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Safety Legislations and Standards for Offshore Lifting and Transportation of Wind Turbine Components

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Abstract:

This project was conducted to explore the relevant legislations, standards, and authorities which influence the safety of personnel during the lifting and transportation of wind turbine components from Danish harbours to offshore installation sites, as well as to analyse if the legislations and standards could be augmented. Hence, information relating to the topic was collected via exploratory research, and was then supplemented by three interviews with industry familiars to gain insight from a practical perspective.The findings of the exploratory research and the interviews were that: (1) the IMO, EU, and DMA dictate safety during transportation (2) the DEA, DS, and WEA stipulate the safety of lifting procedures (3) both ISO and OHSAS provide standards which are applied in the industry, but standards specific to the wind power industry as well as lifting and transportation offshore are provided by the GWO, G9, EWEA, and RenewableUK. (4) the most affective safety practices for the lifting and transportation to offshore installation sites could be provided through a unified international forum and its coinciding standards. It is therefore speculated that the wind power industry should unite under an international forum, potentially through one of the aforementioned wind power forums. Further research into this field could include if an international forum would facilitate safety in other activities (e.g. onshore installation, onshore transportation, and manufacturing) of the wind power industry, or if other aspects (e.g. economic, technical) of the wind power industry could benefit from standardization.

Preface

The presented report, "Safety Legislations and Standards for Offshore Lifting and Transportation of Wind Turbine Components," was written by group RISK7-1-F14 as a compulsory part of the 7th Semester at the Faculty of Engineering and Science, Aalborg University, Campus Esbjerg. The project was carried out from the 3rd of February 2014 until the 27th May 2014. This report is aimed at students and persons who have a particular interest in the offshore wind industry and the legislations and standards related to it. To specify, this report contains information related to the current legislations, standards, and guidelines used in transportation of wind turbine components to offshore installation sites in Denmark, divided into four chapters.

Additionally, a list of relevant acronyms and their coinciding names are provided at the beginning of the report, and a list of sources used in the report can be found in the bibliography section at the end of the report. This project uses the Harvard reference style for referencing sources. In-text citations are shown as a number in squared brackets [X], and are emphasized and between quotation marks. Figures are numbered according with the chapters, where the first number symbolizes the chapter number and the second number is the figure number within the chapter. At the end of the report are (how many appendices) appendices, which are assigned a capital letter and arranged in alphabetical order. Additionally, a CD is attached to the report, which features the report, sources, and the audio file for each interview.

Aalborg University, May 26, 2014

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Acronyms

AWEA	American Wind Energy Association
BP	British Petrolium
BWEA	British Wind Energy Association
BWS	Blue Water Shipping
CWIF	Caithness Windfarm Information Forum
DEA	Danish Energy Agency
DMA	Danish Maritime Authority
DNV	Det Norske Veritas
DNV GL	Det Norske Veritas and Germanischer Lloyd
DS	Danish Standards
DS Certificering	Dansk Standard Certificering
DWIA	Danish Wind Energy Association
EI	Energy Institution
EU	European Union
EU-OSHA	European Agency for Safety and Health at Work
EWEA	European Wind Energy Association
FAR	Fatal Accident Rate per 100 million work hours
FEM	Federation of Material Handling
G9	Offshore Wind Health and safety Association
GWEC	Global Wind Energy Counsel
GWh	Giga Watts per hour
GWO	Global Wind Organization
HSEMS	Health Safety and Environment Maintenance System
HSE	Health, Safety and Environment
HSEQ	Health, Safety, Environmental and Quality

IMCO	Inter-governmental Maritime Consultative Organization
IMO	International Maritime Organization
ISM	International Safety Management
ISO	International Organization for Standardization
LSA	Life-Saving Appliance
LOLER	Lifting Operations and Lifting Equipment Regulations
MARPOL	International Convention for the Prevention of Pollution from Ships
MEPC	Maritime Environment Protection Committee
MICS	Wind Member Institution of Chartered Ship Brokers
MoU	Memoranda of Understanding
MSC	Maritime Safety Committee
MW	Mega Watts
OGP	The International Association of Oil and Gas producers
OPEC	Organization of the Petroleum Exporting Countries
OHS	Occupational Health and Safety
OHSAS	Occupational Health and Safety Advisory Services
OSPAR	The Oslo-Paris Convention
PPE	Personnel Protection Equipment
PSC	Port State Control
PUWER	Provision and Use of Work Equipment Regulation
SOLAS	Safety of Life at Sea
STCW	Standards of Training, Certification and Watch keeping for Seafarers
UK	United Kingdom
WTG	Wind Turbine Generator

Contents

Chapter 1

Introduction

In a continuous development, due in part to global climate change, the wind power industry has drawn attention from many countries all over the world. The high interest in wind power arose from the 1973 Organization of the Petroleum Exporting Countries (OPEC) oil embargo, when alternative energy sources were developed as a reaction to the increasing price of oil. [7]

Offshore wind farms originated in 1991, when in Vindeby, Denmark the first offshore wind farm in the world was installed with an area of three km^2. The wind farm was established with a total of 11 wind turbines with an installed capacity of 4.95 MW, and an estimated annual production of 11.2 GWh/year[8]. The industry outstretched significantly all over the world, being adopted into world government energy plans to comply with the Kyoto Protocol[9] and the Energy Strategy for Europe. Currently, 4.620 MW of offshore wind power is installed in the world, 90% of which is installed in northern Europe, within the North, Baltic, and Irish Sea, as well as the English Channel[10]. Europe is a world leader in implementing offshore wind farms, with 1503 wind turbines fully grid connected in 56 wind farms, producing 4336 MW. According to the Global Wind Energy Council (GWEC), United Kingdom and Denmark represent major markets for offshore wind in Europe followed by Belgium, the Netherlands, Germany, Sweden, Finland and Ireland[11].

Transportation of wind turbine components to offshore installations still presents an enormous logistical task for companies and developers of wind farms. Due to the increasing size of wind farms and inevitably wind turbine components, transportation will have to accommodate components of substantial size while transferring to the offshore installation site. According to the European Agency for Safety and Health at Work (EU-OSHA), transportation of wind turbine components to offshore installation sites includes additional risks, unperceived on road transport. These risks refer to the transfer vessels and are characterized by heavy weather, standing or collision and fire. Also, *"Vessels are subjected to six different motions at sea: rolling, pitching, yawing, surging, heaving and swaying. These motions, particularly rolling and pitching, can be magnified immensely during periods of heavy weather."* In order to avoid risks, all procedures involved in the transportation of wind turbine components require thorough planning. [3]

1.1 Project background

A mutual interest in transportation, legislation, and the wind energy industry led to a unification of these topics into one cohesive project. Furthermore, it was taken into consideration that when transporting very large components such as the wind turbine tower, hub, or blades, there may be associated logistical challenges.

An example of a logistical challenge could be the wings of the wind turbine, which can be around 75 meters long[1]. Likewise, components such as the hub, which is one of the heaviest components of a wind turbine (eight to ten tons[2]) may cause additional logistical challenges. With that in mind, exploratory research was conducted by reviewing cases in which the transportation of wind turbine components caused challenges or accidents. Said research indicated that transportation onshore is strict, and that there have only been a few incidents that caused negative repercussions. During one such incident a wind turbine component fell off the transportation vehicle and destroyed a private residence, although no casualties were sustained[3].

To reiterate, the initial focus was on the transportation of turbine components onshore, which revealed that there are logistical challenges faced during the transportation of said components; however, the onshore industry has already established a strict set of legislation. Furthermore, the offshore wind sector is an emerging and a relatively newer industry than the onshore sector; development is proceeding in Denmark with the intention of being the forerunners in green energy[4].

Considering that the legislation is so strict for onshore transportation, a wondering emerged regarding legislation and standards that dictate the safety of personnel, as well as challenges that are faced when lifting and transporting wind turbine components to offshore installation sites.

In addition to these forethoughts, it was also taken into consideration how the legislation and standards prevent accidents from occurring. For example, how the personnel of an offshore vessel cope with a limited amount of space, and how the weather affects transportation and operation at sea. The American Wind Energy Association (AWEA) states that because of these heavy loads and long components, there are only a few transportation companies which can manage to overcome logistical challenges while transporting wind turbine components. [2] The aforementioned, in combination with the abundance of standards to follow in the offshore wind power industry, (to maintain a high quality and safety through the whole process) causes challenges for new entrants into the market of transporting wind turbine components.

1.2 Project formulation

Exploratory research, which was derived from the project background, was used as input to the problem formulation.

Are the legislations and standards adhered to when lifting and transporting wind turbine components from Danish harbours to offshore installation sites sufficient in creating safety for the working environment, or could they be enhanced?

In order to answer the problem formulation comprehensively, additional questions have been created. These questions are as follows:

1. Which legislations dictate the safety of personnel during the loading and transportation of wind turbine components to offshore installation sites?
2. What standards are used in the offshore wind sector that relate to safety of personnel during lifting and transportation?
3. How do companies utilise their experience and implement safe management practices?
4. Whether or not changes within legislation or standards would enhance safety during lifting and transportation?

These objectives aim to clarify the whole transportation process, and are focused on the safety during the loading phase and transportation to the offshore installation site. Moreover, this project aims to state how safety is managed during lifting and transportation, and could therefore guide interested and emerging transportation companies to comply with the associated legislation and standards of the offshore wind sector.

1.3 Problem delimitation

The safety of personnel when loading the wind turbine components onto a vessel, and during the transportation to the offshore installation site will be the focus of this report. The scope includes loading of components and ship departure from the harbour until it arrives at the offshore installation site. The project will therefore not concern the installation of wind turbine components offshore. Nevertheless, the project will focus on how to maintain a high safety level when lifting and transporting, and how legislation and standards prevent potential risks from occurring without negatively impacting operations.

1.4 Methodology

The overall method for this project, can be seen on the left side of Figure 1.1, which displays that the first step in the project is the research planning stage. It is in this stage that the foundation of the project is planned, to ensure that future planning is in compliance with the initiating step. This particular step is related to chapter one, which also can be seen in

Figure 1.1 right side. The second step in the project is the exploratory research, covered in chapter two. During this step the initial information collection takes place, with an emphasis on the exploration of the field, as explained in the previous step. This step will be more thoroughly explained in the interviewee section. [6]

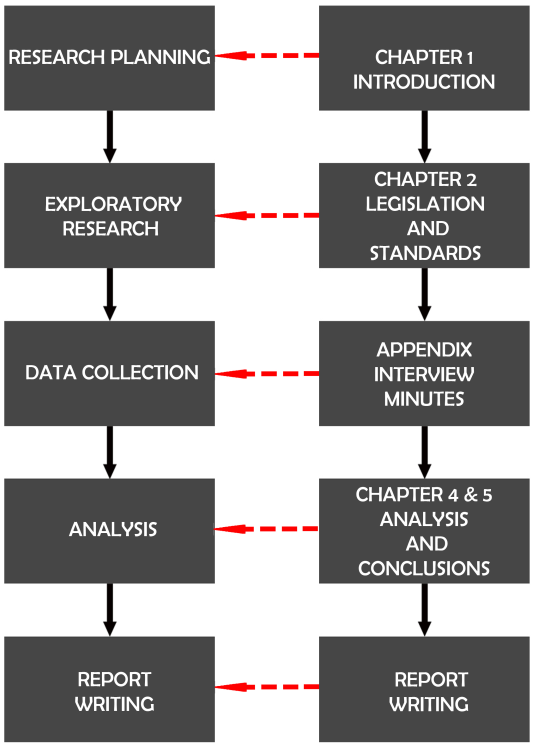

Figure 1.1: Research methods. [6]

The third step of the methodology is the key data collection, acting as input to the analysis. Hence, it was decided that interviews would be conducted with industry familiars in order to gain a practical perspective of the legislation and standards. This step will be explained further in the methodology section. To elaborate, not all information gathered from the interviews are relevant to the project, and are therefore excluded. For the sake of clarity, interviews will be referred to as follows [6]:

(Initials of interviewee|company name; interview time start –interview time end)

Ex. (NK| A2SEA; 00:17-00:18)

Additionally, minutes for each interview are listed in appendix A. The fourth step is the analysis and data collection, which can be found in chapter three of this report. This step regards the findings of steps two and three, which will be connected and analysed. Moreover, the problem formulation will be addressed in the analysis, and summarized in the conclusion. Subsequent to the analysis and data collection step is the fifth step, or the actual report, as presented.

It is intended to describe the methods which were used to answer the previously described problem formulation. Therefore, this section will elaborate upon the methods and work process used to obtain the necessary knowledge, in order to answer the problem formulation. Taking into account the type of information that was needed for this project, and the fact that the group members are of different backgrounds and professions (none of which are directly related to the offshore or wind industry), it was necessary to carry out two levels of research:

First level:

The first level of research was conducted to gain knowledge about the offshore wind industry. In other words, basic knowledge about the wind turbine and the wind power industry were examined, providing a basis for the second phase. During this level, it was determined that the project would focus on the lifting and transportation of wind turbine components to their offshore installation site.

Second level:

After gaining general knowledge about the wind power industry, legislations and standards related to lifting and transporting offshore were examined. Additionally, it was determined that the legislation and standards reviewed would relate to the safety of the crew.

Third level:

To create an all inclusive perspective of health and safety during these phases,interviews were conducted. These interviews provided an understanding of how the legislations and standards are applied, as well as the challenges faced while complying

After elaborating upon the phases of research and why they were necessary, the actual methods involved within the two phases can be examined. The methods used can be described as exploratory research.

Exploratory research

The process involved while conducting exploratory research for this project is described as an iterative process, as seen in figure 1.2. More specifically, it means that each task is evaluated and used as input for the subsequent task until enough information has been acquired. If the desired result is not achieved, changes to the research criteria are made, and then repeated. One of these repetitions is referred to as an iteration, while the whole process is referred to as an iteration.

Figure 1.2: Iteration spiral [5]

As mentioned before there is more than one iteration in this process, but what was not mentioned is how the project group planned each iteration process. One iteration process consisted of four phases brainstorm, structure, evaluate and research as shown in Figure 1.3 which was made for this report. These four phases are connected to each other in a cycle, where the evaluation phase was used to determine if there should be another iteration.

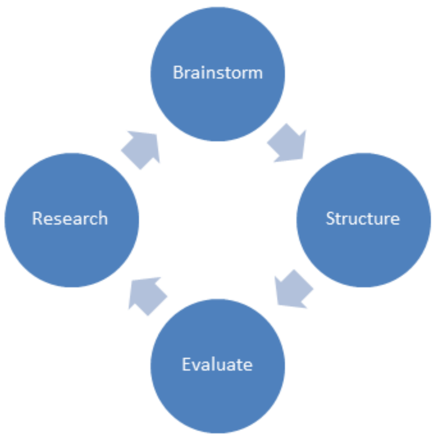

Figure 1.3: One iteration process.

The cycle starts at the brainstorming phase, which is used to explore information, potential issues and contemplate directions for the project. Following the initial phase is the structuring phase, the purpose of which is to organize and structure the ideas from the brainstorming phase. Information gathered individually is then compiled into documents for the sake of structure, as well as future input.

Next is the evaluation phase; one of the most important parts of the iteration process. This phase is used to determine if enough information has been gathered, as well as to plan the next course of action. In other words, it is decided which research methods should be used in the subsequent research phase, and what it will aim to accomplish. The fourth and last phase is referred to as the research phase, consisting of the research field and research method. In these sub-phases are two types of research, conducted in order to explore the unknown. Moreover, it is based on collecting data and/or experience, as explained in the following section.

Research method

The research methods are based on the collection of data and/or experience. In the outset of the project it was necessary to collect a great deal of data to create a deeper understanding of the wind turbine and the industry itself. Additionally, this data collecting was collected from internet sources (e.g. company, governmental and non-governmental websites.)

The next step was utilized with the intention of exploring the practical side that companies experience. To specify, it demonstrated how companies comply with legislations and standards, as well as what challenges they face during the lifting and transportation of wind turbine components offshore. The last part of the research was conducted using the qualitative, semi-structured interview approach to gain knowledge about the wind power industry. The semi-structured approach was chosen as the best way of exploring the companies' experience with legislation and standards.

When selecting interviewees, who could answer questions related to the project the following factors must be taken into account.

- There is not an unlimited time to ask questions.
- How are the people related to the subject(do they actually have the experience and/or knowledge to answer the question).

Therefore, the individuals participating in the interviews have to be carefully selected. The interviewees and their respective knowledge and experience will be covered in the next section

Interviewees

In order to answer the fourth question in the problem formulation, it was necessary to interview industry familiars involved in the lifting and/or transportation process offshore. The three individuals interviewed collectively possessed knowledge of safety legislations and standards regarding lifting and transportation offshore, safety management practices of their respective companies, procedures involved during each phase, and technical requirements for cranes. Listed below are the interviewees, their companies, as well as a description of their company activities:

1. **Søren Steffensen (SS|Melchior Engineering) Owner of Melchior Engineering Aps. Provides engineering consultancy. Interview# 1** The purpose of the first interview with Søren Steffensen(SS|Melchior Engineering) was to gain insight to Søren's experience in the offshore wind industry, where he worked for companies like COWI,

Siemens and Semco Maritime. In addition to this experience, Søren has developed lifting and transport equipment for wind turbine components that are transported offshore (SS|Melchior Engineering; 00:17 – 1:50). The information derived from the interview is the result of many years of practical experience in the lifting process of offshore wind power industry.

2. **Jacob Kjærgaard (JK|Blue Water Shipping) Head of Sales & Development, Wind Member Institute of Chartered Ship Brokers/ M.I.C.S. BWS provides maritime logistical services Interview# 2** The second interview was conducted with Jacob Kjærgaard from Blue Water Shipping (BWS) (JK|Blue Water Shipping); Blue Water Shipping (BWS) is a prominent maritime logistical service provider, which conducts, but is not limited to, the lifting and transportation of wind turbine components offshore. The information from the interview demonstrates the practical implications of legislations and standards during the lifting and transportation offshore. Furthermore, Jacob is head of sales and development at BWS, indicating a high familiarity with how safety is affected by standards and legislations.

3. **Niklas Karlsson (NK|A2SEA) Director group, HSE at A2SEA A/S(until the 15.May.2014, and now working at Siemens A/S) A2SEA provides offshore installations services Interview# 3** The third and last interview of this project was conducted with Niklas Karlsson from A2SEA(NK|A2SEA). In addition to A2SEA being one of the few companies which participates in most aspects of offshore installations, Niklas is the Director of the health, safety and environment (HSE) within the company. This means that he has experience with safety related to lifting and transporting offshore, and that he is responsible for the company's compliance with legislations and standards, and has many years of practical knowledge.

The collective information acquired through exploratory research and the three interviews provided insight regarding how the standards and legislations are applied, as well as the challenges faced, during the lifting and transportation of wind turbine components offshore. In the following section, the information acquired through exploratory research will be examined; included are relevant legislations, standards, and organizations regarding health and safety. Subsequent to the second chapter is the analysis chapter, in which the aforementioned will be reviewed along with the information acquired from the interviews.

Before the interviews were conducted, a questionnaire was created, in order to ensure that the interviews were fulfilling the purpose of exploring what experiences the industry has by working with the legislations and standards. These questionnaires can be seen in appendix A for each of the interviews conducted. All the interviews were recorded and are attached to this report as digital copies. Along with these digital copies, an overview of minutes is provided in appendix A. These minutes were made instead of doing a transcription of the interview, since the purpose of this project is not to quote the interviewees and their statements, but to explore their knowledge about the subject. Therefore and overview was found to be more constructive, in order to understand what the interviews were about, and where to find the needed information. It should however been mentioned, that the interviews were also used in relation to another project, and therefore also have questions, which are not related to this project.

Chapter 2

Legislations and Standards

This chapter will cover the findings of the second phase of the exploratory research, which was conducted in order to gain knowledge about the first and second sub questions, as reiterated below:

1. Which legislations dictate the safety of personnel during the loading and transportation of wind turbine components to offshore installation sites?
2. What standards are used in the offshore wind sector that relate to safety of personnel?

Therefore, the first section of this chapter will present the relevant safety legislations along with their coinciding authorities, and the second section will concern general safety standards that are applicable to the offshore wind power industry. In addition to these general standards, forums providing standards specific to the wind power industry are examined in the third section of this chapter. A more detailed description of each section's content is available at the beginning of each section.

2.1 Legislation

International maritime shipping plays a vital role in facilitating global commerce, and for the moment is one of the most cost effective and energy effective methods used in the world. Due to the amount of goods being transported there is an impact on the world economy, in both developed and undeveloped countries. Because of its international nature, the shipping industry requires global regulation (i.e. legislation and standards) in order to facilitate proper functionality. The international shipping industry is characterized by a large number of globally interested parties which are engaged in areas such as design, construction, operational aspects, crewing, insurance and financial area. For the purpose of functionality in the international shipping industry, controlling authorities which check and guide towards a common goal are necessary. [12]

Displayed in Figure 2.1, which was made for the report, are the organizations and associated legislations which impact safety during the lifting and transportation of wind turbine components; it depicts the international, European, and Danish organizations responsible for establishing and/or enforcing legislation regarding lifting and transportation, along with the most relevant safety conventions and legislations applied, respectively.

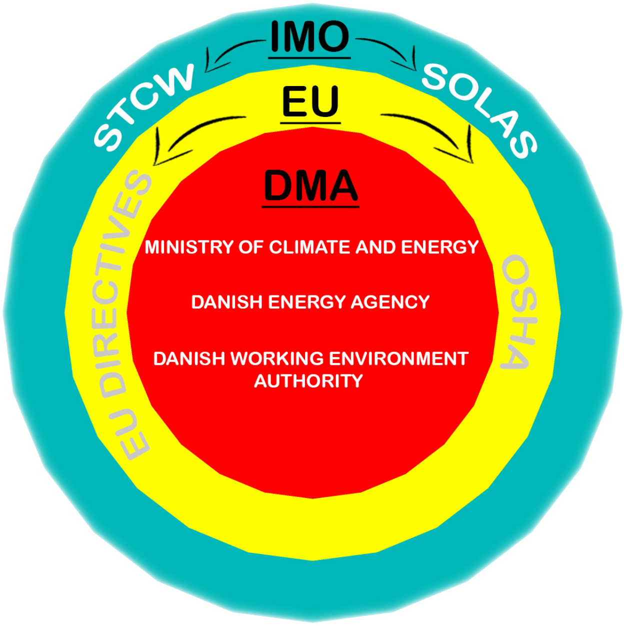

Figure 2.1: A representation of how the legislation and governing bodies are arranged.

The findings of the exploratory research indicate that the safety of personnel during the lifting and transportation of turbine components offshore are dictated by multiple authorities. Additionally, there are various governmental bodies which regulate the lifting process and the transportation at sea.

The lifting of wind turbine components is dictated by onshore legislation, while the transportation is dictated by maritime legislation. Consequently, this section will be divided into two subsections, which are the Lifting and Transportation subsections. In Table 2.1, which was made for this report, the authorities which relate to lifting and transportation are displayed.

Lifting	**Transportation**
Ministry of Climate and Energy	International Maritime Organization (IMO)
Danish Energy Agency (DEA)	Danish Maritime Agency (DMA)
Danish Standards (DS)	EU Directives
Danish Working Environment Authority	

Table 2.1: Overview of authorities in regards to lifting and transporting

2.1.1 Lifting

In order to understand how legislation is affecting the loading and transportation process there is a need to identify the main parties regarding lifting. There is the onshore, maritime and offshore sector. Additionally, the legal framework of lifting operations in Denmark are provided by the Danish Parliament and are as follows [16] [13]

- Executive Order 1480:2010 Fixed Offshore Installations and Pipelines Construction, Design and Equipment
- Executive Order 1481:2010 Mobile Offshore Installations Construction, Design and Equipment
- Executive Order 1482:2010 Operation of Offshore Installations
- Executive Order 1504:2010 Safety Organization, fixed installations
- Executive Order 1505:2010 Safety Organization, mobile installations Act 1424:2005
- Executive Order No. 1109 of 15 the Use of Work Equipment
- Order No. 1101 of the Danish Working Environment Authority [16]

The regulators that enforce the legislation for the lifting operations mentioned above [13]:

- Ministry of Climate and Energy
- Danish Energy Agency (DEA)
- Danish Working Environment Authority

The onshore sector refers to the process of moving the wind turbine components from the harbour on to the ship, specifically the processes involved in manoeuvring the components on the ship, emphasizing the lifting process and the related legislation. The authority in charge of the onshore sector in Denmark is the Danish Working Environment Authority, which enforces the Danish Working Environment Act, stipulating a safe, healthy and constantly improving working environment via effective supervision, appropriate regulation, and the dissemination of information. [16]

The Danish Working Environment Act provides the framework for objectives and requirements in the working environment in order to prevent accidents and the spread of disease. *"The main areas of the legislation are performance of the work, the design of the workplace, technical equipment, substances and materials, rest periods and young persons under the age of 18."* [14] As with all industry sectors, the onshore sector and its associated procedures must adhere to the Danish Working Environment Act. The Occupational Safety and Health Act applies onshore and in territorial waters (twelve nautical miles from shore). [16]

There is no exclusive offshore wind safety legislation currently in Denmark, however the new Offshore Safety Act entered into force on 1 July 2006. The Offshore Safety Act regulates guidelines that deal with health, safety, and environmental matters on offshore installations. The Danish Offshore Safety Act applies only to oil and gas activities and is consequently not relevant to offshore wind. [15]

2.1.2 Transportation

As indicated by Figure 2.1, the International Maritime Organization (IMO) has drafted the Safety of Life at Sea (SOLAS) and Standards of Training, Certification and Watch keeping for Seafarers (STCW) conventions for the purpose of setting minimum safety requirements during transportation. Although the Prevention of Pollution from Ships (MARPOL) convention has significance during the transportation phase, it will be excluded from the project since it concerns pollution rather than the safety of personnel; SOLAS and STCW will be examined further in subsections 2.1.2 and 2.1.2, respectively.[27] [28]

IMO

The IMO is a specialized agency founded under United Nations umbrella, in Geneva on 17th March 1948, and started activity 10 years later in January 1958. Until 1982 the organization was called the Inter-Governmental Maritime Consultative Organization(IMCO). Since its inception, the main focus of the IMO has been to develop international treaties, rules, and legislation regarding safety and marine pollution, as stated in their slogan: *"Safe, Secure and Efficient Shipping on Clean Oceans."* [17] Over the course of 40 years this has been an ongoing process, with the intent of keeping legislation up to date and to ensure more countries join the organization. Currently, 98% of the world shipping is represented by IMO member states[18].

The IMO is the first international structure committed to marine matters; it is responsible for measures which improve the safety and security of international voyages, as well as measures which prevent marine pollution from ships. In addition to these measures, the IMO is "involved in legal matters, including liability and compensation issues along with the facilitation of international maritime traffic." [18] Its role is applied to all aspects of international shipping as follows: *"ship design, construction, equipment, manning, operation and disposal"* in order to maintain a minimum level of safety and environmental conservation. [17]

Currently, the IMO has 170 member states which represent the governing body, also known as the Assembly. Closely tied to the Assembly is the Council, which supervises and co-ordinates the work of the organization. Moreover, it mediates biennial meetings during which budgets, technical resolutions, and recommendations are discussed and planned for the subsequent two years. [18]

The Most relevant committee of the IMO for this project is the Maritime Safety Committee (MSC): This committee represents the highest technical group of IMO. The tasks of the MSC are to *"consider any matter within the scope of the Organization concerned with aids to navigation, construction and equipment of vessels, manning from a safety standpoint, rules for the prevention of collisions, handling of dangerous cargoes, maritime safety procedures* *and requirements, hydro graphic information, log-books and navigational records, marine casualty investigations, salvage and rescue and any other matters directly affecting maritime safety."* Additionally, the MSC submits recommendations and guidelines on safety that could potentially be adopted by the Assembly. Other committees include: the Marine Environment Protection Committee (MEPC),the Legal Committee, the Technical Co-operation Committee and the Facilitation Committee. [19]

In addition to drafting legislation, the IMO is responsible for the necessary legal framework along with the process to adopt the associated legislation; it is the responsibility of each member state to implement the legislation. To clarify, by accepting an IMO convention, a member state agrees to incorporate the legislation into their national law and enforce it. In order to ensure that the legislation is enforced and improves the member state's performance, the IMO formed a special sub-committee in 1992, focused on the Implementation of IMO Instruments (III). This provides more autonomy for the Port State Control (PSC) in all member states. Stipulated in the Memoranda of Understanding (MoUs), the PSC has the right to examine a foreign ship which visits their country to check the condition of the vessel and if the equipment meets the terms with the requests of the IMO, and that the ship is operated in agreement with these guidelines. If a ship fails to meet the aforementioned requirements, the ship will be detained until the situation is remedied. [20]

The SOLAS, STCW, and MARPOL conventions govern maritime regulation for the majority of the world. Each of the aforementioned mandates a different aspect of maritime legislation; SOLAS mandates safety legislation and its associated aspects, STCW focuses on certification and the process involved, and MARPOL sets environmental regulation. The subsequent and ensuing sections contain more detailed information regarding SOLAS and STCW, but will not cover MARPOL, considering it covers environmental factors and is therefore out of the project scope.

SOLAS

Considering that 82% of countries in the world, and 99% of gross tonnage of the worlds merchant fleet is represented by the member states of SOLAS, it comes as no surprise that it is upheld as the most extensive set of rules and regulations regarding maritime safety.[22] SOLAS was established in 1914 in response to the sinking of the Titanic, the aftermath of which illustrated that the maritime safety standards in force were insufficient [23]. While the original convention was never put into effect due to World War I [24], it laid the foundation for its successors, eventually producing the modern version which dictates the maritime safety law of 159[25] countries out of approximately 193 [26] in the world. Since its initial inception many versions have been drafted over the years; the most current adaptation of SOLAS was adopted on the 1st of November, 1974, and put into force on the 25th of May, 1980. Although the newest reincarnation of SOLAS may seem outdated when one solely considers its age, many amendments have been supplemented to the original document ensuring its validity even today. Amendments are adopted by the MSC. [27]

SOLAS has constantly evolved over the last 40 years due to the aforementioned amendments. As stated on the IMO's website, *"an amendment shall enter into force on a specified date unless, before that date, objections to the amendment are received from an agreed number of Parties."* In other words, amendments follow a tacit acceptance procedure, meaning that they are regularly and routinely accepted unless protested by enough members of the IMO. This suggests that SOLAS can adapt to contemporary challenges caused by advancing technology, climate change, and other variables which effect safety at sea, with reduced bureaucratic interference. [27]

As indicated by the name, SOLAS's primary function is to decrease the likelihood of unsafe occurrences causing injury or death while at sea by *"specifying minimum standards for the construction, equipment and operation of ships."* Chapters within SOLAS cover [27]:

General provisions

Details the survey procedure for different ships and their respective documentation, along with how ships are handled in ports of foreign contracting governments.

Construction

Specifies the stability requirements for passenger and cargo ships, the subdivision of watertight compartments (to prevent sinking), machinery and electrical installations, etc.

Fire safety

Includes how the boat should be arranged in respect to fire hazards, the availability of relevant fire safety supplies, how to contain a fire, etc.

Life-saving appliances

Indicates how appliances should be arranged on the vessel. Technical requirements are specified by the LSA (Life-Saving Appliance) code.

Radio communications

States the associated technical requirements.

Safety of navigation

Defines the responsibilities of the ships during their voyage, and the responsibilities of their respective contracting governments.

Carriage of cargo

Lists how cargo should be stowed and secured. Also included is a chapter specifying how dangerous cargo's should be handled.

Management for the safe operation of ships

Requires the party responsible for the ship to implement a safety management system, which is dictated by the ISM (International Safety Management code).

Special measures concerning safety and security

Clarifies which parties are responsible for inspections, how ship identification works, and general security requirements.

Other requirements for specific vessels

Nuclear, high-speed craft, bulk carriers.

Although all of these chapters contain regulations that affect safety, those which directly affect the safety of personnel during the transportation of wind turbine components offshore are chapters covering lifesaving appliances, fire safety, carriage of cargo, and the management for the safe operations of ships. SOLAS, as stated before, sets the requirements for safety while at sea; similarly, STCW stipulates requirements for personnel at sea.

STCW

On 7 July 1978, the IMO held a conference which resulted in the first convention focused on training of safety personal, known as the STCW. [28] The STCW entered into force on 28 April 1984, with two major revisions in 1995 and 2010. This convention dictates the minimum standards involved in training, certification, and watch-keeping for seafarers, which member states are obliged to conform to. It is each individual member states' duty to establish and implement this legislation. [28]

The STCW convention is a set of basic requirements which are described and supported by sections in the STCW Code, part A and part B. [28] Part A explains the minimum mandatory competences necessary for the seagoing personnel. Part B of the code represents recommended guidance in order to help member states implement the convention. These guides are not mandatory and are provided as an example of how the regulation may be complied with. [29] The approval of training courses is the responsibility of each member state which abides by the STCW convention. Furthermore, approval is normally given by the maritime administration of an STCW Party in accordance with the convention requirements. [30]

DMA

The Danish Maritime Authority (DMA) is a relatively new institution, which spawned from the merger of six old maritime institutions (The Danish Ship Inspection Agency, the Directorate of Seafarers, the Directorate of the Maritime Training Program, the Ship Register, the Welfare Office and the Danish Ice-Breaking Service) in 1988. [31] After 2011, when the Danish Maritime Safety Administration was eliminated, the DMA's main responsibilities concerned [32]:

- Safe ships, health and the environment
- Safe waters, buoy age and navigation

- Social conditions, seafarers and fishermen
- Framework conditions, competition and growth

The DMA's field of responsibility is focused on shipping and its framework conditions, including the ship and its crew. In general, it regulates the activities which take place on board the ship. As stated by DMA on their home page: *"The Danish Maritime Authority is responsible for the construction, equipment and operation of Danish ships including safety, prevention of terrorism, navigational regulation, manning, occupational health and environmental protection, as well as port State control of foreign ships in Danish ports, ship registration, the training and education of seafarers, employment, health and maritime social condition, shipping policies, maritime law and industrial policies both nationally and internationally."* [33] As a member state, Denmark complies with the STCW convention [28], and as a confirmed member of the STCW convention has been fulfilling the requirements for several years. [34]

In accordance with the STCW convention order: *"1279 Order on maritime security training on board ships"* was issued by the DMA on 7th November 2013. The purpose was to: *"lay down the requirements for maritime security education and training of ships crews in accordance with regulations VI/5 and VI/6 of the STCW convention."* However, safety of navigation is regulated by the Safety at sea Act (No. 72 of 2014) (in Danish-Bekendtgørelse af lov om sikkerhed til søs) [35], which consolidates the text of Safety at sea Act (No. 654 of 2010)-15 June 2010. The act applies to Danish and foreign ships within Danish territorial waters. The Safety at sea Act (No. 72 of 2014) does not apply to Greenland or to the Faroe Islands. This act consists of 13 chapters the most relevant topic of which are as follows: acts implementation for Danish and foreign vessels, provisions relating to vessel construction, equipment and operation, precautions for the voyage, general obligations and occupational health and safety services.

Although similar in their stipulation for safety, standards differ from legislation; they are adopted by organizations which intend to increase their level of safety. Instead of being enforced by an entity, companies following standards can become certified, indicating that the company has applied the standard in an approved way. [36]

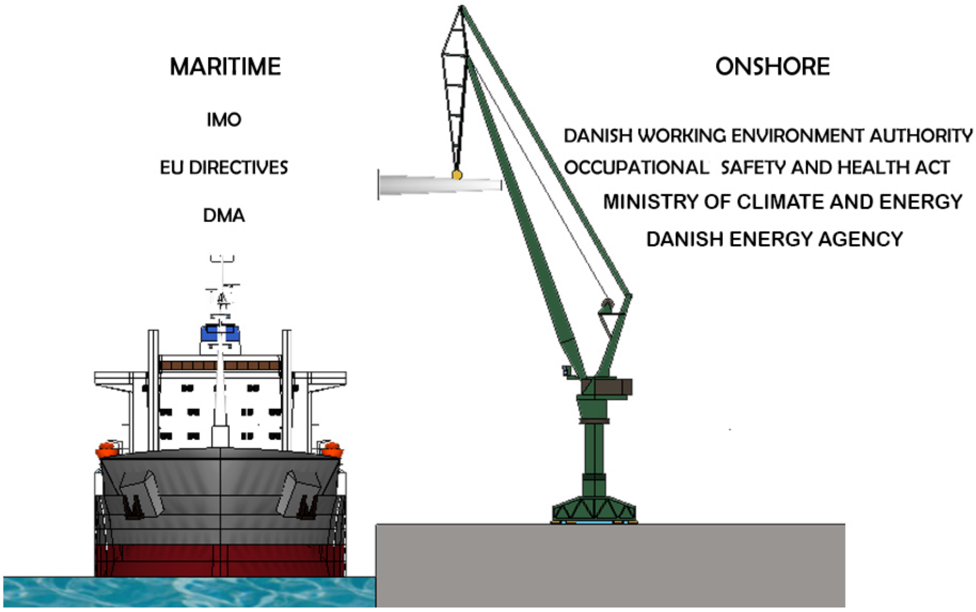

Figure 2.2: Explanation of governing bodies.

Figure 2.2, which was made for this report, explains which governing bodies apply to lifting the wind turbine part to a vessel and when transporting to offshore installation sites.

2.2 Standards

Standards are a way of unifying an industry to ensure quality for the user of the standard and that the user can perform to a specified level. Furthermore, standards are being developed continually and are used by organizations to assimilate into an industry. Currently, there are numerous organizations which create standards for a variety of industries. The most relevant organizations to this project are: The International Organization for Standardization (ISO), The Occupational Health and Safety Advisory Services (OHSAS), The Global Wind Organization (GWO), RenewableUK, and the International Association of Oil & Gas Producers (OGP).

2.2.1 ISO

The most prominent standardization company in the world is the ISO, which is a non-governmental organization. Founded in 1947, it is the world's largest developer of voluntary international standards, and since its conception has published more than 19.500 International Standards covering many aspects of technology and business. The ISO has members from 162 countries. [38] [39] ISO is applicable to companies globally, considering that the standards are made via consensus from industries around the world. Figure 2.3 represents the ISO governance structure.

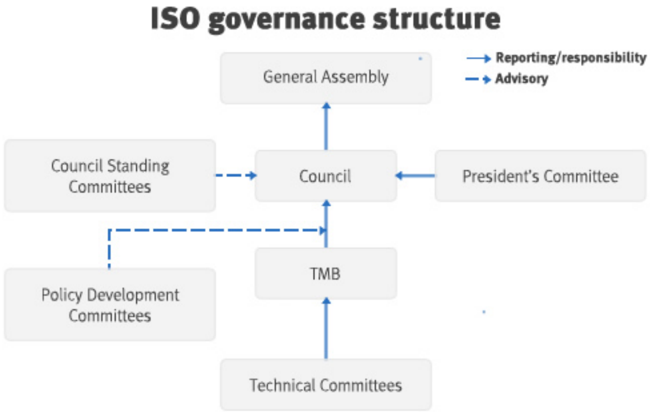

Figure 2.3: A graphical demonstration of the ISO organization. [40]

The ISO organization itself does not certify a given standard for an organization; the primary focus for ISO is to develop the standards, hence the certification process is not conducted by ISO. The certification process is conducted by external certification companies rather than the ISO organization. For example, Dansk Standard Certificering is a company which offers certification services in Denmark (DS Certificering). [41]

In the wind industry, the standards prominently used by companies regarding the lifting and transportation of wind turbine parts to offshore installations are the ISO 9001 [42], ISO 14001 [43] as listed in the following sources. [44] [45] The ISO 9001 standard is a quality management standard which facilitates the implementation of a quality management system. Similarly, the ISO 14001 standard is concerned with environmental management, allowing companies to implement a proper environmental management system. Since neither of these standards are directly related to the safety of the crew while lifting or transporting, they are briefly mentioned, as they are widely applied in the industry.

2.2.2 OHSAS

A health and safety standard that is widely used is the British OHSAS 18001 standard. [47] The standard was developed in an international collaboration called the *"Occupational health and safety advisory services project group"*, which was made to generate a unique united methodology to health and safety. *"The group included representatives from national standards bodies, academic bodies, accreditation bodies, certification bodies and occupational safety and health institutions."* [48] As of December 2013 ISO has approved to develop a new standard, the ISO 45001, which will be built on the properties of the OHSAS 18001 standard. [49] The OHSAS 18001 standard provides a framework around occupational health and safety that helps companies to maintain a systematic approach to health and safety. Occupational Health and Safety is based on three factors [47]:

Hazard identification:

> *"The process of recognizing that a hazard exists (source or situation with the potential to cause harm in terms of human injury or ill-health.")*

Risk assessment:

> *"The process of evaluating the risk arising from the hazard (combination of the likelihood of a Hazardous event or exposure and the severity of injury or ill health that can be caused by the event of exposure.")*

Determination of applicable controls:

> *"Measures relevant to eliminate or reduce risk to an acceptable level. Measures are based on the Hierarchy of control measures."*[47]

The standard has four stages referred to as plan, do, check and act, which starts with the planning part and ends with the checking. In the planning the phase the goal is to establish the objectives and processes necessary to deliver results in accordance to the organizations' health and safety policy. Then the processes previously establish are implemented into the organizations health and safety policy. When the desired processes have been implemented, continuous monitoring and checking of the organizations' performance against their policy is done and results reported to management. The organisation has to continually act upon results reported in order to improve the health and safety policy. [47]

2.3 Forums

Forums are of relevance to the project since multiple wind power forums exist, each of which attempts to provide the tools to implement best practices for various aspects of the industry. The aforementioned best practices are either standards or guidelines, and are directly related to the wind power industry. First, global forums such as the Global Wind Organization (GWO) and G9 will be explored. Next, the European Wind Energy Association (EWEA) will be examined, as it is an EU wide organization. Lastly, RenewableUK and its coinciding standards will be examined, as it is a UK based organization with standards that are applied by Danish wind power companies. (JK|Blue Water Shipping;20:42-20:48) (NK|A2SEA;07:30-08:00)

Additionally, another forum with similar attributes is considered for comparison; the wind power industry is a relatively new industry, so it is necessary to examine a forum from a more experienced industry. Thus, the International Association of Oil & Gas Producers (OGP) is examined, as they set standards for the oil and gas industry in various activities (including offshore operations). The structure of the following sections are based on Figure 2.4, which was made for this report, which displays the forums as they relate to the offshore wind power industry on the left, and the oil and gas producers from the right.

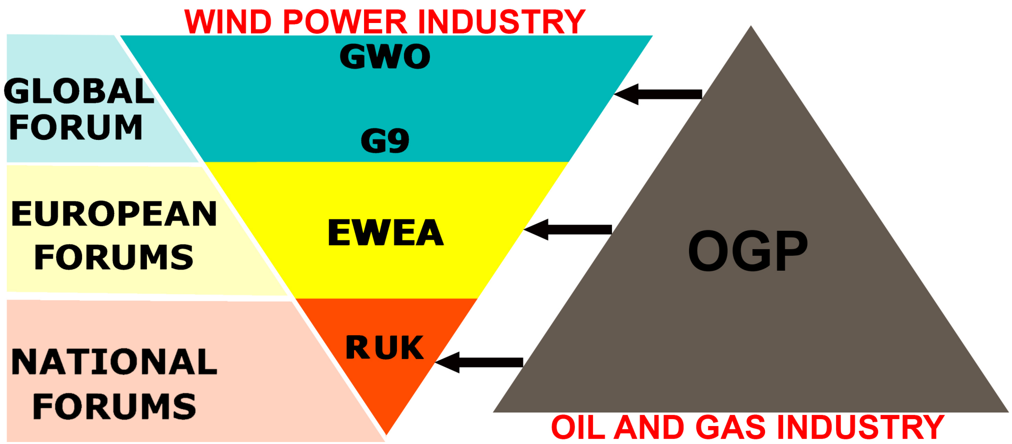

Figure 2.4: OGP compared to wind power forums.

2.3.1 GWO

The GWO is an association of 13 wind turbine owners and manufacturers [50]. The GWO is a non-governmental, non-profit organization that is dedicated to increasing safety in the wind industry through cooperation among the members and setting common standards for safety training and emergencies. The GWO was founded in 2009 and until December 2013 it had not had any secretariat, but as of 2014 the GWO has chosen Denmark and the Danish Wind Industry Association (DWIA) to be their home. [51] Currently, the GWO has only published one standard that is being taught and certified by training companies, called *"basic safety training"*. It covers the following subjects [52]:

- First aid
- Manual handling
- Fire awareness
- Working at height
- Sea survival, which is an addition for offshore training

2.3.2 G9

The world's major wind energy developers joined together in 2010 to establish an association-Offshore Wind Health and Safety Association (G9) on health and safety, covering all offshore wind operations and developments of the wind power industry. To accomplish the aforementioned, member companies meet *"under the auspices of the G9 Board to actively lead the industry in finding solutions to the safety challenges that offshore wind projects face"*. [67] The founding members of the G9 are: Centrica, DONG Energy, E.ON, RWE Innogy, Scottish Power Renewables, SSE Energy Supply Limited, Statkraft, Statoil, Vattenfall. [67]

Using their position as the largest wind energy developers in Europe and co-operation, G9 member companies will strive to provide health and safety guidelines across Europe by endorsing sustainable health and safety culture. [68] Moreover, G9 will act as a forum where safety and industry experts, as well as stakeholders from offshore wind industry can exchange knowledge and establish networks. [68]

Under the guidance of the G9 Board and G9 Focal group, monthly meetings are held in which past incidents, accidents, and experiences are assessed, to share and learn from those practices. G9, in partnership with Energy Institute (EI), have established three Work Groups as follows: Lifting operations, Marine vessel operations and Working at heights. The aim of the work groups are *"to develop good practice guidance publications for the offshore wind industry."* [69] G9 and EI released three *"Good Practice Guidelines"* represented as consultation drafts, the consultation period taking place from the 9th of April 2014 until 21 of May 2014:

- Marine Operations Consultation Draft
- Lifting Operations Consultation Draft
- WAH Consultation Draft (Offshore wind work at height guidance) [70]

The consultation drafts are meant to improve health and safety performance and standardization across the offshore wind operations, and after completion, implementation in the G9 member companies and legislation of northern European governments will follow, in countries such as United Kingdom, Germany and Denmark. [70]

2.3.3 EWEA

The European Wind Energy Association (EWEA) was founded on September of 1982 in Stockholm, Sweden *"to raise the level of cooperation between Europe's wind power organizations and spur an international awareness of the potential of wind energy."* One main activity of the organization is the promotion and development of the wind industry, with the intention of making wind power a leading renewable energy source. The progress of the EWEA in the past 30 years has grown in conjunction with the European wind energy policy, currently playing a key role in the energy industry. [63]

The EWEA perceives the offshore wind industry as a huge potential energy source, which will partially accommodate future European energy demands. European companies' competiveness and leadership in the wind power industry can provide important economic growth and employment opportunities across Europe. [64] Closely tied to employment development throughout the European wind industry, EWEA also covers health and safety, focusing on the *"promotion of best practice and harmonization of HSE regulation, standards, training, safety rules, documentation of work, etc."* [65]

In 2013 EWEA released a health and safety guide *"Working the wind safely"*, addressed to employers in the wind energy industry within the European Union (EU) and members of EWEA. Guidelines provide basic regulation, not being stated as a technical document, aiming to promote and implement European Union Council Directive 89/391/EEC, article 8, paragraph 1, which has been enforced in health and safety legislation of the EU member states. [66]

2.3.4 Renewable UK

In 1978, the British Wind Energy Association (BWEA) was founded, which was an organization focused on the development of alternative energy sources. In 2004, the scope started including wave and tidal energy. Six years later, the name changed to RenewableUK, which is now considered the United Kingdom's leading non-profit renewable energy trade association, maintaining their headquarters in London, United Kingdom [56]. Moreover, the association acts as a promoter for renewable energy by supporting the expansion of wind, wave, and tidal energy. With strong media promotion and significant influence among governmental authorities, RenewableUK has become the leading representative of the industry's interests, providing a forum where business and working affairs can be discussed and developed. [57]

In 2014, SgurrEnergy Ltd. (a renewable consultancy company) prepared a set of procedures for RenewableUK, known as *Offshore Wind and Marine Energy Health and Safety Guidelines*, with the intention of providing information concerning technical and legal issues. These guidelines were established in order to continue the development of safety in the offshore sector of the United Kingdom. The first part of the guide emphasizes the legal framework applied for offshore operations, as well as the health and safety of involved personnel; it aims to provide guidance, and clarifies that the guide does not override current legislation. [58]

Lifting operations in United Kingdom are referred to in the Provision and Use of Work Equipment Regulations (PUWER) [59], which is a guide concerning the lifting equipment on vessels. Moreover, lifting operations and lifting equipment requirements are part of Lifting Operations and Lifting Equipment Regulations (LOLER); the use of lifting equipment on a ship for offshore constructions is subject to LOLER. [60]

In regard to the transportation phase, RenewableUK applies two sets of guidelines:

- GL Noble Denton- Guidelines for Marine Transportations- Process planning guides, approval of particular marine transportations, and non-standard cargo, here referring to transportation on a ship, barge or floating are provided in this guideline [61].
- Guideline - Safety Issues in Wind Turbine Installation and Transportation- Issued by the European Federation of Material Handling (F.E.M.), it addresses crane operators, project managers, and crane manufactures involved in onshore/offshore lifting operations. This guideline covers onshore lifting and the transportation of wind turbine generators (WTG) and components, essentially focusing on the wind effect when WTG components are lifted [62].

2.3.5 OGP

The OGP is comprised of the world's leading publicly-traded, private and state-owned oil and gas companies, industry associates, and major upstream service companies. OGP members produce more than of half the world's oil and about one third of its gas. [53] The management committee is in charge for the organization general strategy and direction. Currently it is comprised of 9 members as well as the chair and vice chairs. The committee is voted every two years and currently, the representatives are British Petroleum (BP) plc, Chevron Corporation, ConocoPhillips, ExxonMobil, PetróleoBrasileiro SA, Shell International Exploration & Production BV, Statoil, Total and Baker Hughes. Their mission is to facilitate continuous improvements in health, safety, environment, security, social responsibility, engineering and operations. [54] The OGP represents the industry via a delegate, which attends assemblies that include but are not limited to: The Barcelona Convention, European Union (EU), IMO, ISO, and The Oslo-Paris Convention (OSPAR). [53]

The OGP has several committees within its organization whose roles are to come up with guidelines and standards to use within the industry. For example, the health committee is responsible for facilitating continuous improvements to health and safety. Amongst the guidelines the health committee has published are [55]:

- Guidelines on minimum standards for HSE governance in joint ventures
- OPG Life-saving rules
- Preventing major incidents by focusing on process safety
- Process safety-recommended practice on key performance indicators

These are only a few examples of what the health committee has published. Members of the OGP have a choice to follow the guidelines set by the committees within the OGP organization but they are highly recommended to do so as meeting at least the minimum standards set by the OGP will increase the reputation of said member and make it more respectable within the industry. The OGP also includes committees concerning communications, decommissioning, environment, EU, geomatics, legal, management, metocean, safety, security, standards and wells.

Chapter 3

Analysis

Legislations and standards compiled in the previous sections impact the safety of lifting and transportation phases for offshore wind turbine instalments. The purpose of this analysis is to explore how these legislations and standards coalesce to impact safety, and to determine if there are improvements which will facilitate safer practices during the aforementioned phases. Although reviewing legislations and standards demonstrates what companies may adhere to, it excludes the practical side of applying these regulations to lifting and transporting. In order to comprehend the challenges presented by applying the legislations and standards, three interviews were conducted with individuals experienced in the field of offshore wind power. The answers provided by the interviewees facilitated problem identification in regard to legislations and standards, and acted as input to suggestions presented throughout the analysis. The interviewees are as follows:

1. Søren Steffensen (SS|Melchior Engineering)
2. Jacob Kjærgaard (JK|Blue Water Shipping)
3. Niklas Karlsson (NK|A2SEA)

3.1 Overview: Lifting and Transportation

As seen in Figure 2.1, the legislation concerning the transportation and lifting of wind turbine components is represented on three levels with their associated organizations; international, European, and Danish law. The conventions set forth by the IMO are incorporated into Danish law, meaning that the international and Danish laws for maritime operations are similar aside from minor changes as stated in section 2.1.2; the IMO drafts the legislation while the DMA enforces them. Furthermore, EU laws intend to keep safety equipment up to date and distributed throughout the vessel correctly as stated in section 2.1. Conversely, lifting operations are not dictated by any international or EU convention; Danish law has established legal frameworks for lifting from harbour to vessel. As stated by Niklas, safety legislation is strictly adhered to in the wind power industry, as it sets the minimum requirements for safety. (NK|A2SEA; 1:31:04 – 1:31:10). For this reason, legislation does not impede upon the lifting or transportation of wind turbine components, nor does it conflict in a manner that causes safety concerns. In other words, little to no improvement is currently required for the laws associated with lifting and transporting.

Standards, however, are expressed as being inconsistent among the industry (NK|A2SEA; 17:30-18:00) (JK|Blue Water Shipping; 22:09 -22:23). While legislation lays the foundation for the minimum safety requirements of an industry, safety standards are created with the intention of maximizing safety. Naturally, these differing standards will not be completely identical, indicating that some standards may cover certain matters in more depth.

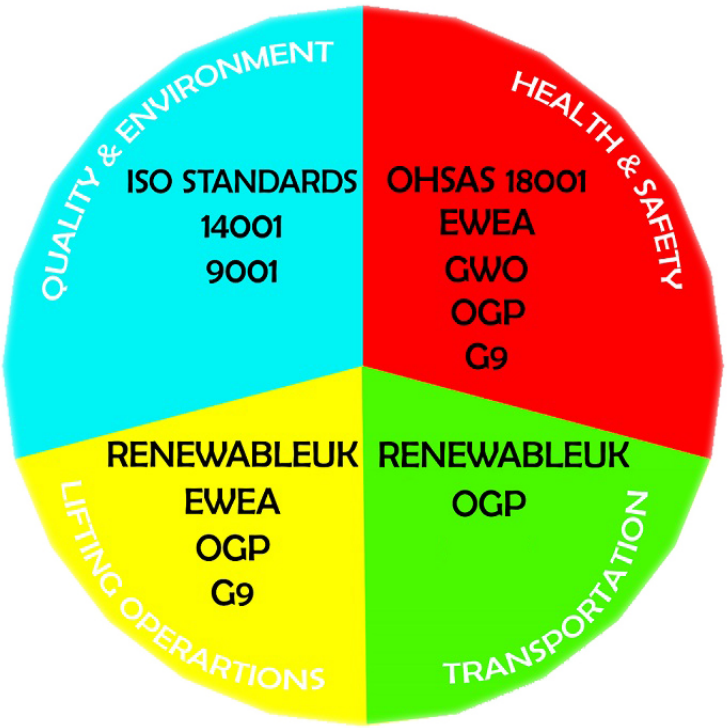

Figure 3.1: Representation of the industry standards.

Figure 3.1, which is made for this report, illustrates which standards are used in the industry and in what aspects. A collective approach to determining the most effective attributes of industry standards would enable the industry to practice the safest possible methods of lifting and transporting wind turbine components. Similarly, the OGP provides a collective approach to creating safety standards regarding lifting and transportation for the oil and gas industry.

3.2 Benefits of forums

To reiterate, the lifting and transportation phases of the oil and gas industry have standards set by the OGP, which maintain safety through health, safety, technical, and procedural specifications. HSE has been standardized within the sectors of offshore operation, land transportation, and more. The OGP holds conferences to make risk assessments, share experiences, and to standardize HSE; the accumulated experience of the industry acts as input to safety standards [53]. One company's experience is not likely to equal the accumulated experience of the industry, meaning a unified approach is more effective than an individual approach to health and safety. Aside from health and safety, the global forum strives to improve oil and gas operations in the aspects described in section. 2.3.5

As can be seen in Figure 3.2, through improved health, safety, environment and maintenance systems (HSEMS) and engineering, the rate of accidents has decreased over time. Incorporating human factors with improved HSEMS and engineering could bring the accident rate even further down as indicated by the figure although it has not been implemented as of now.

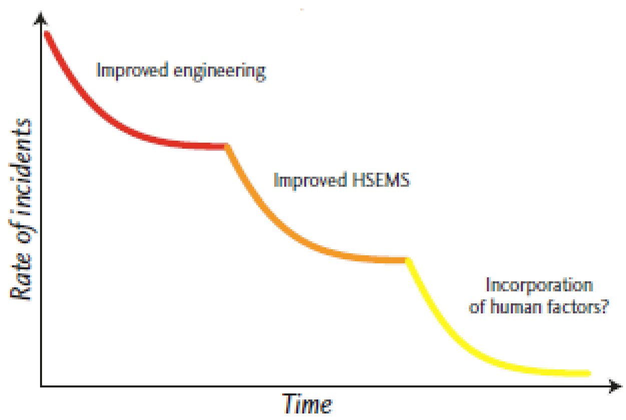

Figure 3.2: The rate of accidents has decreased with improved HSEMS and engineering. [71]

There is also a noticeable difference in the fatal accidents per 100 million hours worked (FAR), as it is trending downwards over time as can be seen in Figure 3.3. Since 2003, the FAR has been steadily decreasing, meaning that there are fewer fatalities per 100 million worked hours. [72] However, the number of fatalities is not decreasing as much as the FAR. So, one could conclude from that the reason for the FAR going down is just that the working hours have increased per fatality but not that fatalities are actually being prevented. In [73] it is written *"Analysis of the fatal incident description has shown that following an OGP Life Saving Rule[74] may have helped to prevent 79% of the fatal incidents reported in 2012."*

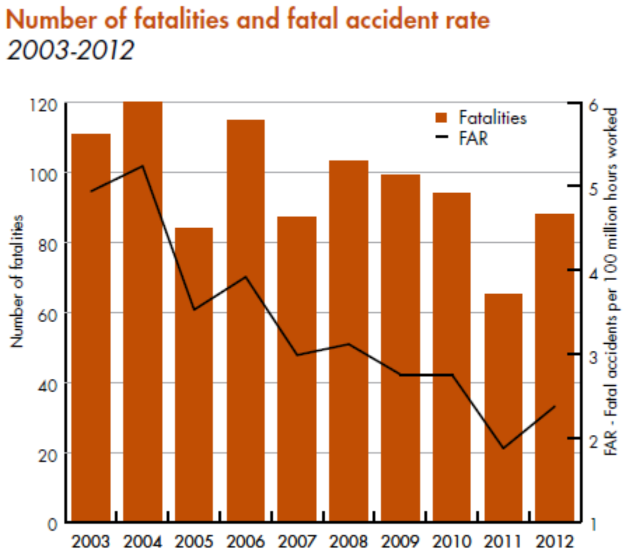

Figure 3.3: Fatalities per 100 million hours worked is decreasing. [72]

The 2012 edition of OGP's annual Safety Performance Indicators report showed that the number of fatalities per 100 million hours worked, the Fatal Accident Rate, has fallen in the last ten years. [73] *"Safety in our operations is a top priority for the industry and we strive to improve our record constantly"* says OGP Executive Director Michael Engell-Jensen. [75] The safety report is OGP's largest annual reporting project. The latest edition provides an analysis of the safety performance of 49 OGP member companies, representing 3.7 million work hours and operations in 107 countries . [73] While these statistics do not indicate that a global forum or standardization is the direct cause of decreased fatalities/accidents, it has certainly contributed by facilitating the creation, adaptation, and implementation of standards along with the proper medium by which to discuss these issues. Above all, the OGP has provided the framework for the oil and gas industry to reduce accidents and fatalities.

3.2.1 International Forums

In section 2.3 of the previous chapter, forums that are significant to the offshore wind industry were described. The forums are: GWO, G9, EWEA and Renewable UK.

The non-governmental organization, GWO, is a global association for the wind power industry, encompassing both the owners of wind power installations and the manufacturers. So far, the organization has only published one standard, called *Basic Safety Training.* These facts indicate that the GWO is a new association, and that it could still improve the publishing of safety standards for the offshore wind sector, to benefit from being in this association. Another organization which is similar to the GWO is referred to as G9, which is also a newly founded organization. Comparable to the GWO, G9 is a relatively new organization which is still evolving; companies have provided input to the forum but have not yet reaped the benefits. The third of the global forum mentioned is the EWEA, which is a European co-operation that seeks to create awareness about the European potential for wind energy. The EWEA promotes HSE regulation, standards, training, and the documentation of work, among other aspects of the wind power industry. Furthermore, the EWEA provides the guidelines related to Health and safety issues, which the European members states have agreed to; it is a more established organization than the GWO and G9. However, the scope of the organization should be considered, as they represent Europe and the region's interests.

Interviewees Jacob (JK|Blue Water Shipping;20:42-20:48), and Niklas (NK|A2SEA;07:30-08:00), elaborated that RenewableUK standards are being applied in the industry for newly established projects. Even though RenewableUK is a national forum in the United Kingdom, it provides standards and guidelines for the offshore wind industry. As expressed by Niklas during the interview, A2SEA regularly uses RenewableUK standards, but may supplement the standards in accordance with project or contract needs (NK|A2SEA;07:30-08:00). Therefore, the offshore wind sector could benefit from integrating or focusing on one forum which would provide all the standards for the industry. Similar standards are published from different forums; both the G9 and the GWO have standards to be certified in working at heights. A unified set of standards would facilitate consistency for safety regulation, especially among the companies which belong to both organizations.

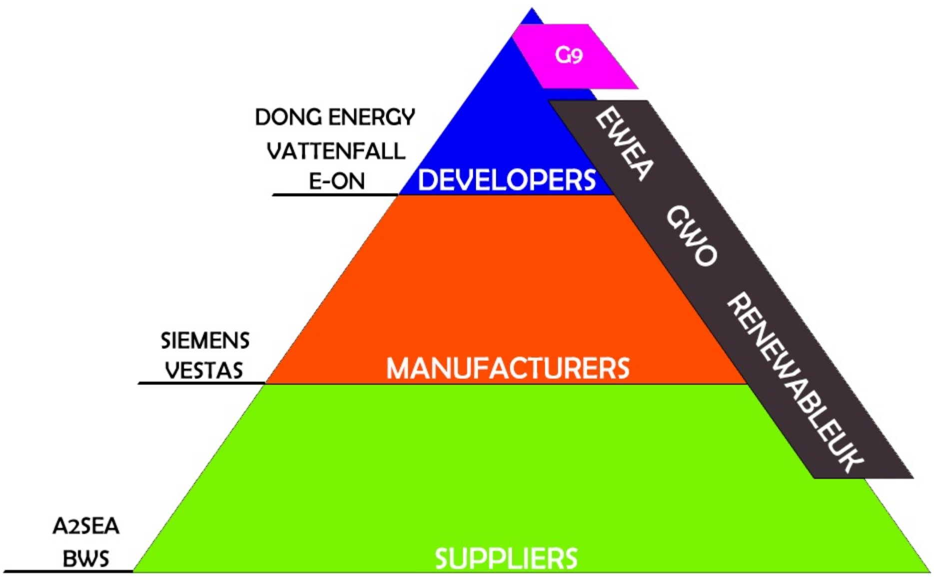

Figure 3.4: How organizations relate to the wind power industry.

Figure 3.4, which is made for this report, clarifies which sectors of the wind power industry the various forums focus on. Relevant companies have been divided into three groups, related directly to their activities in the offshore wind power industry; Developers (energy providers e.g. Dong Energy, Vattenfall, E-ON), Manufacturers (product suppliers e.g. Vestas, Siemens) and the Services Suppliers (provides services e.g. A2SEA, Blue Water Shipping).

Although the OGP is not related to the wind power industry, it exemplifies the purpose of an international forum, which is to provide a single consolidated channel by which industry standards are conceived, discussed, and implemented. The offshore wind industry could benefit from a consolidated international forum, as suggested by Niklas(NK|A2SEA;1:43:50-1:45:00) and Jacob (JK|Blue Water Shipping;22:00-22:36). Moreover, Niklas suggested that the forum or unified standards could be integrated with the European Union(NK|A2SEA;1:43:50-1:45:00). Considering the aforementioned and that the offshore wind power industry is growing fast within Europe, EU wide standards could facilitate safe practices. However, a global forum would allow the standards to be uniform internationally. In terms of a global forum, either G9 or GWO could provide the means to effectively implement international standards.

3.2.2 How the lifting and transportation of wind turbines offshore can benefit from a global forum

As described above, the oil and gas industry benefits from a global forum via the standardization (and intended improvement) of *"health, safety ,environment, security, social responsibility, engineering and operations"*. [53] If the wind power industry adopted a similar global forum, it would have the potential to unite the industry in those aspects. More specifically, it would provide the means to standardize HSE within the wind power industry. Jacob Kjærgaard elaborates on the matter (JK|Blue Water Shipping; 20:54-21:03), stating that in the wind power industry *"HSEQ (has become) an industry in itself, so the guys that are health, safety, environment and quality (HSEQ) officers, they just also sometimes need to promote them self."* In other words, a lack of standardization of HSE policies has created an inconsistent and potentially inadequate work environment for the crew; variations in safety equipment and policies are commonplace in the industry.

Standardization would produce identical working environments, ensuring uniformity among policies, procedures, equipment (personal protective equipment, PPE), and technical requirements. Furthermore, the lifting and transportation phases for offshore instalments could benefit from the standardization of HSE, lifting procedures, and technical requirements, minimizing the potential for accidents as shown in section 3.2. Standards related to both lifting and transportation exist within the oil and gas industry, setting technical, health, and lifting requirements for the phases as stated in section 2.3.5.

"Track record and knowledge of the individual person play also a vital role if you have been on an wind project for five years you for sure have better knowledge of the dangers." (JK|Blue Water Shipping; 23:39 -23:54). Taking the aforementioned and the intention of HSE policies into consideration, familiarizing the crew with their environment and associated risks should be a top priority. If the crew are accustomed to their policies, procedures, and equipment, it minimizes the possibility of an accident occurring. [77] Conversely, if they are performing under continual variation, it becomes more challenging to familiarize with the aforementioned,

thus creating the potential for accidents. *"A safe culture is an informed culture."* [78]

According to Caithness Windfarm Information Forum (CWIF), which collects information about accidents and fatalities with in the wind power sector. The accidents that are reported do not include all accidents that have occurred within the industry. [81]

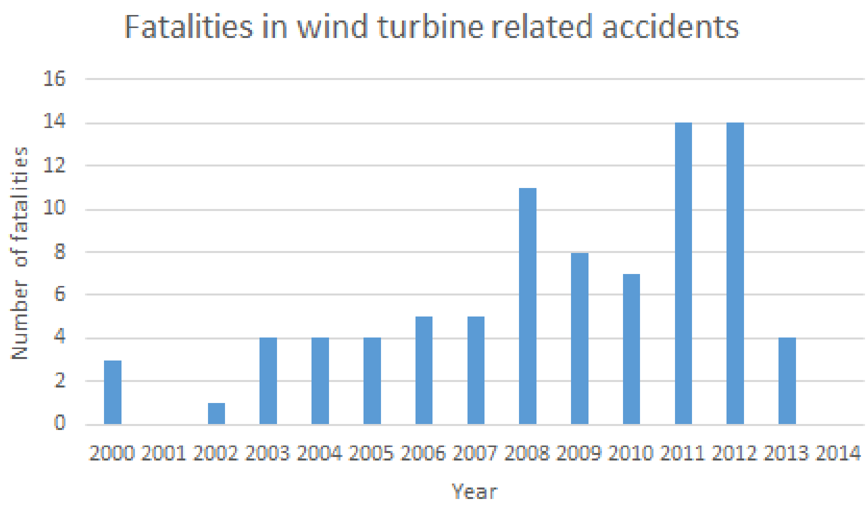

Figure 3.5: An overview of fatalities in the wind power industry.[81]

In Figure 3.5 is a distribution graph for the fatalities that have happened in the wind power industry and it is worth mentioning that these numbers represent the whole wind power industry, offshore and onshore. Since 2000 there have been 122 fatalities recorded in the wind power industry which is significantly less when compared to the oil and gas industry as can be seen in section 3.2. While the wind power industry does not experience many deaths per year when it comes to the loading and transportation of wind turbines offshore as stated above, standardization could facilitate a reduction in accidents. [79] [80]

Since the experience and knowledge of the crew is one of the greatest factors in preventing accidents, and variations in operations inherently create a greater need for experience and knowledge, it is logical to assume that less variation and consequently a decreased requirement for experience and knowledge would facilitate safer practices. Standardization could diminish the variability of technical requirements and procedures used, thus reducing the scope of the crews information needs regarding safety. Many aspects of the lifting phase are subject to danger and variation.

In (NK|A2SEA;11:55 -15:15), Niklas claims that while the lifting procedure for wind turbine components is standardized to some degree, there are still challenges to overcome while loading. One such challenge is the lifting of wind turbine blades; strong winds, in conjunction with the fact that turbine blades are designed to catch wind, pose a threat to the safety of the crew responsible for loading components. Additionally, Niklas specified that lifting equipment and their technical requirements vary depending on the project and the contract. Cranes from both the vessel and harbour (provided by client or turbine manufacturer) are used, and the equipment *"below the hook"* of the crane is designed by the wind turbine manufacturer for the specific component as can be seen in figure 3.6, which was made for this report (NK|A2SEA; 11:55 -15:15).

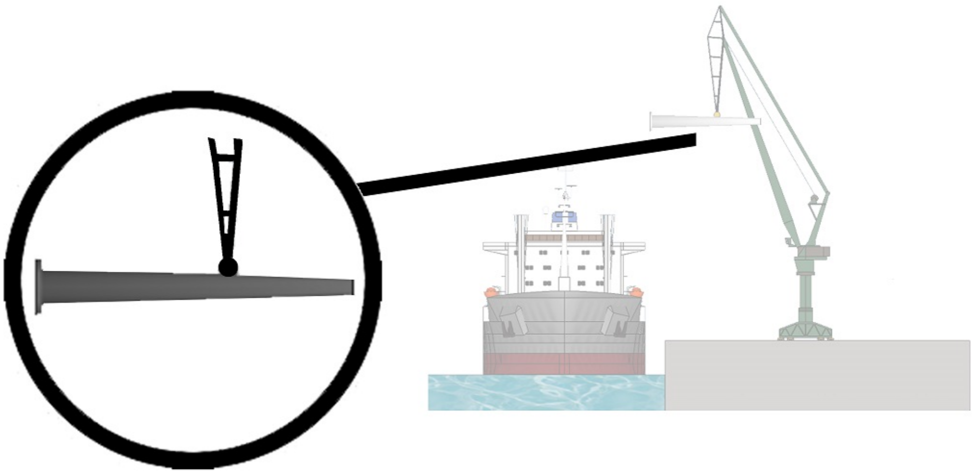

Figure 3.6: Everything below the hook is designed by the manufacturer.

It is impossible to completely standardize technical specifications and procedures due to the inconsistency of project and contract needs, however, a unified global forum (similar to the OGP) for the wind power industry would provide the infrastructure to create work environments that are as consistent as possible. Although a global forum for the wind power industry would not inherently overcome the dangers associated with the loading of turbine blades (or other components), it would provide a network for cooperation; a unified approach to safety would mean that each member would apply practices that are deemed most effective by the industry (e.g. how to safely lift turbine blades).

As mentioned above, the crane and its associated equipment below the hook differ depending on the project and contract. While the lifting equipment is of course subject to what component is being lifted, standards related to technical guidelines for lifting would ensure that the technical requirements and procedures are similar for each lift. BWS and A2Sea follow regulations set by ISO and OHSAS, as well as standards set by the companies respectively (JK|Blue Water Shipping; 22:09 -22:15). [82]

These companies exemplify safety within the wind power industry [83] (JK|Blue Water Shipping; 7:20 - 755), however, emerging and less experienced companies need a benchmark (i.e. a forum which dictates the standards) for safety to minimize accidents. For instance, while the transportation of wind turbine components offshore is not considered a very troublesome phase of offshore instalments, wind turbine blades can interfere with navigation due to their nature. To elaborate, wind turbine blades are designed to catch wind; their placement on deck and heavy winds can cause the blades to impact the manoeuvring of the boat (NK|A2SEA; 11:55 -15:15). Inexperienced and emerging transportation companies may not be aware of the effect wind turbine blades have on transportation or how said effect can be alleviated, indicating that standards are necessary to keep operations as safe as reasonably possible. Other conditions specific to transporting offshore which affect the safety of the crew during transportation would have the potential to be identified and/or ameliorated through a forum for wind power.

As mentioned before, the GWO offers basic safety training for personnel working in the wind power industry. Considering that the GWO is an international recognized wind power organization with 13 members, it could provide a global forum for creating industry standards. Similar to how the OGP unifies the oil and gas industry, it would allow the wind power industry to cooperate in creating standards, assuring that practices are as safe as possible throughout the industry. More specifically, it would provide a forum to standardize health regulation coinciding with lifting and transportation of wind turbine components offshore, reducing the inconsistencies faced in the work environment.

To reiterate, both the loading and transportation phases for offshore instalments could benefit from a unified standard for safety via a global forum for the wind power industry, facilitating similar safety equipment, policies, technical specifications and procedure among operations, which would reduce the amount of knowledge required by the crew and thus the likelihood of accidents occurring. Moreover, other operations (e.g. offshore instalments) within the wind power industry could adhere to similar practices with the same intention. A global forum could improve the uniformity of operations and safety of operations during loading and transportation, it would have the potential to standardize other activities (i.e. social responsibility, security, engineering), as the OGP has for the oil and gas industry.

3.3 Proactive vs. Reactive

Without a forum to implement and predict safety measures, the wind power industry has become reactive rather than proactive in regards to safety. Considering that the wind power industry is a relatively new industry, it could learn from a more experienced industry (such as oil and gas) in an attempt to be more proactive. The oil and gas industry maintains stricter standards than the wind power industry (JK|Blue Water Shipping; 20:00 - 20:30), and although this is a by-product of the nature of the industry, it is also a by-product of experience. The wind power industry should assimilate the OGP's approach to standardization in order to implement safe practices proactively, rather than waiting until the accident has occurred. In (SS|Melchior Engineering; 16:23-17:05), Søren explains that while working for Siemens an accident occurred when a turbine component was being lifted, resulting in the death of a fellow employee. Afterwards, stricter standards regarding documentation were implemented.

This is an example of tackling the situation reactively instead of proactively; if the standards were adequate initially, it may have stopped the accident or at least lessened the severity of its repercussions.

With no organization to unify industry standards, companies may realize too late that their standards are insufficient. Granted, a proactive approach to safety should not completely replace a reactive approach, but rather supplement it. As Jacob states (JK|Blue Water Shipping; 08:29-09:11) BWS has a system to which *near miss* accidents are reported; this proactive approach to safety allows the company to acquire data and experience regarding potential accidents. A2SEA has a *zero harm* policy, which explains that *"we are ALL accountable for our Zero Harm Vision. We strive to reach our Zero Harm Vision through operational excellence. We have the competence to constructively and pro actively influence, intervene and take the lead on safety"*. This proactive approach (NK|A2SEA; 37:39-38:48), enables the company to acquire data and experience in a similar manner to BWS's system.

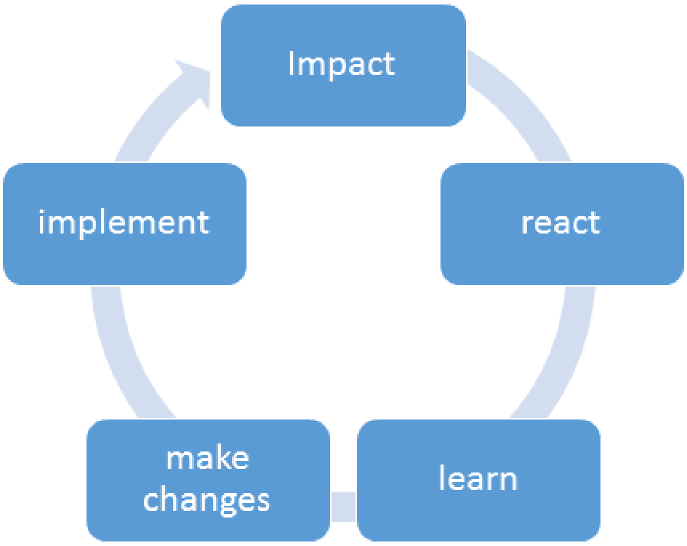

Figure 3.7: The Proactive cycle.

Emerging or inexperienced companies that are less versed in safety matters could assimilate standards that are based on the data and experience of prominent industry members, such as BWS and A2Sea. As the wind power industry grows and new companies emerge, utilizing the experience of established companies and organizations may minimize accidents and enable members to overcome future challenges jointly. By following the proactive approach the companies might be able to use the experience that they or similar industries have acquired, and then learn from the case. These learnings can be implemented so that the incident might not occur again. This process is visually described in Figure 3.7, which was made for this report.

Chapter 4

Conclusion

As described in the analysis, the offshore wind industry is regulated by many laws from different authorities. The transportation of the wind turbines at sea is primarily regulated by the IMO and DMA, with the IMO acting as the international body which creates the legislations for the maritime industry while the DMA ensures that the rules are followed. To a lesser extent, EU policies also affect safety during maritime transport, however its focus is on technical regulation. To reiterate, the safety legislations adhered to in the maritime industry are SOLAS, Safety at Sea Act, and STCW, and are enforced in Danish waters by the DMA. Similarly, lifting is dictated by several European executive orders and the Danish executive no. 1101, however, it is not represented on an international level; lifting laws are enforced by the the Ministry of Climate and Energy, DEA,DS and Danish Working Environment Authority in Denmark.

The interviews and information gathered revealed that legislation is perceived as the minimum safety requirements of the industry, resulting in companies like BWS and A2Sea supplementing this minimum requirement with standards. While the legislations are governed by national authorities, standards are provided by the ISO and OHSAS, which are non-governmental organizations. Their mission is to incorporate a standardizing process and associated best practices, based on the collective experience of the industry; they intend to increase safety levels, via ISO 9001, which is a quality management standard, and through OHSAS 18001, a standard for occupational health and safety.

In addition to these international standards, companies also incorporate internal safety standards, which differ depending on the company's safety culture. BWS and A2Sea incorporate ISO 9001, OHSAS 18001, and internal safety standards into their safety protocol, as well as additional standards if dictated by a contract/project. Standards specific to lifting and transporting wind turbine components offshore are published individually by the GWO, RenewableUK, G9, and EWEA; they cover a wide array of disciplines, such as health and safety, lifting, and transportation.

Via interviews, it was discovered that the health and safety standards used in Denmark are not as consistent as the standards used in the UK. Danish companies, such as Blue Water Shipping and A2Sea, actually are negotiating with the customers to use the UK standards when starting new project. The UK's standardization of health and safety in offshore activities exemplifies a unified approach, but is not the only source of input for an international wind power forum. The GWO, RenewableUK, G9, and EWEA are all potential mediums through which a unified approach to standardization could facilitate practices that are as safe as possible in the wind power industry. Likewise, the OGP acts as the primary international forum for standardization in the oil and gas industry, providing international standards relating to activities like lifting and transportation. It administers companies in the oil and gas industry with the intention of collectively determining the safest practices for various aspects of the industry. An inconsistent work environment caused by differing standards, combined with the benefits of an international forum suggest that the wind power industry should unify under one organization in the same way the oil and gas industry unified under the OGP. A unified approach to create standards would ensure that the safest practices of the industry are of the same standard level, and ensures that companies have a similar approach to safe practices.

As stated in the analysis, a cooperative approach to creating standards would enable the wind power industry to use their collective experience as input to determining safest practices for various aspects of the industry. Specific to the scope of this project, an international forum and industry-wide standardization would provide the opportunity to create a consistent safety environment during lifting and transportation, consequentially reducing the potential for accidents. While it may be speculated that industry "secrets" (i.e. competitive advantages) could discourage companies from joining an international wind power forum, standards can be applied differently, indicating advantage through application. Safety could be interpreted as a competitive advantage within the industry, meaning that individual companies would have to determine if their advantage is worth more than the potential increase in safety industry-wide. Since the wind power industry is an emerging industry that will likely expand in the future and experience new developments, an international forum could provide the infrastructure to tackle future safety issues arising from advancing technology. In conclusion, the GWO, RenewableUK, G9, and EWEA are all potential organizations through which an international forum and subsequent industry-wide standardization would facilitate the safest possible practices of the industry, namely for the lifting and transportation to offshore

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lastpage

Appendix A

Appendix

Interview 1 Søren Steffensen Melchior Engineering

00:00-02:25 Introduction of who Søren is and what he has been working with.

02:25-05:30 Wind turbine lifting process is described.

05:30–06:08 Standards components of a crane is been explored.

06:08–09:25 Which Standards and legislations does have an effect on the way Søren works

09:25–10:57 which dangers are there when loading wind turbines.

10:57–12:08 Whatrisks are involved when lifting wind turbine components on the ship.

12:08–13:29 Which external factors could be complicate the lifting process.

13:29–16:08 Experiences from Søren, about accidents that occurred during a lift.

16:08–17:07 Experience of how accidents affects the legislations and standards

17:07–18:02 Where does he get weather information from, and how do he handle it.

18:02–18:34 Søren explains what he think is the best way to prevent accidents.

18:34–20:01 How does Humans effect a process like lifting wind turbines.

20:01–21:32 What could be damaged during a lifting process.

21:32–24:19 Who is responsible during such a lifting process.

24:19–25:11 What kind of financial losses could be expected.

25:11–26:37 Elaboration, on how the loading process work from the truck to the ship.

26:37–35:47 Closing the interview, and suggestions to further contact in companies.

Questions for Interview 1

- What is the process of lifting a turbine tower?
- What protocol must be followed when loading a wind turbine tower on the ship?
- What kind of lifting system is used for wind turbines when lifting onto the ships?
- What type of crane is used?
- What are the components of the crane?
- What standards/legislations impact your work the most?
- What dangers are faced when loading the wind turbine tower on the ship?
- What risks are involved when lifting a turbine tower?
- What causes failure in the different components of a crane?
- What external factors are involved in the failure of the crane?
- What external factors contribute to the failure of lifting the turbine tower?
- What parties are involved in the process of lifting a turbine tower?
- What accidents can be caused by the aforementioned parties?
- How prevalent is human error within these parties?
- How do weather conditions effect the loading?
- What limitations are faced due to the weather?
- In your opinion what is the key in preventing accidents?
- What damage can occur due the loading?
- Who is responsible in different circumstances?
- What kind of financial losses can be expected if an accident occurs?
- What is the financial worth of the various tools used to load the turbine tower?
- What is the financial worth of the turbine tower?

Interview 2 Jacob Kjærgaard Blue Water Shipping

00:00–03:45 Start up of the interview(preparing)

03:45–04:16 What the process is when loading wind turbine towers to the ship.

04:16–05:11 What kind of lifting system is being used

05:11–06:20 What are the dangers faced during the loading procedure.

06:20–07:17 Which damages can occur during a loading procedure.

07:17–07:53 Which accident could occur in the loading procedure.

07:53–09:27 What they key is to prevent accident from happening.

09:27–09:58 Which parties that are involved in the loading procedure.

09:58–10:46 How they are handling human errors.

10:46–13:21 What financial losses could occur, and what is the worth of crane and tower.

13:21–14:19 which types of cranes are used for loading wind turbine towers to the ship.

14:19–15:04 How weather conditions affect the loading.

15:04–16:08 Which external factors that could contribute to crane failure.

16:08–16:52 Where weather information is from, and who decides to operate or not.

16:52–18:02 How the safety in the wind turbine industry has developed the last years.

18:02–19:11 What is the classification of the transport vessel.

19:11–19:49 How does ISO and OHSAS standards affect the company and its operations.

19:49–21:51 Does BWS have their own standards that exceeds the ISO and OHSAS,

21:51–23:20 How the Industry could improve in a HSEQ perspective.

23:20–24:11 What other forces that could prevent accidents from occurring.

24:11–25:18 How the company monitors that the employees are following safety regulations.

25:18–26:30 Are the legislations and standards to restrictive.

26:30–27:22 Ending the interview.

Questions for Interview 2

- What process is followed when loading wind turbine towers on the ship?
- What kind of lifting system is used for wind turbine towers when lifting onto the ships?
- What dangers are faced when loading the wind turbine tower on the ship?
- What damage can occur during the loading?
- What accidents can occur during the loading?
- In your opinion what is the key in preventing accidents?
- Do you register hazards identified by staff that could cause an accident?
- How do you monitor and report accident rates?
- What parties are involved in the process of lifting a turbine tower on the ship?
- What accidents can be caused by the aforementioned parties?
- How prevalent is human error within these parties?
- Who is responsible in different circumstances?
- What kind of financial losses can be expected if an accident occurs?
- What is the financial worth of the various tools used to load the turbine tower?
- What is the financial worth of the turbine tower?
- What type of crane is used to lift the wind turbine tower?
- What are the components of the crane?
- What causes failure in the different components of a crane?
- What external factors are involved in the failure of the crane?
- What external factors contribute to the failure of lifting the turbine tower?
- How do weather conditions effect the loading?
- What limitations are faced due to the weather?
- How do you deal with the weather window? Do you have direct communication with DMI?
- Have there been any changes in how you work in the last few years?
- What is the classification of the vessels you use to transport the wind turbines?

- Are the people working for BWS certified according to the STWC convention?
- Is there any laws/legislation about insurance for the crew and cargo and transfer vessel you have to comply with?
- How do the ISO/OHSAS standards affect your company?
- Do you have your own standards that exceed the requirements in the international standards?
- Are there any other International standards you are currently using or plan to use?
- Do you use any sort of condition monitoring systems (CMS)?
- What challenges does the company face when trying to comply with existing legislation (which dictates the safety of the crew)?
- What challenges do individual crew members face when trying to comply with existing legislation (which dictates the safety of the crew)?
- Do you feel that the legislation plays a role in preventing these accidents from occurring?
- Are there other forces (standards, job security, etc.) that play a bigger role in preventing accidents?
- How does the company monitor and ensure that crew members comply with safety laws?
- Are any of the existing crew safety laws too restrictive? If so, how would the company benefit from less restrictive legislation?

Interview 3 Niklas Karlsson A2SEA

00:00-02:00 Introduction of the interviewee

02:00-11:55 Introduction of the company

11:55-15:15 Description of the system used for lifting wind turbines(loading procedure)and problems related to it.

15:15–17:30 Do the company add own standard for loading windturbines

17:30-20:18 Challenges related to the standards and legislation in the offshore wind industry/3 industries put together(maritime operation, onshore construction, offshore works)

20:18–20:35 Challenges related collaboration with many different authorities

20:35-29:08 Dangers facing when loading wind turbine on to the ship(learning by doing) there is a problem with there is not so many standard, in this new field.

29:08–34:58 Who set the requirements of used standards (the legislative system is slower to react)

34:58-36:33 Accident occurring during the loading process

36:33–47:22 What is the key to prevent accidents (A2SEA policy is more or less being descript)

47:22-51:58 The company's way of managing the accident, they use a software that gathers all accident and near misses. They identify accident both proactively and reactively.

51:58-56:24 Parties involved in the loading process.

56:24–1:02:00 The challenges when have many parties involved in the loading proces

1:02:00–1:03.00 Financial losses when loading wing tubines(nothing of important to take from this)

1:03:00–1:04:40 Type of crane used when lifting wind tubines

1:04:40–1:06:12 Which kind of external factors can contribute to failure in the loading process

1:06:12–1:09:35 How they deals with weather windows

1:09:35–1:15:25 How has HSE developed true the last couple of years, and challenges

1:15:25-1:21:02 Showing of pictures

1:021:02–1:22:54 How people are certified in order to work within the specific field of operation.

1:22:54-1:24:20 How does ISO and OHSAS affects the company

1:24:20–1:26:12 Which standards do A2Sea have which exceeds the other standards

1:26:12–1:29:00 What new standards are in the scope

1:29:00–1:30:08 What kind CMS systems do they use

1:30:08–1:35:18 Collaboration with the Authorities

1:35:18–1:38:10 Which factors do prevent accidents from happening

1:38:10–1:40:50 Which HSEQ Policies do they follows

1:40:50–1:43:50 Could the Offshore wind industry benefit from known HSEQ policies in the Oil gas industry

1:43:50–1:45:53 Who should set and govern the standards

1:45:53–1:46:33 Ending the interview

Questions for Interview 3

- What process is followed when loading wind turbine towers on the ship?
- What kind of lifting system is used for wind turbine towers when lifting onto the ships?
- What dangers are faced when loading the wind turbine tower on the ship?
- What damage can occur during the loading?
- What accidents can occur during the loading?
- In your opinion what is the key in preventing accidents?
- Do you register hazards identified by staff that could cause an accident?
- How do you monitor and report accident rates?
- What parties are involved in the process of lifting a turbine tower on the ship?
- What accidents can be caused by the aforementioned parties?
- How prevalent is human error within these parties?
- Who is responsible in different circumstances?
- What kind of financial losses can be expected if an accident occurs?
- What is the financial worth of the various tools used to load the turbine tower?

- What is the financial worth of the turbine tower?
- What type of crane is used to lift the wind turbine tower?
- What are the components of the crane?
- What causes failure in the different components of a crane?
- What external factors are involved in the failure of the crane?
- What external factors contribute to the failure of lifting the turbine tower?
- How do weather conditions effect the loading?
- What limitations are faced due to the weather?
- How do you deal with the weather window? Do you have direct communication with DMI?
- Have there been any changes in how you work in the last few years?
- What is the classification of the vessels you use to transport the wind turbines?
- Are the people working for BWS certified according to the STWC convention?
- Is there any laws/legislation about insurance for the crew and cargo and transfer vessel you have to comply with?
- How do the ISO/OHSAS standards affect your company?
- Do you have your own standards that exceed the requirements in the international standards?
- Are there any other International standards you are currently using or plan to use?
- Do you use any sort of condition monitoring systems (CMS)?
- What challenges does the company face when trying to comply with existing legislation (which dictates the safety of the crew)?
- What challenges do individual crew members face when trying to comply with existing legislation (which dictates the safety of the crew)?
- Do you feel that the legislation plays a role in preventing these accidents from occurring?
- Are there other forces (standards, job security, etc.) that play a bigger role in preventing accidents?
- How does the company monitor and ensure that crew members comply with safety laws?
- Are any of the existing crew safety laws too restrictive? If so, how would the company benefit from less restrictive legislation?