Market choice opportunities for gas sweetening technologies

"The case study of Thiopaq O&G technology."

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Title: **"Market choice opportunities for gas sweetening technologies. A case study of Thiopaq O&G technology."**

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Preface

This report is the outcome of my graduation research project for the Master of Science degree of Management of Technology at Delft University of Technology. The research was conducted in Frames, Oil and Gas Company located in the Netherlands with the guidance of my graduation committee from the faculty of Technology, Policy and Management.

The completion of this research could not be realized without the support and guidance of my professors and employees from Frames. First of all, I would like to express my sincere gratitude to Professor Daniel Scholten for his constant guidance and advice during the research. He was always available to help me in order to conduct my research in an academic and valid way. Moreover, I would like to thank Professor Jafar Rezaei who provided me and explained the data analysis tool that I used in this paper. I would also like to thank Professor Robert Verburg for his assistance to solve practical problems that I came across. Additionally, I would to thank dr. Peter Hauwert for his cooperation, guidance and assistance that I got through my internship at Frames, where I learned a lot and I applied my theoretical knowledge to solve critical problems in the context of an Oil and Gas company.

Finally, I would like to thank my family for their endless support in many different ways although we live in different continents, because love does not recognise borders. Moreover, my friends from Greece and the new ones that I made in the Netherlands gave me strength to proceed and achieve my goal to get a Master of Science.

George Bezerianos
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Abstract

The assessment of the external or macro-environment in which a company is operating plays an important role in its market research, when it is trying to find the most promising country to sell a new product. Nowadays, the increasing competition is forcing the companies to conduct rigorous market researches in multiple and different stages. In this paper, we focused on building an assessment framework, which will include factors affecting the market choice for an oil and gas treatment process. We have chosen as a case study, the Thiopaq O&G technology, which is a gas sweetening process. We conducted a literature review regarding the existing macro-environmental assessment frameworks in order to extract the most interesting factors for our case study and build a new framework upon them. Then we carried out a survey by sending a questionnaire to the employees working in the O&G industry in order to understand how they rank the identified factors, which are the Political, Economic, Environmental Laws and Competition. Moreover, we attached sub-criteria to each factor in order to have a better insight and be able to rate them from the most to least important. For the data analysis, we used the Best Worst Method (BWM) that is a Multi-Criteria Decision-Making (MCDM) method, so as to have valuable and reliable results. The result of the data analysis gave as the ranking of the sub-criteria according to their significance and then we used a likert-scale to decide which country is the most promising market to sell Thiopaq O&G. According to our respondents the most important factor is Economic while Competition is ranked last, but their sub-criteria showed an interesting variation. The developed framework is a valuable tool that can be used for other products in the O&G industry, while the sub-criteria can change according to the perceptions of the one who is constructing it. Thus, it is an addition to the existing literature related to the evaluation framework of the external environment.

Keywords: market research, oil and gas, external factors, macro-environment, PEST, Porter's five forces, multi-criteria decision-making (MCDM), best worst method (BWM), Thiopaq O&G

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List of Abbreviations

Item	Description
O&G	Oil and Gas
S	Sulphur
H_2S	Hydrogen Sulphide
CO_2	Carbon Dioxide
CAPEX	Capital Expenditure
MCDM	Multi-Criteria Decision-Making
BWM	Best Worst Method
IT	Information Technology
MADM	Multi-Attribute Decision-Making
MODM	Multi-Objective Decision-Making
CR	Consistency Ratio
CI	Consistency Index
U.A.E.	United Arab Emirates
EPI	Environmental Performance Index

Table 1: List of Abbreviations

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Chapter 1 Introduction

The importance of sustainability in the Oil and Gas (O&G) industry is constantly increasing because of environmental concerns and application of strict regulations. The demand for cleaner hydrocarbon recovery is constantly gaining more attention from the O&G companies.

The focus if this research will be on the natural gas processing and sweetening streams. Natural gas is a combustible mixture of hydrocarbon gases and is a vital component of the world's supply of energy (NGSA, 2015). Natural gas is one of the cleanest, safest and most useful of all energy hydrocarbon sources. So, it is widely seen as a key element in the energy mix that will meet the world's growing demand over the coming decades. In recent years, the production of gas resources has increasingly required the removal of sulphur (S) species as well as hydrogen sulphide (H_2S) and carbon dioxide (CO_2), making the gas treatment process more complex and expensive. Nearly 40% of the world's gas reserves contain high level of H_2S and CO_2, which pose obstacles to the production process. This type of gas is called sour gas and is mandatory to use a desulphurization process in order to remove the hazardous compounds (H_2S, CO_2) and the treated gas can be brought in the market and be sold.

The capital expenditure (CAPEX) of the treating section of the natural gas can sometimes amount to more than 50% of the total CAPEX in developing a sour gas field. Recent tightening of product specifications for sour gas, as well as stricter environmental standards has increased the complexity of the production process. The aforementioned accent the importance of a desulphurization process to remove H_2S from the sour gas, so it can meet the market standards and specifications. So, the market of sour gas desulphurization has increased and the O&G companies, like Frames, are trying to get as much as more market share as possible. But, it is crucial to target a country or a region around the globe to promote and sell a new desulphurization technology.

Frames is a privately owned O&G company, founded in 1984 and headquartered in the Netherlands with offices worldwide to better meet local customer demands. The mission of the company is to deliver sustainable, reliable and high quality products, from single systems to complete integrated installations.

Frames has been designing and building technologically advanced high quality process and control systems for the international upstream O&G industry. Specialized in the design, fabrication, supply, installation and commissioning of complete systems for O&G treatment, separation, heat exchanging, flow control and safeguarding. Frames continuously expands its technologies as well as its costumers base to include virtually all the major O&G production companies. Frames is specialized in supplying technologies, products and processes that can eliminate aromatics, clean waste water and reduce the environmental impact during the production stage.

1.1 Problem Statement

The Frames Thiopaq O&G system aims to remove H_2S components from sour gas streams. These types of systems are used at least for 20 years around the world. Although Thiopaq O&G system offers an efficient, sustainable and relatively cheap desulphurization solution it is not well established in the market. There are many internal and external factors that affect a successful route of Thiopaq O&G in the market. In this research, the market we are searching will be a country or greater geographical region around the world, where big sour gas reserves are located. The decision about the most promising market will be based on the examination, rating and prioritization of the external factors, which are present in the macro-business environment.

Frames engineers are thinking of ways to overcome the obstacles that Thiopaq O&G system faces regarding its overall commercial value. The dominance of a technology and the acceptance in the market does not only depend on its technological superiority over the alternative and competitive solutions, but it must comprise many attributes. Moreover, the Thiopaq O&G process is applied in a very specific market and it has to be assessed precisely. As a result, there is a need to build a framework specifically made for it, which will include factors that apply in this market and technology.

The latter indicates the importance of management of Thiopaq O&G technology in a broader sense in order to create competitive advantage. So, the identification of the external factors plays a major role in the successful promotion and marketing of the technology. This research will try to shed light on the most important external factors and rate them based on a questionnaire, which will be distributed and filled by employees in the O&G industry. Then, the most promising market will be chosen according to the results of the evaluation of the external factors identified in the literature.

Every country has different economic environment, needs, laws and regulations. In other words, the external environment greatly differs from region to region. So, the assessment of the factors will be a guide for the choice of the most promising market. As a result, Frames can target certain countries where there will be more possibilities for selling Thiopaq O&G system.

The O&G market is not carved in stone, so a rigorous research must be implemented in order to increase the possibility of gaining a market share in the gas desulphurization market. So, numerous questions rise related to the choice of the most important factors, the way of assessing them and how the results of this process can lead in the choice of the market. This paper will approach the market research for the Thiopaq O&G technology from the macro-level perspective and specifically focuses on the external factors that dictate a market choice. The variation of those factors will shift the final choice because we will search for a country that satisfies the most important factors according to the perceptions of the people working in the O&G industry.

1.2 Research Objectives

The objectives of this thesis are the following:

- Identify and choose the main external factors that affect the investment decision of a company in the O&G industry.
- Build upon existing macro-environmental frameworks and create a new one, which will include factors that are related to the gas sweetening technologies.
- Apply the framework and use the results from the data analysis to choose the most promising and appropriate market to launch a new product.

It is crucial to know the factors that are present in the external environment of the O&G industry. Although the companies cannot influence or change those factors, the can assess them and choose a market that is friendlier for new investments. The assessment is an essential step for the marketing and promotion of a new product. If a company produces a technology that is technically superior compared to its competitors, it is not guaranteed that it will succeed in the market. It is important to target countries where the macro-environment promises that there are more opportunities for this new product to be sold. So, a research has to be done in advance, and the added value of this research is to create an assessment framework to help companies perform the external environment analysis.

1.3 Research Questions

The company's initiative is to find the best market to sell Thiopaq O&G, according to the premises of the macro-environment. Based on the objectives, knowledge and expertise should be obtained on the market research field, especially for the O&G industry, by answering the following main question:

"*Which is the ideal country to promote and sell the Thiopaq O&G process, according to the evaluation of the external factors?"*

An extended literature review will be performed for this research in order to gather and select the external factors that are mentioned in the literature. The evaluation of the factors will lead to the selection of the most suitable country to target for promoting Thiopaq O&G. Answering this question helps in choosing the market according to the macro-environmental assessment.

In order to reach the research objective is it important to answer the following sub-questions:

"*SQ1: What are the existing frameworks that are used for the external environment scanning?"*

There are many frameworks that are used when a company is performing a market research related to the external environment of their business. We will pick the information from those frameworks and build a new one, which will be more suitable for application in the O&G market. Every industry has its own specifications and

characteristics so there is not a universal framework that can be applied. The new framework that will be constructed, inspired by the existing ones, will be the main scientific addition of this research. The external factors will be attached to the framework and will be assessed.

"SQ2: How do employers, employees and managers working in the O&G industry, evaluate and rank the identified external factors and their sub-criteria?"

The answer of this sub-question will give the information that we need to reach the objective of the research. If we understand how people in the O&G sector prioritize the factors, then we can decide on the country or geographic region that will be selected. The data analysis will reveal the most important external factor that is taken into account before a decision is made. Although, every individual has a different preference, the decision-making process is collective, so the ranking of the factors plays an important role in the procedure.

"SQ3: How the created framework is applied in the case of the Thiopaq O&G process?"

It is important to understand if the framework that we will use is suitable for the technologies and products in the O&G industry, specifically for the Thiopaq O&G case. The answer of this sub-question will come at the later stages of this research, precisely in the data analysis step. It is crucial to evaluate the applicability of the framework, because if it is serves our purpose, this will be an addition in the existing literature related to similar topics.

1.4 Research Framework

The objective of this research is to identify the most suitable market, defined as a country or greater geographic area, for an innovative gas treatment technology. In order to fulfil the objective it is necessary to follow certain steps during the research process. The first step is conducting a literature review in the topics of business macro-environment assessment models, external factors related to investment decision-making and multi-criteria decision-making (MCDM) methods. We will provide an overview of the factors related to our case and create an integrated assessment framework. Figure 1 represents the input and the output of the first step:

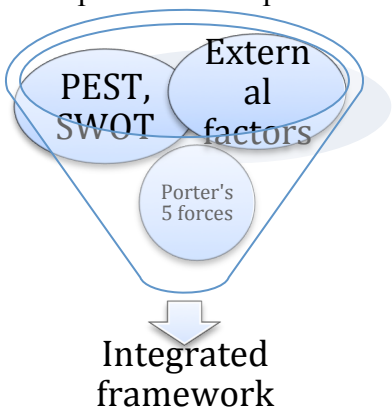

Figure 1 Literature review output

The second step includes the creation of a questionnaire, which will be designed according to the MCDM method that we will use. We will choose the method, after reviewing the existing ones in the literature. The purpose of the questionnaire is to help the respondents rank the external factors. The data collection and analysis will show their preferences from the most to the least important external factors and sub-criteria. Figure 2 illustrates the procedure of step two:

Figure 2 Data collection process

The third step is to give an answer to the research question, which is the choice of the country based on the applied framework and the data analysis that derive from it. The final step is to sum up the most important findings of this research and propose recommendations. Figure 3 represents the research approach:

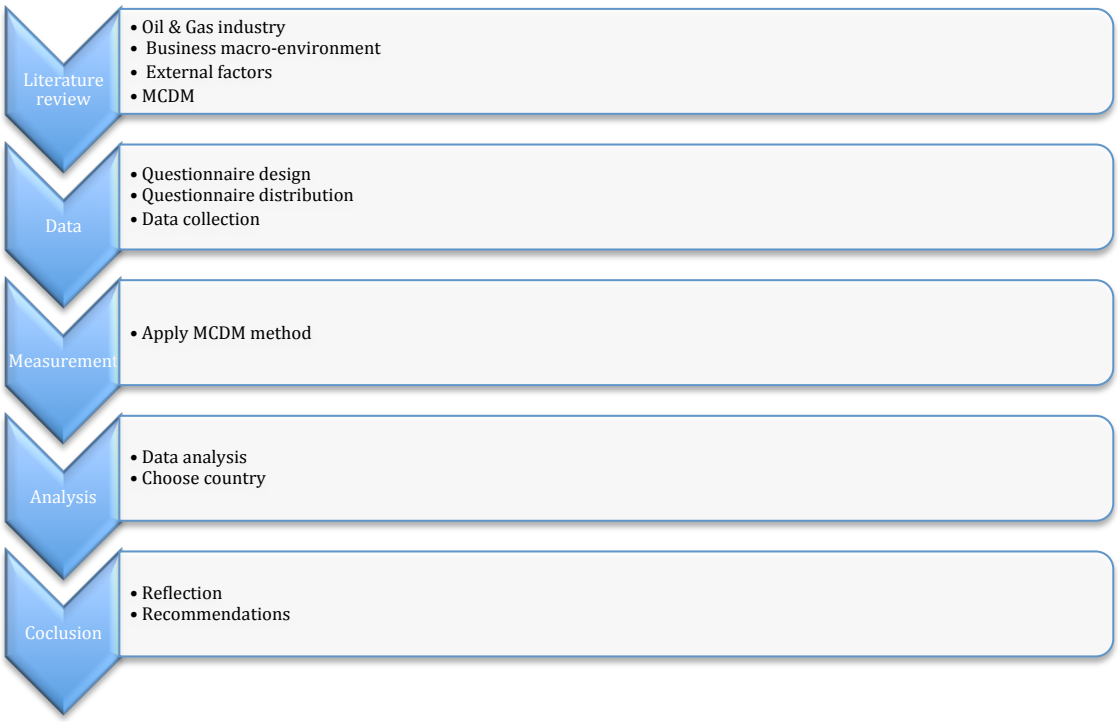

Figure 3 Research framework

1.5 Relevance

The relevance of this research is described in the three following sectors:

- *Academic relevance*

  There is a limited number of literature and research on the impact of the external environment related to a market research in the O&G industry. Most of the studies are conducted for fast paced changing industries such as information technology (IT) or telecommunications. So, it is important to understand, through this research, how people working in O&G firms evaluate and think about the external factors and link them with their intention to sell a new product.

- *Practical relevance*

  This paper will focus on a specific technology, which is the Thiopaq O&G process. So, we will try to solve an existing problem and apply theory into practise. The theoretical background is provided from the Master of Management of Technology at Delft University of Technology and is used to solve the problem that the engineers of Frames are facing. The connection between the literature and a practical problem is an added value of this research. The case study of Thiopaq O&G technology will help us derive concrete results. The company itself will gain more knowledge in the market research and may use this assessment framework for other cases.

- *Societal relevance*

  Thiopaq O&G is an innovative and sustainable technology that intends to replace other technologies, which are more capital intensive and have increased energy consumption. Moreover, this process has less polluting by-products. So, local societies and communities will be benefited by the increased adoption of Thiopaq O&G technology.

Chapter 2 The O&G industry and Thiopaq O&G case study

This chapter provides a brief introduction of the O&G industry and highlights its importance for our society. The O&G value chain is illustrated and explained. Then, the sour gas market and processes are defined and finally linked to the case study of the Thiopaq O&G process.

2.1 Outlook of the O&G industry

Oil and gas are the most important fossil fuels, which are formed from the decomposition and pressurisation of algae, plankton and other organisms (APPEA, 2014). Moreover, they were formed from the remains of animals and plants, which lived in a water environment and layers of mud and dust covered them. Heat and pressure from these layers helped the remains turn into what we today call crude oil (Aliyeva, 2011).

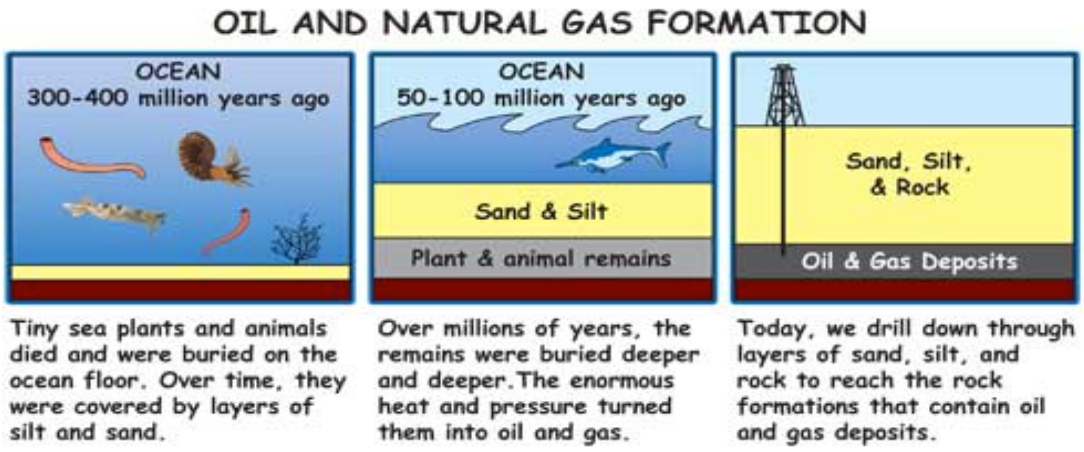

Figure 4 O&G formation (Aliyeva, 2011)

O&G have played a major role through world history and it is more important nowadays because our society and economy is totally dependent on them. The O&G industry keeps evolving and numerous applications of the O&G products have also expanded and become an integral part of today's global economy (BERA, 2013).

O&G companies are trying to minimize their operational costs, meet the environmental standards while increasing their production in order to remain competitive. They have to follow a certain process that starts from the wellhead and ends when the customer receives the final product, oil or gas. Figure 5 illustrates the O&G processes, which are exploration, extraction, refining and marketing of petroleum products (Chima, 2007).

Figure 5 O&G value chain

Although this is the general O&G value chain, operations are different when we refer to the oil and to the gas chain, along those five steps. O&G companies are facing the challenge to find and put the reserves into production and the deliver products to consumer at the minimum possible cost (Chima, 2007). Natural gas and crude oil often can be found in the same location, but the take completely different routes from the exploration till they reach the consumer (API, 2105). Figure 6 and 7 present the different operations that take place from the wellhead to the pump:

Figure 6 Oil value chain

Figure 7 Natural gas value chain

We can notify that the vital different step is the gas treatment, where Thiopaq O&G process can be used. The O&G engineers are focusing on finding innovative technologies for treating the gas especially sour gas that is more difficult to handle. The last couple of years sour gas market is developing fast and technologies like Thiopaq O&G are trying to enter this market and replace the obsolete processing technologies.

The O&G industry is divided into three major sectors according to the O&G value chain and the operations throughout this chain. The first sector is the upstream which involves the exploration and production processes. The second sector is the midstream where we have the oil transportation or the gas processing and transportation respectively. The third and final step is called downstream, which includes the marketing of the final products. The focus of this research is on the midstream sector, specifically on the gas processing. Figure 8 provides an overview of the three streams.

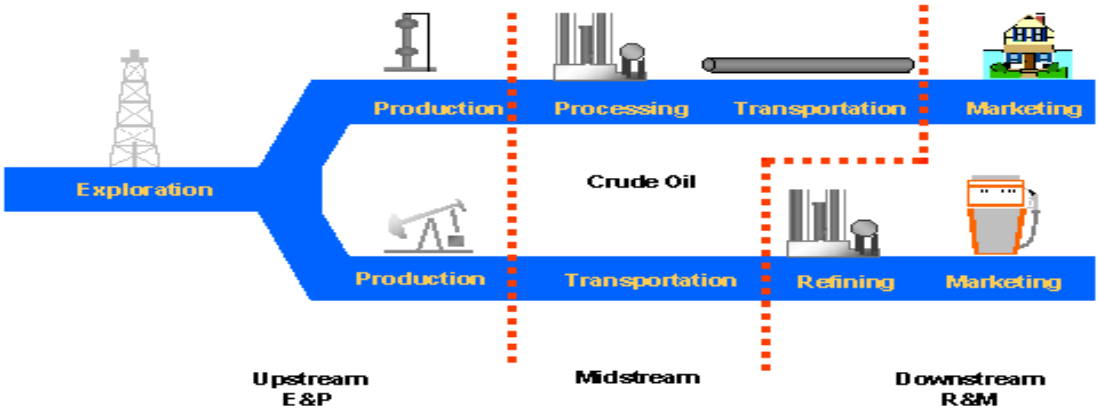

Figure 8 O&G streams (PetroStrategies, 2015)

To conclude, it is obvious that the O&G industry has to coordinate different practices and processes in order to provide our society with the final products. Each stream is a different segment and needs to be studied separately. This research focuses on the midstream, which is the gas processing, and will investigate which external environment is friendlier for adopting a new process.

2.2 Natural gas

Natural gas is becoming one of the vital components of the world's supply of energy, because it is one of the cleanest, safest and most useful of all energy sources (Natgas, 2013). It is predicted that the natural gas demand increases at an average rate of 2.4% annually till 2030 in the world (Najibi, Rezaei, & Javanmardi, 2008). Figure 9 presents the expected worldwide natural gas consumption till 2015, and it is clear that there will be an increasing demand.

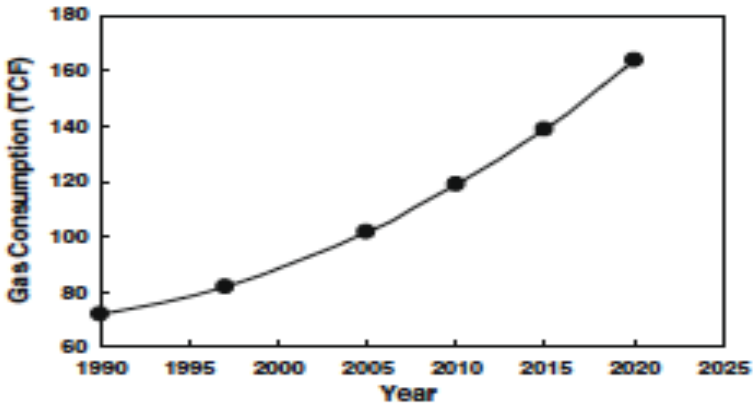

Figure 9 Worldwide natural gas consumption

Natural gas is found in reservoirs beneath the surface of earth. Once removed from a reservoir, it is usually transferred to a gas processing plant to remove impurities and by-products (Alberta, 2014). It is a combustible mixture of hydrocarbon gases and is colourless, shapeless, and odourless. Its typical composition is presented in the following table.

Methane	**CH_4**	**70 – 90%**
Ethane	C_2H_6	0 - 20%
Propane	C_3H_8	0 - 20%
Butane	C_4H_{10}	0 - 20%
Carbon dioxide	CO_2	0 - 8%
Oxygen	O_2	0 – 0.2%
Nitrogen	N_2	0 - 5%
Hydrogen sulphide	H_2S	0 - 5%
Rare gases	A, He, Ne, Xe	Trace

Table 2 Natural gas composition

The end users of the natural gas are residential consumers, commercial enterprises and other industries. Although, oil is mainly used as a primary source of energy more people and companies are willing to switch to natural gas because it is less expensive, more safe and environmental friendly. In other words, natural gas is an attractive fuel because it is clean burning, efficient and ample supplies of it are available from domestic resources (Levine, Carpenter, & Thapa, 2014). Figure 10 illustrates the percentages of uses of natural gas per sector (EIA, 2012):

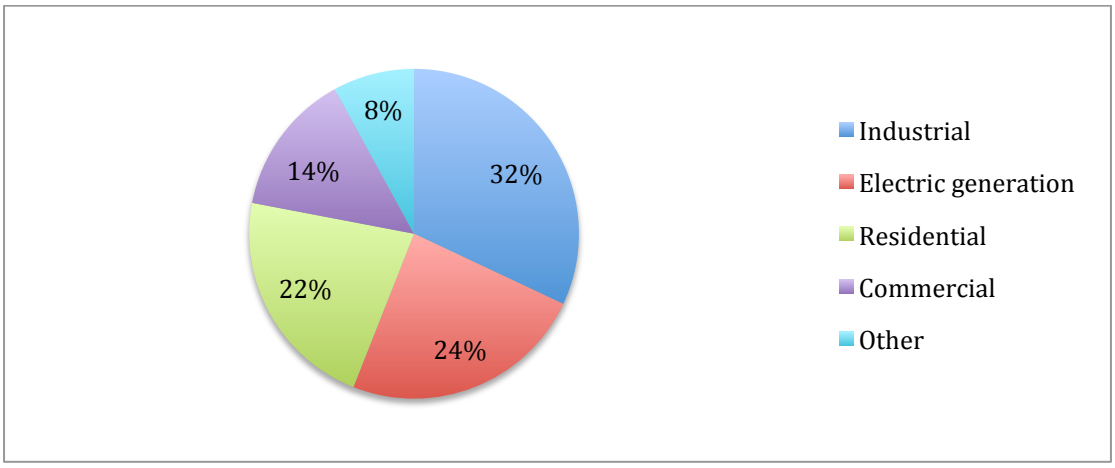

Figure 10 Natural gas use by sector

The aforementioned indicate that the natural gas market is profitable and expected to be because of its numerous advantages compared to other conventional sources.

2.3 Sour gas

Sour gas is natural gas, which contains high levels of H_2S and CO_2. It contains more than 5.7 milligrams of H_2S per cubic meter, which is equivalent to approximately 4ppm by volume under standard pressure and temperature. Sour gas needs further hydrocarbon processing in order to meet natural gas specifications presented in Table 2. This process is called gas sweetening or desulphurization and is mandatory; H_2S and CO_2 compounds must be removed before the gas can be sold and the tighter regulations for air pollution impose 99.9% H_2S removal (Ye, 2014). H_2S is generally converted into elemental sulphur, generating, 24.2 million tons per year, which represents 35% of the total world sulphur production that is 69 million tons (Ye, 2014). Sour gas market is a challenge for the O&G companies because nearly 40% of

the world's reserves contain sour gas (Figure 11), which pose obstacles to treatment and development (Foster & Carroll, 2014).

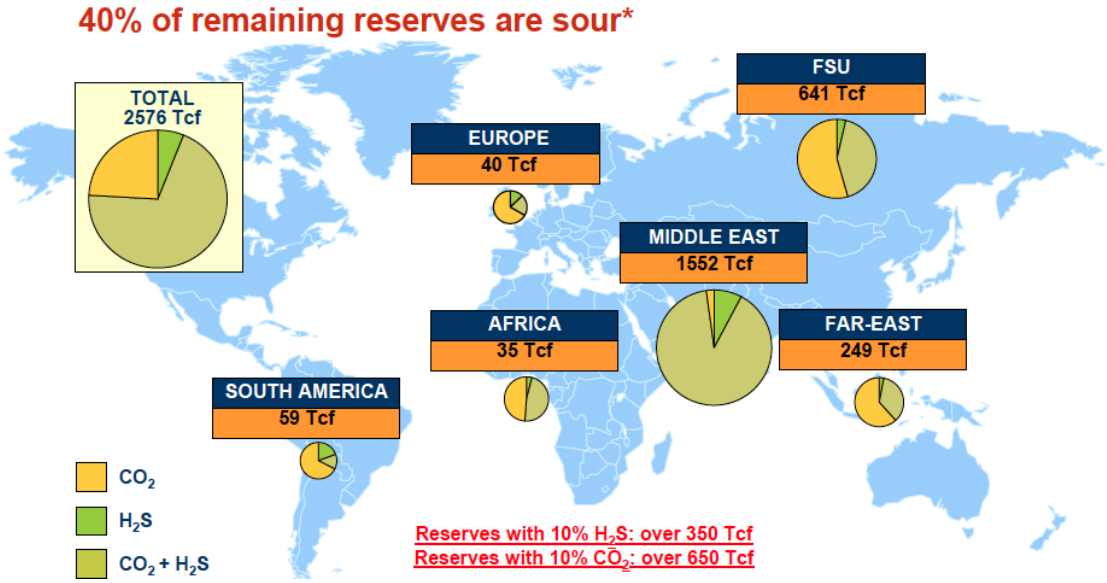

Figure 11 Worldwide gas fields

Sour gas fields are located all over the world but the biggest reserves are found in North America and the Middle East. Is it important to use sweetening gas technologies that are innovative and enable O&G companies to produce gas via economically viable procedures, in compliance with increasingly tough sales gas specifications and environmental objectives (Total, 2012).

2.4 Thiopaq O&G process

Small/medium-scale and large-scale plants serve the market of H_2S removal and recovery. Claus units serve large-scale plants. The tighter regulations have opened up a market for small/medium-scale plants where the Claus units are typically considered uneconomical. The Frames Thiopaq O&G system is applicable for this market and offers an effective and efficient removal of H_2S from the sour gas stream. On the other hand, this process has two by-products, which are a bleedwater stream and the elemental sulphur stream. Those streams need treatment in order to optimize the added value of the Thiopaq O&G process for specific locations and conditions.

The Thiopaq O&G process was initially developed in the 1990s for desulphurization of biogas, relying on scrubbing with a mild alkaline solution and biological solvent regeneration. This process has been upgraded to the flow rates and standards of the oil & gas industry, leading to an economic application range up to 150 tons of sulphur per day. The Thiopaq O&G process can remove H_2S from low, medium and high-pressure natural gas streams. In this process, a gas stream containing H_2S contacts an aqueous soda solution containing bacteria (Thiobacillus species and others) in an absorber. The soda absorbs the H_2S and is transferred to an aerated atmospheric tank where the bacteria biologically convert H_2S to elemental sulphur. Threated outlet gas can readily meet a less than 4ppm H_2S specification. The biological sulphur produced

can be used for agricultural purposes or purified to a high quality sulphur cake. A schematic overview of Thiopaq O&G process is shown in Figure 12 (Zessen & Janssen, 2004).

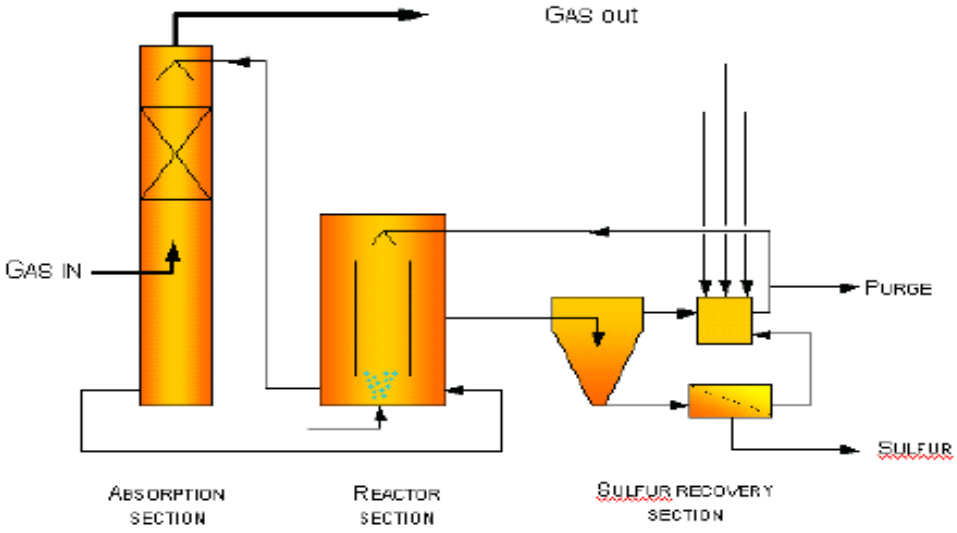

Figure 12 Thiopaq O&G system overview

Chapter 3 Literature review

In this chapter, the results of the literature review regarding the external factors and the theoretical frameworks that assess them are presented. The assessment framework that we will use for this research and the chosen factors and sub-factors are illustrated.

3.1 Technology diffusion

The added value and the benefits of using Thiopaq O&G technology, compared to the traditional sour gas processing technologies are reduced OPEX and CAPEX, ease of operation and improved safety. Although Thiopaq O&G process offers these advantages, is facing difficulties in gaining more market share after its first market introduction. The latter raised questions about the effect of the external business environment on the successful positioning of Thiopaq O&G in the market, because the internal environment is definitely better compared to the competitor technologies. Thus, it triggered our interest to search for the factors that are present in the macro-environment and prevent Thiopaq O&G from dominating the market.

Whilst most would agree that the future of the O&G gas sector depends upon the development and adoption of new technologies, there are wide-ranging views on the current state and future outlook for innovation (McAuley, 2014). The diverse opinions indicate the difficulty, which is faced by the O&G companies, to enable a new technology enter and remain competitive in the market.

The firms are struggling to increase their profits by selling their products and ultimately be recognized as the dominant one. The process in the battle for a dominant design is uncertain; nevertheless researchers in the fields of industrial economics, institutional economics, technology management, standardization and social networks (Van de Kaa, 2009) identified several factors affecting the outcome of the battles for dominance. Moreover, dominant design is selected in markets characterized by increasing returns to adoption (Schilling, 2010), such as the O&G market.

Three main phases are identified in the literature during the process of dominating the market, which are the following (Ortt & Schoormans, 2004):

- Innovation phase: increased attention for research and development to commercialize the product
- Adaptation phase: a market for the technology is created in which the battle for dominance is fought
- Stabilization phase: describes the period after dominance; in this phase there is increased attention for improvement of production process

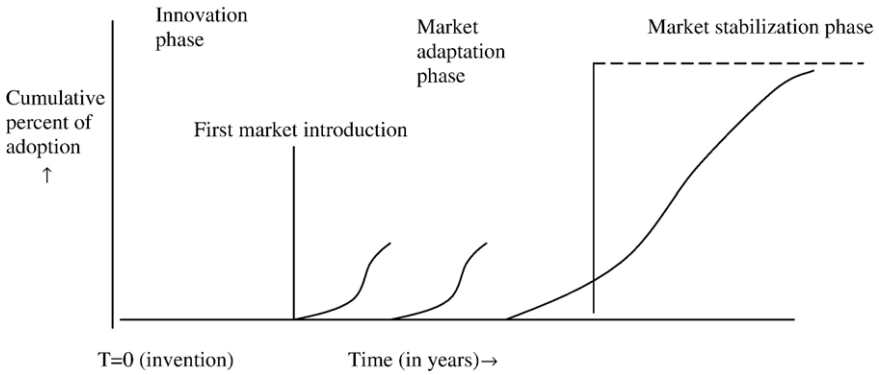

Figure 13 Three phases in the diffusion process (Ortt & Schoormans, 2004)

To conclude, this paper will focus on the identification and classification of the external factors that influence the market research for the most promising country to sell the Thiopaq O&G process, which takes place during the market adaptation phase. This research is part of the formulation of a company's business strategy and presupposes a decision-making process in order to take a decision while taking into account as many data and information as possible.

3.2 Investment decision-making

Managers generally are constantly trying to make decisions with the best outcomes, especially when those decisions concern investments that require capital expenses but have the potential to bring profits to their companies. The making of a decision to invest is a multi-stage interactive process and requires predictions about the future (Derregia & Chittenden, 2015) and assumptions of factors affecting those predictions.

Today's work environment is highly volatile and managers must take the responsibility to maker good or quality decisions in order to ensure the survival of their organization (Moss & Kinnear, 2007). A good or quality decision is a decisions that results from a thoughtful decision-making process, which emerged from a process of seeking, understanding and using the information effectively in situations of uncertainties (Maheran & Jantan, 2009). Thus, the macro-environmental scanning is a tool in a firm's arsenal that can be used to understand and evaluate it (Albright, 2004). So, it is very important to gather information about the external factors that guide the market choice of an organization. There is not a universal list of factors that can be applied in every industry or business sector and a rigorous selection of factors has to be made so as to make a quality decision. Thus, the decision-making process imposes to define a certain business environment, choose or build upon an existing environmental assessment framework and pick the most important factors identified in a certain industry.

3.3 Business environment

Business environment consists of all the factors that have an impact on the business. The term business environment refers to external forces and factors, which are beyond the control of firms and their managers but they a have a bearing on their strategies

and decisions. Given the many challenges and opportunities in the current marketplace, companies and managers are forced to formulate strategies when they are launching a new product or process and the next step is to implement them in order to outperform their competitors. As a result, the firms are straggling to create effective strategies and take strategic decisions with controlled risk.

The aforementioned led to the creation of an academic field, which is called strategic management (Nag, Hambrick, & Chen, 2007) and is executed by the majority of the companies, when it comes to business strategy. Strategic management is defined as the type of management that consists of the analysis, decisions and actions an organization undertakes in order to create and sustain competitive advantage (Dess & Lumpkin, 2004). In practice, the managers are analysing the firm's business environment so as to be able to take decisions, which are expected to be beneficial and profitable.

A company's strategy aims to minimize the risk of making a mistake and carrying out activities by chance in an expanding and highly unstable environment (Yuksel & Ihsan, 2012). In order to successfully formulate and execute this strategy, the managers must carry out a procedure, which is called strategic analysis. Strategic analysis, is the most important stage of strategic management, and involves the analysis of current factors relevant to the environment within which the company carries out its operations (Ulgen & Mirze, 2007). The following figure illustrates the most widely used business tools, which fit into the strategic planning process (FME, 2013).

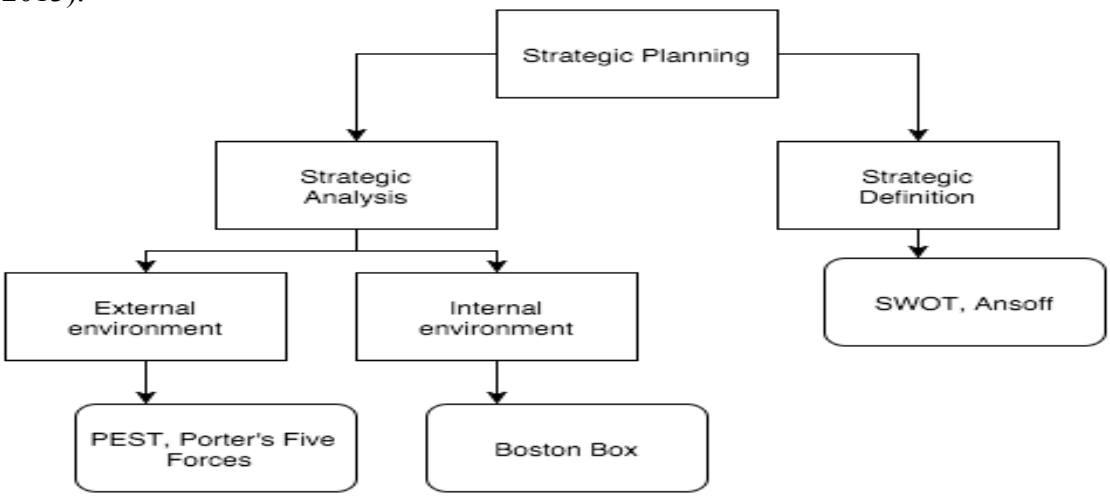

Figure 14 Business analysis tools (FME, 2013)

The latter emphasizes the importance of defining the business environment in which a company operates. The business environment of a company consists of both internal and external environment (Williams, 2014) and is classified into those categories, illustrated in the following figure (Verma, 2012):

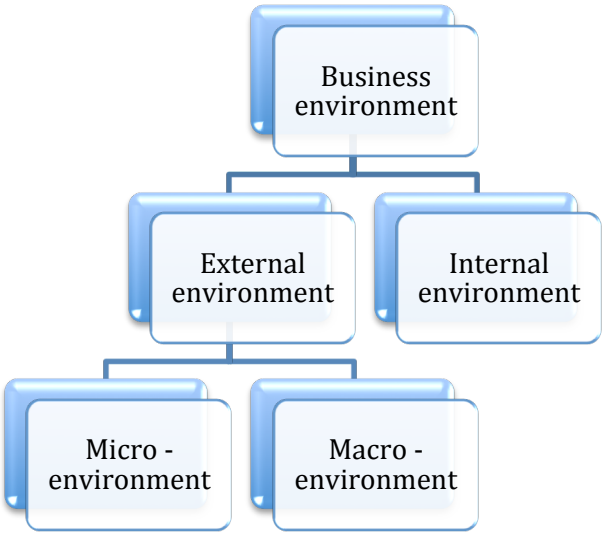

Figure 15 Analysis of business environment

3.3.1 Internal environment

The internal environment is characterized by the forces inside a firm, which affect its operations composed of internal stakeholders and other functional areas within the business organization. The internal environment consists of the organization's resources and capabilities, goals and values, and structures and systems (Grant, 2010).

The internal environment can be as important for managing change as the external, so it is essential to distinct the procedures and activities that take place. For example, those can be the allocation of responsibilities within the firm, the availability of the resources, the attitude of the internal stakeholders and generally the culture of the organization.

It is equally important for a company, after defining those procedures, to use a tool to analyse the internal environment and gain valuable information for its performance. Such analysis helps to identify both strengths and weaknesses (Dess & Lumpkin, 2004), which can determine the potential success in an industry. The results of the analysis can be evaluated and cause structural changes in the internal environment while affecting its strategic decisions.

There is not a certain tool or framework to assess the internal environment of a company, but the most commonly used is the SWOT analysis. SWOT is an acronym that stands for Strengths, Weaknesses, Opportunities and Threats. The purpose of this method is to identify both internal and external factors that can affect a business venture. Strengths are positive and Weaknesses are negative factors related to the internal procedures of the organization. Opportunities are external factors that have a positive interaction with the system (Srdjevic & Bajcetic, 2012), while Threats represent the negative effects, which are present in the external environment. Furthermore, the primary use of SWOT is in the identification of strategic options by linking internal and external factors, which influence the strategy of a company. As a

result SWOT analysis will not be used as a tool because it has a bilateral orientation and serves better a micro environmental evaluation, while this research focuses only on the external environment.

3.3.2 External environment

O&G companies find themselves operating in a fast paced changing environment and they are forced to analyse their external environment in order to remain competitive. The macro-environment is characterized extremely complex and dynamic. It keeps changing drastically and has to be rigorously analysed. The results of the analysis can aid a firm to define and shape its strategy when it plans to sell a new product and searches for the most promising market. In other words, the assessment of the external factors is a major step of the strategic planning process. Those factors are outside of the control of the business but they impact the performance of the firm currently and in the future. It is a necessity for companies to recognize and respond immediately to changes in needs and trends in the external environment (Kotler & Keller, 2012).

In this research, we will use the PEST framework and the "Porter's Five Forces" analysis to extract the main external factors, with the intention to create a new framework inspired by those two. Then, relevant criteria will be attributed to each factor in order to understand and describe the external environment. It is crucial to know which factors and relative criteria are considered more influential in the formulation of the business strategy of an O&G company, when it searches for the most suitable market to sell a new product.

The PEST analysis represents one of most important methods, like the "Porter's Five Forces" model, applied to analyse the macro-environment. A company, during its process to identify the factors of the market environment that influences its operations, can use the PEST framework. The PEST analysis is a useful tool for understanding market growth or decline (Champan, 2012) and enables a company to estimate the potential negative influences from the external environment that can affect the demand for a new product or significantly change the industry structure. In general, managers mainly use PEST analysis when their company is planning to launch a new product, exploring a new route to market or selling into a new country or region (FME, 2013). The PEST framework assumes that there are four factors in the external environment, which affect the business process and they are the following: Political, Economic, Social and Technological.

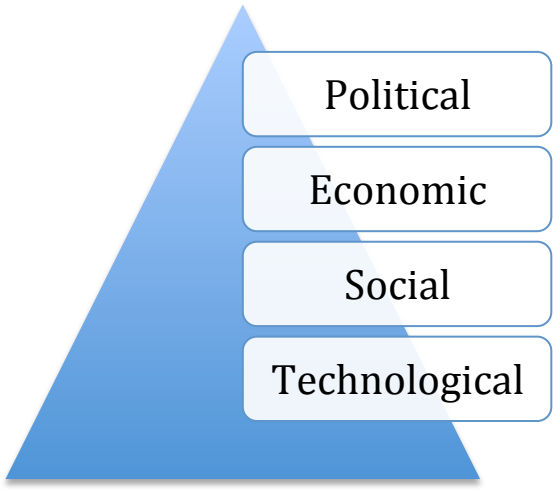

Figure 16 PEST analysis

Nevertheless, each company must identify the main factors in its own environment in order to effectively use the PEST analysis. The intention of the managers of a firm is to classify which factors are likely to change and which ones are expected to have the greatest impact on it (Gillespie, 2014).

Political factor refers to the governmental policies and the political environment in general that affect the business and future investment plans of a firm. Any changes in the policies can result either in the creation of a positive investment environment or cause serious implications. Economic factors depict the fluctuations in categories such as the inflation rate, taxes or trading regulations (FME, 2013). Social factors that can have an impact on the market include the population growth rate, the employment levels or the cultural conventions. Finally, the Technological factors describe the issues that rise form a new technological invention or an unexpected lack of sources.

The "Porter's Five Forces" analysis is applied to the formulation of competitive strategy and relates the company to its external environment. The Porter's framework is an analytical technique, which helps the company analyse its industry as a whole and predicts the industry's future evolution by understanding its competitors and its own position (Porter, 1980). The most important contribution of this technique is that by using it, the ability of the company to define its market properly increases. If the market is narrowly defined, which is called 'marketing myopia', it could be impossible for the firm to work out who the competitors are in terms of market need and opportunities (FME, 2013).

Except of avoiding 'marketing myopia', the "Porter's Five Forces" can be a valuable tool to overcome 'environment uncertainty'. Uncertainty has been a central concept in the organization theory literature, particularly in theories, which seek to explain the nature of the relationship between organizations and their environments (Miliken, 1987). The market uncertainty increases when the company lacks critical information about its environment (Hokroh, 2014), and they can be gathered and analyzed by using the "Porter's" framework. The analysis aims to define the competitors, so as to enable the firm to formulate its strategy to remain competitive and profitable.

The clarification and definition of the potential market presupposes the forecast of the production of new technologies or processes from competing firms, which will be the

counterweight. In other words, the greatest threats are more likely to come from new and emerging technologies or new technologies (FME, 2013). The "Porter's" model assumes that five forces determine the attractiveness of the market (FME, 2013), and mainly focuses on the analysis of the competitive intensity.

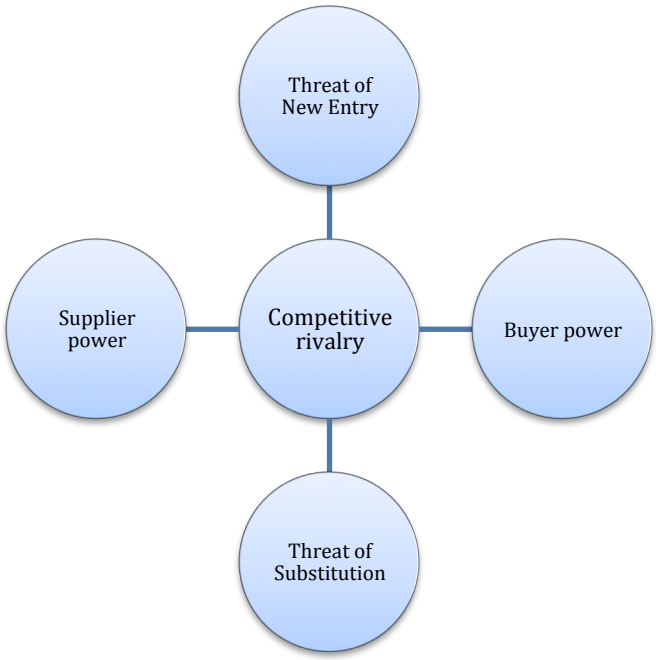

Figure 17 Porter's Five Forces (FME, 2013)

One of the keys to success for organizations is their ability to understand their competitors' actions and marketing strategies (FME, 2013). The evaluation of the competition is a complex and critical process for an organization because it affects the determination of its strategy and its economic performance. Competition works to drive down the rate of return on invested capital (Porter, 1980), which may lead to diminishing returns and finaly elimination of the company.

The threat of new entrants refers to the possibility of new companies entering the market and this is a key factor than has to be quantified. Increased probability of new rival companies entering the market makes difficult the fight to augment profits, without increasing the expenses for investments. New entrants to an industry bring new capacity and the desire to gain market share (Porter, 1980). The same implies for the theat of subistitutes because products from other idunstries with similar specifications but lowe price, may gain a percentage from the market share of a certain industry. As a result, every new product offered by a firm must havea competitive advantage over the competing ones.

Buyers and potential customers are always trying to force the prices down without accepting any reduction in the quality of the service or the product. So, companies want to launch an innovative product while trying to maintain a balance between price and quality in order to remain competitive, which results in increased competition. Finally, the bargaining power of suppliers is an important aspect because powerful suppliers can squeeze profitability out of an industry (Porter, 1980) and put pressure on the companies. The managers have to carefully decide which alliances and agreements they will make for the benefit of their firm.

3.4 External environment assessment framework

In this research, we will build upon the PEST analysis and "Porter's Five Forces" model in order to create an assessment framework. This framework includes the most important elements derived from those two models and serves the purpose of the market research for selling an O&G technology. Both analysis tools have advantages and disadvantages; this is why we are building upon them, so as to minimize the cons. The proposed model is the result of the combination of PEST and "Porter's Five Forces" model that will help us evaluate the macro-environment in which O&G companies are operating.

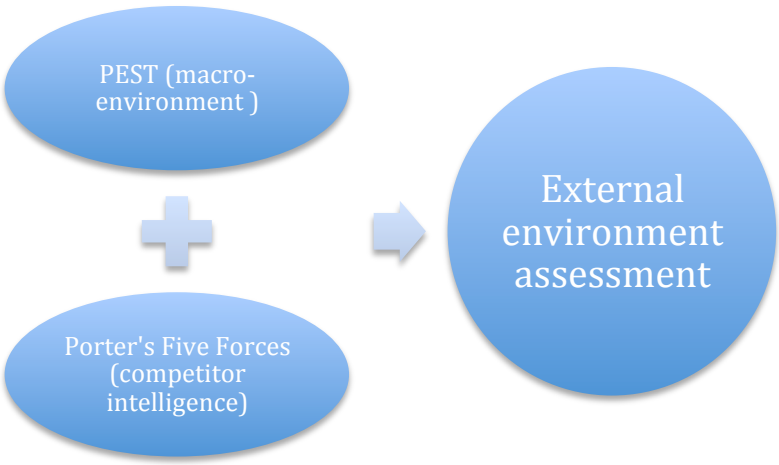

Figure 18 Assessment frameworks integration

The new assessment framework that is created in this report comprises factors from the PEST framework and the "Porter's Five Forces" analysis. We have chosen the most important factors that affect the search of the most promising market, in terms of a country or greater geographical, for launching a new process in the O&G industry. We opted for Political and Economic factor from the PEST analysis and for the Competition factor from the "Porter's Five Forces" analysis. Moreover, we added the Environmental laws factor because it is inseparable when we refer to the O&G gas processing technologies, which have by-products that need to meet certain specifications that vary from country. The added value of this new framework is that it targets the O&G industry and precisely the sour gas treatment technologies, such as the Thiopaq O&G process. The following figure illustrates the factors that will be assessed during the market research process and influence the selection of a country as a promising option to sell a new product:

Figure 19 Factors affecting market choice

It is important to attach to each factor certain sub-factors and sub-criteria that are identified in the literature, so as to have an in-depth analysis of the macro-environment and derive more concrete results. The factors and the sub-criteria are presented in the following figure and analyzed in section 3.5:

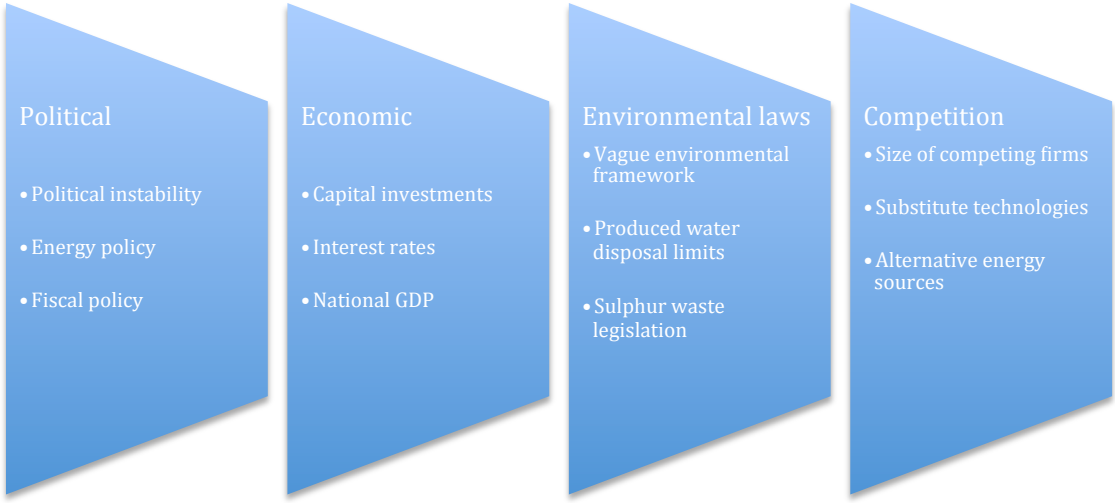

Figure 20 External factors and sub-criteria

3.5 External factors

The selected factors are analysed in detail, so as to clarify why we have chosen their sub-criteria for the marker research.

3.5.1 Political factor

Political decisions related to energy have a direct impact on the O&G industry. Except of defining the legal framework, most of the governments are shareholders of

the O&G firms. The impact of political risk on the business environment and the various means by which firms attempt to deal with this risk (Keillor, Wilkinson, & Owens, 2003), gains increasing attention in business research. Companies formulate their strategies while taking into account the political environment of a country, which can be stimulating if the decisions of the governments aim to increase the investments. The government formulates the regulatory framework that defines a firm's operations, especially in the O&G sector, which increases the social wealth but needs a strict control to operate sustainably. A stable and well-structured political environment is a positive sign and attracts the companies that are planning either to start new operations or expand the existing ones. Regulatory and legislative changes can increase the cost of compliance, thus increasing the operating costs or halting the production process because of adjustments that have to be done.

Political unrest and unstable political environment alters the investment decisions of a company. At the same time, many firms have demonstrated they can effectively manage the political environment through politically oriented strategies and tactics (Shaffer & Hillman, 2000). Political instability is hard to define and measure in a way, which can be used for econometric work (Alesina & Perotti, 1996), but definitely plays a key role in setting up the investment environment. A lot of oil and gas sources are located in the Middle East North Africa, regions that suffer from war conflicts and riots caused by undesired political regimes. Three years have passed since the Arab Spring began in Tunisia and the crisis has moved to most of its neighbouring countries, which raised widespread concerns about oil supply disruptions reignited the ever-recurring debate about energy security (El-Katiri & Fattouh, 2014). The aforementioned had a short and long term effect on the O&G market and many companies are reforming their investment policies in that region. They are willing to scarify asset investment in order to move to countries with a stable political state.

Government's legal reforms can be the force to increase the funding in the O&G industry and do not hold back private investment. Lack of legal certainty exposes the operations to increased risk of adverse or unpredictable actions by government officials (Exxon, 2015), and also makes it more difficult to make new investments. Uncertainty in government's energy policies (Edwards, Isbaq, & Johnsen, 2010) may shift the economic priorities of a firm and look for a country with a concrete policy.

Besides that fiscal policy, which is the tax rate and composition of government spending (Svensson, 1997) can encourage new ventures in the energy sector. The public capital expenditure fluctuates per country and creates an uncertainty in the oil production countries, regarding new investments. If a government decides to spend part of its funds for modernizations of the O&G infrastructures, this will push the private companies to invest on their assets. In recent years the global O&G industry has faced structural changes, including a shortage of key equipment, greater competition for skills and cost escalation in the supply chain (Alexander, 2014). So, they are searching to re-establish their portfolios on countries where thy can maximize their profits.

3.5.2 Economic factor

The first external force that we will examine is the economic. The investments in the O&G industry rely on the economic growth of a country and the companies that are active in the business. Governments and private businesses are investing in the O&G sector because of the constantly increasing returns and profits. This means that the investments involve serious amount of money, so a wealthy economical environment increases the success of a project. Moreover, it is expected that the energy demand will keep increasing, thus the O&G industry will attract more investors to fund the business in order to expand its production and meet the demand. Population growth and increases in income per person are the key drivers behind growing demand for energy (Dudley, 2015).

The largest increases in energy demand will take place in developing countries where the proportion of global energy demand is expected to increase from 46 to 58 percent till 2030 (EIA, 2007). So, it is very important to keep the energy prices as low as possible, because any increase in the price will directly affect their economies. A stable economy promises a better environment for investments and this can be achieved by offering a beneficial and stable taxation system for the O&G companies, while trying to maintain fixed interest rates. As a result, governments and countries that offer such a promising environment will attract the companies that are planning to invest because they can keep high profitability without cutting down their investment budget.

Investment decisions are important for the performance of the economy. Specifically, from the macro-perspective, in a regular business cycle, they account for the majority of the volatility in the Gross Domestic Product (GDP) dynamics, and their magnitude serves as a significant factor of economic performance (Zarnowitz, 1992). As a result, a country with a higher GDP compared to another country gives a positive sign for investments. There is a bilateral relation between the O&G industry revenues and the GDP, because O&G business activity increases the available positions for jobs, produces labour income and enhances government revenues. On the other hand, the amount of GDP is an indicator of economic growth, which attract investors and funds that can finance the O&G industry.

Interest rates are another key factor that belong to the economic force and influence the investment decisions. Their role is so widespread that it might be assumed that they might influence all companies in their decisions (Bialowolski & Weziak, 2014). Interest rates can directly increase the cost of capital and subsequently the firm will shrink their investment spending. Relatively, the governments will have diminished ability to invest or subsidy the O&G companies. O&G firms are cyclical industries, which means that they are sensitive to the business cycle, and their economic performance is associated with the economic prosperity of the external environment. So, the investment budget is more affected by a fluctuation in the interest rates. If the interest rates increase, the financial leverage capacity of the firms will decrease, which will create a neutral or hostile economic environment.

Capital investments are funds provided by a company for the expansion of their current business or acquisition of new assets or knowledge. The company's cost of capital is the overall cost of funds, which are supplied to the company (Sari, 2013).

Energy is a capital-intensive business and the success of many opportunities is tied to the owner's ability to create a new capital asset (Westney, 2011), in order to expand or grow the operations of the company. Capital budgeting may be invested to replace an existing asset and promote research and development operations, aiming to experience increasing returns in the future. The extent of the available funds for investments categorizes the economic external environment whether as positive or negative, and the O&G companies are searching for a positive one, which is more investment friendly.

3.5.3 Environmental laws factor

Environmental issues have steadily grown in significance for the O&G industry over the past four decades (Wagner & Armstrong, 2010). The O&G firms are obliged to comply with the environmental regulatory framework, which is imposed in every country. The companies face implications because every country has different laws and environmental standards. As a result, they have to adjust their practices and change their operational standards based on different regulatory issues, which increases the operational and capital expenditures, while halting new investments because they have to change their production processes and equipment in order to meet the standards. The lack of a universal environmental law is the main source of the problem and it is indicative that there are estimated to be over 700 different international environmental agreements, at bilateral, regional and multilateral levels (CRS, 2009).

Global climate change is the single most important environmental issue facing the international energy industry (Wagner & Armstrong, 2010). The need for the mitigation against climate change can make some companies restrict environmental concerns to emissions (Zalengera et al., 2014). The key environmental restrictions are focusing on the protection of the water sources and the mitigation of the sulphur content contained in the O&G wastes. Moreover, the laws are aiming to minimize the ecological footprint of a process, which leads to air emissions reduction, especially carbon dioxide (CO_2) control, and protection of the air quality. Although, the O&G firms suffer different regulatory pressures (Lin, Chen, & Nguyen, 2011), they have to comply with laws associated with surface, ground and drinking water quality (Kulander, 2013), and remove impurities such as elemental sulphur and heavy hydrocarbons (Mitra, 2015). Thus, the O&G firms are forced to develop and deploy energy efficient and low emission technologies (Wagner & Armstrong, 2010) for all the regions of the world.

Water is considered as one of the most important recourses, agreeably more important than oil. In the O&G industry the produced water is a process by-product and is defined as the water that exists in subsurface formation and is brought to the surface during O&G production (Guerra & Dahm, 2011). The produced water has to be treated before disposal and meet strict standards because if it discharged without treatment may be harmful for the environment. So, wastewater management is crucial in order to avoid water infection and maybe treatment of produced water has the potential to be a harmless and valuable product that a waste (Ahmadun et al., 2009).

Another limitation, which is related to the O&G technologies and processes, is the disposal of sulphur waste and the laws that set the regulatory framework. The waste legislation is restricted to acceptable industry practices regarding the management of sulphur waste (Fernades, 2011). It is observed that the regulations are driving down sulphur levels in fuels and the governments are imposing stringent limits (Bravo, 2014). Moreover, policies or strategies affecting sulphur disposal influence the management of sulphur waste (Fernades, 2011), which means that new practices have to be deployed to make eligible the sulphur disposal.

3.5.4 Competition factor

In recent years, the O&G industry has experienced consolidation, as well as increased deregulation and integration in strategic markets (Statoil, 2014). This growth has resulted in intense competition among the O&G firms, which compete for bigger market share and increasing returns from their investments. So, it is a strategic decision for a company to invest on new technologies to increase its competitiveness, but it is important to access the overall market competition in the region. The managers have to evaluate the potential market and then decide if the investment will move forward or not. Competition is an influential factor and has an effect on the business plans, either positive or negative.

It is important to know which companies are competing in the market and how they are positioned in it. Competitors refer to the companies that are able or willing to offer rival products. Competition for the global gas markets will continue to raise and companies will try to gain access to growing markets (Lukoil, 2013). On the other hand, competition in the mid-term will be among investments in new energy sources of oil and substitute, and investments that reduce the use of oil by greater efficiency (Mitchell, 2012). So, it important for the O&G firms to invest in technologies that exploit unconventional energy resources and investors will be more concerned about the cost-competitiveness of these new projects. Thus, it is critical to identify which energy companies are active in the market that a new technology will be sold and try to measure and estimate the impact of the rival companies on the investment. In other words, the size of the competing firms is an important factor, because the bigger the size of the company, the higher will be the competition, mainly because of their capability to offer competitive prices for similar technologies.

The aforementioned raises one more factor, which is related to competition and this is the existence of a substitute technology. A substitute performs the same or similar function as an industry's product by a different means (Porter, 2008). Substitutes are always present in the market and their significance should not be overlooked because they can create a hostile external environment for a competing technology, especially in the O&G industry, which is highly competitive. It must be mentioned that main criteria to buy a substitute product is its price, but another criteria, which can be of equal importance, is the loyalty and trust of the supplier and the customer. It is difficult to measure this relationship but a fair estimation has to be done, while scanning a new market.

Last but not least, a considerable element that has increasing influence on the O&G market is the alternative energy sources. Although, the predictions indicate that the

companies will have increased profits from investments to alternative sources, those markets are distant and expensive to reach (Mitchell, 2012). So, the O&G firms are willing to invest more money on alternative sources because this market can be very profitable, but serious investments have to be made. Thus, the investments for new technologies for exploitation of gas sources will be reduced. Hence, it is crucial to search for a market with more convectional energy sources, so as to increase the possibility of successful launch and promotion of a new technology.

Chapter 4 Methodology

This chapter summarizes the key points of the methodology used in the research. An overview of the multi-criteria decision-making (MCDM) theories is presented and then the best worst method (BWM), which is the method that we will use, is explained. Finally, the data collection process and application of our framework are demonstrated.

4.1 Research design

The scientific research is a rigorous and precise process, which entails certain steps and follows a protocol. The aims of this process is either test a hypothesis or solve a specific problem by answering questions; in this paper we will give an answer to our research questions. The scientific research has to be organized and planned, including the implementation of a literature review in order to formulate and answer the research questions. The aforementioned are the characteristics of our research design, which is a detailed blueprint used to guide our research so as to realize the research objectives. In other words it is the plan of action prior to implementation, which will be explained. In this paper, we conduct an exploratory research, which is a method used to gather information so as to solve our problem (Sekaran & Bougie, 2010) and give answers to the research questions. This method has six main steps that we strictly follow, so as to conduct our research in a scientific manner.

The first step, which triggered our research, is the identification of a broad problem area. At this point, the problem is recognized and is decided that has to be solved (Polaris, 2012). Moreover, we have to decide on a single and feasible research objective (Verschuren & Doorewaard, 2010); in this paper we focus on finding the country that seems as the most promising market to sell the Thiopaq O&G process. The second step is the design of the phases of the research, the development of our approach and the definition of the problem statement, which specifies our research objective. We also have to choose the research framework that will be applied.

The third step includes the questionnaire design, which is the output of our research design. The questionnaire is the tool that we use to gather our data. Eventually, the next step is the data collection process, where our survey instrument is the questionnaire used to gather the needed information (Polaris, 2012).

The fourth step, which is also very important, is the data analysis. Is it vital to extract the right that are needed to reach our research objective by answering the formulated research questions. In this paper, we use a MCDM method to rate the external factors and sub-factors. The final step is the data interpretation, where we use the results of our survey to answer the questions, and finally pick the market in which we will launch the Thiopaq O&G technology. Figure 21 illustrates the mains steps of this research.

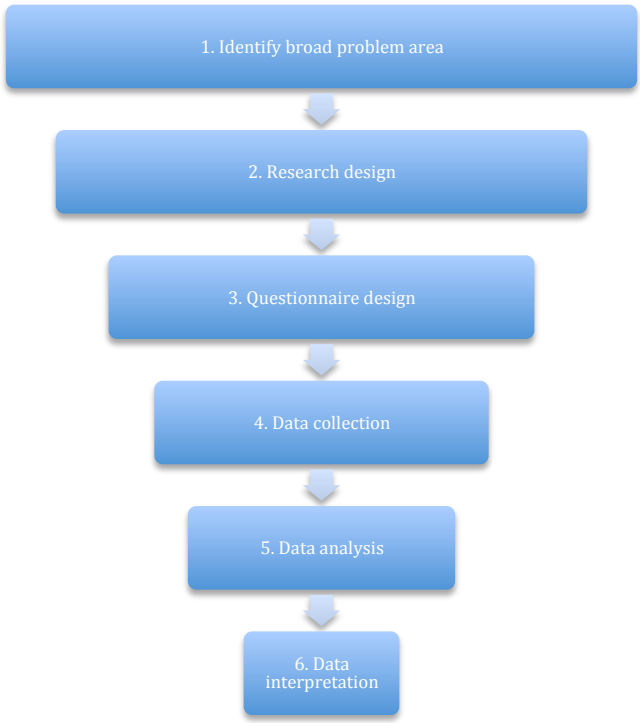

Figure 21 Steps of the research

4.2 Multi-criteria decision-making (MCDM)

Every person is exposed in the decision-making process in a daily basis. We make our choices according to our preferences, based on the evaluation of the information that we have. The purpose of the process is to choose among alternative options in order to attain goals and objectives (Forman & Selly, 2010). So, decision-making aims to find a way to assign weights to the set of alternatives (Saaty & Vargas, 2012) and choose the most suitable. Decision-making process is performed by employees and employers in firms and organizations and is the most essential step to make a decision. It is stated that the whole process of managerial decision-making is synonymous with the practice of management (Herbert, 1960).

MCDM refers to making decisions in the presence of multiple, usually conflicting criteria (Xu & Yang, 2001). It has progressed the last decades because of the evolution and advancement of computer technology. This evolution led to development of software packages that can solve the complex mathematical equations of the MCDM problems. Moreover, the ease of access to infinite number of information generated more difficult problems, which could not be solved without computers. The decision makers rely on computational programs that assist them to rating the different set of alternatives and criteria according to preferences of those who are involved in the decision-making process.

MCDM problems are divided into two main branches. The first is multi-objective decision-making (MODM) and the second is multi-attribute decision-making (MADM) (Zimmermann, 2001). These methodologies share common attributes but they also have critical differences. The shared characteristics are the conflict among criteria and difficulties in selecting the alternatives (Cristobal & Ramon, 2012).

MODM approaches problems in which the decision space is continuous (Triantaphyllou, Shu, & Sanchez, 1998) and there are a theoretically infinite number of sets of alternatives that are not known in advance (Lazarevska, Fischer, & Haarstrick, 2009). MADM are designed for selecting discrete alternatives (Cristobal & Ramon, 2012), which are known in the beginning of the procedure.

In this thesis, we will select a MADM method in order to assess and rate of the external factors that are present in the macro-environment. There is a great number of MCDM methods available in the literature and are applied in different engineering, industrial and managerial areas. Types of application of MCDM include the use of decision analysis in integrated manufacturing (Putrus, 1990), in the evaluation of technology investment decisions (Boucher & McStravic, 1991), in flexible manufacturing systems (Wabalickis, 1988) and in other engineering problems (Wang & Raz, 1991). So, according to literature we should use a MCDM method because we are trying to solve an investment decision problem.

The most widely used method is the Analytic Hierarchy Process (AHP), developed by Saaty (1990), which is an effective tool for dealing with complex decision-making problems and helps the decision maker to set priorities and make the best decision (Saaty, 1990). Other important MADM methods are the following: ANP (Analytic Hierarchy Process) (Saaty, 2001), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) (Yoon, 1987), ELECTRE (Elimination Et Choix Traduisant la Realite) (Yoon, 1987), VIKOR (VlseKriterijumska Optimizacija Kompromisno Resenje) (Opricovic & Tzeng, 2004) and PROMETHEE (Preference Ranking Organization method for Enrichment Evaluations) (Brans, Mareschal, & Vincke, 1984).

The major characteristic of the mentioned methods is the use of pair-wise comparisons, which are used both to compare the alternatives with respect to the various criteria and to estimate criteria weights (Velasquez & Hester, 2013). Pairwise comparisons are used to show the relative preferences of m stimuli or actions in situations where it is unfeasible or meaningless to provide score estimated for the stimuli or actions with respect to criteria (Rezaei, 2015a). Those comparisons require the development of a decision matrix, which has to be done in a structured way (Thurstone, 1927). Although, the use of pairwise comparisons can allow the decision maker to weight coefficients and compare alternatives with relative ease (Velasquez & Hester, 2013), it faces a problem of inconsistency in the developed matrix (Herman & Koczkodaj, 1996). Unfortunately, for reasons such as lack of concentration or complicated structured questions (Rezaei, 2015a) there are recurring inconsistencies in pairwise comparison matrices (Forman & Selly, 2010). So, it becomes important to search for the consistency ratio of the matrices in order to be able to make a decision (Murphy, 1993).

However, according to Rezaei (2015), the main cause of the mentioned inconsistencies is related to a methodological implication, which can be spotted in the unstructured way of the executed comparisons (Rezaei, 2015a). As a result, a new MCDM method, which is called Best-Worst Multi-Criteria Decision-Making Method (BWM), is developed to give solutions to the problems. The main advantage of the BWM is that it requires less data compared to similar methods, because it derives the weights based on pairwise comparisons in a different way (Rezaei, 2015a). Except of

this, the BWM approaches and solves better the problem of the inconsistency, compared to the other methods, which is very important because it provides more reliable results.

4.3 Best-worst method (BWM)

BWM is a new MCDM method that aims to solve real-world MCDM problems. As already mentioned, the BWM method offers two important advantages compared to other MCDM methods and this is the reason why we use the BWM method in this thesis. BWM has been applied in the "Evaluation of the external forces that affect the supply chain sustainability in the O&G industry" (Sadaghiani, Ahmad, Rezaei, & Tavasszy, 2015) and in "Linking supplier development to supplier segmentation" (Rezaei, Wang, & & Tavasszy, 2015c).

4.3.1 Steps of BWM

The steps of the BWM method are five and explained (Rezaei, 2015a, b)

Step 1*:* Determination of a set of decision criteria. In this step, we define a set of criteria $\{c_1, c_2, \ldots, c_n\}$, which will be used to make a decision.

Step 2: Determination of the best (e.g. most desirable, most important) and the worst (e.g. least desirable, least important). In this step, the decision maker chooses the best and the worst criteria, without making any comparison.

Step 3: Determination of the preference of the best criterion over all the other criteria by using a number between 1 and 9, where 1 indicates equal importance and 9 indicates extreme more importance. The outcome of Step 3 is the Best-to-Others vector, which is $A_B = (\alpha_{B1}, \alpha_{B2}, \ldots, \alpha_{Bn})$, where α_{Bj} indicates the preference of the best criterion over criterion j.

Step 4: Determination of the preference of all the criteria over the worst criterion by using a number between 1 and 9. The outcome of Step 4 is the Others-to-Worst vector, which is $A_W = (\alpha_{1W}, \alpha_{2W}, \ldots, \alpha_{nW})^T$, where α_{jW} indicates the preference of the criterion j over the worst criterion W.

Step 5: Calculation of the optimal weights $(w^*_1, w^*_2, \ldots, w^*_n)$. In this step we aim to find the optimal weights of the criteria, such that the maximum absolute differences $\{|w_B - \alpha_{Bj} w_j|, |w_j - \alpha_{jW} w_W|\}$ and for all j is minimized and the problem can be formulated as follows (Rezaei, 2015b).

$$\min_j \max \left\{ |w_B - \alpha_{Bj} w_j|, |w_j - \alpha_{jW} w_W| \right\}$$

s.t.

$$\sum_j w_j = 1, w_j \geq 0, \text{ for all j} \qquad (1)$$

Problem (1) is transferred in the following linear programming problem:

$\min \xi^{L}$

$$\text{s.t.} \left| w_B - \alpha_{Bj} w_j \right| \leq \xi^{L}, \text{ for all j}$$
$$\text{and} \left| w_j - \alpha_{jW} w_W \right| \leq \xi^{L}, \text{ for all j} \quad (2)$$

$$\sum_j w_j = 1, w_j \geq 0, \text{ for all j}$$

Problem (2) is a linear problem, which provides a unique solution to the problem. Then, we obtain the optimal weights ($w^*_1, w^*_2, \ldots, w^*_n$) and ξ^{L*}. For this model ξ^{L*} is considered as a good indicator of the consistency of the comparisons. If values of ξ^{L*} are close to zero, this means that we have a high level of consistency.

4.4 Data collection

Data collection is a term used to describe a systematic and rigorous process of collecting data. There are many purposes of data collection, which could be the following: obtain general or explicit information, keep on record, transfer information or make decisions based on data. In other words, collecting data means putting your design for collecting information into operation (UoK, 2015). The data are classified into two main categories, which are the primary and the secondary data. Primary data are collected first-hand by the researcher from the research field. The researcher needs to control and supervise the primary data collection process. This type of data are generally afresh and collected for the first time (Parab, 2015), when conducting a research. They can be gathered via introspection, unstructured interviews, structured interviews and questionnaires (Sekaran & Bougie, 2010). Secondary data are data that already exist and are available, so they have not to be collected by the researcher (Sekaran & Bougie, 2010). Sources of secondary data are statistical bulletins, government publications, information published or unpublished that are available from an organization, library records, data available from previous research and online data retrieved from the Internet.

In this research, we collected primary data and the data collection tool is a questionnaire. A questionnaire is a survey method, which includes a set of pre-formulated written set of questions and an individual can answer to show his preferences. The researcher writes down the set of variables or alternatives that intends to measure and compare and the respondent have to fill it. Questionnaires can be distributed personally, via mail, e-mail or electronically through online platforms that perform the distribution process (Sekaran & Bougie, 2010). We sent the questionnaires via e-mail to employees working in Frames O&G, which are considered as our targeted population. This distribution method is easy and fast and the respondent could fill the questionnaire without feeling any pressure from a physical presence from the researcher and without having any time limitation. On the other hand, this may be a drawback because sometimes the response rate is low because people are not interested or unwilling to help due to lack of motivation to invest time in filling the questionnaire. Nevertheless, we should add that the average

year of experience of our respondents is 15.6 years from diverse departments such as mechanical engineering, research and development, chemical process and sales. Moreover, the respondents are working either in Europe or in Asia, so we got answers from employees that are based in two different continents.

4.5 Questionnaire

A well-constructed questionnaire requires following certain steps that will help us design a questionnaire from which we will collect our data. The steps are presented in the following figure.

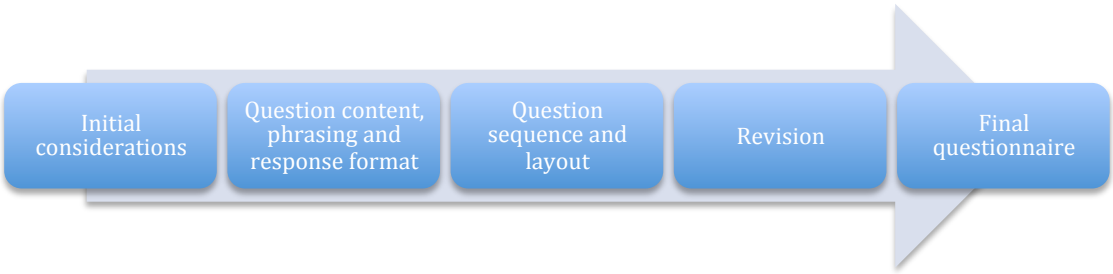

Figure 22 Questionnaire design steps (Kirklees, 2014)

The final structure of our questionnaire is as following:

- The first page has a short introduction about the scope of this research. We present a short problem definition and explain how the respondent will contribute to the research. Moreover, we clearly state that he/she has to write the department in which he/she works and the years of experience because those data may be useful in the analysis.

- The second page presents the instructions to fill in the questionnaire. It is very important to help the respondent to understand how to fill it, without bothering him/her with useless information. So, the wording of the instructions has to be clear and precise, because this questionnaire is designed according to the BWM principals and most of the respondents are not familiar with it. In order to achieve this, we have included a short example, which clarifies the procedure of completing the questionnaire and the respondent can use it, if he/she encounters any difficulty.

- The rest pages of the questionnaire have the actual questions and tables that the respondent has to fill and show his/her preference. We present the external factors that are identified from the literature review and their corresponding sub-criteria. The questionnaire requires from the respondent to follow three steps, which are:

1. Choose the most and the least important criterion, which is present in the external environment, according to his/her opinion.

2. Show his/her preference of the selected most important criterion over the other criteria.

3. Show his/her preference of the other criteria over the selected least important criterion.

According to the BWM method, the respondent shows his preference by using a ratio scale between 1 and 9. A score of 1 indicates that the MOST/LEAST important criterion is of equal importance compared to the other criterion. A score of 9 indicates that the MOST/LEAST important criterion is extremely preferred over the other criterion. The following table illustrates the meaning of a selected number from 1 to 9, including the intermediates.

Score	Meaning	Score	Meaning
1	Equal importance	**7**	Very strongly more important
3	Moderately more important	**9**	Extremely more important
5	Strongly more important	**2,4,6,8**	Intermediate values

Table 3 BWM ranking ratio

At this point, we will illustrate an example of a model answer of the questionnaire in order to make clear how it is correctly filled from a respondent. The first question asks to choose the most and the least important factor that we have identified via the literature review and we are applying in our assessment framework.

The following factors are the most important, which are taken into account when you are trying to find the most suitable and profitable market to sell a new product.

Can you indicate which of the factors you consider as the MOST important and which as the LEAST important, by marking the appropriate box?

Criterion	MOST important	LEAST important
Political		X
Economic	X	
Environmental laws		
Competition		

Table 4 BWM questionnaire - External factors

In this example, we observe that the respondent has chosen the economic factor as the most important, while the political is considered as the least interesting.

Then, the respondent has to use the ranking ratio, as presented in Table 4, to show his preference of the selected most important criterion over the other criteria.

MOST IMPORTANT criterion	Political	Economic	Environmental laws	Competition
Economic	9	1	3	5

Table 5 BWM most important criterion ranking

We reach the conclusion that the respondent evaluates the economic force as extremely important than the political one. Moreover, the competition is strongly more important and the environment laws are not high on his preference list compared to the economic criterion.

Finally, the respondent has to indicate his preference of the other criteria over the selected least important criterion. The following table illustrates this preference according to the BWM method rating scale.

LEAST IMPORTANT criterion	Political
Political	1
Economic	9
Environmental laws	3
Competition	5

Table 6 BWM least important criterion ranking

The format of the rest of the questionnaire is presented in this section and has the same structure for the other factors. The respondent used the ranking ratio and has to fill in the tables. The whole questionnaire, as sent via email to the respondents, can be found in the Appendix A.

Chapter 5 Data analysis and results

In this chapter the results of the data analysis will be presented. In the beginning, we illustrate the results of the rating of the four external factors and then the rating of their sub-criteria. Afterwards, we calculate the global weights of the sub-criteria, so we can list them from the most to the least important. Finally, we select the countries that are considered as the most important and promising markets and we use a likert-scale to link the sub-criteria to those countries and decide which is the best option. All the calculations are done according to the principals of the BWM method.

5.1 External factors ranking

As presented and explained in section 3.5, we have included 4 external factors in our assessment framework. These factors are Political, Economic, Environmental Laws and Competition. As presented in Table 8, the Economic factor is considered as the most important, when a company scans the macro-environment of a country in which is trying to operate and sell new products. There is a significant difference between the Economic factor and the second factor, which is the Environmental Laws factor. Then, the third place belongs to the Political factor while last in the rating is the Competition factor.

The Economic factor is considered as the most interesting and gains the attention of the managers that are searching for new and profitable markets. This result indicates that a wealthy and stable economic environment looks more investment friendly and the potential customers has the economic power to invest on buying new technologies and processes. Specifically, in the O&G industry there is need of increased cash flows from the customers because new products are expensive and a long payback period is expected (EY, 2014). Thus, the Economic factor guarantees that new investments can take place in a country and the number of potential customers may increase because they will be attracted by this situation. To conclude, the Economic environment of a country is an important factor that affects the investment decisions of a company.

The Environmental Laws factor is of great importance in the O&G operations and procedures. The laws affect the daily operations of an O&G company and shape its future investment strategies and decisions. The Environmental Laws vary per country and this variance implies that a firm has to rigorously search for the laws that are enforced in every country. So, a certain process may be applicable in a county but in another one some modifications and changes in its operation must be done. Especially, the by-products of an O&G treatment technology can be an indicator of appropriateness of usage and depends on the environmental framework of a country related to the O&G operations.

The Political factor is ranked third according to the answers that we received in our questionnaire. The political condition and investments in the energy sector are inseparable. In other words, the O&G companies can see the decisions of the politicians as positive or negative signs, because their actions can boost or stagnate investments. Moreover, the political parties vote and decide for the policies of their government, which are related to the O&G industry. As a result, a country with a secure political environment with clear energy policy is more attractive than a country

with a vague policy, where the energy laws are changing and constant political instability is faced.

Last but not least, the Competition factor plays an important role although it ranked fourth and considered as the least important. Increased competition may hamper the launch of new product because every company has to deal with the competitive rivalry. But, on the other hand an increased competition indicates that a market is in growth and as a result economic prosperity is assumed. So, a company is targeting such markets because behind the competition a lot of investment opportunities are hidden. Thus, assessing the Competition factor can result in finding companies, which operate in a country, that are able to adapt and buy new technologies in order to remain competitive and dominate their market by increasing their profits against to their competitors.

The results of the data analysis for the rating of the main external factors are presented in Table 8. We have calculated the average weight and consistency (ξ^{L*}) of those factors, according to the answers of the respondents. The highest the weight of a factor indicates that it is more important compared to the others.

	Political	Economic	Environmental laws	Competition	Consistency (ξ^{L*})
Weight	0.2088	0.3756	0.2627	0.1528	0.1406
Rank	3	1	2	4	

Table 7 External factors ranking

The following figure intends to indicate the significant difference among the external factors because it illustrates their weights that they scored in percentages and is easy to spot them.

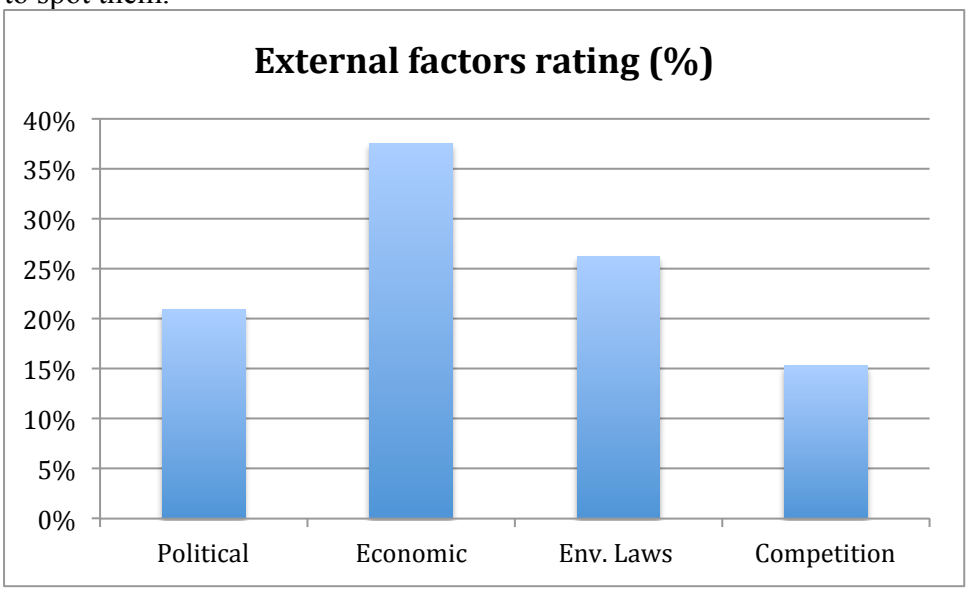

Figure 23 External factors rating (%)

5.2 Ranking of sub-criteria of the Political factor

We have already explained in the literature review, which sub-criteria we attached in every factor to get a better insight on the forces that affect the market choice of an O&G company when it aims to launch a new product. So, the respondent had to rank them, as he/she did the same for the external factors. The sub-criteria that belong to the Political factor and are observed in the external environment are political instability, energy and fiscal policy of a country.

Political instability is ranked first and considered as the most important sub-criterion. Investments under political uncertainty are declining because companies are afraid of doing business and operating in such countries (Kamal & Hossein, 1989). The lack of political security is an inhibitor for investments and especially for the O&G industry, which is very sensitive to geopolitics. So, political initiatives can create a friendly environment for the O&G firms that want to exploit the energy reservoirs of a country, in such a way that both the firms and the government will be benefited. In this way, a company can find more customers and partners in countries that are not suffering from political instability.

The energy policy of a country is ranked second but can be considered as equally important as the political instability because it got the almost the same weight, as it can be seen in Table 9. This can be explained by the fact that political instability can result in formulation and implementation of bad energy policies. Although the energy sector can be very profitable for a government, it needs a stable political state to gain those economic benefits. Otherwise, the investments will be minimized and the O&G companies will not be willing to spend money on new projects and infrastructures. So, there will be less space for selling new technologies. The least significant sub-criterion is the fiscal policy, because the O&G companies are funding their operations through private investments and want to be less dependent on the governmental financing.

The ranking of the sub-criteria of the Political factor and their consistency indicator (ξ^{L^*}) are presented in Table 9, and their weights expressed in percentages in Figure 26.

	Political instability	Energy Policy	Fiscal Policy	Consistency (ξ^{L^*})
Weight	0.4198	0.4195	0.1607	0.1250
Rank	1	2	3	

Table 8 Sub-criteria ranking, Political factor

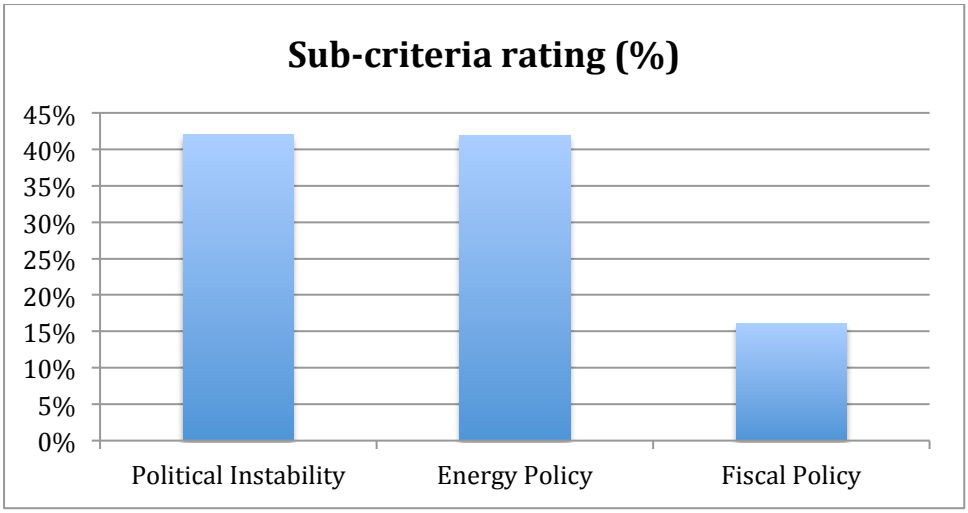

Figure 24 Sub-criteria rating (%), Political factor

5.3 Ranking of sub-criteria of the Economic factor

The Economic factor is ranked as the most crucial according to the results we received from the respondents, but we need to know how they evaluated its sub-criteria. The data analysis revealed that capital investments are considered as the most influential criterion. This makes sense in a capital-intensive industry like the O&G. The O&G firms invest huge amounts of capital in their projects and they expect for increased financial returns. But, they have to choose the most suitable technologies depending on their operations because each project needs different processes. The cumulative expenditures from the O&G industries that are active in a country indicate their intention to invest in energy projects and equipment. As presented in Table 10, it is obvious that capital investments are much more important compared to the other criteria.

The interest rates that are provided in each country influence the leverage of the O&G firms. This means that if the interest rates are low, the companies can borrow more money so the investments are increasing. Thus, the potential clients can buy new technologies that increase the production rate of oil or gas. As a result, the interest rates are an indicator of economic prosperity of a country, because it means that companies are profitable and they are able to pay their debts that derive from the loans that they get in order to finance their business.

Finally, the national GDP is ranked third sub-criterion of the Economic factor. Increased GDP shows that the citizens of a country have the economic power to maintain a high standard of leaving and spend more money in the market. Moreover, they can invest an amount of their savings in business sectors that are profitable in their country and one of the most profitable is the energy sector. So, the citizens can increase the investment ratio and provide funding to the O&G companies and expect increasing returns if the project is successful.

The ranking of the sub-criteria of the Economic factor and their consistency indicator (ξ^{L^*}) are presented in Table 10, and their weights expressed in percentages in Figure 27.

	Capital investments	Interest rates	National GDP	Consistency (ξ^{L^*})
Weight	0.6185	0.2051	0.1764	0.1900
Rank	1	2	3	

Table 9 Sub-criteria ranking, Economic factor

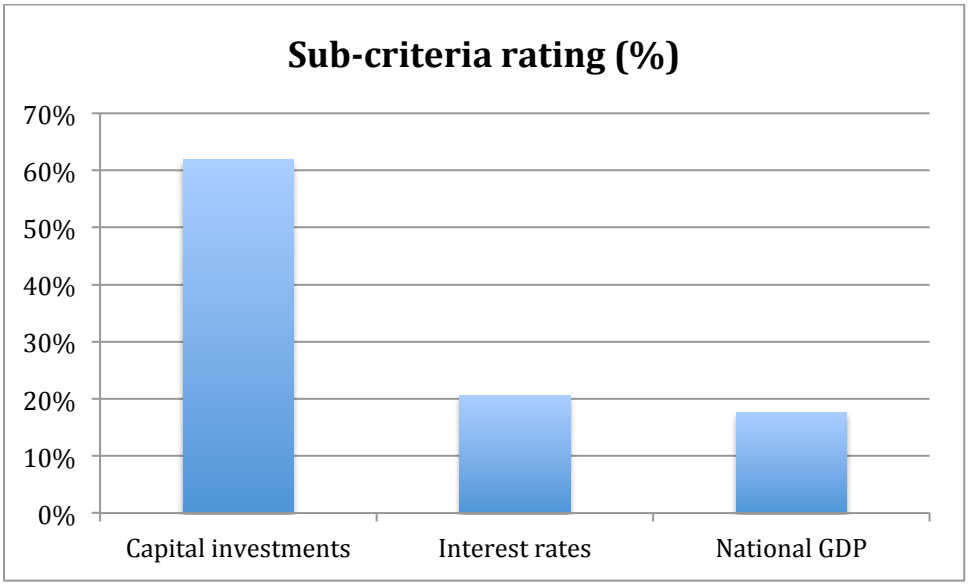

Figure 25 Sub-criteria rating (%), Economic factor

5.4 Ranking of sub-criteria of the Environmental Laws factor

In our assessment framework, we have chosen the vague environmental regulatory framework, the produced water disposal limits and the sulphur waste legislation as sub-criteria that belong the Environmental laws factor. An unclear regulatory framework is an obstacle for the O&G companies because they do not know in advance which are the laws that govern their operations. Each country should have a certain guide that makes clear the obligations of the O&G firms. If this framework is often changing by the government, it negatively affects investments, so the O&G companies will be hesitant to implement new projects.

The extraction of oil and gas produces huge amounts of by-products, which need to be treated before being disposed or re-used in the processes. Especially, during the sour gas treatment the main by-products are water and sulphur. So, it is apparent that these by-products have to meet certain limits before disposal. Each country enacts its own laws regarding the limits that a by-product has to meet before being safely handled or disposed. As a result, the produced water disposal limits must be clear and cannot be violated by the O&G firms. The same implies for the legislation for handling the sulphur waste, which is considered to be as the mot important criterion. Strict limits impose more treatment of the by-products, which leads to more expenses. So,

countries that offer higher disposal limits and flexible legislative provisions are more attractive for companies that are planning to invest on sour gas fields.

The ranking of the sub-criteria of the Environmental Laws factor and their consistency indicator (ξ^{L*}) are presented in Table 11, and their weights expressed in percentages in Figure 28.

	Vague environmental framework	Produced water disposal limits	Sulphur waste legislation	Consistency (ξ^{L*})
Weight	0.2867	0.3532	0.3601	0.1606
Rank	3	2	1	

Table 10 Sub-criteria ranking, Environmental Laws

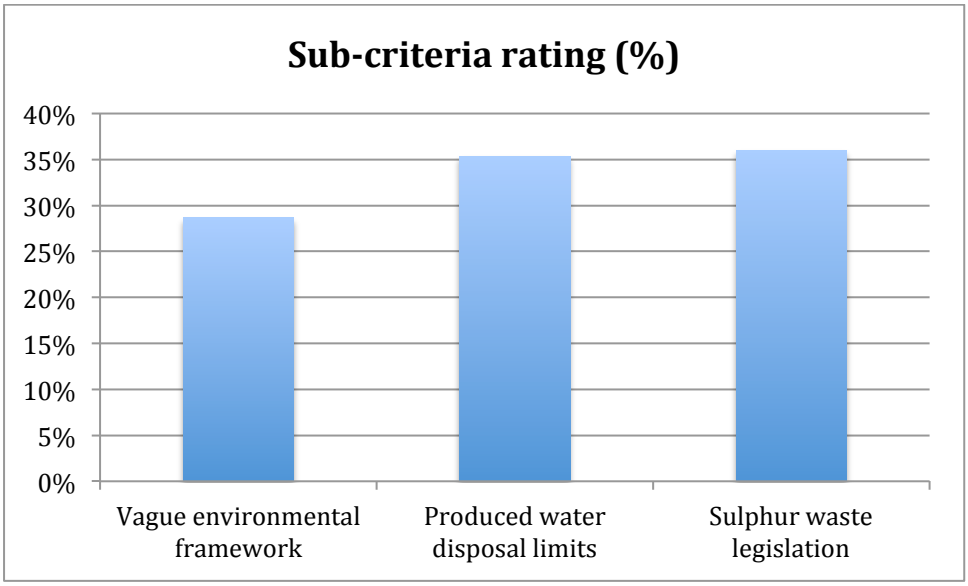

Figure 26 Sub-criteria rating (%), Environmental laws factor

5.5 Ranking of sub-criteria of the Competition factor

Last but not least, we have to shed light on the Competition factor and its relevant sub-criteria. The first identified sub-criterion is the size of competing firms in a country in the O&G business but it ranked as the least significant. Although the size of the rival companies is an index of the increased competition in the O&G industry, this doesn't mean that are active in the sector that a new product is trying to enter. The latter explains why it received the lowest score from the respondents because the size of a firm does not necessarily implies that companies with highest annual turnovers are a threat for a new product.

On the other hand, the number of the substitute technologies is the most important criterion. Substitute technologies offer similar features but of course each technology has its advantages and disadvantages, and those have to be taken into account. The R&D departments of the O&G companies are constantly trying to develop new products and processes that will replace the old ones or create a new market. There is an on-going battle among the O&G firms to offer products that will get most of the

market share and increase their profits but they cannot satisfy all of its potential customers. So, the macro-environmental scanning regarding the substitute technologies must be implemented with care and requires detailed data that will reveal which are the similar products that are sold in every country.

Finally, the usage of alternative sources, such as wind or solar energy, imposes obstacles to the consumption of natural gas. If a country chooses to invest on alternative sources, the remaining energy market share for sour gas will be understated. As result, such countries are not seen promising for selling technologies and products for the gas treatment.

The ranking of the sub-criteria of the Competition factor and their consistency indicator (ξ^{L^*}) are presented in Table 12, and their weights expressed in percentages in Figure 29.

	Size of competing firms	Substitute technologies	Alternative energy sources	Consistency (ξ^{L^*})
Weight	0.1623	0.6075	0.2303	0.1849
Rank	3	1	2	

Table 11 Sub-criteria ranking, Competition factor

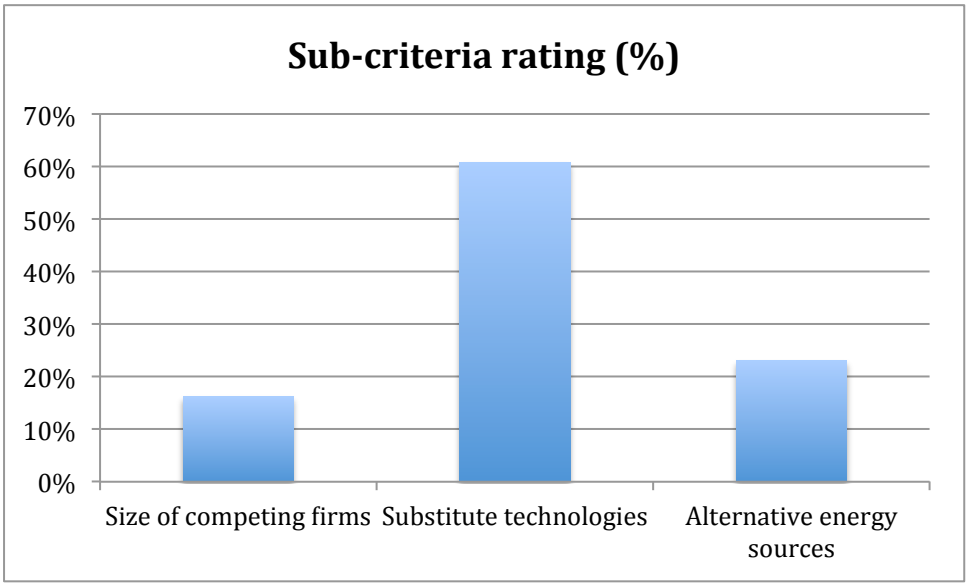

Figure 27 Sub-criteria rating (%), Competition factor

5.6 Overall ranking of the sub-criteria

We have already calculated and presented the local weights of the identified sub-criteria that we included in the assessment framework but this is not enough because we need to rank the twelve sub-criteria compared to each other. So, according to the BWM method, we will get the overall rating of the sub-criteria if we multiply the local weights by the weight of the external factor in which they belong. Thus, we will have the global weights, which means that we can rate all the sub-criteria according to their overall importance. The following table illustrates the calculated global weights.

Sub-criteria	Global weights	Sub-criteria	Global weights
Political instability	0.0877	Vague environmental framework	0.0753
Energy policy	0.0876	Produced water disposal limits	0.0928
Fiscal policy	0.0335	Sulphur waste legislation	0.0946
Capital investments	0.2323	Size of competing firms	0.0248
Interest rates	0.0770	Substitute technologies	0.0928
National GDP	0.0662	Alternative energy sources	0.0352

Table 12 Global weights of sub-criteria

It is meaningful to calculate the global weights, because a sub-criterion that belongs to the most important factor does not necessarily mean that it is more important than a sub-criterion of another factor, and this is very clear in the results that are presented in Table 13.

The following table presents the ranking from the most to the least important sub-criteria, based on their scores of the global weights.

Ranking	Sub-criteria
1	**Capital investments**
2	**Sulphur waste legislation**
3	**Substitute technologies**
4	**Produced water disposal limits**
5	**Political instability**
6	**Energy policy**
7	**Interest rates**
8	**Vague environmental framework**
9	**National GDP**
10	**Alternative energy sources**
11	**Fiscal policy**
12	**Size of competing firms**

Table 13 Overall ranking of sub-criteria

The outcome of the overall ranking of the sub-criteria shows clearly that the capital investments are by far the most important criterion, while the last place goes to the size of competing firms, which means that the respondents are very confident for the dynamic of Frames and the potential market success of the Thiopaq O&G process. Moreover, we can spot that the legislation regarding produced water and sulphur are seriously taken into account when managers search for new markets and then the political condition follows. The latter indicate the importance of the actions of a government regarding the exploitation of new sour gas fields, because the laws and the security they offer to the O&G companies can attract new investments.

5.7 Market choice for Thiopaq O&G technology

The calculation of the global weights of the identified sub-criteria and their prioritization is the most valuable result of our data analysis. It will help us decide which will be the ideal country to sell the Thiopaq O&G process, according to our assessment framework.

First of all, we have to decide which countries we will include in the assessment. It is impossible to include in our comparison all the countries, so we have decided to include the six most alluring countries. Fist of all, we searched for candidate countries per continent. We excluded the European countries because the European Union has raised concerns about sour gas extraction and many of its members have decided to ban exploitation of sour gas sources, citing environmental concerns (IEA, 2014). The data analysis has revealed that the Environmental Laws factor and its sub-criteria are highly ranked and this is another reason why we will exclude countries from Europe. It is only the last decades that the natural gas market is expanding in Africa, so it is early to discuss about the sour gas sources, which are recognized as unconventional sources that are difficult to handle and need special treatment technologies. In other words, still there is no sour gas market in African countries and we should not forget that they suffer from major energy related problems (Eardley-Taylor & Green, 2013), which creates a hostile investment environment.

South American countries have few sour gas sources, so they are also excluded from our selection (IEA, 2014), while some of the countries face political instability issues. On the other hand, in North America and especially in the United States the focus in the extraction of shale gas (Burgers, Northop, & Valencia, 2011), while in Canada a lot of sour gas fields are located. As a result, we will pick Canada from this continent.

The next continent that we will investigate is Asia, where we have selected as possible markets China, United Arab Emirates and Indonesia. 38 large-scale natural gas fields are located in China from which 11 are sour gas fields. Those fields are continuously explored from the O&G companies because they can contribute to the natural gas production in China (Jin, Anguo, & Debin, 2010) and provide huge amounts of sulphur, which is a by-product of the gas sweetening process. Another country that seems very interesting and is rapidly advancing in the sour gas field is Indonesia. The government is trying to attract funds to invest in those fields so as meet the growing demand for gas in that region and especially since 2003 more sour gas wells are drilled (Rurwagautama & Anidka, 2010). Finally, the United Arab Emirates (U.A.E.) could not be absent from our list because there are located the world's most gas reserves (Huo, 2012).

Finally, we will select two countries that belong both to Asia and Europe. Russia is the world's largest producer of natural gas and 34% of its gas resources are sour (Huo, 2012). So, Russia will be the next country that we will select. Another country that invests in the sour gas exploitation is Kazakhstan (Roberts & Armstrong, 2015) and has gained the attention of the biggest O&G companies that are trying to enter and invest on this market. The Australian sour gas market is not yet developed; this is why it is not taken into consideration.

Next, we collected data regarding the sour gas fields that are under development in the selected countries. We have chosen six countries as the most promising markets, which are: Canada, China, Indonesia, Kazakhstan, Russia and (U.A.E.). The data regarding the new sour gas fields in these countries can be found in Appendix B.

As already mentioned the final step is the creation of a likert-scale to rank those countries according to the overall score they achieve compared to the identified sub-criteria. Likert R. developed the likert-scale in 1932 during his effort to measure psychological attitudes in a scientific way (Likert, 1932). In this research, we will use a likert-scale with score from 1 to 5 in order to see what score each country achieves in every sub-criterion. Score of 1 means that the significance of a country related to a criterion is low, while score 5 indicates a high significance among them. Each sub-criterion will have the value of the global weight, which we have already calculated and the global weight will be multiplied with the score of the likert scale that a country receives. Then, we will have the sum of the multiplication for every country and the highest score will reveal the most interesting country, where the Thiopaq O&G should be launched and promoted according to our assessment model.

Below, we present the way we scored every country per sub-criterion, in order to make clear how the score from 1 to 5 is given. Score of is given to the best country according to each criterion and proportional we give scores to the other countries.

- *Capital investments*: The measurement unit is billion dollars ($B) and we gather data regarding the capital investments in the O&G industry. Score 5 is given to the country with the highest amount of money spent.
- *Sulphur waste legislation:* The measurement unit is milligram of sulphur per kilogram of solid waste produced. Score 5 is given to the country with the highest permissibly level, because the stricter the regulations the difficult the application of the technology becomes.
- *Substitute technologies:* Score 1 is given to all the countries because it is assumed that in the countries we have selected all the competing companies can have access and sell similar technologies.
- *Produced water disposal limits:* The measurement unit is milligram of sulphides per litre of produced liquids. Score 5 is given to the country with the highest disposal limit.
- *Political instability:* The measurement unit is the index from -2.5; 2.5 and the country with the highest index gets score 5.
- *Energy policy:* The measurement unit is the energy trilemma index, where all the countries are listed according to three indexes that characterize the energy policy of a country. The country that has the highest-ranking means it implement a good energy policy, so it gets score 5.
- *Interest rates:* The measurement unit is the percentage of interest rates, which means that a country with a low interest rates seems more investment friendly, because companies can easily borrow money. Score 5 is given to the country with the lowest interest rate.
- *Vague environmental framework:* The measurement unit is the Environmental Performance Index (EPI), which is expressed in percentage. The highest the percentage the more clear is the framework that a government applies to environmental issues. Score 5 is to the country with the highest percentage.

- *National GDP:* The measurement unit is dollars of GDP per capita, which the highest the amount, the wealthiest are the citizens. Score 5 is given to the country which gas increased GDP per capita.
- *Alternative energy sources:* The measurement unit is the consumption of electricity in billion kilowatt per hour produced by alternative energy sources. Score 5 is given to the country with the lowest unit because its government invests more on the O&G industry.
- *Fiscal policy:* The measurement unit is the government spending in billion dollars per year. Score 5 is given to the country with the highest amount of spent funds.
- *Size of competing firms:* Score 1 is given to all the countries because it is assumed that the size of competing firms in every country the same and it is difficult to quantify because of lack of data.

All the tables with the likert-scales scores per country and sub-criterion can be found in Appendix C. At this point, we have all the necessary data to construct the table with the global weight each criterion and the selected countries. We have already mentioned that the country with the highest score is the best country to target to sell the Thiopaq O&G process. As shown in Table 15, Canada gets the highest score, which is 3.90 while the U.A.E. come second and the last place goes to Kazakhstan. We can say that we have three clusters of countries, from which the most interesting countries are Canada, U.A.E. with a much better score compared to the second cluster of countries that are Russia and China, while Indonesia and Kazakhstan do not seem attractive according to the results. The following table summarizes the results of this analysis and the whole table can be found in Appendix D.

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Score	3.90	2.73	1.92	1.86	2.97	3.37
Ranking	1	4	5	6	3	2

Table 14 Countries scores and ranking

In order to understand the results we can express the scores of each country in percentages, because in Table 15 the maximum score is 5 and it is not easy to understand the significant difference among the countries. In Table 16, we present the scores expressed in percentages.

Country	Canada	U.A.E.	Russia	China	Indonesia	Kazakhstan
Score	78%	67%	59%	55%	38%	37%
Ranking	1	2	3	4	5	6

Table 15 Countries scores (%) and ranking

Now, it is more obvious that Canada is gaining almost 80%, which is close to the maximum score that is 100%. As a result, Canada can be considered as the ultimate country to sell Thiopaq O&G according to our assessment framework and the answers we received. But, this does not mean that the other countries cannot be seen as opportunities. For example, in the U.A.E. the sulphur waste and produced water legislation is the most tolerant, while in Canada the laws are very strict, so an extensive market research in the U.A.E. can result in finding customers that are willing to the buy Thiopaq O&G technology because they will not face problems related to the disposal of sulphur. The latter proves that the result of this research can

be assessed differently if the targets of the company change. Another remark is that Russia and China scores are very close, so we cannot spot a significant difference among them. Their economies are flourishing, which makes them attractive for the O&G industries that want to operate in their counties but they face problems in their political scene, which is a deterrent factor. If we add the problems of their energy policy and environmental regulations, this can explain their ranking position. Finally, Indonesia and Kazakhstan score low in our decision sub-criteria and they are still immature markets but they should be monitored because if they make structural changes in their policies, they can become more attractive.

5.8 Sensitivity analysis

Sensitivity analysis is a technique used in MCDM to study the uncertainty of the output of a model by changing the values of the input factor. In other words, we will check the robustness of the dominating alternative, which is the country that ranked first compared to the other countries, with respect to changes to the weights of the four external factors. This is very helpful for this research because we can develop scenarios based on changes on the preferences of the main external factors.

The data analysis that we performed, by applying the BWM, revealed that our respondents ranked the factors from the most to the least important as following: Economic, Environmental Laws, Political and Competition factor. Accordingly they ranked the sub-criteria and we derived the global weights. The question that arose throughout this research is how the final ranking of the countries will change if the weights of the four main factors are different. Thus, we did two deterministic sensitivity analyses by manually adjusting the weights of the main factors (Ijzerman & Hummel, 2011), in order to check the impact that those changes will have on the ranking of the countries. It is important to state that the sensitivity analysis is applied only in the main external factors and not on their sub-criteria.

First, we considered the Economic factor as the most important, while we changed the ranking of the three other factors. Afterwards, we developed a scenario in which first we considered the Environmental Laws factor as the most important and giving to this factor the weight of the Economic factor, which is ranked first in our analysis. Then, we changed the ranking and the weights of the other factors, so we did 6 different calculations for every factor that we kept first in the ranking. The same was applied to other two remaining factors. So, in total we have 4 different scenarios and for every scenario we did 6 calculations in order to have all the possible combinations.

We present an example of a scenario, so as to make clear how we conducted the sensitivity analysis. In this example, we assume that the Competition factor is the most important, so the 6 different ratings are illustrated in the following table, where C represents the Competition factor, E represents the Economic factor, E.L. and P represent the Environmental Laws and Political factor respectively.

Calculation	1	2	3	4	5	6
Factor, weight: 0.3765	C	C	C	C	C	C
Factor, weight: 0.2617	E	E	E.L.	E.L.	P	P
Factor, weight: 0.2079	E.L.	P	P	E	E.L.	E
Factor, weight: 0.1540	P	E.L.	E	P	E	E.L.

Table 16 Sensitivity analysis (1) scenario Competition factor most important

The next step is to check what has changed in the ranking of the countries according to this scenario based on the six calculations, so as to understand if the Competition factor has an impact on the ranking. The following table represents the results of the calculations.

Calculation 1

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,35	2,32	1,71	1,77	2,58	2,93
Ranking	1	4	6	5	3	2

Calculation 2

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,23	2,29	1,83	1,80	2,60	2,93
Ranking	1	4	5	6	3	2

Calculation 3

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,21	2,24	1,87	1,75	2,63	2,95
Ranking	1	4	5	6	3	2

Calculation 4

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,31	2,22	1,80	1,66	2,64	2,97
Ranking	1	4	5	6	3	2

Calculation 5

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,44	2,31	1,63	1,68	2,59	2,95
Ranking	1	4	6	5	3	2

Calculation 6

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,43	2,26	1,68	1,63	2,63	2,97
Ranking	1	4	5	6	3	2

Table 17 Sensitivity analysis (1) countries ranking, Competition most important factor

The analysis from Table 18 reveals that the only change that is spotted is in calculation 1 and 6 where Kazakhstan is ranked 5th Indonesia is ranked 6th. Thus, we can state that our results are not sensitive on the scenario in which the Competition factor is considered as the most important. In the scenarios, where the Environmental Laws and Political factor are ranked first not a single change is found in the countries ranking. In the basic scenario, where the Economic factor is ranked first we only spotted that Kazakhstan and Indonesia are switching their preference order. To sum up, there is not a significant change occurring in the sensitivity analysis that we

completed, so we could say that we achieved a high robustness in our research. All the calculations and results are illustrated in Appendix E.

The second deterministic sensitivity analysis is performed as the first one but we assigned arbitrarily a value of 0.6 to the most important factor, then 0.2 to the second factor and 0.15 and 0.05 to the third and fourth factor respectively. In every scenario the sum of the weights has to be equal to 1. The reason we gave such a high value to the most important factor is because we want to test through this sensitivity analysis what will happen if a factor has such a high preference over the other factors. High and low values are assigned to the main factors so as to understand if those ranges will reflect any difference on the ranking of the countries (Daniel & Beek, 2005). So, this scenario development will be a tool for the managers to make assumptions if something changes drastically in the future. Thus, as we did for the first sensitivity analysis, in which we used the values that we extracted from the data analysis, we present the calculations where the Competition factor is considered as the most important. The following table illustrates the six possible combinations.

Calculation	1	2	3	4	5	6
Factor, weight: 0.6	C	C	C	C	C	C
Factor, weight: 0.2	E	E	E.L.	E.L.	P	P
Factor, weight: 0.15	E.L.	P	P	E	E.L.	E
Factor, weight: 0.05	P	E.L.	E	P	E	E.L.

Table 18 Sensitivity analysis (2) scenario Competition factor most important

The next step is to inspect what will be the impact of this scenario take in place in the ranking of the countries according to this scenario based on the six calculations, so as to understand if the Competition factor has an impact on the ranking. The following table represents the results of the calculations.

Calculation 1

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	2,81	1,97	1,45	1,72	2,16	2,47
Ranking	1	4	6	5	3	2

Calculation 2

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,00	1,94	1,31	1,55	2,18	2,50
Ranking	1	4	6	5	3	2

Calculation 3

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	2,71	1,93	1,56	1,75	2,17	2,47
Ranking	1	4	6	5	3	2

Calculation 4

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	2,68	1,84	1,64	1,65	2,23	2,50
Ranking	1	4	6	5	3	2

Calculation 5

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	2,77	1,82	1,57	1,57	2,24	2,52
Ranking	1	4	5	6	3	2

Calculation 6

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	2,98	1,89	1,35	1,50	2,21	2,52
Ranking	1	4	6	5	3	2

Table 19 Sensitivity analysis (2) countries ranking, Competition most important factor

The results from the second sensitivity analysis show that there is not a great impact on the countries ranking if the Competition factor is considered as the most important. The same can also be said for the Political and the Economic factor where no change was observed according to the data analysis. The Environmental Laws factor has a great impact on the ranking of the two first countries, where the U.A.E. is the most promising market and Canada is ranked second. Thus, it is obvious that the environmental policy of the U.A.E. government stimulates O&G investments by offering less strict laws. So, if the preference of the managers change and the Environmental Laws factor is considered so much important compared to the other factors, then the U.A.E. seems as the best market for launching the Thiopaq O&G technology. All the calculations and results are illustrated in Appendix F.

To conclude, the aim of the sensitivity analysis that we conducted during this research was to understand what would be the impact of changes of the preferences of the employees in the O&G industry, on the market choice for the Thiopaq O&G process. This analysis can be a useful tool for developing deferent scenarios and be prepared for potential changes. We deduced that the most important changes are spotted when the Environmental Laws factor is considered more important than the Economic factor.

Chapter 6 Conclusion

In this chapter, the answers to the research questions are given; the concluding remarks of this research are reflections are presented.

6.1 Conclusions

In this research we conducted a market research for the Thiopaq O&G technology, based on the factors that are present in the external environment. The aim was to find the country in which Thiopaq O&G has the most possibilities of successfully entering the gas sweetening market. The macro-environment of a country can be slightly influenced by a company but it can studied, assessed and evaluated in order to decide whether there are increasing chances of success or not. As a result, we conducted a literature review to decide, which critical external factors and sub-criteria we have to take on board on our developed assessment framework. We analysed the received data with the aid of the BWM, which is a MCDM method that provided us with the valuable results. The results helped us give an answer to the main research question. Moreover, we answered the sub-questions that were our guide throughout this research. The answers to the main research question and the sub-questions are the following:

- RQ: "*Which is the ideal country to promote and sell the Thiopaq O&G process, according to the evaluation of the external factors?"*

The main research question was the final outcome of this study and was given after the BWM data analysis and then by using data to apply a likert-scale. The ideal country to sell Thiopaq O&G technology is Canada, without implying that in practice the other countries cannot be considered as opportunities in the future. So, we gave a scientific answer to the research question by using the available literature to construct the assessment framework and collecting data from people that are working in the O&G industry.

Finally, it is revealed that the Economic factor is the most important, followed by the Environmental Laws and the Political, while Competition factor is considered as the least important. But, this research went a step further and attached sub-criteria to each factor in order get more valuable data, because if a sub-criterion belongs to Economic factor this does not mean that it is more important than a sub-criterion of the Political factor. The BWM method helped us rate those sub-criteria in rigorous way by applying mathematical models. Thus, the results are concrete and this is a powerful asset of this framework. The outcome of this research can be valuable tool for the O&G firms, which operate in a very competitive and capital-intensive environment. Moreover, this framework offers the flexibility to the decision-maker to remove factors and sub-criteria so as to add others that can be more interesting according to his/her perception and intention, but the data analysis tool is available and proved to be working.

- SQ1: "*What are the existing frameworks that are used for the external environment scanning?"*

In order to answer sub-question 1, we conducted an extensive literature review on the topics of macro-environmental scanning, assessment frameworks for external factors and market research for product promotion. We came to the conclusion that there is not a framework that can fit in all the cases, so we built upon the PEST analysis and the Porter's Five Forces model and created a new one that served our research. We extracted the most interesting factors according to our judgement and purpose, which are the Political, Economic, Environmental Laws and Competition factor. Finally, through the literature review we attached sub-criteria in each factor so as to specify and narrow down our scope.

- SQ2: "*How do employers, employees and managers working in the O&G industry, evaluate and rank the identified external factors and their sub-criteria?"*

The answer to this sub-question comes from the replies we received in our questionnaire. The BWM method data collection is done through a questionnaire, which we distributed to our sampling sample; people working in the O&G industry. So, their role was to answer certain questions by rating the identified external factors and their sub-criteria from which we derived our valuable data.

- SQ3: "*How the created framework is applied in the case of the Thiopaq O&G process?"*

Although we have created the assessment framework after conducting a literature review and we were optimistic that we achieved our goal, we could not be sure if we reached our goal before receiving the results of the questionnaires. If the respondents could not understand and answer our questions this would be a failure of this research. Hopefully, everyone admitted that the identified factors and sub-criteria are present and have to be evaluated when a market research is conducted by an O&G company.

6.2 Reflections

A scientific research is a step-by-step process that takes a long time to complete because it starts from vague and abstract ideas that are transformed to a defined problem to be answered. So, the nature of a research is inherently challenging because theoretical concepts are used to solve real life problems, like the market research for the Thiopaq O&G technology. The research starts by reviewing the literature, creating a new body of knowledge and finally applying it to a case and understand if we solved the issue that we faced. Even if we do not solve it, we have to search for the reasons that led to this failure and think about what we could change in to order to give a solution to a problem.

It is important to provide the reflections on the literature that we performed, on the method that we used and of course on the results that we got. First of all, there will always be a doubt if we included the proper external factors and sub-criteria for our case. Suggestions can be made only after analysing the data and interpreting the results. We suppose that the performed literature review covered a great extent of issues and we were in the position to choose the appropriate factors. The Economic factor came first at the rating, which was expected because of the nature of the O&G business; capital expenditures are high and constant funding of the O&G companies and projects is needed. The surprising result is the Environmental Laws that were ranked second, which shows that the O&G firms are aiming to operate in a sustainable way and as environmental friendly as possible. The managers have raised the environmental awareness despite the fact that this increases the expenses of a firm. On one hand we could say that the environmental protection is high in all the companies' agendas because employees care more about the consequences of the operations on the environment, but on the other the focus on the environment could be explained as a result of the severe penalties that are imposed in the O&G companies when they are responsible for polluting the nature and the environment.

The Political factor is seriously taken into account because the political stability of a country can be a guarantee for the O&G firms to invest. A tranquil political environment can boost the investments because companies have fewer problems to think about and can focus on their business. Moreover, the environmental policy of a government states its intentions on the energy sector and the companies can estimate if they can operate in this context. The Competition factor comes at the last place, which is wondrous but can be explained because it is very difficult to identify the intensity of the competition before entering a market. Assumptions can be made but a clear insight can be gained when a company starts working on a new market. Retrospectively judging the framework it is safe to say that the Competition factor could not be taken on board and instead another factor can replace it. We have to be critical on the framework and say that two sub-criteria were not quantified because of lack of data; this enhances the perception that the Competition factor have to excluded, especially if someone chooses to use this framework in further research.

The global weights and ranking of the sub-criteria showed that the capital investments are 2.5 times more important than the sulphur waste legislation which is ranked second. The criteria from second to the sixth place are very close that indicates how difficult is to assess those sub-criteria and interpret them during a market research. The remaining sub-criteria are also clustered but are considered less important, but still have an impact on the choice of the country.

The data analysis was done by the application of a MCDM method that helped us gain the local and global weights of the sub-criteria and rank them in order to give an answer to our main research question. We performed a literature review for the available methods to understand in depth how they work and have an insight in this area. The initial results of the review revealed that the AHP method is widely used in similar problems and a lot of solutions are available because of its increased applicability, but has some drawbacks. So, further research gave us information that a new method is developed, which overcomes the disadvantages of the AHP. This method is called BWM, which is a pairwise comparison method such as the AHP but

requires fewer comparisons and provides more consistent results. The latter, triggered our interest to choose the BWM method instead of the AHP for the data analysis. The BWM method proved to be very useful for our analysis, so we can argue that it was the right choice. It is easy and simple to apply the BWM and one of its great advantages is the convenience of interpreting the results. So, overall the BWM was the best choice for this research.

The actual result of the analysis showed that Canada is the most promising market to sell the Thiopaq O&G process. We could say that the other countries cannot be considered as profitable markets according to our research, but in those countries further research may reveal that certain sour gas fields can be an opportunity. For example, a location of sour gas field can play an important role on buying Thiopaq O&G technology instead of a substitute technology. So, the other countries can offer some opportunities but another type of research is needed in order to choose among certain sour gas fields.

The master program of Management of Technology that I followed at TU Delft triggered my interest to explore the market opportunities of a new technology from a different perspective. A technology must have many attributes in order to be successfully placed in the market. As a result, my studies offered me the academic background, theories and methodologies, to conduct this research and apply the knowledge in a real world problem. It is proved that the theories can be a valuable tool to solve a problem and conduct a research in a rigorous way. Moreover, the results are concrete because of the application of the BWM methodology.

6.3 Future research

In this research, we created an assessment framework for the macro-environmental factors. The result of this assessment helps a company in its market research that is done to sell a new product. We received our data from one O&G company, so another researcher can distribute the questionnaire in multiple companies and compare the results. So, he/she can compare the results and comprehend if employees of different companies have diverse opinions. Another possibility is to use other sub-criteria but maintain the same external factors and compare the results to those of this research. Thus, we could say if different sub-criteria lead to the choice of a different country. Moreover, another research based on our findings can focus on the comparison of certain sour gas fields in the countries that we included in our evaluation. So, instead of comparing the external factors of a country in general, there can be an assessment of the sites that sour gas fields are located. It is very important that this paper can trigger further research, based on the created assessment framework and the use of the BWM to analyse the data. Finally, a sensitivity analysis can be extended and applied to the sub-criteria so as to see what the outcome will be.

Bibliography

ABD. (2013). *Downstream Impacts of Water Pollution in the Upper Citarum River, West Java, Indonesia.* Washington: The World Bank.

AECEN. (2008). *Environmental Compliance and Enforcement in Indonesia.* USAID.

Ahmadun, F., Pendashteh, A., Abdullah, L., & Abidin, Z. (2009). Reveiw of technologies for oil and gas produces water treatment. *Journal of Hazardous Materials* , 530-551.

Alberta. (2014, 02). *Alberta energy*. Retrieved 5 2015, from http://www.energy.alberta.ca/naturalgas/723.asp

Albright, S. (2004). Environmental scanning: Radar for success. *The information management journal* .

Alesina, A., & Perotti, R. (1996). Income distribution, political instability and investment. *European economic review* , 1203-1228.

Alexander, D. (2014). *Driving investment: a plan to reform the oil and gas fiscal regime.* London: HM Treasury.

Aliyeva, F. (2011). *Introduction into the Oil and Gas industry.* London: Ztudium.

API. (2105, 03). *Adventures in energy.* Retrieved 07 2015, from http://www.adventuresinenergy.org/Natural-Gas-Processing/index.html

APPEA. (2014, 04). *Voice of Australia's oil and gas industry.* Retrieved 07 2015, from http://www.appea.com.au/oil-gas-explained/resources/how-are-oil-and-gas-formed/

BERA. (2013, 07). *The library of congress.* Retrieved 06 2015, from http://www.loc.gov/rr/business/BERA/issue5/history.html

Bialowolski, P., & Weziak, D. (2014). External factors affecting investment decisions of companies. *Economics E-Journal* , 1-12.

Boschee, P. (2014). *Taking on the technical challenges of sour gas processing.* Oil and Gas facilities.

Boucher, T., & McStravic. (1991). Multi-Attribute Evaluation WIthin a present value framework and its relation to the AHP. *The Engineering Economist* (37), 55-71.

Brans, J., Mareschal, B., & Vincke, P. (1984). PROMETHEE: a new family of outranking methods in multicriteria analysis. *Operational Research* , pp. 477-490.

Bravo, J. (2014). Making sense of the sulphur challenge. (Shell, Interviewer)

Burgers, W., Northop, P., & Valencia, J. (2011). Worldwide development potential for sour gas. *Energy Procedia* , pp. 2178-2184.

Champan, A. (2012). *Businessballs*. Retrieved from http://www.businessballs.com/pestanalysisfreetemplate.htm

Chevron. (2014). *High Sour Wanyuan Block Gas Field Project - Preliminary Design.* Beijing: Worley Parsons.

Chima, C. (2007). Supply-Chain management issues in the oil and gas industry. *Journal of Business & Economics Research , 5*.

ChinaWater. (1998). *National Standard of the People's Republic of China Integrated Wastewater Discharge Standard.* National Environmental Protection Bureau State Technology Supervision Bureau.
Chow, G. (2014). *China's Energy and Environmental Problems and Policies.* Princeton University.
Cristobal, S., & Ramon, j. (2012). *Multi Criteria Analysis in the Renewable Energy Industry.* Springer.
CRS. (2009). *Unconventional Gas Shales: Development, Technology and Policy issues.* CRS.
Daniel, L., & Beek, E. (2005). *Water resources systems and planning management.* UNESCO.
Deloitte. (2015). *Oil and Gas reality check.* Deloitte.
Derregia, M., & Chittenden, F. (2015). *Capital investment decision-making: results from studying entrepreneurial businesses.* Centre for Business Performance.
Dess, G., & Lumpkin, G. (2004). *Strategic Management: Creating Competitive Advantages.* Glasgow: McGraw-Hill.
Dudley, B. (2015). *BP energy outlook 2035.* BP.
Eardley-Taylor, P., & Green, N. (2013). *The Pending Impact of Natural gas on South Africa's Energy sector.* Standard bank.
Edwards, S., Isbaq, O., & Johnsen, O. (2010). *Oil and gas 2030: Meeting the growing demands for energy in the coming decades.* IBM.
EIA. (2012). *Annual energy outlook 2012.*
EIA. (2015). *China: International energy data and analysis.* Biejing: US energy information administration.
EIA. (2007). *International energy outlook 2007.* Washington DC: EIA.
El-Katiri, L., & Fattouh, B. (2014). *The Arab uprisings and MENA political instability.* Oxford: Oxford University Press.
England, J., Bean, G., & Anshu, M. (2015). *Following the capital trail in oil and gas.* Deloitte University Press.
EPI. (2014). Retrieved 2015, from http://epi.yale.edu/epi/country-rankings
Exxon. (2015). *http://corporate.exxonmobil.com/.* Retrieved 2015, from http://corporate.exxonmobil.com/en/environment/climate-change/managing-climate-change-risks/risk-factors
EY. (2014). *Spotlight on oil and gas megaprojects.* Ernst & Young.
Fernades, T. (2011). *Guideliness for landfill disposal of sulphur waste and remediation of sulphur containing soils.* Goverment of Alberta.
Fernandes, T. (2012). *Guidelines for Landfill Disposal of Sulphur Waste and Remediation of Sulphur Containing Soils .* Alberta: Government of Alberta.
FME. (2013). *Strategy skills: PESTLE analysis.* Free maangement ebooks.
FME. (2013). *Strategy skills: Porter's Five Forces.* Free management ebooks.
Forman, E., & Selly, M.-A. (2010). *Decision by objectives.* Washington.
Foster, J., & Carroll, J. (2014). *New challenges & solutions in designing large sour gas projects.* Foster Wwheeler.
Gillespie, A. (2014). *Foundations of Economics.* Oxford.
Grant, R. (2010). *Contemporary Strategy Analysis .* Wiley and Sons.

Guerra, K., & Dahm, K. (2011). *Oil and gas produced water management and beneficial use in the western United States.* Denver: USBR.
Harris, A., Purwanto, B., & Sasongko, D. (2012). Workover and completion operations in East Java sour gas field, Indonesia. *International Conference on Health, Safety and Environment in the Oil and Gas Exploration and Production.* Perth: APPEA.
Herbert, S. (1960). *The new science of management decision.*
Herman, M., & Koczkodaj, W. (1996). A Monte Carlo study of pairwise comparisons. *International Processing Letters* , 9-25.
Hoeven, M. (2013). *Resources to reserves.* International Energy Agency.
Hokroh, M. (2014). An analyis of the oil and gas industry's competitiveness using Porter's Five Forces framework. *Global Journal of Commerce & Management Perspective , 3*, 76-82.
Huo, D. (2012). *The global sour gas problem.* Stanford Energy Club. Stanford University.
ICLG. (2013). *The International Comparative Legal Guide to Oil & Gas Regulation 2013.* London: Global legal Group.
IEA. (2014). *Energy Policies of IEA countries 2014, European Union.* Paris: International Energy Agency.
Ijzerman, M., & Hummel, M. (2011, 11 8). SENSITIVITY ANALYSIS IN MULTI-CRITERIA DECISION (MCDA) MODELS FOR BENEFIT-RISK ASSESSMENT. *International Society for Pharmacoeconomics and Outcomes research* .
Jin, S., Anguo, F., & Debin, Y. (2010). Geological reserves of sulphur in China's sour gas fields and the strategy of sulphur markets. *Petroleum exploration and development* , 369-377.
Kamal, F., & Hossein, S. (1989). The Association between Political Instability and Flow of Foreign Direct Investment. *Journal of international business* , 4-13.
Keillor, B., Wilkinson, T., & Owens, D. (2003). Threats to international operations: dealing with political risk at the firm level. *Journal of Business Research* , 629-635.
Kotler, P., & Keller, K. (2012). *Marketing Management, 14/E.* Pearson.
Kulander, C. (2013). Shale Oil and Gas State regulatory issues and trends. *Case western reserve Law review* , 1101-1141.
Lazarevska, A., Fischer, N., & Haarstrick, A. (2009). *GeoSpatial Visual Analytics.* Springer.
Levine, S., Carpenter, P., & Thapa, A. (2014). *Understanding natural gas markets.* API.
Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology, , 22*.
Lin, R.-J., Chen, R.-H., & Nguyen, t.-h. (2011). Green supply chain management performance in automobile manufacturing industry under uncertainty. *Procedia - Social and Behavioral Sciences* , 233-245.
Lukoil. (2013). *GLOBAL TRENDS IN OIL & GAS MARKETS TO 2025.* Lukoil.

Maheran, N., & Jantan, M. (2009). Capital Investment Decision: Impact from environmental scanning. *Journal of Management Research* .
Mardani, A., Jusoh, A., & Cavallaro, F. (2015, 09 30). Sustainable and Renewable Energy: An overview of the application of Multiple Criteria Decision Making Techniques and Approaches. *Sustainability , 7*, pp. 13947-13984.
McAuley, D. (2014). Oil and gas innovation: the race to be number two. *Global executive briefing network.* Perth: Lloyd's register energy.
Meays, C., & Nordin, R. (2013). *Ambient Water Quality Guidelines For Sulphate.* British Columbia: Ministry of Environment.
Miliken, F. (1987). Three Types of Perceived Uncertainty About the Environment: State, Effect, and Response Uncertainty. *The academy of management review* , 133-143.
Mitchell, J. (2012). *What next for the oil and gas industry?* London: Chatham House.
Mitra, S. (2015). *A Technical Report on Gas Sweetening by Amines.*
Moss, H., & Kinnear, T. (2007). Nothing can eliminate responsibility. *SuperVision* .
Murphy, C. (1993). Limits of the Analytical Hierarchy Process from its consistency index. *European journal of Operational Research* (65), 138-140.
Nag, R., Hambrick, D., & Chen, M.-J. (2007). WHAT IS STRATEGIC MANAGEMENT, REALLY? INDUCTIVE DERIVATION OF A CONSENSUS DEFINITION OF THE FIELD. *Strategic management Journal* , 935955.
Najibi, H., Rezaei, R., & Javanmardi, J. (2008). Economic evaluation of natural gas transportation from Iran's South-Pars gas field to market. *Applied Thermal Engineering* , pp. 2009-2015.
Natgas. (2013, 09 20). *Natural gas organisation*. Retrieved 09 12, 2015, from http://naturalgas.org/overview/background/
NGSA. (2015). *Natural gas Organization.* Retrieved from http://naturalgas.org/overview/background/
Nosal, A., & Pavluk, T. (2005). *Standards for surface water quality in the Russian Federation* . Russian Research Institute for Complex Utilization and Protection of Water .
Olsen, W. (2014). *Indonesia struggling to keep production - hoping for new projects.* Intsok.
Opricovic, S., & Tzeng, G.-H. (2004). Comprise solution by MCDM methods:a comparative analysis of VIKOR and TOPSIS. *European Journal of Operational research* , 445-455.
Ortt, J., & Schoormans, J. (2004). The pattern of development and diffusion of breakthrough communication technologies. *European Journal of Innovation Management* .
Parab, P. (2015). *Data collection: Primary and secondary.* Elico Marketing Ltd.

PetroStrategies. (2015, 02 20). *Petro Strategies Inc.* Retrieved 08 14, 2015, from http://www.petrostrategies.org/Learning_Center/oil_and_gas_value_chains.htm
Polaris. (2012). *The six steps in conducting quantitative marketing research.* Atlanta: Research Life Line.
Porter, M. (1980). *Competitive strategy Techniques for analyzing industries and competitors.* New York: The Free Press.
Porter, M. (2008). The five competitive forces that shape strategy. *Harvard Business Review* .
Putrus, P. (1990). Accounting for intangibles in integrated manufacturing based on AHP. *Information Strategy , 6*, 25-30.
Rezaei, J. (2015a). Best-worst multi-criteria decision-making method. *Omega , 53*, 49-57.
Rezaei, J. (2015b). Best-worst multi-criteria decision-making method: some properties and a linear model. *Omega* .
Roberts, P., & Armstrong, L. (2015). *Challenges for processing oil and gas in Kazakhstan.* Brentford: WorleyParsons.
Rozmarynowska, M., & Oldakowski, B. (2012). *Towards an integrated transport system in the Baltic Sea Region.* Helnsinki: TransBaltic.
RSK. (2007). *Dubai LNG Regasification Project.*
Rurwagautama, G., & Anidka, R. (2010). Material and completion equipment selection for HPHT sour gas field development in Indonesia. *Asia drilling technology conference and exhibition.* IADC/SPE.
Saaty, T. (2001). *Decision Making with Dependence and Feedback.* Rws Publications.
Saaty, T. (1990). How to make a decision: The Analytic Hierarchy Process. *European Journal of Operational Research* (48), 9-26.
Saaty, T., & Vargas, L. (2012). *Models, Methods, Concepts & Applications of the Analytic Hierarchy Process.* Springer.
Sari. (2013). Investment decisions. *Center for energy economics* .
Schilling, M. (2010). *Strategic Management of Technological Innovation.* McGraw-Hill.
Scottish. (2008). *Spends and Trends 2008-2017.* Scottish Development Enterprise.
Sekaran, U., & Bougie, R. (2009). *Research Methods for Business: A skill building approach.* Wiley.
Sekaran, U., & Bougie, R. (2010). *Research methods for business: A skill building approach* (Vol. 5). Willey.
Shaffer, B., & Hillman, A. (2000). The Development of Business-Government Strategies by Diversified Firms. *Strategic Management Journal* , 175-190.
Shell. (2014). *Waterton Gas Complex.* Retrieved 2015, from http://www.shell.ca/en/aboutshell/our-business-tpkg/upstream/e-and-p-canada/waterton.html
Srdjevic, Z., & Bajcetic, R. (2012). Identifying the Criteria set for multicriteria decision making based on SWOT/PESTLE analysis. *Water resource management* , pp. 3379-3393.

StatCan. (2015, 07 06). *Canada Statistics.* Retrieved 09 07, 2015, from http://www.statcan.gc.ca/daily-quotidien/150706/cg-a001-eng.htm
Statoil. (2014). *Statoil.* Retrieved 2015, from http://www.statoil.com/annualreport2010/en/ouroperations/competition/pages/competition.aspx
Svensson, J. (1997). Investment property rights and political instability: Theory and evidence. *European economic review* , 1317-1341.
Thomassen, J. (2013). *ENVIRONMENTAL STATUS REPORT 2012.* Maersk Oil.
Thurstone, L. (1927). A law of comparative judgment. *Psychological Review* .
Tideman, D., Chehade, G., & Kozinchenko, E. (2015). *Capital projects in the oil and gas industry.* Amsterdam: PWC.
Total. (2012). *Sour gas: A history of expertise.* PAris: Total Exporation & Production.
Triantaphyllou, E., Shu, B., & Sanchez, S. (1998). Multi-Criteria Decision Making: An operations research approach. *Encyclopedia of Electrical adn Electronics Engineering , 15*, pp. 175-186.
Ulgen, H., & Mirze, S. (2007). *Isletmelerde stratejik yonetim.* Instabul: Arikan Yayinlari.
UoK. (2015). *Community tool box University of Kansas.* Retrieved from http://ctb.ku.edu/en/table-of-contents/evaluate/evaluate-community-interventions/collect-analyze-data/main
Van de Kaa, G. (2009). *Standards battles for complex systems.* Erasmus University Rotterdam. EUR.
Velasquez, M., & Hester, P. (2013). An analysis of multi-criteria decision making methods. *Intenational Journal of Operations Research , 10* (2), 56-66.
Verma, A. (2012). *Macro factors affecting business environment.*
Verschuren, P., & Doorewaard, H. (2010). *Designing a research project.* The Hague: Eleven.
Wabalickis, R. (1988). Justification of FMS with the AHP. *Journal of Manufacturing Systems* (17), 175-182.
Wagner, J., & Armstrong, K. (2010). Managing environmental and social risks in international oil and gas projects: Perspectives on compliance. *Journal of World Energy Law & Business* .
Wang, L., & Raz, T. (1991). Analytical Hierarchy Process based on data flow problem. *Computers & Industrial Engineering* (20), pp. 355-365.
Westney, R. (2011). Assessing the risk in capital-intensive opportunities. *Oil&Gas Financial Journal* .
Williams, B. (2014). *Macro-environmental analysis for the Alberta midstream Oil and gas sector.* Athabasca University. Athabasca.
WorldBank. (2014). Retrieved from http://data.worldbank.org/indicator/FR.INR.RINR
WorldBank. (2014). Retrieved from http://www.theglobaleconomy.com/rankings/renewable_power_generation/
WorldBank. (2014). Retrieved from http://www.theglobaleconomy.com/rankings/government_spending_dollars/

WorldBank. (2014). Retrieved from http://data.worldbank.org/indicator/FR.INR.RINR
WorldBank. (2014). *Worldwide Governance indicators.* WB.
Wyman, O. (2015). *world energy council.* Retrieved from http://www.worldenergy.org/data/trilemma-index/
Xu, L., & Yang, J.-B. (2001). *Introduction to multi-criteria decision making and the evidential reasoning approach.* Manchester School of Management.
Ye, E. (2014). *Alternative sulphur management solutions to help refiners meet clean fuel and environmental challenges.* Beijing: DuPont.
Yoon, K. (1987). A reconcillation among discrete compromise solutions. *The Journal of the Operational Research Society* , 277-286.
Yuksel, & Ihsan. (2012). Developing a multi-criteria decision making model for PESTEL analysis. *International Journal of Business and Management* .
Zalengera, C., Blanchard, R., & Eames, P. (2014). Overview of the Malawi energy situation and a PESTLE analysis for sustainable development of renewabke energy. *Renewable and Sustainable Energy Reviews* , pp. 335-347.
Zarnowitz, V. (1992). *Business Cycle: Theory, History, Indicators and Forecasting.* Chicago: University of Chicago Press.
Zessen, E., & Janssen, A. (2004). Application of Thiopaq Biosulphur in agriculture. *Sulphur 2004 conference.* Barcelona.
Zimmermann, H.-J. (2001). *Fuzzy Set Theory and its applications.* Kluwer Academic Publishers.

Appendix A

Thesis title

"Market choice opportunities for gas sweetening technologies"
The case study of Thiopaq O&G technology.

Dear Sir/Madam,

I am conducting my research for my thesis at Delft University of Technology, which is mandatory in order to complete my Master's program of 'Management of Technology'. I would kindly ask you to fill in the following questionnaire, so as to collect valuable data for my thesis.

The aim of the research is the identification of the most promising country, in which the gas sweetening technology Thiopaq O&G can be sold based on the evaluation of the external environment. So, you will have to rate the external factors and their sub-criteria, which are present in the macro-environment according to your preferences and perceptions.

The questionnaire requires approximately 10 minutes to be completed. You just have to fill it, save it and send it back. Do not forget to fill in your department and years of experience at the first page of the questionnaire. Your personal information will be treated under confidentiality. In the next page you will find a short description on how to fill the questionnaire. If you have any questions feel free to contact me via e-mail.

Thank you in advance,
George Bezerianos
e-mail: giobezerianos@gmail.com

Questionnaire instructions: Suppose you want to buy a car and you take into account the criteria of price, colour and comfort. You want to rate them so as to identify which is the most and the least important. So, you have to go through the following process, considering your goal, which is to buy a car based on your preferences.

Step 1: You choose the criterion of price as the MOST IMPORTANT and you insert it in the left-hand side cell of the second row. Now use a number between 1 and 9 to show your preference of your MOST IMPORTANT criterion over the other criteria:

MOST IMPORTANT criterion	Price	Colour	Comfort
Price	1	7	9

Step 2: You choose the criterion of comfort as the LEAST IMPORTANT and you insert it in the top cell of the second column. Now use a number between 1 and 9 to show your preference of your LEAST IMPORTANT criterion over the other criteria:

LEAST IMPORTANT criterion	Comfort
Price	9
Colour	4
Comfort	1

Tip: A score of 1 indicates an equal importance over the other criterion. A score of 1 indicates that the MOST/LEAST important criterion is of equal importance compared to the other criterion. A score of 9 indicates that the MOST/LEAST important criterion is extremely preferred over the other criterion.

*Definition of 1 to 9 measurement scales:

1: Equal importance
3: Moderately more important
5: Strongly more important
7: Very strongly more important
9: Extremely more important
2,4,6,8: Intermediate values

Main External Factors

*Department:
*Years of experience:

The following factors are the most important, which are taken into account when you are trying to find the most suitable and profitable market to sell a new product.

Can you indicate which of the factors you consider as the MOST important and which as the LEAST important, by marking the appropriate box?

Criterion	MOST important	LEAST important
Political		
Economic		
Environmental laws		
Competition		

You have selected …….. as the MOST important criterion. Can you indicate your preference of this criterion over the other criteria? Use a number between 1 and 9 to show your preference of your MOST important criterion over the other criteria:

MOST IMPORTANT criterion	Political	Economic	Environmental laws	Competition

You have selected …….. as the LEAST important criterion. Can you indicate your preference of the other criteria over this LEAST important criterion? Use a number between 1 and 9 to show your preference of the other criteria over the LEAST important criterion:

LEAST IMPORTANT criterion	
Political	
Economic	
Environmental laws	
Competition	

Political factor

The political condition of a country directly affects the O&G industry and we consider some important criteria that should be taken into account.

Can you indicate which of the criteria you consider as the MOST important and which as the LEAST important, by marking the appropriate box?

Criterion	MOST important	LEAST important
Political instability		
Energy policy		
Fiscal policy		

You have selected …….. as the MOST important criterion. Can you indicate your preference of this criterion over the other criteria? Use a number between 1 and 9 to show your preference of your MOST important criterion over the other criteria:

MOST IMPORTANT criterion	Political instability	Energy policy	Fiscal policy

You have selected …….. as the LEAST important criterion. Can you indicate your preference of the other criteria over this LEAST important criterion? Use a number between 1 and 9 to show your preference of the other criteria over the LEAST important criterion:

LEAST IMPORTANT criterion	
Political instability	
Energy policy	
Fiscal policy	

Economic factor

The economic situation of a country is a crucial factor related to new investments.

Can you indicate which of the criteria you consider as the MOST important and which as the LEAST important, by marking the appropriate box?

Criterion	MOST important	LEAST important
Capital investments		
Interest rates		
National GDP		

You have selected …….. as the MOST important criterion. Can you indicate your preference of this criterion over the other criteria? Use a number between 1 and 9 to show your preference of your MOST important criterion over the other criteria:

MOST IMPORTANT criterion	Capital investments	Interest rates	National GDP

You have selected …….. as the LEAST important criterion. Can you indicate your preference of the other criteria over this LEAST important criterion? Use a number between 1 and 9 to show your preference of the other criteria over the LEAST important criterion:

LEAST IMPORTANT criterion	
Capital investments	
Interest rates	
National GDP	

Environmental laws factor

The environmental policy and regulations impose standards to the disposal of the by-products of a gas sweetening process, but they vary per country because of lack of a universal environmental law.

Can you indicate which of the criteria you consider as the MOST important and which as the LEAST important, by marking the appropriate box?

Criterion	MOST important	LEAST important
Vague environmental regulatory framework		
Produced water disposal limits		
Sulphur waste legislation		

You have selected …….. as the MOST important criterion. Can you indicate your preference of this criterion over the other criteria? Use a number between 1 and 9 to show your preference of your MOST important criterion over the other criteria:

MOST IMPORTANT criterion	Vague environmental regulatory framework	Produced water disposal limits	Sulphur waste legislation

You have selected …….. as the LEAST important criterion. Can you indicate your preference of the other criteria over this LEAST important criterion? Use a number between 1 and 9 to show your preference of the other criteria over the LEAST important criterion:

LEAST IMPORTANT criterion	
Vague environmental regulatory framework	
Produced water disposal limits	
Sulphur waste legislation	

Competition factor

Competition among the O&G firms and their products from the gas sweetening process shapes the potential market share that a company can get.

Can you indicate which of the criteria you consider as the MOST important and which as the LEAST important, by marking the appropriate box?

Criterion	MOST important	LEAST important
Size of competing firms		
Substitute technologies		
Alternative energy sources		

You have selected …….. as the MOST important criterion. Can you indicate your preference of this criterion over the other criteria? Use a number between 1 and 9 to show your preference of your MOST important criterion over the other criteria:

MOST IMPORTANT criterion	Size of competing firms	Substitute technologies	Alternative energy sources

You have selected …….. as the LEAST important criterion. Can you indicate your preference of the other criteria over this LEAST important criterion? Use a number between 1 and 9 to show your preference of the other criteria over the LEAST important criterion:

LEAST IMPORTANT criterion	
Size of competing firms	
Substitute technologies	
Alternative energy sources	

Appendix B

Country	Sour gas fields	Source
Canada	Caroline, Waterton	(Shell, 2014)
China	Tieshanpo,Yuanba, Chuandongbei	(EIA, 2015), (Chevron, 2014)
Indonesia	East Java, Natuna	(Harris, Purwanto, & Sasongko, 2012)
Kazakhstan	Kashagan, Tengiz	(Hoeven, 2013)
Russia	Kharyaga, Astrakhan	(Total, 2012)
U.A.E.	Shah Arab, Bab	(Boschee, 2014)

Table 20 Sour gas fields under development

Appendix C

Country	Capital Investments ($B), Source	Likert-scale Score
Canada	$250 B, (StatCan, 2015)	5
China	$200 B, (England, Bean, & Anshu, 2015)	4
Indonesia	$30 B (Olsen, 2014)	1
Kazakhstan	$81 B (Deloitte, 2015)	2
Russia	$163 B (Tideman, Chehade, & Kozinchenko, 2015)	3
U.A.E.	$140 B (Scottish, 2008)	3

Table 21 Capital investments score per country

Country	Sulphur waste legislation (mg S/kg solid waste), Source	Likert-scale Score
Canada	500mg/kg, (Fernandes, 2012)	1
China	1000mg/kg, (Chow, 2014)	2
Indonesia	1200mg/kg, (AECEN, 2008)	3
Kazakhstan	500mg/kg, (Fernandes, 2012)	1
Russia	1000mg/kg, (Rozmarynowska & Oldakowski, 2012)	2
U.A.E.	1250mg/kg, (ICLG, 2013)	5

Table 22 Sulphur waste legislation score per country

Country	Substitute technologies, Likert-scale Score
Canada	1
China	1
Indonesia	1
Kazakhstan	1
Russia	1
U.A.E.	1

Table 23 Substitute technologies score per country

Country	Produced water disposal limits (mg sulphide/L)	Likert-scale Score
Canada	0.05 mg/L, (Meays & Nordin, 2013)	3
China	1 mg/L, (ChinaWater, 1998)	5
Indonesia	1 mg/L, (ABD, 2013)	5
Kazakhstan	0.08 mg/L, (Thomassen, 2013)	4
Russia	1 mg/L, (Nosal & Pavluk, 2005)	5
U.A.E.	0.01 mg/L, (RSK, 2007)	1

Table 24 Produced water disposal limits score per country

Country	Political instability (index: -2.5; 2.5)	Likert-scale Score
Canada	1.03	5
China	-0.55	3
Indonesia	-0.50	2
Kazakhstan	-0.38	1
Russia	-0.75	4
U.A.E.	0.92	5

Table 25 Political instability score per country (WorldBank, 2014)

Country	Energy Policy (rank: 1–130)	Likert-scale Score
Canada	7	5
China	74	1
Indonesia	65	2
Kazakhstan	77	1
Russia	49	3
U.A.E.	38	4

Table 26 Energy policy score per country (Wyman, 2015)

Country	Interest rates (%), Source (WorldBank, 2014)	Likert-scale Score
Canada	1.2%	5
China	4.7%	3
Indonesia	6.8%	2
Kazakhstan	16%	1
Russia	3.7%	3
U.A.E.	1%	5

Table 27 Interest rate score per country (WorldBank, 2014)

Country	Vague environmental framework (score: 0-100)	Likert-scale Score
Canada	73.14	5
China	43.00	1
Indonesia	44.36	2
Kazakhstan	51.07	3
Russia	53.45	3
U.A.E.	72.91	5

Table 28 Vague environmental framework score per country (EPI, 2014)

Country	National GDP ($GDP per capita)	Likert-scale Score
Canada	$51958	5
China	$6,07	2
Indonesia	$3475	1
Kazakhstan	$13609	3
Russia	$14611	3
U.A.E.	$43048	4

Table 29 National GDP score per country (WorldBank, 2014)

Country	Alternative energy sources (billion kWh)	Likert-scale Score
Canada	397	5
China	1003	2
Indonesia	22	1
Kazakhstan	7	3
Russia	167	3
U.A.E.	0.02	4

Table 30 Alternative energy sources score per country (WorldBank, 2014)

Country	Fiscal policy (government spending in billion $)	Likert-scale Score
Canada	395	3
China	1296	5
Indonesia	79	2
Kazakhstan	24	1
Russia	409	4
U.A.E.	27	1

Table 31 Fiscal policy score per country (WorldBank, 2014)

Country	Size of competing firms, Likert-scale Score
Canada	1
China	1
Indonesia	1
Kazakhstan	1
Russia	1
U.A.E.	1

Table 32 Size of competing firms score per country

Appendix D

	Global Weight	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E
Capital investments	0,2323	5	4	1	2	3	
Sulphur waste legislation	0,0946	1	2	3	1	2	
Substitute technologies	0,0928	1	1	1	1	1	
Produced water disposal limits	0,0928	3	5	5	4	5	
Political instability	0,0877	5	3	2	1	4	
Energy policy	0,0876	5	1	2	1	3	
Interest rates	0,0770	5	3	2	1	3	
Vague environmental framework	0,0753	5	1	2	3	3	
National GDP	0,0662	5	2	1	3	3	
Alternative energy sources	0,0352	5	2	1	3	3	
Fiscal policy	0,0335	3	5	2	1	4	
Size of competing firms	0,0248	1	1	1	1	1	
	Sum	3,90	2,73	1,92	1,86	2,98	3,3

Table 33 Detailed country ranking, likert-scale

Appendix E

Calculation	1	2	3	4	5	6
Factor, weight: 0.3765	E.L.	E.L.	E.L.	E.L.	E.L.	E.L.
Factor, weight: 0.2617	E	E	P	P	C	C
Factor, weight: 0.2079	C	P	C	E	P	E
Factor, weight: 0.1540	P	C	E	P	E	P

Table 34 Sensitivity analysis (1) scenario Environmental Laws factor most important

Calculation 1

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,65	2,65	2,17	1,94	3,01	3,37
Ranking	1	4	5	6	3	2

Calculation 2

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,63	2,60	2,22	1,89	3,05	3,39
Ranking	1	4	5	6	3	2

Calculation 3

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,47	2,48	2,20	1,86	2,96	3,28
Ranking	1	4	5	6	3	2

Calculation 4

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,32	2,41	2,15	1,89	2,85	3,16
Ranking	1	4	5	6	3	2

Calculation 5

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,34	2,46	2,11	1,94	2,82	3,15
Ranking	1	4	5	6	3	2

Calculation 6

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,50	2,58	2,12	1,96	2,90	3,25
Ranking	1	4	5	6	3	2

Table 35 Sensitivity analysis (1) countries ranking, Environmental Laws most important factor

Calculation	1	2	3	4	5	6
Factor, weight: 0.3765	P	P	P	P	P	P
Factor, weight: 0.2617	E	E	E.L.	E.L.	C	C
Factor, weight: 0.2079	E.L.	C	C	E	E.L.	E
Factor, weight: 0.1540	C	E.L.	E	C	E	E.L.

Table 36 Sensitivity analysis (1) scenario Political factor most important

Calculation 1

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,96	2,60	1,93	1,66	3,05	3,43
Ranking	1	4	5	6	3	2

Calculation 2

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,84	2,57	2,05	1,70	3,07	3,43
Ranking	1	4	5	6	3	2

Calculation 3

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,68	2,45	2,04	1,67	2,99	3,33
Ranking	1	4	5	6	3	2

Calculation 4

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,63	2,36	1,91	1,61	2,89	3,22
Ranking	1	4	5	6	3	2

Calculation 5

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,96	2,60	1,93	1,66	3,05	3,43
Ranking	1	4	5	6	3	2

Calculation 6

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,74	2,40	1,79	1,57	2,87	3,22
Ranking	1	4	5	6	3	2

Table 37 Sensitivity analysis (1) countries ranking, Political factor most important

Calculation	1	2	3	4	5	6
Factor, weight: 0.3765	E	E	E	E	E	E
Factor, weight: 0.2617	E.L	E.L	P	P	C	C
Factor, weight: 0.2079	P	C	E.L.	C	P	E.L
Factor, weight: 0.1540	C	P	C	E.L.	E.L.	P

Table 38 Sensitivity analysis (1) scenario Economic factor most important

Calculation 1

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,90	2,73	1,92	1,86	2,97	3,37
Ranking	1	4	5	6	3	2

Calculation 2

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	4,00	2,71	1,84	1,78	2,99	3,39
Ranking	1	4	5	6	3	2

Calculation 3

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,95	2,63	1,71	1,71	2,89	3,28
Ranking	1	4	6	5	3	2

Calculation 4

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,80	2,56	1,66	1,74	2,77	3,16
Ranking	1	4	6	5	3	2

Calculation 5

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,75	2,66	1,86	1,89	2,86	3,25
Ranking	1	4	6	5	3	2

Calculation 6

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,70	2,58	1,73	1,83	2,76	3,14
Ranking	1	4	6	5	3	2

Table 39 Sensitivity analysis (1) countries ranking, Economic factor most important

Appendix F

Calculation	1	2	3	4	5	6
Factor, weight: 0.6	E.L.	E.L.	E.L.	E.L.	E.L.	E.L.
Factor, weight: 0.2	E	E	P	P	C	C
Factor, weight: 0.15	C	P	C	E	P	E
Factor, weight: 0.05	P	C	E	P	E	P

Table 40 Sensitivity analysis (2) scenario Environmental Laws most important

Calculation 1

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,23	2,66	2,54	2,24	3,01	3,32
Ranking	2	4	5	6	3	1

Calculation 2

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,51	2,79	2,64	2,20	3,22	3,54
Ranking	2	4	5	6	3	1

Calculation 3

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,49	2,74	2,68	2,15	3,25	3,56
Ranking	2	4	5	6	3	1

Calculation 4

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,19	2,52	2,66	2,10	3,09	3,37
Ranking	2	5	4	6	3	1

Calculation 5

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,05	2,45	2,61	2,12	2,99	3,26
Ranking	2	5	4	6	3	1

Calculation 6

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,08	2,55	2,53	2,22	2,93	3,23
Ranking	2	4	5	6	3	1

Table 41 Sensitivity analysis (2) countries ranking, Environmental Laws factor most important

Calculation	1	2	3	4	5	6
Factor, weight: 0.6	P	P	P	P	P	P
Factor, weight: 0.2	E	E	E.L.	E.L.	C	C
Factor, weight: 0.15	E.L.	C	C	E	E.L.	E
Factor, weight: 0.05	C	E.L.	E	C	E	E.L.

Table 42 Sensitivity analysis (2) scenario Political factor most important

Calculation 1

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	4,33	2,66	2,00	1,46	3,32	3,70
Ranking	1	4	5	6	3	2

Calculation 2

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	4,24	2,50	1,76	1,34	3,13	3,51
Ranking	1	4	5	6	3	2

Calculation 3

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	4,22	2,62	2,11	1,50	3,34	3,70
Ranking	1	4	5	6	3	2

Calculation 4

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,92	2,40	2,09	1,44	3,19	3,51
Ranking	1	4	5	6	3	2

Calculation 5

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	3,87	2,32	1,97	1,39	3,09	3,42
Ranking	1	4	5	6	3	2

Calculation 6

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	4,08	2,39	1,75	1,32	3,06	3,42
Ranking	1	4	5	6	3	2

Table 43 Sensitivity analysis (2) countries ranking, Political factor most important

Calculation	1	2	3	4	5	6
Factor, weight: 0.6	E	E	E	E	E	E
Factor, weight: 0.2	E.L	E.L	P	P	C	C
Factor, weight: 0.15	P	C	E.L.	C	P	E.L
Factor, weight: 0. 05	C	P	C	E.L.	E.L.	P

Table 44 Sensitivity analysis (2) scenario Economic factor most important

Calculation 1

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	4,37	3,05	1,76	1,93	3,08	3,54
Ranking	1	4	6	5	3	2

Calculation 2

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	4,09	2,93	1,66	1,98	2,87	3,32
Ranking	1	3	6	5	4	2

Calculation 3

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	4,46	3,04	1,69	1,85	3,09	3,56
Ranking	1	4	6	5	3	2

Calculation 4

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	4,37	2,88	1,44	1,73	2,90	3,37
Ranking	1	4	6	5	3	2

Calculation 5

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	4,23	2,82	1,39	1,76	2,80	3,26
Ranking	1	3	6	5	4	2

Calculation 6

Country	Canada	China	Indonesia	Kazakhstan	Russia	U.A.E.
Weight	4,05	2,85	1,54	1,92	2,77	3,23
Ranking	1	3	6	5	4	2

Table 45 Sensitivity analysis (2) countries ranking, Economic factor most important