The Economic Impact of Environmental Regulations on a Maritime Fuel Production Company

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Abstract

The International Maritime Organization (IMO) and the European Parliament (EP) in 2005 and 2012 established Sulphur Emission Control Areas (SECA) in Northern Europe where from 2015 ships must use fuel with a sulphur content not exceeding 0.1% and 3.5% in non-SECAs. This has spurred active discussion that the regulation has created economic disadvantages for maritime stakeholders who must comply with strict regulations that competitors in other parts of the world are not subjected to.

Through a case study, this work investigates the impact of environmental regulations on the business model of the maritime supply company Viru Keemia Grupp (VKG), which is of national importance to the Estonian economy, especially in the eastern region. It explores the strategic entrepreneurial compliance options for VKG based on their return on investments and associated risk. The findings show that VKG is currently struggling to keep afloat under the weight of the consequences of changes in maritime consumer demand due to sulphur emission regulations and that the most viable compliance options are expensive and risky.

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1. Introduction

By carrying approximately 90% of the world's cargo, shipping plays an important role in international trade and the world economy (Unctad, 2015). Unfortunately, in the process of doing this, it releases harmful emissions such as carbon dioxide (CO_2), sulphur oxides (SOx), ozone depleting substances (ODS), volatile organic compounds (VOC) and nitrogen oxides (NOx) (Jiang, Kronbak, Pil, and Christensen, 2014). International legislation on clean shipping was strengthened because of this and emissions legislation in various nations were further harmonised to make it difficult for the shipping industry to operate without cognisance of the environment (NSF, 2008). There have been several regulations from the Marine Environment Protection Committee (MEPC) aimed at reducing emissions of toxic substances from burning fuel oil which are the main causes of air pollution from ships (IMO, 2015, annexe 1). These emissions are also harmful especially in terms of their social costs to the environment (Notteboom, 2010). One of the significant benefits of environmental improvements is the reduction of the acidification damage to ecosystems, which is expected to improve the standard of living, making it very easy to choose between the long-term cost of taking no action to reduce air pollutant emissions from ships and the short-term cost of implementing control measures (AirClim, 2011).

The sulphur emissions regulation - "Regulations for the Prevention of Air Pollution from Ships" was imposed during the sixth annexe of the MARPOL (International Convention for the Prevention of Pollution from Ships) Convention of the International Maritime Organization (IMO). It was first adopted in annexe VI of MARPOL, 35, in 2005 through the creation of Sulphur Emission Control Areas (SECA) limiting sulphur emissions in these areas at no more than 1.5% (15,000 parts per million (ppm)). SECAs represent about 0.3% of the world's water surface and include the North Sea, the English Channel (together with the coastal waters around the USA and Canada) and the Baltic Sea region (BSR) (IMO, 2008). This regulation also applies to other airborne emissions like NOx, ODS and VOC from 1 January 2015, that sulphur emissions from ships in SECAs cannot be more than 0.1% (1,000 ppm) (IMO, 2014).

On 1 January 2012, MARPOL annexe VI also enforced a new global SOx cap for marine bunker fuels from 4.5% (45,000 ppm) to 3.5% (35,000 ppm) for all ships that operate in non-SECAs (IMO, 2015). At the MEPC 70th session held in London in October 2016, the SOx for bunker fuel was lowered yet again to 0.5% (5,000 ppm) from 2020 (IMO, 2016). This means that irrespective of the outcome of the IMO review in 2018, a ship does not have to operate in a SECA before it must pay attention to the sulphur content of the fuel it uses. In order to increase life expectancy and protect the EU environment by reducing acid rain and particulate matter, which are dangerous to human health, the EU shipping regulations have also included waters and ports in the EU (Directive 1999/32/EC amended in Directive 2012/33/EU), which sets EU-sulphur limits the same as in SECAs. This also includes any vessel at quays in EU ports whether it falls in SECA or non-SECA.

Since the introduction of SECAs, significant changes have been seen with the vessels that operate in the Baltic Sea who now use fuel that is low in sulphur content (Bergqvist, Turesson, and Weddmark, 2015). Despite the seemingly good changes witnessed, there have been discussions on how the sulphur regulation seems to have somewhat created economic disadvantages for maritime stakeholders who must comply with strict regulation which competitors in other parts of the world are not subjected to (Notteboom, 2010). Another flank of the argument is the possibility that the regulations will weaken the competitiveness of

European maritime transport especially in the modal shift of cargo flows from marine transport to inland transport routes (Wiśnicki, 2014; OECD/ITF, 2016). It has already been speculated that the implementation will cost the maritime sector between €2.6 billion and €11 billion by 2020 (AirClim, 2011).

Normally, affected companies respond to regulations by changing their strategies to include the compliance activities as well. Some of their responses are embedded in activities such as research and development, expansion, equipment upgrades and processes triggering discussions on the impact of sulphur regulations on maritime stakeholders. There is still limited information available on the economic impacts of the regulation on some minority stakeholders such as fuel supply companies for knowledge-based and economic decision-making for shipping stakeholders. Maritime fuel producers in recent times have been plagued by downward price fluctuations alongside the usual sector challenges of speculations and economic forecasts, conflicts in different parts of the world, production estimates from the oil producing countries, stock levels, seasonality, weather and accidents (Nugraha, 2009). Fuel producers now have to deal with producing Marine gas oil (MGO) and Marine distillate oil (MDO) which are distillate oils and expensive to refine (Notteboom, 2010).

This study explores the economic impact associated with sulphur emissions regulations and by extension the SECA regulation on maritime enterprises. It uses the case of Viru Keemia Grupp AS (VKG), one of the largest Estonian companies and a producer of shale oil, which has a sulphur content that exceeds both SECA and global sulphur emissions limits. Up until 2015, VKG was able to produce shale oil as a bunker fuel without restraints. Due to the strict MARPOL regulations, the company is presently faced with the challenge of producing the stricter sulphur reduction to 0.5% from the 0.8% sulphur content fuel. In order to meet the demands of the new regulations and survive in a highly competitive market, going forward, VKG must make tough and strategic business decisions linked to high investments and serious financial risks in the maritime fuel market, since successful value propositions are said to be embedded in great business models (Osterwalder and Pigneur, 2009).

The objective of this study is to assess the economic impact of sulphur regulations on the business processes of a maritime stakeholder in the Baltic Sea Region (BSR). It uses VKG, a maritime fuel supplier as a case for studying the possible strategic entrepreneurial compliance options for VKG based on the return on investments and associated risks. By using elements of the business model and in light of the summary by Panagakos (2014) that the new regulation should encourage entrepreneurial innovation for business growth, this study probes VKG business activities as they relate to the sulphur directives by focusing on these research questions: What are the economic implications of the sulphur emission regulations for VKG's business activities? What are the strategic compliance options available for VKG? How attractive are these options for the sustainability of VKG?

This paper is organised as follows: Section II discusses the sulphur regulations and the activities of the maritime sector stakeholders in their bid to comply with the environmental stipulations. It also provides a theoretical analysis of the impact of accumulated regulations on the business activities of enterprises using endogenous growth and strategic management theories. Section III describes the methods used for this research. Section IV highlights VKG's business processes, its challenges, how it is coping with the sulphur and other environmental regulations as well as suggested strategic options for VKG's continued success together with the risks associated with each investment. Section V discusses the implications of the results and Section VI concludes.

2. Literature Review

2.1. Sulphur Regulations and Compliance Options for Maritime Sector Stakeholders

Environmentally-induced regulations usually spark many interests. One of the significant benefits of regulations for improving the environment, such as the sulphur regulations, is the reduction of the acidification damage to ecosystems, which is expected to reduce respiratory and cardiovascular diseases and increase life expectancy (AirClim, 2011). Some studies reported that international shipping produced about 80 times more SOx emissions than aviation in 2000 (OECD/ITF 2016). Sulphur dioxides (SO_2), one of the compound states of SOx, is described as a colourless toxic gas formed by burning sulphur in air through different processes like manufacturing, shipping, aviation or volcanic processes. As a reactive gas, SO_2 reacts with other compounds to form secondary particles that have bad consequences for the health of inhalers (Duke Energy, 2016). This makes it very easy to rationally choose between the short-term cost of control measures and the long-term cost of taking no action to reduce air pollutant emissions.

Usually, regulations accumulate over many years, piling up over time. The build-up of regulations over time often leads to constraints on different stakeholders and sometimes complicates and distorts the decision-making processes of stakeholders operating in such an economy. In its efforts to reduce the compliance costs, the European Commission has put forward a set of measures and has expressed its support for the promotion of innovations for new abatement technologies (IMO, 2013). Maritime stakeholders like ship operators and ports have also been forced to look for innovative ways to adhere to the stipulation of emission reductions from ships and at the same time stay afloat profit wise (Wiśnicki, 2014). On the other hand, ship equipment vendors are venturing into ways of increasing their capital base and gain new business opportunities (EfficienSea2, 2016). Principally, two paths exist for the shipping industry to comply: one is the switch to low sulphur fuels, including LNG and other alternative fuels, or to install exhaust gas cleaning devices – scrubbers in ships (Brynolf et al., 2014).

Seemingly, the easiest solution to the sulphur emission regulation will be the complete change of the use of fuel to low sulphur fuel. However, according to the OECD/ITF (2016), approximately 80% of total bunker fuel is heavy fuel oil (HFO) with sulphur content that is higher than allowed in SECAs. One option for complying with the sulphur regulation will be for ships to travel with more expensive and cleaner low sulphur fuel (marine diesel oil (MDO) – a distillate oil, or marine gas oil (MGO) – a higher grade distillate oil that can be treated to reach a maximum sulphur content of 0.1% for short sea shipping in SECAs. However, ships that sail on other waters other than SECAs have the option of using higher sulphur content fuels rather than the 0.1% sulphur fuels mandatory for SECA, whenever they are out of SECAs (IMO, 2015). The use of the low sulphur content fuel does not require any major investments in remodelling ships, except minor adjustment to tanks and engines. And large ships could choose a hybrid solution that would allow them to switch between high- and low-sulphur fuels whenever they are within a SECA (Bergqvist, et al., 2015). It is noteworthy to point out that distillate fuels do not just serve as just a good option for SECA regulation compliance. They have other beneficial qualities such as a high thermal value that reduce engine wear and the need for frequent engine maintenance and reduced fuel consumption due to the higher energy content resulting in less sludge onboard ships (OECD/ITF 2016).

Liquefied natural gas (LNG) is another type of low sulphur content fuel that has arguably been widely accepted as a promising energy source for shipping in order to solve the sulphur content dilemma. LNG is less costly when compared to distillate oil and heavy fuel oil; however, the costs of distributing LNG to ports and ships is very high and depends on the distance of the port from the LNG import terminals, which is the method of distribution for LNG volumes (Brynolf et al., 2014). Ships also need to be converted to be able to use the LNG fuel. The conversion costs, for example, for a 19,000-tonne Great Lakes bulk carrier is estimated to be USD 24 million (Carr and Corbett, 2015). This high initial cost makes LNG retrofitting less cost-competitive when compared to other options. Apart from the initial costs, there are other added costs like the opportunity costs and a large space required for the LNG fuel tanks. Although it is claimed to completely remove shipping emissions like sulphur, particulate matter, NOx by approximately 90% and CO_2 by 20–25%. It has the negative side effect of methane slip – the emission of non-combusted methane. There are no conclusive studies on the effect of this element yet, but there is a good reason for a careful consideration of its use, the rationale for this is that it might lead to the introduction of a new problem while trying to solve another (Sköld, 2012).

The second abatement option is the use of the scrubber. This is a flue gas desulfurization (FGD) technology, which removes or "scrubs" SO_2 emissions from the exhaust gas. Traditionally, the principle behind the scrubber is the reaction of slake lime – $Ca(OH)_2$ (a white caustic alkaline substance consisting of calcium oxide). When SO_2 combines with limestone and water with the production of heat the primary by-product is calcium sulphate ($CaSO_4$, $CaSO_3$) commonly known as synthetic gypsum – a recyclable product used in the manufacturing of wallboard and cement, and as a soil improver in agricultural and construction applications (Duke Energy, 2016; EfficienSea2, 2016).

The chemical reactions behind the use of scrubbers:

$$Ca(OH)_2 + SO_2 + 1/2O_2 = CaSO_4 + 2H_2O \quad (1)$$
$$Ca(OH)_2 + SO_2 \rightarrow CaSO_3 + H_2O \quad (2)$$

A ship scrubber is a cleaning system that removes sulphur from the exhaust of ships that use heavy fuel oil (HFO). Through some technical consideration and upgrades, there are currently two major types of scrubbers: The dry and the wet scrubbers (Brynolf et al., 2014).

The Dry scrubbers reduce sulphur through chemical reactions that bound SOx to calcium hydroxide in granules to form calcium sulphate in a solid state as stated above. In the past, the dry scrubbers used to be popular for their use in power plants, but recently although not so common some of these scrubbers have been installed on ships (EfficienSea2, 2016).

The Wet scrubbers absorb sulphur oxides in water and are more popular and mostly installed on ships. There are three types of wet scrubbers and are differentiated by the type of water they used to absorb the sulphur oxide from the exhaust. They are open loop scrubbers, closed loop scrubbers and hybrid scrubbers.

Open loop scrubber systems, also called Seawater scrubbing uses the natural alkaline characteristic of sea water to neutralise the acidic exhaust gases. It absorbs the SOx molecules through the seawater, and then discharges the water back into the sea after extraction, storing the sludge which is discharged at port waste facilities. **Closed loop scrubber system**s, also called freshwater scrubbing, uses caustic soda (NaOH) to create a chemical reaction that absorbs the sulphur emission from the exhaust gas. It makes scrubbing possible in shallow and fresh waters that lack sufficient alkaline seawater to buffer the SOx in the exhaust gas. In this system, sodium hydroxide, an alkaline substance, is used to wash out the SOx from the exhaust gas by reacting on its own with a sulphuric product (Bergqvist, et al., 2015). Because of its closed nature, the wash water is continuously recycled making it necessary to have additional equipment like a process tank, sodium hydroxide storage, cooling and other storage tanks on board. The rate of Sodium hydroxide solution use is approximately at a combustion enthalpy of 6L/MWh/(ha.a) and stored according to the quantity needed for the entire voyage (EfficienSea2, 2016). The closed loop system prevents the sediment building up in filters, while the sludge is treated as with the open loop system. **The Hybrid scrubber system** combines the technologies of both the open and closed loop systems and is more flexible to use because it is able to switch depending on the alkalinity of the water. However, its installation is more complex and costly (OECD/ITF, 2016).

The initial investment costs of scrubbers range from €4 to €8 million per ship. The cost depends on certain features such as ship type, scrubber type and new build versus retrofit. In addition, apart from the initial investment, operating the scrubbers increases the rate at which the engine consumes fuel and is estimated to increase between 1–3% (EMSA, 2010). The scrubber needs space for installation and extra space for the equipment for the wash water, piping systems and monitoring on the ship, making it possible to use the scrubbers only in large vessels (Bergqvist, et al., 2015).

2.2. Endogenous Growth Theory and the Ripple Effect of Accumulated Regulations

Endogenous growth theory builds on the premise that the economic growth of a country is primarily dependent on decisions made by actors in the economy—firms and individuals—rather than on external factors (Barro, 1991). Because productivity growth plays an important role in any economy, any distortions that adversely affect entrepreneurial activities have great significances for the growth of any economy (Solow, 1994). The innovation that stems from these activities is the key driving factor for economic grow and social wealth. Innovative products and services emerge more often as a result of a cross-sectorial combination of technologies, design and business models (Olaniyi and Prause, 2016). In other words, the general well-being of the economy of any nation is directly proportional to the growth of the markets therein (Barro, 1991). There have been a lot of debates on the impact of government policies and regulations on national growth. Barro (1991) explained that regulations generally introduce distortions, such as high tax rates, spending, or heavy investments, which do not provide compensating incentives but give room for price and markets alterations that are investment deflators and negatively related to market growth.

Furthermore, there are debates that regulations have cumulative effects. Supporting this theory, Jaffe, Peterson and Stavins (1995) have said that regulatory decisions are too time-consuming and are often characterised by litigation and other legal power struggles that last for decades with more policies being added to the existing ones leading to what they called "transition costs". Regulatory interventions impact investment choices, which ultimately have a great effect on the economy because the build-up of regulations over time often leads to duplicative, conflicting, and even contradictory rules, and the multiplicity of regulatory constraints complicates and distorts the decision-making processes of companies or stakeholders operating in such an economy (Martin and Sunley, 1998). Affected companies usually respond to individual and accumulated regulations by changing their innovation strategies, which are embedded in activities such as research and development, expansion, equipment upgrade and processes (Bourlès, 2013). Rebelo (1991) claimed regulations can be considered the major cause of a decrease in productivity. He used the ratio of outputs (goods and services) divided by the inputs (resources such as labour and capital) as the definition of productivity of affected companies to support this argument. He explained that invariably the productivity of the affected companies would fall because the measured inputs of capital, labour, and energy will be deviated to the production of an additional output (i.e. regulation compliance) or result in inconclusive investment decisions that were not originally included in conventional measures of output/productivity.

New Institutional Economics (NIE) theory, which emphasises that the economic development of a country is governed by its institutions (Coase, 1998), can be used to support this view. Its overview depicts a strong interdependence between institutions and the collective character of a nation. NIE uses an economics perspective to focus on "social and legal norms" and "institutions" and how these elements affect the economic activities of a system (country) (Eggertsson, 2013). However, in NIE, "institution" does not mean organisations like government agencies, industrial associations, corporations, hospitals, and so on, but is defined as the "active rules" (e.g. laws, customs, regulations) of a social game where the players are particular actors and their respective governing bodies (Coase, 1998).

A key feature of this theory is that institutions involve transaction costs (enforcement of contract) that are often undermined during the process of institution creation (Eggertsson, 2013). The purpose of every institution is to provide an established set of expectations for both the actors and their governing bodies, but more often than not, these institutions and their enforcement instruments create limitations that reduce or prevent their total success (Nabli & Nugent, 1989). Transaction costs in NIE can be referred to as regulation compliance costs and the summary of this perspective is that transaction costs are expensive. Transaction costs often interfere with the effective administration of any institution. In his work "The Problem of Social Cost", Coase (1960) argued that low transaction costs would have a lower impact on the productivity level of any given institution (regulations). The use of the approach taken by NIE to endogenous growth theory can be applied to the gap between regulations (institutions) and compliance (transaction costs), which always reduces productivity. Regulations impose large direct and indirect costs on the stakeholders or even more on society. This makes it imperative to balance the cost-benefit of any regulation by identifying and implementing flexible and cost-effective regulatory instruments, whether conventional or the newer kind of market-based interventions because if businesses are constantly subjected to avoidable expenses and investments it could lead to societal waste (Blind, 2012). Jaffe et al. (1995) pointed out that innovation will always divert resources to R&D, and that environmental regulations could especially significantly affect productivity when the costs associated with reduced investments is considered.

In a different light, Solow (1994) argued that irrespective of the distortion any regulation might bring, every economy depends on investments in knowledge creation like research and development and how or the manner in which they lead to the innovation that creates productivity. Economic competitiveness also depends on strong links between research, innovation and actors in an industry (Olaniyi and Reidolf, 2015). This means that theoretically, companies that are imposed upon by regulations are forced to invest in more resources in the production process and although the "production" of new technology may require high financial input sometimes this may yield high returns. Another inference from this is that the impact of government intervention on economic growth is not simply the sum of the direct and indirect costs associated with each regulation. The OECD (2005) explained that even though enterprises are constantly subjected to a series of requirements and obligations through regulations, regulations should not be seen in a negative light, as these obligations are necessary legal impositions in order to regulate the manner in which businesses are being conducted that consider the plight of society. Regulations may sometimes not bring financial gains and sometimes not for everybody, but they create a stability which invariably is connected to wider macroeconomic benefits such as GDP increases, competitiveness and productivity effects and other intangible benefits, such as the protection of fundamental rights, social cohesion, international and national stability, and the economy status of any nation (Renda, 2013). It is important, therefore, that while the benefits of regulations are being analysed, the economic impact, compliance costs, as well as the administrative burden of such additional rules, are also measured (Repetto, 1990). Earlier in 2016, before the new sulphur global cap was confirmed OECD/ITF studies had shown that if the 0.5% global sulphur cap was considered, the cost impact of the regulations will be substantial with increases up to 7.5% in agricultural goods, 3.5% in manufactured goods and 16.4% for industrial raw materials. Since maritime transport costs make up a substantial share of the value of traded goods, this may likely translate into increases in the costs of traded goods.

2.3. The Craft of Strategic Management in Sulphur Emission Regulations Compliance

From the summations of endogenous growth and NIE theories, it will not be gainsaying to imply that compliance with government regulations often leads to the dilemma of investment choices. A lot of the costs embedded in regulations are direct such as capital investments and operational costs. There are also indirect costs such as the costs associated with new and changed personnel, materials purchased, legal costs, paperwork and the like. A single investment choice made per year has the ability to affect the proceedings of future years. Any wrong investment decision can cause an adverse setback, so also can indecision. The strategic decision that is made and the actions that follow by related enterprises are therefore crucial.

According to Porter (1996), because of the ever-evolving markets and demands, the aim of strategic management is to create the future by visualising a company's horizon, planning for the long term, analysing market changes and creating sustainable competitive advantages. Another study, Guohui and Eppler (2008), explained that strategic management creates innovative strategies that are capable of building a market position that is sustainable despite the uncertainties of the fast changing environment, potent competition, and internal challenges. Furthermore, based on the premises of Doz and Kosenen (2010), enterprises need to have the strategic ability to transform their business models if they want to pursue strategic innovation through the process of formulating, implementing and evaluating managerial actions, making strategic management a craft rather than a science (Noble, 1999). This means focusing on continuous adaptation and improvement that is constantly evolving in ways that put the actors in an active situation rather than in a reactive state (Eisenhardt & Brown, 1998). Chesbrough (2010), elucidated that companies with discovery driven attitudes could model their market uncertainties to their advantage. This involves a number of critical steps including scanning the environment for information, selecting relevant data and interpreting it, building a strategic model, testing it and putting it into action (Cray and Mallory, 1998).

The "scanning of the environment for information, selecting relevant data and interpreting them" are some of the bases on which the SWOT analysis is built. For this work, the SWOT analysis will serve as part of the creative strategies for programme-building, evaluation, financial appraisal, and ultimately for implementing or action planning at VKG. The SWOT outcome will enable the company to leverage this strategy with its inherent strengths through opportunities in the environment, and at the same time, exposing its weaknesses. This will be in line with Piercy and Giles (1998) summation that SWOT uses a knowledge of the company's threats to calculate its risk so that actions are taken to mitigate, exploit, avoid any adverse effects and remove the helplessness that comes with the burden of constant changes in the market environment.

The strategic management process also ensures that plans evolve into actions and are executed in a manner that accomplishes the stated objectives and that the resulting committed resources achieve the intended returns (Guohui and Eppler, 2008). One critical challenge for companies implementing regulations and policies, such as the sulphur emission regulations, is the gap between the transformation of investment decisions that stem from regulation compliance, and the investment returns that should ensue in its wake. In principle, compliance to regulations could lead to wide and abiding transformations, but it also has the potential to bring deep risk constraints in their implementation. This is important to note because sometimes the best-formulated strategies may fail to yield the intended result if they are not successfully implemented. It is not surprising that, after a strategic option is put forward, there are usually significant difficulties in the implementation process (Chesbrough, 2010). One of the difficulties in implementing the sulphur emission regulation is in investment choice for compliance.

Taking on an investment does not necessarily translate into the best of returns. It is also difficult to separate the quest for best returns and the associated risk exposure. Investments are usually long-term, so must be carefully chosen, diversified into a broad variety of asset classes (portfolios) and further adjusted to match the company's strategic aims and objectives. As time goes by, these goals will change dynamically to match the volatility of the environment. Consequently, the risks are further adjusted by reviewing the company's tolerance for any volatility that has occurred. Therefore, portfolios can be described as a range of investments held by any company to fulfil its strategic goals (Shipway, 2009).

The portfolio selection method used in this work is based on the theory that investors should focus on selecting optimal portfolios as opposed to optimal assets so as to minimise the risk of a given level of expected return. In order to understand the properties of multiple portfolios, there is a need to know the average figures of highly correlated outcomes from these portfolios. The results of portfolio analysis are logical consequences of its information concerning the intending investments (Markowitz, 1991). The principle of portfolio selection entails three factors; the expected return, the risk associated with the elements of the portfolio and the correlation between each element of the portfolio (Shipway, 2009).

3. Methodology

3.1. Study design

This study explores the activities of a maritime fuel company in Estonia, in the Baltic region of Europe (VKG) with the aim of studying how its business activities were affected as a result of the sulphur emission regulation and by extension the SECA regulations. VKG was used as a single study unit since a case study is a type of research, which investigates an individual, community or group to answer a specific question by seeking evidence that lies in the case setting (Gillham, 2000).

Between September and November 2016, data were collected from the company's records and the yearly financial statement of the company. Face to face structured interviews was conducted in October 2016 with the company's director of sales and the product development manager. Each interview lasted 2 hours and 3 hours respectively. The first part of the interviews focused on the VKG business model using the Osterwalder and Pigneur (2009) business canvas. This was done to gain insight into VKG's key business activities, key partners, key resources, value proposition, customers and customer relationships, distribution channels, cost structure, revenue streams and innovation activities. This information was also used to build the VKG profile. The second part of the interview was based on VKG's sulphur emissions regulations related activities if any, and the actions VKG is taking or planning to take in the future as a result of the change in market demand.

3.2. Data verification and analysis

A day of detached observations of the company's activities was conducted together with a tour of the production site for some first-hand experience. During this, the authors had several interactions with VKG employees from the administration and production department. In order to triangulate the data and to gather a richer contextual description needed for exploring the case according to Miles and Huberman (2014), additional information and clarifications were further accessed through email interactions with the company's certified respondent. Care was taken to look out for discrepant data especially between the records, interviews, interactions and the observation processes.

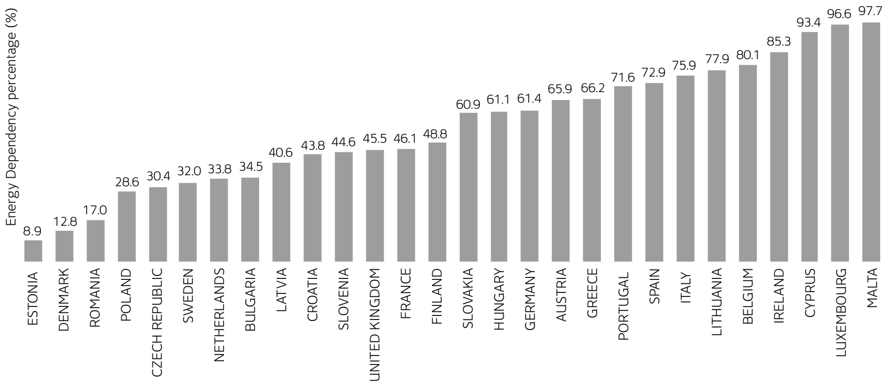
To provide an account of the company in order to generate a VKG profile, a descriptive analysis of the interview data was used. Each statement was put in a grid to classify the responses to each question. An accumulated reflective overview of the summaries and reviews of the data were made to discover how the multiple sources of evidence are related. This was followed by the interpretation and narration of the data according to Yin (1989).

Knowing that the knowledge and understanding of how the environment impacts any business decision is key to the growth of any company (Fleisher and Bensoussan, 2003), VKG's SWOT analysis was carried out through a brainstorming session as a diagnostic technique. The interview data together with the information from the SWOT brainstorming session was used to evaluate VKG's strategic position and to analyse each category (strengths, weaknesses, opportunities and threats), their properties and how they relate to each other vis-à-vis a highly volatile and competitive fuel market to map out different suitable strategic investment options for VKG. Finally, a portfolio selection analysis of all the investment options was made to determine the investment decision factors and their relative significance.

4. Viru Keemia Grupp AS

Viru Keemia Grupp AS (VKG) is the largest oil shale producing company in Estonia. It is situated in Ida-Viru County, an area in Estonia with a population of 148,000. Estonia is a small country at the eastern border of the European Union (EU) close to the Baltic Sea with a population of 1.3 million. It used to be part of the Soviet Union up until 1991. Estonia is the least energy importation dependent country in Europe due to shale oil produced electricity (Eurostat 2016, Figure 1). Estonia predominantly uses 78.3% of solid fuels to produce energy – mainly oil shale.

Figure 1. Energy dependencies in the EU



Source: Eurostat (2016)

Oil shale covers about 65% of the country's needs for primary energy, which has guaranteed the energy independence of Estonia. While the EU imports 53.4% of its total consumed energy, Estonia only needs 11.9% of imports for its energy requirements (Eurostat, 2016). The oil shale industry contributes about 4–5% to Estonian GDP and about EUR 300M to the state budget (including employment taxes, environmental taxes). As a producer of shale oil, VKG can be said to be one of the companies that have a significant impact on the Estonia economy. In 2015, VKG's contribution to the state budget of Estonia was up to €35 million and the company's total turnover was €167 million. From the turnover, €87 million was contributed from shale oil alone (Table 1). VKG started solely as a shale oil producer, but over the years has expanded and diversified its value chain to about 10 enterprises: oil, heat and power generation, heat distribution, electricity distribution, power system construction, oil shale mining, cinder block production, metal structures, pipelines and pressure equipment production, logistics, and assembly and repair companies. As of 2015, VKG employs over 2,100 employees.

Table 1. Business Analysis from 2006–2015

Year	Turnover million (€)	Shale oil Contribution Million (€)	Investment Million (€)	Percentage of investment to turnover (%)	Profit Million (€)	Number Of Employees
2015	166.8	87	59	19.5	-31.9	2101
2014	195.2	128	98	50.2	19.8	2206
2013	220.4	146	90.9	41.2	26.2	2013
2012	215.8	148	65.9	30.5	26.2	2000
2011	183.6	124	51	27.7	37.4	1610
2010	125.5	83	34.4	27.4	19.2	1406
2009	107.5	59	39.9	37.1	9.2	1312
2008	131.5	78	77.3	58.7	14.7	1381
2007	114.2	62	49.5	43.3	18.8	1369
2006	97.1	55	29.0	29.8	19.1	1374

Source: VKG 2015 Financial statement

Oil shale is a sedimentary rock which in its mineral state contains a solid, combustible organic matter commonly called "kerogen" (Siirde et al., 2013). As a solid material, it undergoes thermal treatment to produce shale oil and other products (coke and phenols). VKG uses two types of technology to produce shale oil: The Kiviter technology (a gaseous heat carrier) and the Petroter technology (a solid heat carrier method). The by-product – a waste gas formed in shale oil production is used as a fuel for heat and power cogeneration in Estonia. The produced shale oil is useful as a quality-improving supplement for HFO or diesel supplements in industrial boilers and furnaces.

The majority of VKG shale oil customers are some of the largest oil traders in the world. VKG Transport, a VKG subsidiary is responsible for its logistics and uses freight on board (FOB) – Sillamäe delivery for most of its distribution activities. The distribution process starts from the production site through rail, which transports the shale oil directly to the Sillamäe port where tankers can pick it up for delivery to Rotterdam. Currently, there are marginal sales of VKG products to refineries, however, the majority of the liquid product mass is not sold to refineries but blended directly into product bunker fuel instead.

5. Results

5.1. The Impact of Sulphur Regulation on Business Activities

The sulphur content of shale oil is around 0.8% w/w; this is higher than the 2020 global sulphur limit and even higher than the SECA limit. Although VKG sells its fuel directly to oil traders and not to the end-users, considering the sulphur content of 0.8% w/w as average in shale oil products, might mean it is unlikely that the product is being used in a SECA bunker fuel blend. Apart from its high sulphur content according to the IMO SECA sulphur regulation standard, shale oil has a viscosity-density relationship preferable for specific purposes: especially for improving HFO flow properties and pour point. This is one of the key selling points of shale oil. The density and viscosity are both within the range of the ISO 8217 residual marine fuel specification. Depending on the fraction, the largest portion of blended oil products has a density between 0.99 -1.02 kg/L and a kinematic viscosity between 20 -105 cSt. In the context of ISO 8217:2012 residual marine fuel characteristics, the majority of shale oil products marketed fall into the marine oil density RMK and the viscosity RMD low range. This fact, however, does not separate VKG from the realities of the evolution in bunkering fuel and the regulations that surround it.

Table 2 shows the results of the VKG SWOT analysis. It shows a sustainable company with an advantage of a long value chain from oil shale processing. VKG has access to oil shale resources with its subsidiary operated mining. However, the resource mining limits the allocation system in Estonia coupled with the 60% fine grain and 40% coarse grain oil shale proportions achievable in mining, and VKG's historical oil shale processing capacities have resulted in imbalanced oil shale production capacities.

In 2015, 14.9 million tonnes of oil shale resource was mined in Estonia (Ministry of the Environment, 2016), which was about 25% less than the allowable and acceptable yearly limit set in the oil shale development plan 2016–2030 (Ministry of the Environment, 2015), and VKG has insufficient oil shale mining resource allocation for all processing capacities. VKG is differentiated from other shale oil producers in Estonia through the valorisation of phenolic water formed in the pyrolysis process – a thermochemical decomposition of organic material at high temperatures in the absence of oxygen. VKG has an agile and flexible supply chain considering the fact that most of its logistics operation is carried out by its own subsidiary company.

The SWOT also revealed that VKG has a thriving environment department. As an oil production firm, the company is subjected to diverse environmental laws and regulations, and therefore uses a centralised environmental department (ED) to provide services to all subsidiaries in the VKG group. This department is responsible for the preparation of applications for environmental permits, environmental reporting including reporting of resource consumption and pollution for the determination of environmental taxes, and managing environmental impact assessment procedures if designated. VKG ED is also responsible for European Union (EU) Emission Trading System (ETS) reporting, registration and applications for VKG group subsidiaries. It monitors the best available technology (BREF) documents, EU environmental legislation, and Estonian and other government draft legislation information systems. Because of its industrious promotion of environmental awareness activities, VKG has been consistently awarded the title "Responsible Estonian Business" from 2010 to 2015. Intensive VKG investments in environmental causes had enabled a significant reduction in ecological footprint. About €100 million out of the €900 million in investments VKG made over the years were spent on environmental related activities. One of such is the construction of Kohtla-Järve conveyor, an environmental project that cost about €14 million. From the company's report, emissions of volatile organic compounds have decreased by 53%, sulphur oxide by 69%, and monobasic phenols by 98%. In addition, the Petroter plants' energy efficiency is reported to be as high as 81% due to the improved environmental protection measures and the ecological footprint is said to be several times lower than the formerly used technologies in the company.

From the interviews, it was discovered that the VKG response to the SECA regulation was to lead with a refinery project (a project that was in the pipeline) along with process innovation and the elongation of its product portfolio, especially by-products. Before the SECA regulations, VKG had started a feasibility study on building its own refinery and bunker fuel market change research, a project that cost VKG about €5.5 million. Business wise, running a refinery would have meant a product innovation that will yield Euro V Diesel (the majority of the production) and 0.1% sulphur marine fuel oil and stabilised naphtha outputs. However, the the outcome of the research could not dispel the uncertainties that surrounded the 2015 sulphur regulations and the uncertainties that surround the market reaction to the sulphur regulations.

Table 2. SWOT analysis

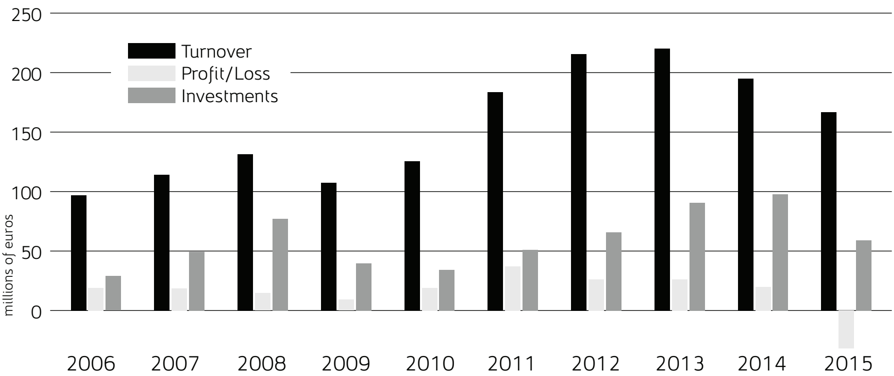
Strengths	Weaknesses
• Access to resource-group operated mining. • Processing technology innovation. • Favourable oil product viscosity properties. • Large-scale project management. • Agile and flexible management. • Long oil shale processing value chain. • Sustainability management. • Effective and sustainable environmental department. • Sell directly to the traders, so do not have to deal with regular end users. • Has control of its logistics by using own transport company.	• Uncompetitive and high fixed costs when compared to pumping costs of crude oil. • Products not common in refineries. • The uniqueness of oil shale - need for adaptation of technologies. • 70% production output (510,000 instead of 750,000 tonnes/year) limitation because of oil shale resource allocation. • Oil shale resource allocation smaller than processing capacity due to the absence of open markets for oil shale. • Ageing workforce due to decreased labour age population in Ida-Viru area of Estonia. • Sell directly to the traders, so do not have the normal interface with end users.
Opportunities	**Threats**
• Redeeming the poor public image caused by historical contamination of production sites. • Readiness for Industry 4.0. • High fixed costs, uncompetitive compared to pumping costs of crude oil. • Product uncommon for refineries giving room to build own-refinery. • The uniqueness of oil shale – need to adapt technologies. • Oil shale resource allocation smaller than processing capacity, no open market for oil shale.	• Poor public image due to historical contamination of production sites by oil companies. • High fixed costs, uncompetitive compared to pumping costs of crude oil. • Product uncommon for refineries. • The uniqueness of oil shale – need to adapt technologies. • Oil shale resource allocation smaller than processing capacity, no open market for oil shale. • Environmental legislation and regulations and taxes. • Resources policies. • Unstable prices – decrease in fuel price. • Dollar/EUR exchange rates. • High market demand for low sulphur content fuel.

Source: Compiled by the authors

Furthermore, the feasibility studies showed that the Front-End Engineering Design (FEED) stage – the cost of the refinery for the raw material processing capacity of 133% VKG shale oil production at 14,000 barrels per day and 750,000 tonnes per year will cost a staggering sum of 400 million EUR coupled with the 5% depreciation of 20 million EUR annually. This confirms how expensive a project of that magnitude would be, forcing the management of the company to put the refinery project on hold. The risk is further magnified because VKG has had to constantly struggle with uncompetitive high fixed costs of its fuel production when compared with that of crude oil and because of the downward trend in fuel prices. Because oil shale is not a common product found in regular refineries, its refining process and activities are quite limited. These attributes also make it difficult to use standard technology in the refining process. Even though VKG has access to a resource based mining group, the oil shale resource allocation is smaller than its processing capacity forcing VKG to only use 70% of its shale oil production capacity (520,000 tonnes/year).

A look at the 10-year breakdown trend of VKG financial activities in Figure 3 and Table 1 shows the sizeable contribution of shale oil to annual turnover, although 2015 shows a decrease in the contribution of shale oil. The fact that for the first time in 10 years VKG recorded a loss in 2015 is also noteworthy. One sellable explanation for this occurrence is that oil prices have fallen drastically, a bitter pill any oil producing company have had to swallow. Further examination also shows that VKG investment was low in 2015 as a percentage of annual turnover (19.5%) when compared to previous years.

Figure 2. Financial Statement for 2002–2015



Source: VKG AS 2015 Financial statements

5.2. Strategic Options for Sulphur Regulations Compliance

The evaluation of the market environment (SWOT), as well as the company's present financial appraisal, were used to create strategic sulphur emissions regulations compliance actions. The SWOT also revealed some weaknesses and threats. The harsh reality is that VKG will continue to be threatened by legislations, regulations and environmental laws that will keep the company on its toes. It will also continue to face the challenge of available open markets for its products and the uncertainties that surround fuel markets. The use of alternative fuel sources (LNG, renewable fuels (II generation biofuels) and methanol) are also gaining more ground as bunker fuels. One of the targets of this work is to use this knowledge to mitigate, exploit and avoid any adverse effects of these threats and weaknesses.

VKG is faced with two major challenges: first, the fuel price collapse and its highly volatile market, and second, sulphur emission regulations compliance investments. From the analysis carried out, there are realistically 5 investment strategies VKG could choose from. These are upward vertical integration, products upgrade, hydrodesulphurisation, product discount and process innovation.

1) **Upward vertical integration:** Blending VKG shale oil with 0.1% MGO or another low-sulphur content fuel, which will basically be an upward vertical integration in its supply

chain process. In this case, VKG will sell directly to its suppliers and will be in charge of how these products are supplied. Apart from serving the end result of being able to sell its 0.8% sulphur fuel, VKG may be able to increase its share in the market by minimising the bottlenecks created by middlemen and reduce its transaction costs, leading to an increase in profits. However, it might lead to decreased supplychain flexibility and end up hindering productivity (Mahoney, 1992). Due to the scarcity of open markets for oil shale, VKG currently sells directly to traders. This has helped the company greatly in its supply chain agility and flexibility. Having to deal with an increase in its distribution chain will increase complexity in its straightforward supplychain system.

2) **Products Upgrade:** Building a new refinery which could result in a change in the marketable products portfolio for VKG such as V Diesel, 0.1% sulphur marine fuel oil and stabilised naphtha. Refining shale oil will also yield commercially valuable products that can be used as a substitution for petroleum derivatives with only minor modifications and adjustments of the operating conditions (Akash, 2003). The refinery would seem like a good investment decision for VKG due to the increased process capacity. An improvement to the present capacity by a mile and according to the preliminary report would produce an output of stabilised gasoline fraction of 61,000 tonnes/year, Euro V diesel of 349,000 tonnes/year as well as SECA fuel oil of 303,000 tonnes/year. In addition, 7,300–7,500 tonne/year elementary sulphur would also be produced. However, the costs involved would be higher than the stated capital expenditure (CAPEX) of 400 million euros. For instance, there will be additional investments in operational costs (OPEX) that involves employing more staff, maintenance, insurance and administration. The cost of operations without depreciation is estimated to be between €30–50 million/year, which will also depend on the price of natural gas and on the amount of raw material (oil shale) processed. It will also take about 5 years before any refinery can adapt to full operation even after such a heavy investment (OECD/ITF, 2016). Building a refinery wedges VKG between volatile market segments (cost and price), and exposure to significant risks, one of which is the susceptibility to closure if unsustainable (CFA, 2013).

3) **Hydrodesulphurisation:** The removal of sulphur (partial hydrogenation) from product oil (desulphurisation) involves a chemical reaction between molecular hydrogen (H2) and another compound or element in this case sulphur, with the help of a catalyst (Kabe, Ishihara, & Qian, 2000). Heavier distillates are usually broken down through this process. While this process will solve the sulphur content challenge of shale oil, hydrodesulphurization could cost VKG between 100 – 150 million euros in capital investments. This option is in direct competition with VKG keeping the status quo of selling its products to the bunker fuel traders. Before taking this step VKG must be able to answer some pertinent questions. What difference will it make if they proceed with an investment of this scale? What if the price spread between HFO and MGO is negligible in the future? What is the return on this type of investment? Part of the speculation over the price of MGO before the SECA limit related to how an increase in demand could affect its price (Notteboom et al., 2010). Other studies, WoodMacKenzie (2016), postulated that a global sulphur cap of 0.5% could result in an increase in the overall price of fuel by 2020. Experts are finding it difficult to speculate fuel prices. Hämäläinen et al. (2016) in their studies discussed several failed attempts by market experts to forecast fuel prices. The uncertainties that surround fuel prices have made it risky for VKG management to make any calculated investment decision.

4) **Product Discount:** VKG can continue marketing its existing 0.8% w/w sulphur content product but at a discount to traders if the future price spread between 0.5% sulphur fuel oil and 0.1% sulphur fuel oil is insignificant. In the first place. Because shale oil is already being sold to traders, there is a negligible likelihood that this oil could still be used in a SECA bunker fuel blend. Therefore, with proper incentives and trade terms, VKG will likely keep their current or most of their current customers. Presently, the greatest threat to this will be increased demand and supply of low sulphur fuel on the market. Some of the things that were considered while appraising the cost impacts in 2020 were the low capacity of refineries for low-sulphur fuel and the resulting price spread between HFO and MGO.
5) **Process innovation:** Process innovation to implement a significantly improved production method (Utterback, 1994) will increase and improve VKG's efficiency (energy efficiency, a mass yield of products and labour productivity) as a key factor for sustainability post-2020 under a global sulphur cap. VKG can also make use of Industry 4.0 automation and data exchange in manufacturing technologies to improve its business and process efficiency, pay better attention to the potential of its other products and convert their opportunities to maximum profits. Because of the fluctuations that are seen in the fuel market, VKG can leverage its fixed fuel price. The need for efficiency improvement will not only be useful for MARPOL regulations, but it will come in handy when other trends and influences like climate policy, stricter environmental legislation, demographics and workforce deficiency trends are combined. Further efforts in waste reduction – such as the greater valorisation of the waste gas and the conversion of solid by-products such as limestone from oil shale mining and ash from shale oil plants, decreasing process losses – can be intensified. Productivity can also be improved by addressing the ageing workforce due to the decrease in labour age population in the Ida-Viru area of Estonia where the VKG production site is situated. Ida-Viru as a county is susceptible to the migration of upwardly mobile and young working population to more attractive pull centres or cities. A situation Prause (2014) said will be a significant disadvantage for the operations of knowledge-intensive companies in rural areas.

5.3. Investments (Portfolio) Selection

The HFO/MGO price spread was used as the major impact factor for selecting the right investment for VKG because based on the 0.5% sulphur emission global cap, there is an expectation that in 2020 there will be a sharp reduction in HFO demand, consequently, an increased demand for MGO or ULSFO. According to the analysis by WoodMacKenzie (2016), by 2020 there would likely be a sharp increase in oil distillates (MGO, MDO, ULSFO-Ultra light sulphur fuel oil) forcing a reduction in the installation of scrubbers on ships. The use of HFO will decrease as a result of this. At such, scrubber installations will only become a viable option for 75% of the existing ships that are less than 10 years old with an engine capacity greater than 17 MW. Furthermore, because the installation capacity of available ships will be limited, coupled with the likelihood that refineries are not going to be very eager to make huge investments in refining HFO, it is predicted that HFO will gradually return to the market. These uncertainties will contribute greatly to the volatility of the fuel price market and further increase VKG investments risks.

As a multi-criteria decision analysis tool, a matrix of the different strategic options for VKG was created using different scenarios related to price spread (table 3). Each scenario of HFO/MGO price spread was defined as, very high, high, constant, low and very low. A constant was used to depict what is presently obtainable. The scale for the outcome of each scenario was set up between -2, -1, 0, +1 and +2. Each scenario was further assessed with two VKG respondents to weigh their relative significance related to VKG as seen in Table 2. The major focus was the impact scale for each option if the price spread was to change.

Where:

0 is comparable to now

+ is company has a better position (+1, +2)

– is company will be worse off (-1, -2)

To determine the probabilities of the HFO/MGO price spread, the spread distribution of July 2015 to the current spread in 2016 was used. First, the range of the price spread was calculated as the difference between the lowest spread ($120) and the highest spread ($220) within this period, which is $100. Second, the intervals between the fuel prices (≥$120 and ≤$220) were calculated using the spread fluctuations within this range. These are $185, $155, $145 and $135. Next, to find the probability (p_s) for each scenario, the differences between the spread intervals (e.g. 220-185 = 35) were each divided by the range ([(220-185) ÷100 = 0.35]).

The total weighted score for each outcome was then calculated by multiplying the probability (p_s) for each scenario by their respective scales as shown in Appendix 1.

Table 3. Decision matrix analysis for investments options

	HFO/MGO Price spread scenarios (Outcomes)						
Options	Very High p=0.35	High p=0.3	Constant p=0	Low p=0.1	Very low p=0.15	Expected value (μ)	Risk (SQRT σ^2)
Upward vertical integration	-1	-1	0	0	-1	-0,8	0,40
Products Upgrade	2	0	-1	-2	-2	0,1	1,58
Hydrodesulphurization	1	1	0	-1	-2	0,25	1,13
Product Discount	-2	-1	0	0	0	-1	0,84
Process innovation	-1	-1	1	1	1	-0,3	0,95

The expectation value (μ) for each option d is:

$$\mu_d = \sum_s P_{ds} \times out_{ds} \tag{3}$$

Where:

P_{ds} = the probability of spread scenarios option for d

out_{ds} = outcome

The variance (σ^2) is calculated as:

$$\sigma^2_d = \sum_{ds} P_{ds} (out_{ds} - \mu)^2 \tag{4}$$

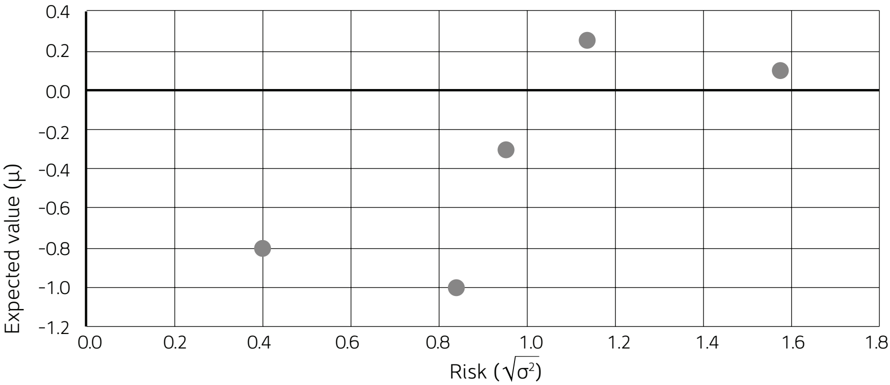
Thus:

$$Risk = \sqrt{\sigma^2} \tag{5}$$

Finally, for the investment portfolio selection, a graph of the expected value (μ) is plotted against Risk ($\sqrt{\sigma^2}$).

From the investment portfolio graph (Figure 3), hydrodesulphurisation, regardless of its high risk, appeared to be the option with the highest return on investment followed by product upgrade. The risk is obviously associated with the uncertainties in fuel prices. An investment of this magnitude will prove futile in the face of a heavy reduction in the cost of fuel. This will make it difficult for VKG to recoup the investment made. Product upgrade was found to be the riskiest option if taken because it is very expensive, and the failure of such a venture could be the final downfall for VKG. Upward vertical integration is the least risky, with little return for the investment and time spent on it. Product discount is the option with the least return on investment.

Figure 3. Investments Portfolio analysis



6. Conclusions

This work focused on three research questions. First, what are the economic implications of sulphur regulations on VKG's business activities? Second, what strategic compliance options are available for VKG? And third, how attractive are these options for VKG sustainability?

The results for the first research question showed that due to the new 0.5% global sulphur emission cap, VKG has found itself in a position where it must make an assessment on the marketability of its 0.8% sulphur content fuel post-2020 if it wants to keep producing and selling marine fuel. This is a situation that is also linked to job creation in the county where it is situated and the economic growth of the host country. Currently, VKG is struggling to keep itself from sinking under the consequences of product demand change as a result of the sulphur emission regulations. Information from interviews shows that the company is still weighing its options on how to go forward in the face of the 0.5% sulphur content regulation. Unfortunately, it does not have the luxury of time before 2020, when the regulation will take effect. Apart from the investment that was made on the refinery and bunker fuel market change research, VKG has not been able to decide what course of investment actions to take. Having been already adversely affected by the downward fuel price trends, it must proceed strategically and cautiously in regard to what investments decision to make. Strategically, because while VKG may still be able to sell its fuel directly to bunker traders, there will also be continued interest in improving air quality along with renewal concerns about air pollution from shipping activities and, follow up regulations might come at any time to interrupt its distribution channel. Indecision will likely prevent a bad investment choice, but on the other hand, any delayed investment could also be risky, in line with conclusions by Rebelo (1991) on the adverse effects of investment indecision. The constant loss of opportunities is counterproductive for any company in any given business environment. VKG also needs to proceed cautiously because nobody is sure about the fuel market or the success of the available abatement technologies for sulphur emissions. The economic feasibility of shale oil is highly dependent on the markets for conventional crude oil.

A continued loss as significant as 2015's will be detrimental to any company of VGK's size and status, especially when combined with the rapid increase in environmental charges. For example, in the past 10 years charges for SO2 emissions have increased by 700%, and waste disposal by 273%. Even though VKG cannot be compared to the big players in maritime fuel markets, such as ExxonMobil, Clipper oil, or Total in terms of manpower, global presence and net worth, the importance of VKG to the economic development of Estonia cannot be downplayed. In the past 10 years, the company has invested close to €900 million in the economy of Estonia and is responsible for over 2,100 jobs, of which, 600 were created within 2011 and 2014. VKG is the largest shale oil producer in Estonia and oil shale covers about 65% of the country's needs for primary energy, which has made Estonia energy independent, cutting almost to zero the importation of energy to Estonia. The oil-shale industry alone contributes between approximately 4–5% (about €300 million) to national GDP every year. In IdaViru County the shale oil industry is responsible for over 6,600 direct and about 13,400 indirect employees which are about 20% of the total regional workforce (Eesti põlevkivitööstuse aastaraamat, 2014). VKG as a company and the oil shale industry are important actors in the growth and prosperity of Estonia. A distortion to this industry will definitely have a grievous consequence on the national economy. Going forward VKG must decide on a sustainable solution for its conformity with the regulations.

Therefore, to address the second question, five investment strategies were projected based on the market environments and VKG's SWOT analysis. These were upward vertical integration, products upgrade, hydrodesulphurisation, product discounts and process innovation. The sulphur emissions are here to stay. VKG must make use of the present market conditions to create for itself a solution that enables it to rise above its challenges. These options are some of the opportunities and strengths that VKG can leverage on.

The third question was answered with the investment portfolio analysis of the five strategic options discussed. The result confirmed that the cost of sulphur emissions regulations compliance is excessively risky and expensive for marine fuel producers, especially VKG. In VKG's case, the transaction costs (cost of compliance) will unavoidably eat away the resources that would have been otherwise used for other growth-induced investments. These costs will generate further social costs like job losses for the region, especially if the company wants to recover its loss. Consequently, a company can only be productive if it can achieve a balance between its transaction costs and its production. Undermining compliance costs by the regulatory bodies when institutions are being set up has grave consequences. While MPEC accepts that the compliance options are expensive (Unctad, 2015), most efforts are concentrated on abatement technologies for ship owners and the port monitoring activities. From NIE theory, the productivity of any institution depends on the cost of transactions, meaning that companies can only thrive if the production processes are without the excessive costs of compliance. The social costs that will ensue are detrimental especially if they result in job losses for a region like Ida-Viru. Industries can only thrive when companies increase their workforce for growth, and any institution that disrupts this process is counterproductive. Larger companies will always have a better edge over smaller ones in the short term due to available disposable resources; however, in the longer term, the effect will become evident through reduced rates of growth. In situations like the sulphur emission regulation, where a regulation is accompanied by high compliance costs, the governing body ought to provide alternative institutions that will reduce the outcome of the transaction costs. In order to reduce social costs and prevent societal waste, the compliance enforcement (allocation of resources and the development of new technologies) depends on the prevailing governance structures.

Another outcome of this work is that VKG as an organisation is sensible and would want to realise a return on any investment that corresponds to the risk involved but VKG could be risk averse. Being risk averse, however, does not mean that it is not open to any form of risk but that when it is presented with different options for investment that seemingly offer similar expected returns, the company would prefer to take the less risky route. Therefore, VKG will likely take on highly risky investments as long as it can be sure that the investments will be rewarded with a higher expected return.

While the conjecture by policymakers that regulations are beneficial is right, the impact of these regulation obligations varies significantly. This study confirmed some of the arguments of the endogenous theory that regulations do not have the same economic impact on large companies as they do for smaller companies. On the basis of size, companies are on different scales. "Smaller" companies like VKG could sometimes lack the capacity to handle the necessary compliance changes that come with regulatory decisions, which is also in line with NIE discussions on transaction costs for institutions. It is noteworthy to mention that the shipping industry incurs such a significant cost for environmental regulations compliance, and so, for sulphur emission regulations like SECA to be rational, there has to be an allowance for level playing among related stakeholders.

The sulphur emissions regulations have been able to yield significant health benefits for the BSR and have reduced the potential acidification damage that sulphur compounds can cause to ecosystems. Clean shipping as a vision was set to make maritime transport greener, and this is presently being achieved through new technologies and changed behaviour on board across all stakeholders in the maritime sector in a concerted and integrated effort of multiple measures. Based on a results presentation and expert interview with Johan Mellqvist (2016), during an EnviSuM (Environmental Impact of Low Emission Shipping: Measurements and Modelling Strategies) partners' meeting, the preliminary tests conducted on sulphur concentrations in most BSR ports since SECA regulations show a significant reduction in SO2 concentration in the air and a compliance rate of 96.5% in the ports.

However, the underlining fact is that regulation compliance will be related to significant investment decisions for maritime stakeholders, and large uncertainties will always encompass each regulation. The VKG case has confirmed that not all regulations are created equal in terms of their costs or their benefits. For example, market-based or economic-incentive regulations, such as those based on tradable permits are likely to be more cost-effective because they provide incentives for companies to adopt a process that will comply with the regulation, unlike regulations that require technological change or establishing conventional performance standards like the sulphur emissions regulations. Agreed that stimulating innovation in the maritime sector for a cleaner environment is crucial, and that technology development may be able to lead the way out of some persistent environmental problems, but a technical solution to a problem should not set the foundation for the creation of other problems.

This work is limited to a single case. However, it contributes to the body of knowledge in the following ways:

First, it contributes to the on-going discussions on the impact of sulphur emissions regulations on the business performance of maritime stakeholders. It concludes that some maritime companies are struggling under the consequences of change in maritime fuel consumer demand due to the sulphur emission regulations and that the viable compliance options are expensive and risky.

Second, it contributes to one of the EU regulation objectives by showing how the cumulative effect of a beneficial regulation that seeks to *"demonstrate clear added value… full benefits at minimum cost …. With a simple, clear, stable and predictable regulatory framework for businesses, workers and citizens…"* (EU, 2012) can pose a significant threat to the economic well-being of a country. From a policy creation and policy execution point of view, the challenge of regulations like the sulphur emission regulations lies in harmonising the implications of the regulations and its policy instruments as they relate to regulation compliance. It is, therefore, recommended that maritime policymakers and regulatory bodies ensure a continuous cross-link between emissions related regulations and innovation, together with the availability of compliance technical know-how that will consequently cause the creation of policy instruments that will cushion its effect on all stakeholders.

Third, this research discussed the compliance options available for fuel supply companies from the opportunities that are both inherent and external to the case company. This contribution can be extended to similar maritime fuel producing companies. The portfolio analysis framework, in particular, will benefit similar companies in their strategic decision-making process. This type of contribution will improve the innovation capacity of related maritime companies and the integration of new knowledge for the maritime sector.

Further research can be made to assess the economic implications of the MARPOL sulphur regulation on other categories of maritime stakeholders in the BSR, such as ship owners and ports for a comparison of the degree of impact. Further research can also explore the measurement of the effect of SECA regulations on clean shipping regulations for the maritime industry in the BSR –such studies will be crucial to the sustainability of emissions regulations.

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Appendices

Appendix 1. Expectation value of investment options

	Price spread scenarios (expectation value)					
	Probability					
Options	0.35	0.3	0.1	0.1	0.15	Expected value (μ)
Upward vertical integration	-0.35	-0.3	0	0	-0.15	-0.8
Products Upgrade	0.7	0	-0.1	-0.2	-0.3	0.1
Hydrodesulphurization	0.35	0.3	0	-0.1	-0.3	0.25
Product Discount	-0.7	-0.3	0	0	0	-1
Process innovation	-0.35	-0.3	0.1	0.1	0.15	-0.3

Note: Scenarios are "very high," "high," "constant," "low" and "very low". Scenario scale is -2, -1, 0, +1, and +2.

Appendix 2. Risk factor ($\sqrt{\sigma^2}$)ʃ each investment

Options	Price spread scenarios (variance)					Risk (SQRT σ^2)
Upward vertical integration	0.01	0.01	0.06	0.06	0.01	0.40
Products Upgrade	1.26	0.00	0.12	0.44	0.66	1.58
Hydrodesulphurization	0.20	0.17	0.01	0.16	0.76	1.13
Product Discount	0.35	0.00	0.10	0.10	0.15	0.84
Process innovation	0.17	0.15	0.17	0.17	0.25	0.95