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Abstract

Serious search has begun for oil and gas deposits within Iceland's exclusive economic zone, more specifically in the Dreki area 335km north-east of Iceland. Icelandic authorities do not have the structure or experience to administrate and supervise offshore petroleum activities. It is however very important that these authorities are prepared if application for exploration drilling are handed in. To avoid starting at the beginning of the learning curve Icelandic authorities should look towards countries that are experienced in administrating and supervising such activities. Norwegian authorities have been quite responsive in adjusting their regulatory framework and regulatory regime to respond to recommended changes following major accidents and new challenges. Norwegian authorities base their regulatory framework on performance base regulations that are then supplemented with few specific requirements. This allows and encourages innovation and possible cost reductions. The chosen solution is however required to result the same performance or better than is required by legislation. The Norwegian management structure for offshore petroleum activities is quite simple. That is partly due to the fact that the Petroleum Safety Authority (PSA) takes on all matters concerning health, safety and the environment and from within collaborates and cooperates with other authorities regarding their respective area of expertise. Icelandic authorities should look towards the Norwegian approach to ensure safe extraction of oil and gas. There is noticeable movement internationally to separate the responsibilities of natural resource management and supervision of offshore petroleum activities. Icelandic authorities should implement performance based regulations and setup a simple management structure. It is suggested that the NEA holds the responsibility of awarding licenses for exploration and production. It is as well suggested that either the ICA or the AOSH take over the supervising responsibility and collaboration with other authorities as they hold considerable experience in processing and evaluating technical documents and information.

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List of figures

Figure 1 – Serious injuries per million workhours in the NCS 1990-2014.....	16
Figure 2 – A highlight of the Dreki area north-east of Iceland.	18
Figure 3 – Distance from coast of Iceland and Jan Mayen to the Dreki area.	19
Figure 4 – The Dreki area with relative block numbers.....	20
Figure 5 - Supervising authorities regarding offshore petroleum activities in Iceland.....	24
Figure 6 - Setup of regulatory offices in Norway regardin offshore petroleum activities	34
Figure 7 - Legislative hierarchy in Norway	40
Figure 8 – The risk assessment process	56
Figure 9 – The emergency preparedness assessment process	58
Figure 10 – Coordinated authorities/institutions.....	63
Figure 11 – Project development process for offshore petroleum activities.....	65

Abbreviations

AIS	Automatic Identification System
ALARP	As Low As Reasonably Possible
AoC	Acknowledgement of Compliance
AOSH	Administration for Occupational Safety and Health
APS	Abandon Platform Shutdown
BAT	Best Available Technology
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
BOG	Decision to implement
BOK	Concretization decision
BOV	Decision to continue
BP	British Petroleum
CRASH	Computerized Risk Assessment of Shipping Hazards
DECC	Department of Energy and Climate Change
DF	Directorate of Fisheries
DLI	Directorate of Labour Inspection
DoI	Department of Interior
DSHA	Defined Situations of Hazards and Accidents
DwH	Deepwater Horizon
EAI	Environment Agency of Iceland
EEA	European Economic Area
ESD	Emergency ShutDown
EU	European Union
FAR	Fatal Annual Rate
FDPP	Field Development and Production Plan
FDPSO	Floating Drilling, Production, Storage and Operation
FMEA	Failure Mode and Effects Analysis
FPSO	Floating Production, Storage and Operation
HAZID	HAZard Identification
HAZOP	HAZard Operatbility study
HSE	Health, Safety and the Environment
IA	Impact Assessment
ICA	Iceland Construction Authority
ICETRA	Icelandic Transport Authority

ICG	Icelandic Coast Guard
INPA	Icelandic National Planning Agency
IRSA	Icelandic Radiation Safety Authority
MCE	Ministry of Climate and Environment
MENR	Ministry for the Environment and Natural Resources
MFA	Ministry for Foreign Affairs
MI	Ministry of Interior
MII	Ministry of Industry and Innovation
MIR	Marine Research Institute
MMS	Mineral Management Service
MoLSA	Ministry of Labour and Social Affairs
MoW	Ministry of Welfare
MPE	Ministry of Petroleum and Energy
MTC	Ministry of Transport and Communications
MTIF	Ministry of Trade, Industry and Fisheries
MTS	Marine Traffic Service
NCA	Norwegian Coastal Administration
NCS	Norwegian Continental Shelf
NDH	Norwegian Directorate of Health
NFSA	Norwegian Food Safety Authority
NEA	National Energy Authority
NoEA	Norwegian Environment Agency
NOG	Norsk Oil & Gas
NPD	Norsk Petroleum Directorate
NR	Norwegian Shipowners Association
PDO	Plan for Development and Operation
PIO	Plan for Installation and Operation
PSA	Petroleum Safety Authority
RIA	Regional Impact Assessment
SE	Safety Evaluation
U.K.	United Kingdom
U.K. HSE	U.K. Health and Safety Executive
U.S.	United States

Contents

- Abstract 2
- Acknowledgements 3
- List of figures 4
- Abbreviations 5
- 1 Introduction 10
 - 1.1 Background and problem description..... 10
 - 1.2 Aim of the research..... 11
 - 1.3 The scope of work 11
 - 1.4 Thesis outline..... 11
 - 1.5 Limitations..... 12
- 2 Development of legal frameworks 13
 - 2.1 Performance or prescriptive based 13
 - 2.2 Changes in legislation following major accidents 13
 - 2.2.1 The United States 14
 - 2.2.2 The United Kingdom 14
 - 2.2.3 Norway..... 15
 - 2.3 Summary..... 16
- 3 The situation in Iceland 18
 - 3.1 Licenses 18
 - 3.2 Cooperation agreements with Norwegian authorities 19
 - 3.3 Conditions at Dreki area 21
 - 3.4 High risk operations..... 22
 - 3.5 Summary..... 22
- 4 Setup of regulatory offices in Iceland connected to offshore petroleum activities 24
 - 4.1 Ministry of Industries and Innovation 25
 - 4.1.1 The National Energy Authority 25
 - 4.1.2 The Marine Research Institute 27
 - 4.2 Ministry for the Environment and Natural Resources..... 27

4.2.1 The Iceland Construction Authority	27
4.2.2 The Environment Agency of Iceland	28
4.2.3 The Icelandic National Planning Agency	29
4.2.4 The Icelandic Institute of Natural History	29
4.3 Ministry of the Interior	30
4.3.1 The Icelandic Transport Authority.....	30
4.3.2 The Icelandic Coast Guard.....	31
4.4 Ministry of Welfare	31
4.4.1 The Icelandic Radiation Safety Authority	31
4.4.2 The Administration of Occupational Safety and Health.....	32
4.5 Summary.....	32
5 Oil and gas management structure in Norway	34
5.1 Ministry of Petroleum and Energy	34
5.1.1 The Norwegian Petroleum Directorate	35
5.2 Ministry of Labour and Social Affairs	35
5.2.1 The Petroleum Safety Authority	35
5.3 Ministry of Climate and Environment.....	36
5.3.1 Norwegian Environment Agency	36
5.4 Ministry of Transport and Communications	37
5.4.1 The Norwegian Coastal Administration	37
5.5 Ministry of Trade, Industry and Fisheries	37
5.5.1 The Directorate of Fisheries.....	37
5.6 Summary.....	38
6 Regulatory framework regarding fire and explosion hazards in Norway	39
6.1 Acts.....	39
6.1.1 The Petroleum Act	40
6.1.2 The Pollution Control Act.....	42
6.1.3 The Working Environment Act	43

6.2 Regulations	45
6.2.1 Framework Regulations	45
6.2.2 The Management Regulations	47
6.2.3 The Activities Regulations.....	50
6.2.4 The Facilities Regulations.....	51
6.3 Recommended practices through guidelines and standards	55
6.4 Summary.....	61
7 The Norwegian Regulatory regime and process	63
7.1 Documentation process.....	64
7.1.1 Impact Assessment.....	66
7.1.2 Plan for development and operation of petroleum deposits and plan for installation and operation.....	67
7.1.3 Application for consent.....	70
7.1.4 Acknowledgement of Compliance.....	71
7.2 Summary.....	73
8 Results and discussion.....	74
8.1 What type of regulatory framework would be ideal for Iceland?.....	74
8.2 Who would be the principal authorities?	75
8.3 What requirements would have to be met?	77
8.4 Potential future work and comments	80
9 Conclusion.....	82
10 References	84
Appendix I.....	91
Appendix II	93
Appendix III	94
Appendix IV	95
Appendix V	97

1 Introduction

1.1 Background and problem description

Icelandic authorities have never faced the challenge of administrating or supervising offshore petroleum activities and thus there is little infrastructure within the regulatory administration to treat applications and supervise such activities. Search for oil and gas has however begun within Iceland's exclusive economic zone. Now Icelandic authorities have to react and prepare. It is important to be ready with sufficient regulatory framework when and if applications for drilling operations are handed in to save both time and money, and even more important is to assure safety to personnel and the environment.

Petroleum offshore activities are high risk operations where large amounts of flammable liquids and gases are extracted, processed and transported. These volumes do not only pose danger to the environment but also to personnel who work on drilling and production facilities if not handled in safe manner. Some of the greatest catastrophes in the industry have been linked to poor management and supervision. The most dangerous accidents are linked to fire and explosion events and as they may spread quickly through the facility and in some cases vast amount of hydrocarbons are released to the ocean. Requirements have to be set to reduce the likelihood of leakage and furthermore prevent ignition.

The offshore petroleum industry is a controversial one, especially in Iceland. Iceland has the image of being a clean and sustainable country. A decision to initiate licensing rounds was not very heated as it was made during the financial crisis in 2008-2011 and gave hope of financial aid from an unanticipated resource. Some did though protest for the environmental impact these activities may have and the risk involved. Iceland's economy is now recovering after the financial crisis and partly due to much increase in tourist traffic. Today there are social and political pressures rising as the industry is believed to result a negative impact on the tourist attraction as well as concerns for the environment.

A legislative approach and regulatory framework has to be established as soon as possible and initiate work on writing regulation that set requirements for the industry. Norway has been successful in their regulatory duties for their offshore industry. They have decades of experience and have been active in developing their legislation and approach to administration and supervision. It would be beneficial for Icelandic authorities to look their way for inspiration and collaboration as they have the experience and relatively large institutions related to the industry.

1.2 Aim of the research

The aim of the thesis is to research and look into how legislation has developed through time in selected countries and what caused major changes. The thesis shall include a research on the status in Iceland, both at the Dreki area where activities may commence and the structure of the regulatory regime. The objective is also to establish what type of regulatory framework approach is appropriate for Icelandic authorities to administrate and supervise offshore petroleum activities especially regarding fire and explosion hazards. The thesis shall also discuss how responsibilities should be separated between key authorities. The thesis will specifically look at the Norwegian administrative approach and regulatory framework and process for inspiration.

1.3 The scope of work

The thesis will research the current situation in Iceland regarding possible offshore petroleum activities, including the regulatory regime and conditions at the Dreki area. It will as well include a comprehensive description of the Norwegian regulatory framework as well as a description of the supervising responsibilities of different authorities in Norway and the documentation process for developments. Finally results and discussion will cover the findings of the thesis and give recommendation on suitable regulatory framework and nominate authorities that are appropriate for different administrative and supervising responsibilities.

1.4 Thesis outline

The thesis comprises of eight chapters. Following this introduction Chapter 2 covers different approaches and development of legislative frameworks for offshore petroleum activities in selected countries.

Chapter 3 describes the situation in Iceland and the conditions at the Dreki area where active exploration and production licenses have been issued.

Chapter 4 describes the setup of regulatory offices in Iceland that will be involved in administrating and supervising offshore petroleum activities in the Dreki area.

Chapter 5 describes the oil and gas management structure in Norway, including a description of involved authorities and agencies and the separation of responsibilities.

Chapter 6 describes the Norwegian regulatory framework regarding in Norway, focusing on aspects related to fire and explosion hazard.

Chapter 7 describes the Norwegian regulatory regime and the documentation process for development of offshore petroleum activities.

Chapter 8 discusses the results from previous chapters and elaborates on the how Iceland may tackle administration and supervision for offshore petroleum activities. The chapter also includes ideas and recommendation for potential future research.

Finally Chapter 9 lists key results of the thesis.

1.5 Limitations

The thesis's scope is limited to the geographical location of the Dreki area.

The thesis specifically focuses on drilling and production operations offshore that are connected to exploration and production of hydrocarbons.

There is little as no structure or experience within Icelandic authorities to administrate or supervise so large developments offshore that results in little research and documentation for such operations regarding regulation, supervision and administration.

2 Development of legal frameworks

This chapter will discuss different approaches to legislative framework for offshore petroleum industries in selected countries. It will also discuss the cause of change and development of legal frameworks that have been implemented as well as development of management structures.

2.1 Performance or prescriptive based

Different countries have implemented different approaches in their legislative framework for assuring safety for their offshore activities. There are two main approaches to regulations that are in use today or a combination of both. These approaches are either prescriptive or performance based legislation. (Dagg, et al., 2011) The prescriptive approach can be described as when regulatory bodies of a country set firm specific requirements that operators must meet. These requirements can be set for structures, technical equipment and operations with the aim of avoiding accidents and minimizing hazards. It is then the regulatory authority's duty to follow up and monitor that these requirements are complied with. Performance based regulations set out specific requirements where certain functions and performance has to be sustained. It is the operator's responsibility to meet those requirements and is given a certain amount of freedom to comply. (Haug, et al., 2010)

2.2 Changes in legislation following major accidents

The United States have been developing their legislation and regulatory infrastructure after the *Deepwater Horizon* (DwH) accident that occurred in the spring of 2010 in the Gulf of Mexico. Eleven people died and seventeen other were seriously injured, furthermore an estimate of 4.9 million barrels of oil were released to the ocean. (National Commission on the BP DwH Oil Spill and Offshore Drilling, 2011). Following the accident an investigation was launched to narrow down the cause of the accident and what can be done to reduce the chances of a similar event happening. Subsequently after several publications of reports from different companies and regulators, changes to the regulatory regime and requirements were recommended in some countries, such as United States, United Kingdom, Norway and Brazil to name a few (Haquet, 2014). The European Commission concluded shortly after the DwH accident that the European Union legal framework concerning offshore activities were too fragmented for the risk involved in the fast evolution of the offshore industry (European Commission, 2010). In 2011 the European Parliament published a legislative proposal regarding safety of offshore oil and gas

prospection, exploration and production activities and a complete directive was put into force in June 2013 which has to be implemented in the EU countries by 19th July 2015 (European Parliament, 2011). The key objectives of the Directive is to (European Parliament, 2013):

- reduce as far as possible the occurrence of major accidents to the offshore oil and gas operations and to limit their consequences,
- establishing a minimum conditions for safe offshore exploration and exploitation of oil and gas,
- improve the response mechanism in case of an accident,
- and separate the regulatory functions of the competent authority from the functions relating to the economic development of offshore natural resources.

2.2.1 The United States

Before the DwH accident the U.S. regulatory regime consisted primarily of prescriptive regulations and often requiring industry standards through regulatory incorporation (Haug, et al., 2010). In this regulatory regime the U.S. Department of Interior (DoI) delegated the responsibility of the three main regulatory responsibilities related to offshore activities to the Mineral Management Service (MMS). These responsibilities were (1) evaluating, planning, and leasing offshore oil and gas resources; (2) implementing environmental and safety regulations; and (3) collecting royalties and managing revenue from energy activities. Recommendations were made to change the approach to the regulatory regime. It was recommended that performance based regulations should be implemented and be supplemented by prescriptive based regulations (National Commission on the BP DwH Oil Spill and Offshore Drilling, 2011). In May 2010 the process of separating the administrative functions was initiated (Dagg, et al., 2011). In October 2011 these functions were transferred to new offices. These offices are (1) The Bureau of Ocean Energy Management, (2) Bureau of Safety and Environmental Enforcement, and (3) Office of Natural Resources Revenue (BOEMRE, 2011).

2.2.2 The United Kingdom

As with the case of U.S. the United Kingdom decided to change their approach to the regulatory regime for offshore activities following an offshore disaster. The disaster is known as the *Piper Alpha* disaster occurred in 1988 where 167 people died. (Dagg, et al., 2011) Recommendations that were made following the accident aimed at transferring the liability to the operators. That the operators should at all times be completely liable for the harm they may cause with their operations. It was also recommended that the preferred form of regulations would be

performance based rather than prescriptive. So that it would be the operator's responsibility to demonstrate to authorities that the design of facilities and operations are safe. (Mannan, 2005) Today the U.K.'s regulatory authority is mainly spread to two offices, each with specific tasks relating to the offshore industry. Department of Energy and Climate Change (DECC) is responsible for licensing, exploration and development of oil and gas whilst the Health and Safety Executive (U.K. HSE) Offshore Division regulates hazardous risk to health, safety and the environment. Parliamentary acts set out the framework and designate responsibilities to ministries. The ministries have the authority to derive regulations from the acts with more details regarding the requirements. The U.K.'s regulatory approach to HSE regulations are performance based and operators are given a certain area of freedom to meet the requirements. Guidelines are published to regulations where applicable and if an operator follows those he can be sure of that he is complying with the laws in place. However, it is the operator's responsibility to demonstrate a continuous minimization of risk to health and environmental hazards to As Low As Reasonably Practicable (ALARP). (Dagg, et al., 2011)

2.2.3 Norway

Norwegian authorities have been quite responsive in implementing changes to their legislative framework following major accidents on the Norwegian Continental Shelf (NCS) and elsewhere. There were two disasters that had the most influence on the development of the regulatory framework in Norway. First the Bravo blowout in 1977 where 9000 tonnes of oil was spilled to the sea over a period of one week. The second disaster was the overturn of the mobile accommodation rig *Alexander L Kielland* in 1980 where 123 people lost their lives. A special committee was established following these events to frame a new petroleum activities act for the offshore industry. A new act came into action in 1985 and focused on improving coordination between regulatory agencies and reduce their number as well as introducing the use of risk analysis and oblige licensees to implement internal control. Since then the main developments have been associated with moving from prescriptive regulations towards performance and risk based regulations. (PSA, 2010)

Today Norway's approach to the regulatory framework is based on laying performance based and risk based regulation that contain few mandatory technical requirements. Operators are required to meet certain objectives for managing their facilities and operation of their activities. They are as well required to choose technical, operational or organizational solutions that reduce the risk of harm to people, the environment and material assets. Guidelines and standards are used to guide the operators to recommended practices. The operators are however free to

adapt new structural features and operational practices whilst they are able to demonstrate that they are as good as or better than what is recommended in guidelines and standards. (MoLSA, 2013) Chapter 6 will cover the Norwegian approach in more detail.

It may be difficult to establish a performance indicator for regulatory approaches but looking at injury count may give a certain assumption. Figure 1 shows the count of serious injuries that occurred on the Norwegian Continental Shelf 1990-2014. Compatible information were not available for years prior to 1990. Because so few fatal accidents occur on the NCS the Fatal Annual Rate (FAR) is not descriptive enough to be used as a performance indicator. The figure shows how injuries have been on the decline in the long run since 1990, especially on board mobile facilities.

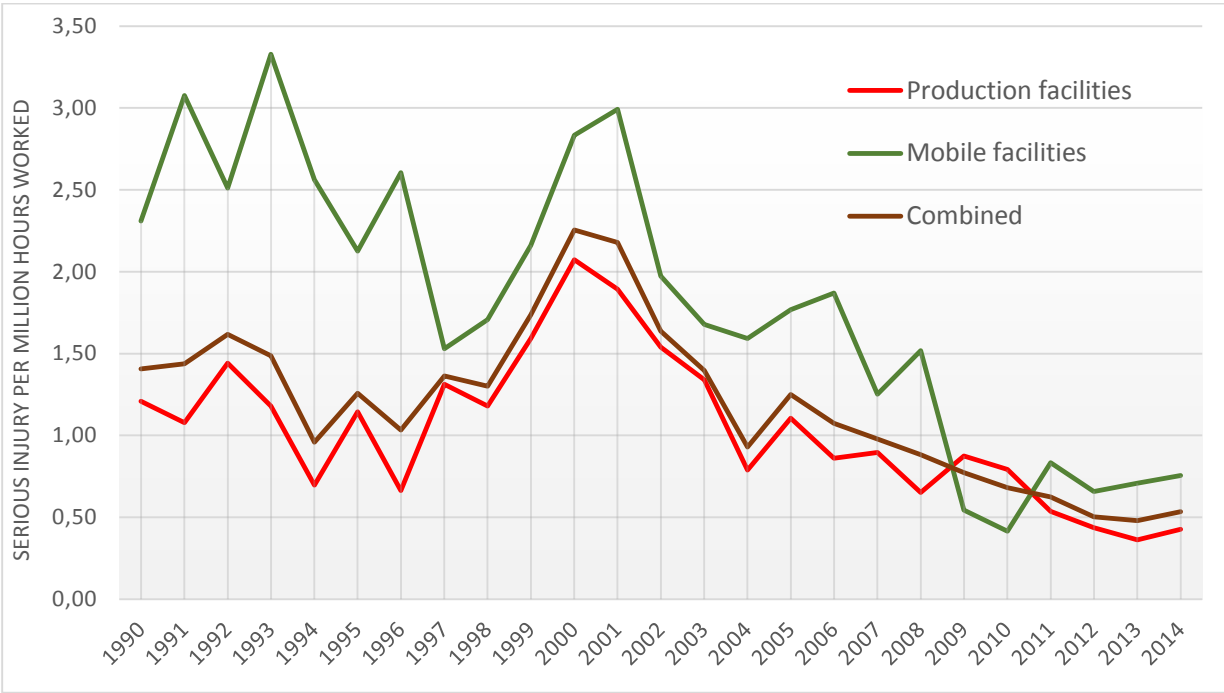


Figure 1 – Serious injuries per million workhours in the NCS 1990-2014 (PSA, 2015)

2.3 Summary

A change in the regulatory setup and regime is noticeable following major accidents. There is an indication of increasing use of performance based approach to safety regulations (Redmill & Rajan, 1997). They provide more flexibility and incentives for innovation when compared with traditional prescriptive requirements as well as giving the operators the chance of reducing cost by choosing a less expensive option that achieves the same level of performance.

(Coglianese, et al., 2002) There has also been a movement towards separating the administrative functions of authorities. Conflict of interest are likely to arise if a single office has the responsibility of awarding licenses for offshore activities and in the same time a regulatory authority that is responsible for overseeing safety for the same operations. Even further is it not wise to have the revenue management within either of these offices, especially if they are combined. (Dagg, et al., 2011)

3 The situation in Iceland

This chapter will discuss the situation in Iceland regarding offshore petroleum activities and the conditions at the Dreki area.

3.1 Licenses

Iceland is not a producer of oil and gas and has never been. Chances are that the situation will change in the coming years. Two licensing rounds for exploration and production rights in the Dreki area have been executed, resulting two active licenses in June 2015. In early 2015 one licensee relinquished his rights due to unfavorable seabed conditions for seismic surveys. The Dreki area is roughly 335 km. northeast of Iceland and the same distance south of Jan Mayen. The most southern part of Dreki area is at latitude 67°N and the most northern part reaches little north of latitude 69°N and limited by Iceland's 200 mile exclusive economic zone. This is illustrated in figures 2, 3 and 4. The whole area is thus north of the Arctic Circle which lies at 66°34'N. The challenges that Iceland faces connected to probable offshore activities is not only that it hasn't been done before and little legislation have past regarding such operations but also the harsh conditions that are known and possibly unknown in the open ocean at this latitude. (MII, 2007)

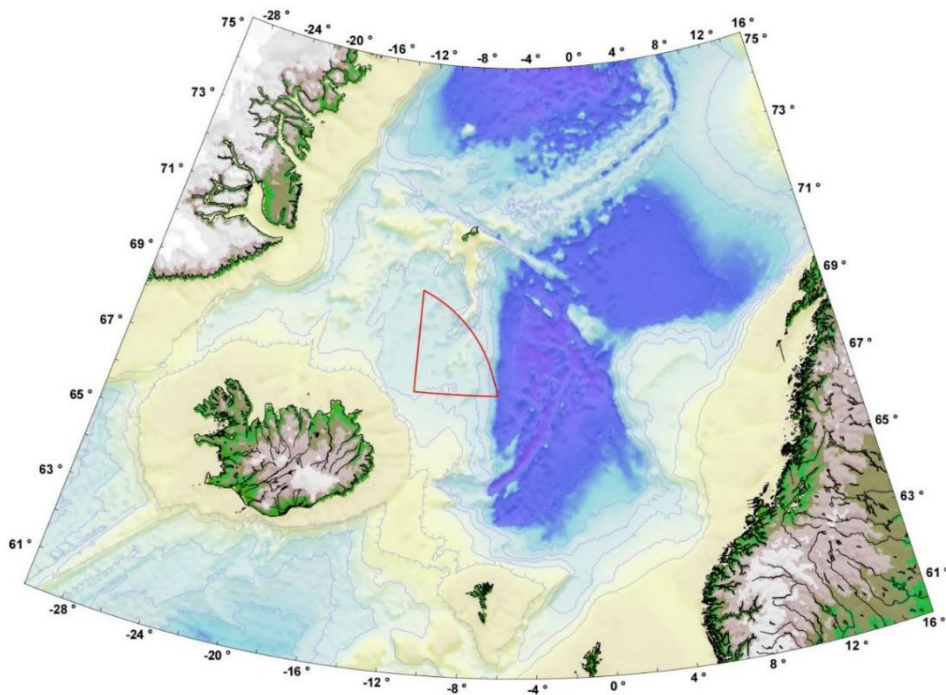


Figure 2 – A highlight of the Dreki area north-east of Iceland. (NEA, 2011)

3.2 Cooperation agreements with Norwegian authorities

The National Energy Authority of Iceland (NEA) is in the process of signing cooperation agreements with both the Petroleum Safety Authority of Norway (PSA) and the Norwegian Petroleum Directorate (NPD). These agreements are made for cooperation regarding matters relevant to hydrocarbon activities in the Jan Mayen area. The agreement with NPD includes sharing of information, data, experiences regarding licensing and legal issues, and geological interpretation. More relevant to the thesis is the contract with PSA where the goal is to promote the development of comparable regulatory framework and policies. It includes exchanges of information on policies, regulations, regulatory methods and processes, practices and other matters within the field of petroleum activities. (PSA & NEA, 2015) (NPD & NEA, 2015) (Geirsson, 2015)

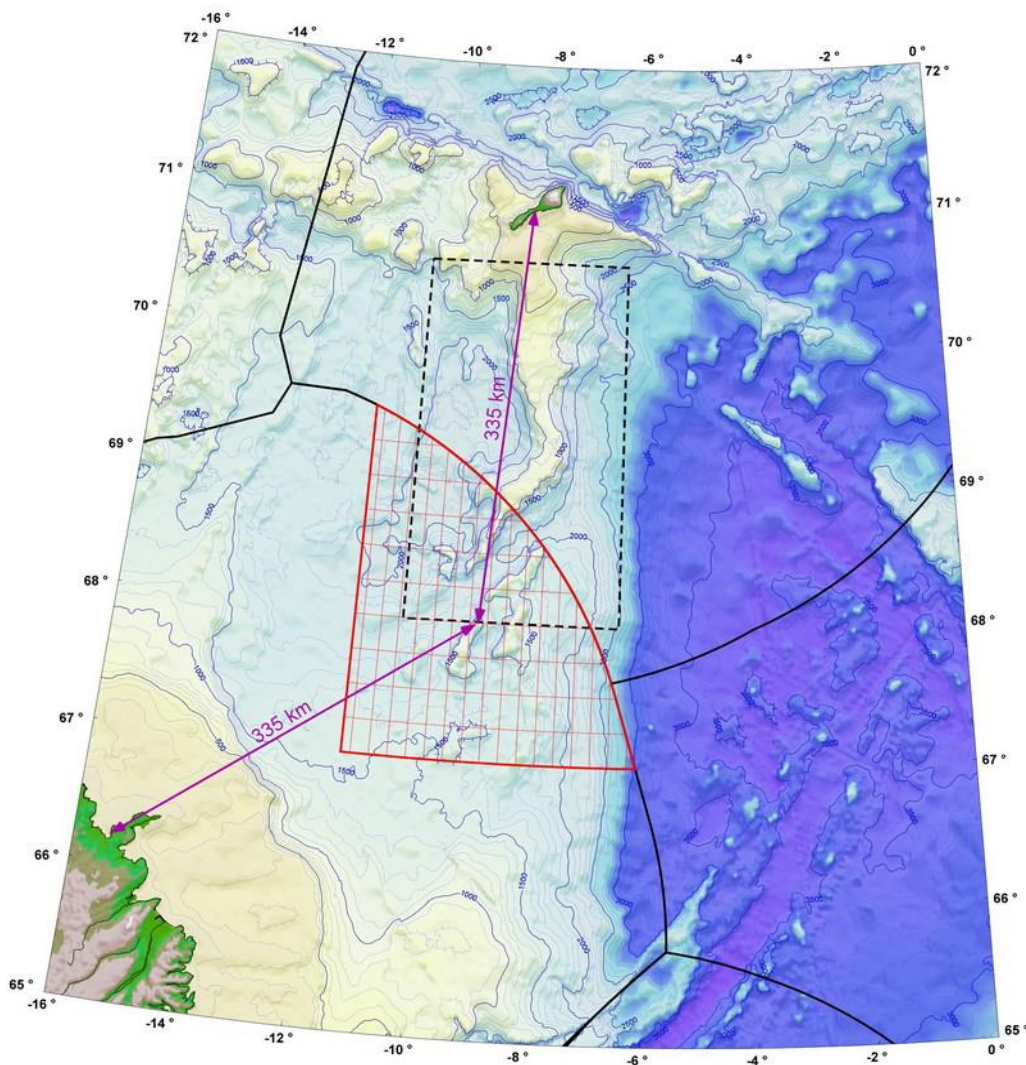


Figure 3 – Distance from coast of Iceland and Jan Mayen to the Dreki area. Red line marks the Dreki area. Black dotted line covers the shared participation area (NEA, n.d.)

The government of Iceland and Norway signed an agreement in the early 1980's on how to divide the area between Iceland and Jan Mayen (Norway). The agreement states that Iceland has control over the 200 mile exclusive economic zone which includes the Dreki area. However, within a certain area that covers both areas of Iceland's and Norway's exclusive economic zone both countries have the right of 25% share in any exploration and production licenses if they so please. (MFA, 1982) Norway decided to exercise that right when NEA issued the exploration and production licenses and Petoro is the shareholder on behalf of the Norwegian State for both active licenses.

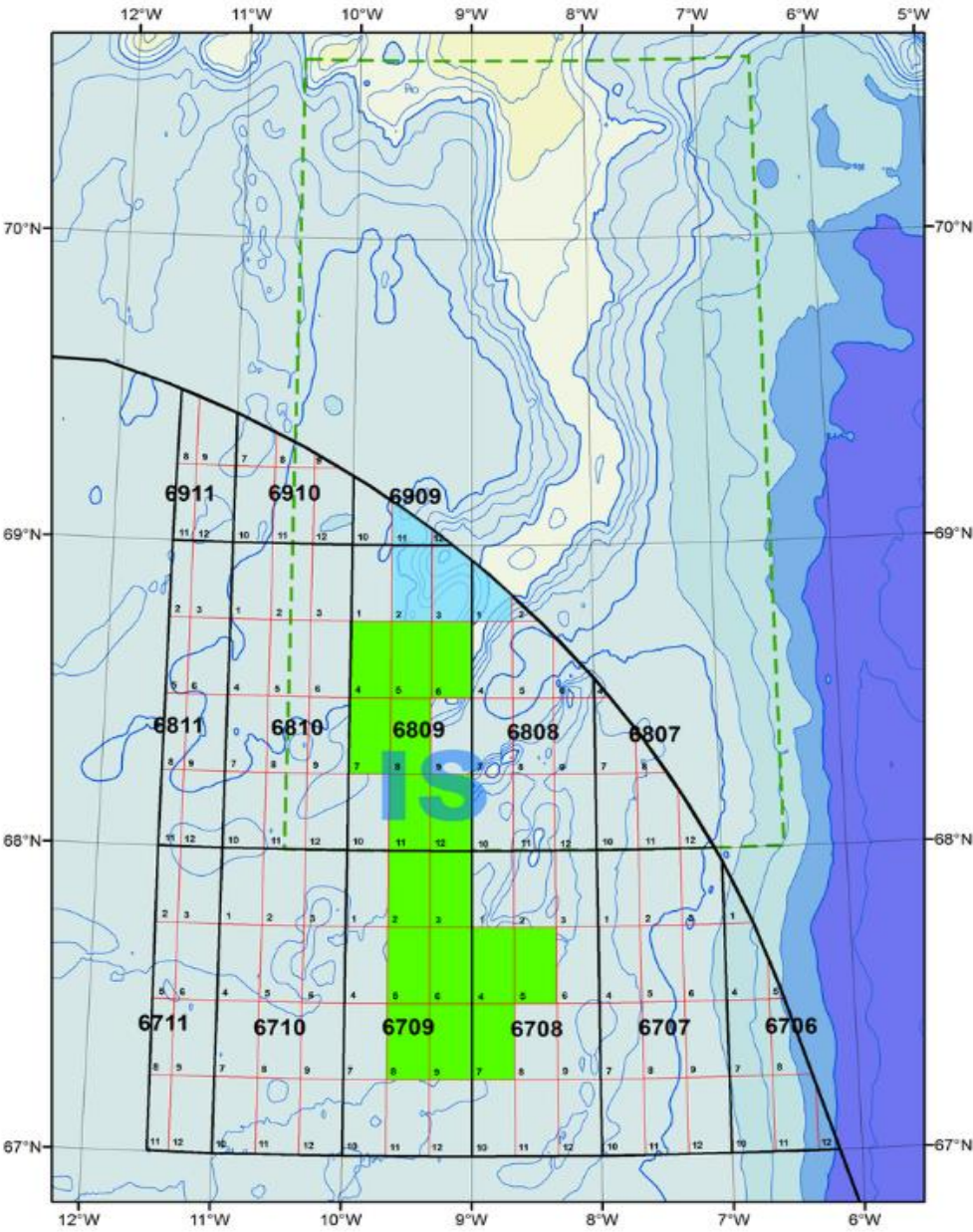


Figure 4 – The Dreki area with relative block numbers. Green and blue areas illustrate the blocks with active licenses. (NEA, 2015)

3.3 Conditions at Dreki area

Weather conditions so far north can get quite harsh and introduce extra challenges to offshore activities. Conditions that can interfere with offshore operations and possibly be the cause of accidents, mishaps and damage to facilities are for example high wind speed, icing and limited visibility (MII, 2007).

Factors influencing visibility are daylight hours, precipitation and fog. Daylight hours vary a lot throughout the year as the sun is not visible during a whole month each year, whilst from May until August there is daylight around the clock. For almost four months there is less than 10 hours of daylight available. Precipitation is very common in the area, especially during autumn and winter. The precipitation is in the form of snow or sleet seven months a year and during winter times. This kind of precipitation can have much effect on visibility. Thunderstorms and lightnings are rare in the area, there were 44 lightnings recorded over a period of four and half years. That is 100 times less than in the Brent area in the North Sea. The main reason for limited visibility in the Jan Mayen area during summer is fog. Fog is believed to be able to limit visibility 20% of the time during high summer. (Auðunsdóttir, et al., 2007)

The average temperature at the Jan Mayen area during winter is -2°C to 0°C and during hottest periods of summer it is 7°C to 8°C . Wind speeds are not favorable as they approach 10m/s on average during winter and 6m/s during summer. Icing is most likely during November until April but rough estimation determines that it is not in such amount that it would cause problems for stability of structures. However this might lead to hazardous environment for helicopters and workers outside. (Auðunsdóttir, et al., 2007)

The sea conditions can have high influence on the safety of operations on offshore facilities and distribution of oil spills. For example high waves can damage structures and low ocean temperature shortens the time humans can stay in water in case of an emergency. The sea temperature is warmer than the air temperature on average through the year or approximately 0°C when coldest and 7°C when warmest (Auðunsdóttir, et al., 2007). Wave heights are relatively low in the area compared to wave heights close to the coast of Norway. The 100 year wave height has been measured as 12m at the Dreki area, whilst 14-16m around Norway (Viggósson, et al., 2007). Drift ice has not been noticed in the area the last decades, however with one exception 40 years ago. Not enough data is available for determining the situation of the ocean currents in the area and further research is needed (MII, 2007).

Distance to the Dreki area is a cause for special attention with regard to safety of personnel and the environment. In a case of emergency where evacuation is necessary and pollution prevention measures are needed, the reaction time has to be available within a certain time frame. A ship from the Icelandic Coast Guard situated to the northeast of Iceland would take about 20 hours to reach Jan Mayen. Helicopters from the Icelandic Coast Guard can reach Jan Mayen but subsequently require refueling before heading back. (Sigurðardóttir, 2007)

The water depth in the area ranges from 1000 meters to 1500 meters (SAGEX, 2006). When water depth is between 300 and 1500 meters it is classified as deepwater drilling. Ultra deepwater drilling is when the water depth is more than 1500 meters. Operations in deepwaters do come with some extra challenges such as huge costs, complex casing programs, high pressures, high temperatures, difficult formations, uncertain seismic, and lack of experienced personnel. (Skogdalen, et al., 2011)

3.4 High risk operations

High risks are included in offshore petroleum activities, mainly connected to fire and explosion hazards. Such operations include large volumes of flammable gas or liquids that may lead to catastrophic consequences if ignited or released to the environment. The same activities include the possibility of high profits for the state and private companies. It is the authority's responsibility to regulate such operations so that they are safe for personnel and the environment.

Very few specific functional requirements have been set for offshore petroleum activities in Iceland. The first and only act for such activities was established in 2001 and mainly covers the licensing process and documentation. Some acts and regulations have been edited in the last few years to include offshore petroleum activities within the scope of some supervising authorities. This has not been completed through all areas of concern. Furthermore there has not been any systematic approach established to carry out the changes to legislation that is necessary so authorities are able to govern these operations. However, recently a consultation group was established that consists of representatives from the authorities that regulate and supervise such activities.

3.5 Summary

There are areas of concern if offshore activities will begin in the Jan Mayen area. Operations have been successful in these conditions separately and no technology stoppers are in the way

of development in the Jan Mayen area. Proven and cost effective technologies are available and could be further improved by the time operation begin in the area. (SAGEX, 2006) However, there is relatively little experience in facing so many harsh factors at once and special care has to be taken when planning such operations. Such situations where the situation is on the verge of being known and unknown may produce an ideal condition for a Black Swan event, if not handled correctly. A Black Swan event can be described as a surprising, extreme event relative to present knowledge/belief. Detailed risk assessments where possible hazards are identified and good communication and transfer of knowledge is essential to meet the black swan type of risk. (Aven, 2015)

4 Setup of regulatory offices in Iceland connected to offshore petroleum activities

Several ministries, authorities and institutions are connected in one way or another with possible offshore petroleum activities in Iceland. A special act regarding prospecting, exploration and production of hydrocarbons (Hydrocarbons Act) came into action in 2001 and was last amended in 2015. The Hydrocarbons Act states that the National Energy Authority (NEA) shall establish and lead a consultation group that shall consist representatives from supervising authorities related to prospecting, exploration, and production of hydrocarbons. The group shall consist of members nominated by the relevant authorities.



Figure 5 - Supervising authorities regarding offshore petroleum activities in Iceland

The role of the consultation group is to create a forum to co-ordinate public control supervising prospecting, exploration and production of hydrocarbons. These authorities and respective ministries are shown in figure 5. (MII, 2011 No. 13) This chapter will focus on the role of these authorities as it is stipulated in acts and regulations.

4.1 Ministry of Industries and Innovation

The Ministry of Industries and Innovations (MII) are responsible for creating cost-effective and efficient framework for energy, industrial, and innovational activities. This includes setting clear rules and establish policies for these matters. (MII, n.d.)

4.1.1 The National Energy Authority

The National Energy Authority (NEA) operates under the auspices of the Ministry of Industry MII. The role of the NEA is wide ranged. It shall act as a supervisory authority regarding energy utilization and advise the Government on energy issues, gather information and carry out research on energy resources, onshore and offshore. (MII, 2003 No. 87)

The Hydrocarbons Act states that the NEA has the role of granting exploration and production licenses on the Icelandic Continental Shelf. As of current legislation the NEA has a comprehensive role regarding offshore petroleum activities and may call for documentation from licensees to ensure their compliance with set acts and regulations. The NEA awards two types of licenses that are related to petroleum activities, a license for prospecting and a license for exploration and production. (MII, 2011 No. 13)

The NEA issues licenses for prospecting for hydrocarbons. Prospecting includes ship-, and airborne surveys, and sample drilling to a depth of no more than 25 meters below the seabed. Thorough description and information on the applicants intended activities and the vessels to be used shall be included in an application for prospecting. Also included shall be the applicants boundaries of the area sought for and the purpose of the planned prospecting. Vessels and aircrafts that are used for surveying are required to notify respective authorities daily with their position and their planned movements. The license does not award prioritization for exploration or production rights. (MII, 2011 No. 884)

A license for exploration and production is awarded by the NEA. In addition to geophysical measurement exploration includes drilling exploration wells that are used to evaluate the size, location and production properties of a hydrocarbon reservoir. Production involves drilling of production wells, pumping or conduction of hydrocarbons to surface, pumping down

hydrocarbons and other substances, treatment and storage of hydrocarbons for transport, loading of hydrocarbons as well as the full life cycle operation of offshore production facilities from construction to decommission. An application for an exploration and production license shall include the same information as for the prospecting license with the addition of information regarding the financial capacity of the applicant, geological appraisal of the application area, cost effectiveness of the intended activities and financial evaluation of the research commitments. Also included shall be a description of the applicant's prior experience, technical competence, experience of staff, organization and other expertise regarding offshore petroleum activities. (MII, 2011 No. 884)

Before any license is awarded the NEA shall consult with the Ministry for the Environment and Natural Resources, Ministry, the Ministry of Industries and Innovation, the Environment Agency of Iceland, the Icelandic Institute for Natural History, the Icelandic Construction Authority, and the Marine Research Institute. (MII, 2011 No. 884)

A licensee that has found a reservoir of hydrocarbons and intends to begin production must submit a Field Development and Production Plan (FDPP) to the NEA for approval. An FDPP consists of (MII, 2011 No. 884):

- A plan for construction, installation and operation of offshore facilities, together with an environmental impact assessment,
- a well founded field development and production strategy,
- description of later stages of operation and production,
- a description of geological and civil-engineering aspects regarding hydrocarbon resources,
- an extraction plan,
- a description of technical solutions,
- information on how the licensee intends to ensure that his activity and employees follow the laws and regulation governing the operation,
- information on operative matters and maintenance,
- estimate of cost and gains,
- information on the permits that have been applied for, approval that has been sought or will be sought, and if it is intended to place any equipment of facilities owned by a third party on land or on the bottom of the sea,
- plan for the intended decommissioning of offshore facilities, production structures and production equipment, when hydrocarbon activities are finished,

- information on the construction and operation of pipelines for the production and transport of hydrocarbons,
- information on the transport of hydrocarbons from the extraction site,
- description of technical arrangements for emergency preparedness,
- other information that is required according to the safety and security legislation valid at any given time.

A duty of precaution is stated in the Hydrocarbon Act and requires exploration and production licensees to take utmost safety measures and that activities shall be in accordance with good international practice for similar situations. It shall not endanger or limit communication, fisheries or other activities. A safe and healthy work conditions shall be provided. Representatives from the NEA or from any of the consultation group shall be granted entry to offshore facilities and vessels to carry out their supervisory tasks. They shall also be granted access to data, samples or other information that they may need for the administrative roles. (MII, 2011 No. 13)

4.1.2 The Marine Research Institute

The Marine Research Institute (MIR) operates under the auspices of the MII. The MIR's role is to conduct research on marine matters including its resources and the environment. The MIR shall then provide the MII with results from their scientific researches and give advice based on them. (MII, 1965 No. 64)

4.2 Ministry for the Environment and Natural Resources

The Ministry for the Environment and Natural Resources (MENR) is responsible for shaping the policy and establishing a framework for environmental protection and sustainable use of natural resources. (MENR, n.d.)

4.2.1 The Iceland Construction Authority

Iceland Construction Authority (ICA) operates under the auspices of the MENR. The ICA supports the MENR by acting as a supervising authority regarding constructions, fire safety, and electrical safety. (MENR, 2010 No. 160) Special acts and regulations have been set for each of these fields for constructions in general, not specially for offshore facilities.

The Act on Construction applies to all constructions onshore and offshore that have a fixed position within the Icelandic economic zone. Normally a designated building inspector is

responsible for issuing construction permits for constructions. In the case of offshore construction that are placed at a certain distance from shore (outside county lines), the ICA is responsible for issuing such permits as well as supervision during the construction phase. (MENR, 2010 No. 160)

The Act on Fire Protection stipulates that the ICA governs fire protection in Iceland. For offshore petroleum activities the operators are required to establish a Safety Evaluation (SE) and to have them accepted by the ICA. The SE shall be revised every five years. The MENR is to establish regulations based on recommendation from the ICA on the implementation of these safety evaluations. The same regulations shall cover the role of the fire brigade in cases of fire and explosion hazards offshore. (MENR, 2000 No. 75)

The scope of the Act on Electrical Safety does not cover offshore facilities. The act however stipulates that the ICA is responsible for surveillance and inspection of high and low voltage electrical equipment and installations. (MENR, 1996 No. 146)

4.2.2 The Environment Agency of Iceland

The Environment Agency of Iceland (EAI) operates under the auspices of the MENR. The role of the EAI is to protect and promote sustainable use of Iceland's natural resources, as well as public welfare by helping to ensure a healthy environment, and safe consumer goods. (MENR, 2002 No. 90) The extensive role of the EAI regarding offshore petroleum activities are listed in a few separate acts.

An Act on Pollution Control applies to offshore petroleum activities as to other operations within Iceland's economic zone. They stipulate that operators are required to obtain licenses for operation if their activities might cause pollution. Before awarding such a license the EAI shall seek for statements from the NEA, the ICA and the Marine Research Institute. The EAI shall act as a supervisory authority regarding operations that require such licenses. In case of acute pollution the EAI shall lead pollution control measures and establish an action plan which divides responsibilities and actions for separate institutes. (MENR, 1998 No. 7)

An Act on Ocean and Coastal Pollution Control stipulates that any operation that may cause pollution to the ocean and coast are required to prepare a plan for acute pollution based on risk assessments before previously mentioned operation licenses are awarded. In the case of pollution or the EIA believes that pollution is likely, they may send a team to examine facilities. (MENR, 2004 No. 33)

An Act on Climate Issues stipulates that any operation within Iceland's economic zone that may emit greenhouse gases has to apply for an emission permit from the EAI (MENR, 2012 No. 70).

4.2.3 The Icelandic National Planning Agency

The Icelandic National Planning Agency (INPA) operates under the auspices of the MENR. The INPA is responsible for the administration and implementation of the Planning Act, the Environmental Impact Assessment Act and the Strategic Environmental Assessment Act.

The Planning Act does not apply outside county lines, and therefore not at the Dreki area. Work is in process to introduce a new act that will cover planning administration for offshore petroleum activities (MENR, 2014).

The Environmental Impact Assessment Act stipulates that those who perform drilling and operations related to petroleum activities are required to submit an environmental impact assessment to the INPA. The Environmental Impact Assessment shall include the direct and indirect effects of the planned operations to the environment and list measures that will be implemented to reduce influences to the environment. The INPA shall supervise and guide the developer through the documentation process and is then responsible for publishing the Environmental Impact Assessment in addition to their opinion on its compliance with acts and regulations. The developer may not receive a license for operation before these documents have been made available to licensing authorities and the public. (MENR, 2000 No. 106)

The Strategic Environmental Assessment Act has a similar scope as the previously mentioned act. However, the difference is that it describes the INPA's responsibilities regarding its supervision of the documentation process for strategic planning in the greater context, not for specific developments. (MENR, 2006 No. 105) A Strategic Environmental Assessment (SEA) named "*Oil exploration in the Dreki Area on the Jan Mayen Ridge*" was published by the Ministry of Industry, Energy and Tourism in 2007 (now MII). The report includes an evaluation of the effect of initiating offshore petroleum activities in the Dreki Area. (MII, 2007)

4.2.4 The Icelandic Institute of Natural History

The Icelandic Institute of Natural History (IINH) operates under the auspices of the MENR. The IINH has the role of carrying out researches on nature, more specifically on botany, ecology, taxonomy, geology and zoology. It shall as well consult on sustainable use of natural

resources and conduct researches to assess the conservation status of species, habitats and ecosystems. (MENR, 1992 No. 60).

4.3 Ministry of the Interior

The Ministry of Interior (MI) is responsible for activities that form the basis of residence, health and prosperity in Iceland. This includes initiating changes that promote strong municipalities, good transport and communication. (MI, n.d.)

4.3.1 The Icelandic Transport Authority

The Icelandic Transportation Authority (ICETRA) operates under the auspices of the MI. The role of the ICETRA is to conduct administration and regulation pertaining to aviation affairs, harbor affairs, maritime affairs, and traffic and road affairs. For offshore petroleum activities its main task is to administrate the use of ships and aircrafts so that they comply with acts and regulations. (MI, 2012 No.119)

An Act on Aviation Matters reveals that ICETRA has the authority to administrate and issue qualification licenses to aircrafts that comply with act and regulations (MI, 1998 No. 60). Similarly an Act on Maritime Administration stipulates that ICETRA is responsible for the administration and supervision of ships to assure safety to personnel, assets and the environment. It is the captain's responsibility to assure that the ship is seaworthy and all operation licenses are in place and all requirements are met that are stipulated in acts and regulations. The ICETRA, in cooperation with the Icelandic Coast Guard, is permitted to make unannounced visits to ships to carry out their supervisory roles. The act covers ships registered in Iceland and sail under the Icelandic flag, the ICETRA is restrained by international law to perform similar tasks for foreign ships, especially outside territorial waters. (MI, 2003 No. 47)

The ICETRA is responsible for the operation of a Maritime Traffic Service (MTS). The MTS's objective is to secure safe navigation within Iceland's exclusive economic zone and thus ensuring safety of passengers, crew and vessel traffic safety. The MTS also has the role of developing and implementing pollution control measures related to pollution from vessels. The services that the MTS provides includes handling communication with vessels and monitoring and surveillance of vessel's Automatic Identification Systems (AIS). By communication is meant that the vessels give information on their situation regarding cargo, passengers and their intended route. The MTS provides reports on weather, wave heights, currents and etc. to vessels. The MTS is the first contact in case of an emergency offshore, either through direct communication, the AIS or being non responsive through normal means communication. The

MTS then alerts relevant authorities or vessels that may be of help for search and rescue operations. The ICETRA has made a service agreement with the Icelandic Coast Guard to operate the MTS.

4.3.2 The Icelandic Coast Guard

The Icelandic Coast Guard (ICG) operates under the auspices of the MI. The ICG is responsible for search and rescue, maritime safety and security surveillance, and law enforcement within Iceland's exclusive economic zone, and in some cases outside.

An Act on the Icelandic Coast Guard defines the role of the ICG. The main roles that the ICG holds that are directly relevant to offshore petroleum activities are their responsibilities for pollution surveillance and response, and search and rescue operations. Crew onboard vessels or facilities on sea are obliged to comply with ICS's instructions and to allow them access on board for inspection and surveillance. In cases where it is deemed necessary the ICG is permitted to direct ships to port, and in some case take full control of vessels. This authority may however be restricted by international agreements regarding foreign vessels and facilities. (MI, 2006 No. 52)

The Act on Ocean and Coastal Pollution Control stipulates that any operator of offshore facilities shall notify the ICG without delay about any emission to the ocean or atmosphere that has not been permitted based on acts and regulations. The EIA shall decide what equipment shall be on board ICG's patrol vessels. (MENR, 2004 No. 33)

4.4 Ministry of Welfare

The Ministry of Welfare (MoW) is responsible for general legislation for labour affairs, including occupational health and safety. (MoW, n.d.)

4.4.1 The Icelandic Radiation Safety Authority

The Icelandic Radiation Safety Authority (IRSA) operates under the auspices of the MoW. An Act on Radiation Protection stipulates that the IRSA is responsible for administration and supervision of radioactive materials and radiological equipment. Production, import, export, ownership, storing, use, reuse, recycling and disposal of radioactive substances (pure or mixed) are subjected to licenses granted by the IRSA. This act however does not reach out to the Dreki area, as its scope only applies within county lines. (MoW, 2002 No. 44)

4.4.2 The Administration of Occupational Safety and Health

The Administration of Occupational Safety and Health (AOSH) operates under the auspices of the MoW. The AOHS has the role of ensuring that employers in Iceland comply with the Act on Working Environment, Health and Safety in Workplaces which sets requirements for workplaces with one or more employees, excluding shipping and diving operations. It does as well have the responsibility of inspecting technical equipment to ensure that they comply with acts and regulations. This act however does not cover Iceland's exclusive economic zone, only on land and territorial waters. (MoW, 1980 No. 46)

The Act on Working Environment, Health and Safety in Workplaces stipulates that employers are required to establish a plan for health and safety in the workplace and the AOHS is to have supervision over those matters. Those who use toxic chemicals in their operations are required to obtain a permission from the AOHS. Where dangerous substances or chemical products are used in amounts that might cause hazardous situations to personnel and the environment, the employer shall see to that safety measures are in place to prevent them from happening or reduce their consequences. The AOHS shall observe that such measures have been implemented and that they are competent. (MoW, 1980 No. 46)

The Administration is allowed to make surveillance visits to fulfill their roles as supervisory authority. For any operation that is covered by the Act, the operator is required to obtain a operation license issued by the AOHS and states that the operations comply with recognized standards, provisions in acts and regulation that concern working environment, health and safety, as well as the Administration's own instructions. The operation license will not take effect unless all other licenses that might have to be awarded, according to acts and regulations, for the specific operation. A special four man committee shall be established with a representative from the AOHS, the Environmental Agency, the Construction Authority, and Iceland Civil Defense to ensure cooperation and collaboration in case of industrial accidents. (MoW, 1980 No. 46)

4.5 Summary

There are numerous ministries, ministers, authorities, agencies and institutions that would have administrative and supervisory roles and would govern offshore petroleum operations in the Dreki area. Given that the scope of some of the authorities' responsibilities would be widened so that they would cover such activities. If this structure would be unchanged some significant

coordination and collaboration would have to be established so that holistic approach to administration and supervision can be achieved.

5 Oil and gas management structure in Norway

First production licenses in Norway were issued in the mid 1960's, about 50 years ago. Since then the petroleum activities have been a significant source of income to the state. In 2013 the petroleum sector's share of total revenues to the state was 29.1% (MPE, 2014). The management structure of offshore petroleum activities in Norway regarding administration and supervision is divided between few ministries, agencies and authorities. Figure 6 shows the agencies and their governing ministries. This chapter will list the main characters in this structure and describe their role.

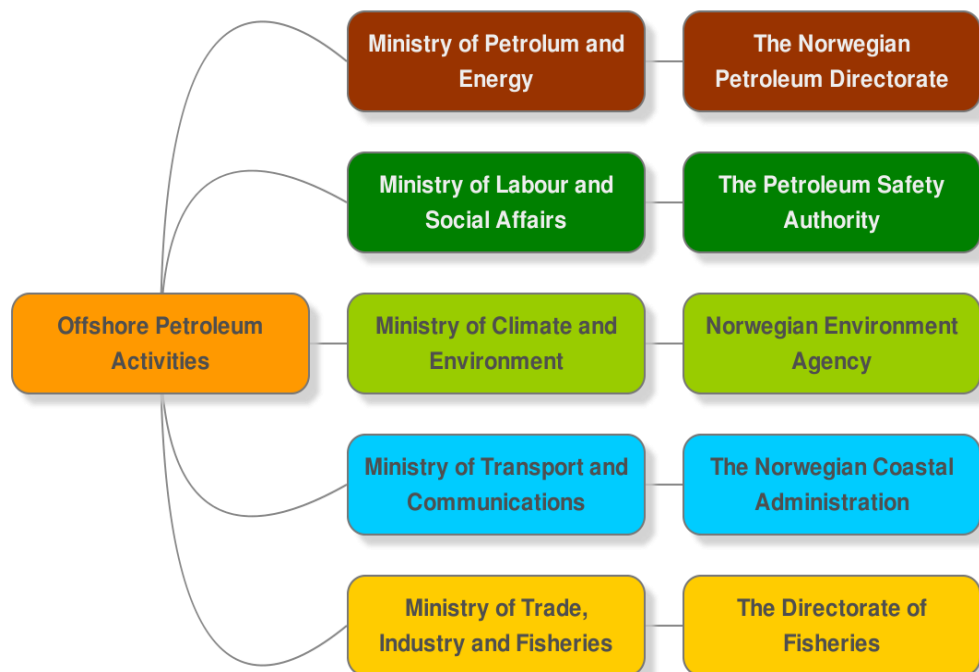


Figure 6 - Setup of regulatory offices in Norway regarding offshore petroleum activities

5.1 Ministry of Petroleum and Energy

The Ministry of Petroleum and Energy (MPE) is responsible for establishing an energy policy that maximizes value creation through prudent resource management. The MPE is consequently responsible for the petroleum sector as a whole and its resource management. In addition the MPE manages the state's direct financial interest that they hold through ownership of three companies. These companies are Statoil, Petoro and Gassco. Statoil is an operator and licensee at multiple fields, Petoro is a licensee at several fields including a 25% share at both active

licenses in the Dreki Area, and Gassco is the operator of the gas transport system from the Norwegian Continental Shelf (NCS). Based on input from the Norwegian Petroleum Directorate the MPE takes a final decision on what blocks shall be open for each licensing round as well as which companies are awarded exploration and production licenses. (Petroleum Act, 2011 No. 38)

5.1.1 The Norwegian Petroleum Directorate

The Norwegian Petroleum Directorate (NPD) operates under the auspices of the MPE. The NPD has regulatory powers and acts as an administrative authority for petroleum exploration and production on the NCS. The Directorate's main areas are data management and organization, analysis and framework, development and operations, and exploration. This involves the process from storing and analyzing data from the NCS which is then used as basis when opening areas and then subsequently issuing licenses for exploration and production. The NPD cooperates with the MPE during the licensing round by handling technical parts of the application. This includes reviewing geological, technical and economic evaluations and consider the technical expertise and resource management of applicants. Companies are then ranked and results given to the MPE for a final decision. (Petroleum Act, 2011 No. 38)

5.2 Ministry of Labour and Social Affairs

The Ministry of Labour and Social Affairs (MoLSA) has overall responsibilities for regulating and supervising the working environment, safety and emergency preparedness. The MoLSA has delegated these responsibilities to the Petroleum Safety Authority for petroleum activities. (MPE, 2014) (Haug, et al., 2010)

5.2.1 The Petroleum Safety Authority

The Petroleum Safety Authority (PSA) operates under the auspices of the MoLSA. The PSA was established in 2004 following a decision made by the government to divide the responsibilities of the NPD, which was responsible for their current role as well as supervising safety. The PSA is regulatory authority and takes on the supervising and administrative roles regarding health, safety, the environment (HSE) and emergency preparedness for the petroleum sector in Norway. Its responsibilities are relevant through all phases of the petroleum industry, from design to commissioning of facilities and operations. The PSA's professional competence is divided into six main disciplines (PSA, n.d.):

- Working environment
- Drilling and well technology
- HSE management
- Structural integrity
- Logistics and emergency preparedness
- Process integrity

The HSE related responsibilities of the PSA, operators, licensees and other players in the petroleum industry are stipulated in the Petroleum Act and HSE regulation. The PSA shall perform their supervisory roles with a risk based approach, which is prioritizing their supervision on areas that faces the highest risk. The PSA is permitted to carry out audits and verifications on their own and in cooperation with relevant regulators to ensure that operations are acceptable. It is however the companies them self that are required to have their own internal systems for inspection and control and assure that facilities, equipment and operations comply with legislation. The PSA shall only be considered as a supplement.

The PSA is responsible for the collaboration with other agencies that have independent regulatory responsibilities within the petroleum industry for HSE. Coordination is also established with agencies that don't have independent regulatory responsibilities and the PSA seeks their support and expertise when needed. The PSA's responsibility in an emergency situation is ensuring that the operators complies with regulatory requirements, notifying relevant agencies and expand safety zones if required.

5.3 Ministry of Climate and Environment

The Ministry of Climate and Environment (MCE) is responsible for ensuring integrated governmental climate and environmental policies. The MCE oversees that authorities in different sectors implement the environmental policies as well as initiating, developing and implementing their own measures and actions. The MCE sets requirements for acute pollution preparedness for municipalities and private organizations. (MCE, 2014)

5.3.1 Norwegian Environment Agency

The Norwegian Environment Agency (NoEA) operates under the auspices of the MCE. The Norwegian Climate and Pollution Agency and the Norwegian Directorate for Nature Management was combined into one directorate in 2013 as NoEA. The NoEA is a regulatory authority and has the role of carrying out inspections and environmental audits. The role of the

NoEA is to monitor pollution and waste management as well as ensuring that legislation is being complied with. The NoEA is as well responsible for approving emergency response plans. (MCE, 1981 No. 6)

5.4 Ministry of Transport and Communications

The Ministry of Transport and Communications (MTC) is responsible in general for the framework conditions for postal and telecommunications activities, for the civil aviation, public roads and trail transport sector, ferry services, for coastal management, the marine environment and port and sea transport policy. (MTC, 2014)

5.4.1 The Norwegian Coastal Administration

The Norwegian Coastal Administration (NCA) operates under the auspices of the MTC and is delegated the responsibility for services related to maritime safety, maritime infrastructure, transport planning and efficiency, and emergency response to acute pollution. The NCA is responsible for the coordinating national oil spill preparedness. The NCA is on duty on behalf of the government to be prepared in case of acute pollution which may not be handled sufficiently by the polluter's and/or municipal's contingency plan. (NCA, 2012)

5.5 Ministry of Trade, Industry and Fisheries

The Ministry of Trade, Industry and Fisheries (MTIF) is responsible for designating industrial and seafood policy with regards to value creation. The MTIF is connected to the petroleum sector through their responsibility for ensuring seafood safety, fish health and welfare. (MTIF, 2014)

5.5.1 The Directorate of Fisheries

The Directorate of Fisheries (DF) operates under the auspices of the MTIF. The DF is responsible for promoting sustainable management of marine resources and the marine environment. Their role is to perform legislature and regulative work and give advice on policy setting. The DF is then responsible for implementing policies as well as monitoring and controlling activities. (DF, 2010)

5.6 Summary

The regulatory regime in Norway is quite simple, there are a few ministries and each has a specific authority who carries out most of their responsibility concerning offshore petroleum activities. Each of these authorities then have clear responsibilities for administration and supervision for these activities.

6 Regulatory framework regarding fire and explosion hazards in Norway

Norway has been one of the front runners in safe extraction of oil and gas offshore, they focus on resource management and value creation whilst reducing risk to the environment as much as possible. Their main aim is for the offshore industry on the Norwegian continental shelf to generate the greatest possible benefits in the best interest of the Norwegian society. To be able to meet these objectives clear regulatory framework have to be set. In this chapter the Norwegian legislative and regulatory framework for the industry, regarding fire and explosion hazards, will be described and how safety is ensured.

The state governs the offshore oil and gas industry by introducing legislation. The legislative power is in the hands of the elected government and the parliament (*Storting*). The legislative hierarchy in Norway concerning petroleum activities is shown in Figure 7. Acts are made to set out the Governments policy and regulatory power is given to the ministries and other authorities within their separate area of specialization. Regulations in Norway are mostly performance based with supplementary prescriptive requirements. Main regulations concerning offshore activities have assigned guidelines that give instructions and more detailed information how to comply, in some cases standards are referenced. Guidelines and standards are not legally binding, however is the operator required to demonstrate that his facility design or way of operating is equivalent or better than what is stated in guidelines and standards. (Haug, et al., 2010)

6.1 Acts

There are three main Acts that are connected in some way with fire and explosion hazards during offshore activities. The most comprehensive is the Petroleum Act. It is an “umbrella” legislation as it covers the main focus point of the policy set by the Norwegian Government. The Working Environment Act puts emphases on assuring safe and acceptable working environment for employers, and to include them in the design of their work processes. The Pollution Control Act focuses on maintaining the quality of the environment and protect it against pollution whilst promoting better waste management.

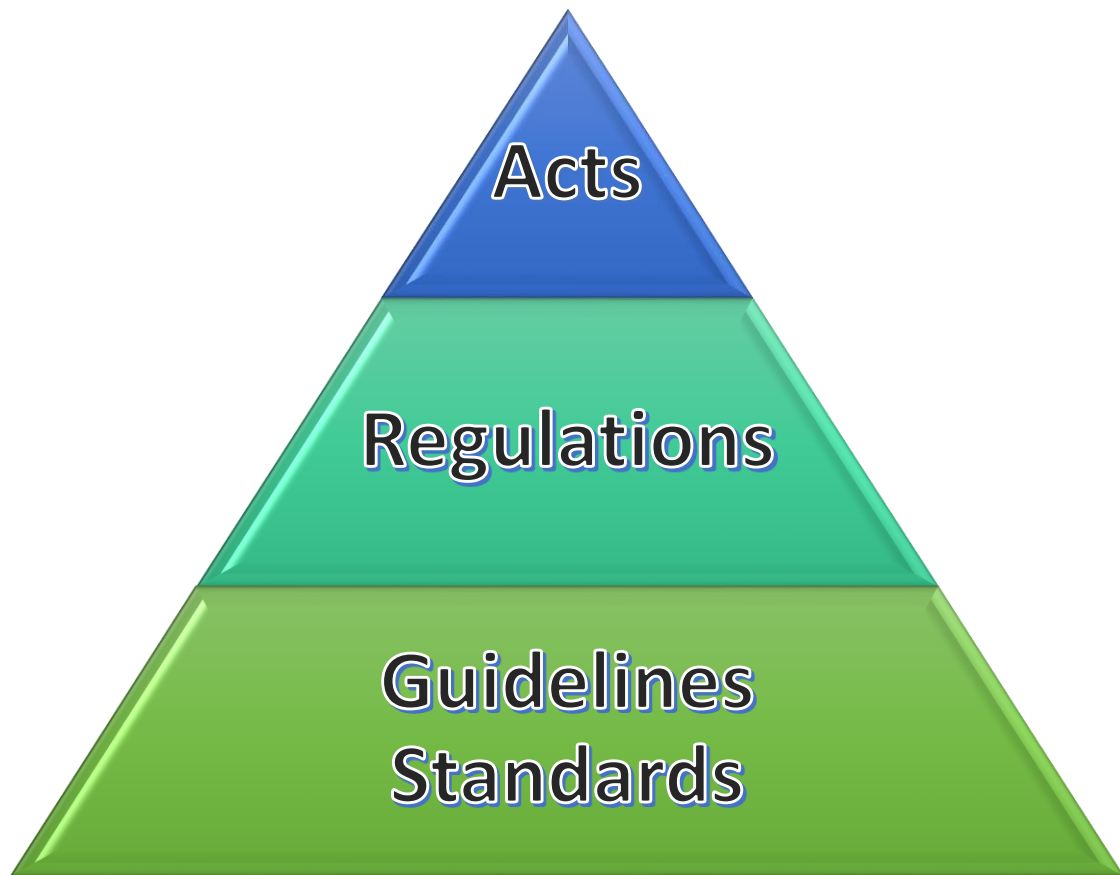


Figure 7 - Legislative hierarchy in Norway

6.1.1 The Petroleum Act

Act no. 72 from November 1996 (last amended in June 2011), or the “*Petroleum Act*” is issued as a framework law for offshore petroleum activities in the Norwegian jurisdiction. The act acknowledges that the Norwegian state has the exclusive right to the subsea petroleum deposits and is responsible for resource management. Resource management is to be handled by the King and in compliance with existing acts and regulations and decisions made by the Storting. In practice, these responsibilities are placed within the Ministry of Petroleum and Energy, and The Ministry of Labour and Social Affairs. The objectives of the resource management are to assure benefits to the Norwegian society as a whole by supplying income to the state. The revenue is then to be used to ensure welfare, employment, improved environment whilst reinforcing Norwegian trade and industrial development. (Petroleum Act, 2011 No. 38)

The Petroleum Act also states that when a licensee determines to develop a petroleum deposit, he is required to submit a plan for development and operation. A special plan for installation and operation of facilities for transport and utilization of petroleum is required when

appropriate. Often included in these plans are impact assessments. These plans shift the responsibility of ensuring safety to personnel and environment to the licensees, as they have to prove that their installations are as safe as possible. These plans are described in more detail later on in Chapter 7.

The safety requirements listed in the Petroleum Act are reasonably general. It is required that petroleum activities shall be conducted in such a manner that high level of safety is to be maintained and continuously improved in accordance with technological development. Measures are to be taken for emergency preparedness to reduce the risk of harmful events and minimize their effects if they are to happen. Contingency plans are required to deal with deliberate attacks against facilities and security measures maintained to avoid such attacks. It is the licensee's responsibility that workers are trained and qualified to perform their job. The Ministry has regulatory supervision over the petroleum activities and if the Ministry believes that a licensee is not complying with applicable legislation it is authorized to stop its petroleum activities for as long as considered necessary. Licenses may be revoked in case of repeated violations to the Petroleum Act or in case of a serious incident. (Petroleum Act, 2011 No. 38)

In the case of pollution damage caused by petroleum activities the licensee is liable without regard to fault. Liability cannot be claimed against manufactured and delivered equipment or against contractors that perform any kind of services in agreement with the licensee unless it is a result of a gross negligence or willful action. If pollution damage is caused during a joint venture the compensation is directed at the operator. If the compensations is not paid in full or partly on the due date the unpaid part shall be covered by the other licensees relevant to their participating interest in the venture.

When a facility is placed on the seabed or when a mobile facility is anchored, a safety zone is established. The zone is defined as the area from the seabed directly under the facility and reaching 500 meters above its highest point. The zone reaches as well 500 meters horizontally from all extreme points of the facility. The area is restricted to all unauthorized vessels. Only vessels, including aircrafts, which have been given permission by the operator or authorities are allowed to enter the safety zone. It is the operator's duty to monitor all activity inside the safety zone and outside. If the operator is aware of an vessel that is in the process of entering the safety zone without authorization it shall be equipped to alert the vessel if it is believed to be a safety risk to the petroleum activities. In such cases the operator is required to notify the Joint Rescue Coordination Center, the PSA and the appropriate police authority. (MoLSA, 2013) Collision risk models are available on the market for vessels and offshore platforms. These models are

used to assess ship collision risk using input data from previous traffic data, environment condition and geometrical information. There are two main models that are in use in the Norwegian Continental Shelf (NCS), the Computerized Risk Assessment of Shipping Hazards (CRASH) and COLLIDE (Ellis, et al., 2008).

6.1.2 The Pollution Control Act

The purpose of the Pollution Control Act is to maintain the quality of the environment and protect it against pollution whilst promoting better waste management. Pollution is defined as the following factors that may cause negative effects to the environment (MCE, 1981 No. 6):

- the introduction of solids, liquids or gases to air, water or ground,
- noise and vibrations,
- light and other radiation to the extent decided by the pollution control authority,
- effects on temperature.

The act stipulates that the efforts made to limit pollution and waste shall be based on the best available technology. The Norwegian Environment Agency (NoEA) is responsible for issuing emission/discharge permits as well as handling documents related to the natural environment such as company analyses of environmental risk and emergency preparedness against oil spills. All activities that may cause serious pollution may be required by the NoEA to be assessed in regards to its impact to the environment. The environmental impact assessment shall normally include a study of:

- which types of pollution the activity will generate during normal operations and in the event of all conceivable types of accidents, and the likelihood of such accidents,
- what short- and long-term effects the pollution may have. If necessary, studies shall be made of natural conditions in the areas that may be affected by pollution. In particular, it shall be ascertained how pollution will affect people's use of the environment and who will suffer particular nuisance as a result of pollution,
- alternative locations, production processes, purification measures and ways of recovering waste that have been evaluated, and reasons for the solutions chosen by the applicant,
- how the activity will be integrated into the general and local development plans for the area, and if relevant, how it will restrict future planning.

Significant pollution that occurs suddenly and is not covered by the permits issued by NoEA is defined as acute pollution. In the event of acute pollution the operator is required to notify authorities and have in store an emergency response system. The emergency response system shall be able to prevent, detect, stop, remove and limit the impact of the pollution. The NoEA may require operators to join forces for a joint emergency response system. The NoEA is then required to assure that private, municipal and state emergency response systems are coordinated in a national emergency response system.

NoEA is permitted to issue regulations connected to this act, which has been done. These regulations will not be discussed in more detail than that is covered by the regulations that have been issued in connection to the Petroleum Act as they cover the focus areas regarding offshore activities.

6.1.3 The Working Environment Act

The Working Environment Act sets the standard for a secure and healthy working environment in Norway. The Act focuses on adapting employee's working situation to the capabilities and circumstances of each one and that employees are active in safeguarding and developing their working environment in cooperation with their employers.

The Working Environment Act stipulates that both parties, employers and employees, have certain duties. It is the employer's responsibility that all provisions in the Act are being complied with. To sustain systematic health, environment and safety work the employer shall (DLI, 2005 No. 72):

- establish goals for health, environment and safety,
- have an overall view of the undertaking's organization, including how responsibility, tasks and authority for work on health, environment and safety is distributed,
- make a survey of hazards and problems and, on this basis, assess risk factors in the undertaking, prepare plans and implement measures in order to reduce the risk,
- during planning and implementation of changes in the undertaking, assess whether the working environment will be in compliance with the requirements of the Working Environment Act, and implement the necessary measures,
- implement routines in order to detect, rectify and prevent contraventions of requirements laid down in or pursuant to the Working Environment Act,
- ensure systematic prevention and follow-up of absence due to sickness,

- ensure continuous control of the working environment and the employees' health when necessitated by the risk factors in the undertaking,
- conduct systematic supervision and review of the systematic work on health, environment and safety in order to ensure that it functions as intended.

In cases where work may involve hazards to life or health, the employees must be made aware of accident risk and health hazards and receive training, practice and instruction how to perform their tasks. Written instruction shall be made available for work that may involve hazard to life of health and should include what safety measures have been implemented.

The employee's duties are to cooperate in the process of design, implementation and follow up of work concerned with health, environment and safety as well as actively cooperate when measures are being implemented to create satisfactory and safe working environment. The Act specially lists a few duties that the employees must comply with, these are:

- use the prescribed protective equipment, exercise caution and otherwise contribute to prevention of accidents and injury to health,
- immediately notify the employer and the safety representative and to the extent necessary other employees when employees become aware of faults or defects that may involve danger to life or health and they themselves are unable to remedy the fault or defect,
- interrupt work if the employees consider that it cannot continue without involving danger to life of health,
- ensure that the employer or the safety representative is notified as soon as employees become aware of harassment or discrimination at the workplace,
- notify the employer if an employee suffers injury at work or contracts disease which the employee believes to result from the work or conditions at the working premises,
- cooperate on preparation and implementation of follow-up plans in connection with total or partial absence from work owing to accidents, sickness, fatigue or the like,
- take part in a dialogue meeting when summoned by the employer,
- obey instruction issued by the Labor Inspection Authority.

Safety representatives shall be elected by employees for each department or shift team. Each area that a representative is responsible for shall be clearly defined and should not be larger than he can manage. A senior safety representative shall be voted by other representatives to coordinate their activities. The duties of the safety representatives, as they appear in the

Working Environment Act, are listed in Appendix I. The employers are required to ensure that safety representatives get the training needed for them to perform their duties. The safety representatives are allowed to halt operations, given they have no other choice, if they believe that the life or health of employees is in immediate danger. In such cases the reason for halting operation shall be documented and reported to the employer. Larger workplaces with 50 or more employees shall have a working environment committee. The working environment committee shall consist of the safety representatives, representatives of the employer and from the occupational health service. The committee's duties are to assist with establishing a fully satisfactory working environment and be involved in planning and follow up of developments that affect the safety, health and welfare of the employees.

The provisions pursuant to the Working Environment Act cover the offshore facilities as well. To underline and supplement these provisions the regulations connected to the Petroleum Act also cover some key areas of the working environment on offshore facilities. As with the Pollution Control Act the applicable provisions will be discussed as they appear in the regulations in the following section.

6.2 Regulations

As stated in the Petroleum Act from 1996 the King is permitted to issue regulations to supplement or delimit the provisions from the same act. Five regulations that are pursuant to the Petroleum Act have been adopted for health, safety and the environment (HSE regulations). The HSE regulations do have framework regulations that cover the sub-regulations in a more general manner. The five HSE regulations are: the Framework Regulations, the Management Regulations, the Activities Regulations, the Facilities Regulations and the Technical and Operational Regulation. The Technical and Operational Regulations cover land-based facilities and mirrors the Facilities and Activities Regulations and will not be discussed further in this report. Requirements that are specifically aimed at the working environment and pollution control during offshore activities are incorporated into the HSE regulation where appropriate (PSA, n.d.) (Haug, et al., 2010). These focus points will be discussed as they appear in the HSE regulations.

6.2.1 Framework Regulations

The Framework Regulations set the standard for prudent and safe operation of offshore activities. *Section 11* of the Framework Regulations is frequently cross referenced from other HSE Regulations in matters concerning the working environment, design and operation of

facilities as well as risk reduction. *Section 11* covers risk reduction principles and describes the focus point of the HSE Regulations where the focus is set on principles that are to be implemented to prevent or reduce the harm to people, the environment or material assets. Further the risk shall be reduced to the extent possible. Requirements are set to limit or prevent harm or danger to people, environment or material assets. The responsible party shall choose a solution that reduces the risk as much as possible whilst the cost is not significantly disproportionate to the risk reduction achieved. In other words the Best Available Technology (BAT) principle is being introduced, where the responsible party is obliged to use as a basis the technology and methods for the operation that have delivered the best results. (MoLSA, 2013)

The Framework Regulations stipulate special provisions to the Working Environment Act. These provisions are mainly connected to the working hours and minimum age. Employees must have reached the age of 18 and working hours on offshore facilities may not exceed 12 hours per day and off duty periods shall be at least 11 hours continuous. Some exceptions are possible but may not continue for long and have to be corrected by extra rest time. Offshore periods may not exceed 14 days. The operator must ensure that his employees, contractors, subcontractors are certified and capable to carry out their work in a prudent manner. In addition to a health certificate issued by a doctor personnel working on offshore facilities are required to undergo a course on basic safety and emergency training. The operator may in addition request personnel to pass additional training or expertise courses. (NOG, n.d.)

To ensure necessary emergency preparedness in the areas of health, safety and environment every operator is required to cooperate with his colleagues and establish joint emergency preparedness plans. The Framework regulations stipulate that authorities that are designated by the Petroleum Safety Authority are allowed to access facilities and vessels at any point in time as along with being granted access to information and documents that is necessary to perform their supervisory tasks. The operator shall provide transport and accommodation for the representatives. Furthermore the operators shall prepare and retain material and information that prove his operations are in compliance with regulations and carried out in a prudent manner.

The Framework Regulations stipulate that maritime mobile facilities registered in a national ships' register can choose which set of requirements they will follow. They are required to follow the chosen maritime regulation in their entirety. These requirements can be from their flag state or relevant requirements from the Norwegian Maritime Directorate's regulations for mobile facilities. The PSA is allowed to stipulate further requirements based on safety related considerations. Mobile facilities are not permanently placed on the seabed, these are for

example mobile drilling vessels and well intervention facilities. Storage ships and floating production units are not considered to be mobile facilities. A potential operator is required to hand in plans and applications depending on the type of activities he is seeking to operate. These consents and application are discussed in Chapter 7.

6.2.2 The Management Regulations

The risk reduction principles that are described in the Framework Regulations are introduced in more detail in the Management Regulations. Risk Management as it is described by the regulation consist of key principles such as risk analysis, emergency preparedness, and barrier management. Acceptance criteria for major accident risk and environmental risk shall be made by the responsible party. It works as an upper limit for what is considered as an acceptable risk level. Acceptance criteria shall be set for (PSA, et al., 2014):

- a) the personnel on the offshore or onshore facility as a whole, and for personnel groups exposed to particular risk,
- b) loss of main safety functions,
- c) acute pollution from the offshore or onshore facility,
- d) damage to third party.

The result from the acceptance criteria shall harmonize with the requirement for suitable risk and preparedness analysis. The risk analyses and emergency preparedness assessments are carried out to reveal a comprehensive picture of the risk related to the operations. The guidelines to the Management Regulations specially mention the *NORSOK Z-013* standards to be used as a reference to fulfil requirements of the analyses. The risk analyses shall:

- a) identify hazard and accident situations,
- b) identify initiating incidents and ascertain the causes of such incidents,
- c) analyse accident sequences and potential consequences,
- d) identify and analyse risk reducing measures.

The analyses is used for decision making when:

- a) identifying the need for and function of necessary barriers,
- b) identifying specific performance requirements of barrier functions and barrier elements, including which accident loads are to be used as a basis for designing and operating the installation/facility, system and/or equipment,
- c) designing and positioning areas,

- d) classifying systems or equipment,
- e) demonstrating that the main safety functions are safeguarded,
- f) stipulating operational conditions and restrictions,
- g) selecting defined hazard and accident situations.

The responsible party is required to have a set a strategy for emergencies that may happen on site. These measures have to be designed with coordination with other facilities that are nearby and public emergency preparedness resources. The operator is responsible for leading and coordinating the emergency preparedness resources in the case of an accident or hazard until the authorities take over the situation. Included is everything from injury to a member of staff to a catastrophic oil spill or fire. The authorities are able to demand a standby vessel (ship/aircraft) at the facility as a safety measure that react in emergency situations, e.g. man over board and for facility evacuation. Emergency preparedness analysis is carried out and used for decision making when:

- a) defining hazard and accident situations,
- b) stipulating performance requirements for the emergency preparedness,
- c) selecting and dimensioning emergency preparedness.

The results from these analyses shall be submitted as well as a description of how they plan to act against such emergencies if they are to happen.

Barriers are very important when trying to reduce the risk of catastrophic incidents. They aim at reducing the possibility or avoiding completely an incident that could cause harm or disadvantages to personnel, environment or equipment. The risk assessment is a starting point to reveal the risk picture of the operation which is a key tool when assessing the need for barriers to reduce the risk to an acceptable level (PSA, 2013). The Management regulations describe the role and requirements of barriers. An important function of barriers is to prevent a chain reaction of incidents that may cause damage, this calls for independencies between barriers. That means that barriers that have similar goals may not be dependent on each other, which is if one fails the other is not allowed to fail as well. Barriers can be of physical and non-physical measure or a combination of both. Examples of barrier functions on an offshore platform are leak prevention, ignition prevention and ensuring safe evacuation. Performance requirements have to be described for the barriers put in place and documented in a safety performance standard. These documents shall ensure that the barriers and other safety systems and their functions: (PSA, 2013)

- are suitable and fully effective for the type hazards identified,
- have sufficient capacity for the duration of the hazard or the required time to provide evacuation of the installation,
- have sufficient availability to match the frequency of the initiating event,
- have adequate response time to fulfil this role,
- are suitable for all operating conditions.

The operator is required to stipulate and develop objectives and strategies to improve health, safety and the environment, and set internal requirements that contribute to achieving those objectives. The operator shall plan his activities in harmony with the objectives, strategies and requirements and that his operations and work processes are in agreement with *Section 11* of the Framework Regulations. Minimum requirements have to be established for manning of functions that may have serious consequences for health, safety and the environment and those who reduce the likelihood of mistakes and accident situations. It is the operator's responsibility that the personnel manning positions on offshore facilities have the competence to perform their tasks safely. The operator is as well required to perform necessary working environment analyses. The analyses are then used to ensure a sound working environment and assist with selecting technical, operational and organizational solutions.

Continuous improvement is required in regards to health, safety and the environment. The operator is required to follow upon its own activities by using system audits, management reviews, self-assessments, verifications, validations, measurements and surveys. Investigations of hazards and accident situations shall be executed and used in addition to experiences from other activities for implementing necessary improvement measures.

At principal milestones, the operator is required to receive consent from the PSA. The application for consent is processed through the PSA, and only when the application is approved the operator may continue his plan to the next milestone. The application for consent is described in more detail in Chapter 7.

The Management Regulations stipulate that the operator is required to notify PSA immediately in the event of hazard and accident situations that might have or have led to death, serious injury, acute life-threatening illness, acute pollution, or serious impairment or discontinuance of safety related functions of barriers, so that the integrity of the offshore facility is threatened. Hazards and accident situations are listed in Appendix II.

Handling of hazardous situations is described in Activities regulations.

6.2.3 The Activities Regulations

The Activities Regulations set requirements for planning, prerequisites for use, the working environment, work arrangements, health-related aspects, the external environment, maintenance and emergency preparedness. (PSA, et al., 2014)

A joint working environment committees shall be established to give employees the opportunity to influence the safety and environment in their own workplace. Establishment of this committee does not reduce the responsibility of the operator to have a working environment committee as described in the Working Environment Act. The Activities Regulations requires the operator to ensure that the working environment on offshore facilities are organized in such manner that hazardous exposure is avoided and unfortunate physical and psychological strains are put on employees. Requirements set for ergonomic design and other factors that affect the working environment are stipulated in the Facility Regulations.

The Activities Regulations stipulate that the operator is required to perform necessary preliminary surveys ensuring that prudent installation, use and disposal of the facilities can be carried out. In addition the loads that the structure faces in its life cycle from installation to disposal shall not exceed the loads the structure is designed to be able to withstand.

Maintenance of the facility and its equipment is required to withhold functional properties throughout all phases of their lifetime. Systems and equipment shall be classified with regard to the consequence of their failure to health, safety and the environment. Further analysis is required for functional failures that may have serious consequences. Fault modes, failure mechanisms and prediction for the likelihood of each failure mode has to be identified. A plan and type of maintenance activities is then based on this analysis, the frequency of maintenance and the need for spare parts. The effectiveness of maintenance activities shall be systematically evaluated and used to support continuous improvement of the maintenance program.

The Activities Regulations cover the handling of hazardous situations. The strategy for emergency preparedness as mentioned in the Management Regulations plays a great role in limiting the consequences of hazardous situations and so that it is less likely that it develops to an accident situation. Emergency preparedness action plans shall be established for identified hazard and accident situations. The contents of such plans are listed in Appendix III. In the event of hazard and accident situations the operator is required to ensure that necessary measures are taken as soon as possible so that:

- the right notification is given immediately,

- hazardous situations do not develop into accident situations, response measures shall be implemented. Response measures to limit acute pollution shall be implemented as close to the emission source as possible,
- personnel can be rescued during accident situations,
- the personnel on the facility can be evacuated quickly and efficiently at all times,
- the condition can be normalized when the development of a hazard and accident situation has been stopped, e.g. through monitoring and clean-up of the pollution and restoring the environment, thereby restoring the condition to its state before the hazard and accident situation. Criteria shall be set for normalization of the external environment.

6.2.4 The Facilities Regulations

The Facilities Regulations set requirements for design and outfitting of facilities, e.g. safety functions, loads, physical barriers and emergency preparedness. (PSA, et al., 2014)

When choosing and designing a development concept some key factors have to be considered. Focus areas of this process is listed in Appendix IV and relevant factors will be discussed in more detail in this section. Robust and simple design of installation and equipment is required such that the possibility of human error is limited, they can be operated, tested and maintained without risk to the personnel and with the lowest possible risk of pollution, and that they are suitable for use and able to withstand the loads/actions they can be exposed to during operation. Facilities shall be designed to withstand loads and actions that can occur, such as accidental load from falling objects, so that it will not result in unacceptable consequences. Before implementing new technologies or methods to petroleum activities some criteria has to be set for its performance and then tested to ensure that it meets requirements for health safety and the environment.

Main safety functions have to be clearly defined and ensure safety to personnel and limit pollution in case of accident situations. Facilities that are permanently manned are required to maintain the following main safety functions:

- preventing escalation of accident situations so that personnel outside the immediate accident area are not injured,
- maintaining the capacity of main load-bearing structures until the facility has been evacuated,

- protecting rooms of significance to combatting accidents so that they remain operative until the facility has been evacuated,
- protecting the facility's safe areas so that they remain intact until the facility has been evacuated,
- maintaining at least one escape route from every area where personnel are found until evacuation to the facility's safe area and rescue of personnel have been completed.

Safety functions (\neq main safety functions) have the purpose of detecting abnormal conditions, prevent abnormal conditions from developing to hazard and accident situations, and limit the damage caused by accidents. Operators are required to equip their facilities with these functions and their status shall be available in the central control room. It shall be possible to test and maintain the safety functions without impairing their performance.

Systematic mapping of possible ignition sources has to be performed and technical, operational and organization measures implemented to reduce the risk of ignition as far as possible. Safety functions in areas that are classified as explosive areas are required to be functional in an explosive atmosphere. Ignition sources that are non-critical to the operation shall be deactivated automatically in case of gas detection. In addition a manual deactivation shall be available in a strategic or central position.

A clear route shall be available if an evacuation has to take place on an offshore facility. The facility is required to have at least two escape routes from areas with regular traffic. The evacuation route shall be designed that it can take place in a simple, quick and safe manner. The facility shall as well be equipped with alarm systems that notify personnel with audio and visual cues in times of hazard and accident situation. Ventilation of a facility should be designed in a way that smoke from fires can be controlled as well as hazardous and flammable gases.

Design requirements of the working environment on offshore facilities are stipulated in the Facilities Regulations. Requirements are set for ergonomic design, e.g. that employees shall not be subjected to work activities or work environments that may cause physical or mental strain. In addition the design of monitor-based equipment and other equipment that are used for controlling, monitoring and operating machines, installations or production processes shall be in a way that important information is readily available and easy to understand. As well shall necessary action be available for implementation.

Physical barriers that are required by the Facilities Regulations are:

- Passive fire protection: includes requirements for sufficient fire resistance of structures and equipment, as well as separation of room with regards to their functions. Rooms shall be classified and assigned a fire rating.
- Fire and gas detection system: shall be installed for quick and reliable fire and gas detection on the facility. The system is required to be independent of other safety systems. Automatic actions shall be taken in the case of fire or gas detection to limit the consequences of fire or gas leak.
- Emergency shutdown systems: independently from other safety systems it shall be possible to close emergency shutdown valves. It shall be possible to initiate the emergency shutdown by manually pressing emergency buttons that shall be strategically placed at the facility, as well as in the control center. The emergency shutdown is implemented to prevent development of hazard and accident situations as well as to limit consequences in case of accidents.
- Process safety system: are required for process system to enter and maintain a safe condition in an event of fault. The process safety system shall be independent so that it is protected from failing due to a dependent error.
- Control and monitoring system: shall be equipped with alarms that notify personnel of incidents, nonconformities or faults that are significant to safety. The alarms are required to be issued in a way that they can be easily understood and responded to within a timeframe that allows safe use of equipment, plant and processes.
- Gas release system: is required to be available to depressurize equipment when such action would prevent escalation of hazard and accident situations. It shall be possible to take this action from the control center. The released gas shall be routed to a safe emission site and may not cause damage or harm to equipment or personnel.
- Firewater supply: shall be sufficient to combat fires and/or suppress gas explosions if this can result in lower explosion pressure. Firewater shall be available at all locations of the facility. Independent supply of firewater is required with fire pumps, these pumps shall be automatically activated in case of fire or gas detection. Activation shall also be made available from the control center.
- Fixed fire-fighting systems: shall be implemented in areas which are regarded as explosion-hazard areas, areas that are considered to be subjected to major risk of fire as well as areas where equipment contain significant amount of hydrocarbons. It shall be possible to activate the system manually and automatically in case of fire detection (and

gas in case of cooling) and its firefighting purpose is required to be carried out quickly and efficiently.

- Emergency power and emergency lighting: in case of a main power failure a reliable, robust and simple emergency power system shall be readily available. Automatic disconnections from the power system shall be limited as much as possible so the main power failure does not entail operating problems. To assist in evacuation, manual firefighting and operation of other safety functions lighting shall be made available in the case of a main power failure.
- Ballast system: floating facilities shall be able to ballast under normal operation and also in case of flooding of any space adjacent to the sea.
- Open drainage systems: facilities shall be equipped with unpressurized drainage systems for oil and chemicals to reduce risk of fire, harm to personnel and pollution.

The Facilities Regulations stipulate special requirements for drilling and well systems. These include the well barriers shall be implemented so that the integrity of the well is ensured during its lifecycle. Well barriers are meant to prevent unintended influx and outflow to the external environment. It shall be made possible to test the performance of well barriers to assure it is functioning efficiently. Floating facilities are required to be equipped with a disconnection system that disconnects the riser and secures the well without unacceptable consequences to the environment. The design of the well head and the christmas tree shall ensure that prudent well control can be performed through recovery, workover and well intervention.

Emergency preparedness measures that are mentioned and described in the Facilities Regulation concern evacuation and rescue of personnel. It is required that facilities are equipped with two independent system to handle a man over board situation. The results from the emergency preparedness analyses as mentioned in the Management Regulations shall include the need of emergency preparedness vessels and its functions. The same analyses results shall include the number of survival suits and life jackets. They shall then be readily accessible and stored in a way that will not compromise their quality. Manual firefighting equipment shall be available to effectively combat incipient fires and prevent escalation. The means of evacuation can be a combination of a few methods. On bridged facilities the primary evacuation may be considered as the bridge. On facilities that are not bridged or the bridge is not available for evacuation the prioritized mean of evacuation is via: (1) helicopter, (2) free-fall lifeboats, (3) escape chute with life rafts (NORSOK, 2008).

6.3 Recommended practices through guidelines and standards

Each HSE regulation is followed up by a guideline that is to assist with implementing the performance based requirements set by the regulators. They are not legally binding but are however a certain benchmark to aim for. The guidelines reference standards that are applicable to the relevant provision. The Framework Regulations mention that with the use of recognized standards the responsible party may assume that the regulatory demands are met. If the recognized standards are not used it is the responsible party's duty to document that his chosen solution fulfils the same regulatory performance requirements as are set by the standards.

Focus area in the legislation for management of fire and explosion hazards is the execution of risk and emergency preparedness assessments. Risk assessments include risk identification, risk analysis and risk evaluation. The results from such assessments are then used in the concept selection, design process and when evaluating the need for risk reducing measures, barriers and other safety systems. These assessments are also completed during operation when small changes and modification are implemented. Different requirements are set for risk and emergency preparedness assessments during different phases of the project life cycle. NORSOK Z-013 is referenced in the guidelines to be used when risk and emergency preparedness assessment are being executed, the standard lists the requirements set for these assessments.

General requirements are set for the execution of risk assessments, they shall always (NORSOK, 2010):

- identify hazardous situations and potential accidental events,
- identify initiating events and describe their potential causes,
- analyze accidental sequences and their possible consequences,
- identify and assess risk reducing measures,
- provide a nuanced and overall picture of the risk, presented in a way suitable for the various target groups/users and their specific needs and use.

Figure 8 illustrates the process of executing risk assessments. Firstly a context shall be established where the scope and criteria is set for the rest of the process. That is defining the objectives, scope, responsibilities, methods, models and tools that are to be used as well as defining the system boundaries, risk acceptance criteria and lastly defining the execution plan. HAZard IDentification or HAZID is a very important element in the risk assessment process. The objective is to identify hazards that are linked to individual systems and to assess what may

cause the hazard and their potential consequence. The events and circumstances that may lead to unfavorable consequences are then listed and possible risk reduction measures are identified. Checklists and step-by-step methodologies such as a HAZard and OPerability study (HAZOP) or Failure Mode and Effects Analysis (FMEA) can be used for HAZID.

Following HAZID a pair of analysis shall be performed. These analyses are of potential initiating events and their consequences. The initiating events shall be analyzed with regards to the potential causes of them occurring and the probability/frequency of them happening. In a separate analysis the potential consequence of initial events shall be assessed and the potential sequence that may occur following the event. It should also include an analyses of the influence of performance of barriers, harm to personnel, environment and assets.

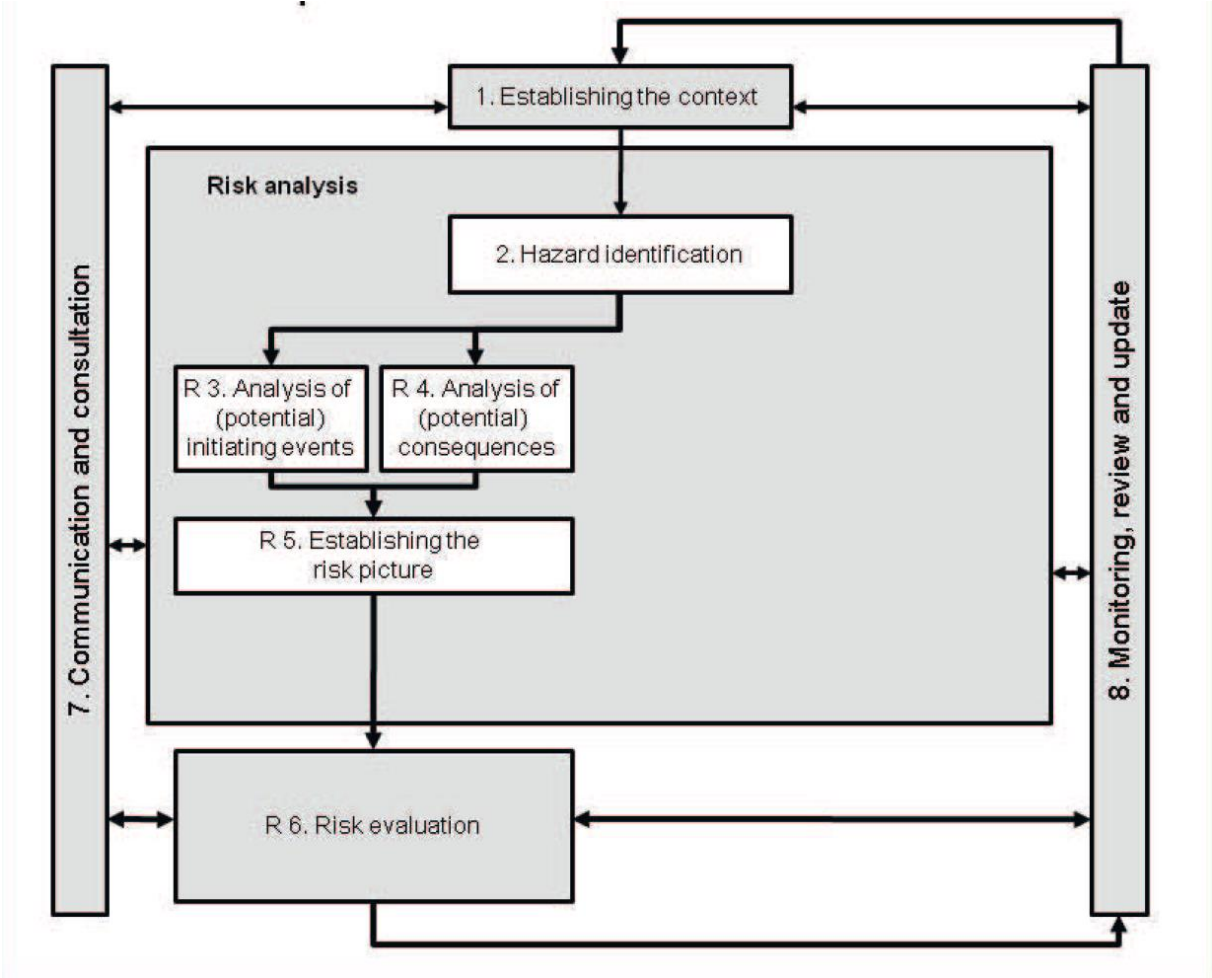


Figure 8 – The risk assessment process (NORSOK, 2010)

The results from the previous steps are then used to establish a risk picture that serves as an easily understood and useful synthesis of the risk assessment that decision makers can use for further work. Finally the results of the risk analysis is evaluated. The risk is either deemed acceptable or not and whether additional risk reducing measures are needed or not. Throughout the whole process communication and consulting shall take place with internal and external stakeholders so that they are aware of the risks and to get additional information from personnel that have operational knowledge of systems that are of importance when executing risk assessments. Also a monitoring, review and update of the risk assessment is required at times when new knowledge is available or the context of assessment is updated.

The process of emergency preparedness assessment is illustrated in Figure 9. As can be seen the process is common with the risk assessment process as the inputs to the emergency preparedness analysis come from the HAZID and also from the results of potential initiating events and consequence analyses. With those results the first step is to identify Defined Situations of Hazards and Accidents (DSHA), these include (NORSOK, 2010):

- major accidents,
- accidental events, without being identified as major accidents, as long as they represent separate challenges to the emergency preparedness, including accidental events with an annual probability lower than 1×10^{-4} ,
- events that have been experienced in comparable activities,
- acute pollution,
- events for which emergency preparedness exists according to normal practice,
- temporary risk increase e.g. drifting objects, man over board, instable well in connection with well intervention, and environmental conditions, etc.

The second step in the emergency preparedness analysis is to list the requirements that are required by authority's regulations, possible classifications society rules and applicable standards and specifications as well as the principles and philosophies (e.g. ALARP) that the operator has set. The third step is to identify and evaluate measures and solutions and response strategies that supplement the previously identified governing performance requirements. This three step analysis shall produce input to emergency preparedness solutions such as (NORSOK, 2010):

- escape routes,
- safe area including main muster and evacuation area,

- means of evacuation,
- equipment for rescue of personnel,
- use of and interaction with external resources and possible interface with 3rd party,
- standby vessels,
- equipment and means for mitigation environmental impact from acute pollution,
- dimensioning of the emergency preparedness organization and necessary equipment.

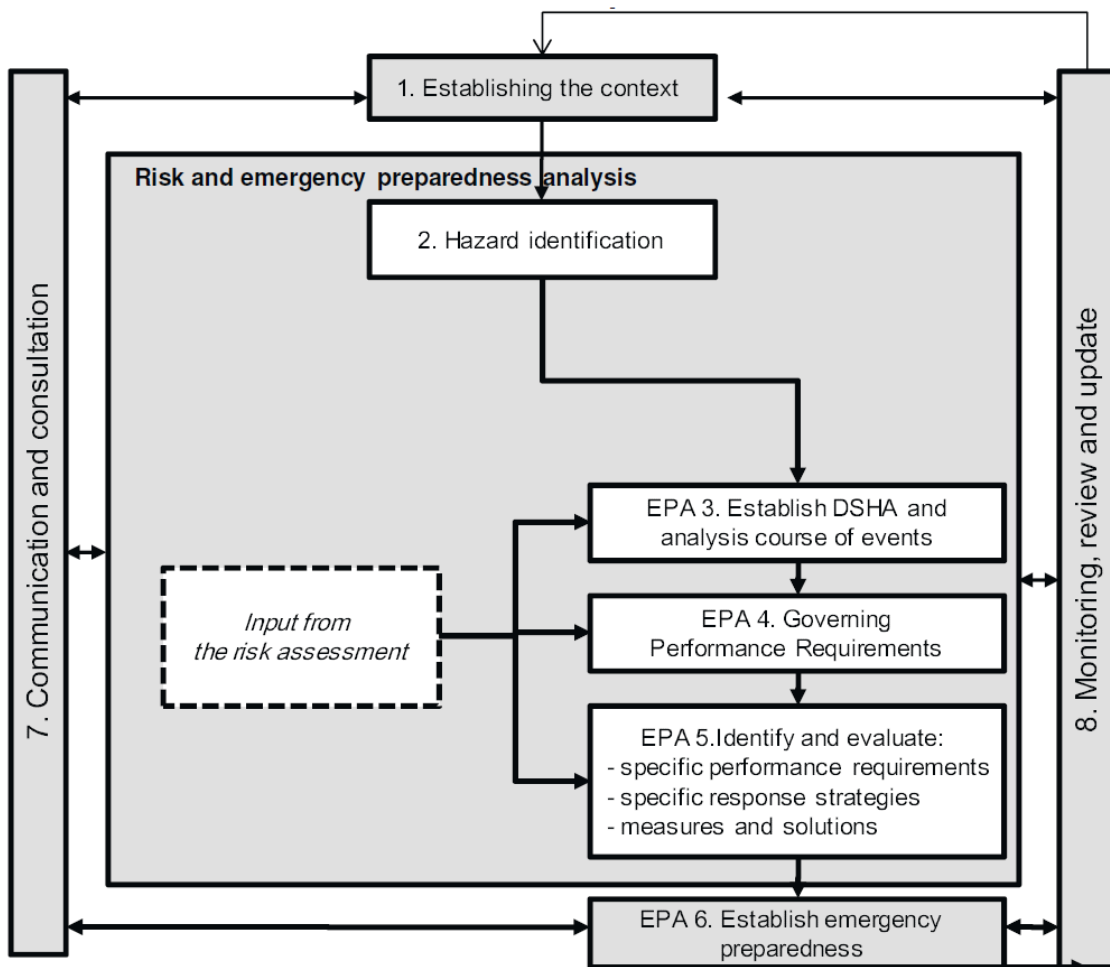


Figure 9 – The emergency preparedness assessment process

NORSOK S-001 standard on technical safety and ISO13702 standard on control and mitigation of fires and explosions are referenced in the HSE guidelines as recommended practices when designing facilities with regards to safety systems and barriers that prevent fire and explosion hazards altogether or prevent escalation of hazardous situations.

Layout of a facility is a very influential factor for minimizing the possibility of hazardous accumulation of liquids and gaseous hydrocarbons, reducing likelihood of ignition and reduce the consequences and spreading of fire and explosion to other areas than the accident site. A key consideration when designing a layout of a facility is to place the accommodation area and the primary evacuation means upwind the dominant wind direction. Facilities shall be divided into main areas (accommodation, utility, drilling, wellhead, process and hydrocarbon storage) and have in place fire and blast divisions that prevent spreading of hazardous situations to adjacent areas. Special considerations shall be taken when placing the main electricity generator. This is a critical equipment in firefighting and evacuation of facilities. (ISO, 1999)

Gas detection system shall be in place and monitor continuously areas for the presence of flammable or toxic gases before it reaches a concentration that may cause harm to personnel or installations. The system shall be capable of alerting personnel and allowing control actions to be taken manually or automatically to prevent or reduce possible consequences. Actions shall be taken to reduce the likelihood of ignition in case of loss of containment of flammable liquids and gases. For example it shall be possible to shut down electrics in areas that are believed to contain hazardous concentration of flammable gas and to identify areas where leaks are likely and specially choose equipment that have less chance of being a source of ignition. The fire detection system does have similar requirements as the gas detection system as it shall continuously monitor for the presence of fire and smoke and alert personnel and allow actions to be taken manually or automatically. In case either of them activates emergency shutdown shall be initiated, heating ventilation and air conditioning is shut down and fire water pumps activated. Additionally when fire is confirmed in hazardous areas blow down is activated as well as firefighting equipment. (NORSOK, 2008)

Passive fire protection that is required by the standards instruct that areas with important safety functions and those who are categorized as high fire risk areas shall be separated from surrounding by adequate fire divisions. The safety critical equipment that is intended to function during fire shall be protected, this equipment can be for example important cables, suspension for important pipes, emergency shutdown and blow down valves and their activation systems as well as flare lines. Passive fire protection shall also protect escape routes and safety havens where personnel gather for evacuation, so that there will always be at least one safe route available from anywhere on the facility. (ISO, 1999)

Fire-fighting systems or active fire protection is a combination of safety functions that facilities are required to be equipped with. They have the objective of limiting damage to structure and equipment by controlling and extinguishing fires. Fire-fighting systems may consist of all or part of following systems: (ISO, 1999)

- Fire water pump systems; delivers the pressure and flow required for water based fire-fighting systems.
- Fire-water mains; transfers fire-water from the fire-water pumps to the point of use.
- Fixed deluge systems; are used to control pool fires, provide cooling of equipment and apply foam to extinguish hydrocarbon pool fires.
- Water mist systems; are used for flaming fires as they extinguish them by heat extraction and oxygen displacement.
- Foam systems; uses foam to extinguish fires as it is capable of flowing over burning liquid surface, cooling it and excluding it from air supply.
- Automatic sprinkler systems; are placed in areas where slow fire growth is expected. The system is not suited for extinguishing fires in flammable liquid spills.
- Fire-water monitors; are used manually or remotely for water jet or spray coverage, water-foam solutions or to supplement fixed deluge systems.
- Hydrants and hose reels; should be placed in the probable direction of approach of fire teams and should permit effective fire-fighting. They should not be connected to the same fire-water main as the deluge system protecting the same area.
- Dry chemical fixed systems; are an effective mean for extinguishing fires and has the benefit of being non-reliant on external energy sources.
- Gaseous systems; commonly use carbon dioxide to reduce the oxygen flow in an area and thus extinguishing the fire or preventing it. Special care shall be taken as carbon dioxide has negative effect on personnel and thus are visual and audible warnings necessary when the system is activated. It shall not be used in commonly manned areas.
- Mobile and portable fire-fighting equipment; are used as first line of defense in case of small fires.

The emergency shutdown (ESD) system shall when activated isolate the facility from hydrocarbon inventories in pipelines and reservoir by closing ESD valves as well as shutting down potential ignition sources and vent pressurized hydrocarbon to a safe depressurized place. It shall be possible to initiate ESD manually from the central control room, helideck, lifeboat stations, bridge connections, drilling areas and exits from process and wellhead areas.

Blowdown shall be initiated automatically in case of ESD. During the process design special attention has to be given to the volumes of flammable gases or liquids that are cut off to be released or stored in pipelines. These volumes can be significant and can allow catastrophic situations to evolve if not handled correctly. Different levels of ESD are show in Appendix V. A blowdown and flare/vent system shall be in place to reduce pressure and risk of rupture of process segments. (NORSOK, 2008) (ISO, 1999)

At least one escape route shall be ensured in case of a hazardous incident so that personnel are able to reach designated mustering areas from any position of the facility. The facility shall ensure a refuge for personnel as long as required for a controlled evacuation. The most preferred mean of evacuation is via helicopter, other evacuation means are free-fall life boats and through escape chute with life rafts. The main evacuation area shall be equipped with lifeboats that accommodate at least the maximum number of personnel on board the facility plus one additional life boat.

Personnel shall be trained or be familiar with all systems for evacuation and escape to the sea, emergency preparedness plans shall as well be available and strategically located around the facility. The combination of evacuation methods are to assure independence from external assistance. Equipment such as survival jackets shall be available in case no evacuation methods are available other than abandoning the facility into the ocean. Recovery and rescue arrangements shall be established for personnel via stand-by vessels or other available means. (NORSOK, 2008)

6.4 Summary

The continuous development of Norwegian legislation regarding HSE matters for offshore petroleum activities has resulted in a structured and simplified regulatory framework. There are three main acts that cover offshore petroleum activities that concerns fire and explosion hazards. The Pollution Control Act, the Working Environment Act and the Petroleum Act. These acts stipulate the responsibilities of the operator regarding the scope of each act. These acts list general requirements that the operator must comply with.

Requirements that are specific to offshore petroleum activities are then stipulated in the HSE regulations. And finally guidelines and standards list recommended practices and help with the implementation of the performance based requirements set in the regulations. These are not legally binding but with the use of guidelines and recognized standards it may be assumed that requirements have been met. The operator decides not to follow the guidelines or recognized

standards he required to document and prove that his solution fulfils the same regulatory performance requirements as are set by the guidelines and recognized standards.

7 The Norwegian Regulatory regime and process

The Petroleum Safety Authority (PSA) is the cornerstone of the regulatory offices in Norway governing technical requirements, including fire and explosion hazards, for offshore facilities. It acts as a head supervisory authority and coordinates and collaborates with other offices in relation to their respective areas of authority.

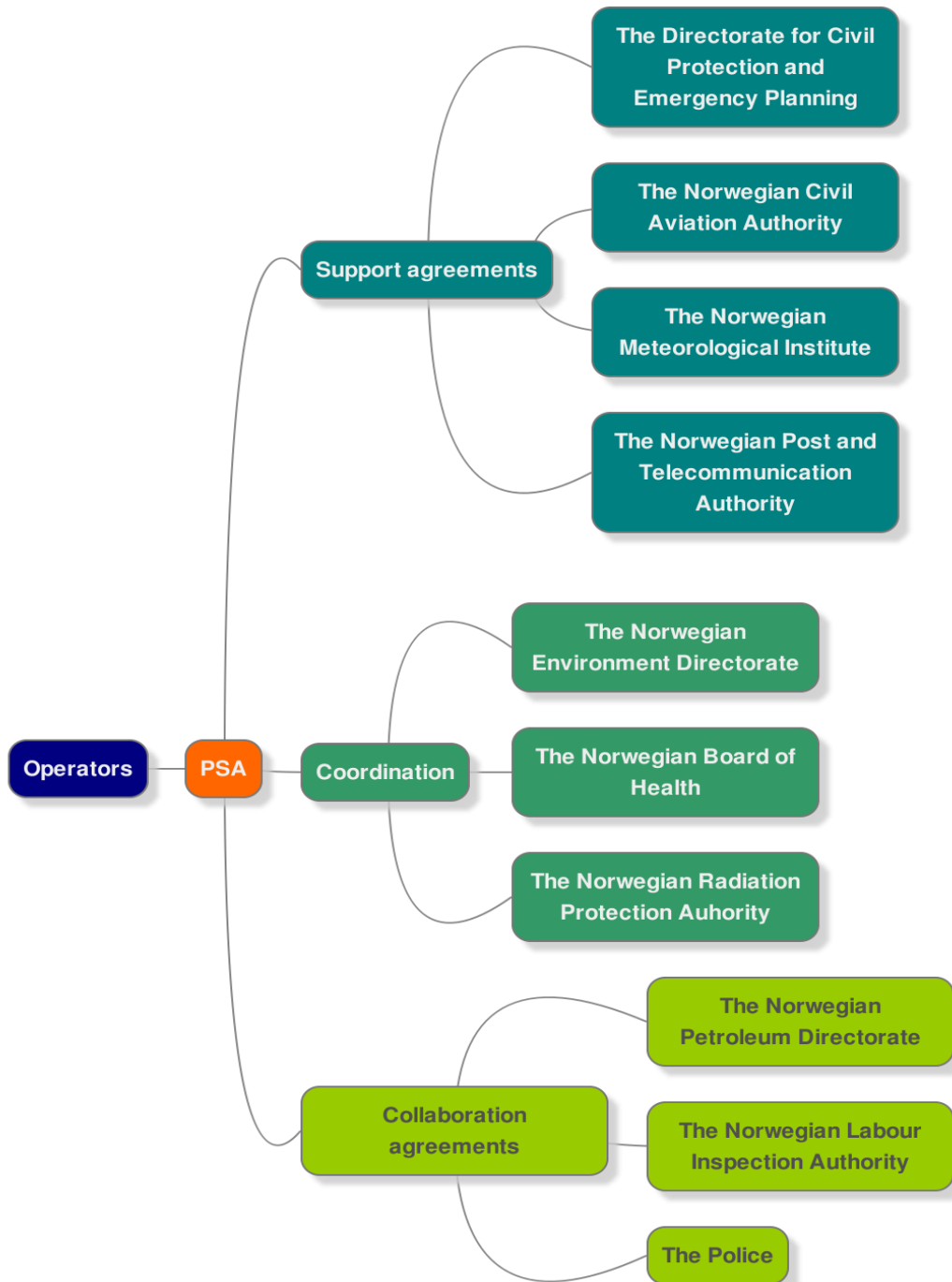


Figure 10 – Coordinated authorities/institutions (PSA, n.d.)

The authorities, institutions and agencies that assist and coordinate with the PSA regarding petroleum activities are shown in Figure 10. Each authority is responsible for implementing regulations necessary to supplement the Framework Regulations for the respective area of authority. Administrative decisions are mostly made by the Petroleum Safety Authority, the Norwegian Environment Agency and the Norwegian Board of Health in Rogaland. (MoLSA, 2013)

7.1 Documentation process

Licensees are required to gain approvals from authorities for activities before they begin installation and operation. This section will list and describe the main documents that have to be submitted by licensees and approved by the Norwegian authorities. Figure 11 illustrates a project development process from idea generation to production. A few milestones are there in between where submission of documents are required or advised. Most documentation takes place in the planning phase of the process which sets out to sort out if the project is technically feasible, if uncertainties are manageable, if it satisfies regulatory requirements, and if it is profitable. Three decision points are spread through the planning phase, these are the “*concretization decision*” (BOK), “*decision to continue*” (BOV), and “*decision to implement*” (BOG). At BOK a description of one or more concepts shall be ready with cost frameworks. At BOV technical and financial basis shall be ready and documented for the development(s) that the licensee wants to go further with. At BOG the licensee shall have finished further development of the business concept so that a decision to implement can be taken. (MoLSA & MPE, 2010)

Licensees should contact the NPD and the PSA and notify them when they have reached BOK and include information regarding their plans to organize, manage and carry out the work as well as information on their competence to perform the work. Also included should be a description of the general decision criteria, with focus on HSE, economy. The planned concepts should be described and activities that will be implemented to qualify partially pre-engineered or prefabricated facilities to be used for the planned petroleum activities. (MoLSA & MPE, 2010)

A meeting with the PSA and the NPD during the time between BOK and BOV may be advised to discuss alternative concept solutions, problems, scope and process of BOV and other documentation. Licensees should submit results of conceptual studies to the NPD and the MPE when they have reached BOV. A formal confirmation that BOV has been reached shall be sent

to the MPE, the PSA and the NPD, including reference to documentation that the decision is based on. (MoLSA & MPE, 2010)

When BOG has been made, a Plan for Development and Operation of petroleum deposit (PDO) and/or a Plan for Installation and Operation of facilities for transport and utilization of petroleum (PIO) can be submitted. Impact Assessments (IA) are a part of the PDO/PIO and have to be submitted at the same time or before. In fact a draft of the IA can be submitted when a BOV has been reached so that they can notify the licensees about issues and thus allow applicants to make adjustments to their submission of the final document. Necessary impact assessments shall be carried out and study requirements have to be fulfilled before PDO can be approved or consent for installation and operation is granted. Operators are then required to obtain consents at certain milestones in the project’s lifecycle, including exploration drilling. Owners of mobile facilities are required to apply and be granted Acknowledgement of Compliance for their facilities. (MoLSA & MPE, 2010)

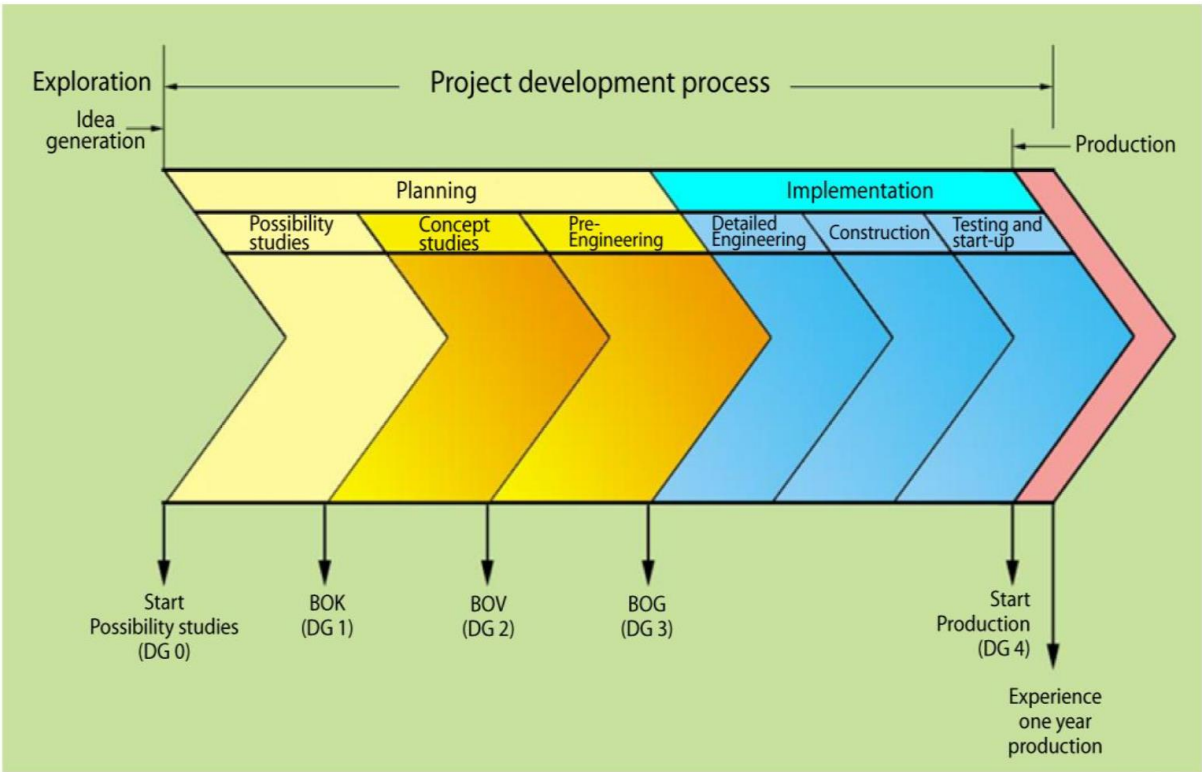


Figure 11 – Project development process for offshore petroleum activities (MoLSA & MPE, 2010)

7.1.1 Impact Assessment

Impact Assessments (IA) are an integral part of the PDO/PIO and are used as basis in the approval process. Thus IA has to be completed and study requirement have to be fulfilled before a PDO/PIO can be approved. The purpose of IA is to explain the impact that development, installations and their operation will have on the environment, natural resources and the society in general. The IA process is open to everyone, including the public, that allows the society to be aware of the possible consequences and different alternatives put forward by the developer.

Operators are obliged to complete IAs and should begin their work on it when their drilling and testing have given signs that the deposit is commercially interesting for them. The IA process is an open process and shall be sent out for consultation to the affected ministries, directorates, county municipalities and interest groups. It allows those, including the general public, who have an opinion on certain developments to express their thoughts and to make them aware of the possible consequences and possible alternatives. IAs shall, based on available knowledge, describe (MoLSA & MPE, 2010):

- Plans for development, installation and operation: includes a description of the licensees, production plans, alternative development solutions considered, selection of the development solution and production strategy, criteria's the selection was based on, health, working environment and safety, economy and cessation of the activates.
- Summary of consultation statements received: in connection with the IA programme.
- Environmental consequences and remedial measures: includes the effects the development could have on environmental factors, and what preventive and remedial measures will be taken. Any tie-ins to other fields or land facilities shall be described. It shall also include an account of how environmental criteria and consequences have been used as a basis for the technical solutions selected and the consequences they may have. Discharges to sea and soil shall be listed as well as emissions to air and its consequences to plant and animal life in the sea and along coastlines (including acute and non-acute spills). A description of how the BAT principle will be safeguarded in the planned development shall be included.
- Consequences for the fisheries and other maritime industries: includes a description of how the development will affect fisheries and where development solution will be placed.
- Social consequences: includes analysis of local and regional business and industry competence and capacity to service the company's needs in development and operations

phases as well as an analysis of labour availability and measures that will be taken with respect to these analyses.

- Summary of remedial measures and follow-up studies and monitoring: a description of follow-up studies and environmental monitoring as well as remedial measures that shall be needed.
- Emergency preparedness: shall include an evaluation of technical and organizational preparedness measures.

Licensees may be required to execute a special IA that is called Regional Impact Assessment (RIA). Operators are not automatically required to execute a RIA, however the MPE may require them to perform the assessment. These are mostly relevant where multiple developments are planned in the same area and are limited to the effect on the regional consequences of a development and its operations. If operators choose to perform RIA's or are required to do so, the work shall be finished before work on IAs begin. Completing RIA will simplify the work on IA as RIAs have to go through consultation before IA is sent out for consultation. This allows operators to use documents and studies from the RIA and improve them based on the results from the consultation process. (MoLSA & MPE, 2010)

7.1.2 Plan for development and operation of petroleum deposits and plan for installation and operation

All licensees that decide to develop a petroleum deposit in the Norwegian jurisdiction have to submit a Plan for Development and Operation (PDO) for approval to the Ministry of Petroleum and Energy, Ministry of Labor and with copies to the NPD and PSA. The Plan for Installation and Operation (PIO) is a similar documentation regarding installation of facilities that have the function of transport of petroleum. The plans may be combined in a single plan if suitable. The PDO/PIO is a comprehensive document covering all major aspects related to the operation. The document shall include an account of economic aspects, resource aspects, technical, safety related, commercial and environmental aspects in addition to information regarding the decommissioning and disposal at the end of operation (Petroleum Act, 2011 No. 38). The Ministry of Petroleum and Energy coordinates the evaluation of the PDO/PIO and no contractual commitments can be made or construction work started before the plan is approved. The main topics that have to be addressed in a PDO are (MoLSA & MPE, 2010):

- Description of the production license: a concise description of the history and current status of the license and its licensees.

- Unitization of petroleum activities: when developments are being considered for multiple separate deposits that extend over multiple production licenses, it is required to consider unitization by cooperating production, transport, utilization and cessation. A unitization agreement must be approved by MPE before submission of the PDO.
- Contract strategy: a description of the contract strategy that is organized by the licensees and based on the analysis of the opportunities for ripple effects in the region.
- Use of facilities owned by others: if the licensees choose to use facilities owned by others for production, transport or utilization of petroleum, the facility has to be described, including necessary modifications for tie-in. A clear description of the boundary between the licensee's and others' facilities and the respective responsibilities shall be included.
- Description of the scope of the development: an overall description of the development regarding the deposits and facilities that are included. If a development is split into two or more stages, the description shall include all further stages or alternative stages to the extent possible.
- Reservoir factors: includes a technical description of the deposit that the licensees are planning to develop. This section shall include information about the petroleum volume estimate, production schedule, recovery rate, a study of alternative production methods and highlight uncertainties involved.
- Production strategy: a description of short-term and long-term plans that affect the production rate and overall recoverable volume of petroleum.
- Development solutions: a description of the selection development solution. Alternative solutions shall be described briefly. However if choosing a single solution is difficult, multiple solutions may be documented equally. The licensees shall indicate what solution would be chosen for a given situation.
- Description of facilities and concept evaluation: shall be documented if changes have been made to previously submitted documentation (BOV documents).
- Technical description of facilities: shall contain a description of selected type of facility, facility's flexibility regarding different production schedules, solutions that prevent major accidents and how hazardous emissions are reduced. The need for safety zones are to be listed and in case of new technology and plan for its qualification shall be described. Special information is required for load-bearing structures, deck arrangement and subsea facilities, process and support facilities, accommodation capacity, transport systems and metering systems.

- Costs in the development phase: reasonably accurate estimates for investment cost, including operating cost and CO₂ and NO_x tax shall be listed. The estimate should include a sensitivity analysis to describe the range of uncertainty of the project.
- Organization and execution: includes a description of the planning, execution and organization of the development as well as a plan for employee participation.
- Operations and maintenance: shall describe the philosophy used for operation and maintenance and what requirements are set for those activities.
- Main plan for drilling and well activity: proposed drilling schedule and well activities shall be listed including sketches with clear indication of well barriers and technical solutions for completion and permanent plugging of the well. This section shall as well list a summary of potential problems that can occur and the identified risk and safety measures implemented. Any use of oil-based drilling fluids and a plan for disposal of drill cutting shall be accounted for.
- Disposal of facilities: a description of how facilities can be disposed of at the end of operation on site and a cost estimate shall be included.
- Financial analysis: includes a description of financial aspects for the project, including an uncertainty assessment. The possible profitability shall be calculated and supplemented with assumptions that were used. The financial analysis shall include a break-even price and internal rate of return before and after tax.
- Naming of fields and designation of facilities: application of consent to name the field.

The required topics of PIO's are very similar to the PDO's topics. Some of the previously mentioned topics are not relevant to PIO's as they are not applicable to facilities that the plan covers. However there are some additional information that has to be covered by PIO's. That includes the purpose of the installation, dimensions and capacity as well as the pipelines' destination and route. (MoLSA & MPE, 2010)

Although many of the previously mentioned topics are important to HSE factors, there are some additional information that must be documented and is specifically aimed at safeguarding HSE. These topics include the objectives for HSE and risk acceptance criteria and how the operator handles interfaces between the participants in the development. Preventive and curative health services, and other health-related preparedness shall be described. An overview of standards and specification that will apply to the development and documents that may expand on the description provided in the plans. Licensees shall in addition document other factors that are of significance to HSE. (MoLSA & MPE, 2010)

7.1.3 Application for consent

A consent is a prerequisite for all offshore activities on the Norwegian continental shelf. It is the PSA that grants consents to operators and in the meantime indicates its confidence that activities can be executed within requirements set by legislation . A consent must be obtained by operators at important milestones in the projects life cycle. A consent must be obtained before: (PSA, et al., 2014) :

- starting investigations which involve drilling deeper than 200 meters below seabed,
- starting exploration drilling,
- starting manned underwater operations,
- bringing a facility or parts of it into service,
- implementing major modifications or changes in use,
- using a facility beyond its established operating life and conditions of use,
- disposing of/removing/moving a facility,
- removing or changing the use of a vessel with a significant safety related function.

By handing in an application for consent, the operator binds himself to comply with all relevant regulations set by the Norwegian authorities. The authorities then use the consent application as a basis for their supervisory tasks. An application for consent shall include (PSA, et al., 2014):

- information on which activities the applicant wants to carry out,
- a description of the activities covered by the application, and the progress plan for these activities,
- and overview of governing documents for the activities covered by the application,
- a description of the management systems for the activities covered by the application,
- an overview of exemptions granted according to the health, safety and environment legislation and an assessment of these in the view of the activities consent applied for,
- information on whether agreements have been entered into with contractors, and possibly which enterprise is considered the principal undertaking in connection with these agreements,
- a description of the analyses and assessments that have been carried out as regards health, safety and the environment for the activities and offshore or onshore facilities covered by the application, and the results and measures that will be implemented as a result of these assessments,

- a description of the results from internal and external follow-up, and a description of planned follow-up of the activities covered by the application,
- general drawings of the offshore facility,
- a statement regarding the application from the employees' elected representatives,
- a summary of the results from the environmental risk and emergency preparedness analyses, as well as a description of how the planned emergency preparedness against acute pollution will be safeguarded in the areas where the results are also of significance to health, safety and working environment, when this information has not already been submitted to the PSA,
- an overview of which other permits for activities have been applied for and, if relevant, granted.

When an application has been submitted to the PSA it may take four to nine weeks to be processed. The processing time is determined by how detailed the authorities consideration will be. The authority's consideration approach is related to the experience they have with the operator, operators' contractors, and the relevant facility. Also affecting the detail the consideration is the planned lifetime of the project and special safety, environmental and working environment challenges linked to the activities. (PSA, n.d.)

7.1.4 Acknowledgement of Compliance

In cases where mobile facilities registered in a national ship register are to be used in petroleum activities, the facility is required to be warranted an Acknowledgement of Compliance (AoC) before operations are started. This includes mobile drilling facilities, living quarter's facilities, facilities for production, storage and offloading (FPSO), and facilities for drilling, production, storage and offloading (FPDSO). Units that are only used for storage are not required to acquire AoC. To be warranted AoC the applicant is required to document that the facility satisfies the HSE regulations or international flag state rules. International flag state rules only apply if they result a similar safety level. It is the applicant's responsibility to document that fact. (NOG & NR, 2011)

The applicant for AoC can be the owner of the facility or anyone that will be in charge of daily operations and has made or is planning to make an agreement with an operating company to perform offshore activities on the operator's behalf. The document is then used in the application of consent process later on by the operator. Preconditions to an agreement between the operator company and the applicant require that the applicant has in place a most adequate

management system for his activities and is realistically capable of conducting his specific task. The applicant is required to possess the required resources and available competent personnel throughout the process and at all levels, including own or contracted personnel and equipment. Such an application can be divided into the following subcategories (PSA, 2011):

- Purpose and plans: shall include a general description of the facility and prerequisites for use as well as a description of plan for maintenance, planned activities and milestones.
- Management system: includes a description of management and control systems (manuals, handbooks, etc.), governing documents for the facility, quality assurance requirements set for contractors. It shall also describe the organizational matters during normal operation and emergency situations as well as a plan for work force participation.
- Assessments: shall include the objectives set for safety and working environment and risk acceptance criteria for people, environment and material values. Shall also include the assessments based on risk analyses, as well as decisions made regarding safety and the working environment. A description of the safety and working environment challenges and measures implemented to reduce the probability and/or limit the consequences of hazardous situations.
- Technical conditions: includes a statement that all technical conditions of relevance to safety and working environment have been assessed and taken a stand on.
- Non-conformities: shall include a description of identified non-conformities related to requirements stipulated in legislation including possible compensating measures and deadlines for implementation.
- The applicant's own supervision: shall include a conclusion of the facilities audits and verification activities carried out before the application as well as a description of activities that are to be performed to verify that health, environment, safety and emergency preparedness requirements are maintained during the facilities activities. It shall also describe the objective, priorities and principles of independence that are used as a basis for the applicant's internal and external supervisory activities.

By warranting AoC the PSA expresses that the facility can carry out petroleum activities within the framework of the regulations. The process usually takes three months and applicant should consult with the PSA before and during the process (PSA, 2011). An AoC is independent from

consent applications, however facilities that are operated directly by the operator only need to apply for a consent and do not need AoC. (NOG & NR, 2011)

7.2 Summary

Although a considerable amount of documents and information has to be submitted to authorities before commencing offshore petroleum activities the process itself is relatively simple. For new developments the operator is required to submit a PDO of petroleum deposits and in some cases where special installations are needed for transport of petroleum a PIO has to be handed in as well. These plans are comprehensive documents covering all major aspects related to the development, including technical, safety, commercial and environmental aspects. PDO's and PIO's have to be supplemented by an IA. The IA has to be approved before the PDO/PIO's. Operators have to apply for consents at important milestones in the project life cycle. Thorough documentation has to follow with the application that indicates that activities will comply with requirements set by legislation. Mobile facilities registered in a national ship register and are to be used in petroleum activities have to be awarded (AoC) before commencing operations.

8 Results and discussion

This chapter will discuss the results from previous chapters and elaborate on how Iceland may tackle administration and supervision for offshore petroleum activities.

8.1 What type of regulatory framework would be ideal for Iceland?

Although the previous chapter didn't list all provisions that may have effect on offshore petroleum activities in Iceland it is reasonable to assume a lot of effort is necessary before any major operations may be commenced in the Dreki area. Iceland is in the process of recovering after a financial crisis and faces new opportunities in the form of a new industry that some may welcome thus they would certainly help with economic growth. This is the offshore petroleum industry that may be developed within Iceland's exclusive economic zone, more specifically in the Dreki area. The uncertainty involved in whether hydrocarbons will be found in quantities that makes operations financially viable makes the process of preparing acts and regulations difficult as well as preparing supervising authorities for new areas of responsibility. This process is expensive and possibly not a priority for any government to spend much funds on preparation that might not be necessary after all. It is quite clear that a new authority or authorities will not be established in Iceland to take on responsibilities for regulating and supervising possible offshore petroleum activities in the Dreki area.

This work is although very important and should be completed to sufficiently administrate and supervise operations if or when they commence. Offshore petroleum activities introduce high risk to personnel and the environment. Clear and concise regulatory framework and effective administration is required if these operations are to be carried out in such a manner so that risk is reduced as feasibly possible and necessary measures are taken to protect health, safety and the environment. Special attention has to be given to fire and explosion hazards as such events instigate the most catastrophic accidents in the industry. Especially when operations are so far from shore and response time for assistance is significant.

Many countries have extensive experience in the field of offshore petroleum activities and Icelandic authorities have a great opportunity to learn from them. It is very important for such high risk operations that authorities administrating and supervising offshore petroleum activities do not begin at the starting point of the learning curve. That can be done by seeking assistance and collaboration with authorities that have the experience. The most obvious path would be to reach out to Norwegian authorities for this assistance for several reasons. Norway is a neighboring country that is facing similar conditions as in the Dreki area. The Norwegian

state, through Petoro, has a 25% percentage share in both active licenses in the Dreki area. Norway has been one of the leading administrators where a clear focus is on reducing risk to HSE. The NEA has taken the first steps and is in the process of signing collaboration agreements with both PSA and NPD.

Norwegian regulatory framework has been continuously updated and improved their legislation when they see that improvements are needed. That may both be a result from their own supervisory tasks, collaboration with operators or based on recommendation following accident investigations. Norwegian authorities have set focus on establishing performance based regulations that give the licensee a certain freedom to choose and develop new approaches to achieve the required performance instead of setting strict prescriptive requirements that give little freedom to optimize operations. This has resulted in disagreements on who responsible for accidents when operators have acknowledged and complied with all requirements set by authorities. The Norwegian method does clearly pass the responsibility over to the operator to prove that his way of operation is on par with performance requirements as stated in act, regulations, guidelines and standards.

It would thus be beneficial to take up a similar system to administrate and supervise offshore petroleum activities as done by Norwegian authorities. That would simplify the collaboration with Norwegian authorities if a similar regulatory structure is on both sides as well as simplifying implementation of requirements and administrative procedures in Iceland.

8.2 Who would be the principal authorities?

When separating responsibilities of authorities and agencies it is important to ensure that no grey areas are created, where it is disputed who has the administrative and supervisory role. It is just as important to guarantee that no two authorities or agencies have the same responsibility so that risk of duplicate work and confusion is reduced. The role of each authority has to be clear and easy communication with regulatory and administrative authorities is essential.

Extensive documentation of planning, financing, technical descriptions and etc. are required to obtain permissions and licenses for operation and development of such operations offshore. It is important that authorities that are given the administrative and supervisory roles are backed up with experienced personnel for each department and satisfactory budget so that they are able to carry out their responsibilities. The offshore petroleum industry would be something completely new to the Icelandic labour market and the Icelandic work force has very limited

experience in the field, both for the operations and administration. This calls for extensive training for those parties.

There is a clear movement internationally to separate responsibilities of authorities to avoid conflict of interest as might happen if the same institution issues licenses and administrates HSE matters. Iceland and Norway are members to the European Economic Area (EEA) and through that membership required to implement certain legislation passed by the European Union (EU). The EU have passed a legislation that requires authorities to separate the regulatory functions of the competent authority from the functions relating to the economic development of offshore natural resources. This legislation will however not be implemented in Norway or Iceland as the wide geographical scope of the legislation is not in accordance with the EEA agreement (Barðadóttir, 2015). Norway did though separate these authorities in 2004 with noticeably positive results. These authorities are NPD and PSA. Where NPD has the role of evaluating and ranking applicants for licensing and which the MPE then uses as basis when awarding exploration and development licenses. The PSA administrates and supervises all main aspects of HSE matters. The PSA is the main contact for operators regarding HSE matters. The PSA contacts other authorities or agencies where it believes it is necessary for specialized input. The only sensible thing given the current movement in these matters worldwide, that is a result from decades of experience of operation and what have been learned from accidents, is to have two individual authorities have the responsibility of resource management and another who supervises HSE matters..

Several Icelandic authorities and agencies under numerous ministries and agencies are connected to probable offshore petroleum industries. It is clear that some clear administrative structure is required for the administration and supervision of these activities. It should be simplified as much as possible to avoid confusion. A dispersed administrative structure would result in knowledge being scattered through several agencies and no single authority could support operators but to a limited amount. With the Hydrocarbons Act the NEA was assigned to be a key contact during the licensing rounds and the licensing authority for exploration and production licenses. The NEA is an obvious choice for this role. It is responsible and has extensive experience for awarding licenses for development and exploitation of energy and mineral resources in Iceland.

As mentioned before a lot of technical documentation is included in the process of developing and obtaining operation licenses for offshore petroleum activities. For numerous major areas regulations have not been set for the scope of these documentation or how they are to be

processed. If a similar approach would be taken as Norway has done, a single authority would have to be chosen to serve the responsibility of supervising HSE matters for offshore petroleum activities. This authority would then have to act as a regulatory authority and manage all HSE matters so that it is ensured that no uncertainty or grey areas are left behind and everything is covered regarding legislation and supervision responsibilities. The same authority would then need to establish strong collaboration with other authorities and agencies which have administrative control over specific areas of offshore petroleum activities. It would be practical to choose an authority for this role that has experience in supervision of technical operations or construction and that will in any case have a great supervisory role in the petroleum industry. This structure would allow operators to have direct contact with an authority that supervises technical aspects of the activities.

Based on previously mentioned criteria there are mainly two authorities in Iceland that are eligible for this role. That is the AOSH or the ICA. The ICA is a regulatory authority that administrates and supervises construction with regards to building regulations, fire safety and electrical safety. All of these are major areas in HSE matters. The AOSH has the role of preventing accidents and health damage in workplaces. Both authorities are experienced in evaluating compliance with legislation and standards based on technical documents as well as supervising development and operation of constructions.

8.3 What requirements would have to be met?

Special effort should be made to prepare a sufficient legislative regime for HSE matters for offshore petroleum activities in the Dreki area. A large part of regulations that are to set requirements for these activities are unwritten. A few amendments have been made to existing regulations where the scope has been widened to cover offshore petroleum activities. This situation gives a great opportunity to implement legislation that has been proven to be effective. Icelandic authorities could thus aim at implementing the same legislative approach as is done in Norway and tailor it to the Icelandic regulatory structure.

The requirements set should be performance based and supplemented with minimum requirements and risk based approach. The harsh conditions, at the Dreki area, and their unknown consequences set a high standard for constructions and their resilience to conditions that facilities may face. The Dreki area is far away from shore and thus requires extra measures with regards to safe evacuation of facilities and pollution control measures. Implementation of technical safety measures may never be so efficient that they completely remove the risk of human error. However, safety measures and good barrier management can be implemented

based on risk assessments to prevent escalation of incidents into catastrophic accidents. This applies as well to technical failures.

There are mainly two documents, concerning fire and explosion hazards, which have been implemented in Icelandic legislation and licensees or operators are required to submit before commencing operations offshore. These are the Field Development and Production Plan (FDPP) that is submitted to the NEA and the Safety Evaluation (SE) that is handed in to the ICA. Approval of these documents are a prerequisite for commencing offshore petroleum activities and thus an essential tool for setting requirements for offshore petroleum activities.

Regulations have been implemented that generally describe the required contents of FDPP's, these were listed in chapter 4.1.1. Majority of the topics concern fire and explosion hazards one way or another, these topics are:

- A plan for construction, installation and operation of offshore facilities, together with an environmental impact assessment,
- a well founded field development and production strategy,
- a description of technical solutions,
- information on how the licensee intends to ensure that his activity and employees follow the laws and regulation governing the operation,
- information on operative matters and maintenance,
- information on the permits that have been applied for, approval that has been sought or will be sought, and if it is intended to place any equipment of facilities owned by a third party on land or on the bottom of the sea,
- plan for the intended decommissioning of offshore facilities, production structures and production equipment, when hydrocarbon activities are finished,
- information on the construction and operation of pipelines for the production and transport of hydrocarbons,
- information on the transport of hydrocarbons from the extraction site,
- description of technical arrangements for emergency preparedness,
- other information that is required according to the safety and security legislation valid at any given time.

Regulations have not been implemented to establish the required scope of the SE. Based on recommendations from the ICA the MENR shall implement such regulations that lists the required information so that the SE's are based on reliable sources. Here is a key opportunity

to look towards the Norwegian legislation and process to use as a basis regarding risk analyses and emergency preparedness. The SE could have a similar function as the application for consent does in Norway. The SE regulation should require the operator to:

- Document risk analyses where hazardous situations are identified along with identifying their initiating incidents, sequences, consequences and possible risk reducing measures.
- Establish a sufficient barrier management which is based on the risk analyses. With barrier management, the consequences of incidents are prevented from escalating and developing into major accidents.
- Establish an emergency preparedness strategy including a description of measures and coordination with authorities and other available resources. The regulations covering SE should permit authorities to require standby vessels on site as an emergency preparedness measure for MOB situations and in case of facility evacuation.
- Establish objectives and strategies to improve HSE and set internal requirements. This includes setting requirements for the competence of employees that operate functions that may have serious consequences to HSE.
- Introduce measures for continuous improvement, such as internal system audits, management reviews, self-assessments, verifications, validations, measurements and surveys.
- Establish a maintenance strategy including analyses on failure mechanism and the consequence of those failures to HSE.
- Choose a robust and simple design of installation and equipment where the risk of human error is limited and operations can be carried out with the lowest possible risk.
- Implement safety functions that ensure safety of personnel and limit pollution in accident situations.
- Establish a holistic approach to passive and active fire protection measures.
- Assure that workers are not subjected to work activities or work environments that cause physical or mental strain.
- Establish a new SE if the design or layout of facilities change.

There is no legislation in Iceland on the working environment where the scope includes offshore petroleum facilities other than what is stated in the Construction Act and Fire Protection Act. Either the scope of the Act on Working Environment, Health and Safety has to be widened to cover offshore petroleum facilities or new act that covers the operations specifically has to be implemented. Iceland should then maintain collaboration with Norwegian authorities as well as

operators in the Dreki area to exchange thoughts on possible improvements with regard to legislation and supervision.

8.4 Potential future work and comments

The thesis work aimed at producing a holistic view of a recommended approach for administration and supervision of offshore petroleum activities that would hopefully be used as aid for Icelandic authorities during their implementation of a regulatory framework for such activities. This thesis makes a sizeable effort to describe and illustrate the regulatory, administrative and supervisory approach of Norwegian authorities that ensures that offshore petroleum activities are developed and operated with as little risk to health, safety and the environment. It has revealed that performance based regulations are the way to go to ensure continuous improvement and encourage innovation. The work has as well resulted that natural resource management and supervision of HSE matters should be completely separated between two different authorities.

The main challenges that were faced during the work of this thesis was the fact that very limited information on procedures within Norwegian authorities were available. The only procedures that were available were those who are listed in acts and regulations. Initially the plan was to describe internal procedures of authorities such as the PSA including a quality control procedures. This information was not available so by reviewing acts and regulations the process was describes as well as feasible.

There are mainly three areas that come to mind for potential future work:

- 1) Setting the policy and writing regulations: It is very important that relevant Icelandic ministries to establish a policy and a regulatory approach for administration and supervision of offshore petroleum facilities so that a clear framework can be formed and regulatory authorities can start writing their regulations.
- 2) Effect of increased vessel traffic in the north: it would be noteworthy to analyze the effect of increased vessel traffic to north. Not only for supply and service vessels for offshore petroleum activities but as well the anticipated increase in traffic of cruise vessels. What extra safety measures have to be taken to counterweigh collision hazards with offshore facilities and emergency plans for search and rescue of thousands of passengers?
- 3) A legal study status of international flag state vessels: it is important that Icelandic authorities have right to administrate and supervise vessels that are operating in offshore petroleum activates. Iceland has made international agreements that may have limited this

authority. A legal assessment should establish the right of the Icelandic authorities to carry out their responsibilities for international vessels and if the right is limited then discover changes required to allow Icelandic authorities to administrate and supervise all vessels that operate in offshore facilities within Iceland's exclusive economic zones.

9 Conclusion

Modification of regulatory framework and administrative structure governing offshore petroleum activities are noticeable following major accidents. Including changes to the legislative approach and responsibilities of authorities. There is an indication of increasing use of performance based regulations, as they provide more flexibility and gives an opportunity for innovation and finding more efficient solutions that achieve the same level of performance. Due to a possible conflict of interest there has been a movement towards separating responsibilities of authorities so that the same authority does not issue licenses for exploration and production of hydrocarbons and in the meantime supervise risk to health, safety and the environment. Norwegian authorities have been responsive in developing administrative and supervising responsibilities and have implemented.

There are two active licenses for exploration and production in the Dreki area north-east of Iceland. The Dreki area is more than 300km from the Icelandic coast and is placed north of the Arctic Circle. The conditions at the Dreki area known to be quite harsh. Technical solutions have been proven to be cost effective and successful in areas with partly similar conditions. However, there is relatively little experience in facing so many harsh factors at once so special care has to be take, especially to emergency preparedness and evacuation means.

There are numerous ministries, ministers, authorities, agencies and institutions in Iceland that would have administrative and supervisory roles and would govern offshore petroleum operations in the Dreki area. This makes coordination and collaboration that much harder.

The Norwegian regulatory regime is much simpler. Each ministry has relinquished most of their responsibilities concerning offshore petroleum activities to another authority. This is achieved by joining most of the administration and supervision of HSE matters under one authority.

A well-structured and simplified regulatory framework is a product of Norwegians continuous development of the regulatory framework. All main aspects concerning offshore petroleum activities are included in three main acts and four regulations. These acts list general requirements that the operator must comply with. Requirements that are specific to offshore petroleum activities are then stipulated in the HSE regulations. And finally guidelines and standards list recommended practices and help with the implementation of the performance based requirements set in the regulations. These are not legally binding but with the use of guidelines and recognized standards it may be assumed that requirements have been met. The operator decides not to follow the guidelines or recognized standards he required to document

and prove that his solution fulfils the same regulatory performance requirements as are set by the guidelines and recognized standards.

The approval process is relatively simple although vast amount of documents and information is required to assure Norwegian authorities that operations comply with requirements set by regulations. For new developments the operator is required to submit a PDO of petroleum deposits and in some cases where special installations are needed for transport of petroleum a PIO has to be handed in as well. These plans are comprehensive documents covering all major aspects related to the development, including technical, safety, commercial and environmental aspects. PDO's and PIO's have to be supplemented by an IA. The IA has to be approved before the PDO/PIO's. At all major milestones in a project life cycle the operator is required to apply for a consent. Thorough documentation has to follow with the application that indicates that activities will comply with requirements set by legislation. Mobile facilities registered in a national ship register and are to be used in petroleum activities have to be awarded (AoC) before commencing operations.

Icelandic authorities are in a great position to look towards the Norwegian regulatory, administrative and supervision approach for offshore petroleum activities. That would not only provide Iceland with an approach that is a result of decades of experience but as well simplify the collaboration with Norwegian authorities. It also simplify implementation of requirements and administrative procedures in Iceland. The regulatory framework would then be based on a performance based approach and supplemented with few specific requirements.

The NEA is the obvious choice for natural resource management and thus an administrator of licensing exploration and production licenses. Both the AOSH and ICA are experienced in administrating and supervising. They are as well experienced in processing technological information and evaluating them with regards to legislation and recognized standards. Both of them will in any case have a large responsibility for supervision of offshore petroleum activities.

It is important that operators are required to submit sufficient information and documentation. The FDPP that is submitted to the NEA and is similar to a PDO. Regulations setting the scope of the SE has not been established. Here is a key opportunity to look towards the Norwegian legislation and process to use as a basis regarding risk analyses and emergency preparedness. The SE could have a similar function as the application for consent does in Norway.

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Appendix I

The following lists the duties of safety representatives as they appear in the Working Environment Act.

- The safety representative shall safeguard the interests of employees in matters relating to the working environment. The safety representative shall ensure that the undertaking is arranged and maintained, and that the work is performed in such a manner that the safety, health and welfare of the employees are safeguarded in accordance with the provisions of this Act.
- The safety representative shall particularly ensure:
 - a) that employees are not exposed to hazards from machines, technical installations, chemical substances and work processes,
 - b) that safety devices and personal protective equipment are provided in adequate numbers, that they are readily accessible and in proper condition,
 - c) that the employees receive the necessary instruction, practice and training,
 - d) that work is otherwise arranged in such a way that the employees can perform the work in a proper manner with regard to health and safety,
 - e) that notifications concerning occupational accidents, etc. are made, pursuant to section 5-2 of the Working Environment Act.
- As soon as a safety representative learns of circumstances that may result in accidents and health hazards, the safety representative shall immediately notify the employees at the location, and if the safety representative is unable to avert the danger himself, he shall bring the matter to the attention of the employer or the employer's representative. When so notified, the employer shall give the safety representative a reply. If no action has been taken within a reasonable space of time, the safety representative shall notify the Labour Inspection Authority or the working environment committee.
- The safety representative shall be consulted during the planning and implementation of measures of significance for the working environment within the representative's safety area, including establishment, exercise and maintenance of the undertaking's systematic health, environment and safety work,
- The safety representative shall be informed of all occupational diseases, occupational accidents and near accidents in his or her area, of reports and measurements relating to occupational health and of any faults or defects detected.

- The safety representative shall familiarise himself with current safety rules, instructions, orders and recommendations issued by the Labour Inspection Authority or the employer.
- The safety representative shall participate in inspections of the undertaking by the Labour Inspection Authority.

Appendix II

The following is how hazard and accident situation are defined as it appears in the guidelines for the Management Regulations.

Hazard and accident situations include:

- a) situations where there is a danger that vessels or drifting objects can collide with facilities,
- b) blowout from wells,
- c) explosions and fires,
- d) major accident hydrocarbon and chemical discharges of significance to safety and the working environment,
- e) accidental discharges of petroleum, drilling fluid and chemicals of significance to the external environment,
- f) incidents where the use of radioactive sources is out of control.

Notification should be given of the following situations:

- a) situations where the emergency response organization is activated, or where preparations for evacuation are implemented,
- b) situations where preparations have been made for moving personnel, or personnel have been moved as a consequence of meteorological forecast,
- c) situations where the safety delegate demands that dangerous work be stopped.

Hazard and accident situations of less acute nature that shall be notified to PSA the first workday after the situation is realized include:

- a) situations where special hygiene or health preparedness measures have been implemented, e.g. in connection with
 - a. Illness attributed to the water of food supply,
 - b. Failure of normal hygienic procedures resulting in increased risk of illness.
- b) less serious situations in connection with positioning, pipeline systems and load-bearing structures,
- c) violation of safety zones or areas subject to special limitations,
- d) situations which have led to loss of deck cargo, anchoring, mooring and towing equipment, and drilling and well equipment. The notification should indicate the exact position,
- e) accidental hydrocarbon and chemical discharges of lesser significance to safety and the working environment,
- f) accidental discharges of petroleum, drilling fluid and chemicals of lesser significance to safety and the working environment,
- g) situations where radioactive sources are stuck in the well,
- h) situations where individual measurements show that employees have been exposed to radiation of more than 20 mSv during the course of twelve months.

Appendix III

The following are the required contents of emergency preparedness plans as they are listed in the guidelines for the Activities Regulations.

The emergency preparedness plans should include:

- a) a description of purpose, scope and responsibility,
- b) a description of organization, notification, mobilization and communication
- c) action plans,
- d) a description of fields and facility(ies) and prioritized vulnerable environmental resources in the impact area for acute pollution,
- e) a description of unit resources, area resources, regional resources and external resources and equipment,
- f) instructions for emergency preparedness personnel,
- g) any coordination procedures vis-à-vis other involved parties,
- h) any cooperation procedures and agreements.

Action plans mentioned in litera c) should cover, inter alia

- a) emergency preparedness strategy, emergency preparedness measures and decision criteria for the emergency preparedness phases,
- b) in order to handle acute pollution, the emergency preparedness strategy should comprise objectives for protection of prioritized, vulnerable environmental resources. The description of emergency preparedness measures and decision criteria for the various emergency preparedness phases should include response times for relevant emergency preparedness measures, remote measurements, choice of emergency preparedness measures based on minimum environmental damage considerations, shore clean-up and environmental surveys in case of acute pollution,
- c) for the health-related emergency preparedness, treatment of:
 - a. personal injuries in the event of major accident situations,
 - b. personal injuries in the event of industrial accidents,
 - c. Acute illness,
 - d. psychological reactions,
 - e. communicable diseases,
 - f. poisoning.

Appendix IV

The following are the focus points during design of development concepts as they appear in the Facilities Regulations and its guidelines.

When choosing a development concept, the following shall be considered:

- a) major accident risk – important risk contributors,
- b) type of operation – organization, staffing, maintenance, transport solution, working environment, any manned underwater operations
- c) risk of pollution – operational discharges and emissions,
- d) geographical location – infrastructure, other fields and facilities, distance to land and bases, fishery activities and shipping lanes,
- e) location conditions – route, sea depth, seabed conditions, wave height, wind and other natural conditions,
- f) reservoir properties – recovery rate, pressure, temperature, oil or gas, corrosiveness and shallow gas,
- g) regularity requirements – delivery obligations and economy,
- h) lifetime – flexibility and expected changes in operating conditions, as well as future use,
- i) any subsequent removal – removal and reuse,
- j) need to develop new technology.

Facilities shall be based on the most robust and simple solutions as possible, and designed so that:

- a) no unacceptable consequences will occur if they are exposed to the loads/actions as the regulations stipulate,
- b) major accident risk is as low as possible,
- c) a failure in one component, system or a single mistake does not result in unacceptable consequences,
- d) the main safety functions are maintained,
- e) materials handling and transport can be carried out in an efficient and prudent manner,
- f) a safe working environment is facilitated,
- g) operational assumptions and restrictions are safeguarded in a prudent manner,
- h) barriers are established that can both detect abnormal conditions and reduce the potential for failures and hazard an accident situations developing, and which can restrict possible harm and disadvantages,
- i) health-related matters are safeguarded in a prudent manner,
- j) the lowest possible risk of pollution is facilitated,
- k) prudent maintenance is facilitated.

Materials to be used in or on facilities shall be selected considering:

- a) the load/action requirements,
- b) manufacturing, joining and construction processes,
- c) possible use of materials protection,

- d) fire-resistance properties,
- e) probable changes in operating conditions,
- f) the opportunity to reduce future use of chemicals and pollution,
- g) the opportunity to reduce, reuse and recover waste,
- h) the employees' health and working environment,
- i) potential future removal.

Appendix V

Different emergency shutdown (ESD) levels as shown in NORSOK Z-013.

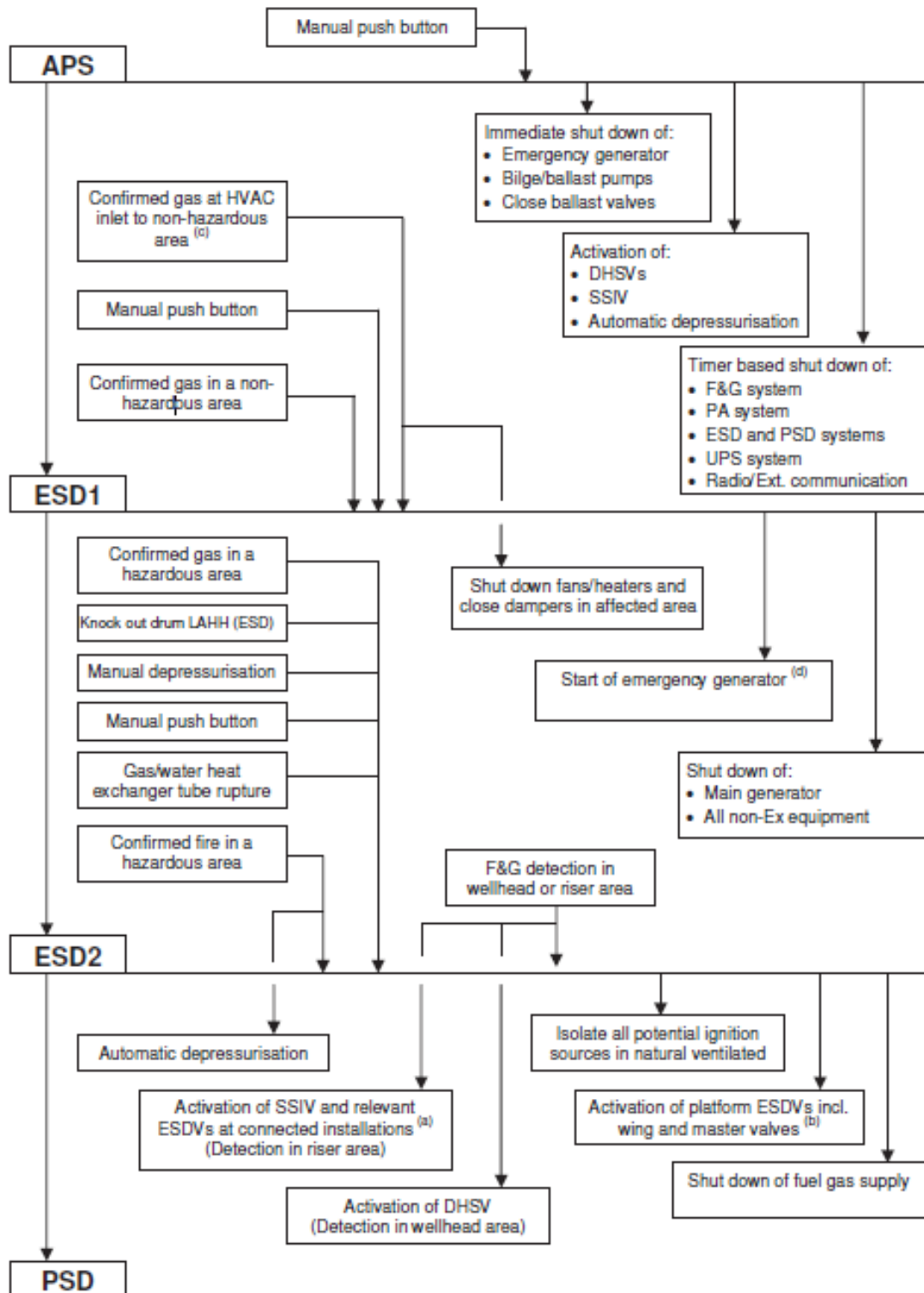


Figure 2 - Emergency shut down (ESD) principle hierarchy

(a) Can be sub-sea well template, wellhead platform, compressor platform, onshore plant.

(b) Local shut down of flow from subsea templates and upstream platforms by ESD or PSD.

(c) Alternative to ESD1 can be ESD2 and selective electrical isolation depending on location, see Table 2.

(d) Alternatively inhibit start of emergency generator may be considered due to ISC.