Master's degree thesis

LOG950 Logistics

Reverse logistics and lean waste management of drill cuttings at Shell, Kristiansund

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Acknowledgement

It is well known that time goes fast. Rarely we calculate the minutes waiting in airports or ferries but mostly we don't notice the time. The day when question about topic for research design came with the question about future supervisor my attention was pointed on the topic given by Per Engelseth about management of hazardous waste at Vestbase. Later, proposal was successfully passed and next days the interview was taken at Shell's office in Kristiansund with guidance from my supervisor. I still remember clear that moment when the question was presented by Per Engelseth to the respondent about "*So, what type of cargo takes most of your time?*"-"*Well, drill cuttings!*"-"*Mm.. What is this?*"

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Abstract

Purpose. This study is an independent single case in offshore oil and gas industry in Norway that is guided by Shell. The main focus of this thesis is to present the value created by all actors involved into the process created, present the results of implemented reverse logistics and lean into the "downstream" business of Shell. The question about how that value was created, the built network, information flow and waste flow will be presented. Barriers, challenges and possible solutions will be presented.

Design/methodology/approach. This study is a qualitative and exploratory case study. The main structure of this thesis was kept by three created research questions that presented the linking between all of them presenting one flow. Discovering and understanding the first research question will help to receive the basic knowledge for the second research question and later, for the third. All research questions are with detailed technical characteristics that prove their complexity. The literature review relating to reverse logistics, hazardous waste management, lean implementation, green lean, green supply chain management, logistics and value creation presents the new definition of reverse logistics, lean and model based on value creation. The collection of data was done through interviews and few observations.

Findings. The empirical findings show how the reverse logistics and lean was already implemented by Shell into the process that was created by the hazardous waste Shell had to produce during drilling operations and how the value was created by each participator in the reverse supply chain.

Research limitation/ implication. This case study is a single analysis in one single Norwegian oil and gas industry. Thus, findings cannot be taken for other industries. Given recommendations are based on the explanatory case study using non-parametric analysis.

Originality/value. The case study presents the unique process created by hazardous waste produced in offshore that was handled by twelve actors presenting the complexity.

Keywords: offshore, Norwegian Continental Shelf, Shell, ownership, drill cuttings, hazard, oil-based drilling mud, hazardous waste management, reverse logistics, lean, just-in-time, green supply chain management, logistics.

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List of Abbreviations

Abbreviation	Explanation
ADR	European Agreement concerning the International Carriage of Dangerous Goods by Road
Avfallsforskriften (Waste Regulations)	Forskrift om gjenvinning og behandling av avfall (Regulations relating to the recycling of waste)
CCB	CLEANCUT cuttings blower
CLSC	Close-loop supply chain
CTT	Cuttings Transport Tank
DS	Drill Ship
DSB	Direktoratet for samfunnssikkerhet og beredskap (Norwegian Directorate for Civil Protection)
EC	European Council
EEA	European Environment Agency
EIONET	European Topic Centre on Sustainable Consumption and Production
EPA	Environmental Protection Agency
EU	European Union
EWL	European Waste List (EAL in Norwegian)
Fylkesmannen	County Governor
GSC	Green Supply Chain
GrSCM	Green Supply Chain Management
IMDG	International Maritime Dangerous Goods
IMR	Institute of Marine Research
ISO-tank	ISO-pump unit
JIT	Just-in-time
HSE	Health, Safety and the Environment
HW	Hazardous Waste
HWM	Hazardous Waste Management
LM	Lean Management
LNG	Liquefied Natural Gas
LSCM	Lean SCM
Miljødirektoratet	Norwegian Environmental Agency
MSW	Municipal solid waste
NCS	Norwegian Continental Shelf
NEMAK	Norsk Engelsk Mineralolie Aktieselskap
NFFA	Norsk forening for farlig avfall
NOROG	Norsk olje og gass (Norwegian Oil and Gas Association)
NORSAS	Norsk kompetansesenter for avfall og gjenvinning (The Norwegian Resourse Centre for Waste Management and Recycling)
NPD	Norwegian Petroleum Directorate
OBDC	Oil Based Drill Cuttings
OBDF	Oil Based Drill Fluid
OBDM	Oil Based Drill Mud
PLC	Programmable Logic Controller
PSAN	Petroleum Safety Authority Norway
PSC	Petroleum SC

PSV	Platform Supply Vessel
RL	Reverse Logistics
RSC	Reverse Supply Chain
SCM	Supply Chain Management
SS	Semi-Submersible
Statistisk sentralbyrå	Statistics Norway
TBR	Transocean Barents Rig
TCC	Thermomechanical Cuttings Cleaner
TDS	Total Development System
TMS	Total Marketing System
TOC	Total Organic Carbon
TPS	Total Production System
TQM	Total Quality Management
T-JIT	Total system JIT
VSM	Value stream mapping
WEEE	Waste Electrical and Electronic Equipment
WFM	Waste Flow Mapping
WM	Waste Management

1.0 Introduction

1.1 General background

Few decades ago due to the newest technologies that time the history of Norwegian oil and gas industry in offshore had been started. A huge amount of oil and gas was found out and the first production process in Norway from the drilling installation, Ecofisk, was started. Since that time, the number of drilling wells was incredibly increased as well as the volume of oil and gas produced. New technologies every year present new materials that can be used for drilling operations from drilling rigs or drilling ships. Different soil layers require different type of materials that can be used for more effective drilling. In practice it was found that some soil layers don't need for drilling operation any materials at all. Nevertheless, the volume of waste received on boards of drilling installations is increasing at the same time. Very often one material must be replaced by another that will allow providing better and quicker drilling. However, the characteristics of these materials may influence not only on the environmental safety and health, but on the human health also. Increased global energy production also makes a negative influence on emission globally that is increasing nowadays. Following new discoveries drilling engineers face with new mix of soil, stones and conditions at seabed. Thus, new drilling technologies are improved presenting new types of drilling.

The empirical research presents the interesting case where one company is the operator of two fields located along Norwegian Continental Shelf. At the same time, this company is the organizer of all drilling operations made from drilling installation at these two fields. Therefore, it is also, the waste producer. The type of waste produced at drilling installations is not a normal, simple one. Thus, it cannot be stored on these drilling installations until the special containers/units will be full and only then, delivered to the shore as it can be done with other types of waste produced on the installation (medicine waste, used batteries, lamps, bio waste). This type of waste should be considered by the reader as waste that needs to be carried out to the shore carefully and without delays. Otherwise, the costs will be increased incredibly. The amount of this type of waste is huge as well. The analysis of the flow of this type of waste from offshore platform to the recipients through supply base on the coast will be presented.

The situation that is presented in this paper is a unique case to be studied and examined. Due to the kind of services company provides the number of actors being involved into the process is big. Some of actors are regular participants while others became involved recently at the time when the necessity for the main organizer came up. The case study presents the most suitable ownership structure for the time that waste was produced at drilling installations under guidance of waste producer, in year 2014-2015.

One of the main underlines is the fact that this type of waste was not a raw material used for product before, but the raw material that became a waste without being a product. Furthermore, this waste became the unit of trade for all actors involved into the product this waste created.

This paper is divided on six chapters. In the chapter 1 presented the main network actor, its upstream and downstream business, its view on environment and health, its activities in two fields in offshore. Furthermore, the research problem with three research questions, relevance and limitations of the study are displayed. Chapter 2 provides the literature review giving the overview of the ownership, reverse logistics, hazardous waste management, lean waste management, green lean and green supply chain management. Chapter 3 is focused on research methodology and data collection. It interprets how the new theory is built according the empirical case. Chapter 4 presents the empirical case description given better understanding of the process created by waste chosen, actors involved, their contribution into the process and the value each of them had created according the type of waste. In chapter 5 the discussion and analysis is provided. Chapter 6 provides the conclusion and recommendations for the main actor, the waste producer.

The main aim of this paper is to provide better understanding and more clear definition of the reverse chain/process that was created by this type of waste at the time it was produced. Furthermore, the study presents the behavior and the point of view of waste producer according waste but not the detailed point of view of all companies that are operators of other fields along Norwegian Continental Shelf. One more important point is that before the empirical case study was done the waste producer already used tools and practices of reverse logistics and lean.

One more fact that needs to be marked out is that most of articles used for this study were from year 2014-2015, the newest one. During empirical study the gaps in the literature were marked out to require further researches. The author of this paper considers that the framework that is built in this case study will “shed the light” on the future cases.

1.2 The main network actor, A/S Norske Shell (Shell)

The running of the business of “Shell” was started almost 180 years ago by antique dealer Marcus Samuel in London, UK, importing shells from the Far East to develop an exotic décor. Currently, Shell turned into a huge global holding company of energy and petrochemical companies named Royal Dutch Shell plc (Shell, 2014a). Furthermore, in the beginning of 21th century the company began the moving to the new direction – the expanding market in the East where such countries as Russian and China are located and present new projects in oil and gas industry. Today Shell works and has running major projects in many countries all over the world.

The integrity, honesty in front of customers and partners, mutual respect together with proper ethical behavior are set by Shell as values. As for any other company, the reputation for Shell is one of the main parts in a business, and can be upheld and lived up to company’s values. Considering that the demand for oil and gas is increasing during last decades, Shell considers the opportunity to meet the demand in environmentally friendly ways performing the ecologically sustainable and efficient consumption of natural resources.

In January 1940 A/S Norske Shell's history begins in Norway after being named NEMAK (Norsk Engelsk Mineralolie Aktieselskap) during 28 years since October 1912 (Shell, 2014a).

1.2.1 Shell's upstream and downstream business

Upstream business

The operations related to investigation and production of natural gas and crude oil – is the upstream business of Shell. It also includes the liquation and transportation of gas and oil to the market. The two other directions in the Shell's upstream business are presented by production of bitumen and development of wind power, a kind of renewable energy (Shell, 2015b).

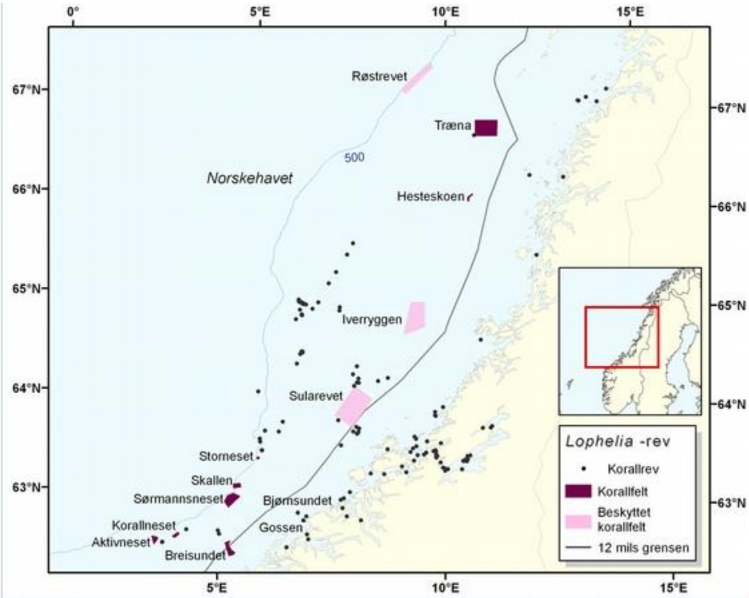
Shell is a leading actor in Norway as well as the significant player on NCS with high production volumes. In Norway the company operates on the oil field Draugen and gas field Ormen Lange. To operate at any field on NCS, Shell has few production licenses as the owner and few - as a partner. The head office is located in Aukra and Kristiansund, Møre og Romsdal (Shell, 2015c).

Downstream business

Shell's activities for chemicals and oil products according to the refining and marketing are performed in a downstream business. Production and procurement of crude oil are included in refining. Marketing includes the sale of different kinds of products for industrial customers. Moreover, the trade of crude oil is also presented in the downstream. Shell uses the large fleet of oil tankers and liquefied natural gas (LNG) carriers. Furthermore, different projects in CO2 management are considered by Shell (Shell, 2015b). The head office of Shell in Norway is located in Oslo.

1.2.2 Environment and Health at Shell

The NCS besides the huge reservoirs of oil and gas also presents the deep water coral reefs. These kinds of corals construct reefs in dark cold water very slowly, only few millimeters each year, than tropical coral reefs. Some of deep water coral reefs around the world date back at least few thousand years. However, today, oil and gas production together with bottom trawl and pollution have its own impact on the ecosystem destroying it slowly and Norway is one of countries that needs to consider such situation in more detailed way.



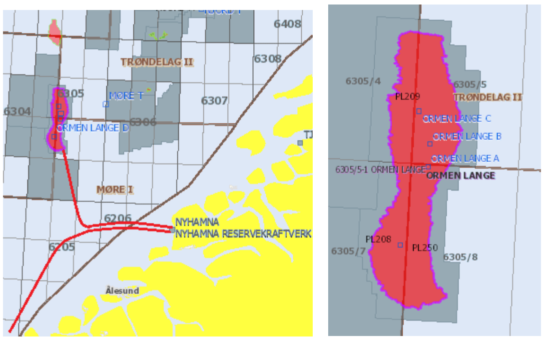
Picture 1: Detailed map of coral reefs in Mid-Norway (IMR, 2015).

Some programs were created and financed by Shell and other partners all around the world to help fishermen to increase the fishing while protecting and restoring the part of the Coral Triangle and the environment at the coast in Pacific Ocean. Thus, every next project or the application of new technologies for operations requires the protection of biodiversity – that is a very significant factor for Shell.

The standards of life along with population are rising up. This fact also affects energy consumption. The retention of clean sea water is very important for the environment, thus, Shell pays attention to the best high quality materials offered by suppliers, such as non-metallic materials produces according low-carbon technologies (Shell, 2015d). The environmental impact directly has an influence on human health: employees at Shell and communities nearby. Therefore, the environmental safety is a core direction at Shell's business.

1.2.3 Shell's activities at Ormen Lange

The second largest gas field in Norway is named Ormen Lange and is located in the Norwegian Sea. According Shell (2015e), the seabed depths at location of Ormen Lange vary between 850 and 1100 meters and reservoir is situated 3km below the sea level and 120 km from Kristiansund. The Ormen Lange field is divided on four areas. New projects for the further development require improvement of technologies.



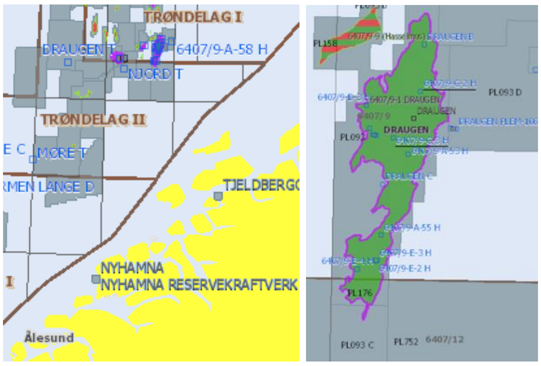
Picture 2: Ormen Lange field (NPD, 2015).

From Ormen Lange gas flows by gas pipeline Langeled to the land facility in Nyhamna (Aukra kommune in Møre og Romsdal). There gas is quickly separated from liquids and, being compressed, is routed to the South England, Easington.

The license partners in Ormen Lange are Shell (operator), Statoil, Petoro, Dong and ExxonMobil (Shell, 2015e).

1.2.4 Shell's activities at Draugen

In 1984 the oil field Draugen was found in Norwegian Sea at the place where geologists could not expect and 9 years later, year 1993, the production by Shell, as operator, has begun as well as the important step in the Norwegian oil history.



Picture 3: Draugen field (NPD, 2015).

The water depth at the field is almost 250 meters and reservoir is situated 150km from Kristiansund. The life of the field is estimated as 17-20 years and now Draugen is one of the Norwegian fields with the highest recovery rate of around 70% (Shell, 2015f). As the expected period was finishing in the year 2013, Shell created few projects to extend the life of Draugen. Furthermore, the field presents more oil than it was expected.

Partners in the Draugen license is Shell (operator), Petoro and VNG (Shell, 2015f).

1.3 Research problem

This empirical case study presents the independent research project that was done for the waste producer, Shell, Kristiansund. The type of waste presented in the study has its uniqueness due to the fact that it cannot wait when it is collected but to be transported to the special plant where the treatment can be provided. This case study shows that waste is considered by some companies as not a waste but a product that can be transported, delivered, handled, unloaded/loaded and thus, be profitable. What is the mover for these companies? Yes, the value each of them created and creates during handling if this type of waste.

The case study probably could be not that interesting if the type of waste was normal one. The understanding will be clearer as soon as the reader imagines the drilling process and how strong should be the drilling drill to drill not the sandy soil but the stone like a limestone, how much dust can be produced during the drilling process. Therefore, chemicals have to be used for such process, and thus, this waste is a hazardous waste that requires more rules and attention to be paid.

The important fact is that the reader should not mix hazardous waste with household and industrial waste due to their characteristics and content. Other moment to be taken into consideration is that this waste has to be delivered at the right condition at the right place at the right time and at the right amount waste producer settled with other actors. Otherwise, the process will be more costly for the organizer of the whole process.

1.3.1 Research questions

To understand how it is possible to solve the research problem, more detailed research questions should be created and answered later. This step is considered as the important one as it is the “empty book” with white pages that should be filled out during the research process. Any research faces with barriers, limits and challenges therefore, new solutions should be found and implemented on the way to improve the previous results. Waste management is very complex and presents not only the movement of the waste but the quality of this movement, how it is organized, how it is performed, how it is done. The quality of waste management shows up the impacts on the social, environmental and economic side of any business company has and provides. Hence, three research questions were created, explained by findings in the literature and answered by presented empirical case and are:

- RQ1: What type of cargo is transported in Cuttings Transport Tank (CTT)/ CLEANCUT ISO-pump (ISO-tank)?
- RQ2: What is the RL process that this type of cargo created?
- RQ3: How RL process for this type of cargo is managed?

All research questions are linked with each other presenting the one flow. Discovering and understanding the first research question, the reader receives the basic knowledge for the second and third research question. All research questions are technical and complex. The importance of reverse logistics, hazardous waste management, lean, lean waste management, green supply chain management and logistics in supply chain management is provided to give better and clear understanding of the case presented.

1.4 Relevance of the study

Due to the fact that this paper presents an independent research project, the other picture of reverse logistics, hazardous waste management, lean and green supply chain management will be presented based on the empirical case and empirical data received. The interest of participating of each actor involved into the process due to the type of services it provides, will be shown due to the value it created during the process hazardous waste designed. The network, information flow and waste flow between actors will be drawn up to present the complexity of the process and more detailed understanding that can be used for analysis of other cases in the future. The strong cooperation and coordination from the waste producer's side can impress due to the volume of work its managers have been done. The challenges the organizer of process faced and can face are mostly predictable due to the parts of chain hazardous waste is handled in. Therefore, this paper can be used by researchers as the guidelines for similar cases in the Norwegian oil and gas offshore industry.

1.5 Limitations of the study

The limitations presented in this case study could be divided by the author into two parts: limitations of the researcher and methodological limitations.

Limitations of the researcher. The number of respondents could be more as well as the data shared. Some of key respondents were busy for a very long time, thus, the significant information was not provided in this paper. However, from respondents that could answer on question from the author's side share a lot of important information that was used, analyzed and presented to the reader. Therefore, more accessed data can be received by researcher in the future if the search for connections will be done in advance.

Methodological limitations. Due to the fact that the necessary data was not provided by each actor, the lack of contingency of data collection is almost obvious. Some information was collected from another informant but was related to those informants that were not reachable. Another limitation is that this study is done in a single industry and cannot be applied in the other industry. The detailed and specific information provided present the uniqueness of the case only in this specific type of industry. The outcomes or results are presented due to the literature the author used and the data the author received.

2.0 Literature review

2.1 Introduction

The global population few years ago almost reached seven billion and today this number is higher for sure. Newest technologies presented to us not that long time ago newest product – IPad with a touch screen. Product consumption is rising up rapidly. However, these products afterwards are turned into the waste. Production activities are important for the progress. The production process by its own provides significant but undesirable impacts on the environment. Thus, the improved and effective management is required to fulfill legislation according better "eco-system", new challenges are necessary and have to be controlled.

As the amount of waste is increasing from year to year and advanced technologies present and create new products and materials, the amount of hazardous products and materials is growing up as well. To be the owner of hazardous product has its own advantages and disadvantages as the owner uses a maximum characteristics of the product and after this throw it away. The owner of hazardous waste can still use some of characteristics of that product but has to apply correct operations for treatment. In offshore industry hazardous waste little bit differs from onshore hazardous waste, thus, other legislations and requirements must be fulfilled.

The literature review, first, will present to the reader the understanding of what and how does it look like to be the owner of offshore hazardous waste. The meaning of the ownership and the ownership of hazardous waste totally and in Norway due to very developed oil and gas industry and operations among NCS will be given together with some of regulations. As this paper is focused on the hazardous waste, the flow in which the treatment of hazardous waste happens – reverse logistics, as a part of downstream supply chain, will be presented. The next will be provided the understanding of the purpose of reverse logistics – to make supply chain management more efficient with the help of lean, its tools and practices to create the value for logistics in green supply chain management for company's business.

2.2 What does it look like to be an owner of offshore hazardous waste?

Population and economic growth during last few decades presented the increase of the consumption of goods as well as volume of waste which needs to be transported by road, ship or railway on a long distance and across boundaries. Due to the strict rules of some countries the treatment of not every type of the waste, especially hazardous waste, is allowed inside of the country. In addition, the trade of the waste, as well as hazardous waste has an economic value for its owner.

Pongracz and Pohjola (2004) discovered that the definition of waste has its own effect on the ownership. Also, waste can be considered as not a waste at all but as a substance/resource that can be used again. As it was seen on practice, the idea of ownership provides the influence on recognizing the waste. Furthermore, it is understandable that everything in the nature that is not owned by human is owned by the nature; and everything what is owned by human becomes a waste afterwards.

Becoming the product's owner, the owner does not recognize that he becomes also the owner of the waste in the future. Thus, it is understandable that as soon as the object/material is totally considered as used and the owner has no wish to continue to use this object because all matter properties are already used, the owner hurries to throw the object away. Then, such situation makes the effort to locate a secondary owner that can find out new advantages (Pongracz, 2002). The re-use is one of examples when value from waste can be taken. In the real life the ownership of waste moves to the sub-contractors as soon as the size of waste increases fast (Zakar and Clift, 2010).

The situation described above shows that the waste for one participant can be not a waste for another. This fact strongly connects with the value created from being the waste's owner and differs from type to type. One type of waste can be very useful while another must lead to landfill. Pongracz and Pohjola (2004) indicated the ownership over a thing as an opportunity to manipulate the properties of the thing with the imposed on the owner responsibility. Thus, the value relates to how much profit can be received from waste. Such case requires therefore a very well organized process where negligence and profusion must always be eliminated (Jensen and Meckling, 1976). Such process also connects with not only technical resources but with human resources as well. Therefore, another side of process reveals – the creation of social value. This will help to direct owners' efforts more effectively (Dam and Scholtens, 2012). Furthermore, by Ducassy and Montandrau (2015) it was found that social performance receives a negative influence from the concentrated ownership.

Being involved into the any process/chain the owner becomes also the participant of this process. He faces with everything what is happening around him. The space, environment, present him both negative and positive moments for future business. That is why ownership structures most suit the conditions under which companies act (Demsetz and Villalonga, 2001).

Besides activities happen around, the owner needs to make his decisions correctly as well. Nowadays it is also possible to see the situation when waste doesn't reach another owner because first owner considered the waste already as waste. The waste, however, was only temporarily useless and owner made a mistake throwing it. Another example could present the unwillingness of the first owner to deliver it to the second one – neglect of duty or, even, neglect of opportunities.

In addition to the mentioned above, the owner may transfer his ownership to the next owner through the sale of waste. One of reasons that may lead to this action is that the expenses are becoming more than the gained profit (Pongracz and Pohjola, 2004). Such case may be happen if the process created by hazardous waste is complex and needs the participation of more than two companies on a par with requirement of storage and transportation. The owner of the storage capacity where hazardous waste is located, for example, for transportation, should only unload the hazardous waste from it. The owner of the storage where the hazardous waste should be stored must request a special license from the Ministry.

Hazardous wastes present a bigger risk to the human health and environment than non-hazardous wastes, therefore, require stricter rules and control (European Commission, 2015a). In addition, the higher attention to prevent the risk for human health and the environment should be presented to prohibit the mixing of hazardous waste. Being collected and handled in an appropriate way, the impact on the environment is strongly reduced.

In 2013 nearly 1.3 million tonnes of hazardous waste were handled in accordance with approved treatment methods according to Statistics Norway (Environment.no, 2014). The increasing of volume of hazardous waste was registered since the 20^{th} century. It was experienced in Norway that offshore oil and gas industry became a large-scale producer of oil-contaminated hazardous waste. The volume of this type of waste is still expands. Due to improved methods of collection, some types of hazardous waste were minimized in volume right being in offshore. Some other type of hazardous waste were sorted and collected by more correct way and then, delivered to the onshore supply bases for further treatment. Nowadays it is more than desired to have the volume of waste produced equal to the volume of goods consumed.

According to the national plan the production of hazardous waste by year 2020 should be dropped to the level of year 2005, the increased security of treatment of hazardous waste should be provided by new more advanced technologies and that the percentage of recycled waste should be reduced to 75%.

At the national level few central sources where the information is available are The Norwegian Pollution Control Authority and Statistics Norway. This fact directly shows the importance for the Norwegian Authorities of any activities that are carried along the NCS. Furthermore, almost half of the country's territory is located above the Arctic Circle where weather conditions are harsh and the ozone layer becomes thinner because of air pollution. That is why Norway is presented as an active participant in the improving regulations for hazardous waste producers. In addition, there are many programs and projects for hazardous waste already founded and financed in Norway. Some private hazardous waste producers are participants of these programs and thus, receive subsidies.

On the European level hazardous waste is regulated by rules in Directive 2008/98/EC, Articles 17 – 20. By Directive 2008/98/EC hazardous waste is identified as "waste which displays one or more of the hazardous properties listed in Annex III" such as toxicity, flammability or explosiveness (EC, 2008). All types of waste including hazardous waste are presented in the EU standard for waste's classification, European Waste List (EWL).

On the Norwegian level hazardous waste is regulated by one of chapters of Avfallsforskriften (Waste Regulations). All types of waste are presented in Norwegian waste code.

Every year better technologies present new products for offshore industry to improve drilling activities. This gives more knowledge about properties of hazard that must be added to the list. Moreover, on board of installation other types of hazardous waste, differ from drilling operations, are created as well. It is well known the largest volume of waste in offshore is provided during well drilling. Thus, the oily waste is located on the first position along with other types of hazardous waste in offshore (Statistisk sentralbyrå, 2015).

The hazardous waste producer becomes the owner of hazardous waste and responsible for the correct management of hazardous waste produced. In addition, Pongracz and Pohjola (2004) consider that in such situations the legislation enforces owner by the responsibility of ownership. Thus, the maximum information needs to be provided about also the physical state of the waste into documented routines for the correct treatment way if it becomes required. And even so, some types of hazardous waste can be registered correctly that may provide a negative effect later.

Norwegian oil and gas industry represents the wide area for many huge companies for their activities in different fields that connect with such industry. There are a lot of companies-players that lead this of that direction. Nowadays when the sustainability is very important, many players have a direct support from and control by the State. Faccio and Lang (2002) made an analysis of few thousands companies in Western Europe to understand the influence on the business by type of ownership structure (widely held or family controlled). It was found that in Norway almost 14% of companies are under the State control while in UK, the country with very well developed offshore industry as well, such percentage is only nearly one percent.

The Norwegian Pollution Control Act created in 1981 plays a role of unified law in Norway regarding waste and pollution issues. It marks out hazardous waste from industrial and household waste. Nevertheless, even the thing is thrown away and is considered as a waste, it should be not identified as hazardous waste.

Nowadays, when the population is growing up and the volume of waste is increasing as well, technologies are improving and new, more hazardous materials are created, the nature faces with bigger volume of hazardous waste. It is well known that if something is already regulated, it can be managed easier. Thus, regulations tightly bound with an efficient reverse logistics in a waste management.

2.3 Reverse Logistic in waste management

2.3.1 Reverse Logistics activities

Many authors divide the supply chain into two parts: forward and reverse. When the product is produced and through distributor/retailer is sold to the customer, the forward supply chain is performed. Rogers and Tibben-Lembke (1998) considered such a complex flow of activities “from the point of origin to the point of consumption” where customer’s requirements will be satisfied, as logistics. Chan et al. (2010) noted that forward logistics directly relates to business performance.

In the 90s when computer technologies became a part of grown electronic industry the volume of electronic waste (e-waste) became bigger (RecycloBekia, 2015). This fact was already predicted by many companies and requested to take some steps to reduce the volume. The customer/owner of the product believes that he already used all good qualities of the product and he throws it away. The product enters to the other stream – reverse supply chain where reverse logistics start to act. Such a complex flow of activities “from the point of consumption to the point of origin” where the value is recaptured or not (is sent to the disposal) received the name “Reverse Logistic (RL)” (Rogers and Tibbe-

Lembke, 1998). In other words the process begins from the first customer (end user). RL was identified earlier as only one of five leading actions to set up the supply chain.

Thus, the RL, in other words, is the opportunity to give a new destination to the products that, in theory, are not useful to society anymore (Reverso Logistica, 2015). The product/material turns to new raw material that can enter to the supply chain again. So, the RL was identified as the stream of materials or products inside of return direction. RL is a part of some programs for hazardous waste, recycling, recovery and disposition.

The network of forward and reverse supply chain will present a close-loop supply chain (CLSC) which was created by Tonanont et al. (2008) and the detailed process is presented on the figure below.

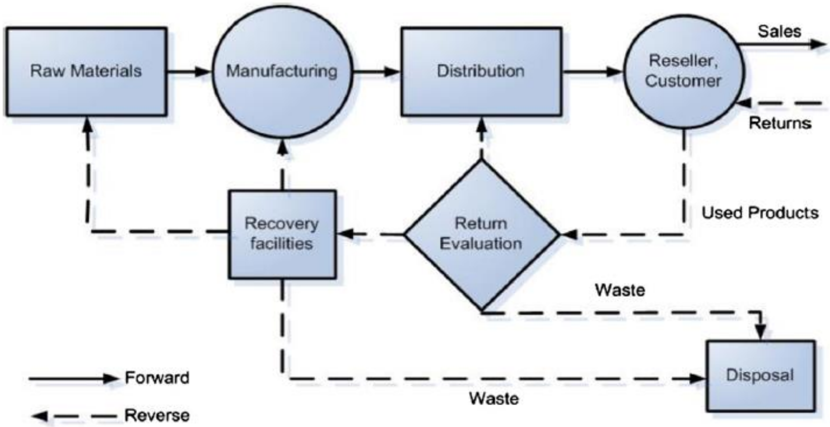


Figure 1: Form of CLSC: forward and reverse logistics (Tonanont et al., 2008).

By Govindan et al. (2015) was given a definition to CLSC management that this is a system that is designed, controlled and operated to create the maximum value from different volumes and types of products returned. This may help some companies to become a little bit more calm according cost reductions because RL and CLSC will present better results. CLSC is considered as a totally new part to be researched in the literature if to compare with RL. Therefore, there is no information about CLSC in prior publications and not that many articles that can be used to perform the future courses in RL and CLSC studies.

So far, not that many companies paid any attention to RL. Their authorities still consider that the business plan created by them is the best one for now for the company. Unfortunately, many companies still don't understand that a lot of competitive advantages can be gained by improving their logistics processes (Srivastava, 2008) and depends on the industry and the direction the business acts in.

When the product becomes a waste and arrives at waste management company, first of all, it needs to identify the type of waste this product relates to, to estimate its condition and to understand can this product be sold or to be sent. Tibben-Lembke (2002) mentioned that the creation of center for returns where the sortation of waste and packaging can be made will present more advantages than the same center but created in the forward SC.

The real life shows that the interest to RL during last decades increased. It becomes more understandable that it is possible to give the second life to the waste and this case is even more profitable. Thus, many companies began to pay attention not only to the management but to RL as well, that was not done earlier. RL was found as a new direction where many new businesses can be involved in and have an increased demand for their services. Furthermore, some authors noticed that big players-companies identified the importance of value created by system that RL management has organized.

RL process is indicated as new challenge in the environment of logistic and presents more benefits than if company just reuses products or recycles material. Rogers and Tibben-Lembke (1998) mentioned that the size of advantage gained using RL process by any large company depends on how big is the return rate. That is why the advantages for the whole industry worldwide could be imagined.

Different authors see the different number of stages inside of RL process. This depends on which one smaller step is included in which stage. However, mostly there are four main stages.

Srivastava (2008) presented the RL flow of activities as it is shown on the figure below. The first phrase, test, may consist of three first stages of four in RL process: entrance, collection, sorting and disposal. The weakest connection is the collection of waste; the products in the top right corner have the biggest recovered value.

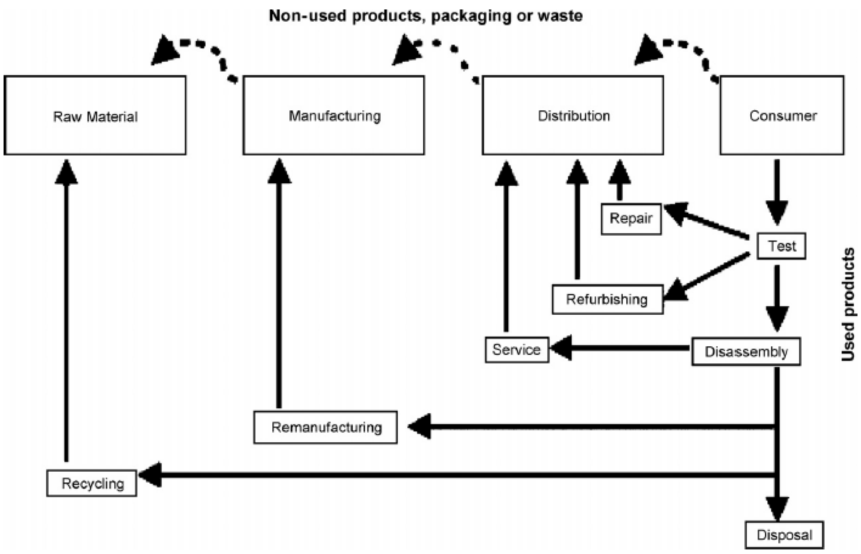


Figure 2: RL flow of activities (Srivastava, 2008).

The first stage, entrance, presents the following: as soon as the product is considered as waste, it also is checked on whether it can enter into the system or not. There are a lot of situations when the product can be still useful, thus, costs can be controlled as well we the management of the system. Next stage, collection, provides the division of collected products into groups. Furthermore, in this stage some products enter after being renewed earlier or due to some damage or restore. At the third stage, sorting, more detailed divisions is done, the fate of every item is identified: some products can be repaid or refurbished and sent to distribution (Lambert, Riopel and Abdul-Kader, 2011). Others being going through disassembling process can be sent through the service back to further distribution, the rest – to be remanufactured and sent to manufacturing or recycled and sent as raw material. The disassembly was found out as the most promising activity because it requires time and labour. The second phrase, disposal, presents the last stage at which the rest of products "without any positive future" received a destiny of waste disposal. The disposal option for each product will be found during this phrase.

In between these phrases and stages such activities as inspection, transportation and costs for inventory are presented as well and also require a lot of attention from any company. Other authors consider RL as the sum of inventory control and plan for distribution and production.

Rogers and Tibben-Lembke (1998) offered to researchers in RL process their own system that is divided into two spheres: reverse flow of products and packaging. It was clearly understandable that the percentage of return rate is different in every kind of industry and is very high for the printed media. These companies, publishing houses could review their back management system, create return programs and became more profitable.

Furthermore, the following strategy was identified: as soon the product entered into the RL process, it can be refunded or resold, or sold to another stock, or sent for further selling abroad. The following table is created by Rogers and Tibben-Lembke (1998) and presented below and shows the possible activities in RL process for products and packaging. In the case of not finding any other good solution for the product thrown because of its bad state the company will send the product to the disposal.

Material	Reverse Logistics Activities
Products	Return to Supplier Resell Sell via Outlet Salvage Recondition Refurbish Remanufacture Reclaim Materials Recycle Landfill
Packaging	Reuse Refurbish Reclaim Materials Recycle Salvage

Table 1: Common activities at RL (Rogers and Tibben-Lembke, 1998).

The activities listed in a table above show also the framework of RL. Furthermore, from the logical point of view, the company should find how it needs to behavior in correct division of used products to become more effective and profitable – is the main result from implementing of RL activities. Moreover, good coordination, planning and inventory

management in the aggregate provide better conditions for the company to gain its goals related to RL. This fact presents the direct effect on the company's reputation that also can influence on customer retention (Srivastava, 2008).
The real life worldwide shows that because of legislations the different situations call up. For example, in Germany the price of packages includes the sum intended for some recycling programs. In USA buyers packaging is under control of recycling companies (Tibben-Lembke, 2002). Furthermore, some materials such as pallets or plastic boxes for transportation can be used many times due to RL; others can be involved into RL process just because the customer considered this product as with defect but actually it has not. However, it is clear that the product request more activities in RL than packaging.

Everyday business experience shows that nowadays companies use a lot of different strategies that are oriented on the long-term, thus, such strategies should be well managed. This is not possible without information flow inside and a logistics. In addition, RL allows companies to identify the weakest points in the supply chain and take away materials for recycling if the situation needs such action instantly. As we can see, during each step of using RL activities the company identifies the value. Also, RL may show how the new product differs or not from the previous version along with fixing quality problems (Tibben-Lembke, 2002). Moreover, the information helps to manage the return process with disposal system as well as it helps to connect different departments. Therefore, in each company the own type of disposal system is created on the way to become more successful. Today's technologies allow the company to receive a satisfactory result from implemented RL already during only few years if to compare with few decades ago.

Still the disposal system requires a lot of attention from company's authorities. Regulations of landfill become stricter each year and the volume of many types of waste being disposal must be decreased as well. Most of all these questions relate to hazardous waste. The legal disposal put many limitations on this process, however, new technologies also creates new hazardous material that can be landfill after being properly treated on the special plants.

In the nearest future it is considered that RL should become a service activity. Furthermore, being a part of SC, environmental impacts from implementing RL relate to green SC (GSC) that showed an increased researcher's interest. Economic side, consumer pressure and keeping the law are identified as three main keys that guide the GSC in a lot of industries especially petroleum. Moreover, Govindan et al. (2015) noted that those companies that present best practices provide themselves SC's sustainability. This fact shows the importance of correct connection between different activities in RL process. In addition, last year's researches showed that customers became more interested in green elements in products than in previous decades (Chan et al., 2010).

As it is possible to note, RL has a significant positive effect cost reduction, increasing the profit, decreasing the environmental footprint, improving many systems inside of company structure. In addition, Srivastava (2008) notes that returns according timing, volume and quality, also, complexity according evaluation and product defines the environmental impact of RL. Furthermore, the created right RL system allows satisfying all necessary requirements of different Directives according each type of waste, even the hazardous waste. Thus, RL plays an important role and upgrades the environment, economic and strategic business areas in every company.

2.3.2 Real-world examples of RL implementation (WEEE as a hazardous waste in Turkey, model for solid waste management)

Nowadays such type of mobile phones as flip phone almost passed away from the market because new technologies offered touch screen phones with quick internet inside on a par with the opportunity to play on it as on a real guitar. As almost two decades ago the industrial boom in electronic industry was predicted, the amount of electrical and electronic waste (WEEE) became critical in some countries. As most of WEEE are consisting of materials that are identified as hazardous, the recovery process requires creation of unique network of RL system from economic and environmental point of view. Turkey became rapid developing country where the amount of WEEE is increasing very fast. This situation received a big interest among researchers. As in was mentioned earlier, the right RL structure helps to pick out almost the maximum cost of recovery system. Considering that Turkey is the country that is a lengthwise country, the most developed cities are located in the west part, thus the amount of WEEE is distributed unevenly. Kilik et al. (2015) took into consideration this situation and due to environmental regulations according hazardous waste and economic options created their own mathematical model according to the amount of units collected for possible locations for storage, recycling, second market and disposal centers. Turkey is the member of European Union (EU) that requires the keeping European Law. In turn, the European Law considers different rules for different amount of WEEE and also, establishes stricter rules. Hence, few scenarios were chosen and implemented into the model. The result is shown on the figure below.

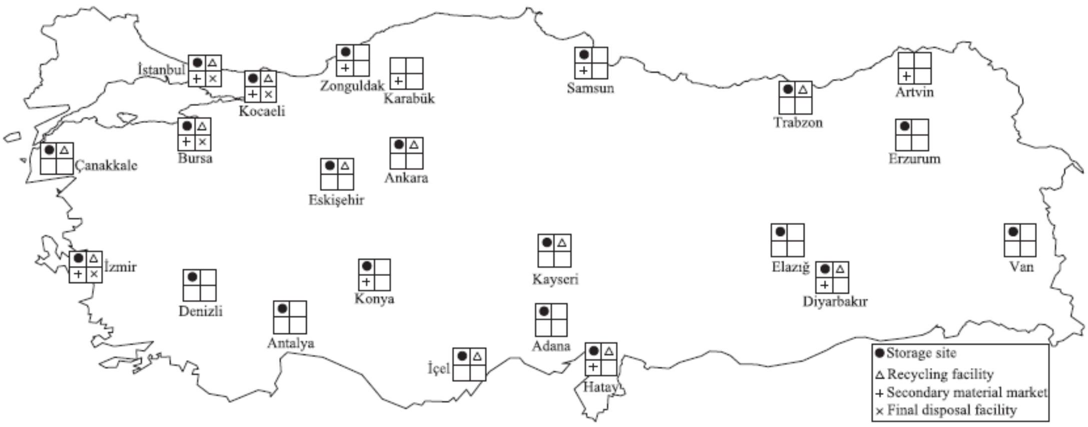


Figure 3: The probable location for storage, recycling, secondary market and disposal in Turkey (Kilik et al., 2015).

The possible locations were offered for future storage, recycling, second market and the disposal in view of distance, required transportation costs, possible plant capacities, storage capacities, recycling capabilities, environmental footprint, and possibility to accept for treatment hazardous waste. According research made by Kilik et al. (2015), circuit boards and chlorofluorocarbon are hazardous elements in WEEE needs the special type of treatment and thus, can be sent not to any disposal facility. The model gave also the possible solution for hazardous waste in the next table.

No	From (recycling facility)	To (final disposal facility)	Circuit board (kg)	Refrigerant (kg)
1	Ankara (Manual 1)	Kocaeli	58,257	21,302
2	Kocaeli (Manual 1)	Kocaeli	165,079	8952
3	Kocaeli (Automatic 1)	Kocaeli	476,769	36,305

Table 2: The flow of hazardous waste (Kilik et al., 2015).

The table shows the location of possible recycling facility and final disposal on a par with possible amount of hazardous waste that is required to be transported between recycling and disposal facilities. In addition, the copper was identified as the most recycled element from metal scrap that shows the profit during RL system in all given scenarios. It was found also, that such mathematical model can be also implemented by any company and can be redesigned according individual requirements of the company.

Searches in different electronic systems showed that the interest to improving the handling and treatment of hazardous waste was also big in 1980s and 1990s among researchers. Different models for optimization of transportation or vehicle problems or models for optimal storage were created in accordance with technologies provided that time. Nowadays technologies are more developed and new problems are shown up, thus, new optimal models are required.

Another example of RL's implementation is presented in municipal solid waste (MSW) management. MSW was identified as an important part for townsfolk's life; hence, it is important to provide better management in accordance with fast changing types of waste: planning, collection, sorting, transportation, inventory and treatment system. The mathematical model also was used in this case. Three waste collection centers were located in three cities that could transport the MSW to two distribution centers and from there, soring the waste – to four disposal plants that provide four types of disposal: composting, remanufacturing, incineration and landfill. Transportation capacities, the amount of MSW, capacities for storage and disposal plant were taken into consideration creating the model. In addition, possible transportation costs, uncertainty and environmental footprint were also included.

ton	$t=1$	$t=2$	$t=3$
$i=1$	[225, 235]	[180, 225]	[190, 210]
$i=2$	[125, 135]	[130, 150]	[145, 160]
$i=3$	[120, 130]	[145, 155]	[160, 175]

Table 3: Waste production in three cities (Zhang et al., 2011).

The result showed better direction for each waste collection center, distribution center and disposal plant with minimum operation cost each time period according their capacities and costs for landfill and treatment. This research also can be implemented in any company after short redesign process according price and capacity parameters. Furthermore, presents a new model for MSW management designed under up-to-date technologies, requirements and law.

2.3.3 Future of RL and challenges

As every company has its own plan to improve its RL system, besides positive issues, obviously, company meets barriers both inside business space and outside. Rogers and Tibben-Lembke (1998) interviewed a large amount of companies to present the list of barriers that these companies faced during business activities in forward and reverse supply chain. Answers were classified into few groups. The following list is shown below.

Barrier	Percentage
Importance of reverse logistics relative to other issues	39.2%
Company policies	35.0%
Lack of systems	34.3%
Competitive issues	33.7%
Management inattention	26.8%
Financial resources	19.0%
Personnel resources	19.0%
Legal issues	14.1%

Table 4: Barriers to RL (Rogers and Tibben-Lembke (1998).

As we can see, the highest percentage concerns to importance of RL towards other activities. Furthermore, as it was mentioned earlier, for publishing houses RL plays a significant role and shows good results continuously. Some companies are still on the way to implement RL into their business. That is why, RL was considered as not an important part. Thus, policy of the company presents a direct effect on the quality of development and improving of RL (35%). Hence, negligence and disinterest can be shown up. This fact directly can relate to the financial issues of non-interested company's authorities (19%). To great surprise, the smallest percentage was given to legal issues. This displays the Government as the third party that provides an impact from the side (Reverse Logistics Talk, 2013). Thus, all these listed groups present the real company's readiness and willingness to recover as much as possible value from implemented RL.

Pokharel and Mutha (2009) presented their research according possible improvements in RL. They consider that besides structure and activities, RL system also consists of inputs and outputs. Inputs represent the collection process where used parts/materials or recycled products such as pallets are delivered. Rogers and Tibben-Lembke (1998) also showed up the importance of gatekeeping process meaning that most of waste is selected by not correct way. This fact makes more difficult the further movement of product-waste. Thus, better improved collection should be organized.

As the result of RL process is sometimes a new materials or remanufactured materials, price for them should be determined to provide the competitive strength to them on the market. In addition, the importance of information, trust and awareness for customer was set up and thus requires more attention in RL business. The collaboration is the result of this. Moreover, good information flow should be provided between parties involved into RL system. Therefore, challenges should go through not only created RL system from economic point of view but through well designed system (collection, disassembly, and disposal) to identify the most effective direction to manage and reduce returns (Reverse Logistics Talk, 2013).

Furthermore, more attention should be given to the flexibility of created RL system because newer products replace old in forward supply chain in view of improving technologies, and new possibilities such as reduction of energy costs using incineration of waste are shown up during recent years. Rogers and Tibben-Lembke (1998) considered the faster processing as a good possibility for efficient RL system providing shorter circle for the waste received.

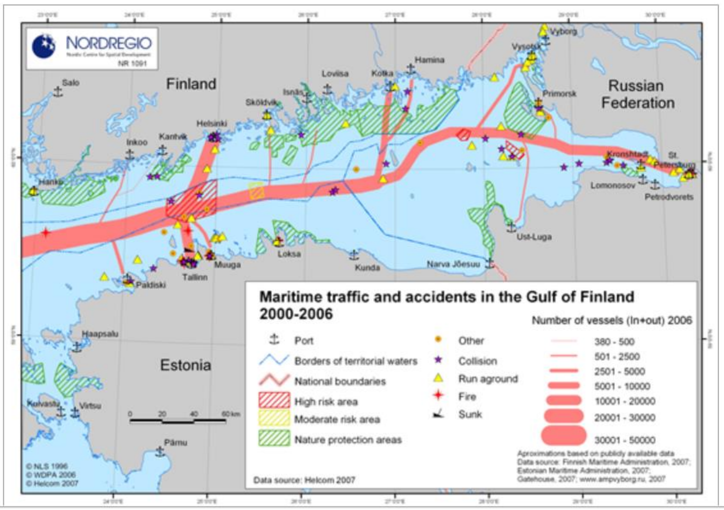
2.3.4 Multimodal SC, risk estimation (South Finland)

Nowadays we are familiar with such concept as “holding company”. Few decades ago people just could imagine the existence of this concept in future. One of the main reasons of creating the holding company is to gain better profits in each business area. Thus, at least three players are involved into the process: seller, buyer, and carrier. Therefore, global SCs are created by global holding companies presenting logistic process as a complex system with a lot of different types of activities. The whole process collides with continuing disintegration. Each company performs its operations in co-operation with others. Larger number of connections between participants makes chains weaker. Such fact creates by itself the vulnerability to be divided on smaller parts not only because of many factors inside but also outside of holding company. In most real-world cases the visibility of each chain becomes poor; control at holding company becomes weaker as well. Such situation turns into the minefield with a lot of created risks. Half of risks in SCs of companies examined by Vilko and Hallikas (2012) were shown up in view of their visibility. Most of risks are related to the areas where companies act. Thus, there is a necessity to find out the parts of SC where such risks can be suddenly shown up to protect the whole SC. In addition, the unwillingness to share the information or the limitation of shared information makes its own negative effect on the sustainability of SC inside. Furthermore it was found out that the risk at operation is not that big as the risk of violation or disruption.

The mentioned above shows the necessity of choosing the right strategy by company's authority and then, the creating right SC management (SCM). Therefore, the sources of lack of clarity must be found out and settled transforming logistics in SC into the single process. As a result, the holding company obtains the force and economic/finance sustainability but only for a short period. Then, new risks are formed and shown up again. Thus, there is a direct interconnection between unpredictable disintegration and further company's activity.

Among all types of packaging the cargo, maritime containers present the highest percentage and are used not only for maritime transportation. Multimodal maritime SC at Finnish shore got an attention from Vilko and Hallikas (2012). The amount of studies in literature in this sphere is very small.

The Gulf of Finland where the research was done presents one of main routes in Baltic Sea.



Picture 4: The Gulf of Finland (NORDREGIO, 2015).

Furthermore, few main seaports are located in the South of Finland, in the Gulf of Finland. Until there is a necessity of cargo flow from Baltic Sea to Gulf of Finland, these ports will provide services and play a main role for customers inland. Therefore, any risks that are shown up must be estimated, analyzed for a source of reason and possible solutions for multimodal maritime SC. Moreover, the impact of such risks should be also evaluated to see how vulnerable and sensitive the SC is and how long these risks can have an influence on SC. Hence, the business of downstream companies involved into the multimodal maritime SC (ports operators, custom services companies, forwarding agencies, warehouse companies) becomes also sensitive for negative challenges generated by such risks.

After interviewing representatives from different companies in Finnish ports at Gulf of Finland the following figure of transport SC was built to find out the possible risks.

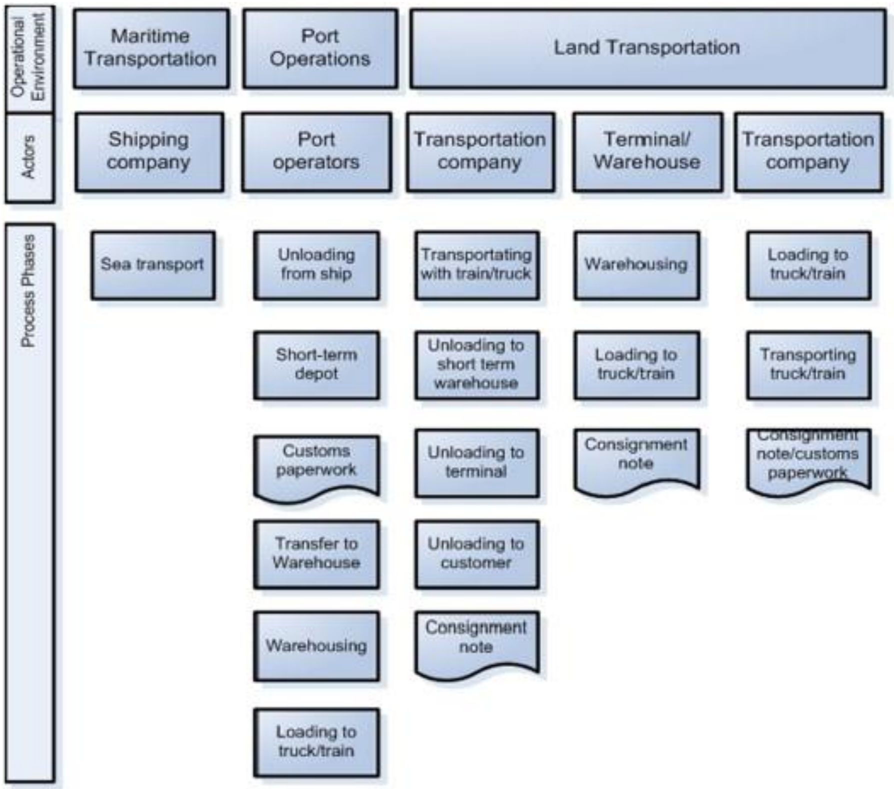


Figure 4: Transport SC (Vilko and Hallikas, 2012).

Such schema permitted to be concentrated on every step keeping the connection between steps. All possible risks were divided into following groups: supply, security, operational, macro, policy and environment risk and added into the table. The risk impacts were classified in three categories relating to the time, finance and quality. Time category presented the possible delay and showed the different meaning for each step: ship can be delay for few days due to the weather conditions, however if there are any problems at custom clearance, the truck is not allowed to pick up the container on time. The quality type was presented by conception "cost" and "damage". Terrorism and strikes of employees were identified as the most costly while such incident as fire was found out as most destructive. Among all risks listed the most risky became strikes, fire and ice conditions during the winter. The reasons for disruption were problem in energy supply a fire as well.

The second part of the research consisted of model on the delay impact due to shown up risks. As a result of it, terrorism, the chain of financial problems and problems during custom clearance were identified by model as the most reasonable to maximize the delay. In addition, it was clearly understandable that small companies such as truck companies with simple structure are weaker in front of risks and uncertainty than bigger companies-players with complex structure and more possible solutions. The results provided a good understanding of players' position on a par with created value for each of them from a holistic view. Moreover in the whole SC most sensitive to the time became a cargo because only it is the main driver of such a complex process.

2.3.5 Hazardous waste management

The problem with waste got a place in the human's history long time ago. However, only almost two centuries ago the disposal and sewage systems got more attention and were developed. In addition, from year to year the volume of waste produced is growing up, more advanced technologies present new materials which consist not-well known mixing of hazardous material, thus the further handling of those materials becoming dangerous not only for the environment but for the human's health as well. The material is considered as hazard due to its state and structure. Furthermore, when the hazardous goods are used and should be collected as waste, the hazardous characteristics still should be taken into consideration. Moreover, the incineration of the hazardous waste requires fulfillment of more strict regulations as quality of pollution is different from pollution after incineration of non-hazardous waste. Therefore, the right, more specific management of the hazardous waste should be organized and applied in the real life being changed according to the new created hazardous mix of materials. From the other hand, the main aim of the WM is to minimize the waste and, even, to remove the waste at all.

A number of researches found different structure of hierarchy of waste management. The simple hierarchy of WM presents the following steps according to the Pentstech (2015):

- ✓ identify the types of wastes;
- ✓ identify the source of the waste;
- ✓ determine the potential health hazards from waste;
- ✓ determine the volume of waste generation;
- ✓ identify safe collection method;
- ✓ identify safe transportation methods;
- ✓ identify safe disposal methods.

Pongracz (2002) discussed the hierarchy of WM as old-fashion form contained waste minimization, re-use, recycling, incineration and disposal:

- ➢ waste minimization – is considered as most pleasant alternative. In addition, this means not only the reduction of the volume of waste produced but better recycling of waste, re-use of some types of waste including hazardous waste. At the same time, this level contains four alternatives which differ from each other: 1) to decrease the volume of material being used for production of product – the less waste should be treated; 2) production of durable products to be used longer than previous versions of product; 3) waste prevarication – the total avoidance of waste production changing the process of production at the beginning or increase the percentage of utilization up to 100%; 4) decreasing the volume of used harmful substances – improve the production process of less dangerous goods;
- ➢ re-use – is considered as the opportunity to recycle the waste to receive almost the same quality of the material which can be used further in production process. Re-use can not be placed in every case. By EC (1994) in Annex II it is stated that packaging shall be so manufactured that the presence of noxious and other hazardous substances and

materials is minimized with regard to their presence in emission when packaging is incinerated of landfilled;

- ➢ recycling – plays an important role and provides a great impact on the WM, is a process when waste turns into new material which can be used again in the production process as well as re-used waste being created for the purpose;
- ➢ incineration – is identified as alternative to landfill, however, the pollution has place to be as well as impact on the environment while landfill, thus filters should be installed in incinerator's plants especially in regions where the percentage of landfill disposal is high;
- ➢ disposal – not the same as landfill, it also includes thermal destruction, which in some cases may actually be the best option for neutralizing hazardous waste (Pongracz, 2002). Some of hazardous waste in Europe are disposed in underground or loaded on the land. As well as incineration, disposal provides high volume of methane than CO2.

Nowadays mostly in Europe the special solid waste plants are built and it became allowed to reduce the volume of waste at plant before the landfill and incineration.

The following hierarchy was created by countries-members of EU according policy and Waste Law. The definitions are set in Directive 2008/98/EC (European Commission, 2015b).

Figure 5: WM hierarchy (European Commission, 2015b).

The difference between hierarchies offered by Pongracz (2002) and European Comission (2015b) is in the occurrence of "Recovery" process. It is necessary to understand that during the incineration there is no energy recovered. Recovery is considered as the replacing other materials that could be used for special purpose.

Hazardous waste is the type of waste that requires a lot of attention due to its content that is hazard and toxic for both, the environment and human health. Due to this fact, the environment's health and safety are at risk. It is reasonable to continue recovering value from waste until it is economically effective and technically possible, then, it should be disposed by environmentally friendly way. Therefore, hazardous waste management (HWM) transforms the hazardous waste into less hazardous, neutralized or environmentally friendly at all. Thus, HWM provides processes that are drawn to change chemical, biological and physical features of hazardous waste, and controls the waste flow that should be disposed at the end. In addition, because of difference in features of hazardous waste treatment technologies should be designed for each waste type. Every year the regulations becoming stricter due to increased environmental footprint of hazardous waste treatment. Therefore, new alternative solutions and methods are required.

Eduljee (2011) found out four categories of HW treatment technologies: thermal, physicochemical, physical and biological processes. The type of biological treatment depends on the oxygen level of material. Biological process goes with activity of aerobic bacteria that provides the oxidation and anaerobic bacteria acts during lack of oxygen. As a result, the end product is a liquid that still requires the further treatment to "pump out" the all volume of gas produced by bacteria. Such biomass degrades the waste material and thus, is urgent for successful treatment process (Eduljee, 2011). The whole biological process goes through a mud recycle system. In addition to aerobic and anaerobic bacteria soluble ions and methanogenic bacteria are used as well for treatment industrial waste. Physical process presents filtration and usage of centrifuges and is considered as most cheapest. Thermal treatment presents the usage of different types of kilns for incineration: rotary or cement. Moreover, plasma arc or electrically heated cylinders present new possibilities for thermal treatment (OTA, 1983).

The flow of hazardous waste in Portugal during last few decades also attracted attention of researchers and European Environment Agency (EEA) and is presented below. A lot of changes were done according legislation framework – minimization of hazardous waste and its management. Due to the fact that Portugal is also the member of EU, the government follows few Directives concerning hazardous waste.

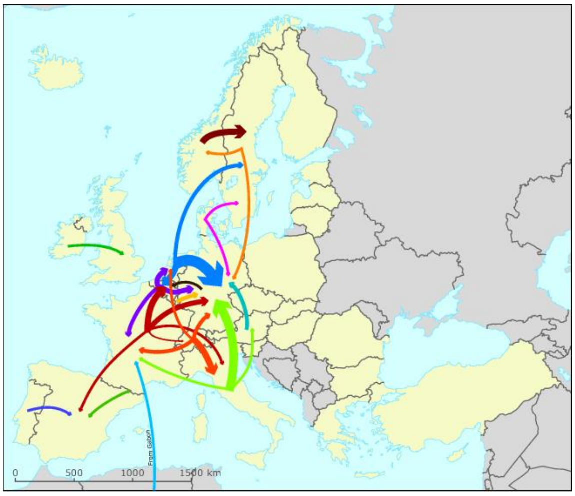


Figure 6: Largest flows of HW in EU, 2009 (EEA, 2015).

In accordance with them hazardous waste can be considered as hazardous if it contains more than two hazardous elements. In the end of twenty's century Portugal became a part of strategic plan for managing industrial hazardous waste. Because of some circumstances according development of technologies for few new plants in Portugal, there was the necessity to postpone the law. In addition, some kinds of hazardous waste are hazardous by nature. The research was done by Couto et al. (2013) concerning the management waste produced. Data showed that the biggest volume of hazardous industrial waste belongs to used oil and most of waste was oriented for further incineration. An overview showed that after application and modification of new law and developed management methods the percentage of recovered waste was slowly increased, few new landfills were built and received licenses. Therefore, regulations are necessary for effective waste management. Still better solutions are required to manage the hazardous industrial waste in Portugal.

Nowadays technologies allow to integrate environmental and operation management and improve the waste management SC. Companies have tools and principles for waste management; however, every company has its own strategy of how to use these tools and principles (Kurdve et al., 2014). One of such tools is the handling of materials which consists of collection, transportation and storage of waste. Costs and expenditure of human labour, impact of noise and pollution are also tools that can be used. Furthermore, tools with methods chosen should support cooperation, improve responsibility and increase the sharing information to become more effective. Thus, each company involved in WM process needs to fulfill the requirements more carefully, with avoidance of negligence.

Nowadays in Belgium, Antwerp, Waterleau offers different solutions and services according waste treatment. The last achievement of the company is the development of new technology which allows treating in rotating kiln mix of combustion of solid, liquid hazardous and toxic waste including medical waste providing low emission for CO and NOx (Waterleau, 2015). Furthermore, according to the report by CEWEP (2013) in year 2010 2.8mln MWh of energy were generated on the waste-to-energy plants in Norway: 2.5mln were used as the heat and 0.3mln – as electricity while in Germany – 18mln and 8mln respectively.

The waste flow mapping (WFM) needs to be done using tools and principles in the current situation. In the beginning the stream of value of waste should be drawn together with information flow. The second step considers the horizontal analysis of waste reduction to minimize the volume of new raw material. The third step considers vertical analysis to eliminate non-value operations. Kurdve et al. (2014) noted the improvement of waste management in the companies where WFM was implemented. Furthermore, the better visibility of the whole waste process was shown in a better way. At some plants became possible to reduce unnecessary waste. Therefore, better savings and reduced costs were presented to financial departments. In addition, it was noticed that investments into equipment during treatment hazardous waste could be covered quicker. Hence, the implementation of WFM confirmed its operational issue and possible improving in the future.

2.4 Lean waste management

2.4.1 Importance of lean and lean's tools

Nowadays new, advanced technologies provide factories by new raw materials and modernized equipment. In the beginning of 20th century to become successful companies met with two opposite business directions with their own weaknesses: to produce goods in a big lots being storing in a large warehouses with possible high amount of defects or be able to meet all requirements from customer to present a lot various goods. However, according to Holweg (2007) by 1950 by Toyota in Japan was found the way how to merge economies of scale together with small produced banc of goods and in 1990 the term "lean production" became important in management's language presenting the effective method.

At the same time as it was mentioned by Holweg (2007) the lean is the unique management system and specific logic that differs from traditional production approach and can be applied by everyone everywhere on a par with adapted lean principles to reach faster new horizons becoming more profitable. It is a new change of company's business and it showed positive results in many industries worldwide. In addition, lean is a way forward for stakeholders' companies (Melton, 2005). Being the part of supply chain, the lean production can make a great impact on the whole management system in the company in the following parts: to eliminate the waste, identify the value and generate to the customer the flow of value.

Figure 7: Lean's benefits (Melton, 2005).

The benefits of implementing of lean in most companies are shown on the figure. However, due to a lot of companies already accepted lean to their businesses and are satisfied with significant results, there is almost no necessity to implement it again. Other companies are still in deep thoughts to implement the lean or not, thus, the lack of material benefits may have a place in their non-upgraded businesses. Also, due to increasing demand for some products, some industries need to react quicker, thus, the implementing of lean is required. Furthermore, putting the lean into operation, the other effective directions can reveal.

Due to fact that every method has its tools and principles, Chiarini (2014) discovered that for manufacturing companies the lean tools are effective at improving environmental impacts even though some tools are more effective than others, and that other, less measurable aspects, can affect the results as well. Thus the lean can play a role of implemented pattern for greening production. Therefore, early changes can reap huge savings as it was mentioned by Melton (2005). This fact may present different results being used in other sectors and countries due to strict regulations.

Furthermore, the customer plays a very important role in SC as he values the product and then, the moment when the product becomes the waste. Due to the customer's behavior the producer needs to make some changes in the manufacturing process. When the most of steps are visible, it is becoming easier to see the bottlenecks and remove the unnecessary waste. Here, such word combination means the unnecessary activities or operations. This step allows companies to improve the management while being focusing on value. It is understandable that the value is the main mover in the whole process in each type of industry. Moreover, one of lean's tools in manufacturing, the value stream mapping (VSM), found a use in environmental management and by engineers in a production (Kurdve, 2014). However, some types of waste cannot be removed due to the nature of business (additional checking of documents, additional correspondence due to delays).

The value is also the origin of flow of activities that are necessary for lean. Managers should see and understand that they manage correctly. Any process is possible only with the participation of people as they are the other type of movers of operations. For managers it is necessary to know that workers understand what they do, what they need to do, how to do and why it should be done this way (Kurdve, 2014). These small activities are the part of bigger process - production. As soon as the problem is formed and the gap is shown up, delays are displayed and require attention. Thus, the variables and constraints have all time place to be in the system and every participator must follow the rules and instructions. In turn, managers should follow their plans and accepted solutions, otherwise the following picture can appear: the over production causes inventory and extra movements, problems at manufacturing cause defects and waiting, undesirable effects come up. In some places the bottlenecks are appeared, and the delay presents its own effect on the throughput delay. Therefore, the knowledge helps to develop better and more efficient strategies becoming perfect using the lean method.

Melton (2005) offered his schema-instruction of how to use the lean: observation of current situation, make an analysis of data received during observation, draw the possible changes, set these changes in motion and evaluate the benefits. Depending on the industry there are tools and the improvement of each step. Hence, the lean develops significant results not only during manufacturing but also in supply chain. This fact shows that lean thinking is suitable for all businesses and provides the value for company’s business becoming “a light in the darkness” for managers.

Chiarini (2014) observed five companies that produce motorcycle components. The lean tools were implemented into the production process during five year after which companies measured the minimization of environmental footprint and other positive results for their businesses. This fact confirmed assumptions according effectiveness of lean. Furthermore, the reduction of waste in a par with costs of pollution was shown. However, new solutions or directions of how it is possible to improve environment were not offered.

Three important types of waste of time (Muda) that were marked out for multimodal supply chains – waiting, waste during transportation and inventory. Very often in the real world these three types interconnected. Waste in waiting could be appeared while heating the cargo like oil or the syrup in oil tanks/cisterns or cooling due to the type of cargo while it is located on the warehouse. Such case also consumes the energy and electricity that costs money and increase company’s expenses. Unnecessary inventory presents the usage of space on a par with electricity that also increases expenses. Long distances require more fuel as well as for heating/cooling the cargo if it is necessary. In addition, the level of emission also increases. Thus, using VSM to reveal unnecessary activities allows lean tools show the positive effect on the environment. In addition to this fact, other real situation of decreasing the footprint on the environment is savings of raw materials and water. Therefore, lean tools can be implemented into RL also to develop better waste management. It is evidently that implementation of lean into the production process makes its own effect on introduction of stricter rules and operations that workers should follow due to strict legislation in country or union (Chiarini, 2014). Hence, the reality of strong connection between lean and environmental benefits is obvious.

2.4.2 Total just-in-time practice (T-JIT)

One of lean principles that is known during last decades and which was created at Toyota – is just-in-time (JIT). This principle together with RL was identified as two important management philosophies that may decrease the environmental footprint (Chan et al., 2010). JIT provides its own impact on RL due to the fact that customer requires the product while the supply indirectly depends on the amount of returned products. Thus, JIT model may present effective RL as well as better control on cost. In addition, Holweg (2007) noticed that some researchers found out that JIT was disseminating the lean message worldwide showing as an example, an effective businesses in other countries in addition to Japan.

Green et al. (2014) noticed that nowadays the improved area in company's SC is not that valued as the competitive strategies implemented in SC. Furthermore, than more efficient the SC's strategy is than stronger SC is inside providing strong connection between its parts. JIT also is considered by some authors as an advanced strategy that went through the test of SC showing good results. Two kinds of integration were identified: external and internal. External presents the integration through sales and information that makes possible to keep the sustainability and make lower uncertainty, therefore is consists of JIT-selling and JIT-information. Internal presents the integration through logistic, planning, production and purchasing that allows SC to become more flexible, thus, JIT-purchasing together with JIT-production were established. Due to such division JIT presents the total system of JIT (T-JIT). As SCM is the whole process, the SCM strategy is only one small part of SCM that may present result that can be improved by T-JIT. Moreover, the purpose of JIT is the reduction and elimination of waste of time, better utilization of resources.

JIT-information is one of the most important strategies from T-JIT as the information maximizes the effectiveness of implementation of JIT into SC and makes the visibility along SC better for all participators involved into the process. Even the JIT-information is considered as external integration, it also make an effect on internal integration as the information goes through the whole SC. The quality of the information plays an important role as well developing new links between activities inside SC and moving the waste as unnecessary element. Furthermore, information develops the connection between customer and supplier. Another goal of JIT is to present required products at the right time and at right place. In such situation the ability of the company to realize such steps and become successful depends directly on the very developed supply chain strategy and supply chain competency.

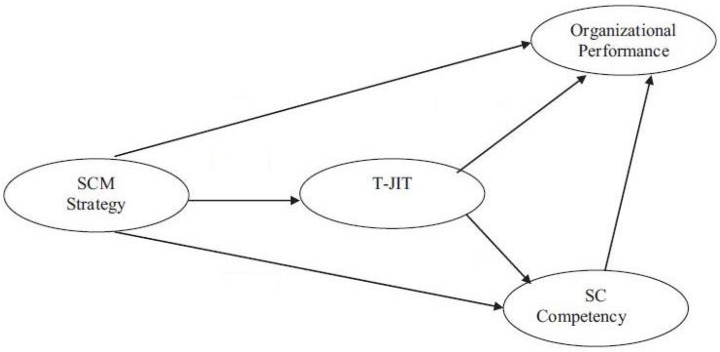


Figure 8: T-JIT model (adapted from Green et al., 2014).

The figure presented shows the possible impact of implementation of T-JIT inside SC. Furthermore, it was found out that T-JIT together with SCM strategy increase the SC competency strengthening the company's performance. T-JIT acting together with SCM competency showed good results in increasing the production performance. SCM strategy positively impacts of creating value by the customer, thus, the demand is growing up, SC competency is increased, and both influence on a good way on organizational performance.

At the same time JIT-purchasing and JIT-selling help to develop and make stronger most of activities inside SC such as financial performance, unification of the relationship, and better company's position on the market. Thus, the combined action of SC competency and SCM strategy show significant result and, hence, the impacts of implementation of T-JIT are obvious.

Due to unexpected quality related problems that appeared during manufacturing process even T-JIT system was implemented, Amasaka (2014) considered necessary to establish new, integrated JTI that will consist of three main parts: Total Development System (TDS), Total Production System (TPS) and Total Marketing System (TMS) and become surpassing. The author was concentrated mostly on companies that are focused on customers as the customer is a kind of main mover that push the whole process. In view of the fact that technologies are changing rapidly, new movements became necessary. Even the T-JIT practice consists of four processes, the best result will be measured after implementing the whole T-JIT.

Nowadays the global production requires high standards from manufacturers, thus, each company should not only to develop the best strategy for its own production process but also to be competitive with others inside the industry, and improve the results becoming more required by global production. Hence, new changes are required to help the company to survive. Regarding the fact that today the customer can get the information easily and quicker than few years before, flexible system at company must be developed on a par with the competence for urgent movements.

During last years it was found out that variety of products made the life cycle shorter than before. Hence, manufacturers have to be more active concerning customers through supplies implementing required skills and technologies. As the customer is very sensitive to any changes related to the product he prefers, companies need to create an attractive one and discover, understand and read the customer's reaction. The goal of TDS is almost similar to JIT-information: to sharing of information, improve the quality of the whole process, use best technologies and develop great solutions based on technologies. The purpose of TPS is similar to JIT-production and follows to solving the problems that appeared in technical process and improving control. TMS is similar to JIT-selling and requires product planning and the development of strategies for better production process on the global level. In last decade the new JIT was implemented into business of many companies worldwide and benefits were showed up and measured. The utilization of new JIT was corroborated on a par with advantages obtained.

2.4.3 Green lean

As a result, each of four T-JIT's parts provides the reduction of something or reduces a number of unnecessary activities presenting new benefits to a company; being a great philosophy of lean, JIT shows its positive impact not only on the environment but on the whole SC continuously marking out unnecessary operations and making it more effective and greener. The focus of lean on exclusion of seven waste of time can be an example. Thus, lean provides the cleaner production when the question comes to energy and unnecessary operations (Kurdve et al., 2014).

Furthermore, even the lean is concentrated on seven "muda", it also presents great solutions for waste management as well like waste handling process providing green characteristic in RL. Therefore, the connection between lean and green is obvious. Collaboration together with communication and attempts to solve appeared problems are other advices for better and greener waste management through SCM.

Dhingra (2014) noticed the following meaning of Local Government Management Board in UK that waste management is required to go far from safe disposal and be more focused on problems that make negatively influence on sustainability of consumption and production process of the company that provide the development of healthy industry. The fact that the produced product, production process and the range list of services also have their own impacts on the environment shows the effect of green initiatives on a par with lean. In addition, it shows the increased responsibility concerning the environmental footprint.

Lean to green was already marked by a lot of manufacturers as a one part of progress that can be issued naturally. One of those examples could be the reduction of hazardous products. It could be replaced by using more development technologies, new investigations and re-designing of the product. That case could become from one side - a kind of new eco-product and from another side – a benefit concerning savings and reduction of a lot of risks during life cycle of that product. Additionally, waste management by its own could be carefully analyzed together with the source of waste to figure out new possible frameworks. Some authors recorded positive changes in companies' businesses such as decreasing of disputes between departments and better work environment. By others was marked the appreciated difference between usual and new eco-products.

Offshore wind power became the totally new perspective last years for most of European countries that have a coastal zone. Wind farms allow using the produced energy instead of diesel or gas for turbines on rig installations' boards. There are a lot of large projects for next years in deep waters that will present the tangible result according demand on fuel decreasing it. This area is very young if to compare it with other industrial sectors, however, the quick growth and the success are obvious already. For today the sustainability and efficiency of offshore wind power industry on a par with increased production of electricity by 2030 up to 14% (from 10% in 2010) will be not presented without strong SC (Arapogianni et al., 2012).

A lot of researches are made according integration of green thinking and lean, and, green practices and lean. Moreover, ordinary management systems were compared with lean-based and some benefits were achieved. Another type of research was presented about routing problem where normal routes were compared with lean-based routes in case of distance, fuel consumption and emission. However, such cases need more attention and time to be discovered better due to overcame barriers. The results showed that both can be realized together or independently. It is clear that lean provides the cleaner production and effect significantly on the sustainability due to the fact that the social, environmental and economic parts are three measurements of sustainability. Green practices are situated on the same line with sustainability, furthermore, lean leads to green and there is no doubt (Dhingra et al., 2014).

2.4.4 Creative triangle: lean, SC and sustainability.

Even previous subsections provided to the reader a clear idea about lean, JIT and green practices, the author considered necessary to present the separate subsection as an overview.

As the economic part is one of three measurements of sustainability, a lot of companies found reasonable to adopt the Lean Management (LM) to achieve better results (Martinez-Jurado and Moyano-Fuentes, 2014). Some of researches showed that the lack of ability to care process long term gave results that were not that much expected. However, the better connection between customers and suppliers were gained. As lean has its own impact on the SC, and there is a direct link with sustainability, the following figure gives better view of such linkage.

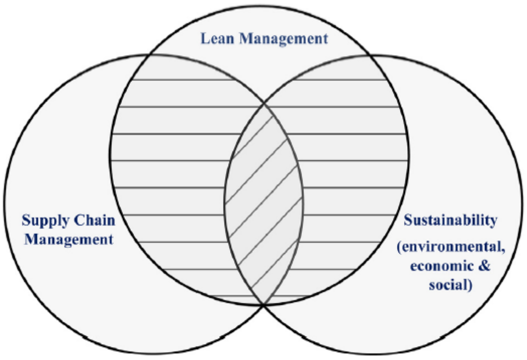


Figure 9: The successful triangle (Martinez-Jurado and Moyano-Fuentes, 2014).

At the same time Govindan et al. (2014) interviewed a list of automobile companies in Portugal to identify the most valuable links between lean practices and three dimensions of sustainability. The cross-case analysis presented the following figure where the thing lines shows the suggested propositions figured out from the literature, while the thick lines show the reality of companies' businesses.

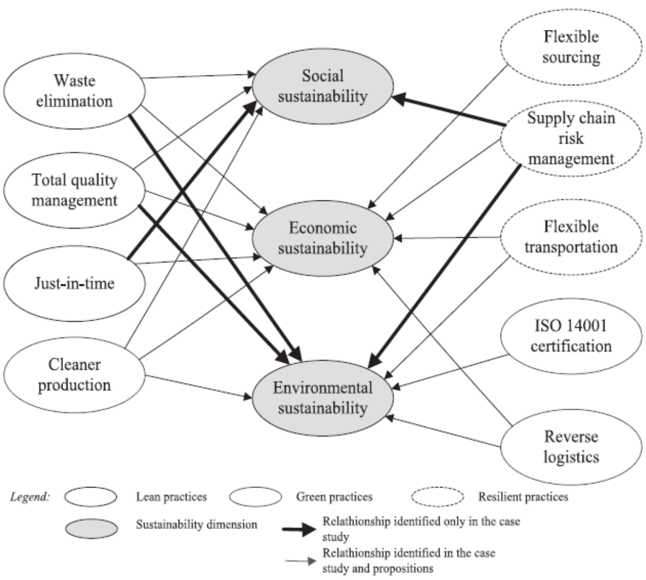


Figure 10: Impact of lean, flexibility and green SCM practices on SC sustainability (Govindan et al., 2014).

As it can be seen, the "elimination of the waste" that is focused on minimization of waste until zero has its impact not only on the economic side using seven "muda", and social sustainability as it was assumed in the literature but also, on the environmental side preventing the environmental pollution and the reduction of waste at its point of origin (Martinez-Jurado and Moyano-Fuentes, 2014).

"Total Quality Management" (TQM) assumed its impact according environment as well as the "elimination of waste". Furthermore, it was figured out that these two practices have bigger impact on environment than "JIT" practice. At the same time "JIT" impressed researchers by its strong impact on the social side that was not considered before in the literature on a par with not that strong impact on environment.

The green practice such as the "cleaner production" with focus on correct usage of recourses and energy to design new product using best technologies didn't disappointed the researchers presenting the impact on all three dimensions.

"SC risk management" showed its impact on environmental and social side of sustainability. The analysis showed that the impact was significant. Other lean practices lived up researchers' expectations. Summarizing the results can be possible to present the following clear picture that “waste elimination” together with “TQM’ and “SC risk management” have a great impact on the environmental sustainability, while “JIT” with “SC risk management” have a great impact on the social sustainability that was not shown up in the literature earlier.

2.4.5 Importance of lean and green SCM

As LM is the part of SCM, practices and principals of LM can be applied for the whole SC turning it to the Lean SCM (LSCM). The purpose of it is to find the best solution for all operations being focusing on customer’s view for long-term. To present better quality removing linkages, being flexible reducing costs – all activities that LSCM is concentrated on. Due to the fact that average SCM considers how to manage correctly the flow of finances, information and materials, LSCM is interested to provide better management of these elements concerning sustainability and being, still, focusing on environmental, social and economic issues. Therefore, it is the key element for environmental sustainability of SC (Martinez-Jurado and Moyano-Fuentes, 2014). A lot of researches are made on the analysis of implication of lean “upstream” and not that many – on the “downstream”. Thus, newest researches would be desirable. One of those cases of applied LM through SC on automobile production underlined better financial status and improved relationship with customers. Nowadays most researchers are focused on discovering the effect made by LSCM on the economic and environment than on social aspects.

Results of implementing LM into LSCM in companies are studied not that much due to information’s limitation. Nevertheless, it can be seen that VSM in LSC is still very important and that is why the companies need to carry on this tool for their businesses. Furthermore, by Martinez-Jurado and Moyano-Fuentes (2014) underscored that logistics and distribution systems require improvement to provide LSC with sustainability.

It was mentioned earlier that having the improved whole process is better than have improved parts. Thus, the achievement of better results in some parts is not that much effective for SC as the achievement of results due to whole successful process. One of such examples – the pollution that is presented along the whole production process from the moment the product is produced until the moment it is dissembled, treated and disposed. In addition, by researchers was underlined also the fact that environmental sustainability together with LSCM is developing in parallel with Green SCM (GrSCM) (Martinez-Jurado and Moyano-Fuentes, 2014). Importance of sustainability and GrSC is growing up nowadays.

Srivastava (2007) described GrSCM as the “quality revolution” at 1980’s and the SC revolution in the early 1990s”. GrSCM is concentrated on better relationship between supplies and customers bring them together, on designs of new products and analysis of activities inside SC. Therefore, GrSCM is considered by authors as higher level than LSCM being focusing on business as it is and on the environmental footprint. Nevertheless, LSCM and GrSCM are both focused on the “minimization of waste” through the whole process. LSCM can act as an assistant to GrSCM in coordination for designing process and designing new product to become more efficient. Fortes (2009) underlined that green design is a very significant area for GrSCM. Furthermore, the life cycle was identified by some authors as a part of green design while RL – as a green operation that can be effective only if it is done correctly.

In addition, GrSCM can make a good influence on identification of week places in the relationship between supplier and customer making the customer be involved into the process more than before. The same week moments can be shown up during the inventory and transportation, therefore, the integration of process inside the SC will become stronger showing the effectiveness of challenges.

From another side, it was discovered that such philosophy as JIT presents a good results as well. However, when the question comes to the situation of delivery product in small lots, it shows up increased diesel consumption together with emission.

Following all mentioned in this sub-chapter, it can be seen that all companies have their own reasons to turn their businesses to "green". For some of them the motivation is very understandable, for others – no, however they understand that such challenges will be better for them and for eco-system. Nevertheless, for both groups it is clear that the cost reduction together with profitability is a mover for their successful and effective businesses. Moreover, some authors noticed that practices of GrSCM are focused on effective issues in any case on economic and environmental performance. In addition, GrSCM can be strongly balanced to another developed practices, and assisted to improve the environmental performance (Seman et al., 2012). LSCM also shows how sensitive it is according implementation of LM. Risk management together with business uncertainty is presented in the next sub-chapter.

2.4.6 Risk management and business uncertainty in petroleum industry

Nowadays a lot of companies are focused on the environment issues because the buyer is interested in the environmentally friendly products and services. However, the focus is made under the pressure of such situation than with the wish for it. Among a huge number of different solutions SC managers are required to choose the most effective and successful directions for their businesses that will present better financial results, develop new capabilities and improve the interaction between suppliers and customers. As SC consists of forward and RL, and that forward logistics is focused on activities that turn raw materials to the produced product while RL – turns that product after disassembling to something valuable, some authors underlined that forward logistics needs to support the RL by investments while RL – forward logistics.

Such collaboration can be well designed and operated, and, thus, present significant results, especially, customer loyalty, or can be poorly structured at all and, thus, add the addition cost with weak feedback or return. The last case creates undesirable moments such as risks that provide the undesirable uncertainty. Investments in RL or reverse supply chain (RSC) are required to be studied. The interesting question is how managers accept or perceive the business uncertainty and how they must behave according risk propensity.

It is necessary to understand how the situation looks like when the question comes to RSC investments. First of all the decision making should be done by manager. That is why the business uncertainty is shown up and is considered by Kocabasoglu et al. (2007) as the input; next one comes the readiness to accept the risk; and the last, third one, is the movement – performed investment, and the behavior, as the output. Therefore, the risk management should be done very carefully by manager. Due to all parties are involved into the process and RSC but act separately, the risk of investments becoming stronger. Moreover, investments are presented as the necessary part of business resulting by legislations, suppliers and competitors where each party makes its own influence on further activities. These factors also have an impact on business uncertainty. Hence, the risk propensity is identified for forward logistics and RL differently.

Kocabasoglu et al. (2007) discovered the linkage between investments and risk propensity in forward SC, RSC and business uncertainty. They created hypothesizes according literature and after interviewing companies presented the results of statistical analysis in the following figure to understand better the real movers of RSC investment.

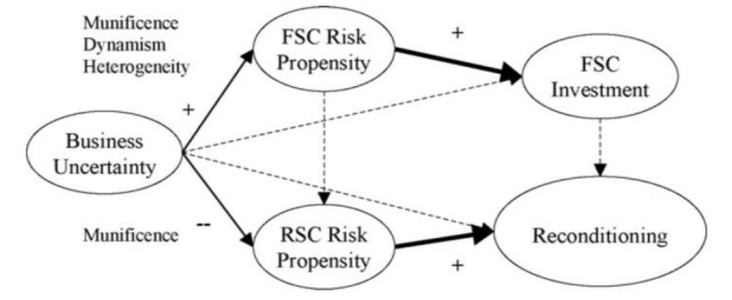


Figure 11: RSC investment (Kocabasoglu et al., 2007).

The results showed that the relationship between forward SC and RSC is not straight. That is why managers are required to invest in RSC as well. In the forward SC managers pay more attention to the supplier – customer relationship while in the RSC waste management and recycling process are most important. It was found that some managers consider that RSC "imports" resources right from forward SC what is wrong. Moreover, it was shown up that regulations and customers don't make a huge impact on RSC as it was considered by researches in the literature. Furthermore, between investments and business uncertainty was identified the important element, the organizational risk propensity (Kocabasoglu et al., 2007).

Petroleum SC (PSC) nowadays is presented by very developed processes and infrastructures: drilling ships, rigs, platforms, pipelines and subsea equipment that are quite expensive. This industry transports and moves to its customers a huge volume of valuable petroleum products. Due to high costs the industry is very sensitive for any changes on financial markets as the price for oil/gas can jump in a wide range. Thus, a significant risk can be appeared in front of PSC in any time. Therefore a lot of companies that are involved into the process put enough attention to risk management for PSC.

PSC consists of two flows: upstream that presents exploration drilling, production and transportation of cargo, and downstream that presents petroleum refining, storage, transportation and retail. PSC risk management relates to the qualitative approach. Therefore, there is a necessary to create a framework that could provide to the company the method for further behavior.

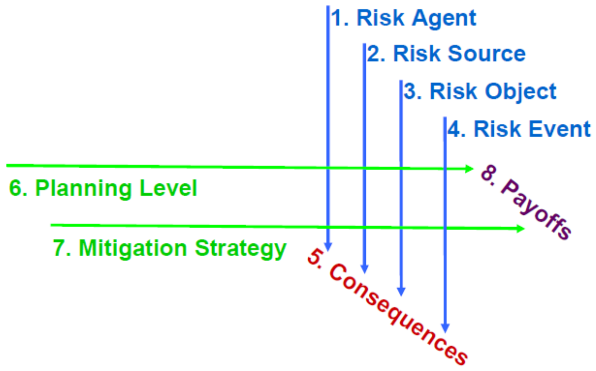


Figure 12: Risk management framework (Fernandes, 2010).

The framework is built by two processes within which risk is identified and mitigated. During the first process the identification of risk occurs vertically and at the same time it looks as a nesting doll that "the risk agent (financial area) includes a risk source (value added tax) which can affect the risk object (tax structure) thereby generating a risk event (reduced profit)" (Fernandes, 2010). Then, the results or the consequences are identified. Horizontally the mitigation occurs: planning level presents the time period, long/mid-term, and, mitigation strategy that presents measures that can reduce the possibility of risk's origin. The payoffs create results after identification and mitigation processes that can be applied for further usage of qualitative data. Such structure shows the typical risk and possible solutions to decrease it according requirements in PSC.

2.4.7 Logistics in SCM

The logistics by its own originates from activities in the military when it was necessary to move troops into the battlefield and then was used by companies (SupplyChainOpz, 2015). Some authors believe that logistics is the necessary part of the company's business and thus, the SC. Others think that logistics goes in parallel with SC but is not the part of it. Last decades the importance of logistics at all was increased incredibly towards the value creation. Lummus et al. (2001) presented a clear differentiation between SC and logistics explaining that logistics consists of activities: planning, coordination and controlling, that are performed effectively, and is an efficient part of SCM. Each department do its own functions being concentrated only on operations and tasks for its own while SCM plays "the leader's role" above all departments. Every year the SC becomes more complex due to newest technologies and customer's requirements. This needs better integration inside SC.

Being presenting advanced technologies most of operations become fatal to the environment, decrease profits, increase costs and provide a big amount of unnecessary activities. Green RL is the part of SC and presents a lot of activities oriented on better results and more effective business for companies. Furthermore, LM protects SC from unnecessary movements that can be considered as waste making SCM greener. Thus, logistics plays a significant role for SCM and surely creates the value for those parties who had a willingness and readiness to become involved in to the chain and take all risks related to such a movement.

Ruther and Langley (2000) discovered a risen question: “Does logistics creates value or presents the cost? And how logistics created the value?” it can be seen that logistics by its own implies the delivery of the product/cargo at the right customer at the right time at the right place in a right condition and quality. Thus, the logistics are focused on the customer’s satisfaction. Services provided on the good and required way create the value for the customer, guarantee the customer’s attachment and add advantages to SC through the time. Furthermore, the customer’s satisfaction is more meaningful than a customer service; the quality of the thing that was used is a value. Best quality of logistics, customer service and profit/cost creates better logistics value (Ruther and Langley, 2000). Nevertheless, nowadays some companies consider logistics not as the big change to present the value to SC.

2.5 Summary

This chapter summarizes the important findings in the literature and shows up some gaps due to the fact that most of activities during last years became new for companies and their managers. Furthermore, one industry differs from another, thus, the time is required to see the results, identify the problems and their source, and to design solutions that need to be implemented to gain new, better results on new horizons. This chapter can be examined as the research to provide better understanding, create new explanations and show up the value created.

Rapidly increased volume of hazardous waste in Norway due to the increased consumption of oil and gas along NCS presented the position of the owner of hazardous waste according regulations and legislation in Norway and, Europe. More strict requirements for treatment and handling of hazardous waste press the owners to be more flexible for changes in their businesses as well as to create more flexible processes. Such challenges change the back direction of SC – RL. The difference between forward and reverse logistics was given together with reverse logistics activities that are examined differently by some authors. The implementation of RL in Turkey and the RL model for solid waste management was presented to provide better understanding of results found in the literature and in the real world. It is understandable that practices showing results today have a direct impact on changes in the future, therefore, they were overlooked as well.

Handling of hazardous waste among NCS requires involving of many parties and kinds of transport. The amount of participants directly makes an effect on risk creation. The multimodal SC and risk estimation was examined based on research in the South Finland to be an example for Norwegian oil and gas industry in offshore.

Being a part of supply chain management reverse logistics is directly dependent on correct hazardous waste management. Different structures of hierarchy of waste management were presented to give the better understanding of the SCM. All movements on the way to reach the desirable results are connected to the process named “lean”. Lean waste management, its importance, tools and practices such as “just-in-time” were presented as well as the its purpose – to make the supply chain management “greener”. Thus, green lean, green supply chain management with importance of logistics value and logistics in supply chain was examined and analyzed.

As it was mentioned earlier, there are not that many researches analyzing the implementation of RL, lean and practices that make SCM greener as industries differ from each other. However the literature review presents now a very good base for further movement – to analyze the real situation presented in year 2014-2015 to identify the value created by participators of SC that was created by the product and waste producer.

3.0 Research Methodology

3.1 Introduction

Every company driving its business needs to define the value in logistics process or management system at all to reach new goals, become more profitable and successful. Thus, every step in business requires to be made right and carefully. Therefore, every case in every company may become a new case research to develop incredibly new theory and new method for further movement of the whole business. Hence, this chapter will describe the research methodology that is used in this paper.

3.1.1 Research design

Referring to the Voss et al. (2002) methodology assists, depending on the type of company’s business, in creation of detailed interviews, correct time scheduling, and helps to use right received, sometimes, limited data however, to see at the end the results which will have a very high impact in future. Thus the methodology is performed as logical plan of the further steps.

By Yin (2009) were identified few elements which should be performed in research design:

- ✓ study questions – they should show the type of research applied in the research project, be explained and to present the purpose of their implementation, to indicate why and how “this” was done. Relating this element to the case study, it will be necessary to understand how the management of hazardous waste is organized at Shell - delivery from installations operated by Shell at Ormen Lange and Draugen to Vestbase and to the further recipients (in container by truck), how the hazardous waste is handled at Vestbase (how it is unloaded, stored and loaded on truck) and why the management of hazardous waste is organized this way;

- ✓ study propositions - assist to identify the start point of the research project. The proposition is the detailed value stream mapping of hazardous waste, create the network, present the results of implementation of reverse logistics, hazardous waste management and lean in supply chain management organized by Shell in more detailed way from the drilling installation where the hazardous waste is produced until the recipients;
- ✓ unit of analysis – should be chosen for the research design and connect future programs and decisions with each other. For current research study the unit for analysis is the hazardous waste delivered from Shell's installations through Vestbase to the further recipients. It plays the main role in WM process as well as network at Vestbase and can be considered from new perspective;
- ✓ connecting data to propositions – special technics should be chosen to provide right analysis of the data due to the case study. Collected data at Vestbase and from other main parties and right analysis will give the complete picture of the situation;
- ✓ criteria for interpreting the findings – usually empirical data received can be compared with available statistical data or data received from earlier studies. Received findings at Shell can be compared with further theories and regulations. Furthermore, the connect of the ownership of hazardous waste could present better understanding of the case study

3.1.2 Classification of research design

Following Ellram (1996) all research methodologies could be divided into two groups: due to "the type of data" that is used and "the type of analysis" that is provided for the data. Type of data can be divided into empirical data that is collected for analysis based on real-worlds cases, and modelling data that uses real-world data in a model. The analysis can be also divided into two types: quantitative considering the statistical analysis, and qualitative considering the non-parametric analysis.

The case study is qualitative due to the usage of non-parametric analysis and empirical – due to the empirical data collected. In this case study no one model is calculated or presented and no statistical analysis is done. The case is an independent single study and made based on empirical data from year 2014-2015.

3.2 Case study type and case selection

Yin (2009) divided all case studies into three following groups:

- ➢ descriptive – studies a real life phenomenon that occurs in the question. To help to descript the phenomenon the researcher is required to act according the descriptive theory;
- ➢ explanatory – is applied in the situation if the question needs the transformation of the real case;
- ➢ exploratory – is applied to the cases where the phenomenon is estimated not that clear.

The current case study presents the descriptive part where the whole process of handling hazardous waste at Shell is resented, as well as the type of logistic and management are applied; the exploratory part explore how handling process is done at Shell as well as reverse logistics, hazardous waste management and lean are already applied; the explanatory part explains how the handling of the waste is provided as well as the RL, HWM, lean and SCM at Shell.

In addition, following Yin (2009), the case study is classified into single-case with holistic design (presents one unit of analysis), single-case with embedded design (presents multiple unit of analysis), multiple-case with holistic design (based on the single unit of analysis) and multiple-case with multiple design (based on the multiple unit of analysis).

The current case study is single cases study with holistic design according the fact that the single case – waste producer Shell, the single unit - hazardous waste. Nevertheless, Shell is only the main organizer of the handling process while a big number of actors are involved. Therefore, the case study can be considered as the embedded single-case with holistic design.

3.3 Sampling techniques of number of respondents or interviews

Each time the case study must be analyzed, the question about the number of respondents comes up. All researchers consider different number but their point of view is the same according the type of case the research is. Some authors consider that the number for ordinary study research should be equal to five; others – that for theory research should be up to twelve. Thus, the high quality of the case study and the data saturation require the bigger number of researchers.

The total number of companies involved into the process is twelve. Two (SRG and TOT) are the transport companies that were not necessary to be interviewed. One (Franzefoss Lia), the owner of the licensed landfill relates to the other (Franzefoss) that was interviewed a lot and was able to share the confidential information. Waste management company (NGI) was able to share the private information also, thus the representatives from supply base (Vestbase) were not interviewed. The category "PSV" presents few companies and the question to be on board was declined due to weather conditions and other urgent requirements. Nevertheless, the necessary data about PSV was provided by respondent from Shell as well as about CTT and ISO-tanks due to the impossibility to connect with their owners - suppliers of drilling fluids (Halliburton and MIS). Another minimum data could be required from owners of drilling rig and drilling ship, however the necessary detailed data was found on internet resources that relate to newest data for Norwegian oil and gas industry.

3.4 Data collection

The collection of data is a very important process that makes the research being dependent on. Therefore, the research question creates the criteria for collection of data. The information collected can be used for drawing flows, data collected can be used for further analysis. Two groups of data: primary and secondary.

Primary data is the data that is collected for the special research problem; furthermore, the specific methods that can help to analyze the problem better are used. Each next analysis presents new primary data that may it possible to improve the knowledge and help researchers in the further researches. Primary data can be qualitative, that provides better understanding of the research case, or quantitative, that is provided in numbers, constants and variables.

Data collection can be made by interview. The important fact is to present the questions on the way that can help to receive the necessary information from the respondent. At the same time, questions performed can allow the respondent to share the information especially when it is more private than opened. Furthermore, the interview can be an open ended – questions about interviewee's point of view and facts that could be received; focused – all necessary questions should be presented during a short time period being focusing on answers; survey – more structured model of questions to be presented.

In a case study were used only open ended and survey interviews due to the limit of time of interviewees and that most of interviews were done via e-post. Open ended interview was used to understand the barriers and obstacles for each actor shown up into the process while survey interview – to cover gaps in the understanding of situation and curious details.

Nevertheless, as Yin (2009) underlined, the interview by its own has weaknesses due to the lack of structure in questions, lack of interviewer's assurance during the interview; has strengths due to more detailed questions and short-time interview.

The number of questions asked during interviews was different. Questions were not that much detailed in the beginning of the research process but better constructed later. From all respondents the answers were given back quickly, thus, new questions shown up had to be created quickly and asked immediately to not lose the interconnection between details and understanding of some operations during the handling of hazardous waste. To provide the author of this paper a better understanding some respondents share additional confidential documents that provided a significant help in the research.

Another opportunity to collect the data – direct observation that, following to Yin (2009), becomes more reliable after each next observation. The strength of direct observation is the opportunity to study the situation being there in a real time. The weakness – the time limit for observation to see, remember and understand a lot of moments because they gives better understanding for the research.

For this case study only two observations were done. First one was allowed and organized by respondent from Shell – the author of this paper received an opportunity to visit Vestbase at the moment CTT with OBDC and OBDM were delivered by PSV with the delay due to harsh weather conditions. Photos of storage of CTT, movements of CTT by reach stacker from place of storage to trucks arrived and loading CTT on trucks provided by SRG were made. Furthermore, by respondent of Shell another opportunity for the author was presented – the chance to follow CTT from Vestbase to the treatment plant of Franzefoss at Husøya. And later, the opportunity to be at the plant watching the emptying and washing process of CTT, treatment process at plant and loading of empty CTT from place of storage at Husøya on trucks for further transportation according instructions given by Halliburton (due to CTT. MIS - ISO-tanks). Photos of emptying, washing process and loading are provided in this paper as well as the photos made inside of the plant giving better understanding of the treatment process.

For this paper the secondary data was also used. Hox and Boeije (2005) considered the secondary data as data that can be also used later for another research. The strength of the secondary data – its availability and time saving; the weakness – the difficulty to be found.

For this case study the secondary data was used as well: information was found of websites of Shell, Halliburton, M-I Swaco - Schlumberger, Transocean, Seadrill, Vestbase, NGI, SRG, Franzefoss, TOT. Due to lack of name of companies that provided PSV to Shell, the information to present the understanding of company's business were found on different websites and provided. A big amount of secondary data was collected from researches, journals in the relevant areas in literature and websites.

3.5 Data analysis

The case study presents the description of the case or situation. The data analysis should be done based on collected data and its type. The results received will present a new theory and new point of view on the situation examined. In this case study new position of the hazardous waste owner was provided together with results this owner received implementing reverse logistics, hazardous waste management, lean thinking and green supply chain management together with important logistics.

Following Eisenhardt (1989) first of all to build the theory from the case, the explanation of research question should be provided. Next step should be done toward selection of hypothesis or theory. Identifying methods that can be applied for data collection – is step further. Due to the fact that literature is the theoretical area and real case – practical area, the common area must be found. Thus, the overlapping of data collected and analysis presents – one more step to build the theory from case. Analysis of data is considered as the important of data analysis process. One more step – presents the concentration of the data analyzed and therefore, creation of correct research questions. Next to last step – present the comparison of literature choosing the most relevant for research questions created. And the last step – the completion of building the theory.

In this case study three research questions were created and set. As the unit of analysis is a hazardous waste, several sub-cases were presented. The analysis of data collected was provided, research questions were defined better, the number of researches in the literature was decreased due to more structured research questions and closure of the analysis and research case was provided.

According to Yin (2009), the quality of any case study can be criticized by following tests: construct validity, internal validity, external validity and reliability. Each test judges the specific area of case study.

In the current case study multiple sources of evidence were used to collect the data; the chain of evidence has a place in the whole analysis part. The explanation building is presented from the research question to the conclusion part. To create the value for each actor being involved into the chain as well as network and other types of flow the logical models were created. Thus, the relevance of construct and internal validity is clear. This paper is a single case study, thus, the theory was used according only this case. In addition, the database for the current case study was build, therefore, the relevance of external validity and reliability is obvious.

The generalization of all findings provided in the case study is required. The main moments should be presented giving better understanding for the reader about case study provided. In addition, the way how the generalization is given influences directly on the case study quality.

Being the single case study, this paper presents the understanding of the real case based on the theory providing the logical generalization in each chapter. Furthermore, the generalization of findings may be presented based on results that are defensible and credible.

3.6 Summary

In this case study all elements that should be presented in the research design are given: study questions, study propositions, unit of analysis, connection of data to propositions and criteria for interpreting the findings. The study is qualitative due to the usage of non-parametric analysis and empirical due to empirical data collected. The case is an independent single study that is made based on the empirical data that relates to the moment the situation was created – year 2014-2015. The current case is an embedded single-case with holistic design due to the fact that the unit of analysis is a hazardous waste, and the number of actors involved into the process where hazardous waste is handles is twelve. The data for this paper was collected by interviews that were not that much structured in the beginning of the survey but became better detailed later. The types of interviews were the open ended and survey. The number of interviewees was three due to time limit of researcher and time limit of some interviewees. To the author of this paper was giving an opportunity to make a direct observation on Vestbase, on the way Vestbase – Husøya and at the treatment plant at Husøya. Besides primary data the secondary data was using as well. The quality of paper can be seen from generalizations of findings in each chapter.

4.0 Empirical Case Description

4.1 Introduction

The chapter presents the case that was founded on collected empirical data from ten actors taking a part in the process related to the Norwegian offshore industry. The short presentation of their business, positions in business area and business relationships provide better understanding of the scale of the process created by special type of waste. Therefore, the empirical findings in this chapter make it possible to answer on three research questions presented earlier.

4.2 The actors

The section presents shortly the business areas and activities of all actors that became involved in the production, handling, transportation and treatment process of one type of hazardous waste produced in offshore by a big player in the whole Norwegian oil and gas industry, Shell.

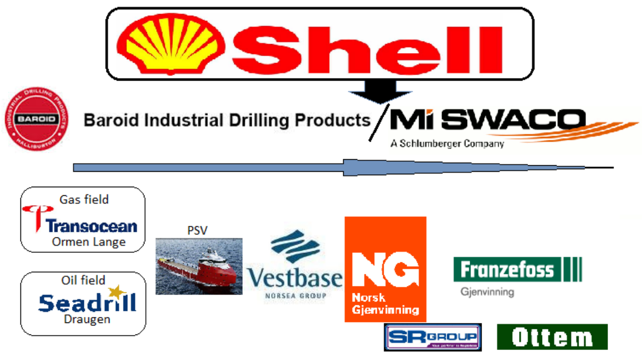


Figure 13: Network of hazardous waste at Shell.

The network of handled hazardous waste is shown in the figure below presented the waste producer, Shell, two companies that provide the drilling fluid for drilling operations, storage capacities and the special systems for the cargo produced, and other actors involved into the chain to provide further operations according the chain and process created by this type of cargo.

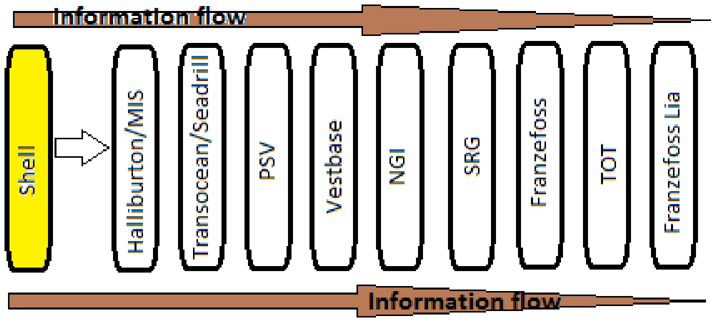


Figure 14: Information flow of hazardous waste at Shell.

The information flow is presented on the next figure. All actors are involved into the process, the information is shared is provided, all actors are working together presenting the cooperation in the activities according the handling of special type of cargo.

The whole chain created by this type of cargo is very complex and presents a lot of activities to be correctly organized, provided and regulated. Therefore, all these actors were chosen and presented to realize their business relationship and the whole process in more detailed way.

4.2.1 Transocean LTD (Transocean)

The history of Transocean has been traced to the drilling operations in offshore in career of Mr. Stoneman in earlier 1920th who, being a pioneer in offshore drilling, bought the first drilling rig. In the 1940th two legacy entities emerged with a young company. Next, more important steps in the history of Transocean have happened in the 2000s relating to the mergers and new for offshore drilling established world records. In 2010th Transocean was recognized as a leading trusted provider of offshore contract drilling services for oil and gas wells on international level (Transocean, 2015a). The company improves its technologies showing the possibilities to open resources in offshore more being focused on harsh environment and deepwater drilling services for its largest fleet in the world. Nowadays Transocean owns 28 ultra-deepwater, 8 deepwater, 7 harsh-environmental offshore drilling rigs, 15 midwater floaters, and 10 jack-ups (Transocean, 2015b).

Performing operations at sea, the most beautiful Earth's places, the company considers that all activities should not have an adverse effect on the environment. Thus, well invested waste management and energy conservation together with usage of up-to-date systems may guarantee the environmental protection reducing Transocean's environmental footprint every next day.

4.2.1.1 Transocean Barents Rig (TBR)

In the beginning of august 2014, Petroleum Safety Authority Norway (PSAN) gave consent to Shell for using one of 7 harsh-environment offshore drilling rigs to start drilling activities at gas field named Ormen Lange (Norwegian Sea), at appraisal well 6305/8-2 (OET.com, 2014). Conditions at seabed and water depth gave a Transocean a great possibility to check technological innovations. Thus, Shell has a written and signed contract with Transocean for drilling operations.

Status	Operator	Start	End	DayRate	Comment
Active	Shell	01.08.2014	31.08.2015	$601 000	
	Det norske Oljeselskap	01.07.2012	30.06.2014	$570 000	
	Det norske Oljeselskap	01.10.2011	30.06.2012	$561 000	

Table 5: Contract history of TBR (Offshore.no, 2015a).

According Offshore.no (2015a) TBR is a semi-submersible (SS-Halvt nedsenkbar) built in Western Norway and completed in 2009; the size of it is: length- 394ft and breadth-253ft that allows 140 (exp. 160) be on board of the rig; furthermore, the maximum water depth for TBR can be 10000ft (3km) and the maximum depth for drilling operations – 35000ft (10.67km).

Picture 5: TBR (Offshore.no, 2015a).

List of characteristics of TBR such as storage capacities and drilling equipment (Transocean, 2015b) shows that there are not enough capacities to keep many kinds of liquids on board of the rig. The important detail from drilling equipment is the number of shale shakers that varies for all harsh-environmental rigs of Transocean from 4 to 5.

Storage Capacities	
Liquid Mud	5,675 bbls.
Drill Water	18,895 bbls.
Bulk Material	(mud + cement) 27,546 cu. ft.
Sack Storage	5,000 sacks

Drilling Equipment	
Mud Pumps	4 x AKMH Wirth model TPK-7-1/2 inch x 14 inch 2,200 hp 7,500 psi working pressure.
HP Mud System	Rated for 7 500 psi
Solids Control	4 x Axiom AX-1 Dual Shakers

Table 6: Storage capacities and drilling equipment at TBR (Transocean, 2015b).

4.2.2 Seadrill Limited (SL)

SL, as an independent company, started its business in 2005 and by nowadays became one of leaders in offshore drilling operations. The company is interested into customers' interests and in customer's customers' interests such as – to unlock more oil and gas in the safest and efficient way. SL has the most young and modern fleet if to compare with other drill contractors and is presented by 69 rigs: jack-up, SS, drill ships that are available for drilling operations in harsh environments at ultra-deepwater areas (Seadrill, 2015a). The company provides very high quality of drill operations in different offshore drilling sectors.

4.2.2.1 West Navigator (WN)

In December 2012 Shell received a consent from PSAN to use WN Drill ship on Draugen field which allows to drill and complete production wells at G-area (G1, G2 and G3) (OET, 2012). As WN is the drill ship, there are two pipelines which go from it to a floating buoy where other ships can load the oil.

Status	Operator	Start	End	DayRate	Comment
		01.07.2015	31.05.2020	$0	Rosneft cont. terminated 14/3
IDLE		**01.12.2014**	**30.06.2015**	**$0**	**Warm stacked**
	Centrica	01.10.2014	30.11.2014	$620 000	
	Shell	01.01.2013	30.09.2014	$609 000	
	Shell	01.01.2009	31.12.2012	$620 000	

Table 7: Contract history of West Navigator (Offshore.no, 2015b).

According Offshore (2015b) West Navigator is a Drill Ship (DS) constructed in 2000; the size of it is: length – 830ft and breadth – 138ft that allows 117persons be on board of the ship; the maximum water depth for WN can be 8200ft (2.5km) and the maximum depth for drilling operations – 29500ft (9km).

Picture 6: West Navigator (Offshore.no, 2015b).

List of characteristics of WN shows that, if to compare with TBR, WN has 6 shale shakers (Seadrill, 2015b).

STORAGE CAPACITIES		MUD SYSTEM	
Drill water	1840 m3	Mud pumps	3 x NOV 14-P-220
Liquid mud	950 m3	Pressure rating	7500 PSI
Cement	315 m3	Shale shakers	6 x Thule VSM 300

Table 8: Storage capacities and drilling equipment at West Navigator (Seadrill, 2015b).

4.2.3 Platform Supply Vessel (PSV)

PSV is a kind of the ship that is used in offshore oil and gas industry and has a special design to supply oil platforms in offshore. Moreover, these ships differ in the length and the task. Fundamental function is to provide the transportation of necessary equipment, food, deck and bulk cargo, personnel from and to the platforms, and the logistic support. The range of types of PSV is wide and they are equipped with tools for: fire control on platforms, assistance during the cleaning of spill at sea, and implementation of a particular job.

Key factors to be successful for such companies are innovations, the environment and safety. Zero damages and zero injuries are very important moments nowadays in every business related to the offshore industry. Furthermore, the fleet needs to be modern and customized for different kinds of operations in different weather conditions, especially under harsh weather as well as with the ship's crew onboard with long experience. Thus, the best focus on teamwork, high level of quality, creative solutions together with flexibility in operations (emergency and daily operations on board) present values of the company, the owner of offshore vessels.

4.2.4 Vestbase AS (Vestbase)

In year 1970 Kristiansund was recommended as the place for activities in oil investigation in exploration areas close to the coast in the middle of NCS. The benefits of such project for the region were urgent. At the end, in year 1975 the National Assembly chose to Kristiansund as the important base presenting services to gas and oil industry in Mid-Norway. The harbor close to Kristiansund was chosen for base aims. Later, in 1978, Statoil ASA and the Municipality of Kristiansund became partners of risky agreement to build base providing services and supply and be named Vestbase.

Picture 7: Location map of Vestbase (Vestbase, 2015a).

Nowadays, Vestbase is one of the nine supply bases of the NorSea Group, the national leading operator of broad range of services at base and port and accommodated to the requirements of the Norwegian oil and gas industry. Vestbase plays a role of industry and business center being located close to the gas field such as Ormen Lange and oilfield such as Draugen being operated by Shell since year 2007 and 1993 respectively. Many companies are established on the territory of the base, some of them represent companies being located outside.


Picture 8: Vestbase AS in Kristiansund (Vestbase, 2015b).

At Vestbase the Technical and Logistics Departments were identified as main. To meet and manage the increasing demand of the companies providing control of operations on their geographical areas, Vestbase provides good logistic services at warehouse, base and terminal with rental personnel and technical services at heavy lifting, transportation of bulk products, rig maintenance and personnel training.

4.2.5 Norsk Gjenvinning Industri AS (NGI)

NGI is the part of Norway's leading environmental services provider, Norsk Gjenvinning AS, presenting various recycling solutions, steady waste management, and collection of hazardous waste (NG, 2014a). The company is active in upstream market providing to domestic companies, such as Shell, waste management services, and in downstream market providing to regional businesses the production of secondary raw materials and sales of them. NGI makes efforts to reduce the volume of waste to be landfilled and increase percentage of energy and material recycling. The company considers that in future more waste should be turned into the necessary raw materials and that new challenges in technologies can be conductive to become the leading recycling company in Scandinavia.

The company has the recycling plant at the Vestbase to recycle drain water and own warehouse where waste is stored until the volume will be enough to transport it to downstream companies. Not all volume of waste is treated by NGI, the company has downstream parties that recover energy and provide further waste management. Due to the strict Government regulations some wastes are sent out of Norway (Engelseth and Ahmed, 2014).

One of divisions of NGI is "Offshore and industry" that means the collection of hazardous waste, its treatment, pipe inspection, services onboard of rigs, cleaning of tanks (NG, 2014a). One of NGI's offices is located at Vestbase in Kristiansund.

As hazardous waste needs a special control during transportation and further treatment, NGI trusts to waste producer, Shell, that information provided in documents corresponds with the contents of the container where the waste is loaded from the offshore base.

4.2.6 SR Group AS (SRG)

The history of SR Group AS is started from the integration of two companies (Waage Transport, Kristiansund, year 1974 and SR Transport, Stavanger, year 1983) in 2010 (SRGroup, 2015a). Nowadays the company performs transportation and logistics services with advanced storage facilities to the main players in the offshore industry. SRG provides services for transportation of waste, dangerous goods (ADR) and chemicals in tanks in Norway as well as abroad providing necessary documents (SRGroup, 2015b). More than 100 vehicles of different sizes, airplanes and ships are available in the fleet of SRG to present the best planned and coordinated logistic services together with good SCM at domestic and international level. In addition, SRG is focused on customers' time saving and expenses' minimization. Furthermore, the company, being with long experience, appreciates the feedback from its customers that may become the reason for better challenges in customer services in the future.

4.2.7 Franzefoss Gjenvinning AS (Franzefoss)

Franzefoss is a largest company and leading provider in waste management in Norway. Company's business area is the management of industrial waste (metal, wood, iron, plastic), hazardous waste, treatment of drilling waste and tank cleaning. Receiving, handling, sorting, treatment and recycling of waste (OBDC, OBDM and polluted water from a big number of different places) from Norwegian offshore activities along NCS and shipping, inspection and consulting – are services offered by Franzefoss. Company has three strategically located plants at Sotra (Bergen), Husøya (Kristiansund) and Repparfjord (Hammerfest-waste from Barents Sea) where the deep water enables ships to deliver cargoes directly to the plants. Together plants process more than 150 000 tons of drilling mud and drilling cuttings and 80 000 tons of oil water. Different types of different waste's categories are recycled at plants of Franzefoss as raw materials for smelting industry, for new products, alternative fuels for oil, coal and electricity. Franzefoss is the biggest player in the treatment of waste oil, oily water, cuttings and waste water (Franzefoss, 2015c).

4.2.8 T. Ottem Transport AS (TOT)

TOT was established in 1969 and today it offers a wide range of transport operations between Central and Eastern Norway (Ottem, 2015a). The fleet of the company is presented by hook vehicles and lift trucks that can be used for transportation of solids in bulk up to 40m3 in volume. TOT together with Ottem Resirk AS, the recycling company, performs the OttemGruppen that performs services for transportation of hazardous waste, sawdust , waste from a slaughter house, waste in bulk and units as well as non-standard goods (Ottem, 2015b).

4.2.9 Halliburton AS (Halliburton)

Nowadays Halliburton, which was established in 1919, is the leading provider of different services and products to the energy industry and has offices all around the world (Halliburton, 2015a). For its global operations the company uses newest technologies, innovations and integrated solutions. First steps in Halliburton's business were made in cementing of oil well in USA and then, in offshore presenting its business on all continents. One of Halliburton's offices is located at Vestbase in Kristiansund.

The success in a long term inseparably linked with responsibility and sustainability. That is why the company tries to put into practice the best experience to show how it behaves worldwide. Furthermore, this fact has an effect on customer/supplier's relations. Halliburton, as a qualified supplier, presents also services and technologies to customers in oil and gas industry in upstream. This ranges from production of drill bits, drilling fluids and analyzing geological data to management of drilling waste.

4.2.10 M-I Swaco, division of Schlumberger Norge AS (MIS)

MIS is a very well-known company worldwide in oil and gas industry. The company is a leader-supplier of drilling fluid system that is designed to make better drilling operations: to provide drilling fluid, tools for drilling and solutions for optimized drilling. MIS is known as the company that serves its customers presenting newest technologies. These technologies allow MIS to foresee possible changes during activities in the downhole environment. Thus, the risk related to drilling fluid spill can be prevented immediately. In addition, the company also presents management of drilling waste.

In 2010, the merger of two companies, MIS and Smith International, allowed MIS to become a part of Schlumberger, division in Norway (MI Swaco, 2015a). Optimization of drilling operations was the main reason of this strategic step. Furthermore, the experience of larger company, Schlumberger, could present longer life for wells and significant cost savings.

Schlumberger nowadays provides customers with newest technologies and best solutions for activities in oil and gas industry. In addition, the company offers the widest line of services and products in exploration field (Seismic and geophysics services and software) and production (drill bits and production software) (Schlumberger, 2015).

4.3 Case description

Once the geological data in offshore is analyzed, the place for drilling is chosen, the contracts for drilling activities are signed between all companies and the drilling rig or drilling ship, both should have on board the drilling derricks, is set up at the right place. Then, the drilling for exploration and appraisal begins. As a result, samples from different drill places are taken to set up many different characteristics of oil and gas in the field discovered such as the quantity, quality and others. When it is understandable that there is a weighty reason to continue drilling, the main drilling activities are started. The drilling rig is set up for the whole period of drilling activities until there will be necessary to set up the production rig.

Transocean Barents

Kart | Aktivitet | Boreplan | Siste leteoppdatering | Uønskede hendelser | Nyheter

Brønn	Lisens	Borestart	Boreslutt	Type	Formål	Innhold	Operatør	Felt	Vanndybde
6305/7-D-5 H	208	26.12.2014		DEVELOPMENT	PRODUCTION		A/S Norske Shell	ORMEN LANGE	854
6305/8-2	250	24.09.2014	21.11.2014	EXPLORATION	APPRAISAL	GAS	A/S Norske Shell	ORMEN LANGE	815

Table 9: Activities of TBR (Oljefakta.no, 2015a).

From Table presented above it is possible to see the movements of TBR at the end of year 2014. It was set up for two months (24.09.2014 (“Borestart”) till 21.11.2014 (“Boreslutt”)) in one of Ormen Lange’s (“Felt”) part according the License 250 (“Lisens”) (“Innhold” - gas) for exploration and appraisal operations (“Type” and “Formål”) at the depth

(“Vanndybde”) of 615 meters and then, after one month, moved to another Ormen Lange’s part – for production operations according the License 208 at the depth of 854 meters until nowadays.

West Navigator

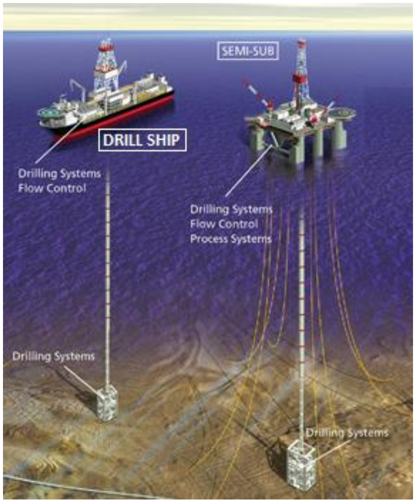
Kart | **Aktivitet** | Siste leteoppdatering | Uønskede hendelser

Brønn	Lisens	Borestart	Boreslutt	Type	Formål	Innhold	Operatør	Felt	Vanndybde
6407/9-G-2 H	093	06.03.2014	19.07.2014	DEVELOPMENT	PRODUCTION	OIL	A/S Norske Shell	DRAUGEN	245
6407/9-G-3 H	093	02.03.2014	04.07.2014	DEVELOPMENT	PRODUCTION	OIL	A/S Norske Shell	DRAUGEN	268
6407/9-G-1 H	093	17.02.2014	05.06.2014	DEVELOPMENT	PRODUCTION	OIL	A/S Norske Shell	DRAUGEN	259

Table 10: Activities of West Navigator (Oljefakta.no, 2015b).

From Table we can see all movements of WN almost from the beginning of year 2014. It was set up in Draugen for production activities according the License 093 (oil) but moving to different places inside of that area (“Brønn” G-1 to G-3 to G-2) almost at the same depth on average 257 meters.

Different depths require different sizes of drilling rigs and different type of anchor to keep the rig in a steady position. Also, at some depths SS cannot drill, thus the drill ship accepts drilling operations on its own responsibility. Furthermore, type of formations affects period for drilling and problems that can reveal.



Picture 9: Drilling ship and Semi-Sub (Cameron, 2015).

The information flow is very important in offshore industry and, that’s why, the lack of it may become a reason that the whole chain of operations will be stopped and performed as very costly. In this paper two types of drilling rig are performed.

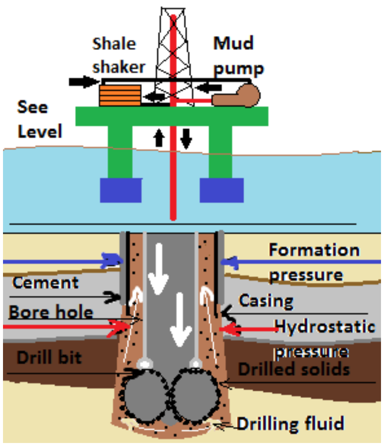
At the right place the surface casing should be cemented to keep the formation pressure. In addition, subzero temperatures on the seabed at NCS together with extreme weather conditions require to make a drilled well wider.

4.3.1 RQ1: What type of cargo is transported in Cuttings Transport Tank (CTT)/ CLEANCUT ISO-pump (ISO-tank)?

This section shortly describes the drilling process, the kind of waste produced at the end of this process that needed to be loaded into special storage facilities on boards of TBR and WN during appraisal and production operations during the period "end of 2014-2015".

The drilling well can be viewed as a closed system. The drilling bit breaks rocks below the seabed moving deeper in the solid and, sometimes, frozen ground. To improve the well drilling the drilling fluids/muds are used.

Today technologies are very well developed and the appraisal drilling can identify the rock formation and, then, the well's type. Thus, the correct type of drilling mud should be chosen for further successful drilling activities. Another element of the drilling mud besides the drilling compounds – clay particles. This fact provides higher density to a liquid. Drilling bit consists of, at least, three conical rollers with metal teeth. While working, the drilling string is turning and, therefore, it turns the drilling bit also. Drilling mud goes down through the drilling bit to the hole where it acts as lubricant substance to drill the rock easier (US Emerald Energy, 2015). The necessity of drilling mud is the fact that it acts as a cooler for drilling bit during drilling. Furthermore, while drilling operations it keeps fluids in rock formation and provides stability in the hole. Moving down deeper, new tubes are set in the hole, the area around is cemented to increase the casing's strength.



Picture 10: Drilling the well.

When the borehole is drilled deep enough but there is still no oil or gas available, drilling operations are stopped. The well hole is filled up with drilling mud and uncased. Then, one of two following decisions can be made: continue drilling further and start the production, or block and leave it.

Nowadays, when expenses become higher in oil and gas industry, the type of the drilling mud can also be identified according technical performance, cost and environmental footprint. In that way the following types of drilling mud are presented: water-based, oil-based and synthetic-based. Synthetic-base drilling mud decomposes quicker, has less environmental footprint and, thus, is in demand for offshore wells. Water/oil-based drilling muds are used for onshore wells. Oil-based drilling mud (OBDM) contains petroleum products, mostly diesel fluid. For drilling operations on TBR by Halliburton and WN by MIS was chosen and used OBDM.

While the drilling bit breaks the rock in the borehole reaching the oil and gas reservoir, the drilling mud lifts the soil, stone chips (sand, shale, limestone, granite) and pieces of rock (drill cuttings) up to the surface. The size and texture of drill cuttings vary a lot. On the board of the drilling rig there are special shale shakers (vibrating screens) that help to separate/treat the drill cuttings and drilling mud. Mostly, nowadays, drill cuttings are hold, next, into special containers - skips. Carrying to the surface the drill cuttings, the drilling mud becomes contaminated the firm soil. It is cleaned on the board of the drilling rig for the further usage few times - through the mud pump down to the borehole, and, that is why, has a value for the drill operator. Thus, used drilling muds and drill cuttings – are two types of drilling waste/slush produced during the well-drilling process.

OBDM is considered as the hazardous cargo; carried up to the surface drill cuttings become oily and contain now residual oil, therefore, they are called oil-based drill cuttings (OBDC) and are considered as a hazardous waste. Therefore, this type of cargo must be delivered to shore for the further treatment.

In addition, some stone chips or rock’s pieces may contain radioactive materials such as limestone or granite, however the level of radioactivity is very low and it is allowed to consider them as non-radioactive materials.

4.3.2 RQ2: What is the RL process that this type of cargo created?

This section describes and presents the first two parts of RL process, the collection of waste and the pack. In this paper such part is provided by two systems that are set on board of TBR by Halliburton and WN – by MIS and containers settled on PSV, two companies – suppliers of OBDM. The flow of hazardous waste created by drill cuttings at Shell is presented below and shows all parts of RL process in a par with actors involved.

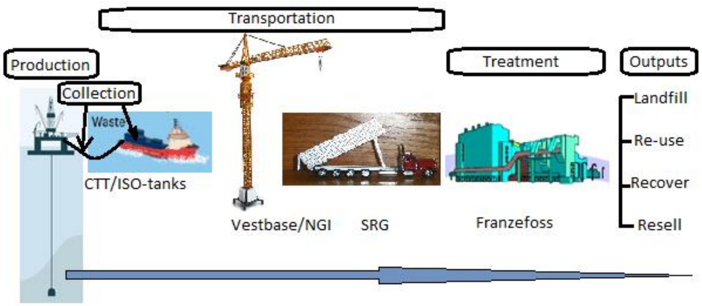


Figure 15: The flow of hazardous drill cuttings at Shell.

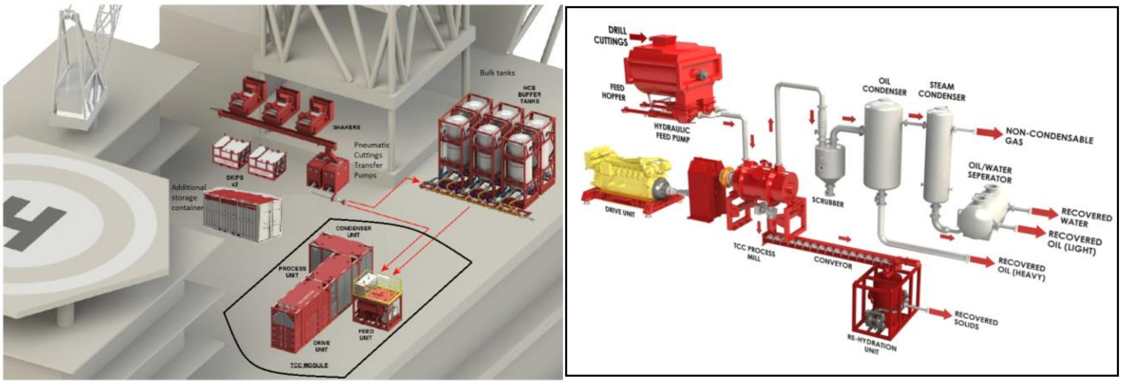
Respondents of Shell and Franzefoss were asked to understand the difference between two systems and the challenges that can make an effect on the further events at Shell. The third part, dispatch, is presented by logistic network created by drill cuttings. The detailed process is provided below. One part of this detailed process is shown as a complex in view of the importance. In addition, the created value by drill cuttings also is presented afterwards.

4.3.2.1 Collection of this type of cargo

In different areas oil or gas is located at different depths as well. This fact directly affects on the increasing the waste. Nowadays any challenges concerning waste are costly. It was found that OBDM can provide better drilling with decreased volume of drilling waste. Furthermore, meeting strict regulations, drill operators make efforts to minimize the waste in general and waste to landfill, minimized the footprint on the environment and increase the volume of oil recovered.

On the board of offshore installation besides shale shakers and skips the special system is settled “to mix and handle the fluids” (based on the interview with respondent from Shell). Every next system differs from each other as it is designed, planned and set up in accordance with requirements of the customer, f. e., limited rig space, weight, electric power.

On TBR’s board Halliburton set up Baroid’s Thermomechanical Cuttings Cleaner (TCC) unit which consists of Condenser unit, Process unit, Feed unit and Drive unit. Baroid’s TCC unit is created to process oily drilling waste carried up to the surface: cuttings, mud. Inside of TCC unit the high temperature is used: water and oil are vaporized, oil from cutting is totally (>99%) recovered. The flow diagram is also presented. On leaving Baroid’s TCC unit the following byproducts are received: recovered solids, water, oil (light), oil (heavy) (Halliburton, 2014). TCC technology is created to use the steam method and present solids that are totally free from oil and, thus, can be disposed. In addition, the automatic system does not require much labor, transportation costs by ship to shore are reduced, environmental footprint is minimized, and all units are movable on the rig.



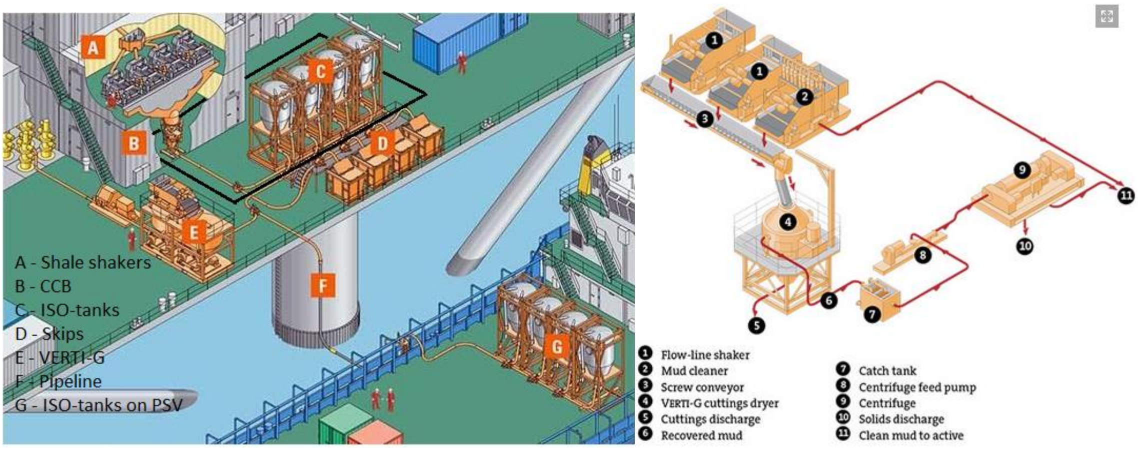
Picture 11: TCC process and flow diagram on offshore installation (adapted from Halliburton, 2014).

Besides Baroid’s TCC unit, as secondary equipment, can be used additional storage container, Pneumatic Cuttings Transfer Pumps, bulk tanks (HCB Buffer tanks) (Halliburton, 2014). Also, by Halliburton, centrifuges and cutting dryers can be offered.
On WN’s board MIS set up the CLEANCUT cuttings collection and transport system which consists only of two parts: the CLEANCUT cuttings blower (CCB) and ISO-pump (Schlumberger, 2014). Drill cuttings from shale shakers move to CCB and then – to ISO-pump. ISO-pump unit (ISO-tank) is a storage tank/container that can be lifted up/down by crane. The whole system is closed and pneumatic and meets the statutory requirement. The idea of its creation was to present the temporal storage for drill cutting on rig’s board for the further transportation to shore. MIS considers that the system gives to the drill operator the possibility to keep ISO-tanks longer on the board in case of bad weather, thus, such flexibility has a positive effect on money savings.

CLEANCUT ISO-pump. CLEANCUT cuttings blower (CCB M8).

Picture 12: CLEANCUT system (adapted from Schlumberger, 2014).

Besides CCB and ISO-tanks to maximize the storage volume, additional ISO-tanks can be used. The thermal treatment of drilling waste takes place in another system where VERTI-G cuttings dryer plays the main role. From shale shaker drill cuttings fall down to the VERTI-G cuttings dryer and then go through two types of centrifuges, and the following byproducts are received: solids and the clean mud that can be used for further drilling operations.



Picture 13: The CLEANCUT system and the thermal treatment with VERTI-G (adapted from MI Swaco, 2015b and 2015c).

However, the respondent from Shell mentioned: "*Nowadays it was found that it is better to pump all drilling waste into containers, Cuttings Transport Tank (CTT)/ISO-tanks, and deliver them by boat to onshore then maximize the volume of drill cuttings treating the drilling waste through the shale shakers. This process needs much longer time*".
Furthermore, "*just small amounts of cuttings, 1-2 CTT was produced last year*" (appraisal period, 24.09.2014 till 21.11.2014) and "*there will come in between 25 and 30 filled CTT next week and that's it for 2015*" (production stage, 26.12.2014 till September 2015) was explained in interview with respondent from Shell.

It is very important to understand that even there is a one kind of liquid mud/slush in the tanks, we "*must separate drill fluids and drill cuttings, because they have different codes. But both can occur in drilling waste sent in to NGI*", - says the respondent of NGI.

4.3.2.2 Logistic network created by this type of cargo

Importance created by drill cuttings: The whole transportation process of the drill cuttings on a par with CTT/ISO-tanks has many different operations inside presenting the complex by itself. Thus, it is very important for Shell, as for a main player and an organizer of this chain, that all operations, movements will be done on time providing high quality of services carried out and zero damages. These strict requirements need to be provided because any delay or the stoppage of work will result delays and stoppages of drilling activities at TBR/WN. It was discovered that part of tanks should be on shore while other part – offshore (PSV) to maximize the efficiency of the chain created. Few downstream parties are involved in it.

Following main parts present the logistic process that was created by the drilling waste loaded into CTT/ISO-tanks: unloading, storage, transportation to downstream companies, treatment and further disposal activities, and are shown in a Figure below.

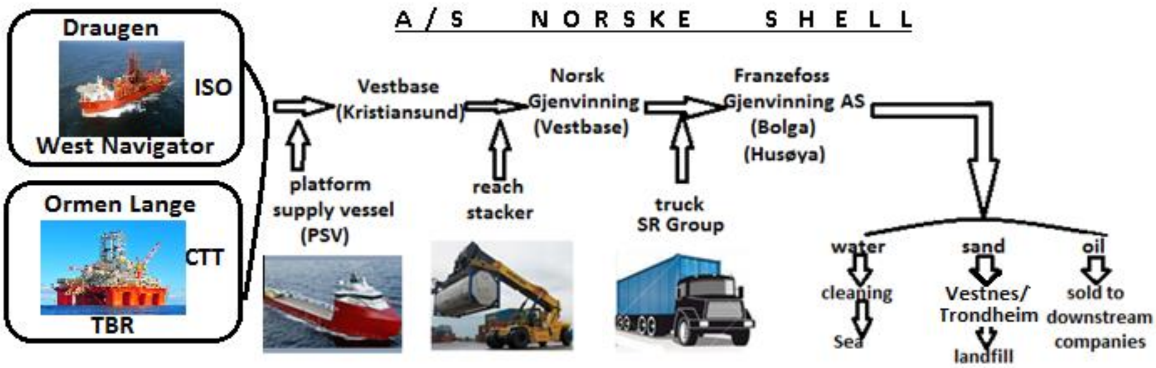
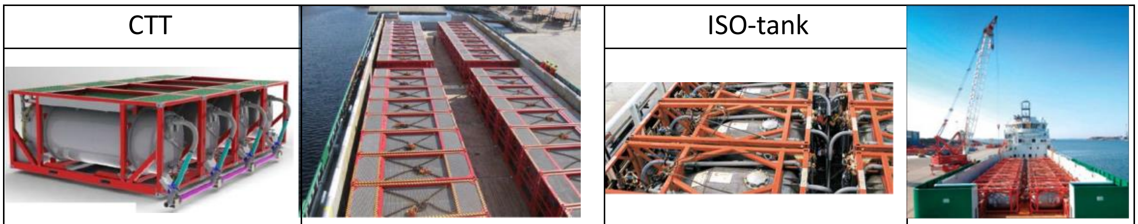


Figure 16: Drilling waste logistic activities under Shell's control.

Activities on PSV's board: PSV is located near drilling installation (TBR/WN); on its board empty CTT/ISO-tanks are settled horizontally/vertically; by pipeline from boards of TBR/WN drilling waste is pumped into CTT/ISO-tanks. Raw materials are delivered from sedimentary rocks from Ormen Lange and Draugen area as OBDC with OBDM in orange (ISO-tanks) and red (CTT) tanks. According ISO Standards, ISO-tank has the size: 2.438m*2.591m*6.059m (length*width*height); weight of full ISO-tank – up to 32.5tons with "working volume" of 15m^3 (26,5 tons) (Schlumberger, 2014) and CTT with "working volume" of 30tons.



Picture 14: CTT and ISO-tanks on PSV (adapted from Bilstad, 2013, MI Swaco, 2014 and Drilling Contractor, 2009).

Shell is considered as a producer of the drilling waste on board of TBR/WN. PSV also is considered as a producer of waste – it has its own waste produced on the vessel, f. e. spent fuel. In addition, drilling waste pumped into CTT/ISO-tanks – OBDM with OBDM – hazardous waste. Thus, on board of PSV special document, Declaration (detail description), should be completed for each tank and has unique number. The form gives necessary information for further handling, transportation and treatment. The form can be used as a document which allows transporting of dangerous goods but not radioactive waste that is dangerous goods (NORSAS, 2013).

Declaration, Appendix B Form 2-6. The declaration form is divided on two parts by the line: part of form above the line must be completed by waste producer (Shell) about himself and the waste, the part of form below the line must be completed by waste collector. For oil and gas offshore industry Declaration forms are printed in English and Norwegian language. The Declaration form is composed of five copies (five colors) that must be distributed: Green – to the final disposal place, Red – to NORSAS, Purple - not regulated, Blue – for waste collector, Yellow – waste producer. Today the filling out the declaration form can be made electronically: put information into the system, register it, then print the copy and bring it with container.

Picture 15: Pumping of CTT with OBDC with OBDM from board of TBR/WN (Photo: Alexandra Boyarinova).

CTT/ISO-tanks are not lifted from PSV up to the board of TBR/WN. However, from board "*PSV also brings other deck cargo - different types of cargo and skips"*, - mentions the respondent from Shell.

<u>PSV arrives at Vestbase</u>: The volume of waste produced by Shell is the biggest for Vestbase if to compare with other companies. For further treatment drilling waste should be delivered by PSV to shore, supply base, Vestbase. PSV is mooring to Vestbase's berth.

<u>Unloading from PSV:</u> Vestbase presents its own transport facilities for movements at its area. Special movable crane is located on the berth. It lifts CTT/ISO-tanks from PSV to berth.

<u>Movements at Vestbase:</u> To the place where tanks are left from PSV, another crane arrives – reach stacker. It lifts tanks and delivers them to the special, chosen place at Vestbase for short time storage.

Together with CTT/ISO-tanks from PSV Declarations are delivered - to NGI's employees. One of NGI's branches is located at Vestbase's territory. In addition to scanning and recording of Declarations into NGI's system, NGI creates some "*internal documents for the logistic coordinators such as inbound manifests etc., these documents are for control of the units and tracking etc.", -* mentions respondent from NGI.

At Vestbase there is a plant of NGI for treatment of water. However, "*the permission and the facilities don't allow NGI to treat cuttings. The water treatment at plant is done by NGI for washing water and slops*" (respondent from Shell). Therefore, CTT/ISO-tanks need to go to Franzefoss, the downstream party. Moreover, "*during the day it is necessary to use only 3 cars to deliver CTT/ISO-tanks from Vestbase to Franzefoss*" (respondent from Shell).

CTT requires a special truck and it can be offered by SRG. When next instructions are received, trucks for transportation are arrived at Vestbase; coordinator sends instructions to reachstacker's driver. Tanks are lifted from storage place, delivered at trucks and loaded on trucks. Trucks leave Vestbase in the direction of Franzefoss's treatment plant at Husøya.

Picture 16: Handling of CTT at Vestbase and their delivery to Husøya (Photo: Alexandra Boyarinova).

For handling process of CTT/ISO-tanks at Vestbase are involved the following workers: crane's driver, flagman, reachstacker's driver, coordinator, truck's driver.
<u>Movements at Husøya</u>: At Husøya CTT/ISO-tanks are delivered to the plant by SRG's drivers directly to one entrance from the sea side. Before the empting will happen, the driver gives to a foreman Declaration for CTT/ISO-tank delivered by his truck (Appendix B Form 7, 8). In addition to this, all workers/drivers that are involved into the process must be acquainted with rules and instructions at SRG related to the usage of CTT and risks (NGI, 2014). Driver uses the special system on the truck to uplift the CTT for empting (manually or automatically) following the procedure of empting the tank. This process is shown on the picture.

Picture 17: Empting of CTT tank by special way (Photo: Alexandra Boyarinova).

After the CTT is emptied, one worker gets into the CTT with water hosepipe to clean the CTT from within. The rest of drilling waste together with used grey water fall down to the special pool.

Picture 18: Special washing process of CTT (Photo: Alexandra Boyarinova).

Before transportation of CTT, before lifting CTT, during the empting and after empting of CTT the driver must fill in the special checklist given by SRG with many points that can be “OK”/”Not OK” (Appendix B, Form 9). This check list is also checked later by NGI.
The treatment process of drilling waste that happens at Franzefoss’s plant will be described below. Empty CTT/ISO-tanks are lifted up from truck by reachstacker and loaded on the special area in front of plant until further instructions from Halliburton/MIS are received.

Picture 19: CTT at Husøya, Kristiansund (Photo: Alexandra Boyarinova).

In addition, if reachstacker is not available, the forklift can be used for handling of empty CTT as well.

Picture 20: Possible handling of empty CTT by forklift at Husøya (Photo: Alexandra Boyarinova).

When all CTT/ISO-tanks arrived at Husøya, the special document, Registration form, is created with different information for Franzefoss about handled tanks at this period: № of Declaration, producer of the drilling waste (rig's name), ID number of CTT/ISO-tank, gross weight, tank's weight, net weight, marks. In addition, the follow information should be also written in the same document: deliver, transporter, data, price per ton (including the empting process), waste code, receiver, contact person, the name of cargo received, field's name cargo produced in and mark (Appendix B Form 10, 11). Later, empty truck arrives at Husøya, reachstacker lifts up CTT/ISO-tank and loads it on truck.

Picture 21: Handling of empty CTT by reachstacker at Husøya (Photo: Alexandra Boyarinova).

<u>Further movements</u>: Usually empty CTT/ISO-tanks can be transported/returned back from the plant at Husøya to NGI for certification and further handling during few days and in one day if few tanks are delivered at the same day. Thus, this fact can have a positive influence on the reduction of number of tanks and the cost of renting tanks. The certification is considered as: "*the tank needs to be checked for any damages and is approved to be sent out again*", - mentions respondent from NGI.

<u>In addition</u>: "*During year 2014 at Franzefoss, Husøya, were handled approximately 40 ISO-tanks which came under Shell's and Schlumberger's (as a producer of drilling fluid) control from Draugen and some fields in North Sea by PSV to Vestbase, Florø (Sogn og Fjordane, the most Western Norway) and Stavanger, and from supply bases by trucks to Franzefoss, Husøya",* - mentioned respondent from Franzefoss.

4.3.2.3 The treatment process at Franzefoss, Husøya

The treatment of the drilling waste at Franzefoss, Husøya, presents the complex process. Franzefoss is almost the last downstream company that is involved at the whole WM network created by drill cuttings.

The receiving and treatment of mud, cuttings and oily water is presented at a processing plant at Husøya. According to the Måleprogramm written by Franzefoss (Franzefoss, 2014), water treatment plant and resoil plant are two units of the plant. At resoil plant the thermic treatment of mixed liquid is: drill cuttings and drill mud. At Water treatment plant the treatment process of water received from resoil, oily water and wash water is performed. Adopted advanced technologies at Franzefoss's plant at Husøya allow separating oil, solids and water. The plant has a pipeline which goes from water treatment plant from Husøya into the sea 300 meters until the depth of 29 meters.

Picture 22: Plant at Husøya, Kristiansund (adapted from Franzefoss, 2015b; Photo: Alexandra Boyarinova).

The plant at Husøya started to operate not so long time ago. That is why the date of material's analysis is not that huge. The closeness of the plant to the residential houses requests to keep always the regulations according environmental impacts/pollution. The authorities of Franzefoss pays attention to how the performance of control is performed at the plant: air emissions, emissions from water treatment, oils separators, noise and the feedbacks from recipients. Furthermore, some measurements are questionable and this fact requests to consider new steps to reduce the uncertainty. The assessment of environmental impacts/pollution is fulfilled periodically.

Figure below shows how the treatment system at the plant is operating. OBDC is mixed with used OBDM inside of CTT. "*There are water slops- with density of almost 1.0-1.2. Also, there are oily slops as 0.8 consistent. Mud is higher than 1.3*", - mentions respondent from Shell. The drilling waste is unloaded from CTT which is settled on the truck directly into Pool1.

As the consistence of mixture is dense, the huge scoop is used to transship part of mixture from Pool1 to Pool2. This huge scoop is coordinated by worker in machine room. Periodically boats arrive at the plant from sea side and pump the slop into the huge tanks of 3500m3 which are located right near the plant. Then it is partly pumped into the plant, Pool2 and goes through the water treatment system.

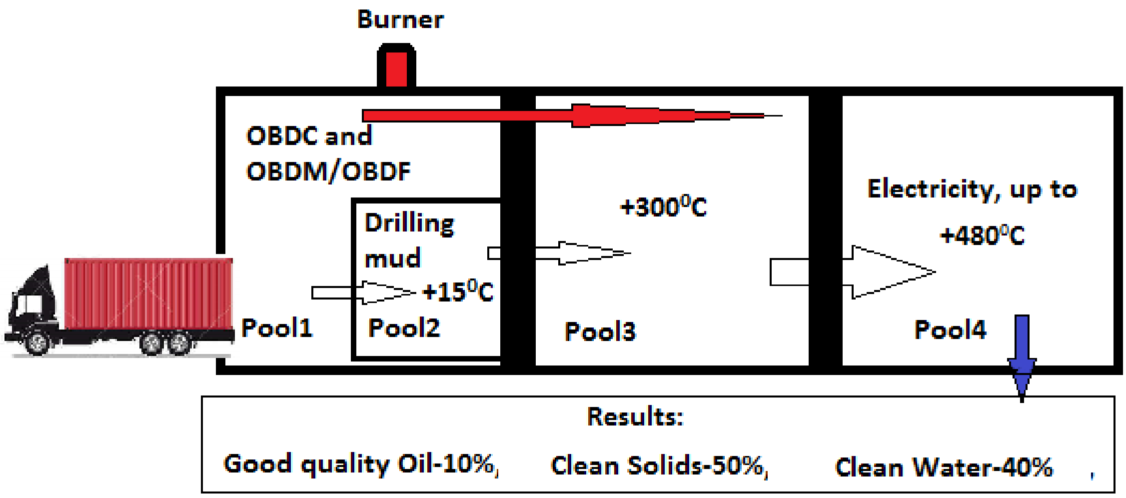


Figure 17: Flow diagram of treatment system.

In Pool2 the consistence of mixture is becoming softer. The average temperature inside of Pool2 is +15^{0}C. By pipeline this mixture is sent to the Pool3 where the temperature increases up to +300^{0}C and more oil and solids is separated as a residual product and water, as a vapor, turns into the condensation. Then, the mixture is pumped to the Pool4 where the temperature reaches +480^{0}C by using electricity (GEO365.no. (2015). Then, solids are collected and cooled.

Picture 23: Treatment process at the plant (Photo: Alexandra Boyarinova).

On the Figure below is presented a schema of water treatment plant. At point “T52” there is an entrance for the pipeline to the sea. The water treatment plan is working during the whole year. To keep the continuous circulation system, water goes through the whole process again and again. In the process line several sampling points are selected. Results show how the process goes and controls. During this step, values of pH, nutrients, O2, chlorides, temperature, TOC and conductivity can tell where the process line should be regulated. If so, the outlet of cleaned water to the sea will be delayed in 4-6 days. In a case of defects in the process line, PLC facilities and other alarms will notify immediately.

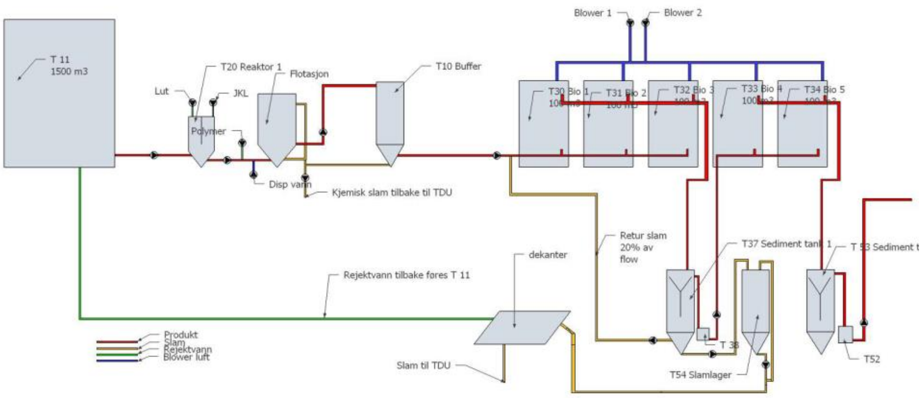


Figure 18: Flow diagram of water treatment system (Franzefoss, 2014).

The water treatment system consists of two areas: chemical purification and biological purification. "T11" presents a tank of 1500m3 where external water is mixed to the desired concentration with the water from soil-machine. On the way to "T10" the liquid goes through the chemical precipitation. In "T10" more chemicals are used to separate deposition. Then the second part of the purification of water starts. There are 5 Biotanks at water treatment plant. Biological process there is performed by usage of microorganisms under special conditions to separate more heavy metals, oil and destroy phenols. Three of Biotanks ("T30", "T31", and "T32") have an activated sludge. Two ("T33", "T34") – liquid contact filters. After water treatment 99% of water – perfectly cleaned water is sent directly to the sea. The rest, 1%, goes again to the treatment process. Furthermore, for the bio sludge there are two sedimentation tanks ("T37", "T53") and a tank for sludge storage ("T54"). Sludge is dewatered in a centrifuge and goes through the thermal treatment in soil-machine.
As a result, the drilling waste (OBDC with OBDM0 from NCS ends up at plan of Franzefoss at Husøya as oil, stones and water. These days it is not possible to receive more separated solids than 50%, water - than 40% and oil - than 10% at temperature higher than $+480^0$C.

Control of treatment process is performed by the crew of the plant at Husøya, 18 employees. There are 2workers in a machine room who control the treatment process during shift, 8hrs. The plant is working 24 hours, thus, 12 employees are working in a machine room. 6 persons are working day time.

4.3.2.4 Value created by this type of cargo and challenges in WM

Nowadays it is well known that any business is successful and is driven for benefits until there is at least one positive reason and motivation to continue. This fact very strong connects with the value that business derives. Respondents from NGI and Franzefoss were interviewed about the value that was created for them as downstream parties during the WM of drill cuttings.

One of the values identified at Franzefoss is the time of handling and empting of tanks. The emptying process of ISO-tank differs from CTT and varies much. "*That is very* *difficult to answer. It depends on the consistency/viscosity on the cuttings*", -mentions respondent from NGI. From ISO-tank the drilling waste is pumped out by air compressor. Air compressor has a pipeline that connects the plant for further treatment.

One **CTT** requires approximately 45minuts - 1 hour. From time to time CTT with OBDC with OBDM but without painting/coating are delivered at the plant at Husøya. The mixture inside of CTT becomes much sticky to the metal. Therefore, workers at the plant need up to 3 hours to clean the CTT properly. In such situations, Franzefoss immediately informs Halliburton about which CTT is not painted/coated inside. Next time this CTT will be replaced by another one. Then, the average time to clean one CTT is agreed between NGI and Franzefoss as 1,5 hours.

One **ISO-tank** requires approximately 20 minutes. A special unique designed form ("a drop") of ISO-tank requires a usage of air compressor/vacuum pump to empty/clean it inside but not a manual labour as it is impossible to penetrate into it like in CTT. There were some ISO-tanks that needed longer time to be cleaned.

Furthermore, the following tree byproducts are received by Franzefoss at Husøya and present the value created by drill cuttings.

Solids. The formation of solids received at the plant is different from what geologists are used to. Solids are not a hazardous and cannot be pumped, thus, they are loaded to the cutting skips/tanks and delivered to the nature as landfill by trucks. The samples of solids at landfill show that percentage of oil is below 2% that is permitted and can be used as an advantage. The total organic content is considered as "clean". In view of the fact that oil is inert, the leakages had being never seen.

Water. Nowadays at the plant it is not possible to receive more than 40% of water after water treatment process.

Oil. Oil is used as a sale product. Franzefoss sells 90% of oil to the industrial customers in Norway and 10% is used at the plan as alternative for electricity - fuel/diesel for "Burner" to heat machines and keep the temperature in Pool3 up to +300^{0}C, thus, this oil is burned. Three times during the year ships are coming to load the oil received after treatment process.

Nowadays the plan of Franzefoss at Husøya has not a possibility to sell the received oil to industrial customers outside of Norway in view of the fact that bigger amount of cars and bigger volume of OBDC with OBDM is required as well as bigger amount of customers in Europe. That fact shows oil can be used as a product for "Resell" to, probably, the last customer that still can create the value from this byproduct.

Barriers for PSV: WN was located and TBR is located on NCS where the weather conditions are harsh with almost a stormy weather all time. That is why the risk of rapid change of weather is big. This fact directly influences on the time schedule of PSV to deliver CTT/ISO-tanks to the shore, Vestbase. Thus there could and can be undesirable delays in the whole chain. This fact shows the reality of unpredictability, lack of clarity and unstability.

Risks during handling/transportation: Vestbase is the supply base and provides different services to many companies including those which work in oil and gas industry in offshore. Thus, there are a lot of movements at Vestbase's area by cranes and heavy vehicles besides movements related to handling of CTT/ISO-tanks. Therefore, during the handling of CTT/ISO-tanks "*there is always a risk of damages and injuries*", - mentions respondent from NGI. In addition to this, there is very important that everybody will follow the required procedures during handling heavy goods from PSV to the berth.

Challenges at Vestbase: The most important thing at Vestbase is to provide the whole process of handling CTT/ISO-tanks without any damages and injuries at all even "*being inside the tight time schedule of the rig*", says respondent from NGI.

Challenges for NGI: CTT/ISO-tanks are considered by NGI as a very important type of cargo in view of the fact that inside of tanks there is a hazardous waste that must be handled properly and according regulations and instructions. Thus, "*it has a big monetary value. And it's one of the most important things in the contract we have with Shell*", - mentioned respondent from NGI.

Challenges related to received products after treatment at Husøya:

Solids: "*solids can be used in concrete and asphalt production (Must be approved from the users)*", - mentions respondent from Franzefoss. "The ideal would be if we could adopt the sand. Nowadays this question is under discussion with buyers" (GEO365.no, 2015).

Water: Water has to be returned to the nature, at sea, as well as solids and thus, has a negative value (which is the cleaning cost for the water and negative monetary effect for Franzefoss). Until today another opportunity for usage of this type of water, unfortunately, was not found.

Oil: "*Received oil can be reused instead of burning (energy utilize) it in industry*", - respondent from Franzefoss mentions. Furthermore, there are some obstacles: "*Barriers against pollution: Oil collector and operator instructions*", - respondent from Franzefoss adds.

Based on the information received from respondents and other information about actors' activities related to the case description, the model of value creation from drilling waste is presented below.

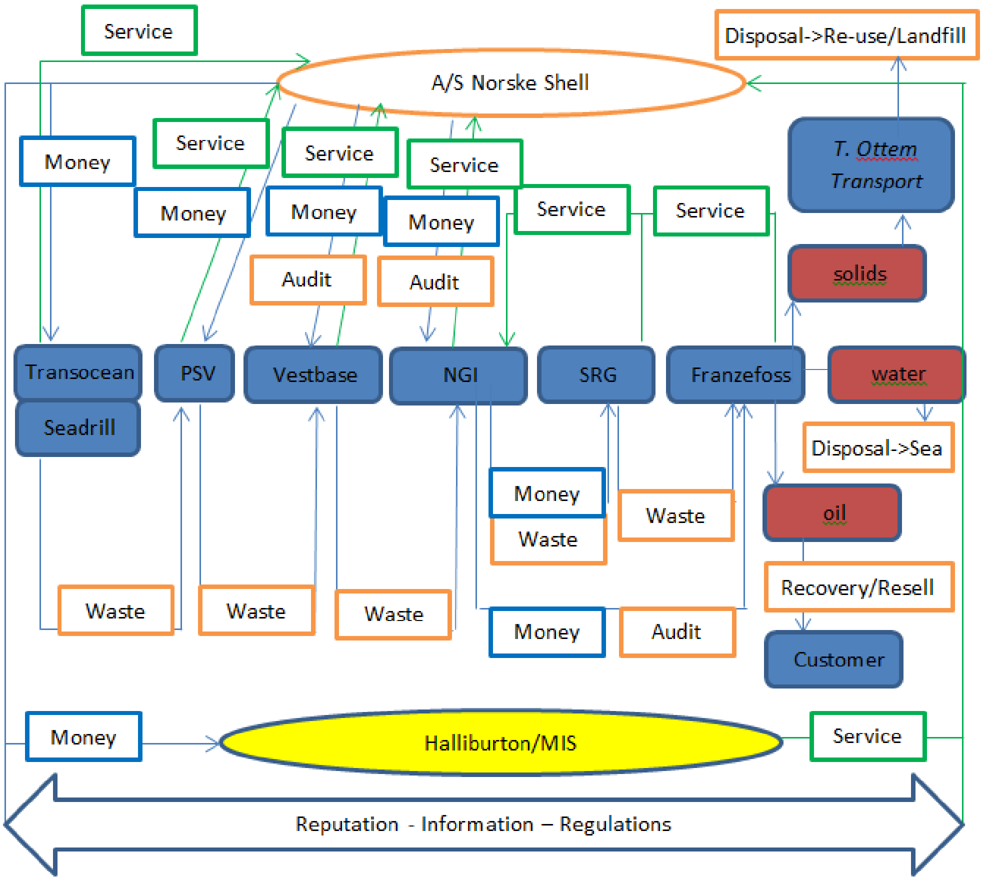


Figure 19: Value creation from drill cuttings.

From the figure above it is seen that Shell pays a main role in the whole chain. Furthermore, information goes through whole chain between downstream parties, keeping the law and applying regulations is one of cores for Shell, thus, reputation of every participant in a chain has its direct effect on the Shell's reputation. In addition, only three company: Halliburton, MIS and NGI have Shell's credit for further fulfillment of activities in the RL under their control. Money, service and audit were identified as main characteristics of value created by drill cuttings.

The current case presents the full picture of movements and business relations between participants. Based on mentioned above, drill cuttings has a great value for NGI and almost don't give any financial benefits to Franzefoss as water and solids are disposal and only oil can be profitable.

4.3.3 RQ3: How RL process for this type of cargo is managed?

In this section will be given explanation of how RL process that was created by OBDC with OBDM is managed presenting the business relationship between waste producer Shell and other actors according contracts signed by them, the importance of fulfilment requirements of the main organizer of the whole drilling waste stream, Shell, according safety, detailed presentation of integration treatment process at Husøya meeting the regulations, and the list of regulations that need to be observed for better handling and transportation of OBDC with OBDM from TBR/WN up to the last customer.

Nowadays, the increased demand of oil and gas and, thus, the increased environmental footprint at all require the creation of new technologies to minimize the waste and to present greener ways for the treatment. As Halliburton and MIS play a role of suppliers of drilling fluids and the system to boards of TBR and WN, Shell shows the respect and the trust to them and their best solutions for drilling waste management.

Halliburton is well known as the company that presents wide line of equipment for different operations in oil and gas industry that has a special design required by customer. Furthermore, different methods are planned for maximization of drilling efficiency, oil recovery and, at the same time, the safety - of all operations and also, the safe transportation of drill cuttings on PSV. In addition to this, the company pays much attention to the meeting of environmental standards and requirements of legislation in force because it directly relates to the reputation of the company, possible savings for the customer and thus, the effective business relationship. Moreover, the company presents very effective control and support according handling of CTT in onshore. Good environmentally friendly solutions in the past today require new challenges. That is why Halliburton changes its technologies continuously improving them and developing more environmentally friendly drilling fluids to provide better drilling waste management (Halliburton, 2015b).

MIS considers that as soon as drill cuttings are carried up to the surface, they become a loss for the company – operator in offshore and have a negative effect for its profit. Thus, the request comes to more efficient handling of the drilling waste and its treatment (MI Swaco, 2015a). MIS offers good solutions for drilling waste based on safety, correct design of the system delivered on board and on PSV. The design of ISO-tank presents its own positive characteristics that give advantages over other type of tanks.

4.3.3.1 Contracts

Business relationship between actors is presented by the following:

Shell – Transocean/SL. Shell has signed contracts for drilling operations with Transocean and SL from boards of TBR at Ormen Lange and WN at Draugen. The rig/drilling ship day rent is paid by Shell.

Shell – PSV. According to the interview with respondent from Shell, the company has contracts with several shipping companies that provide PSV. It is considered in the contract with Shell that PSV will supply drilling ships and platforms at Ormen Lange and Draugen with necessary goods from Vestbase in Kristiansund. The payment is according the contract between Shell and PSV owners.

Shell – Vestbase. Shell has a contract with Vestbase. This contract is a supply base contract, handling of materials going out and coming in from the off-shore installations. Shell pays to Vestbase for provided technical and handling facilities: crane‘s handling of

CTT/ISO-tanks from/on PSV's board, reach stacker's movements with driver, storage of CTT/ISO-tanks on qui side, all kinds of way support-provides at Vestbase.

Shell – NGI. The company has signed contract with NGI for total treatment and processing the waste (covers all fractions of waste produced by Shell). Furthermore, in this contract NGI provides industrial services: cleaning the tanks on board of PSV, storage of tanks on PSV. Thus, Shell being the major offshore producer of the waste delivered to Vestbase by PSV, pays special attention to the proper fulfilment of duties by downstream companies according the environmental friendly treatment as this has a direct influence on the reputation of the company. NGI is the last company in the chain Shell pays to. Trading of the drilling waste (OBDM with OBDC) starts by NGI.

NGI – SRG. As NGI is involved in the value chain, the company has a signed contract with SRG, as the subcontractor, for all transport operations from Vestbase to Husøya using the special frame suited for the tanks to empty them.

NGI – Franzefoss. NGI is interested into safe and environmental friendly treatment of waste. The company pays to Franzefoss for further treatment of drilling waste - all operations at Husøya. NGI doesn't have a written and signed contract with Franzefoss for treatment of OBDC with OBDM. This kind of business relationship allows NGI, if NGI has such desire, to deliver tanks from Vestbase to any another treatment plant in any day. As the plant at Husøya is at a short distance from Vestbase, the transportation costs are competitive and suit the authorities of NGI. Furthermore, NGI and Franzefoss has an agreement about the approximate number of tanks delivered to the plant and the area the OBDC with OBDM is coming from (Ormen Lange from TBR) as well as the price per ton. In view of the fact that at Husøya's plant Franzefoss obtains from drilling waste good crude oil, clean water and clean solids, the trading of oil starts at Husøya by Franzefoss.

Respondents from NGI periodically check the correct performance of treatment process at the plant at Husøya. As each tank is accompanied with Declaration, and Declaration is scanned by NGI, NGI is informed about actual waste tonnage delivered at the plant.

Franzefoss - T. Ottem Transport AS - Franzefoss Lia. Until 1st February 2015 the transportation of solids was performed by Brødrene Bakk AS to the licensed solid waste landfill at area in Vestnes controlled by Vestnes Renovasjon AS. From 1st February 2015 the transportation is performed by T. Ottem Transport AS to the licensed landfill in Trondheim area being under control of Franzefoss Lia. "*This has a negative value (cost) for Franzefoss in Kristiansund*", - added respondent from Franzefoss. On the picture below it is possible to see that licensed landfills are engineered by special way to prevent any leakage and safe the environment and the land belonging to nearby residents. Periodical reports and records about condition of landfills are always done to present that the requirements of a law are implemented.

Picture 24: Landfill at Franzefoss Lia, Trondheim (Franzefoss, 2015d).

Shell – Halliburton/M-I Swaco. For drilling operations on WN Shell had the signed contract with MIS for delivery of drilling fluids system: drilling fluid, equipment and ISO tanks system. For drilling operations on TBR Shell has the signed contract with Halliburton. It includes the delivery of drilling fluid system with CTT. The respondent from Shell mentioned the following: "*The system in use depends on what is the company that has the contract for delivery the drilling fluids to the operation*".

4.3.3.2 Safety under the guidance of Shell: Vestbase - NGI – SRG - Franzefoss

Running a safe business is one of the main core principles of sustainability for Shell. Any operations that are not planed or discussed in details or are done without permission may result incidents, harm people, cause fatalities. Thus, the responsibility occurs. It is supported by presented HSE reports and safe work conditions. Furthermore, in each of 19 administrative regions/countries in Norway (fylke) authorities (fylkeskommunen) issue the permissions and law that should be performed by every participant in the chain controlled by Shell. "*Every CTT has a yellow paper with the name "Shell*", - was mentioned by respondent from Shell and is presented on the picture below.

The safety culture is very important for Shell; therefore, attention is paid to a safe behaviour. There was a belief that it is possible to provide operations with zero incidences or fatalities, thus, Goal Zero programme was created for staff together with 12 Life-Saving Rules which became mandatory and are presented in Appendix A Picture 1 (Shell, 2015g). These rules are printed on the flexible plastic material that can be easily washed and be together with ID card hung on the neck. The failure to implement these rules can lead up to the termination of employee's contract with Shell immediately and in the future. As a result, year 2014 became a first safe year for Shell.

Halliburton/MIS. These two companies also play the important role in a whole chain related to the handling and transportation of drill cuttings, thus, the safety for both of them has a value and is a major part in their business. Halliburton created for its workers 10 Life Rules that should be known and used at work to prevent and minimize until zero any risks and damages. Zero incidents are a significant movement for Halliburton to improve its HSE (Appendix A Picture 2). MIS created its own 18 Life Saving Rules: 8 of them are identified as Core Rules and other, 10, as Supplementary Rules (Appendix A Picture 3).

Vestbase – Franzefoss. In addition to all listed above, there is another moment that should be taken into consideration. The Husøya is an inhabited island where Franzefoss's plant was built. Roads on the Husøya are disposed in close proximity to houses. Furthermore, few houses and the plant are situated not that far from each other. The noise made by engines of truck cars on Husøya disturbs inhabitants. Thus, the special agreement and rules were created: all truck cars' movements are allowed and must be done at Husøya only during Monday-Friday by 5pm. On this account all CTT or ISO tanks delivered at Vestbase on Fridays evening must be stored during the weekend.

SRG – Franzefoss. Carrying CTT or ISO-tanks by trucks is enough dangerous even container's door in CTT or outlet in ISO-tank are closed. Any inattentiveness or negligence on the road is a risk. Therefore, according to the interview with Shell's respondent, it is not allowed for truck drivers to use mobile phones while driving from Vestbase to Husøya and back: do not answer on phone calls/messages, do not make any calls/messages, and do not use any Bluetooth hands free.

Picture 25: Labeling with declaration number on Shell's CTT at Vestbase (Photo: Alexandra Boyarinova).

AS for Shell the total waste produced at TBR or WN is a kind of special kind of expenses that cannot be covered that much, the company is interested and tries to minimize the volume of waste at all. Being a leading player in the oil and gas industry, Shell is interested to keep the good reputation longer. That's why the company is interested in everything goes as it was agreed, as it was planned and according rules. Furthermore, the company is interested in good results of audit and an inspection of all participants in the chain and has a right to carry out a small audit if it is necessary (such as putting oily water into the sea at Husøya).

4.3.3.3 Emission, sampling and frequency. Keeping the regulations at Franzefoss, Husøya

Nowadays the most used kind of drilling mud is OBDM that cannot be dumped on the seabed. Thus, it requires to be delivered to onshore for the further treatment process. If to compare with mining industry, during last years the harmful emissions from the oil industry especially from operations, were significantly reduced (GEO365.no, 2015).

The preparation of samples and the frequency is discussed with externally accredited laboratory. This step is very important. Production plans – are the one side and correct documentation – is another side. If results differ, the frequency of sampling will be varied.

Every day several samples are taken at the plant. A mix of daily sampling presents the month sample. At “T52” samples of effluent water are taken. The most valuable parameters are of TOC, oil and barium. As water-soluble barium compounds are highly toxic and have a flotation characteristic, there is a necessity to get as good as possible challenges. Furthermore, every day measurements allow regulating the operation process and emission without interruption. Several other parameters vary not much, thus, they can be measured monthly.

Analysis of per- and polyfluorinated compounds in a waste is a costly analyzes and are allowed to checked every six months. Some parameters can be measured twice per year and be reconsidered after three years.

Parameter	Importance	Frequency
pH	Is a key parameter for good operation process	Monthly
TOC	Relates to emission, feed tank and production line, provides efficient operations	Daily
Heavy metals	Relates to sea disposal	Monthly
oil	Relates to sea disposal	Monthly and weekly
barium	Small parties can fail to precipitate in water	Monthly
O2, temperature, conductivity, Cl, NO3, NH4, P	Are essential for bacterial activity in the biological process. An adjustment operation	Daily

Table 11: Overview of monitoring of emissions from process water.

The volume of water discharged to the sea from the water treatment plant is measured by water gauge located on the pipeline.

The sampling from oil separator, before water is discharged to the sea, is taken twice in a year and does not show the necessity to increase the frequency of sampling.

In a case when drill cuttings have a radioactive materials, the plant of Franzefoss at Husøya has a license to receive and store radioactive waste with radioactivity up to 10 Bq (Be-7, C-14, F-18, Cl-38, K-40) (LOVDATA, 2015).

Resoil facility is presented by three thermal processing machines. Each has its own oil burner. The gas from burners is discharged from blowers – air emission. Special sensors to measure the gas are mounted on the pipe. There are limitations to values of total dust, TOC, HF, HCl, SO2, NOx and CO which should be measured every 7th day.

The closeness of the plan at Husøya to residential houses requires Franzefoss to limit the noise according to the contract.

The Plans for emission reduction/purification are sent periodically to Miljødirektoratet, are detail discussed.

Every 4 years the impacts of emissions from Resoil plant and water treatment plant should be monitored to present the biological conditions and influence of emissions on living organisms and benthic fauna. Data from emission control from the previous year should be reported by 1 March each year to the Miljødirektoratet via Altinn.

According to the report about status during 2012, the plant of Franzefoss at Husøya was characterized as moderate ecological condition and presents a good example of recycling process. Thus, it was recommended to continue following the scheduled measuring program about receiving, storage and treatment of specified types of hazardous waste.

Modern technological society nowadays has created hazardous waste which we cannot get rid of on a simple way (Franzefoss, 2015c). Only the plant that received a special license from Fylkesmannen and Miljødirektoratet has a right to collect, handle, treat and manage hazardous waste. When truck with tank arrives at Husøya, the driver presents the completed and signed Declaration form.

Furthermore, plant has special modern mobile equipment and technics from the mining industry to process the waste into materials in environmentally positive way as possible. Franzefoss is a fully qualified vendor in Achilles and processing plants are all ISO NS-EN 14001 and ISO NS-EN 9001 certified (Franzefoss, 2015a). These licenses allow to collect, storage, pack and deliver different amount of hazardous waste. Authorities of Franzefoss are interested to present the best technologies which are available these days to improve process and quality of performed services. Furthermore, continuous update on development and government regulations together with professionalism and are appreciated by companies in Norwegian oil industry.

Authorities of the plant at Husøya is a solid player in the oil environment field in North-West Norway and offer cost effective flexible waste solutions that can be customized and where environmental sustainability is a priority (Franzefoss, 2015b). All cars and drivers that transport OBDC with OBDM are ADR approved.

4.3.3.4 Waste Management in Norway. Regulations

According statistics from NGI, the amount of hazardous waste received from TBR and handled by NGI at Vestbase in a period January - July 2013 was 97%; two major categories of hazardous waste were: drilling waste and oil contaminated material, 30% and 70% respectively (Ahmed, 2014).

Today management and rules are connected: effective management of the waste requires following the rules and keep the law.

According to the fact that Halliburton/MIS were using OBDM for drilling operations at TBR/WN, drill cuttings becoming oily and are considered as hazardous waste. In case of radioactive content in drill cutting more than 1Bq/g, they must be treated as radioactive waste. The handling process of hazardous waste needs the implementation of strict requirements of law.

To classify hazardous wastes regarding to its state, in Norway the special codes were created and registered in the Norwegian waste code ("avfallsstoffnummer"). They are divided by 3 categories and are provided in Norwegian and English language: hazardous, radioactive, to be landfilled and radioactive not to be landfilled.

British Petroleum in its HSE Directive 6 for hazardous materials and waste on the NCS, Attachment 6, considers the drilling waste in CTT/ISO-tanks, OBDC with OBDM, as "Borerelatert avfall" or "Kaks med oljebaser borevæske" under the code "7143" ("avfallstoffnmr") for the Norwegian waste code list and "165072" for EWL (EU system) (Ravnås, 2015).

Drill cuttings together with drilling mud are collected at systems on board of TBR/WN or at CTT/ISO-tanks on PSV's board and, therefore, the "Common declaration form for hazardous waste and radioactive waste" for each container is filled out correctly under waste producer's responsibility. One source that provides waste producer (Shell) with the information regarding guidance for correct filling out of Declaration is "An introduction to handling and declaration of hazardous waste 2013" written by NORSAS. Another source where the information can be received is the Norwegian Oil and Gas Association (Norsk olje og gass, NOROG) which presents Norwegian oil and gas industry. Guidelines are created in accordance with other regulations, guides and standards, and, recommended on the assumption of better WM and environment. Classes, categories of hazardous waste and required documentation are provided in five attachments to 093-Recommended guidelines for Waste Management in the offshore industry.

According recommendations from NOROG (2013) big bags should not be used for transportation of drill cuttings that may hold fluids and packaging should to be labelled with declaration number (the yellow sticker of Shell on one of CTT at Vestbase (Picture 25). In addition, packaging and labelling are also regulated by rules in Article 19 of Directive 2008/98/EC (EC, 2008).

The intensive supervision of all operations regarding OBDC with OBDM as a hazardous waste made on board of TBR/WN, on PSV, outside of shore, is exercised by Norwegian Environment Agency. This means that waste producer (Shell) as soon as OBDC with OBDM are carried out up to the surface, no longer control movement of hazardous waste because Norwegian Environment Agency borrow/accept it for further control. The Norwegian Environment Agency is operating under the Ministry of Climate and Environment.

Regulations related to the recycling and handling of OBDC with OBDM as a hazardous waste are regulated in Chapter 11 of Waste Regulations (Avfallsforskriften) presented by the Norwegian Environment Agency (Miljødirektoratet) in 2004 and provided in the unofficial translation from February 2012 (Miljødirektoratet, 2012). Waste Regulations for hazardous waste are created to guarantee that its handling does not cause pollution or damage to people or animals (Waste Regulations, 2012). In addition, the regulations for handling radioactive waste are presented in chapter 16 in Norwegian language.

Transportation of OBDC with OBDM from offshore (TBR/WN) by PSV to onshore supply base (Vestbase) is regulated by IMDG, regulations for transportation by sea of hazardous waste that can cause a "safety risk to fellow travelers. Such goods are called dangerous goods" (NORSAS, 2013). In addition, master of PSV need to fill out the shipper's declaration with ship's name. The special Multimodal dangerous goods form need to be filled out for transportation of OBDC with OBDM (Appendix B Form 1).

Transportation of OBDC with OBDM from Vestbase to Husøya, Franzefoss, is regulated by ADR, regulations for transportation of hazardous waste by road.

The civil protection and safety during the handling and transportation of OBDC with OBDM as a hazardous products including hazardous waste by rail transport and road is regulated by Norwegian Directorate for Civil Protection (Direktoratet for samfunnssikkerhet og beredskap). Human lives (workers at Vestbase, NGI, SRG and Franzefoss) are protected by regulations from DSB.

The Norwegian Pollution Control Act is a typical enabling act, gives regulations for OBDC with OBDM as a hazardous waste treatment and regulates of almost all operations in WM process such as packaging, delivery and declaration. The treatment of hazardous waste is allowed unless this is permitted by law.

The handling of hazardous waste on a par with chemical waste and the disposal of these types of waste is regulated by Guidance on hazardous waste management provided (Deklarasjon og transport av farlig avfall på vei) by NFFA. Handling of OBDC with OBDM in CTT/ISO-tanks from Vestbase till Husøya is under control of NFF regulations.

It is recommended by NOROG (2013) that OBDC with OBDM as a hazardous waste should be delivered to the waste facility which has a special license and this fact fully fulfilled by Shell and NGI that send the drilling waste in CTT/ISO-tanks to Franzefoss's licensed plant for further treatment located in Norway, Husøya.

Solids received at Franzefoss are sent by trucks by TOT to landfill disposal according to a specific guidance recommended and presented in "Guide to characterization and recipient control of waste for disposal" ("Veileder til karakterisering og mottakskontroll av avfall til deponi" 2010).

In addition, three Norwegian Waste Regulations, two Landfill Directives and Incineration Directive present the national legislation in Norway (EIONET, 2015). Two Landfill Directives regulate the landfill in Trondheim.

4.4 Summary

Oily drill cuttings, the type of product, hazardous waste, produced in NCS on board of TBR/WN and then, pumped into CTT/ISO-tanks provided by Halliburton/MIS on PSV's board, delivered to Vestbase and then to Husøya through NGI and SRG for further treatment and transportation by TOT for further disposal presented better understanding of the complex technical process, the part of RL, created by them. Furthermore, the management of RL process was explained in details. Business relationship between all actors involved into the created by Shell (waste producer) business process was presented to show the interests of every participant. In addition, it was give the understanding that the successful business requires the fulfillment of strict regulations created by different Administrations in Norway. In addition, any business can be successful and efficient until there is one big interest to continue the business - the value created by every strong participant in the whole process was provided to the reader.

5.0 Analysis and discussion

5.1 Introduction

The main purpose of this study is the understanding of how the reverse logistics of hazardous oily drill cuttings is organized and presented at Shell, how the lean is implemented into the reverse supply chain; how the value is created from the handling of hazardous waste by Shell and other actors that are involved into the process due to the type of services they can provide and provide to the main waste producer, Shell.

Three research questions are presented. The first research question displays the discussion of the role of ownership of hazardous waste for their first owner, Shell, and further owners to those this type of cargo is delivered according the researches in the literature and real case; the role of each actor was described and presented; the complexity of the whole process and the importance of being the owner is discussed. The second research question discussing the role of RL for Shell, importance of rules created by Shell, Halliburton and MIS as the main participants, the participation of all actors and their contribution to the RSC, their cooperation, discussion of the possible percentage return rate after the treatment process due to strict law and legislation. The parallel between real world cases of RL implementation and the possible usage of these practices for Shell was discussed together with the risk assessment in the multimodal SC presented in the real situation with hazardous drill cuttings and supported by research in the literature, the organization of HWM at Shell and other actors, possible usage of research in Portugal for more effective handling of hazardous drill cuttings at Shell. The third research question discusses the results of implemented lean, lean WM at Shell and presents the results of green lean, sustainability and green SCM at Shell. Furthermore, the importance to analyze the risk management at Shell together with business uncertainly was discussed being supported by reteaches in the literature in a par with the importance of logistics in SCM. Moreover, some gaps in the literature were presented due to the fact that researches just have been started not so long time ago and need the time to see the results to fins new solutions or directions for more efficient results.

5.2 RQ1: Oil-based drill cuttings transported in CTT/ISO-tanks

Every year the number of drilling rigs set along the NCS is increasing. The difference in depths presents a different amount of drill cuttings received on the surface. Norwegian oil and gas offshore industry still is placed on the leading position producing the hugest amount of oil-contaminated hazardous waste. Furthermore, the well drilling provides the most amount of waste in offshore. This paper presents the behavior and the point of view of Shell according drill cuttings but not the point of view of all companies that are operators of other fields along NCS.

The first research question describes and presents the basic understanding of the type of the cargo, drill cuttings, that is produced during drilling operations in offshore in Norwegian Sea, on the board of drilling rig, TB, that relates to the company named Transocean, in gas field Ormen Lange, and on board of drilling ship, WN, that relates to the company named Seadrill, in an oil field Draugen. The operator in both fields is Shell. It was found that better quality for drilling operation at these fields OBDM can provide, thus, drill cuttings become oily and turn to hazardous waste type. As the main player and organizer of the whole process is Shell, it becomes the owner not only of the gas and oil pumped on the surface and pipelines for further selling but of drill cuttings that are a hazardous waste.

In most cases in offshore oil-based drill cuttings together with oil-based drilling mud are pumped on the surface where they are separated on drilling rig or drilling ship inside of shale shakers and being without oil at all can be loaded to skips as a bulk dry non-hazardous cargo and then transported by PSV to the shore, Vestbase for further storage and landfill afterwards. Or after being separated and being gone through shale shakers can be discharges to the seabed or to the empty placed between soils' levels near the drilling well, in an injection well.

However, the situation that is presented in this paper presents a unique case to be studied and examined. The ownership is presented in the figure below.

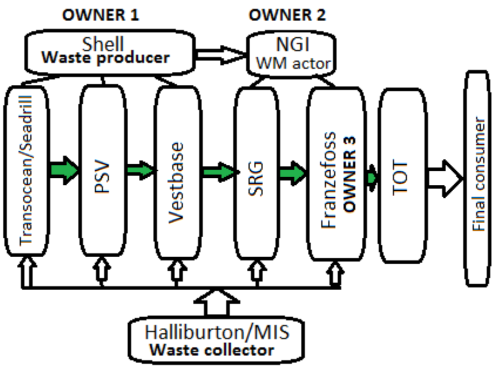


Figure 20: Ownership of drill cuttings.

OBDM carries OBDC on the surface of TBR and WN, and are pumped directly to the CTT/ISO-tanks that are located on PSV and transported to the shore, Vestbase. As it was noticed earlier, such way was figured out by Shell as the most effective way for that time. In case of bad weather conditions or other reasons to transport CTT/ISO-tanks from offshore to Vestbase, shale shakers and skips are more than used on boards of TBR and WN. The chain that was created by OBDC with OBDM is really very complex and long, and thus, involves many participators from the owner of TBR and WN until the owner of the plant at Husøya, Franzefoss, and the owner of licensed landfill in Trondheim. Furthermore, this chain is not only controlled by Shell but by NGI, Halliburton and MIS that have a respect and trust from Shell's side.

It can be seen that the whole chain is unique by its own and as Pongracz and Pohjola (2004) mentioned, has its own effect on the ownership. Carrying OBDC as the hazardous waste Shell has to fulfill the rules and legislation's requests. Thus, the company transports OBDC to Vestbase by PSV as it is provided by contracts Shell – PSV and Shell – Vestbase, and delivers the hazardous cargo to the next owner, NGI, also in accordance with contract Shell – NGI. Therefore, NGI is the secondary owner that found out new advantages of hazardous waste in CTT/ISO-tanks (Pongracz, 2002). At Vestbase Shell considers OBDC with OBDM as the waste that cannot be carried anymore further by its own because the value of cargo is already exhausted for Shell. In addition to this, expenses for Shell become more than the profit gained, and it shows the situation when the ownership is transferred to the next owner (Pongracz and Pohjola, 2004). Nevertheless, Shell can transfer it to the sub-contractor as Zakar and Clift (2010) underlined, to NGI. The cargo becomes a unit of trade presenting the economic value for its owners. Here it is seen that OBDC with OBDM is considered and recognized by NGI as not the waste but as the resource that can be used again and the profit can be received. as it was mentioned earlier from interview with respondent from NGI, there is a big monetary value for the company to carry OBDC with OBDM. As the secondary owner of cargo, NGI gets an opportunity to manipulate the properties of the hazardous waste and becomes responsible.

PSV and SRG provide the transportation of OBDC with OBDM inside of CTT/ISO-tanks by sea and road. Therefore, as the owner of storage capacity (tanks) with hazardous waste is required to carry these tanks from TBR/WN to Vestbase and from Vestbase to Husøya delivering tanks on a safety way without any right to use this cargo for own purposes. TOT delivers clean solids from Husøya to landfill in Trondheim and is interested in the economic issue of the transportation presented. PSV, SRG and TOT provide vessels, trucks with a special design and truck for dry bulk cargo to the chain where they are involved in and that is created by OBDC with OBDM. During transportation of CTT/ISO-tanks there is no environmental footprint left by tank or hazardous waste they have inside but the emission PSV and trucks emit.

Vestbase providing storage crane facilities presents a good quality of services being a mediator between PSV and NGI. Providing the space for storage to other types of cargoes coming from other rigs and drilling ships from other oil and gas fields, Vestbase plays an important role for Shell being involved into the process, as an owner of the licensed terminal for handling hazardous waste such as OBDC with OBDM in CTT/ISO-tanks.

Franzefoss is the last participant in the process that carries OBDC with OBDM as the hazardous waste that is pumped into CTT/ISO-tanks. The plant at Husøya presents the treatments process (chemical and biological) that produces at the end the clean oil, clean water and clean solids. Franzefoss being involved into the process becomes the owner of not tanks with hazardous cargo but only of hazardous cargo. Strict rules and legislation press Franzefoss for reduced emission and decreased footprint on the environment around plant.

It is possible to assume that Franzefoss still can have an opportunity to use advantages of clean solids and not think about them as temporary useless and not “throw” them away to landfill providing the negative value for the company. It is possible to assume that Franzefoss has not a neglect of opportunities but the lack of more possible opportunities to use water and solids better and with economic issues due to legislations according pollution and instructions that Franzefoss receives from collector of oil and operator. Though water has a negative value for Franzefoss and there is no other opportunity to use the clean water but only for returning it back, to the sea, the possibility to use it for washing tanks or other storage capacities could be examined. The question about usage of solids or sand is, unfortunately, under discussion with buyers nowadays (GEO365.no, 2015).

The situation at Franzefoss shows that the biggest economic value from byproducts received after treatment process, only oil has its positive effect, and the efficiency can be increased due to new available technologies and bigger amount of OBDC with OBDM delivered to the plant.

Some researches shows that drill cuttings can be beneficially reused, however, the owner must be sure that these drill cuttings are clean enough and don’t contain oil or salt being in a contact with oil-based or bate-base fluid/mud. “Oily cuttings serve the same function as traditional tar-and-chip road surfacing” (DWMIS, 2015). Thus, clean solids can be used as a base for asphalt. Furthermore, it was discovered that clean cuttings can be useful for construction purposes such as block and brick manufacturing. Many positive issues depend on the percentage of oil cuttings/solids still have after thermal treatment. Some experiments were done in United Kingdom where dry clean drill cuttings were used as a fuel at a power plant where they were mixed with coal (DWMIS, 2015).

Halliburton and MIS play a role of mediator in such chain providing TBR and WN with necessary equipment on boards for further treatment of OBDC with OBDM (Baroid TCC unit, skips, HCB Buffer tanks and Pneumatic Cuttings Transfer Pumps on TBR; CLEANCUT cuttings blower, ISO-pumps with VERTI-G cuttings dryers on WN), and proper oil-based drilling fluids for drilling operations from board of TBR and WN in gas and oil fields respectively. It is understandable that these two companies are important players in the chain as the only one creator and mover of drill cuttings producing them in the drilling well and turning them to hazardous type of waste. Both companies are partly owners of drill cuttings and thus, act according the value drill cuttings produce - the whole process.

As a result, enough complex process requires the negligence and profusion to be eliminated (Jensen and Meckling, 1976); shows up the value of each participator that moves them and the process; shows up the social value created during the process that presents to the owners more effective directions; explains how the environment impacts on each of participants and how they act on challenges evoked; presents the most suitable ownership structure for the time OBDC with OBDM were produced at TBR and WN under guidance of Shell.

Based on description of oil-based drill cuttings and oil-based drilling mud the author of this paper answered on the first research question about what is the type of cargo transported in CTT/ISO-tanks. The complexity of the process created by this type of cargo and the importance of being the owner of such type of hazardous waste at each part of the long and complicated process where only one company is the organizer and the most interested in handling and treatment of this type of hazardous cargo, Shell, was presented.

5.3 RQ2: RL of drill cuttings

As the forward supply chain or upstream business of Shell consists of investigation and production of natural gas and crude oil, drill cuttings, thus, are a part of upstream business. However, drill cuttings originate from the drilling well's bottom which is moving deeper each time the drill bit is in the action. Then drill cuttings are lifted up on the surface by oil-based drilling mud becoming oily. This moment is very important to understand because drill cuttings become a hazardous waste as soon as they left the drilling well's bottom being even not used as a product in the forward supply chain. Therefore, OBDC are not participating in the flow up "to the point of consumption" as Rogers and Tibben-Lembke (1998) underlined but is participating in the opposite direction, "from the point of consumption to the point of origin" but being separated, treated and cleaned at treatment plant at Husøya related to Franzefoss. Thereafter, became an unnecessary part of the drilling process oil-based drill cuttings as a hazardous waste should be handled and treated accordingly. During the process created by this type of cargo, the value is recaptured by each company involved. Examining the fact that theoretically, from the beginning OBDC are a hazardous waste and cannot be used again, RL gave a new destination to this waste presented three new byproducts/raw materials to Shell, NGI and Franzefoss: oil, water and solids which are cleaned enough and can be used in further operations and enter again into SC. Furthermore, for hazardous waste a lot of programs include RL.

As it is can be seen, in the examined chain each company pays attention to RL creating plans, rules (10 Life Rules at Halliburton, 18 Life Saving Rules at MIS and 12 Life-Saving Rules at Shell), following rules according handling of hazardous waste, creating internal documents at NGI, filling out Declarations for each CTT/ISO-tank where OBDC with OBDM is pumped in. The atmosphere inside of the process is very active and very intensive. Each company-participator was chosen by Shell according the kind of services it provides: PSV, Vestbase and NGI.

By NGI was chosen transport company SRG and Franzefoss due to the closeness to Vestbase. This fact was explained earlier in this paper. TOT and licensed landfill near Trondheim was chosen by Franzefoss. The first contract for delivery of OBDF to WN was between Shell and MIS where ISO-tanks were provided on WN and on PSV. However, due to the quality of OBDF or other reasons next company who delivered OBDF on TBR was Halliburton according signed contract with Shell. It is necessary to underline that the time for empting ISO-tanks and CTT is totally different and shows up the value presented by MIS and Halliburton to Shell and Franzefoss. Nevertheless, not only the time issues should be set on the first place. Therefore, it is necessary to notice that these companies (actors) understood and already gained competitive advantages to improve logistics processes they are involved due to the Norwegian oil and gas industry following to Srivastava (2008). In addition, the treatment plant at Husøya acts already during more than five years that gives clearer picture that authority of Franzefoss know this type of hazardous waste, the conditions of this waste is also estimated, thus, can and have a right to treat it accordingly and properly. Hazardous waste by its own present higher risk to the environment and human health than non-hazardous waste according notices of European Commission (2015a) and the treatment plant at Husøya fulfillments the requirements and strict rules correspondently.

As it is possible to see from the case examined, the interest to RL is big and RL gives a right to more companies to be involved to increase the demand on their services in new chains that was not done earlier. In the literature review it was mentioned that big actors already figured out the importance of value created by system that RL management organizes. Such example can be Shell, the company that not only organized the whole process for handling hazardous waste but also, gave possibilities to show up opportunities and importance of process for chains' actors. Following underlines of Rogers and Tibben-Lembke (1998) that the big return rate depends directly on the size of advantage the company gains, Shell transfers hazardous waste in CTT/ISO-tanks to NGI as soon as tanks were unloaded from PSV on the Vestbase's berth, NGI on its turn, transferred cargo to Franzefoss for proper treatments. Unfortunately, by respondent of Shell it was mentioned that for Shell OBDC with OBDM is only extra expenses and the simple waste that needs to be treated properly. Probably there is an opportunity to sell the oil or water received at Franzefoss to Shell, however another extra expenses will be created and presented due to the transportation costs for Shell. Thus, there is a very small advantage for Shell to pull in OBDC with OBDM as a hazardous waste into the process that was created for TBR and WN.

Different authors mark out that RL has different number of stages that depends on the company's business but four stages are identified as the main. The author of this paper created the RL flow of activities for Shell based on Srivastava (2008).

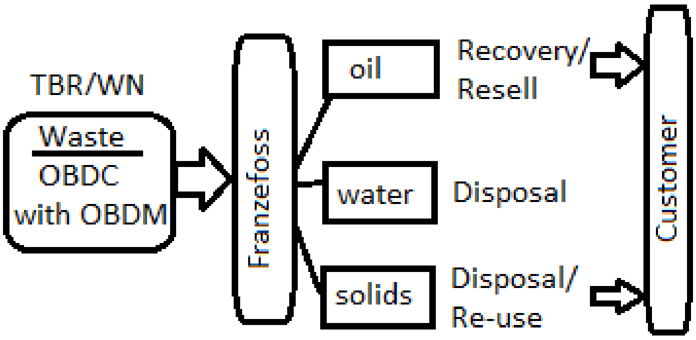


Figure 21: RL flow of activities for OBDC with OBDM at Shell.

As it is possible to understand from the figure, drill cuttings are delivered from TBR/WN to Franzefoss for the treatment where produced clean oil can be resold to the further customer and be recovered at the same place, plant at Husøya as the fuel for burner; water can be only disposed for today as it has no value and "no positive future" for Franzefoss while solids can be sent for disposal as well for now by TOT to landfill near Trondheim or for further re-use that can be discussed later. Thus, a lot of attention from actors is paid to the cost for inventory when it is necessary on Vestbase, transportation by sea and road, and inspection together with control along the whole chain created by drill cuttings as a hazardous waste.

It is necessary to underline that if OBDC with OBDM could be separated and treated only on board of TBR/WN and loaded into skips and transported to Vestbase, there would be no requirement to add the Franzefoss and its treatment plant at Husøya into the chain. However, the solution for situation in 2014-2015 was chosen by Shell (to load OBDC with OBDM into CTT/ISO-tanks) and deliver them for separating and treatment at Husøya. The reader considers this moment as the given opportunity and chance for Franzefoss being invited and involved into the RL created by drill cuttings. Besides this fact, Franzefoss presented the good part of RL after itself inviting TOT, the transportation company, and licensed landfill near Trondheim owned by Franzefoss Lia.

Rogers and Tibben-Lembke (1998) identified besides the flow of packaging, the flow of products showing up the fact that the percentage of return rate is different. This case is possible to see clear in the situation examined in this paper as drill cuttings could be separated on TBR/WN presenting one percentage of return rates of drilling mud and cuttings, and totally different being separated at Husøya. Therefore, Shell has created two different return programs that present different profits and costs. However, the program that suited Shell at 2014-2015 was chosen in spite of some disadvantages it shows up. Rogers and Tibben-Lembke (1998) underlined the "Resell", "Recycle" and "Landfill" as the positive activities in RL process and it is can be seen that Franzefoss utilizes these activities getting advantages of them. Besides this, at Husøya the quality of "new" oil received after treatment is identified as a good and does not differ from the "previous version" following underlines of Tibben-Lembke (2002).

Other actors: PSV, Vestbase and NGI are the permanent actors in the chain of RL created for Shell by drill cuttings in two return programs and, thus, it is clear that these companies due to their good quality services and flexibility in business are chosen by Shell as such characteristics present the direct effect on the company's reputation according Srivastava

(2008). From the other side, it is understandable that implementation of RL activities by Shell allows it to decrease the environmental footprint, decrease costs, decrease the amount of waste for landfill and its quality. Nevertheless, for the main waste producers and organizer, Shell, the return program is not that profitable as for other actors in the chain, and not a maximum cost of recovery system is gained.

The opposite side presents the keeping the law, Directives and legislation. One of them – is the required decreasing of pollution and emission at Husøya and on the way "Vestbase – Husøya" because trucks should deliver CTT/ISO-tanks with hazardous waste inside for further treatment. In addition to the fact that was mentioned earlier in description part, the closeness of the plant to houses is small and stricter rules have place to be according facilities at Husøya and operations at its area. The fact that NGI has chosen Franzefoss due to the closeness to Vestbase presents the environmental impact from implementing RL that relates to green SC. Following Govindan et al. (2015), keeping the law, Directives and improving the economic side which are main keys for green SC, all actors provide to themselves a SC's sustainability and this situation is also presented in empirical case study.

The real situation, empirical case, is oriented on the long-term by Shell. Therefore, different strategies are analyzed by this company and implemented being well managed. It is clear that such process, implemented RL, cannot work without information flow and logistics inside. Moreover, the weakest points are showing up periodically due to RL and are well managed by Shell, as the main actor. In spite of legislations and Directives that are becoming stricter each year, the reader can see that Franzefoss is keeping the regulations on its plant providing required and necessary reports and documents to the appropriate bodies periodically. In addition, relevant programs and instructions are created by Franzefoss as well and were presented and overlooked earlier in this paper.

As it can be seen, the complexity of the process is clear; RL plays an important role for Shell and the downstream chain of activities created by such a hazardous waste as OBDC with OBDM inside of CTT/ISO-tanks; RL also improves the economic, strategic and environment areas of business for each actor that participated in that SC.

In the literature review was presented by Kilik et al. (2015) the case of RL implementation in Turkey, for hazardous waste such as WEEE for possible locations for recycling, storage and disposal of waste according the amount received. In addition to this, the requirements of European Law for hazardous waste and other rules related to Turkey, as the part of Europe, were taken into consideration for creation the specific model. Even the model presented all possible locations in Turkey, as the whole country, such case was examined by the author of this paper to see and overlook possible challenges for the chain created by drill cutting, as also, the hazardous waste but created in Norway. Furthermore, the distance, plant capacities and transportation costs were already added as well as the special type of treatment that was required by some hazard elements inside of WEEE. Thus, such a model could be used as an example for Shell to achieve better return rates and be more profitable in the case of handling drill cuttings from TBR/WN to the last consumer.

Besides the model for handling hazardous waste created and implemented in Turkey, there are a lot of researches for optimal storage or for optimization of transportation such as vehicle problems that are created in accord with provided technologies that time. Nevertheless, even new problems are evoked some optimal model can be still implemented.

Another mathematical model that was overlooked in the literature review was created by Zhang et al. (2011) concerning municipal solid waste management. The possible directions and locations were examined in accordance with location of waste, transportation costs, and transportation capacities, type of disposal at plants, distance, and inventory required. The purpose of the model was to provide the minimum operation cost and time keeping the rules, Directives and law. The uniqueness of this model is the possibility to be implemented in any company after short redesign process according capacities and prices.

RL and its challenges and future were examined in one of sub-chapters in the literature review. Rogers and Tibben-Lembke (1998) interviewing companies identified few groups of barriers that companies faced during their businesses in reverse SC as well. The author of this paper considers that the highest percentage that relates to the connection of RL with other issues as a barrier has a place to be in the process organized by Shell, as the economic issues are very important for the company and, unfortunately are not that good enough. Looking from the other side, the negligence of Shell towards RL at all will have an incredible negative impact on the reputation. Another barrier, the management inattention, is considered by the author as not that high at Shell, as the control of the whole process was presented all the time while the author was at Vestbase and Husøya to be more familiar with the process created by hazardous OBDC with OBDM. The legal issues as a barrier are also not that high at Shell due to the fact that the company is interested to present as small as possible environmental footprint during handling and treatment such type of cargo in CTT/ISO-tanks. Therefore, the willingness and readiness of Shell as the main actor and the organizer of the whole reverse SC to recover the possible value from implementation of RL is obvious.

Pokharel and Mutha (2009) identified inputs and outputs that are parts of RL which are presented in the empirical case as the storage capacities, CTT/ISO-tanks on PSV's board as the inputs, and three new produced byproducts produced according Directives, legislations and relevant rules as the outputs. Therefore, the trust, information sharing, collaboration and the awareness between Shell and other actors is very important, provides the strength to all and has a place already in the reverse SC created by hazardous drill cuttings and well designed by their owner, Shell.

In addition, the author considered necessary to examine the research of multimodal SC and the risk estimation in the South Finland, Gulf of Finland presented by Vilko and Hallikas

(2012). The real world cases show that than more companies are involved into the one process than weaker the connection become between them that may create and evoke undesirable risks at the uncomfortable place and time. Authors underlined that the visibility, collaboration and sharing information in the process is very important as they can display a half of risks and thus, find best possible solutions to protect the whole SC. From the other side, the isolation of any actor of the unwillingness to share the information with others leads to the negative effects on the sustainability inside of SC. Moreover, it was identified that the risk of disruption of business activities in any business area is more dangerous than the risk of not well done operation.

In the empirical case study the sharing of information is presented very well and the willingness of each participator was shown up in the strong collaboration during the process created.

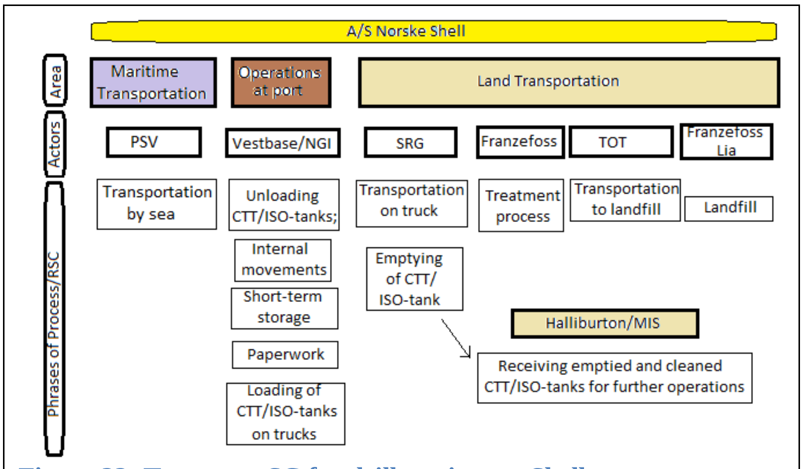


Figure 22: Transport SC for drill cuttings at Shell.

The maximum required and necessary equipment is provided at each part of the reverse SC from TBR/WN until Husøya. Non one actor was considered by the author of this paper as the actor with the isolation; therefore, the amount of risks that can be shown up is very small. The visibility in the process created by hazardous drill cuttings is also obvious as well as the sustainability. Such facts present a "warm atmosphere" in the whole reverse SC. Therefore, the right strategy was chosen by Shell and implemented to display the strong and right SCM. Thus, the further company's activities in SC are not sensitive or vulnerable but secured and protected.

For better understanding the figure above presents all activities at sea, port and land that were created according handling of hazardous drill cuttings. As NGI is party located and operates at Vestbase, the company was added to the "Operations at port". Halliburton /MIS are companies that provided CTT/ISO-tanks for TBR and WN respectively and only controls the position and status of each containers used by Shell. The time is a very significant element in the whole process as any delays that are shown up lead to delays at the whole reverse SC and present increased costs.

Following to the groups of risks created by Vilko and Hallikas (2012) and the most influences risks as fire, terrorism, strikes, ice conditions or custom clearance present not that a big impact on activities from Ormen Lange/Draugen to Vestbase and Franzefoss. Furthermore, it is clear that most sensitive to any delays in the process is the hazardous drill cutting that are pumped into CTT/ISO-tanks and delivered at Husøya for the further treatment process.

Due to the fact that drill cuttings were in a contact with oil-based drilling fluid while oil is considered as an inflammable liquid, OBDC must be considered as a hazardous waste and the proper and correct management of such hazardous waste should be created and be provided. The result of the thermal desorption processing is that essentially there is no oil and chemicals traces in the solid particles and water (Ecology, 2015). As soon as after the thermal treatment process at Husøya the drill cuttings become solids with the oil content near 2%, the solids can be considered as not-hazardous. The biological and chemical treatment methods swap the molecular form of the waste material (Encyclopædia Britannica, 2015). It is understandable that actors that handle CTT/ISO-tanks with OBDC and OBDM should fulfill more strict regulations according transportation, handling, treatment and pollution generated by related activities especially at Husøya. Furthermore, due to new improved technologies and created oil-based drilling fluids, new mix of materials that acts with drill cuttings presents new requirements for treatment process at any treatment plant. It is obvious that waste for one can be not a waste for the other. However, the minimization of waste is required and appreciated while the elimination of the waste at all is the main purpose of the WM.

Different authors presented different structures and hierarchies of WM. Following Pentstech (2015), the type of waste is identified – drill cuttings; source of waste – bottom of Norwegian Sea; hazard from waste to the health – hazard due to the oil-based drilling fluid used for drilling; the volume of waste – differs from time to time, however is stored in CTT/ISO-tanks with loaded volume up to 20-22tons; collection method is safe due to pumping process from TBR/WN to PSV by pipeline; transportation methods are also safe due to stable fastening on board; disposal methods are safe as well due to correct treatment process at Husøya.

According to the hierarchy of WM presented by Pongracz (2002), the waste minimization, re-use and disposal (landfill) have a place in the reverse SC created by hazardous drill cuttings. Following the Directive 2008/98/EC, the process of recovery is also presented in the RSC.

As it was mentioned earlier, the safety and the health of the environment are at risk due to hazardous content of hazardous waste. Furthermore, it is reasonable to recover the value from the waste until the process is economically effective and possible by used technologies presenting the environmentally friendly operations.

OBDC, as a hazardous waste, naturally content hazardous components and thus, present the risk to environmental safety and health being transported from TBR/WN by pipeline (that can be damaged) into CTT/ISO-tanks on PSV's board through Vestbase to Husøya for the unloading from CTT/ISO-tanks and treated at the plant. In addition, the empirical case study shows up the point where Shell, as the waste producer and organizer of reverse

SC, presents its opportunity to deliver CTT/ISO-tanks to Vestbase and then, to give these tanks to NGI, as waste management company. New hazardous elements are created each year. Furthermore, the reader can see that facilities at Husøya for today make it possible not only to separate hazardous drill cuttings from OBDM but to produce clean enough byproducts. Thus, the plant of Franzefoss at Husøya very fits the requirements of NGI according distance and transport costs, and Shell, presenting alternative and environmentally friendly solutions for treatment. Therefore, HWM is very important for Shell because it transforms hazardous drill cuttings into the products (water and solids) that do not contain oil or any other hazardous elements.

Following Eduljee (2011) only one of four categories of HW treatment technologies is presented at the plant at Husøya: biological. As it was presented and explained earlier in the empirical description part, microorganisms under special conditions are used to provide the separation of more oil, heavy metals and destroy phenols. This process happens in five biotanks: an activated sludge is in three biotanks and liquid contact filters – in other two.

The research about industrial hazardous waste's flow in Portugal that was done by Couto et al. (2013) was explained and presented in the literature review earlier in this paper. That research received an attention from EEA due to the scale of the problem shown up. The possible solutions for hazardous waste minimization and HWM were created and displayed. The data showed the big amount of oily industrial waste and waste for further incineration. The implemented solutions presented the increased percentage of recovered waste.

Such research could be an example of developed management methods and detailed analysis of the content of hazardous waste could display new possibilities and create new solutions for Shell in the future. The given licenses to just built landfills presented their own positive impact on the treatment volume of hazardous waste in Portugal. Nevertheless, two landfills that were used by Franzefoss for solids, in Vestnes and near Trondheim, already have their licenses and are known as a good quality service companies. In addition, Norway, as Portugal, in a member of EU and the government also follows few Directives related to hazardous waste.

Following to the research about tools and practices for WM done by Kurdve et al. (2014), collection, transportation and storage of waste was united to the one of tools, the handling of materials. Other tools were related to the impact of noise, costs and pollution.

The handling of materials is also presented into the WM of drill cuttings created by Shell: collection of hazardous drill cuttings into CTT/ISO-tanks on PSV's board, transportation by sea from TBR/WN to Vestbase by PSV and by road from Vestbase to Husøya, storage of CTT/ISO-tanks at Vestbase until the further instruction will be given by NGI. Impact of noise and pollution from Vestbase to Husøya was explained and presented in the empirical case description displaying the willingness of inhabitants at Husøya according truck activities near their houses due to the closeness to the treatment plant and the received limitation for transport operations during Monday – Friday by 5pm.

As it can be seen, Shell has its own tools and practices for WM and its own strategy of how to use these tools and practices. Furthermore, the systems provided by Halliburton and MIS on boards of TBR and WN, and the CTT/ISO-tanks for collection of hazardous drill cuttings allow Shell to integrate the operation and environmental management on the way to improve waste management SC. Another fact shows that methods chosen by Shell improve the responsibility of each actor, strength cooperation and increase the sharing information to be more effective. Further to, the reader can see that each actor involved into the RSC created by hazardous drill cuttings completely fulfill the requirements of the main organizer of the process and does his best to avoid the negligence during his activities.

On the way to better WM using principles and tools Kurdve et al. (2014) underlined the performance of WFM examining the whole WM process according the created value horizontally and vertically, and elimination of non-value operations. The results of implemented model showed the significant improvement of WM for the company.

The WM organized at Shell already shown up positive operations in view of the value they present to the actors. In addition, the author of this paper considers that the possible minimization of non-value operations at the process created by hazardous drill cuttings is very small due to the fact that all operations are under supervision of Shell at Vestbase and Franzefoss to eliminate the waste in time of handling drill cuttings inside of CTT/ISO-tanks. Therefore, reduced costs and savings related to the time used for operations was already presented and is obvious for the reader. Thus, the implementation of WFM could present to Shell small but positive results in the future.

5.4 RQ3: Lean waste management of drill cuttings

Due to the ability of Toyota in Japan to try and make new movements in their management system, such term as “lean production” entered to the management’s language showing the effective method. Holweg (2007) underlined the lean as the unique management system that totally differs from traditional production approach. A lot of authors mention that lean principles can be adapted easily and lean can be implemented by any company at any industry to gain new levels in economic and environmental areas. Furthermore, lean is considered as a new challenge for business and presents positive results. Lean management is the part of SCM and is focused on elimination of waste and creation of value. Examples worldwide show that a lot of companies already accepted lean to their businesses and gained significant results. Further to, lean helps the company to react quicker on any undesirable changes and reveal new direction for activities. In addition, lean has its own tools and principles that can improve environmental impacts and present the greening production as underlined Chiarini (2014). Thus, lean implemented in the early business phrases allows company to gain higher savings according Melton (2015). Moreover, being visible, all operations and steps allow lean to show up bottlenecks and decrease and eliminate unnecessary activities as the waste in a chain.

The empirical data presents the management system created by hazardous drill cuttings and organized by their owner, Shell. The uniqueness of the whole process is very complex and contains a lot of activities on sea, road and land terminals. The empirical cease description presented detailed process that allow reader to understand and see how visible are most of activities in that process and the interest of each company involved into the chain. Furthermore, the respondent from Shell noticed that “Shell is working with lean all the time”. The uniqueness of hazardous drill cuttings is not only the hazard they present to the human health and the environment, but the fact that “drill cuttings cannot wait (according time) and require more time and attention that other waste” (respondent from Shell). Other waste can be collected on board of TBR/WN until the skips or other volumes/capacities will be full or the time for delivery will be soon, for example, medical waste or bio-waste, and only then be delivered to the shore.

As it is possible to understand from the whole SC, TBR and WN are only the small points in the beginning of the process created by hazardous drill cuttings. Environment is an important issue for Transocean and Seadrill, as the company, but on the board of their own rigs. Both companies try to minimize the volume of drill cuttings on board using the systems developed by Halliburton and MIS due to the type of drilling fluid they delivered for drilling operations. Baroid’s TCC unit on TBR and CLEANCUT system on WN are designed to present the minimum environmental footprint: clean solids without oil content that will be loaded to special skips for further transportation to the shore, and the good enough quality of drilling fluid that can be used again in drilling operations cooling the drill bit in the drilling well.

The empirical data according PSV shows that CTT/ISO-tanks settled on board are filled up with oily drill cuttings and drilling mud by pipeline from TBR/WN. Being full CTT/ISO-tanks are closed and no more present the danger to the environment and human health due to the designed strong metal construction, thick tank’s walls, good painting and special designed outlet that not allows the liquid go out. The CTT/ISO-tank’s framework is designed so that the safety of OBDC with OBDM inside is good enough even the container will follow down from the PSV due to some reasons; it will not present any environmental footprint or danger. Therefore, Halliburton and MIS display their interest in minimization and decreasing of environmental footprint that is very important for such a big actors in the Norwegian oil and gas industry inoffshore.The transportation costs by PSV by sea are not that cheap and the transportation of hazardous waste requires the fulfillment of strict rules and Directives not only on the world or European level but a Norwegian legislation first.

Weather conditions are the most significant factor in the process created. Ormen Lange and Draugen are located on the Norwegian Sea on the distance almost 120-150km from Kristiansund. From September to May the possibility of storms there is very high as well as the length of these storm in days. TBR and WN are designed and built according harsh weather conditions as well as all PSV granted to the operations for Shell. Nevertheless, bad weather conditions creates undesirable delays that from time to time present the negative impacts on further activities in the process created by hazardous drill cuttings.

Operations at Vestbase differ from other operations in the process. The availability of the required equipment on the berth and the rest of Vestbase's terminal is obvious. Having the reach stacker at terminal gives an opportunity for Vestbase to rearrange CTT/ISO-tanks if it is required or necessary, or to unload/load CTT/ISO-tanks from PSV/on SRG's trucks without reference to the weather conditions. From time to time the delays can be presented due to the transport occupation or the further instructions. The amount of operations at Vestbase is already minimized if no other requirements from Shell or NGI have a place to be. The time used for these operations at the terminal is also limited and worked until the "automatic" level dues to the huge amount of activities at Vestbase not only because of Shell's business. The workers at PSV, Vestbase, NGI and Shell are working in the close cooperation to gain better results according time, quality and the environment. Therefore, handling of hazardous waste at Shell's installations and at Vestbase relates to both lean and the environmental management. While centralization of facilities, minimization of transport costs from Vestbase to Franzefoss is clear due to NGI's willingness to gain more economical issues. Furthermore, as it was presented in the empirical case description, NGI does not have any sign contract for handling CTT/ISO-tanks with OBDC and OBDM inside with Franzefoss's treatment plant at Husøya.

Transportation of CTT/ISO-tanks by SRG from Vestbase to Husøya presents its own limitation that was partly explained in the case description part. One of them is the limitation of truck activities on the weekend period due to the closeness of the treatment plant to the houses where inhabitants are living. The noise provided by engines of special designed trucks for CTT/ISO-tanks and pollution present another fact related to the limitations on Vestbase – Franzefoss direction. One more fact to display is the saving rules created by SRG – the prohibition of mobile phones while driving the truck. The ban is presented due to the importance of the cargo truck drivers carry, the narrow road and the closeness of the road to houses. Both show the availability of NGI, SRG and Franzefoss for new challenges, better environmental issues and economic issues.

The treatment process at Husøya was described in the empirical case description with the detailed information about process and phases presented there. It is obvious that for today Franzefoss due to facilities available can prove at the end of treatment process of OBDC with OBDM loaded from CTT/ISO-tanks only 50% of non-oily solids, 40% of clean water and 10% of clean oil. The empirical data showed that periodically inspections at Husøya meet the necessary requirements of Norwegian legislation and European Directives, special recommendations and solutions are implemented each time new instructions are created and received by authorities at treatment plant at Husøya. Having the reach stacker at Husøya gives an opportunity to Franzefoss, without reference to the weather conditions, to unload emptied CTT/ISO-tanks from SRG's trucks to the Franzefoss's berth for further storage, if it is required, and load on next truck to deliver it for further operations for Halliburton or MIS.

The value stream mapping as the one of lean's tools was identified as an important element in the environmental management. From the mentioned above it is understandable that all actors involved in are moved inside the chain due to the value they created and the economic issues they figured out for themselves in the handling process of hazardous drill cuttings. Therefore, it is clear that the value is the source of flow of activities related to such hazardous waste that are necessary for lean. Such activities as rechecking of documents or addition movements of CTT/ISO-tanks or addition calls due to delays cannot be eliminated as waste.

Due to the good cooperation inside the process between actors and good coordination of most of activities by the main waste producer and organizer, Shell, the management is presented correctly; the participation of workers with their concentration of the process is obvious. Furthermore, it is clear that all workers involved into the process created by hazardous drill cuttings understand what they are doing, how they are doing, what they need to do and why following Kurdve (2014). All workers depending on the company they work for follow the instruction and 12 Life-Saving Rules created by Shell or 10 Life Rules created by Halliburton, or 18 Life Saving Rules created by MIS.

Plans, timetables and created solutions are accepted and followed. The minimization of non-value operations by each actor is presented. Therefore, lean method is already implemented into the process created by OBDC and controlled by Shell; the good quality of services provided is presented simultaneously with gained environmental positive results. In addition, it is can be seen that lean thinking is suitable for Shell and other actors being "the light in the darkness" for their managers.

Inventory, waste during transportation and waiting were identified by some authors as important types of "waste of time" (muda) that are in the connection with each other in most of real-life business situations. Waste during transportation of CTT/ISO-tanks at sea could be presented while waiting in the open sea the possibility to deliver CTT/ISO-tanks by PSV to Vestbase due to bad weather conditions. The unnecessary, extra emission from PSV is obvious as well as the costs for diesel used and time spent. Waste during inventory could be presented while waiting reach stacker for loading CTT/ISO-tanks on SRG's trucks or waiting due to the coming weekend with no right to deliver tanks at Husøya earlier or further instructions from Shell or NGI.

It is evidently that lean tools at Shell are already implemented into RL providing better waste management with gained positive results in environmental issues. Strict rules and operations provided depend on each other presenting the impact on processes and requiring the following these rules. Therefore, the connection between environmental benefits and lean is clear.

One of lean principles created also by Toyota is JIT. JIT on a par with RL was underlined by researchers as significant management philosophy that, as Chan et al. (2010) identified, can provide decreased environmental footprint and better supervision of costs. Both, JIT and RL cooperate with each other and present their own impact on each other. Therefore, JIT established a reputation as an effective business.

Following Green et al. (2014) the strength of SC directly depends on the strategy that company chose for its SC. Strong connection and cooperation between departments as well as actors is a very important factor. It is clear that the connection between actors is strong enough to present on time delivery while the weather conditions are good and the time is "before 5pm on Friday".

The underlining of respondent of Shell that "Shell is working with JIT all the time" created the reason to examine the JIT areas in researches presented in the literature. By some researchers JIT was divided on internal and external kind of integration. JIT–information was referred to external kind due to be widely adopted. JIT–logistics and JIT–planning, both were referred to internal kind due to given flexibility.

In a RSC created by hazardous drill cuttings JIT–information plays a very significant role as only it helps actors to be in the cooperation with each other sharing available information creating possible solutions for problems shown up and gaining better results. In addition, the information increases the effectiveness of SC due to applied JIT-information. Therefore, it is clear that information goes through the whole SC and thus, JIT-information can be considered as an internal kind of integration as well. Shared information also allows presenting the product/cargo/waste at the right place at the right time and at the right quality. SCM strategy has a positive influence on creating value by customers and so, the demand on the product/cargo/waste handled. Thus, a very well developed SC strategy and SC ability for further steps present success to the company that is possible to say about Shell.

JIT–logistics and JIT–planning, both are also important in the process controlled by Shell as best planning presents best logistics. However, sometimes a good planning cannot provide a good logistics due to undesirable conditions shown up unexpectedly.

At the empirical case study three JIT can be united to the total system of JIT, or, the T-JIT. That is why, the main destination of JIT, better utilization of resources and minimization of "waste of time" is also presented at Shell. Furthermore, due to new possible oil-based drilling fluids created and rapidly changed technologies, Shell will be required to relook its SCM and T-JIT system to find and create new possibilities to keep the strength of the current SCM, design new solutions to achieve better results, to survive being more flexible for urgent movements.

As it was mentioned earlier, the implementation of lean according Kurdve et al. (2014) provides cleaner production when the case comes to elimination of unnecessary operations. The presentation of right solutions for WN that supply the green characteristics in RL make the fact of interconnection between green and lean clear.

One of great solutions for RSC implemented by Shell was the minimization of "waste of time" during transportation. As soon as CTT/ISO-tanks are loaded by OBDC with OBDM, in a good weather conditions, PSV arrives at Vestbase's berth, unloads tanks. Required instructions from NGI are prepared. At the same time reach stacker loads tanks on special designed SRG's trucks that are already waiting for CTT/ISO-tanks at Vestbase. The day of delivery is a working day, "Monday-Friday" that still allows NGI to deliver hazardous drill cuttings to the treatment plant at Husøya. The process presented the real situation with minimized time at each operation. To see that the required equipment and required services are provided at the right time is very important for Shell as the company works with JIT philosophy already for a long time. The process displayed has a limited number of activities as well as movements. Strong communication together with collaboration between actors and Shell is shown. Therefore, the human labour, pollution, amount of used diesel for PSV, crane, reach stacker and trucks is minimized presenting greener and cleaner issues for RL and WM through SCM organized by Shell for handling hazardous drill cuttings.

Following Dhingra (2014) the important fact is that tools and practices should be more focused not on the safe disposal but on problems that may have a negative impact on sustainability and the process, as they provide the growth and the strength of the whole industry. Thus, well provided services directly affect on environmental issues decreasing the environmental footprint. As it can be seen, all operations from TBR/WN until the treatment plant at Husøya are done well, on time and with the responsibility.

Halliburton and MIS providing TBR and WN with OBDF have set proper treatment systems that are designed for minimization of solids and recovering maximum drilling fluid for the further usage, show their interest on decreased environmental footprint at sea and the land. Both companies, being leaders in produced types of drill fluids and using newest technologies, can present in the nearest future new eco-products or re-designed already existent products. Therefore, the lean to green is evident as well as economic issues for operator at Ormen Lange and Draugen, Shell. In addition, the analysis of WM and creation of new framework are done by Shell every time new questions are shown up into the chain.

One of new possible challenges at TBR/WN could be the usage of offshore wind power from wind farms settled not that far from drilling installations. According Arapogianni et al. (2012), this type of energy presents a lot of perspectives in a future. NCS is washed by Norwegian Sea, thus, a big number of storms is presented together with strong wind flow. Such industry is very new and young. However, it shows big promises to some industries, especially, offshore oil and gas industry in Norway.

Another side where lean at Shell is also implemented is vehicle routing. In the literature this area is discovered well and presents a lot of models and solutions. Being the organizer of WM for hazardous drill cuttings, Shell gave a right and opportunity for further control to NGI, a WM company. Hence, for treatment process was chosen a plant at Husøya that relates to Franzefoss. It is obvious that NGI is interested in decreased environmental footprint as well as Shell and got a Shell's trust and respect. As it can be seen, Shell is focused on lean, green practices and lean thinking.

A real-world examples show that all companies can be divided into two groups: those who is ready for challenges in their business and those who don't share the interest of first group. The empirical case description marked out the ability of Shell to care the process long term and the impact of lean on the SC that presents a direct link to the sustainability. Based on the figure displayed by Martinez-Jurado and Moyano-Fuentes (2014), SCM, LM and sustainability have a common area in a company's business that helps to achieve better results. In the literature review was presented the research that was done by Govindan et al. (2014) about links between lean practices and sustainability's dimensions that are financial, social and environmental. The results showed that what was assumed in the literature a little bit differs from the companies' businesses in reality. Therefore, new links were shown up.

Following to Govindan et al. (2014) the link between such a green practice as "cleaner production" of drill cuttings and "environmental sustainability" are obvious due to the usage of special designed CTT/ISO-tanks that allow the safe transportation by sea and road from TBR/WN to Husøya and the handling of tanks at Vestbase and Husøya; "cleaner production" and "social sustainability" are connected due to the health safety; "waste elimination" and "environmental sustainability" are linked due to successful treatment process provided by Franzefoss at its treatment plant at Husøya that produces clean oil, solids and water using well developed equipment and technologies; for NGI as well as for Shell, the treatment process of hazardous drill cuttings are economically attractive and confirms "waste elimination" and "economic sustainability" connection; "quality management" allows to organize and control all operations and activities related to the handling of hazardous drill cuttings in the process, providing the social sustainability, minimization of operations' and activities' number shows the positive impact on economic and environmental sustainability.

"JIT", at the author of this paper considers, is the most influence part at the whole process created by drill cuttings as it presents the significant impact on all dimensions of sustainability providing safety for all participants during work process, minimization of costs during operations made by each actor and minimization of environmental footprint on the way from TBR/WN till Husøya.

Rely on the facts displayed in the literature review LM can be implemented into the whole SC transforming it to the LSCM being concentrated to find better solutions for all activities and keep the customer's willingness to cooperate for long-term. Reduction costs, good quality of services provided and elimination of "waste" through the whole SC are done better due to LSCM. Furthermore, it improves the present management being focused on correct flow of information, finances and materials. According to Martinez-Jurado and Moyano-Fuentes (2014), LSCM plays a significant role for sustainability in the environmental area. It was shown up during discovering articles for LSCM that the fact of implementation of lean in "downstream" is not that much studied by researchers. That is why there is a gap that is desirable to be covered in the future. One of cases in the automobile production presented the improved relationship between supplier and customers as well as achieved better financial results and position. Therefore the fact of better changes in the company's business relating to environmental footprint and economic issues due to LSCM is clear.

According the empirical case description, Shell provides the control of all activities and operations at sea, supply base Vestbase, road and Franzefoss all the time since the chain became created by hazardous drill cutting till the time when Shell finds another possibility how to handle this type of hazardous waste: the normal situation, as it was explained earlier, is to provide the treatment process on boards of TBR/WN using provided systems by Halliburton/MIS, the case discovered in a period 2014-2015 presented the willingness and necessity of Shell to pump OBDC with OBDM directly from TBR/WN to the CTT/ISO-tanks on PSV for further treatment without treatment process at TBR/WN. Due to instructions and guidelines from Shell, as the waste producer and the organizer of the reverse chain, the author of this paper considers the correct LM provided due to the environmental issues, but not economical. Unfortunately received after the treatment process at Husøya the clean oil, water and solids are managed only by Franzefoss. Oil is not sold to Shell for the further re-use, as well as the clean water. Solids cannot be used by Shell due to the kind of the industry Shell is working. Thus, drill cuttings are the type of waste that is not only a hazardous and requires the fulfillment of strict rules and legislation but the waste that is mostly an economically not profitable for the company. That could be not considered according the environmental issues because the handling of hazardous waste allows Shell to achieve real significant results. Therefore, the implementation of LM in to the reverse chain management for handling hazardous drill cuttings is obvious according the size of environmental footprint "TBR/WN – Husøya".

In the literature not that much is studied the results of implemented into LSCM the LM. However, the value stream mapping in LSC still is a very significant factor and therefore, companies are required to carry on this practice. The VSM was also presented in the empirical case description where the most important flows were relating to finances, quality of services provided and the information sharing. Therefore, the results of improved parts are not that valued as the results of improved process.

As it can be seen, the whole reverse SC created by hazardous drill cuttings is a complex, well organized process that presents the minimization of pollution, emission, time, costs, number of activities, decreased volume of human labour, well developed management, well created and implemented solutions when the weather conditions are good enough to provide all these elements on time. At the same time, when the weather conditions are harsh at Norwegian Sea and delays are created, Shell showed its ability to control all actors on the way to provide minimizes expenses according elements presented. These elements display and confirm the existence of green SC and green SCM that is increasing last decades. Following to Fortes (2009) the realization of correct analysis of activities by Shell shows a green design of the system, that is a very important factor, and thus, the results of implemented GrSCM relate to the improved environment issues as well as implemented JIT philosophy.

At the same time, the week places in the relationship between Shell and other actors involved into the handling process of hazardous drill cuttings such as the limitation to deliver trucks from supply base, Vestbase, to Husøya on weekends and the requirements of decreased pollution and noise at Husøya on the way to the treatment plant due to the type of engines SRG uses, or the unavailability of reach stacker at Vestbase for loading CTT/ISO-tanks on SRG's trucks were shown up.

Due to the facts explained above, SC managers at Shell are required to choose the most effective way and solutions to improve results according financial, social and environmental side following the strict rules on the European level as well as county's level. Furthermore, it is well known that if something is already regulated, it can be managed easier. According the literature review in this paper was presented the suggestion of some researchers about importance of investments for RL as it can support the forward logistics partly. In case of Shell such support could be very suitable. Furthermore, the well-organized process presents the significant impact on the reputation of Shell, as one of leading companies in the Norwegian oil and gas industry. Unfortunately, there is not that much information about results of investments in RSC and RL to use it for analysis of business at Shell as risk propensity and the uncertainty can be provoked.

What was discovered by researches and presented in the literature review is the fact that when the question goes to RSC investments. Important role is given to the manager, then, due to the uncertainty, manager has to decide if it is worthwhile to accept it or not. And then, the results will be shown up – desirable or not. Therefore, the well-considered risk management should be done and is presented and provided by managers at Shell according environmental questions.

Forward SC is very sensitive in the petroleum SC due to the expensive equipment is used. The requirements to increase the volume of oil and gas has an influence on the increasing the number of drilling wells, thus, the amount of hazardous drill cuttings. Therefore, much attention is paid to the forward SC as well as the reverse SC.

The activities in the process created by hazardous drill cuttings at all parts provided by all actors involved into the chain are not possible without logistics. Literature review allows adding that by some researchers logistics considered as the activity that goes in parallel with SC while others – that it is a required part for business. Lummus et al. (2001)

underlined that logistics is the efficient part of SCM as each department or the actor provides tasks and operations according the own plan, challenges accepted and requirements of their customers. Each actor that handles hazardous drill cuttings creates a value from services done and provides required quality of logistics for itself and for the main organizer, Shell. Hence, the logistics is very important element for SCM and companies that show their willingness and readiness to take all risks that can be created during any challenges.

Based on the mentioned above explanations, it is possible to notice that all actors deliver CTT/ISO-tanks with drill cuttings and drilling mud inside at right place at the right time at the right quantity and at the right, safe, condition due to the fact that such type of cargo is hazardous for the environment and for workers that handle CTT/ISO-tanks on the whole way from PSV to Franzefoss's treatment plant at Husøya.

5.4.1 Norwegian offshore petroleum industry and possible ways for Shell to minimize the volume of hazardous drill cuttings

Due to the explanation of drill operations in the empirical case description, the reader is already familiar with the process how drill cuttings are produced as well as the type of liquids, drilling fluids, is used for successful drill operations. Furthermore, it was mentioned that the most volume of waste produced during drilling operations are drill cuttings and used drilling fluid – the mud. From the other side, usage of oil-based drilling fluid does not allow drilling companies to do the discharge of cleaned (after treatment process on board) drill cuttings on the seabed in offshore due to the almost none percentage of oil inside. Hence, oily drilling cuttings and drilling mud have to be transported to shore. In addition to this fact, it is obvious that a lot of companies already tried to find solutions for minimization of waste during drilling operations, however, regulations and the cost were limits that companies were faced with.

According to Veil (2002) in the past some used drilling waste management practices could not protect the public health and the environment and thus, were forbade by regulatory agencies. Therefore, the suitable strategies and management of drilling cuttings as well as drilling waste was required. Furthermore, if OBDF is used, the case needs more regulations and rules for proper handling and disposal. Within the supply chain the ownership for waste could be easily identified to present the opportunities for minimizing the waste.

To consider the minimization of drill cutting in the volume first, drilling programs should be created. Following to Caenn et al. (2011) the important elements in drilling operation's planning are the type of mud used, size and the depth of the hole and the system to control solids.

Type of mud used. Real examples showed that at some drilling wells the necessity in drilling fluid is huge while others can be drilled without usage of drilling fluid at all.

Furthermore, the type of drilling fluid may affect the volume of cuttings produced. It was found that water-based fluids provides not a clean hole as synthetic-based fluid, thus, more drill cuttings. By EPA (1996) OBDF are considered as the most harmful to the environment and drill cuttings oiled by it cannot be discharged in offshore from platforms. According Onwukwe and Nwakaudu (2012) one of important methods implemented for minimization of amount of drill cuttings is the usage of not toxic drilling fluids or less toxic.

Halliburton and MIS had delivered oil-based drilling fluids on board of TBR and WN for drilling operations at Ormen Lange and Draugen. This type of OBDF was discussed with Shell according profitability of drilling operations at those oil and gas fields. Due to the usage of OBDF, the Baroid and CLEANCUT systems were delivered on boards of TBR and WN. As it was mentioned earlier, water-based drilling fluid is more “green” for the environment than OBDF. However, the quality of drilling operations is different using them. Therefore, it is obvious that for drilling operations at Ormen Lange from board of TBR nowadays OBDF was used and it will be used until the termination of drilling activities.

Size and the depth of the hole. Drilling wells for oil and gas can be of different depth. The more deep the drilling bit goes than longer the well is. The construction consists of multiple layer of pipe – casing. The diameter of every next layer is narrower than previous one. Thus, it is clear that the largest diameter is at the surface while the narrowest, most slim – in the bottom. Every layer is fixed by cement to prevent the power from outside. Nowadays technologies allow scanning of the ground to understand the exact depth of the future drilling well. Therefore, the diameter of the hole and the amount of layers can be calculated before the drilling operations will be started. As it is underlined by Aird (2008), the direction drilling can be horizontal or extended-reach. Extended-reach drilling is used more for offshore drilling.

Drilling operations for Shell are done from boards of TBR that belongs to Transocean and WN which belongs to Seadrill. The possibility to use the scanning of the ground to define the depth of future drilling well is more available than decade ago due to better technologies. Therefore, the question about possible minimization of the diameter for drilling hole comes to the engineers at TBR, as all drilling operations at WN are already finished.

System to control solids. The systems for separating OBDC from OBDM are different and mostly consist of shale shakers, vertical cuttings dryers and cuttings dryer.

At WN was provided the CLEANCUT system for treatment of oily drill cuttings, however, such system was used only when ISO-tanks were full and on the way to supply base Vestbase and to treatment plant at Husøya. At TBR was provided the Baroid system and also it was used while waiting for the available free CTT on PSV after they were emptied at Husøya. Both systems for solid control were chosen by companies-suppliers of OBDF on TBR and WN. Therefore, it is under the question that as soon as Halliburton supplies new, greener type of OBDF for drilling operations at TBR, the system for treatment could be changed.

Norwegian Sea is considered as the most studied area in the world due to high activities because of offshore oil and gas industry. Due to Bakke et al. (2013) the discharge of OBDC was allowed until 1984, then, diesel oil was replaced by less toxic type of oil. The studying of the impacts of drilling waste showed the influence of them on the sediment ecosystem. During last decades with the help of the Norwegian Government the size of areas affected by discharged treated OBDC was reduced in few times.

The reader considers the opportunity for Shell to work with Franzefoss as the given great opportunity to present three clean byproducts after the treatment process at Husøya. Such possibility presents safety and better health for the environment around Husøya, for its inhabitants and the licensed landfill near Trondheim. EPA (1993) described the criteria for minimization of risks from landfills presenting the design of landfill, required operations and management. From year to year rules and legislations according landfills becoming stricter, as well, trying to prevent the linkages and, thus, the possible impact on the human health. The landfill near Trondheim is located on the distance from settlements, it is not the seismic zone, is located on the required distance from airport and flood plant, is an unstable area. The landfill related to Franzefoss Lia is intended for reception only of bulk waste. It is obvious that Franzefoss Lia provides good quality services to Franzefoss at Husøya, NGI and Shell, the main participant in the reverse SC created by hazardous drill cuttings from TBR at Ormen Lange and WN at Draugen.

5.5 Implications for the study

Many researches that were analyzed in the literature had found were emerged with the real world case where they could be implemented to present more efficient results, improve the current situation. Better definition of hazardous drill cuttings, reverse logistics, hazardous waste management, lean, lean management, green supply chain management and the importance of logistics in SCM are the settled implications.

The empirical case study presented another situation from the normal one when the hazardous waste produced at drilling installation are treated on its board and only then, are delivered by PSV to shore for further landfill. Therefore, this study is different from the traditional situation and new in practice.

Theoretical implications. This study presenting the not traditional situation could be used further to improve the theory of ownership, reverse logistics, hazardous waste management, lean and green supply chain management relating to the handling of hazardous waste produced in offshore along NCS. Being the member of Europe and EU, the legislation, a big amount of Directives and rules becoming stricter due to creation of new hazardous waste that can improve the drilling operations but still can present the harmful influence not only on the environmental safety and health, but on the human health as well. Therefore, better study is required in the future.

The involvedness of a big number of actors in the chain created allowed the author of this paper to present the value created by each actor, their interest to cooperate, and availability to take risks due to problems and undesirable questions shown up. The role of owner of hazardous waste produced in offshore is not that much studied, however, based on researches about ownership at all, made it possible to provide the understand of how really important the ownership is.

Being explaining the handling of hazardous waste, the “downstream” direction of supply chain was presented. Due to the fact that the waste was produced in the drilling well and didn’t participate into the “upstream” direction, the situation gives the understanding of its uniqueness as most of waste can be the raw materials for the same product they were, but not a hazardous drill cuttings. Hence, participation only in one direction is real.

It was found discovering articles for lean SCM that facts of lean implemented in the “downstream” direction is not that much studied by researchers as well as the results of investments in reverse SC and reverse logistics. This study due to its uniqueness could be used as the base to create a new theory of value creation. Therefore, the studies are required for analysis of company’s business according uncertainty and risk propensity that can be provoked.

Managerial implications. The empirical case study is very complex and consists of a big number of actors involved, that is twelve, and a big number of operations that should be done for effective handling of hazardous waste produced in offshore. For waste producer, Shell, such practice was new however, findings of this study showed that Shell had an implemented reverse logistics as well as the lean before the empirical case study was started. RL and Lean showed the productivity of their implementation presenting the “green” moments that are met through the whole process. These “green” moments are related to the environmental and social issues but, unfortunately, not for economic issues that are required and desirable by the main waste producer and organized, Shell. However, for all other actors these issues are achieved.

The value of OBDC, as a hazardous waste, presents the new understanding of waste in the oil and gas industry. Required activities according legislation, Directives, Act and rules were presented with minimized environmental footprint and the social health and safety. The results of implementation of lean and lean management in this study can be different from another case in the same industry due to the time studies were done and situations were happened. This study could be used as a guideline for handling OBDC in tanks provided by Halliburton and MIS. The focus could be concentrated also on the responsibility all actors were presenting during the handling drill cuttings.

Hence, this research study could be the increased knowledge and understanding for managers at “downstream” direction to find new and created better solutions in the area study is done to achieve more efficient results according economic, social and environmental issues implementing RL, green lean improving green SC, logistics and green SCM in the company's business.

6.0 Conclusion, Recommendations, Limitations and Further Research

6.1 Conclusion

This chapter presents the important findings, recommendations that are based on findings, limitations of the case study and possible direction for further research.

The type of this case study was empirical and presented the case from the real life being focused on possible improvements during the research. The study was done under the guidance of the main actor, Shell, in the process that was created by the hazardous waste, drill cuttings, that Shell produced. The process created involved eleven companies that became actors and presented their services due to the area they have business in. The case study presented the complexity of the process due to big number of participants and number of operations done during the process.

The study presents a single case that occurred in the Norwegian offshore along Norwegian Continental Shelf – Norwegian oil and gas industry, the largest industry in a country. The unit of analysis became the type of hazardous waste – drill cuttings. Being waste, drill cuttings created the process for their handling in the "downstream" Shell's business, reverse chain. The knowledge about drill cuttings, their uniqueness and the specificity of their handling was improved by researches in this area. Furthermore, a big number of searches (theories and analysis of real-world cases) in the relevant areas were found and used to make the support of the real case by literature credible.

The main structure of this paper was kept by three created research questions that presented the linking between all of them presenting one flow. Furthermore, discovering and understanding the first research question could help the reader to receive the basic knowledge for the second research question and later, for the third. All research questions were with detailed technical characteristics that proved their complexity as well.

The first research question was focused on describing *what type of cargo is transported in Cuttings Transport Tank (CTT) / CLEANCUT ISO-pump (ISO-tank)?* The answer on this research question gave to the reader the detailed description of drilling operations in offshore that occurs every time the decision about drilling new hole is shown up by engineers. Furthermore, the better understanding of the waste – what exactly it is and how it is produced – was presented to create the base for further research and analysis provided. The role of the literature for this research question was to support the understanding of the ownership of waste and the ownership of hazardous waste, and the value each owner creates handling it. In the discussion part was described the position of the first, main owner of offshore hazardous waste, Shell, and further actors-owners that became involved into the process due to their relation to these hazardous drill cuttings according the real case that occurred in year 2014-2015 and according the Norwegian legislation and regulations, European Directives. The role of each actor was described and presented; the importance to be the owner was discussed.

The second research question was focused on describing *what is the reverse logistic process that this type of cargo created?* The second research question became the biggest among the others. It is important to mark out that the reverse logistics was already implemented by Shell. Therefore, the discussion of the role of RL for Shell was presented. The unit of analysis was partly the storage capacities: CTT provided by Halliburton and ISO-tank being provided by M-I Swaco. Moreover, the complexity of the process created the necessity for all participants to follow the strict rules of Shell, Halliburton and M-I Swaco as the main actors. The contribution of each actor to the reverse supply chain due to their participation was displayed. It is necessary to underline that the cooperation between all actors was very good, intensive and strong. It is understandable that any company being relating to the reverse logistics will be interested to increase the percentage return rate after the treatment process. This moment was discussed according legislation and strict law. Drilling cuttings being produced at drilling installation rig, TBR, and drilling ship, WN, pumped into CTT and ISO-tanks were required to be delivered to the shore, supply vase, Vestbase, by PSV, handled under NGI guidance, transported by SRG's trucks to Husøya, Franzefoss's treatment plant and participated in the multimodal transportation. The presented in the literature review the research about risk assessment in the multimodal supply chain was considered to be used to support the real case study presenting opportunities for improvement of the process by Shell and was discussed together with results of implemented reverse logistics. The hazardous waste management at Shell and further actors was not left without attention from the author of this paper presenting the important role for the case study. Another real-based research made in Portugal and related to hazardous waste was applied for the current case study for more effective for Shell handling of CTT/ISO-tanks with hazardous drill cuttings inside.

The third research question was focused on the description of *how reverse logistics process for this type of cargo is managed?* Another important moment to mark out is the fact that such helpful methodology for any company's business as lean was already implemented by Shell and due to the positive results was used until today. Therefore, the discussion of results of implemented lean by Shell had place to be discussed. One of efficient philosophies such "just-in-time" being implemented by Shell earlier was examined. The significant fact was that waste producer, Shell, had to use this practice all the time the question comes to the handling of oily drill cuttings from drilling rig/ship to the treatment plant. All deliveries were required to be provided and done in time: being delivered at the right condition at the right amount at the right place at the right time as any delays occurred had a direct influence on the increased costs related to Shell's business. Besides JIT practice, discussion of another one "seven waste of time" was presented analyzing those "wastes" that were relevant to the current case study: waste in transportation, inventory, motion and waiting. Furthermore, the implementation of lean thinking was provided. The implementation of lean touched the lean waste management at

Shell, thus, the results were discussed as well. Furthermore, results of green lean, green supply chain management and sustainability at Shell were examined and presented. Green lean and green supply chain management could be not green without experience how to manage the risk. Thus, the importance to analyze the risk management and business uncertainty at Shell was considered with support from the relevant research in the literature. In addition, the significant role of logistics in supply chain management at Shell was presented.

Answering on all three questions the author of this paper faced with gaps in the literature that related to the necessary facts occurred in the empirical case. These gaps were presented and found the explanation in just started researches and not enough amounts of results received.

6.2 Recommendations for Shell

All twelve actors that are involved into the process created by hazardous oily drill cuttings already created the value from participating in the reverse supply chain organized by Shell. Therefore, recommendations will be according the increasing the value creation. Due to the fact that this case study is the qualitative and none parameters were used, recommendations for Shell can only be taken into consideration.

Waste in inventory. At Vestbase when CTT/ISO-tanks are unloaded from PSV and delivered to the place for further storage, it would be required to eliminate the storage part at all if there is an opportunity to provide three trucks by SRG right at the time CTT/ISO-tanks are unloaded from PSV. The elimination of inventory could present the savings in financial part for Shell as well as to provide the time saving. The limitation to this recommendation could be the day of week PSC arrives at Vestbase's berth as any deliveries of CTT/ISO-tanks from Vestbase to Husøya are forbidden since Fridays 5pm till Monday's morning. This limitation was considered by the author of this paper as more significant than the weather conditions at Vestbase during storage. Another recommendation could relate to the request of Shell NGI to give more priority to Shell's CTT/ISO-tanks than to other cargoes handled at Vestbase due to high costs and impossibility to wait.

Any recommendations according reduction of transport distance have no weigh due to the real closeness of treatment plant at Husøya to Vestbase. The recommendations according reduction of transport distance from TBR (WN already finished participation in July 2014) to Vestbase by PSV have no weight as well due to the fact that Vestbase is the most close supply base where CTT/ISO-tanks could be delivered. Recommendation according the building of treatment process for Shell at Vestbase is declined automatically due to the cost and advantage over Franzefoss.

6.3 Limitations

This study is a descriptive and exploratory case study that is leaded by Shell's hazardous waste management. Due to the complexity of the process created and organized, and a big number of participants, thus, a big number of operations and connections to be studied and covered, more data collected could be required. Companies-suppliers of drilling fluid, CTT/ISO-tanks and treatment system on board of TBR and WN, Halliburton and MIS could be asked for data collection to understand how they created value from the this process as secondary participants after Shell. Theoretical limitations could relate to the lack in the literature of results of implementation of lean management into lean supply chain management that are not studied that much due to limitation of information received. Furthermore, results of investments in reverse logistics and reverse lean supply chain were not studied much. Hence, better discussion and analysis of the process could be performed.

6.4 Further research

This case study presented the analysis and discussion based on the data collected from there participants. One of them was the organizer of the whole process, Shell. It would be recommended for the further research to collect the data from secondary participants – Halliburton and M-I Swaco to discover the value created by them being involved into the process. It would be required also, to examine the reverse logistics, lean and supply chain management separately due to the large scale of research and, to analyze the possible opportunities to increase the value creation. In addition, the importance of logistics and its impact on hazardous waste management would be required to be researched.

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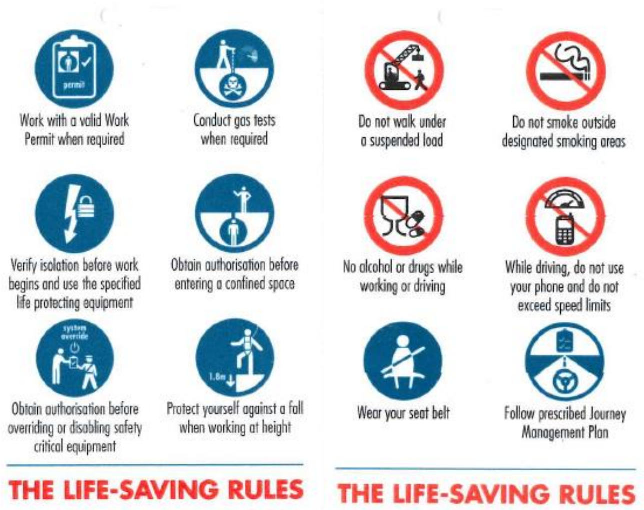
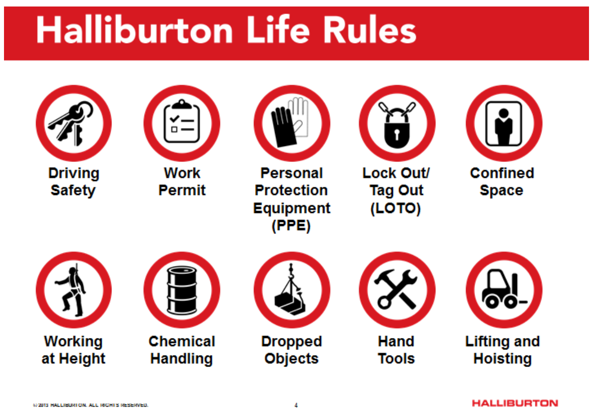
8.0 Appendices

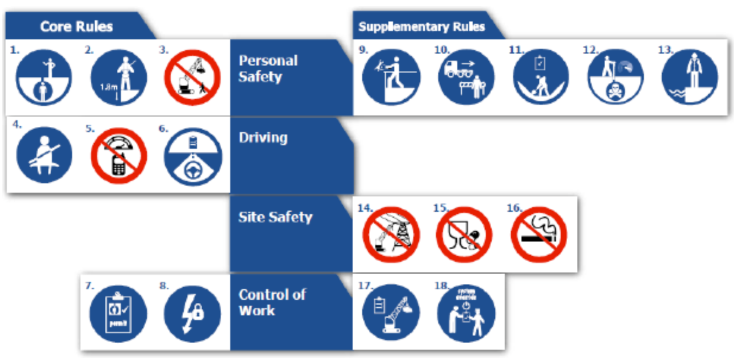
8.1 Appendix A



Picture 1: The Life-Saving Rules at Shell (Photo: Alexandra Boyarinova).



Picture 2: Halliburton Life Rules (Halliburton, 2013).



Picture 3: Life Saving Rules at MIS (Walker, 2014).

8.2 Appendix B

Form 1: Multimodal dangerous goods form. Appendix 4 to 093-Recommended guidelines for Waste Management in the offshore industry. (NOROG, 2013).

1 Shipper/Consignor/Sender	2 Transport document number	
	3 Page 1 of pages	4 Shipper's reference
		5 Freight Forwarder's reference
6 Consignee	7 Carrier (to be completed by the carrier)	
	SHIPPER'S DECLARATION I hereby declare that the contents of this consignment are fully and accurately described below by the Proper Shipping Name, and are classified, packaged, marked and labelled/placarded and are in all respects in proper condition for transport according to the applicable international and national governmental regulations.	

8 This shipment is within the limitations prescribed for: (Delete non-applicable)		9 Additional handling information
PASSENGER AND CARGO AIRCRAFT	CARGO AIRCRAFT ONLY	
10 Vessel/flight no. and date	11 Port/place of loading	
12 Port/place of discharge	13 Destination	

14 Shipping marks	*Number and kind of packages; description of goods	Gross mass (kg)	Net mass (kg)	Cube (m3)

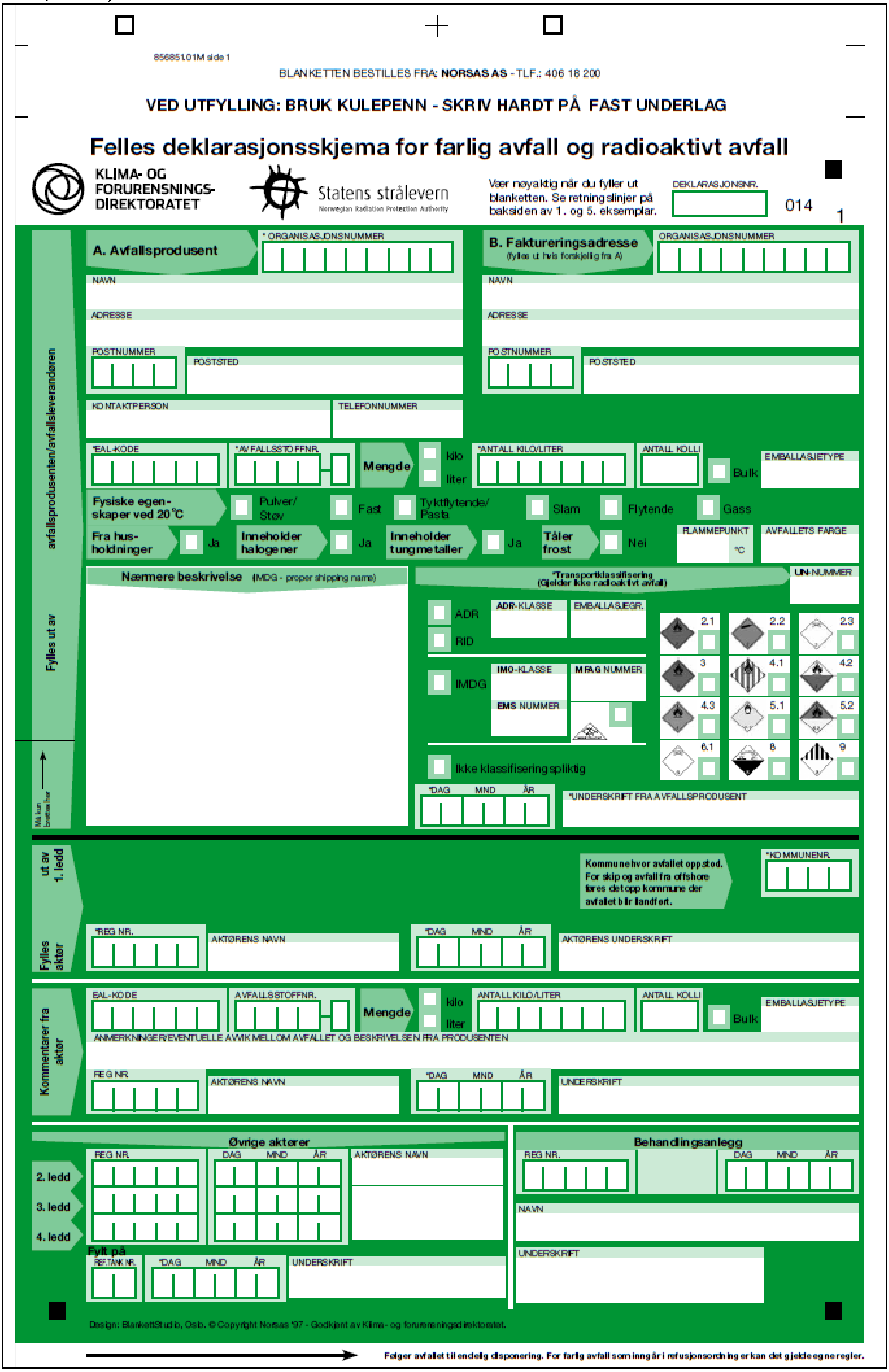
15 Container identification No./ vehicle registration No.	16 Seal number(s)	17 Container/vehicle size & type	18 Tare mass (kg)	19 Total gross mass (including tare) (kg)

CONTAINER/VEHICLE PACKING CERTIFICATE I hereby declare that the goods described above have been packed/ loaded into the container/vehicle identified above in accordance with the applicable provisions.** **MUST BE COMPLETED AND SIGNED FOR ALL CONTAINER/VEHICLE LOADS BY PERSON**	21 RECEIVING ORGANIZATION RECEIPT Received the above number of packages/containers/trailers in apparent good order and condition unless stated hereon: RECEIVING ORGANIZATION REMARKS:	
20 Name of company	Haulier's name	22 Name of company (OF SHIPPER PREPARING THIS NOTE)
Name/Status of declarant	Vehicle reg. no. Signature and date	Name/status of declarant
Place and date		Place and date
Signature of declarant	DRIVER'S SIGNATURE	Signature of declarant

* **DANGEROUS GOODS:**
You must specify: Proper Shipping Name, hazard class, UN No., packing group, (where assigned) marine pollutant and observe the mandatory requirements under applicable national and international governmental regulations. For the purposes of the IMDG Code see 5.4.1.4.

** For the purposes of the IMDG Code, see 5.4.2.

Form 2: Common declaration form for hazardous and radioactive waste (1) (NORSAS AS, 2011).



Form 3: Common declaration form for hazardous and radioactive waste (2)

85685101M side 2

BLANKETTEN BESTILLES FRA: **NORSAS AS** - TLF.: 406 18 200

VED UTFYLLING: BRUK KULEPENN - SKRIV HARDT PÅ FAST UNDERLAG

Felles deklarasjonsskjema for farlig avfall og radioaktivt avfall

KLIMA- OG FORURENSNINGS-DIREKTORATET

Statens strålevern
Norwegian Radiation Protection Authority

Vær nøyaktig når du fyller ut blanketten. Se retningslinjer på baksiden av 1. og 5. eksemplar.

DEKLARASJONSNR. 014 2

Fylles ut av avfallsprodusenten/avfallsleverandøren

A. Avfallsprodusent *ORGANISASJONSNUMMER

NAVN

ADRESSE

POSTNUMMER POSTSTED

KONTAKTPERSON TELEFONNUMMER

B. Faktureringsadresse (fylles ut hvis forskjellig fra A) ORGANISASJONSNUMMER

NAVN

ADRESSE

POSTNUMMER POSTSTED

*EAL-KODE *AVFALLSSTOFFNR. **Mengde** kilo liter *ANTALL KILO/LITER ANTALL KOLLI Bulk EMBALLASJETYPE

Fysiske egenskaper ved 20 °C Pulver/Støv Fast Tyktflytende/Pasta Slam Flytende Gass

Fra husholdninger Ja **Inneholder halogener** Ja **Inneholder tungmetaller** Ja **Tåler frost** Nei FLAMMEPUNKT °C AVFALLETS FARGE

Nærmere beskrivelse (MDG - proper shipping name)

*Transportklassifisering (Gjelder ikke radioaktivt avfall) UN-NUMMER

ADR RID ADR-KLASSE EMBALLASJEGR.

IMDG IMO-KLASSE MFAG NUMMER EMS NUMMER

2.1 2.2 2.3 3 4.1 4.2 4.3 5.1 5.2 6.1 8 9

Ikke klassifiseringspliktig

*DAG MND ÅR *UNDERSKRIFT FRA AVFALLSPRODUSENT

Må kun brettes her

Fylles ut av aktør 1. ledd

Kommune hvor avfallet oppstod. For skip og avfall fra offshore føres det opp kommune der avfallet blir landført. *KOMMUNENR.

*REG NR. AKTØRENS NAVN *DAG MND ÅR AKTØRENS UNDERSKRIFT

Kommentarer fra aktør

EAL-KODE AVFALLSSTOFFNR. **Mengde** kilo liter ANTALL KILO/LITER ANTALL KOLLI Bulk EMBALLASJETYPE

ANMERKNINGER/EVENTUELLE AVVIK MELLOM AVFALLET OG BESKRIVELSEN FRA PRODUSENTEN

REG NR. AKTØRENS NAVN *DAG MND ÅR UNDERSKRIFT

Øvrige aktører

REG NR. DAG MND ÅR AKTØRENS NAVN

2. ledd

3. ledd

4. ledd

Fylt på REF.TANK NR. *DAG MND ÅR UNDERSKRIFT

Behandlingsanlegg

REG NR. DAG MND ÅR

NAVN

UNDERSKRIFT

Sendes til Norsas AS, Postboks 6412 Etterstad, 0605 Oslo av første ledd

Form 4: Common declaration form for hazardous and radioactive waste (3)

85685101M side3

BLANKETTEN BESTILLES FRA: **NORSAS AS** - TLF.: 406 18 200

VED UTFYLLING: BRUK KULEPENN - SKRIV HARDT PÅ FAST UNDERLAG

Felles deklarasjonsskjema for farlig avfall og radioaktivt avfall

KLIMA- OG FORURENSNINGS-DIREKTORATET

Statens strålevern
Norwegian Radiation Protection Authority

Vær nøyaktig når du fyller ut blanketten. Se retningslinjer på baksiden av 1. og 5. eksemplar.

DEKLARASJONSNR. 014 3

Fylles ut av avfallsprodusenten/avfallsleverandøren

A. Avfallsprodusent — * ORGANISASJONSNUMMER

NAVN

ADRESSE

POSTNUMMER — POSTSTED

KONTAKTPERSON — TELEFONNUMMER

B. Faktureringsadresse (fylles ut hvis forskjellig fra A) — ORGANISASJONSNUMMER

NAVN

ADRESSE

POSTNUMMER — POSTSTED

*EAL-KODE — *AVFALLSSTOFFNR. — **Mengde** — kilo / liter — *ANTALL KILO/LITER — ANTALL KOLLI — Bulk — EMBALLASJETYPE

Fysiske egenskaper ved 20 °C — Pulver/Støv — Fast — Tyktflytende/Pasta — Slam — Flytende — Gass

Fra husholdninger Ja — **Inneholder halogener** Ja — **Inneholder tungmetaller** Ja — **Tåler frost** Nei — FLAMMEPUNKT °C — AVFALLETS FARGE

Nærmere beskrivelse (IMDG - proper shipping name)

*Transportklassifisering (Gjelder ikke radioaktivt avfall) — UN-NUMMER

ADR — RID — ADR-KLASSE — EMBALLASJEGR.

IMDG — IMO-KLASSE — MFAG NUMMER — EMS NUMMER

2.1 — 2.2 — 2.3 — 3 — 4.1 — 4.2 — 4.3 — 5.1 — 5.2 — 6.1 — 8 — 9

Ikke klassifiseringspliktig

*DAG MND ÅR — *UNDERSKRIFT FRA AVFALLSPRODUSENT

Må kun brettes her

Fylles ut av aktør 1. ledd

Kommune hvor avfallet oppstod. For skip og avfall fra offshore føres det opp kommune der avfallet blir landført. — *KOMMUNENR.

*REG NR. — AKTØRENS NAVN — *DAG MND ÅR — AKTØRENS UNDERSKRIFT

Kommentarer fra aktør

EAL-KODE — AVFALLSSTOFFNR. — **Mengde** — kilo / liter — ANTALL KILO/LITER — ANTALL KOLLI — Bulk — EMBALLASJETYPE

ANMERKNINGER/EVENTUELLE AVVIK MELLOM AVFALLET OG BESKRIVELSEN FRA PRODUSENTEN

REG NR. — AKTØRENS NAVN — *DAG MND ÅR — UNDERSKRIFT

Øvrige aktører

REG NR. — DAG MND ÅR — AKTØRENS NAVN

2. ledd

3. ledd

4. ledd

Fylt på — REF.TANK NR. — *DAG MND ÅR — UNDERSKRIFT

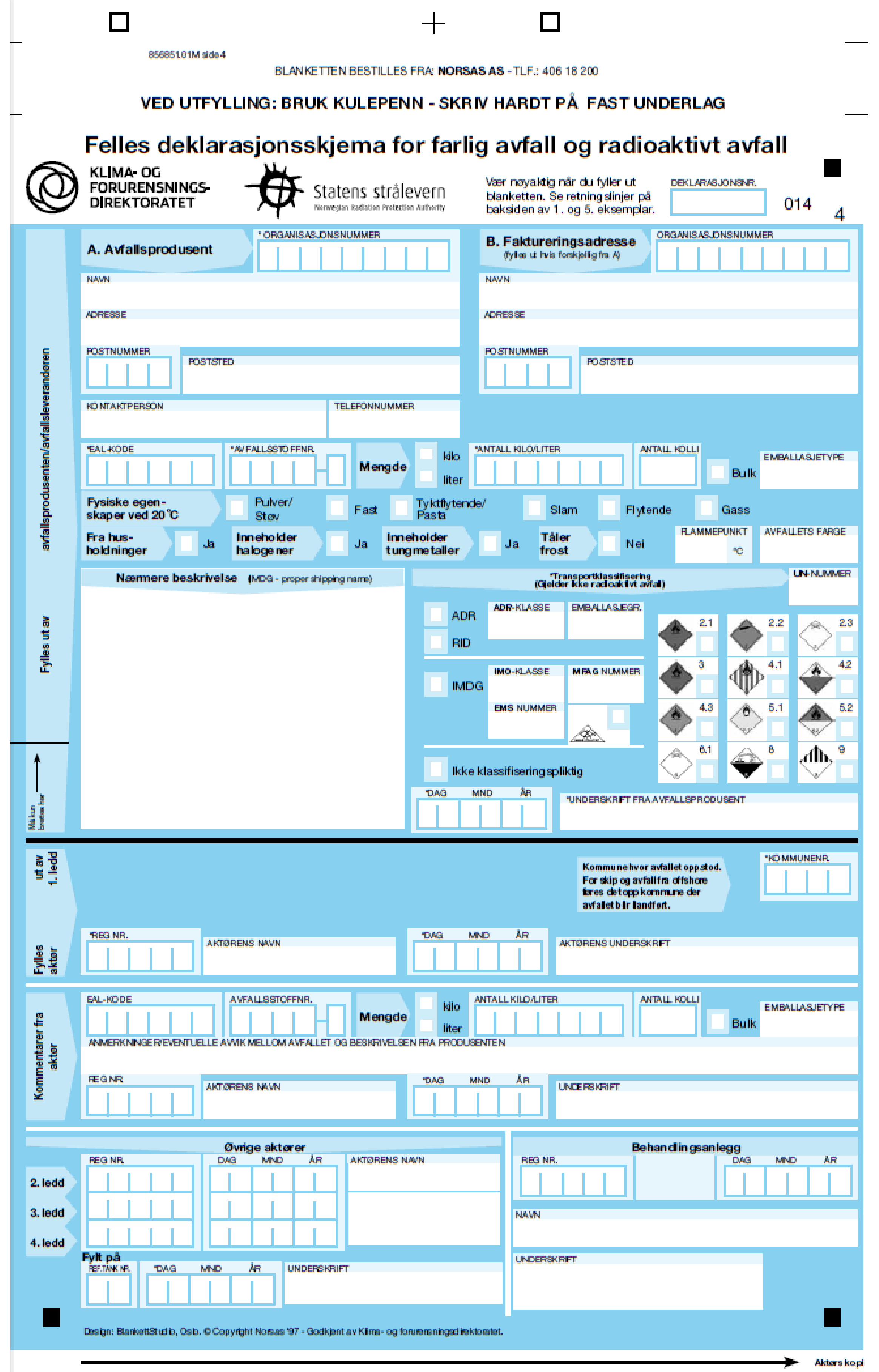
Behandlingsanlegg

REG NR. — DAG MND ÅR

NAVN

UNDERSKRIFT

Form 5: Common declaration form for hazardous and radioactive waste (4)



85685101M side 4

BLANKETTEN BESTILLES FRA: **NORSAS AS** - TLF.: 406 18 200

VED UTFYLLING: BRUK KULEPENN - SKRIV HARDT PÅ FAST UNDERLAG

Felles deklarasjonsskjema for farlig avfall og radioaktivt avfall

KLIMA- OG FORURENSNINGS-DIREKTORATET

Statens strålevern
Norwegian Radiation Protection Authority

Vær nøyaktig når du fyller ut blanketten. Se retningslinjer på baksiden av 1. og 5. eksemplar.

DEKLARASJONSNR. 014 4

Fylles ut av avfallsprodusenten/avfallsleverandøren

A. Avfallsprodusent — *ORGANISASJONSNUMMER
NAVN
ADRESSE
POSTNUMMER — POSTSTED
KONTAKTPERSON — TELEFONNUMMER

B. Faktureringsadresse (fylles ut hvis forskjellig fra A) — ORGANISASJONSNUMMER
NAVN
ADRESSE
POSTNUMMER — POSTSTED

*EAL-KODE — *AVFALLSSTOFFNR. — **Mengde** kilo / liter — *ANTALL KILO/LITER — ANTALL KOLLI — Bulk — EMBALLASJETYPE

Fysiske egenskaper ved 20 °C: Pulver/Støv — Fast — Tyktflytende/Pasta — Slam — Flytende — Gass

Fra husholdninger Ja — **Inneholder halogener** Ja — **Inneholder tungmetaller** Ja — **Tåler frost** Nei — FLAMMEPUNKT °C — AVFALLETS FARGE

Nærmere beskrivelse (IMDG - proper shipping name)

*Transportklassifisering (Gjelder ikke radioaktivt avfall) — UN-NUMMER

ADR — RID — ADR-KLASSE — EMBALLASJEGR.

IMDG — IMO-KLASSE — MFAG NUMMER — EMS NUMMER

2.1 — 2.2 — 2.3 — 3 — 4.1 — 4.2 — 4.3 — 5.1 — 5.2 — 6.1 — 8 — 9

Ikke klassifiseringspliktig

*DAG — MND — ÅR — *UNDERSKRIFT FRA AVFALLSPRODUSENT

Må kun brettes her

Fylles ut av aktør 1. ledd

Kommune hvor avfallet oppstod. For skip og avfall fra offshore føres det opp kommune der avfallet blir landført. — *KOMMUNENR.

*REG NR. — AKTØRENS NAVN — *DAG — MND — ÅR — AKTØRENS UNDERSKRIFT

Kommentarer fra aktør

EAL-KODE — AVFALLSSTOFFNR. — **Mengde** kilo / liter — ANTALL KILO/LITER — ANTALL KOLLI — Bulk — EMBALLASJETYPE

ANMERKNINGER/EVENTUELLE AVVIK MELLOM AVFALLET OG BESKRIVELSEN FRA PRODUSENTEN

REG NR. — AKTØRENS NAVN — *DAG — MND — ÅR — UNDERSKRIFT

Øvrige aktører: REG NR. — DAG — MND — ÅR — AKTØRENS NAVN
2. ledd
3. ledd
4. ledd

Fylt på: REF.TANK NR. — *DAG — MND — ÅR — UNDERSKRIFT

Behandlingsanlegg: REG NR. — DAG — MND — ÅR
NAVN
UNDERSKRIFT

Design: BlankettStudio, Oslo. © Copyright Norsas '97 - Godkjent av Klima- og forurensningsdirektoratet.

Aktørs kopi

Form 6: Common declaration form for hazardous and radioactive waste (5)

85685101M side 5

BLANKETTEN BESTILLES FRA: **NORSAS AS** - TLF.: 406 18 200

VED UTFYLLING: BRUK KULEPENN - SKRIV HARDT PÅ FAST UNDERLAG

Felles deklarasjonsskjema for farlig avfall og radioaktivt avfall

KLIMA- OG FORURENSNINGS-DIREKTORATET

Statens strålevern
Norwegian Radiation Protection Authority

Vær nøyaktig når du fyller ut blanketten. Se retningslinjer på baksiden av 1. og 5. eksemplar.

DEKLARASJONSNR. 014 5

Fylles ut av avfallsprodusenten/avfallsleverandøren

A. Avfallsprodusent — *ORGANISASJONSNUMMER

NAVN

ADRESSE

POSTNUMMER — POSTSTED

KONTAKTPERSON — TELEFONNUMMER

B. Faktureringsadresse (fylles ut hvis forskjellig fra A) — ORGANISASJONSNUMMER

NAVN

ADRESSE

POSTNUMMER — POSTSTED

*EAL-KODE — *AVFALLSSTOFFNR. — **Mengde** — kilo / liter — *ANTALL KILO/LITER — ANTALL KOLLI — Bulk — EMBALLASJETYPE

Fysiske egenskaper ved 20 °C — Pulver/Støv — Fast — Tyktflytende/Pasta — Slam — Flytende — Gass

Fra husholdninger — Ja — **Inneholder halogener** — Ja — **Inneholder tungmetaller** — Ja — **Tåler frost** — Nei — FLAMMEPUNKT °C — AVFALLETS FARGE

Nærmere beskrivelse (MDG - proper shipping name)

*Transportklassifisering (Gjelder ikke radioaktivt avfall) — UN-NUMMER

ADR — RID — ADR-KLASSE — EMBALLASJEGR.

IMDG — IMO-KLASSE — MFAG NUMMER — EMS NUMMER

2.1 — 2.2 — 2.3 — 3 — 4.1 — 4.2 — 4.3 — 5.1 — 5.2 — 6.1 — 8 — 9

Ikke klassifiseringspliktig

*DAG — MND — ÅR — *UNDERSKRIFT FRA AVFALLSPRODUSENT

Må kun brettes her

Fylles ut av 1. ledd aktør

Kommunehvor avfallet oppstod. For skip og avfall fra offshore føres det opp kommune der avfallet blir landført. — *KOMMUNENR.

*REG NR. — AKTØRENS NAVN — *DAG — MND — ÅR — AKTØRENS UNDERSKRIFT

Kommentarer fra aktør

EAL-KODE — AVFALLSSTOFFNR. — **Mengde** — kilo / liter — ANTALL KILO/LITER — ANTALL KOLLI — Bulk — EMBALLASJETYPE

ANMERKNINGER/EVENTUELLE AVVIK MELLOM AVFALLET OG BESKRIVELSEN FRA PRODUSENTEN

REG NR — AKTØRENS NAVN — *DAG — MND — ÅR — UNDERSKRIFT

Øvrige aktører — REG NR. — DAG — MND — ÅR — AKTØRENS NAVN

2. ledd

3. ledd

4. ledd

Fylt på — REF.TANK NR. — *DAG — MND — ÅR — UNDERSKRIFT

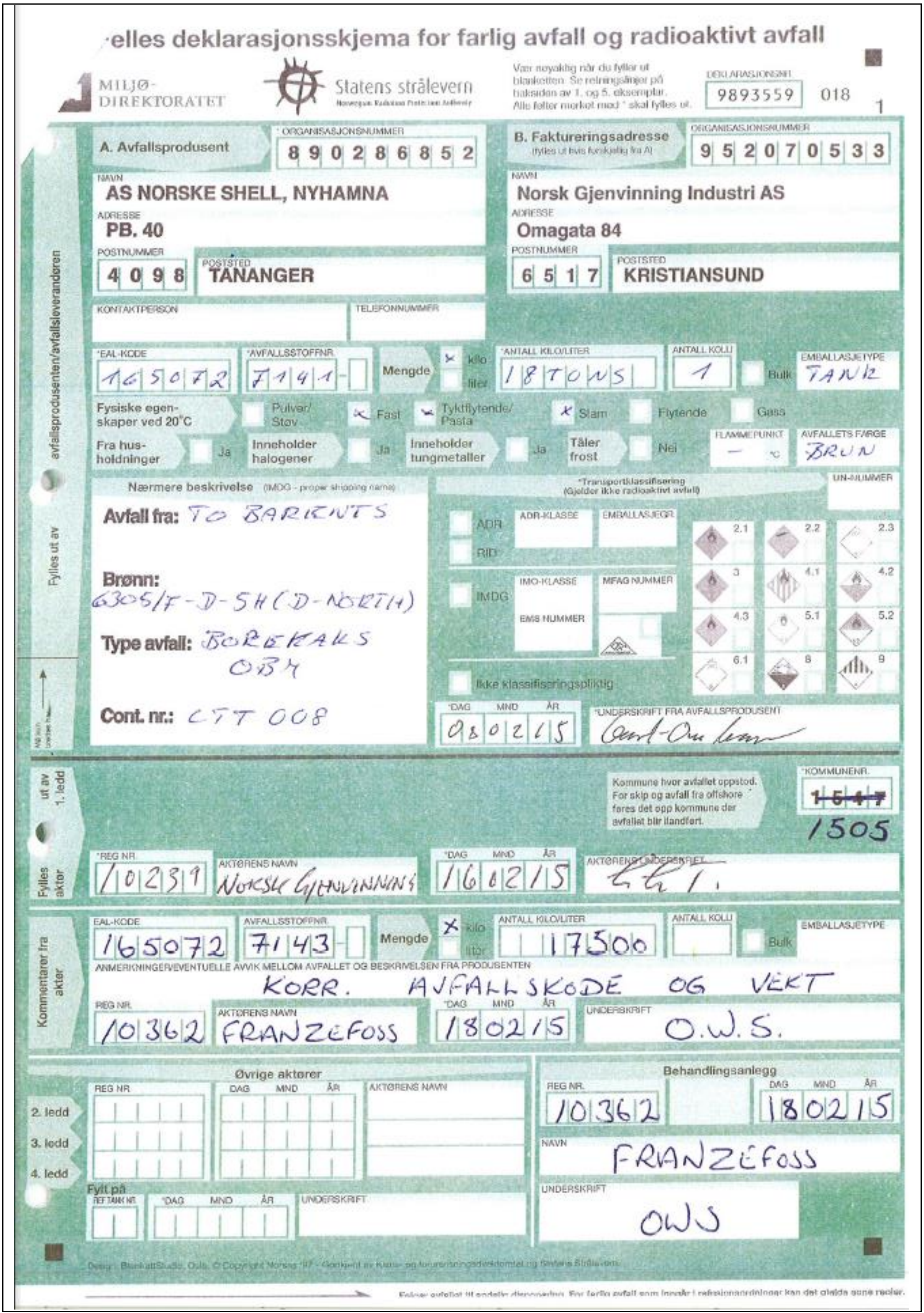
Behandlingsanlegg — REG NR. — DAG — MND — ÅR

NAVN

UNDERSKRIFT

Avfallsprodusentens kvittering

Form 7: Declaration form from Shell (CTT) (Permission from Franzefoss).



·elles deklarasjonsskjema for farlig avfall og radioaktivt avfall

MILJØ-DIREKTORATET | Statens strålevern

Vær nøyaktig når du fyller ut blanketten. Se retningslinjer på baksiden av 1. og 5. eksemplar. Alle felter merket med * skal fylles ut.

DEKLARASJONSNR. 9893559 018

1

A. Avfallsprodusent — ORGANISASJONSNUMMER: 8 9 0 2 8 6 8 5 2

NAVN: AS NORSKE SHELL, NYHAMNA

ADRESSE: PB. 40

POSTNUMMER: 4 0 9 8 — POSTSTED: TANANGER

KONTAKTPERSON — TELEFONNUMMER

B. Faktureringsadresse (fylles ut hvis forskjellig fra A) — ORGANISASJONSNUMMER: 9 5 2 0 7 0 5 3 3

NAVN: Norsk Gjenvinning Industri AS

ADRESSE: Omagata 84

POSTNUMMER: 6 5 1 7 — POSTSTED: KRISTIANSUND

Fylles ut av avfallsprodusenten/avfallsleverandøren

*EAL-KODE: 165072 — *AVFALLSSTOFFNR: 7141 — Mengde: X kilo / liter — *ANTALL KILO/LITER: 18 TONS — ANTALL KOLLI: 1 — Bulk — EMBALLASJETYPE: TANK

Fysiske egenskaper ved 20°C: Pulver/Støv — X Fast — X Tyktflytende/Pasta — X Slam — Flytende — Gass

Fra husholdninger: Ja — Inneholder halogener: Ja — Inneholder tungmetaller: Ja — Tåler frost: Nei — FLAMMEPUNKT: – °C — AVFALLETS FARGE: BRUN

Nærmere beskrivelse (IMDG - proper shipping name)

Avfall fra: TO BARENTS

Brønn: 6305/7-D-5H (D-NORTH)

Type avfall: BOREKAKS OBM

Cont. nr.: CTT 008

*Transportklassifisering (Gjelder ikke radioaktivt avfall) — UN-NUMMER

ADR — RID — ADR-KLASSE — EMBALLASJEGR.

IMDG — IMO-KLASSE — MFAG NUMMER — EMS NUMMER

2.1 — 2.2 — 2.3 — 3 — 4.1 — 4.2 — 4.3 — 5.1 — 5.2 — 6.1 — 8 — 9

Ikke klassifiseringspliktig

*DAG MND ÅR: 08 02 15 — *UNDERSKRIFT FRA AVFALLSPRODUSENT: Gert-Ove [signature]

Fylles ut av 1. ledd

Kommune hvor avfallet oppstod. For skip og avfall fra offshore føres det opp kommune der avfallet blir ilandført. — *KOMMUNENR.: ~~1547~~ 1505

Fylles ut av aktør

*REG NR.: 10239 — AKTØRENS NAVN: NORSK GJENVINNING — *DAG MND ÅR: 16 02 15 — AKTØRENS UNDERSKRIFT: GGT.

Kommentarer fra aktør

EAL-KODE: 165072 — AVFALLSSTOFFNR.: 7143 — Mengde: X kilo / liter — ANTALL KILO/LITER: 17500 — ANTALL KOLLI — Bulk — EMBALLASJETYPE

ANMERKNINGER/EVENTUELLE AVVIK MELLOM AVFALLET OG BESKRIVELSEN FRA PRODUSENTEN: KORR. AVFALLSKODE OG VEKT

REG NR.: 10362 — AKTØRENS NAVN: FRANZEFOSS — *DAG MND ÅR: 18 02 15 — UNDERSKRIFT: O.W.S.

Øvrige aktører: REG NR. — DAG MND ÅR — AKTØRENS NAVN

2. ledd

3. ledd

4. ledd

Fylt på: REF TANK NR. — *DAG MND ÅR — UNDERSKRIFT

Behandlingsanlegg: REG NR.: 10362 — DAG MND ÅR: 18 02 15

NAVN: FRANZEFOSS

UNDERSKRIFT: OWS

Design: BlankettStudio, Oslo. © Copyright Norsas '97 - Godkjent av Klima- og forurensningsdirektoratet og Statens Strålevern

Følger avfallet til endelig disponering. For farlig avfall som inngår i refusjonsordninger kan det gjelde egne regler.

Form 8: Declaration form from Shell (ISO tanks) (Permission from Franzefoss).

Felles deklarasjonsskjema for farlig avfall og radioaktivt avfall

KLIMA- OG FORURENSNINGS-DIREKTORATET

Statens strålevern
Norwegian Radiation Protection Authority

Vær nøyaktig når du fyller ut blanketten. Se retningslinjer på baksiden av 1. og 5. eksemplar.

DEKLARASJONSNR. 8605856 014 1

A. Avfallsprodusent
ORGANISASJONSNUMMER: 914807077
NAVN: AS NORSKE SHELL
ADRESSE: RÅKET 2, PB 2244
POSTNUMMER: 6503 POSTSTED: KRISTIANSUND N.
KONTAKTPERSON: Matr.mann/
TELEFONNUMMER: 71 56 40 00

B. Faktureringsadresse (fylles ut hvis forskjellig fra A)
ORGANISASJONSNUMMER: 952070533
NAVN: Norsk Gjenvinning Industri AS
ADRESSE: Omagata 110 C
POSTNUMMER: 6517 POSTSTED: Kristiansund N.

EAL-KODE: 165072
AVFALLSSTOFFNR.: 7143
Mengde: X kilo / liter
ANTALL KILO/LITER: 20000
ANTALL KOLLI: 1
Bulk
EMBALLASJETYPE: TANK

Fysiske egenskaper ved 20°C: Pulver/Støv · Fast · Tyktflytende/Pasta · Slam · Flytende · Gass
Fra husholdninger: Ja · Inneholder halogener: Ja · Inneholder tungmetaller: Ja · Tåler frost: Nei
FLAMMEPUNKT °C · AVFALLETS FARGE

Nærmere beskrivelse (IMDG - proper shipping name):
Farlig avfall fra innretning navn: WEST NAVIGATOR DRAUGEN G1
BOREKAKS /OBM

Cont. nr.: 1PO-421 20T

Transportklassifisering (Gjelder ikke radioaktivt avfall): ADR · RID · IMDG · ADR-KLASSE · EMBALLASJEGR. · IMO-KLASSE · MFAG NUMMER · EMS NUMMER · UN-NUMMER
2.1 · 2.2 · 2.3 · 3 · 4.1 · 4.2 · 4.3 · 5.1 · 5.2 · 6.1 · 8 · 9
X Ikke klassifiseringspliktig

DAG/MND/ÅR: 13 05 14
UNDERSKRIFT FRA AVFALLSPRODUSENT: [signature]

Kommune hvor avfallet oppstod. For skip og avfall fra offshore føres det opp kommune der avfallet blir ilandført.
KOMMUNENR.: 1505

Fylles ut av avfallsprodusenten/avfallsleverandøren · Fylles ut av 1. ledd · Fylles ut av aktør

REG NR.: 10239
AKTØRENS NAVN: NORSK GJENVINNING AS
DAG/MND/ÅR: 15 05 14
AKTØRENS UNDERSKRIFT: [signature]

EAL-KODE · AVFALLSSTOFFNR. · Mengde: X kilo / liter
ANTALL KILO/LITER: 18500
ANTALL KOLLI · Bulk · EMBALLASJETYPE

ANMERKNINGER/EVENTUELLE AVVIK MELLOM AVFALLET OG BESKRIVELSEN FRA PRODUSENTEN

Kommentarer fra aktør
REG NR. · AKTØRENS NAVN · DAG MND ÅR · UNDERSKRIFT

Øvrige aktører
REG NR. · DAG MND ÅR · AKTØRENS NAVN
2. ledd
3. ledd
4. ledd
Fylt på: REF.TANK NR. · DAG MND ÅR · UNDERSKRIFT

Behandlingsanlegg
REG NR.: 10362
DAG/MND/ÅR: 15 05 14
NAVN: FRANZEFOSS
UNDERSKRIFT: OWS

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Form 9: Checklist – Empting of CTT (NGI, 2014).

Sjekkliste tømming av CTT Tanker

Nr	Prosess	Sjekkpunkt	Sjekket OK
1	Før transport:	Diesel og olje på aggregat	
		Aggregatet starter	
		ISO fester låst	
		Strøm fjernkontroll	
2	Før tipping:	CTT tank kjørt bak på tralle	
		Hydraulikk tilkoblet	
		Henger står beint (sjekk vater)	
		Støttebein satt ned	
		Låsesplint til sikringsbolter fjernet	
		Luft tilkoplet	
		Åpne sikringsbolter	
3	Tømming:	Åpne luke	
		Start tipping	
		Sjekk at tanken er rengjort innvendig	
		Slipp ned tipp	
		Lukk luke	
		Steng sikringsbolter, og sett i låsesplint	
4	Etter tømming:	Åpne ISO fester for å løse CTT tank fra Chassis	

Form 10: Registration form of Franzefoss for handling containers. CTT (Permission from Franzefoss).

Mottaksregistrering

Franzefoss

No.	Dekl. No.	Produksjons- rigg	ID-nummer	Kontrollveid bruttovekt	Taravekt	Faktisk nettovekt	Skader avdekket
1	9893559	Transocean Barents	CTT 008	24 700	7 200	17 500	Treg/defekt hydraulisk kobling
2	9893568	Transocean Barents	CTT 019	24 900	7 200	17 700	
3	9631869	Transocean Barents	CTT 032	24 300	7 200	17 100	Liten skade i rammen
4	9893570	Transocean Barents	CTT 064	23 900	7 200	16 700	
5	9893556	Transocean Barents	CTT 071	21 700	7 200	14 500	
6	9893551	Transocean Barents	CTT 077	23 500	7 200	16 300	
7	9631375	Transocean Barents	CTT 078	23 400	7 200	16 200	
8	9893553	Transocean Barents	CTT 081	25 100	7 200	17 900	
9	9893552	Transocean Barents	CTT 088	26 000	7 200	18 800	
10	9631866	Transocean Barents	CTT 095	25 300	7 200	18 100	
11	9893557	Transocean Barents	CTT 099	23 200	7 200	16 000	
12	9631872	Transocean Barents	CTT 101	24 100	7 200	16 900	
13	9893554	Transocean Barents	CTT 102	25 300	7 200	18 100	
14	9893571	Transocean Barents	CTT 103	11 200	7 200	4 000	
15	9893561	Transocean Barents	CTT 104	25 300	7 200	18 100	
16	9893555	Transocean Barents	CTT 106	26 300	7 200	19 100	
17	9893560	Transocean Barents	CTT 111	25 100	7 200	17 900	
18	9893569	Transocean Barents	CTT 112	23 700	7 200	16 500	
19	9893543	Transocean Barents	CTT 116	24 900	7 200	17 700	
20	9631870	Transocean Barents	CTT 122	23 700	7 200	16 500	
21	9631871	Transocean Barents	CTT 130	23 700	7 200	16 500	
22	9893562	Transocean Barents	CTT 134	24 200	7 200	17 000	
23	9893558	Transocean Barents	CTT 139	23 800	7 200	16 600	
				547 300	165 600	381 700	

Leverandør:	Norsk Gjenvinning Industri
Transportør:	SR Group
Dato:	18.02.2015
PO nummer:	
PRIS:	1750/tonn inkl. tømming
Avfallsstoffnummer:	7143 (Kaks)
Mottatt av (navn):	Multi Marine
Kontaktperson NG:	Jøran Sandøy
Mottatt i:	Kakskaret
Faktura merkes:	

Form 11: Registration form of Franzefoss for handling containers. ISO tanks (Permission from Franzefoss).

Mottaksregistrering

Franzefoss

Leverandør:	Norsk Gjenvinning Industri
Transportør:	SR Group
Dato:	15/5 2014
PO nummer:	
Tonnpris:	1750/tonn
Avfallsstoffnummer:	7143 (Kaks)
Mottatt av (navn):	Multi Marine
Kontaktperson NG:	Frode Sandøy/Jøran Sandøy
Mottatt i:	Kakskaret
Felt:	Draugen G1
Merknad:	Prisen inkluderer tømming

No.	Dekl. No.	Produksjons- rigg	ID-nummer	Kontrollveid bruttovekt	Taravekt	Faktisk nettovekt	Skader av dekket
1	8605856	West Navigator	IPO 421	24 500	6 000	18 500	
2	8605855	West Navigator	IPO 528	25 000	6 000	19 000	
3	8605854	West Navigator	IPO 378	25 000	6 000	19 000	
4	8605853	West Navigator	IPO 191	25 000	6 000	19 000	
5	8605852	West Navigator	IPO 288	24 600	6 000	18 600	
6	8605851	West Navigator	IPO 513	24 000	6 000	18 000	
7	8605850	West Navigator	CMHU 000084	13 000	6 000	7 000	
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				161 100	42 000	119 100	