlig måte. Det er rederiets ansvar å sørge for at bemanningen er sikkerhetsmessig forsvarlig jf. skipssikkerhetsloven § 6 andre ledd. Det er rederiet som driver skipet og som har best forutsetninger for å vurdere hvilken sikkerhetsbemanning som er forsvarlig.

Hva som skal til for at skipet skal være sikkerhetsmessig forsvarlig bemannet er nærmere beskrevet i skipssikkerhetslovens forarbeider[4]. Skipet må i alle fall tilfredsstille kravene til minimumsbemanning. Det er likevel ikke alltid minimumsbemanningen oppfyller kravet om en sikkerhetsmessig forsvarlig bemanning. I de tilfeller minimumsbemanningen ikke anses å være tilstrekkelig er det viktig at rederiet vurderer om det er nødvendig med tilleggsbemanning. Vurderingen om å ha ekstra personell om bord i de tilfeller sikkerhetsbemanningen alene ikke kan utføre alle operasjoner må gjøres ved førstegangs drift og fortløpende[5].

Bemanningsforskriften[6] er gitt med hjemmel i skipssikkerhetsloven og forskriften gir mer detaljerte bestemmelser om fastsettelse av bemanning.

Det er rederiet selv som fremsetter forslag om sikkerhetsbemanning og kriteriene som skal ligge til grunn for søknaden er listet opp i bemanningsforskriften § 8. Etter bemanningsforskriften § 4 første ledd bokstav b skal rederiet ved bemanningssøknad sende inn dokumenterte synspunkter fra skipsfører og tillitsmannsapparatet. Rederiet skal synliggjøre at det har vært en dialog i forkant av bemanningssøknaden. Det er imidlertid ikke et krav om at det skal foreligge enighet.

Hovedregelen for maskinrom er at det skal være maskinoffiser på skip med fremdriftskraft mer enn 750 kW[7]. Klager viser for det første til at rederiets søknad om å bemanne skipet med maskinpasser ikke respekterer regelverket. Dnmf anfører videre at skip med likestrøm, uansett volt, skal bemannes med elektriker eller minst

[3] lov om skipssikkerhet av 16. februar 2007
[4] ot.prp. nr. 87 (2005-2006) s. 113-114
[5] jf. bemanningsforskriften § 12
[6] forskrift nr. 666 om bemanning av norske skip av 2009
[7] Jf. forskrift nr. 1523 om kvalifikasjoner og sertifikater for sjøfolk av 2011 § 3 (2) og bemanningsforskriften § 9 (2)

en maskinoffiser med klasse M2 for at det skal være tilstrekkelig kompetanse om bord. Klager oppfatter at Sjøfartsdirektoratet og organisasjonene er enige i denne påstanden.

Fremdriftsmaskineriet på Ampere LFEA var opprinnelig 900 kW. Rederiet søkte imidlertid om at skipet ble bemannet med maskinpasser og viste til dokumentasjon fra Siemens om effektreduksjon til 749 kW. Ettersom skipsfører og de tillitsvalgte var i mot at skipet ble bemannet med maskinpasser besluttet rederiet å legge til grunn opprinnelig effekt på 900 kW. Det ble derfor i tråd med praksis og regelverket satt inn maskinoffiser med minimum kompetansesertifikat klasse tre i sikkerhetsbemanningen[8].

Sjøfartsdirektoratet presiserer for ordens skyld at vi på grunn av overnevnte legger til grunn at fremdriftsmaskineriets effekt på Ampere LFEA er 900 kW og at vi ikke har tatt stilling til om dokumentasjonen om effektreduksjon er i henhold til våre krav i RSV 04-2011. Vi ser derfor heller ikke grunn til å kommentere klagers anførsel om maskinpasser i sikkerhetsbemanningen.

Klager anfører videre at skip som har anlegg med likestrøm skal bemannes med elektriker eller minst en maskinoffiser med kompetansesertifikat klasse to. Sjøfartsdirektoratet antar at begrunnelsen for påstanden er at høyspentkompetanse inngår i sertifikatene for skipselektrikeroffiser og maskinoffiser med kompetansesertifikat klasse to. Det er ikke regulert i gjeldende forskrifter hva som regnes som høyspent. Direktoratet antar at Dnmf viser til at det i bemanningsforskriften av 1987 var tatt inn en anbefaling om at det ble vurdert om det var behov for elektriker i sikkerhetsbemanningen dersom spenningen var over 1000 volt eller dersom det var likestrømsanlegg. Denne anbefalingen ble ikke videreført i gjeldende bemanningsforskrift fordi det var en anbefaling, og ikke et krav[9] (vedlegg 6). Sjøfartsdirektoratet presiserer at vi ikke er enige i påstanden fra Dnmf slik det anføres i klagen. Det er rederiet som må vurdere hvorvidt det ut fra det elektriske anlegget om bord bør være skipselektriker eller maskinoffiser med høyere kompetansesertifikat i sikkerhets- og/eller tilleggsbemanningen.

Klager er videre av den oppfatning at rederiet ikke har fylt ut kontrollskjema KS0308-1 B på riktig måte. Kontrollskjemaet klager viser til er en sjekkliste som bygger på bemanningsforskriften § 8. Rederiet skal i kontrollskjemaet bekrefte at de opplistede punktene i bemanningsforskriften § 8 er vurdert ved søknad om sikkerhetsbemanning. Sjøfartsdirektoratet kan ikke se at noen av de punktene klager peker på kan tilsi at bemanningsforskriften § 8 ikke er oppfylt. Klagers innvending synes generelt å være at det må tas særskilte hensyn i bemanningsfastsettelsen fordi Ampere LFEA har batteridrift. Det er rederiet som må vurdere om besetningen behøver ekstra kompetanse på grunn av batteridrift[10]. Sjøfartsdirektoratet har ikke hjemmel i gjeldende regelverk til å kunne kreve særskilte kvalifikasjonskrav for besetningen på skip med batteridrift.

Sjøfartsdirektoratets vurdering er at vedtaket om sikkerhetsbemanning er tilstrekkelig og i henhold til kravene i skipssikkerhetsloven og underliggende forskrifter.

Til slutt peker klager på at rederiets begjæring om differensiert bemanning ettersendes i en e-post. Dette har ikke betydning for direktoratets vedtak ettersom begjæringen ble fremmet under saksbehandlingen og før det ble fattet et vedtak om sikkerhetsbemanning. Vi kan ikke se at det ikke er adgang til å gjøre ønskede eller nødvendige justeringer eller endringer i løpet av saksbehandlingen slik klager anfører. Endringen som ble gjort i fremdriftsmaskineriets effekt og tilhørende stilling i bemanningssertifikatet i denne saken er også et eksempel på at det ikke alltid er samsvar mellom rederiets søknad og endelig bemanningsvedtak. Det avgjørende for Sjøfartsdirektoratets vurdering er at vi mottar tilstrekkelig dokumentasjon og at eventuelle endringer er i henhold til regelverket slik at den endelige bemanningen er sikkerhetsmessig forsvarlig.

Etter direktoratets vurdering har vi mottatt tilstrekkelig dokumentasjon fra rederiet før vedtak om sikkerhetsbemanning ble fattet. Direktoratet kan ikke se at det foreligger holdepunkter for at bemanningsforskriften § 8 ikke er fulgt. Sikkerhetsbemanningen er fastsatt i henhold til de krav som fremgår av skipssikkerhetsloven § 15, jf. bemanningsforskriften.

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[8] jf. bemanningsforskriften § 9 (2) jf. kvalifikasjonsforskriften § 39 andre ledd
[9] Jf. forskrift nr. 175 om bemanning av norske skip av 1987 § 4 nr. 8 og RSR 11-2009
[10] jf. skipssikkerhetsloven § 6 (2) jf. § 15, jf. bemanningsforskriften § 8.

Sjøfartsdirektoratet
Norwegian Maritime Authority

Sjøfartsdirektoratet opprettholder vedtak av 18. november 2014 om sikkerhetsbemanning på Ampere LFEA.

Saken oversendes til Nærings- og fiskeridepartementet for endelig avgjørelse, jf. forvaltningsloven § 33 (4).

Med hilsen

Olav Akselsen
sjøfartsdirektør

Lars Alvestad
avdelingsdirektør

Dette dokumentet er godkjent elektronisk, og har derfor ikke håndskrevne signaturer.

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