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Master in Management

Evaluation of the opportunities of Oil and Gas companies for the transition to the Circular economy

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Sadovskaya Valeria

Research advisor:
Iya Churakova,
Associate Professor

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АННОТАЦИЯ

Автор	Садовская Валерия Олеговна
Название магистерской диссертации	Оценка возможностей нефтегазовых компаний к переходу к циркулярной экономике
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Описание цели, задач и основных результатов	Цель данной магистерской диссертации состоит в том, чтобы создать инструмент для определения возможностей нефтегазовых компаний к переходу от экономики линейного типа к циркулярной экономике. В первой главе данной работы представлены основные теории и бизнес модели циркулярной экономики; описаны составляющие нефтегазового сектора и новейшие технологии по реконструкции оборудовании и переработке выбросов (шлама). Во второй главе представлена информация по имеющимся индексам для экономики замкнутого цикла, описана методология создания индекса, перечислены использованные методы сбора данных, типы данных и их источники. Третья глава представляет основную часть работы, где описываются элементы индекса. В четвертой главе представлена количественная и качественная оценка индекса, методология и результаты экспертной оценки индекса, подсчитаны значения индекса для группы компаний, а также разработаны рекомендации. В результате работы был получен индекс, с примерами его расчета для 14 компаний из разных стран, а также созданы рекомендации для каждого возможного значения индекса, что может расцениваться как “дорожная карта” для нефтегазовых компаний.
Ключевые слова	Циркулярная экономика, линейная экономика, экономика замкнутого цикла, нефтегазовый сектор, создание индекса, нефтегазовые компании

ABSTRACT

Master Student’s Name	Sadovskaya Valeriya Olegovna
Master Thesis Title	Evaluation of the opportunities of Oil and Gas companies for the transition to the Circular economy
Faculty	Graduate School of Management
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Description of the goal, task, and main results	The goal of the master thesis is to create a tool for oil and gas companies, which they can use to analyse opportunities of transition from a linear economy towards a circular one. The first chapter focuses on main theories and business models of Circular economy; describes main elements of the oil and gas industry and the latest technologies for the reconstruction of equipment and processing of emissions (sludge). The second chapter provides information on existing indexes for a Circular economy, methodology of index creation and data collection. The third chapter represents the main part of the paper, where the elements of the index are described. The fourth chapter provides the quantitative and qualitative index assessment. As a result the index was obtained, calculations for 14 representative companies were provided and recommendations for any index value were created, such recommendations can be considered as “road map” for oil and gas sectors.
Keywords	Circular economy, linear economy, close loop economy, oil and gas sector, index creation, oil and gas companies

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Introduction

Circular economy and Oil and Gas sector

Nowadays topics such as “sustainable development”, “lean management” and “zero waste economy” are becoming more and more popular in both business and science areas. Problems of “destruction of the ozone layer” and “the greenhouse effect” are also from time to time raised on different conferences and government meetings.

Since humans have appeared on earth the nature has changed a lot. Trying to make life more comfortable and safe, our ancestors created hunting tools and started domestication of plants and animals. They were trying to change the world under their needs and this process is still going on. Humankind continuously improve their life by adjusting the nature towards their desires. Of course, thanks to science, engineering and medicine, people live twice longer and travel much more faster. But while humans investigated the world and developed everything around, the nature has suffered a lot. Only in the last several decades the global society started to be concerned about the fact that people’s activities are damaging the planet: garbage patches were created around the world; thousands of animals species have disappeared forever; many plants and animals are endangered; global warming process started; ozone layer is damaging etc.

The main reason for all these consequences are really bad forecasting skills. Many people are sure that we will always have pure water, enough food and clean air. We can hunt as much as we want, we can produce whatever we want and consume as often as we want. Nowadays every action of ours affects the future.

But actually many developed countries are trying to fight fire with fire around the world until it is not too late. So that’s why almost everyone heard at least once in their life about “destruction of the ozone layer” and “greenhouse effect” – global society has created awareness for every part of the world about such problems.

The main goal is to keep our world the same for our descendants and give them the same opportunities and to meet people’s needs and development goals without harming the natural processes while giving an opportunity to provide natural resources and ecosystem services according to the Sustainable development goals. (Macarthur, 2013).

One of the main hot topics is that many resources are limited (oil and gas) and many created goods can not be recycled by nature and only way to get rid of them is to burn them. This creates the harmful effect on the ozone layer. So that’s why the Circular (Close-loop) economy was created or in other words “zero waste”. From the title we can understand the main idea of this kind of economy – moving away from linear economy (traditional economy made-use-

reduce). The plan is to create a world where no harmful garbage exists and limited resources are strictly controlled.

Russia as a developing country and is not so advanced in contemporary ecological methods but people are already trying to implement popular European systems and to influence on others, they organised separate waste bins, collecting batteries, second hand use and many other initiatives.

But this paper will raise the problem of ecology and make it in bigger scale. What is the largest and the richest industry in Russia? What is the dirtiest production in Russia? Right. The Oil and Gas sector. That's why it was decided to implement principles of circular economy in the oil and gas sector.

First of all it is decided to create a road map for Oil and Gas producing and refining companies (especially Russian one). An will be created the index which is aimed to help companies analyse their external and internal environment and evaluate their opportunities for implementation principles of Circular economy. Moreover in addition to the index the recommendations will be provided which will navigate company with all suitable business models and appropriate solutions.

Problem description and research gap

Although the Oil and Gas sector represents the Linear economics there are high prospects for Circular economy elements. Actually many researchers are creating more and more business ideas for Oil and Gas companies such as, how to implement Sustainable initiatives (Ellen MacArthur, 2016). Circular economy is still quite immature according to some researchers but last decade, dozens of ideas and articles have been published on that topic. One of the directions is to create an Index which will help to evaluate the desired Circularity level of economy. One of the most popular Index is Circular Economy Index developed by Reuter, where 25 different KPIs help to assess a particular company activity in the sense of the desired level of circularity in business. Actually the main functions of CEI is firstly, to measure performance of a company on the circular economy area, secondly, to compare the performance with competitors and lastly to suggest a kind of road map for business what they can use to implement the Circular Economy. But it's worthwhile to say that this index is quite general and does not use any sector-specific differences. So there were suggested Circular economy index for consumes goods sector (Verbeek, 2016). Also we should not forget about one of the most well-known index created by Ellen Mac Arthur Foundation, The Material Circularity Indicator. There are several researchers in Russia as well who created Circular Economy Index (Pahomova, Rihter, 2016).

Although there are a lot of published well-known Indexes but there is still no recognised way on how to identify the prospect of a particular company (especially from the oil and gas industry) to transfer from Linear economy towards the Circular one. It's important not to randomly suggest for every company to implement circular economy initiatives but to make more customised suggestion, to assess what kind of initiatives are appropriate for the company.

Aim and research questions

The aim of this research is to create The Index for companies from the Oil and Gas industry that can be used for evaluation of companies' capabilities for transition from the Linear towards the Circular economy. Index was created based on general economy principles and specifics of industry, using the experience of the other indexes creation. So the main research question that will be answered in this paper:

What kind of the Index can help to evaluate a capability of a company from the Oil and Gas sector to transfer towards the Circular Economy?

In order to make the answer on the main question more complete it is important to answer on these sub questions:

RQ1 What variables should be included in the Index to evaluate opportunities for transition towards a circular economy?

This is important as it will help to understand which directions it is better to focus. To answer this question it is crucially important to describe the Oil and Gas industry and the Circular economy process in detail. So that's why it is planned to create frameworks for these needs.

RQ2 How company can use the index results?

So this is the most important part of the index. How to use the Index after calculating the value? What to do with the result? So this the index will be divided on intervals of values and for the each interval special suggestions 'what to do' will be created.

RQ3 What are the reasons why company can decide to transfer towards Circular Economy?

The motivation of the company helps to understand on what kind of advantages we should focus and how to compensate the expenses that company probably will suffer transferring towards CE. Moreover it will help to suggest recommendations after getting the Index results.

Relevance

Oil and Gas sector is the biggest and the richest sector in Russia and the most harmful for our environment, the global community is increasingly worried about irreversible changes in our world as global warming, ozone layer resolution, disappearance of animal and plant species and

so on. So that’s why more and more companies are forced to implement some Circular activities in everyday life. But it is not clear if every company can do that? That is why it is important to evaluate their capabilities for these initiatives.

Moreover this paper can make a real contribution to the science as 1) There are lack of the Circular economy Indicators, especially in the Oil and Gas sector 2) The methodology and Idea of this index can create examples for other young researchers for creation of the similar indexes for other sectors.

Scope

The scope of this research is to evaluate the prospect of the Circular economy implementation in Oil and Gas companies around the world, there are almost no limitations only if there is lack of necessary information or information is considered as unreliable. There are several different Indexes as it was said earlier but most of them are aimed to evaluate the existing level of Circularity. But Author considered that there are no real practical value as it is more important to understand if company really can implement more principals of Circular economy and suggest which one it is better to implement.

Chapter 1 Sustainable ecology systems and oil and gas sector

1.1 Circular economy

Circular economy. Circular economy is a new mainstream all over the world. «Zero waste economy» - that's a new "religion" in the modern society. The linear system "take, produce, consume and dispose" was replaced by "take, produce, consume and reuse" (Picture 1). The main idea of circular economy is to move to economy without any waste, where we can use things again and again, giving them second, third or even fourth life, where all goods, all components of any device, of any pipe can be converted without any harmful waste to the nature.

The theory of circular economy was topped by many different schools (Ghisellini et al., 2014). The economist Pearce and Turner (1990) primary introduced this concept promoting transition from Linear economy towards Circular one.

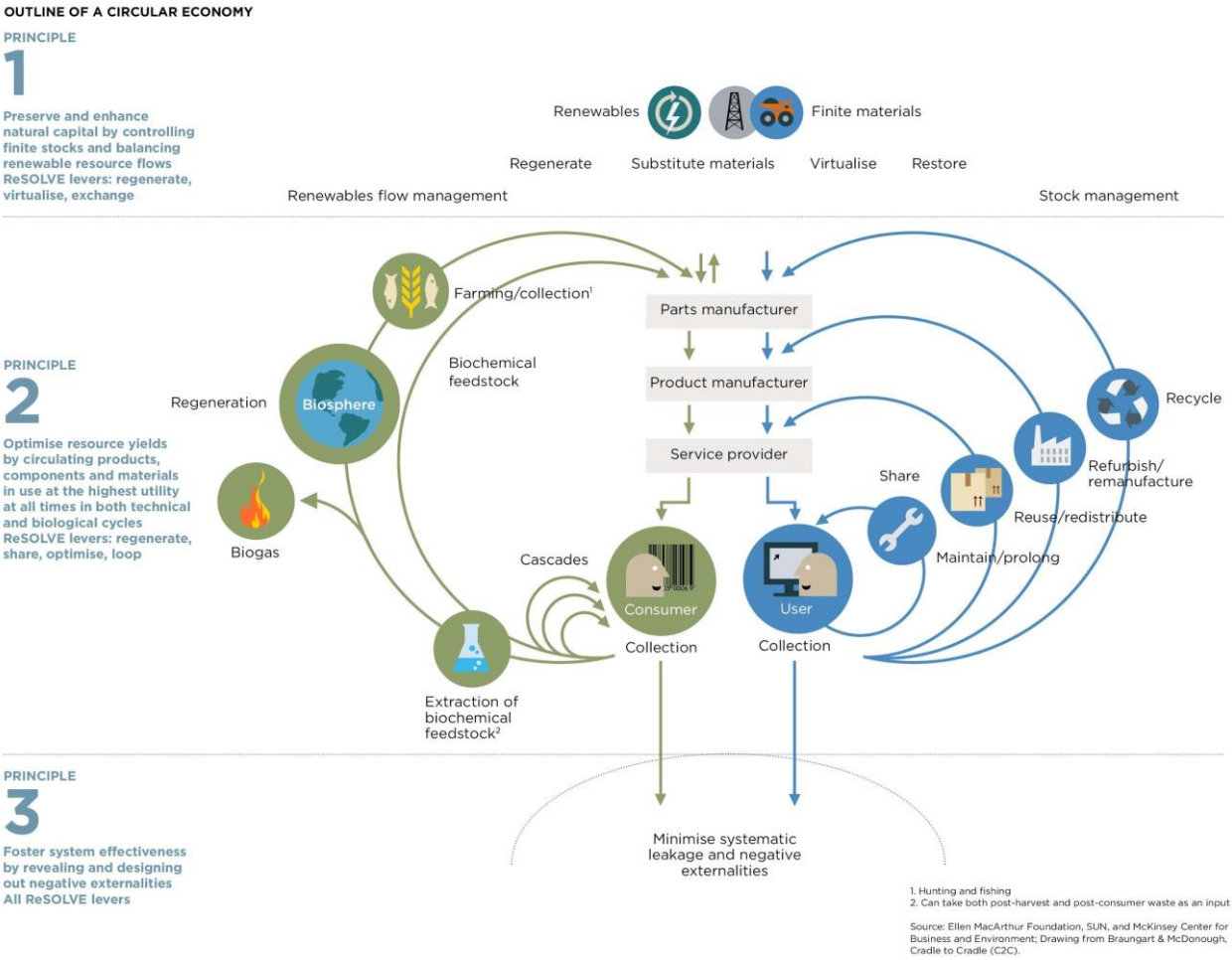
Circular economy - an economy that is restorative and regenerative by design and aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles (EMF, 2015, p.5).

The idea of circular economy is a solution for many human problems, such as environmental ones, scars of materials and etc. Nowadays almost everyone heard about the greenhouse effect and what kind of consequences can appear in the future? And what about sustainable economy? (Dossa, 2014) We should leave our world with the same life opportunities and resource reserve for future generations as we had. That's hot topic for last few years in so many nature friendly countries as Norway, Scotland etc.

Circular economy should be widespread in every industry that exists in the world and moreover only strong partnership in all the industries can make this idea work. Why? Because, for example, materials from the oil and gas sector can easily be re-used in wide range of other sectors (Epstein, 2016).Moreover we should not forget that circular economy itself can create big amount of new jobs, new businesses and can improve technical sources.

Nobody can say that it is easy to change everything towards Circular economy but it is only possible way to keep our world the same for next generations.

On the Diagram 1 the Circular economy framework made by Ellen McArthur foundation shows how circular economy actually works from inside.



<u>Diagram 1. Model of Circular economy</u>

Source: Ellen McArthur foundation, 2014

In 1970 the main way to utilize the waste was to create landfill. So the islands of trash are all over the world, in oceans, in forest. So there are so many stories about a fish which was eating carbon waste! We are constantly ruining the world where we live.

The concept of a circular economy was created and described by economist Pearce and Turner(1990). In Economics of Natural Resources and the Environment they discussed the absence of the perspective of recycle in linear economy, what makes our planet as "waste reservoir" (Boulding, 1966). So they suggested the close loop economy and named it as circular economy. The transition from open-loop towards close-loop economy creates many challenges for the companies.

World experience. First move towards this new economy was made unsurprisingly by Germany (Bilitewski, 2007) in 1996. In China the new economy was presented a little bit in a different way not as improved environment management but as a totally new policy. The main

focus of circular economy is moving from “narrow waste recycling” towards real efficiency-oriented control of close loop flows. Beside waste problems, energy, water and land problems were also considered as key issues (Zhou, 2014).

In European Commission strategies connected with circular economy initiatives are more focused on boosting recycling, creating job opportunities as well as economic growth and preventing loss of important limited resources. The idea was introduced by Robert Ayres in 1990s, he created an idea about industrial metabolism: “Generally speaking metabolism of industry is the process of mixing material, energy, labour into final goods” (Ayeres, 1994).

Also he introduced an idea that this close loop cycle can last until there exists an external energy supply. So there are only two ways to make usage of resources long: recycling and reuse or dissipative loss (Bocken, 2016).

In the McDonough and Braungart paper, the “cradle-to-cradle” economy (circular) should be moved to “cradle-to-grave” economy (linear) by changes in technical and biological loops (Carson, 2002).

“We should learn how to restore to the nature the wealth that we borrow from it”– by these words it was noted the idea that we have limits of resources and energy and any waste just ruined our planet, so this is a start of realizing that we need circular economy.

Implementing circular business we are actually trying to use renewable energy widely, forget about mass market clothes and reuse materials in our ordinary life. Actually people are already using some parts of circular economy by second hand stores, using eBay. Actually eBay is a literally Circular economy platform where we create second, third and sometimes even forth life for the products.

In reality nowadays business is not ready change anything only because of “idea” of sustainable society. That’s worth to say that it is not bad because that is also part of circular economy principles– create products in most cheap and effective way. So now we need to show that sustainable production is also can be profitable moreover it creates a brand image for the company what actually lead to growing market share and therefore revenue. So everything has a connection. So introduction of Circular economy should first influence people – consumers, who, having a bargain power will influence on companies and government. So government creating taxes and bonuses will influence on corporate part as well.

But we should also create good business models to satisfy the people’s demand and economical efficiency (Bakker, 2014).

Generally we can say that circular economy, close-loop economy, “cradle-to-cradle” economy –it is all the same things, but still we should show that there are different between 1) reuse of product and 2) recycling materials.

So there are three actual strategies which was invented by Staheland McDonough and Braungart and the fourth is added by author.

1. Slowing resource loops: the idea of creation product that can be used long time, create all conditions for product-life extension (different services)
2. Closing resource loops: Recycling of resources – that we can use it afterwards
3. Resource efficiency or narrowing resource flows: use resources really efficiency
4. Reuse of products

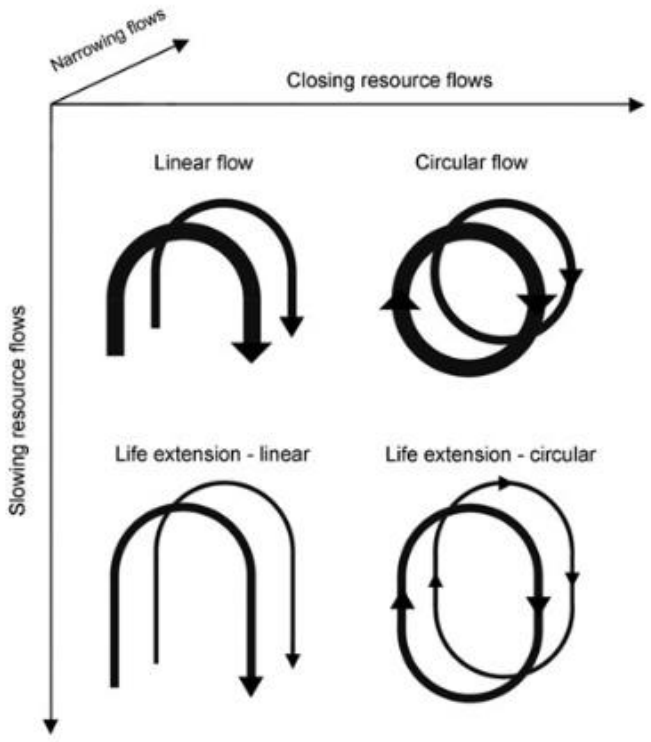


Diagram 2. Circular and linear economy theories: comparison.

Source: Staheland McDonough

Russia. Russia is the developing country where most of all economic processes are on the initial stage, our country is on the way towards democracy and all the principles that associated with this definition. But nevertheless Sustainable projects are not rare now (Cooper, 1999). And a lot of people are trying to create activities to support this new "fashion" in the economy. For example, in many Universities, as Graduate School of Management students support circular economy by collecting accumulators. That's small step towards conscious consumption.

Extractive industry is most polluting one in Russia but it is also considered as the most profitable and huge industry. Moreover, russia is rightfully considered as the resource economy

(sometimes we can see such definitions as the resource dependence economy). The oil and gas industry creates around 40% of Russian GGP, that's huge part of Russian economy. Looking on this number it's obvious which sector of the economy should first implement the principles of circular economy. Why?

First of all, as we said it is the dirtiest industry in Russia (actually in the world). So if we want to find the best, shortest and most effective way to get rid of the waste widespread in Russia. Implementation of circular economy in oil and gas sector is the best way.

But it cost huge money to reconstruct operational and managerial processes. So we move to the second point.

Secondly, this is the richest industry in Russia. The biggest amount of money created exactly here by such companies as Lukoil, Gasprom, Surgutneftegas and etc. So if these companies will have the good motivation they can spend some on R&D towards the idea of circular economy.

Oil and Gas are the major sectors in Russia that's why that is strategically important to show their readiness to change something towards new economy.

There are opinions that such an initiatives we should start from the small movements. To answer on this concern first we need to understand the nature of this questions. Why some people think so?

First of all starting from the small activities we can change the mindset of people, by small steps we can move towards 'zero waste economy". Secondly, on the first stages we create the structure that can be implemented and can be expropriated to the biggest industries as oil and gas, automobile, etc.

So, we have answer on this questions.

If we speak about changing the way of thinking, we should notice that a lot of initiatives were created since 1990, "second hand shops", leasing companies and etc. After that such platforms as eBay were created. The only difference is motivation, why we do so? To create the value, to get a profit. But the result is the same – this is part of circular economy philosophy.

We do not have time to gradually implement all this initiatives we need a great move towards better world that's why oil and gas sector is the best option in Russia nowadays.

Providing investigations, it was found that there are two areas where we can implement re-use and no waste principles.

First, the developing, oil and gas sector is the area which generated a lot of such products as associated gas. These products can be collected and used as energy resources but sometimes companies consider this process too costly and just burn it. But namely this action is one of the

reasons of greenhouse effect and global warming problems. Therefore we just get rid of one of the non-renewable resource and harm the environment.

Secondly, we have huge problem with rigs decommissioning. Most of the decommissioning companies do not really care about what they leave on the place of the developed mineral deposit.

One of the projects in Europe “The great recovery” is related towards the implementing principles of circular economy in different sectors, about the methods how to implement it , and also they considered oil and gas sector. They created joint report with Zero waste Scotland program where they included lots of interesting information, ideas about what parts of rigs can be sold and eventually re-used in different sectors.

1.2 Other theories correlated to Zero waste

There are also many concepts which basically have the same goal as Circular economy and can be considered as Circular economy principles and be implemented as additional Circular economy business models.

1.2.1 Lean management

Lean management - the concept of managing a production enterprise, based on a constant desire to eliminate all types of losses. Lean production involves each employee in the process of optimizing the business and maximizing customer focus. There was an interpretation of the ideas of Toyota's production system by American researchers of this phenomenon.

The starting point of the concept is the evaluation of the product's value for the end user, at each stage of its creation. The main task is to create a process of continuous elimination of losses and the elimination of any actions that consume resources, but do not create values for the end user. As a synonym for the notion of loss, the term from the Toyota production system – muda, meaning all possible costs, losses, waste and garbage.

In accordance with the concept of lean production, all the activities of the enterprise are divided into operations and processes that add value to the consumer, and operations and processes that do not add value to the consumer. The task of "lean production" is the systematic reduction of processes and operations that do not add value.

1.2.2 The rule of 6 sigma

Six sigma is a production management concept developed by Motorola in 1986 and popularized in the mid-1990s after Jack Welch used it as a key strategy in General Electric. The essence of the concept is to improve the quality of the outputs of each of the processes, minimizing defects and statistical deviations in operating activities. The concept uses quality

management methods, including statistical methods, requires the use of measurable goals and results, and also involves the creation of special working groups at the enterprise that implement projects to eliminate problems and improve processes ("black belts", "green belts").

The name came from the statistical notion of the standard deviation, denoted by the greek letter σ. The maturity of the production process in this concept is described as the σ-deviation rating, or the percentage of defect-free output, so the quality control process 6σ yields 99,99966% of the outputs without defects, or no more than 3.4 defective outputs per 1 million operations. Motorola set as goal the achievement of a quality score of 6σ for all production processes.

1.4 Oil and Gas sector

1.4.1 Description of oil and gas industry

The oil and gas sector is usually understood as part of the economy or a set of industries and enterprises, the end product of which is a variety of fuels derived from oil and gas. Along with the production sphere, most of all types of activities are also referred to the oil and gas sector (transport, storage and retail trade).

At the same time, the oil and gas sector is divided into two large segments an upstream and a downstream. The first segment includes only those activities that are directly related to the extraction of oil and gas from the ground (geological exploration and production), and the second - everything else, i.e transport, processing, distribution and sale.

Often within the oil and gas sector, there is suggested a kind of "intermediate" segment, the midstream, that is represented by oil and gas transportation, storage, trade and distribution that collectively serve the aggregate supply from producers and the aggregate demand from consumers.

The Upstream is the face of the oil and gas industry. Since energy resources are consumed by countries all around the world, practically in any economically developed country there is an oil refining industry, while only limited amount of countries can afford oil and gas extraction. It should be noted that the resources are not distributed equally, 82% of the world's proven oil reserves is distributed amongst only ten countries. And the first twenty countries have 94%.

In the oil and gas industry there are type of companies as vertically integrated ones, these companies provide the entire complex of extraction, processing, transportation, storage and sale. Also, there are specialized companies that provide only one or several types of activity, for example, only extraction.

1.4.2 Methods of collecting waste

The process of building wells is accompanied by the use of materials and chemical reagents of varying degrees of environmental hazard (Yagafarova, Barahnina, 2006). The main objects of pollution during drilling of wells are geological environment (groundwater), hydro- and lithosphere (open water bodies, bottom of water areas, soil and vegetation cover).

Sources of pollution during drilling of wells can be divided into two parts: permanent and temporary. The first one includes filtration and leakage of drilling mud from slurry barns. The second group includes sources of temporary action - absorption of drilling mud during drilling; release of formation fluid to the surface; violation of the tightness of the cemented cavernous space, leading to interplastic overflows and cavernous manifestations; flooding of the drilling site due to high water during the spring flood or intensive melting of the snow and spilling the contents of slurry barns.

The greatest danger for objects of the natural environment is the technological waste from drilling, which is accumulated and stored directly on the drilling place.

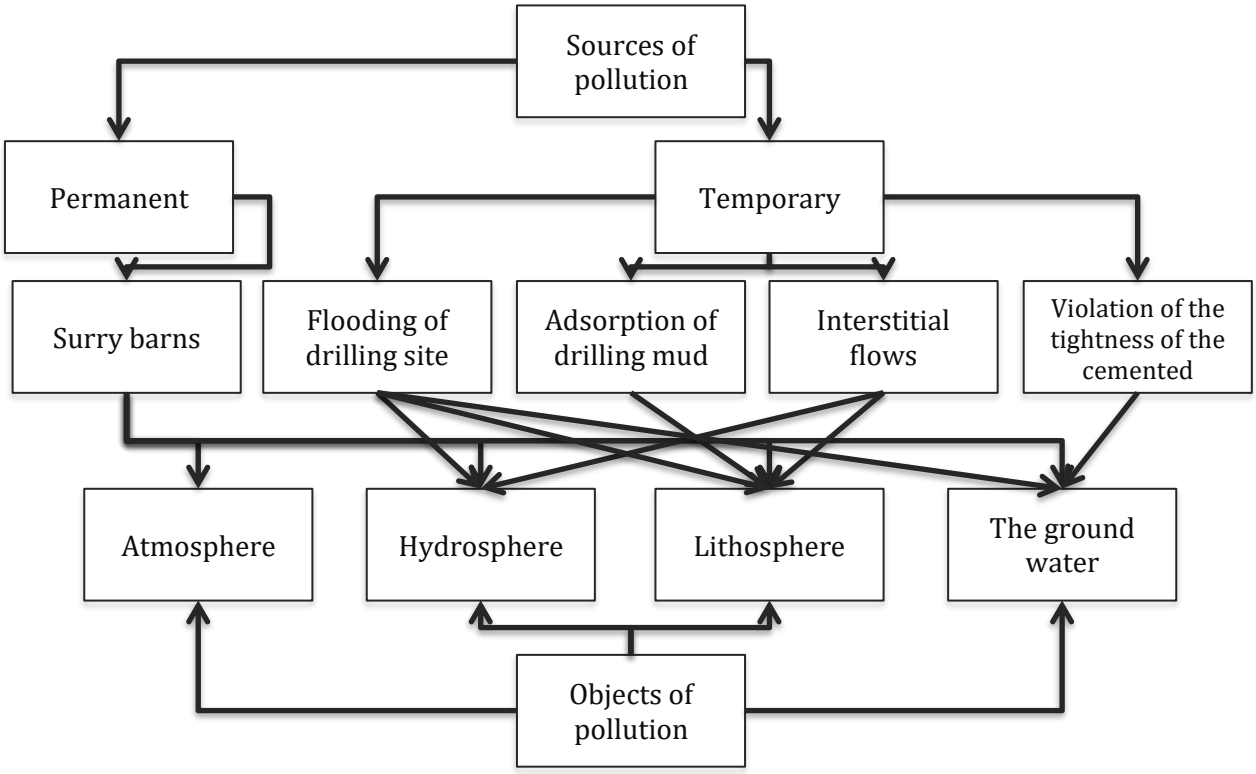


Diagram 3. Different sources of pollution

Source: Yagafarova, Barahnina, 2006

It is known that while the process drilling was provided on the Sakhalin Shelf by Sakhalin Energy Investment Company Ltd., 60,000 m3 of drilling mud and 15,000 m3 of sludge from one platform per year and approximately 640 m3 of produced water per day are expected to

be discharged. At the Piltun-Astokhskoye field, 70,000 m3 of drilling waste have already been dumped in the sea during the two-year period of the first stage of production drilling.

According to Kogalymneftegaz, when drilling a 2,600-meter deep well, the barn contains about 65% of water, 30% of cuttings (cuttings), 5.5% of oil, 0.5% of bentonite and 0.5% of various additives that ensure optimal performance drilling rig.

The process of self-purification of natural ecosystems is notorious, but their ability to process such amounts of pollution is not unlimited. Rivers and lakes of the Far North, in comparison with the water of temperate and southern latitudes, are poorly saturated with oxygen therefore, organic life is not so diverse and abundant.

Table 1. Waste components when drilling first and subsequent wells

Source: Yagafarova, Barahnina, 2006

Waste components	Composition when drilling the first well (2600 m), t	Composition when drilling subsequent wells, t
1. Water	314,0	314,0
2. Sludge	150,0	150,0
3. Oil	29,64	26,64
4. Bentonite	2,8	1,4
5. Surfactant-Neonol	0,073	0,073
6. CMC	0,364	0,182
7. APPL	0,052	0,052
8. GKZ	0,080	0,080
9. Calcined soda	0,042	0,042
10. Caustic soda	0,150	0,150
11. KSSB	0,161	0,161
12. Graphite	0,150	0,150
13. Barite	0,096	0,096
14. Cement	0,722	0,722
15. Hypan	0,172	0,086
16. NTP	0,045	0,045
17. "Nitron" - wastes	0,170	0,170
18. Lubricant additive ICB-4TM	0,520	0,520

Therefore, if in areas of the middle belt the water of rivers can be self-cleaned on sections of 200-300 km, then the length of the river in 1500-2000 km is often insufficient for self-purification of water under northern conditions. Such a low efficiency of the process of self-purification of rivers and lakes in the Far North limits the discharge of drilling waste into reservoirs. It is especially huge, the harmful effects on the soil of petroleum products. In contaminated soil, the ratio between carbon and nitrogen changes drastically, what makes the nitrogen regime even worse in the soils and disrupts the root nutrition of plants. In hydrocarbon contamination of soils, oxygen is displaced from them, the soil loses its productivity and the fertile layer is not restored for a long time. Self-cleaning of soils is very slow.

The impact of drilling waste on natural objects may not necessarily be manifested in a toxic effect on the biosphere, but can be expressed in violation of the ecological balance in biotopes of different trophic levels when biotops interact with an abiotic environment that has a mechanism of functional damage to the ecosystem. While wells are drilling, the task of cleaning slurries from environmentally hazardous drilling wastes is most relevant. The basic scheme of processing of drilling waste is presented in Diagram 4.

But there are several methods how to reduce the drilling waste. Several of them are still create some waste that harm environment but there are several methods used by European countries and USA which are considered as the best methods.

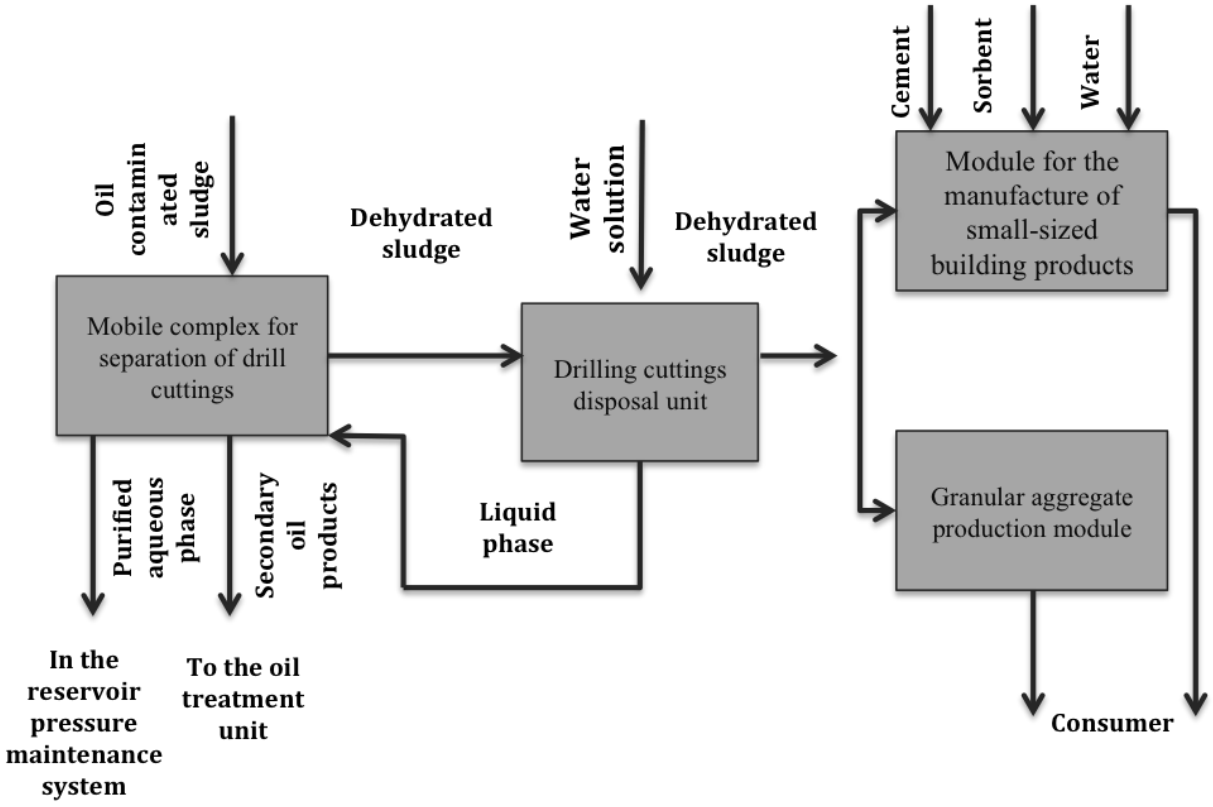


Diagram 4. The general scheme of drilling waste process

Source: Yagafarova, Barahnina, 2006

A promising method for eliminating drilling waste is a curing method (solidification), followed by burial under a layer of mineral soil or use in economic activities. Clay-like hardened mass serves as a building material or, after grinding, as a fertilizer. To cure drilling waste, it is treated with activating additives.

1. Reinjection technology is the injection of drilling waste into the annular space or into a specially drilled well, injection into the well after completion of drilling operations. The main conditions for the application of reindex is a geological opportunity for pumping (the presence of a receiving stratum, water-resistant layers above and below the receiving reservoir to prevent contamination of groundwater).
2. The American firm Hughes Drilling Fluids developed an autonomous installation for cleaning and processing slurries in the case of oil-based muds. The plant consists of a vacuum-distillation unit intended for slurry processing and a computer control unit.

All known technologies for the processing of drilling sludge by methods of processing can be divided into the following groups (Table 2). The thermal method for neutralizing drill cuttings is considered to be the most effective and practically accessible.

Table 2. Characteristics of the main methods of drilling waste disposal

Source: Yagafarova, Barahnina, 2006

Method	Description
Thermal	Burning in open barns, different types of furnaces, obtaining bituminous residues
Physical	Burial in special repositories, separation in a centrifugal field, vacuum filtration and filtration under pressure, freezing
Chemical	Solvent extraction, curing with the use of inorganic (cement, liquid glass, clay) and organic (epoxy and polystyrene resins, polyurethanes, etc.) additives, the use of coagulants and flocculants
Physicochemical	The use of specially selected reagents that change the physicochemical properties, followed by treatment with special equipment
Bio	Microbiological degradation in soil directly in storage areas, biothermal decomposition

1.4.3 Second-life equipment in Oil and Gas sector

In Russia we are also trying to implement circular economy by using the second hand equipment. But the thing is that we have to close the loop and encourage use of second hand equipment different industries (after making some reconstructions).

Lest consider the case with utilization of drilling platform “Hutton” (Zhestkov, Nozamusinov, 2008).

The usage of the upper structure of the Hatton platform during the construction of the Prirazlomnaya oil production platform ensured the reduction of the commissioning period. But the life cycle of marine equipment is completed by disposal, and the development of options for its implementation should be carried out in advance. In domestic practice, there is no experience in disposing of such large structures and it is necessary to develop appropriate technologies.

In July 2002, Sevmorneftegaz and Sevmashpredpriyatie concluded a contract for the production of a platform support base. To reduce the cost and speed of its construction, it was decided that the lower part of the platform, the so-called caisson (about 30% of the cost of the project), would be built at the Russian enterprise, and the upper part - the above-water part of the structure (residential, drilling and technological modules) is advisable to purchase the finished one: to buy the top structure from the foreign platform which was removed from the operation (in this case, "Hutton TLP" of the company "Kerr-McGee").

The oil rig "Hutton TLP" was built in 1984 by the Scottish company "Highland Fabricators", it extracted oil for about 15 years for Kerr-McGee North Sea (UK) Ltd at the Hutton field (British North Sea sector) , then it was withdrawn from use and was planned to be disposed in Stavanger. Sevmorneftegaz purchased only the upper structure from Monitor TLP Ltd, which, in turn, bought Hutton from Kerr-McGee; The registration point for the platform was the port of Bergen, Norway.

In March-April 2003, the specialists of FSUE PO "Sevmash" and two shipyards (Murmansk 82nd and SRV "Nerpa") dismantled the equipment and separated the top of the platform from the lower one.

At this time, Sevmashpredpriyatii continued to build the gravity foundation of the future platform. This design also includes the upgraded upper part of the Hutton platform.

The service life of the platform "Prirazlomnaya" (as an object of marine technology) will end in the forecastable future. Thats is why it it is necessary to solve questions of recycling beforehand.

As we can see there are real problems in recycling and reconstruction of platforms in Russia. There are dozens of platforms have to be put into operation in the foreseeable future.

1.4.4 Products of oil and gas sector

Today it turns out that so many goods that we use in our daily lives are oil refining products. There are about 6000 such products, and maybe even more. There is a list of only some of them.

Vaselin. Vaseline is also a well-known and widely distributed product. Vaseline is invented by the English chemist Robert Chezbro, who, thanks to his curiosity and observation, could see the useful properties of this product in the remains of oil refining as early as the end of the 19th century. Vaseline is now used for medical purposes, in cosmetics and even as a food supplement.

Lipstick. Cosmetics in general women have been using for thousands of years. Earlier the lipstick often included harmful components. But today, lipstick due to the development of chemistry has not only aesthetic effect, but also moisturizing, nourishing, anti-inflammatory effects. Some of the components of lipstick are hydrocarbons: liquid and solid paraffin, ceresin and others.

Aspirin. Aspirin has long established itself as one of the most reliable and safe drugs. Each year, several billions of aspirin tablets are consumed in order to get rid of the headache. Aspirin is also used as a preventive method to cardiovascular diseases. Acetylsalicylic acid in combination with chemical salicin help to get rid of pain. Interesting that the production of aspirin begins with benzene and hydrocarbon, which are derivatives of petroleum products.

Another widespread product, which has hydrocarbons in its composition, is chewing gum. The chewing gum is made both from natural components, and from polyethylene and paraffin resins. Due to the fact that gum is derived from petroleum derived polymers, its decomposition takes a very long time. Therefore, do not throw the cud on the street, otherwise it is like plastic bags, it's in the ground for long and long years.

Clothes production improves a lot by adding polyester fibres which created more flexibility to the clothes. Polyester is a polymer obtained as a result of oil refining. It is produced in the form of fibres or plastic. Thanks to polyester, the fabrics acquire useful properties. They do not crumple, easily wash and do not stretch.

Solar panels. Alternative energy sources, such as solar panels, are designed to replace non-renewable energy sources. But ironically, oil refining products are also needed for their manufacture. The fact is that photocells transforming solar energy into electrical energy are applied to panels made from oil resins.

Another unique material that we get from oil is nylon. Millions of modern women wear nylon pantyhose for comfort and to be in fashion. Nylon - a strong, light synthetic fiber - has a wide application. Today nylon is used in the manufacture of a huge number of things, from

dishwashing agents to parachutes. Also, nylon is used in industry for the manufacture of bushings, bearings, etc. This polymer was invented in 1935 in the laboratory of DuPont.

In childhood, many of us used colored paraffin pencils. And this is also a product of oil refining. Such pencils are made from paraffin resins. Incidentally, candles are also made from them.

We all know that oil is the raw material for obtaining fuel for our vehicles (gasoline and diesel fuel for cars, aviation kerosene for jet aircraft engines). Fuel is one of the main products that is derived from petroleum.

One of the most common products of oil refining is polyethylene or plastic. Plastic plays an extremely important role in the modern world. Millions of tons of polyethylene plastic are used to make plastic bags, food containers and other consumer goods. The use of plastic is convenient in that it can take any desired shape. In addition, the properties of plastic products can also be changed in accordance with specified conditions.

As we can see Oil and Gas industry creates so many useful things for daily life without it some people can not imagine even their life, With this chapter author wanted to show how Oil and Gas is important . Therefore this is crucial to make this industry last as longer as possible and give an opportunity to create as much useful products as we can. So oil and gas companies are responsible for maintaining resources and their effective use. More and more attention pays towards companies who flare associated petroleum gas which can be used as energy resource. So this is irresponsible attitude to natural resources. According to the article of WWF 2017 “Problems and prospects of associated gas using in Russia” (Kniznikov, Ilyin, 2017), if oil and gas russian companies use all the associated gas it would mean the annual production of 5-6 million tons of liquid hydrocarbons, 3-4 billion cubic meters of ethane, 15-20 billion cubic meters of dry gas, or 60-70,000 GWh of electricity.

1.5 Existing business models for Circular Economy

For last several decades researchers created several business models (Table 3) which give ideas for companies from different industries how Circular economy can be implemented in their daily activity (Pahomova, Rihter, Vetrova, 2017), (Lacy, 2015).

Table 3. Circular Economy Business models descriptions

Sources: Lacy, 2015; Pahomova, Rihter, Vetrova, 2017

Business models	Description
Circular suppliers	The supplier delivers only the fully recyclable or biodegradable resources that underlie the circular production and consumption system
Resources	It contributes to the elimination of resource losses (waste generation) and

recovery	increases the profitability of production from return cash flows
Sharing platforms	It creates and promotes platforms for interaction between product users, individuals or organizations
Product life extension	The company provides post-purchase-service or improvement of the consumed product due to its repair, modernization, reconstruction or restoration
Product as a service (leasing)	It serves as an alternative to buying a product by providing it for use, for example, through a lease, leasing contract, etc., which increases the incentives for the creation of durable products, the extension of its life cycle

The circular supply chain model is highly important, as if company have renewable, recyclable, or biodegradable materials that makes the perfect base for sustainable products creation. It removes insufficiency. In the Diagram 5, it is shown how this business model is working. Using sustainable resources we create products that can be reused in the future and then can be recycled without harmful effect on the nature.

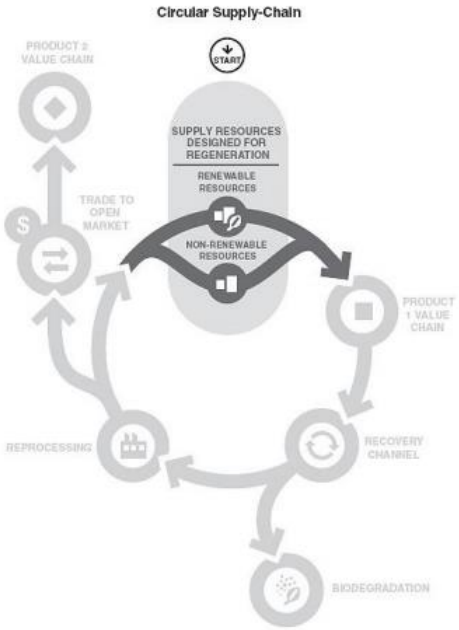


Diagram 5. Circular suppliers business model

Source: Lacy, 2015

Resource recovery business model. This business model can be considered as the most significant nowadays as we already have plenty of products (as devices, clothes and etc) which have clearly limited life-cycle but we can give these products second and third life or new life as material for next products. Organization of platforms as EBay creates opportunities for many goods become desirable by other people. Or some things can be reconstructed towards another

product. This business model gives an opportunity for reduction of price on resources and creates new way how to protect resources.

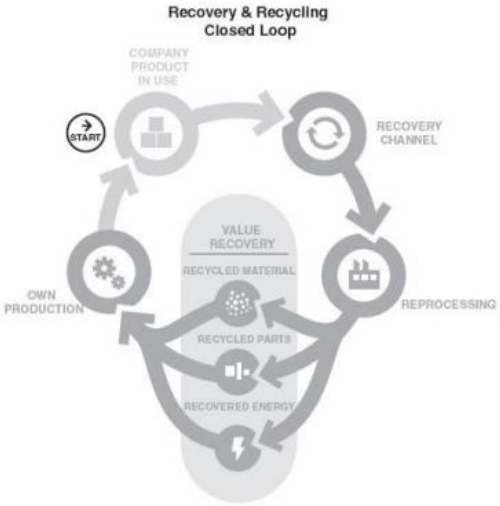


Diagram 6. Resource recovery business model

Source: Lacy, 2015

Creation of the sharing platforms means to create the place where people or organizations can share, trade different goods. There are several global platforms which already exist as EBay, where people can easily buy some phones, TVs or furniture for low price. Actually it is interesting to notice that all these people, who are using EBay, participate in global close loop economy. So all this people subconsciously take care about our planet.

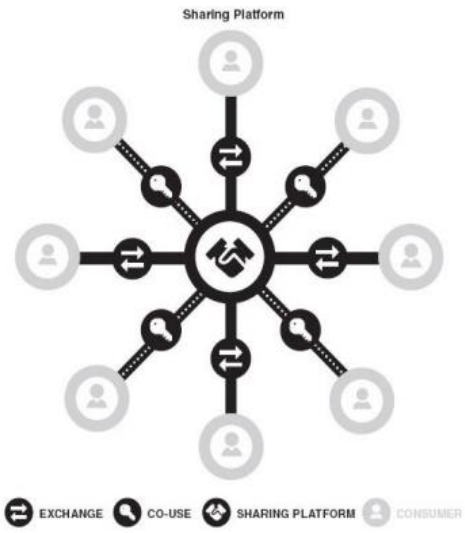


Diagram 7. Sharing platforms business model

Source: Lacy, 2015

In Diagram 8, we can see how The product life-extension business model is implemented in the cycle. Creation of the post-purchase services for consumers increases not only the consumer loyalty but also product life-time, making the lifetime of consumer product longer (time between buying and discarding product). So the main idea of this business model is to extend life-time of the model as longer as it technically and economically possible. It can be made by reselling product, remanufacturing it, and as it was said early to repair it.

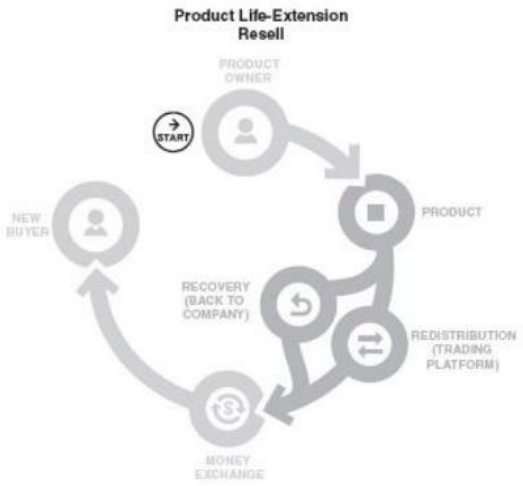


Diagram 8 Product life extension business model

Source: Lacy, 2015

Last but not least, Circular business model that presented on the Diagram 9 suggests to use product as a service. Actually it is really popular nowadays and most of the people do not really realise that they participate in the Circular economy initiatives. Instead of the normal buy-to-own model people start providing service solutions which offers multi-issue value for customers. Therefore this model provide re-use of the products, long-life of the product, as the owner always takes care of this product to be sure that it will have long-life. Using this model company can reduce raw materials, energy usage and waste generation.

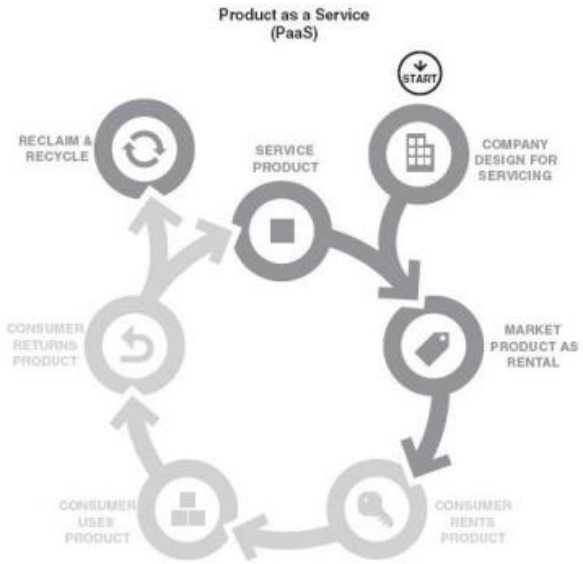


Diagram 9 Product as a service business model

Source: Lacy, 2015

All these business models help us to create customized suggestions for the companies, what they should use if they want sustainable business model. These business models are the basis for the Circular economy Framework that was created by author, Diagram 12.

Chapter 2 Methodology

2.1 Literature review of exists indexes

Circular economy is fast becoming quite popular and this idea has surfaced in a plethora of articles, journals and academic papers. An increasing number of companies have started to develop their businesses based on the Circular economy values. Therefore, there is a demand for tools by which companies can measure their performance in Circular initiatives and benchmarks with competitors in this field. So this the reason why several well-known indexes were created which have the same goal but suggest different vision on the way how Circular performance of the company or industry should be evaluated. Brief descriptions of this method will be discussed in the following paragraphs.

2.1.1 The Material Circularity Indicator (MCI) (Ellen MacArthur Foundation, 2015)

Ellen MacArthur Foundation is the largest organization that provides different initiatives in Circular economy theoretical background preparation, collecting all the existence research on this topic and providing their own projects in this field.

Mac Arthur foundation was the first which decided to create the tools by which the circularity can be measured, gave the method to evaluate the level of the transition of the company towards Circular economy, created indicators can be used for decision making by the entrepreneurs and other purposes as evaluation of the companies, rating them or creation of interim reports.

The Index was mainly focused on the restoration of materials flow and development of Material Circularity Indicator (MCI). All indicators were created for the product and company aims.

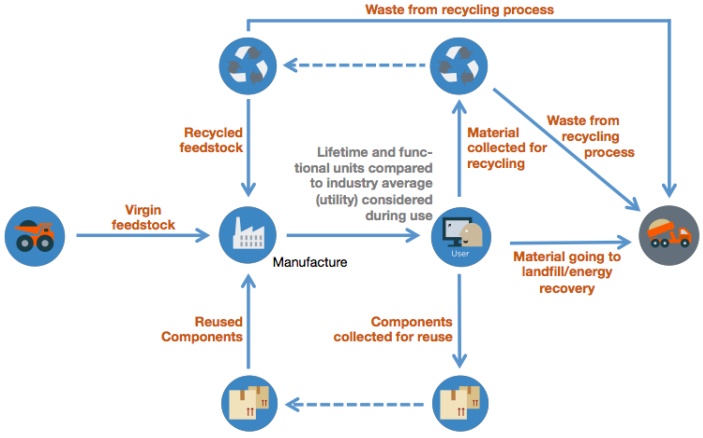


Diagram 9. Materials flow in material circularity indicator

Sources: Ellen MacArthur foundation, 2015

In the Diagram 9, it is clear how the flows in the MCI was made. The MCI itself measures the level of circularity, taking values within [0;1], where 1 is the highest value of Circularity. Similarly, it is constructed from the combination of three products: M – mass of virgin raw materials, W – mass of uncoverable waste , X- length and intensity of the product use. The methodology of the compilation of the Indexes is quite long and it is not necessary for this paper to suggest full description. So we show only the final formulas of indexes.

Total amount of waste generated:

$$W = \sum_x (W_{o(x)} + \frac{W_{f(x)} + W_{C(x)}}{2}) \qquad \text{(Equation 1)}$$

$W_{f(x)}$ - the waste generated to produce any recycled content used as feedstock;

$W_{C(x)}$-the quantity of waste generated in the recycling process;

$W_{o(x)}$ - the amount of waste generated at the time of collection for each sub-assembly, part, and/or material.

The total amount of virgin material al for each sub-assembly, part, and/or material:

$$V = \sum_X V_{(x)} \qquad \text{(Equation 2)}$$

Linear Flow Index

$$LFI = \frac{V+W}{2M+\sum_x \frac{W_{f(x)}+W_{C(x)}}{2}} \qquad \text{(Equation 3)}$$

The methodology of index is mainly based on the material consistency in the final product. The more apt approach in this regard is that if all the losses (from the raw material extraction to refinement to final assembly) considered but it will be too complicated for companies, as this approach is highly detailed and in practice the time period can be limited. Furthermore, when companies have a detailed picture of their materials flow it will be possible to change methodology in a more detailed manner.

2.1.2 The Circular Economy Performance Index (Ruiter, 2015)

Measuring the level of Circularity of business is considered a challenge by many researchers. There were no sustainable indicators which would allow to evaluate how far business from the Circular Economy.

So, Reuter made a pertinent attempt to develop the Circular Economy Performance Index in 2015. The main goal of the index is to suggest businesses useful tool for assessment of Circularity level of business and can be used for benchmarking. There were 25 KPI created for this assessment.

Actually the index was developed in three steps. Firstly it was important to get together all information about Circular economy, all scientific papers, events, organizations and

initiatives; resultantly, Reuter created the Circular Value Framework. Secondly, she analyzed many different Indexes that exist on this topic like the Dow Jones Sustainability Index. It was important to understand the whole picture of Sustainability initiatives that exist and unearth the most apt manner on how to assess Circular economy. Moreover, she conducted interview with experts where they share their views on this topic. Similarly, she wanted to avoid common mistakes among Index developers, when for example, for indexes companies need highly detailed information which they simply do not possess. After that using all knowledge she provides interviews with employers from different companies (and industries).

Thus, having all this inside information- from business side to the academic realms- she created the 25 Circular economy KPI's (Appendix 4) which contains information about circular strategy, circular servicing and circular enablement , as the main topics to evaluate Circular economy level of the company.

Also, the Index created was mainly based on all kinds of circular activities but did not include activities related to the social dimensions of sustainability. Every KPI should be assessed according to this: scale 1) doing nothing or little on sustainability, 2) operating sustainable, 3) operating somewhat circular to 4) completely circular. Furthemore, Reuter divided all 25 KPI on the three most important categories : High Impact (red), Medium Impact (orange) and Low Impact (green). So using all the information every KPI should be counted according to the Scoring Table 4. So as we can see the max score that company can get is 114 and the minimum -57.

Table 4 Scoring Overview

Sources: Ruiter, 2016

Weight	# of KPIs	Score per category				Score incl. weighting				Scores per KPI category			
		1	2	3	4	Min			Max	Min			Max
3 (High)	10	-1	0	1	2	-3	0	3	6	-30	0	30	60
2 (Med)	12	-1	0	1	2	-2	0	2	4	-24	0	24	48
1 (Low)	3	-1	0	1	2	-1	0	1	2	-3	0	3	6
Totals										**-57**	**0**	**57**	**114**

To rank companies according to their performance The Circular performance Ladder was created, where a company was placed according to its Index score. From reading this Ladder it becomes quite clear as to how the company made (or did not make yet) the transition from Linear towards Circular economy.

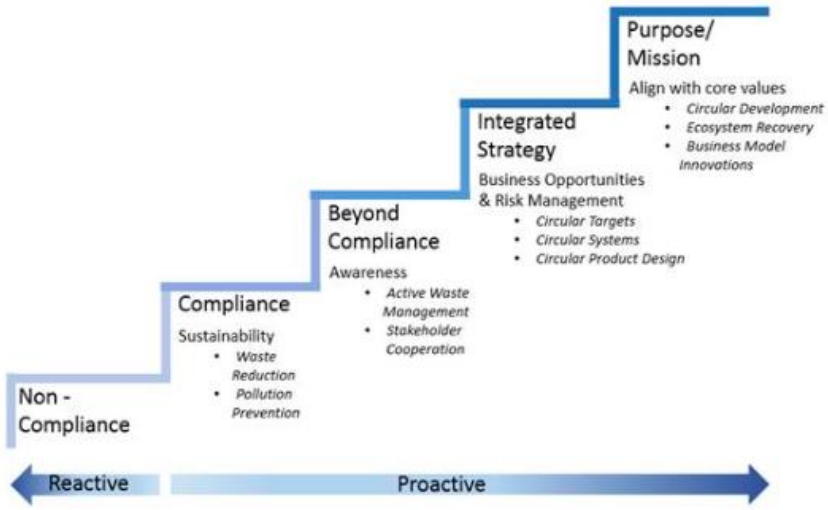


Diagram 10 The Circular performance Ladder for the index levels

Sources: Ruiter, 2016

A company can find its location on the Ladder by comparing with its Index score with the performance steps, as shown in the Table 5. Firstly, we can find companies that never undertake any sustainability initiatives, on the last step there are companies which can be considered as the best example of sustainable companies, which made a transition towards circular economy. The Compliance step shows companies which focus on sustainability but not on the circularity, that means that they have some waste control initiatives, and values of the company integrated with sustainable values but they do not follow any Circular Economy initiatives. Likewise, Beyond compliance, the next step consists of the companies who are aware of the Circular economy theories and try to follow some principles. Companies who are located on the Integrated strategy step are fully into Circular economy values and are aware about all the circular economy opportunities, developing their business according circular economy targets.

Table 5 Performance steps

Sources: Ruiter, 2016

Step	Non-Compliance	Compliance	Beyond Compliance	Integrated Strategy	Purpose/Mission
Credits	-50 - 0	1 - 25	26 – 50	51 - 75	76 - 100

2.1.3 Circular Economy Development Index (Pahomova, Rihter, Vetrova, 2017)

The Circular Economy Development Index (CEDI) was created to reduce uncertainty and assess the current level of development of the circular economy within a single company or in

the industry as a whole. This Index was brought in accordance with the theoretical model of the circular economy of Ellen MacArthur.

The index reflects the main elements that ensure the closure of supply chains, namely, maintenance, reuse, recovery and processing in quantitative indicators of the volume of products and waste for industries. However, the coverage of waste management methods and waste products in the proposed index is more pronounced than in other similar models, as it goes beyond the management of only solid municipal waste. Due to this, the possibilities of using this index for evaluation were being expanded, which can be carried out at the level of both the individual company and the industry. Since all methods of handling waste and end-of-life products have a different impacts on the resulting social, economic and environmental effects inherent in the development of the circular economy, each of these methods was assigned a weighting factor in the formation of the index, depending on the achieved savings in resources, profitability.

$$CEDI = \frac{(L \times i_1 + R \times i_2 + M \times i_3 + C \times i_4) \times 100\%}{W} \qquad \text{(Equation 4)}$$

L – volume of products that have been serviced (tons or monetary units); R - volume of reusable products (tons or monetary units); M - volume of recovered products (tons or monetary units); C - volume of processed products and waste (tons or monetary units); $i_{1,2,3,4}$ - weight coefficient of the applied method of waste management and waste products for industrial sectors; W - the total volume of industrial waste and decommissioned products (tons or monetary units).

The weights for the indicators used in the construction of the index are determined based on the priority of a particular waste management method that is consistent with the principles of the circular economy, and also taking into account their environmental and economic advantages.

2.2 Methodology of Circular economy index creation

2.2.1 Index creation

The methodology for creating an index can vary significantly, there are many ways to create it. The author decided to adhere to the Analytical Method, when an in-depth analysis of the the topic was conducted.

This index is quite apt to be used in the oil and gas industry. The author of this work has more than three years experience working with this subject and there are publications in journals from the list of VAK. Accordingly, extensive experience in the oil and gas industry the index was created. In addition, the main works on Circular Economy were studied, by integrating experience and obtained knowledge, index was created on the basis of economic logic. Further,

to adjust the index it was decided to use the method of expert assessment. After receiving the expert evaluation, the index will be checked on historical data to confirm its validity and reliability.

The creation of the Index will take place in several stages:

Stage 1. Study of theoretical material on the Oil and Gas Sector, the Circular economy and the theory of index creation;

Stage 2. The construction of the elements of the index, based on the material studied;

Stage 3. Conducting an expert survey;

Stage 4. Analysis of expert assessments and adaptation of the index;

Stage 5. Index calculations for companies.

2.2.2 Expert assessment

An important point is the methodology of the Expert Survey. Presently, there are many different methods for assessing the expert opinion, since this method is in great demand when making managerial decisions. Expert assessments method is using to find the probabilities of the emergence of problem situations, assessments of the significance of the characteristics (from the standpoint of which the solutions are evaluated), the competence coefficients of experts, and the estimates of alternatives on various grounds.

Since most economic decisions are made in the conditions of uncertainty and incompleteness of information, in this case, expert evaluations are the best solution.

Thus, any problems and issues can be assessed, where the expert can express her opinion. Weights are usually specified on a scale from 0 to 1 so that their sum is 1. If the weights of the characteristics are presented in another quantitative scale, for example 100 points, then the rationing procedure is applied.

The expert assessment for this paper was decided to be conducted in several stages:

Stage 1: Selection of experts

The selection of experts is a key step in the process of making group decisions. It is quite obvious that experts should be qualified specialists competent in the issue under consideration who can make an adequate decision.

Step 2: Create a survey (interview guide)

The survey consists of questions about both personal information and questions about index (about significance of the variables).Each expert will need to assess the significance of each variable presented, quantitatively, in the range from 1 to 100. To simplify the solution, the experts will be presented the division of the main interval, into seven shorter ones with their qualitative and qualitative characteristics.

Step 3. Provide an assessment.The assessment will be conducted using the "Delphi Procedure" method. The famous iterative expert procedure Delphi developed in 1964 by Norman Delki. The main characteristics of the procedure:

1. Anonymity of opinions of experts;
2. Participation of all experts;
3. Adjustable feedback;
4. Group answer, which is obtained using statistical methods and displays the generalized opinion of the examination participants.

Experts who gave extreme answers, if they did not agree with the group response, gave a written justification for the chosen value and why their divergence was so great with the group's opinion.

After providing assessment and got all the answers the author needed to evaluate all the answers and get the final result - rating.

2.3 Data

In this paper, both secondary and primary data will be used. Primary data, in the first group, was gathered from the expert and in-depth interviews and consisted of the individual ranking of variables which have been got from experts.

Deep interviews are a series of individual interviews on a given topic, conducted according to the discussion guide. The interview is conducted by a qualified interviewer, who is well versed in the subject, and is well-equipped in the technique of conversation. Each interview takes place within 30-40 minutes and is accompanied by an active participation of the respondent. In-depth interviews, unlike the structured ones used in the quantitative survey, allow deeper penetration into the respondent's psychology and better understand his point of view, behaviour, attitudes, stereotypes, and so forth. Deep interviews, in spite of the long time duration (in comparison with focus groups), are very useful in situations where the atmosphere of group discussion is undesirable.

The survey will be conducted using the Delphi method (one iteraction), in which their anonymous responses are collected over interview, and through a review of the intermediate results, a group assessment of the process is obtained.

Secondary data. To estimate the index, secondary data will be used for different companies. Various annual and sustainable companies reports have been used. Many different articles that provides rating of countries and companies have been used as well. Moreover, in this paper many databases were used as World Bank Data, Eurostat, OECD stat and Thomson Reuters.

Chapter 3 Circular economy Index for Oil companies

In this paper, it was decided to develop an index, CEOG (Circular economy at Oil and Gas sector). The purpose of this index is to determine the possibility of introducing the principles of the Circular economy in oil and gas companies, with different levels of vertical integration (upstream, downstream, midstream). The basis for the index are the main economic principles, as well as business models created by such researchers as Ellen McCarthour.

For index creation, it was necessary to determine main elements in the index and, then provide interview with a group of experts from the economic sphere to confirm the significance of all the index elements (the in-depth interview was provided), as the next step to determine a sample of countries and companies, to calculate the Index for these companies, to test the quality of the index and if the results are logical or not. To comply with the methodology of the index, it is necessary:

- That the index will include all the economically significant elements that affect the process of transition from Linear to the Circular economy, taking into account the specifics of the industry;
- Also, it is necessary to take into account the dependence of the variable and index (direct or inverse) or take into account only the absolute value of the element;
- Expert evaluation should be independent;
- It is necessary to determine the scale of the index and ensure that it fully fulfills each element;
- The index should reflect the reality when it is evaluated on historical data.

When all these standards are taken into account, the index is considered correct and ready to be used. This index is based on the country's macroeconomic indicators, as well as the company's economic indicators. Both external indicators and internal ones will be used. The work decided to use the Down-top metho, where we first describe the entire process of creating an index, characterize each variable and their correlation, and then compose all variables into one index. As the next step the results of “in-depth” interview with experts will be presented as well as an evaluation of quality and significant of elements of index.

The final step is to make the index adjustments, taking into account the opinions of experts, historical data and choose the best form of index. After determining the main variables, according to the author's expertise, as already mentioned, it was decided to create a deep survey of experts on the importance of variables. For the interview, a short case with brief explanations of index details was created as presented in Appendix 1. To complete this index, it is necessary

to determine the intervals of values, which will be done by calculating the index for several representative companies from different countries and check if the results correspond to the principles of economics and logic.

3.1 Frameworks

This section with deal with the important arguments for selecting variables that are considered as potential index elements. The author decided to create two frameworks, which are not the result of the main goal of this work, but a by-product, which does not entreat their contributions to the development of this topic. The frameworks created are the result of a long research and analytical work of the author, who tried to unite all the acquired knowledge and experience. The first framework displays a complete system of elements of the oil and gas sector, while the second describes all areas of work in the circular economy. Also, it should be noted that these frameworks are not specific and do not limit the range of directions for working with them (the framework for the oil and gas sector is not limited to the work of the circular economy and the reverse is also true), they can be characterized as complete and general frameworks.A detailed description of these frameworks is presented in the following section.

3.1.1 Oil and Gas framework

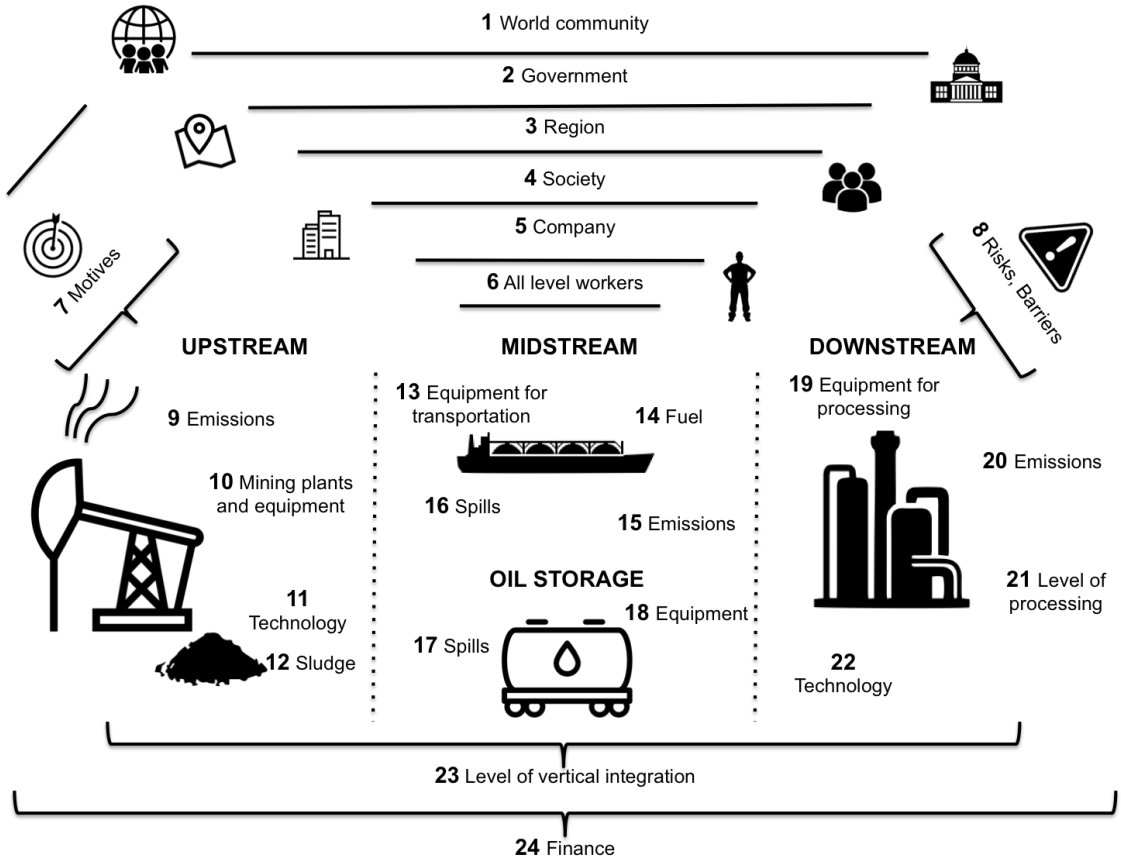


Diagram 11. Oil and Gas industry framework

Source: created by author, 2018

This framework, as it has already been mentioned earlier, is general in nature, not specific, and is useful for business decisions. In this framework, the whole functioning of the oil and gas sector is displayed, but it does not have a technical, economic or political inclination, it is not included in the range of tasks addressed by this framework.

1. The author undertook to list the goals for which the given framework can be used. To study the oil and gas sector as a whole. In this case, each of the elements requires division into sub-segments, depending upon the direction of the training;
2. Conducting various business evaluations, assessing the prospects for development or finding bottlenecks. This framework can be used as a "road map" for research, that would consider all the parts and not miss anything;
3. Solutions of business cases for the oil and gas sector, which guarantees full coverage of all directions.

It is worth noting that this case does not explain the technological fundamentals, and does not take into account all the nuances; each element can be divided into many others. Nevertheless, as the framework is considered quite detailed, further detail is considered unnecessary and is only given in the comments to the framework.

Brief characteristics of the framework's elements are:

1) World community

   Includes the three main elements

   - World standards of regulation;
   - Oil and gas companies (OPEC);
   - World trends.

This element takes into account the influence of the world community on this sector, as there are ongoing changes in the regulatory conditions (processing level, CO2 emission limit). Also, there are various associations with their restriction (restriction on extraction). Here it is necessary to take into account the trends that occur not at the legislative level, returning to the subject of this work, the widespread distribution in the European countries of the Circular economy strongly influences the developing countries because to figure on global platforms it is necessary to correspond to the values of consumers.

2) Government - it includes two main elements:

   - Level of development of the country, its institutions, quality of investment and business environment, and the level of corruption;
   - State regulation within this sector: taxes, subsidies, standards and so forth.

This element takes into account the impact of the conditions of existence of the company (industry) within the country. Do not neglect the qualitative indicators (the level of corruption,

the level of democracy), since the oil and gas sector is quite sensitive to the conditions of the country, since for the most part the largest oil and gas companies are state-owned, as well as bordering on the high cost of fixed assets, a long period of return on investment and so on.

3) Region - this element takes into account the peculiarities of the region, the special features of the region's constitutions and any other specifics (many regions can submit their demands for purification).

4) Society - this element takes into account the influence of society on the activities of the oil and gas sector. In this case, it is possible to take into account various initiatives of this kind, such as speeches, rallies, which entail changes in the legislation and the general norms of society and values.

5) Company - under this category we take into account everything that is not related to employees and financial components. That is, they are company values, certain rules, technical components and everything else that is not taken into account in other variables.

6) All the workers. This determines all workers and what is connected, the amount (what the company characterizes), training, the proportion of highly qualified personnel and so forth.

7) Motives. This paragraph determines what motivates the company's activities, finance, brand, social assistance and other factors.

8) Risk/Barriers. This parameter obviously speaks about all the problems that the company meets on its way. In particular, this includes the company's competitors and the problems associated with it.

Upstream

9) Emissions. All types of emissions that are obtained during extraction. Both in the atmosphere and in the hydrosphere (air pollution, CO2 emissions, APG flaring, groundwater pollution).

10) Mining plants and equipment. This provides all the relevant information about equipment, installations, the number of years in use, repairs, what happens after the completion of the development of the field and so forth.

11) Technology. All the technology that is used in mining, with waste disposal (effective use of associated gas, production rate).

12) Sludge. Sludge is also a big problem for mining companies, so everything related to the methods, the level of slurry processing is taken into account in this paragraph.

Midstream

13) Equipment for transportations - what type of transport does the company use to transport oil and gas products.

14) Fuel - what type of fuel (and its quality in terms of a sustainable economy) is used by the company in its transport for the transportation of oil and gas products.

15) Spill - how often spills occur and how the company fights against them, and how effectively.

16) Emissions - which waste is produced as a result of transportation.

Oil storage

17) Spills - during storage, oil spills can also occur (especially from tankers). It is observed that how often does this happen and how do they deal with this.

18) Equipment - what equipment does the company use to store oil and gas products?

Downstream

19) Equipment for processing - what equipment does the company use to process oil and gas products. The age of the equipment, the country of production, how it is serviced and other parameters.

20) Emission - what kind of contamination is produced during oil refining.

21) Level of processing- level of oil refining.

22) Technology - what technologies are used for processing, what is the ratio of output of products with different processing levels (light oil, bituminous oil, fuel oil and so on).

23) Level of vertical integration - is the company vertically integrated and what level of integration has been attained by the company.

24) Finance - it includes all financial indicators

25) Currency - what is the currency, what is the ratio of this currency to the US dollar.

3.1.2 Circular economy framework

This framework will be significantly different from all the well-known frameworks created by Ellen MacArthur foundation, presented in the theoretical part of this work. This framework is aimed at describing the overall business models in Circular economy. The framework obtained in this work is more of a guide to the company, a road map of which of the business models consists of a circular economy. Using this framework, the company will receive the full range of initiatives.

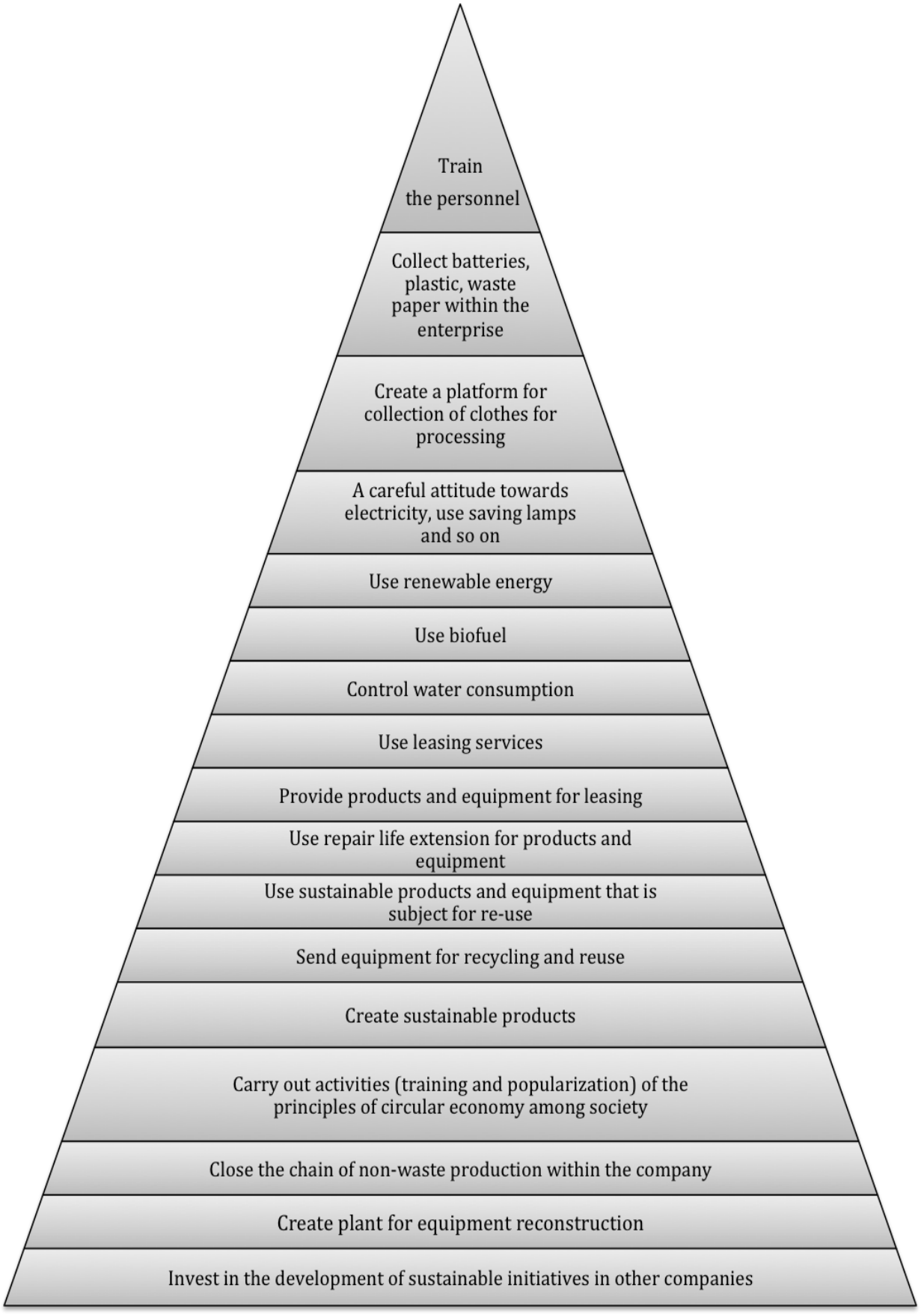


Diagram 12. Circular economy framework

Source: created by author, 2018

3.2 Index variables

In this part, the presented integration of the received framework, and an explanation of why it was chosen to concentrate on certain directions and listed all the selected variables, which in the future will be evaluated by the level of significance by the selected experts.

The most important variables identified were: finance, technology and state influence. Finance in the first place will respond to the financial condition of the organization, the volume of fixed assets and the ability to invest. The transition from the linear economy (especially in the oil and gas sector, which in itself is the ancestor of the linear economy) to the Circular economy is not an easy; it is long and an expensive process at certain stages- a long payback period (return on investment). Accordingly, to implement these initiatives, the company must first have a stable financial position and secondly have a free flow of funds that can be invested in the development of the principles of the Circular economy.

The technological component characterizes the current situation of the company, its basic level, as some principles of a closed cycle already work for some enterprises, or the company owns a high level of manufacturability, updates equipment and so on. In this case, the company is, of course, more flexible and easier to change and innovate, which of course will help the Closed-loop Economy or Sustainable Initiatives.

The influence of the state has two constituents, first it is the initial level of the country's development, institutions, investment attractiveness, the level of the country's irrationality and, secondly, state initiatives and laws that contribute to (or impede) the realization of the circulatory economy. For the purpose of this study, it was decided not to take into account the international factor, since the index is intended to assess companies, it is possible to compare them, accordingly, the world community has equal influence (within a certain level of significance).

For the level of risks and barriers, it was decided not to use an additional or specific index, since in some measure it will be taken into account in the state element (level of institutions) and in the ratio relative to finance (in the case of a stable state, the risks are lower).

Point of Motivation, will display the Brand parameter (where the company's propensity to invest in brand and reputation), as well as the financial component of the index, will be reflected, since in one way or another it will reflect the financial interest and influence of the state (the requirement to fulfil certain principles at the state level), and so both within the framework of this work and after studying the features of the circular economy - these are the three most important reasons why companies resort to such changes, then this is enough.

It was also decided to neglect the Region parameter, although some regions also present certain legislation and requirements to companies, but this is not considered to be so significant.

Society and all types of workers, although they have different influence in meaning, but the same mathematical. Therefore, it was decided to use a similar indicator (and use it to some extent as a unified level of awareness.) Awareness of society encourages the introduction of a circular economy due to the brand and pressure on the company (various public organizations), as well as the state, which in turn If the society knows about the circulating economy, the higher the pressure and the more it affects the company. Awareness of workers makes it easier for companies to train workers and explain changes to them.

Upstream, Midstream, Downstream and Storage – these are important components that will be interrelated with the level of vertical integration. The coefficients for each type of activity are decided to be made unified (not to separate technologies, equipment). Further explanations will be given below in the variable description format.

Below are all the elements of the index with a brief characteristic.

1. **Level of development of institutions – r (level of development of institutions)**

Variable characteristics:

Level of development of institutions was decided to determined by the existing ratings made by the World Economic Forum. The Corruption perception Index or Global Competitiveness Index were used. The ratings provide for most of the countries. The maximum value of index is 7 and the minimum is 0. In the CEOG Index this parameter is included as: (Global Competitiveness Index) /7.

This index was decided to be used as an indicator of the health of the national economy. Since with a strong concentration of government attention on the resource sector this leads to such consequences as, inertia of the sector (the difficult introduction of new technologies) which goes hand in hand with "cherry-picking" (The method of extraction, when only highly profitable and high-quality oil is extracted, for which complex technologies are not required). These consequences characterize the participants of the industry, in such a way that they choose a smaller income with minimal investments now, the greater the return in time with the larger investments later. Such a philosophy of the industry is also obtained under the influence of the high riskiness of investments in a given country and uncertainty / uncertainty in the future.

Impact on the index:

This variable is a macroeconomic component that reflects the external conditions of the company's existence. For example, if a company operates in a stable state, stable state support, a well-established credit system and in stable economic conditions, the introduction of any innovations is much easier, since the payback period of investments in ten years is not something new.

While, if the company exists in a third world country, where, besides an unstable economic situation (unstable currency, high interest on loans), an unstable political situation (change of leaders, changing the rules of the game in the market, the presence of ruling elites), this leads to risk-averse behaviour, and the desire to get the return on investment as quickly as possible.

2. Circularity of the country - C

Variable characteristics:

This variable reflects the level of circularity of the country. What does this mean? To what extent public policy, the general business atmosphere promotes the introduction of such initiatives, this variable has some overlap with another indicator that reflects Russian laws on the level of processing. But in general, this coefficient can be considered self-sufficient, since it does not only take into account the policy of the state, but also the behaviour of other companies, and competitors.

In determining this indicator, there were several ideas, but it was decided to focus on using the already available "Circular Economy Development Index" CEDI (Pakhomova, Richter, Vetrova, 2017). This index is calculated for Russia and Germany (6 and 55% respectively), but with the available methodology, the data index can easily be calculated for other oil and gas countries.

$$\text{CEDI} = \frac{(\boldsymbol{L+R+M+C})\times\mathbf{100\%}}{\boldsymbol{W}} \qquad \text{(Equation 4)}$$

where L - is the volume of output that has been serviced (tons or money units); R - volume of reusable products (tons or monetary units); M - volume of recovered products (tons or monetary units); C - volume of processed products and waste (tons or monetary units); $i_{1,2,3,4}$ - weight coefficient of applied method of waste management and waste products for industrial brancheš; W - is the total volume of industrial waste and products that are out of operation (tonnes or monetary units).

Impact on the index:

This index in the model will be applied within the limits of [0; 1] (not as a percentage). The index characterizes the level of development of the circular economy, respectively, the higher the ratio, the higher the index.

3. Brand focus – B

Variable characteristics:

This variable is internal and displays company preferences. The meaning of the variable is how important it is for the company to maintain the brand, its perception by consumers and partners, namely brand image. For example, if the company's activity is strongly influenced by

the perception of brand by consumers as sustainable brand, then this variable is significant for this company, and therefore should be included in the index. How it works?

The introduction of circular economy in companies is an image component of companies (especially in the Russian reality), which reflects the values of the company and raises its rating in the eyes of consumers and partners. Most (especially Russian) companies introduce initiatives first of all, to make a certain impression that they care about nature, and then about the benefits of introducing a close-loop economy (which of course is sometimes also a motivation). Accordingly, when the company values its brand and is ready to implement initiatives, to increase the rating, it means that there is an additional incentive (strong enough) for the introduction of the Circular economy.

The indicator has been decided to present, as the average share of advertising costs, PR and other costs of increasing brand recognition and perception in total operating costs (or variable costs) for the last 15 years by the time the coefficient is calculated.

$$B_i = \sum_j \frac{C_{ij}}{VC_{ij}}/N \qquad \text{(Equation 5)}$$

where Cij - is the cost of the year j for advertising in company i; VCij-variable costs of the company i years j; N - is the number of years.

It is accepted not to use all the costs in the denominators, but only operational ones, since the oil and gas industry is characterized by rather high equipment costs, which will distort the picture, therefore it is important to look at the share in variable costs.

It is planned to add a coefficient to the parameter, which the company can evaluate in a detailed manner (for example, if the very purpose of the company, the introduction of a closed-cycle economy, is to create a sustainable brand, then it is worth adding a greater factor, if the company knows that it spends significantly on advertising, but in the long term, this became irrelevant and the reason for introducing the circular economy is quite different, then we need to add the weight j∈ [0; 1) (in case of weight zero, the company wants to completely abandon such influence).

Impact on the index:

This index reflects the company's interest in brand development and reputation creation as a sustainable or / and social responsible company, which significantly increases the attractiveness of the introduction of this economy and increases the likelihood of success. Accordingly, this indicator enters the model with a plus sign having a direct relationship with the index (the higher bij the higher the index).

As it mentioned earlier, the variable enters the model with a coefficient that the company determines expertly (within the given limits).

4. **A. Circular economy awareness – aw**

Variable characteristics:

This variable characterizes the level of the Company's level of Circularity (which also takes into account the level of awareness of the personnel). This index is difficult to obtain. This view of the modified Circular Economy Index (CEI) (Ruiter, 2016), which in its original form requires the company to collect information on 25 KPIs in accordance with the results, the value is from 1-100. Information on the wording and methodology is provided in Appendix 4 Of the proposed 25 KPI's, 12 of them were selected, which makes sense to evaluate. When answering, the company will be asked to answer the proposed questions for each KPI, which determines the degree of circularity of the company (no circularity, at the initial stage, development, advanced stage), the values are assigned (0, 1, 2, 3, respectively) . In the original index of the company, it is also proposed to assess the degree of importance of KPI, which was also decided to simplify. So the value of the index varies within [0; 36], so it was decided to represent the value of the index as a function of CEI / 36.

Impact on the index:

This variable will be normalized within [0; 1], accordingly it will reduce the overall size of the index, but the higher the variable, there is less index reduction, which in general does not contradict logic, as the higher the variable, the better for the company.

B. Circular economy awareness – as * this variable is recognized as excessive

Variable characteristics:

This variable will be counted by polling a sample of the population in several cities, people will be asked if they know what the Circular economy is and whether they apply any principles of a closed economy.

Impact on the index:

This element also reduces the overall index, but the greater the awareness, the less it reduces.

The following 3 indexes are aimed at assessing the quality of the company's activities and its willingness to introduce new technologies, as a rule, companies characterized by high indicators of available technologies are more prone to transition to a circular economy.

5. **Variable Upstream - A_u**

Variable characteristics:

This indicator is created for companies that are engaged in oil production both onshore and offshore. The main goal of the index is to determine the technological readiness and the

company's prospects for the transition from Linear to the Circular Economy. One can select the main three indicators that can perform this function:

- Percentage of effective use of APG (associated gas)
- Percentage of effective use of sludge
- Depth of oil production

The easiest to use is the percentage of effective use of associated gas, the values of which are presented in the annual WWF study. The depth of production is too difficult to track, as this affects the quality and characteristics of the field and the composition of the oil.

Impact on the index:

This coefficient will be normalized within [0; 1], where 1 means that all associated gas is used efficiently, and 0 means that the company burns all produced associated gas. The coefficient itself contributes to the index and has a direct relationship (the higher the ratio, the higher the index). Data can be taken from official sources or provided from its own reports. Appendix 7 presents data for 12 Russian companies.

6. Variable Downstream- A_d

Variable characteristics:

This indicator refers to those companies that are engaged in oil refining. The main goal of the index is to determine the technological readiness and the company's prospects for the transition from Linear to the Circular Economy. The main indicator for describing the manufacturability of companies of this type is the depth of processing that the company achieves. Also, this indicator can be determined by the proportion of high quality products in the total proportion of products created.

Impact on the index:

This coefficient will be normalized within [0; 1], where 1 means that oil is not completely processed into the cleanest product, and 0 means that oil is not processed at all. The coefficient itself contributes to the index and has a direct relationship (the higher the ratio, the higher the index).

7. Variable Midstream - A_m

Variable characteristics:

This indicator is created for those companies that are engaged in transportation of oil by different types of transport (tankers, cars and so on). In this case, there are several parameters that can show if the company is ready for the transition towards the Circular economy. Firstly, the main problem of companies when the they provide transportation of oil - the oil spill. The second problem is that most of the companies do not use environmentally friendly fuel - biofuel. It is necessary to take into account these issues, to understand the company’s technological level.

It was decided to create a questionnaire for the company, questions are drawn up so that answers to questions will help to understand the technological level of midstream sector of particular company. The questionnaire can be found in the Appendix 8.

Impact on the index:

This coefficient will be normalized within [0; 1], where 1 means that all answers to questions were positive, and 0 means that the answers were negative. Has a direct impact on the index, the higher the number of positive answers, the higher the final contribution to the final index.

8. Variable Storage - A_s

It was decided not to use this variable, as it is considered as not significant.

9. The level of the vertical integration of the company

Variable characteristics:

This variable helps to take into account the type of company involved, whether it is engaged in production, transportation, storage, processing, or all together. To do this, we use the well-known mathematical function indicator.

IA(x) is an indicator function (membership function), a function defined on the set X that determines the membership of the element x in the set A ($x \in A$), takes the values 1 in the case of membership and 0, if not.

In this case, we will use the indicator on the sets U, M, D,, where U is the set of companies dealing with upstream, M-set of companies dealing with midstream, D- a lot of companies dealing with downstream.

I U, M, D (x) – This feature level indicator of integration of the enterprise, which takes the value 1 if the company belongs to one of the sets: U, M and D. It is important that this indicator will face variables related to one of the industries (Upstream, Downstream, Midstream), that is, if the company is from upstream, then the variable contributes to the index, if not, it is simply reset. If you look at the diagram 11, it becomes clear why you need to do this, the work process and components of these industries are completely different, accordingly it makes sense to distinguish between these variables. It is important to note that some companies are vertically integrated, then we understand that a company may have some or all of the indicators equal to 1.

Impact on the index:

This indicator is an auxiliary one, which allows us to introduce indicators of technical equipment of Au, Ad, Am in the formula. Thus, the indicator of the level of vertical integration

is a coefficient for the indices Ai, where i∈ [U; M; D]. The indicator takes the values 1 and 0, respectively, should not be a denominator.

10. **Financial indicators (complex variable)**

Variable characteristics:

The purpose of this parameter is to reflect the financial viability of the company, to show that firstly, it has enough funds to support current activities and secondly, there is FCF for future investments. That is, the variable that consists of two parts. As a measure of the company's financial stability, it is logical to use the widely known ROE and ROA (average for 5 years, as it will exclude extremes) from Thomson Reuters database.

In this case, it was decided to use the function max {ROE, ROA}, as this will help to reflect the strong side of the company.

The second indicator is much more difficult, as it is necessary to understand the company's potential for investment, it can be both an analysis of current investment activities and an analysis of the availability of free funds for investment. The most suitable indicator in this case can be considered the monetary return on capital: Monetary profitability of capital (Rf) = free cash flow (for the current period) / invested capital (average for the last 2 years).

What does this indicator give us?

Initially, it was clear that it was important to take into account the FCF, that is, the cash flows that do not participate in the current maintenance of the company's activities and can go either for dividend payments or for investment. But the problem is that the absolute value of FCF by itself does not tell us anything about the company, without taking into account the size of the company, investment activity and so on. Therefore, we need to consider this variable relative to another parameter, which will show that on an enterprise scale, these cash flows are sufficient or insufficient to implement any initiatives. Therefore, it was decided to refer the indicator to the investment capital of this company. To investment capital, as it shows whether there is enough cash flow relative to the company's ordinary investments.

Impact on the index:

This indicator is an independent term and is in direct relation to the index, the higher the coefficient, the higher the value of the index.

11. Government Law and World community Law

It was decided to remove this indicator from the index, since part of its influence was taken into account in the factor of quality of institutions and the factor of circularity of the economy. It is also worth noting that most of laws are of a recommendatory nature, that is why it should not be regarded as a significant factor.

12. Size of the enterprise - S

Variable characteristics:

There were two variants on how to determine the size of enterprise by counting personnel, or taking into account the geographic dispersion of the company, which is especially important for extractive companies, since more deposits in the account of companies, more problems it creates to manage the company. But it is Impossible to use both variables the same time as they obviously have a very high correlation.

Preference was given to the variable expressed by the number of employees. There were several reasons for that, firstly, this indicator, in addition to the complexity of implementing initiatives due to the size of the company and, accordingly, the lack of flexibility, also takes into account the fact that more the people, the harder it is to change mindset and train staff (and top management). Secondly, the logic of rejecting a variable that reflects the number of deposit was that the more deposits, the more difficult to implement, but in this case there is another factor that the more deposits, the higher the investment potential of the company, which will contradict the assigned role for this variable.

Impact on the index:

The variable will be qualitative and quantitative, where the coefficients of the company's number of staff will be assigned coefficients.

It is logical to assume that larger the company, the more difficult it is to implement the principles of the Circular economy, both in technical and managerial terms. Therefore, this coefficient will be inversely related to the index.

Table 6 Firm size gradation

Source: created by author, 2018

The name of the group	Amount of workers	Value of a variable
micro enterprise	<100	1
Small enterprise	100-250	0,95
Middle enterprise	250 - 5000	0,9
Big enterprise	5000-10000	0,85
Large entreprise	>10000	0,8

3.3 Index

Providing the whole analyses of the variables there were chosen ten appropriate ones for this index. These are the obtained mathematical form of index (fully created by the author):

$$\mathbf{CEOG_i}=\left(\frac{\sum_i (\boldsymbol{I_i}(x)\times \boldsymbol{A_i})}{\sum_i \boldsymbol{I_i}(x)} \times \boldsymbol{S} + \mathbf{max}(\boldsymbol{ROA};\boldsymbol{ROE}) \times \boldsymbol{Rf} + \boldsymbol{a_w} \times \mathbf{B} \times \mathbf{C}\right) \times \mathbf{r}, \quad \text{(Equation 6)}$$

where

$I_i(x)\begin{cases}1, x \in A_i \\ 0, x \notin A_i\end{cases}$, where $i \in \{U, D, M\}$

$b_j = \Sigma_i \frac{Cij}{VCij} \Big/ N$ (Equation 5)

where C_{ij} - is the cost of the year j for advertising in company i; VC_{ij}-variable costs of the company i years j; N - is the number of years.

$C = CEDI = \frac{(L+R+M+C)\times 100\%}{W}$ (Equetion 4)

$a_w = CEI/36$ (Equation 7)

The index (Equation 6) is divided into three elements, technological part, finantial part and awareness part - all these parts of index will be explained more detailed further. Further steps that we need to assess are the significance of every included variable, determine with experts' help the weight of every index element.

Chapter 4 Index practical implementation

In this chapter firstly it is important to involve external assessment tools to understand if all the chosen variables are objectively included in the index and it is also important to weigh all the variables. Secondly, we should not forget to challenge index on historical data and relying on the data created in the index intervals which helps companies to understand the Index value. Moreover, as one of the goals of this paper to create a proper roadmap for companies managers for oil and gas industry there will be recommendations regarding the future steps the companies should take according to their index value.

4.1 Index assessment

This index was created based on an analytical study of the oil and gas industry, as well as the foundations of the circular economy and its existing application experience among companies. Some variables relied on data, but the calculation methodology was still determined based on the subjective evaluation of the researcher's goals for the index itself. Accordingly, it was required to determine how to evaluate the quality of the index. It was decided to use two methods, the first method is to calculate the index for representative companies with different level of Circularity and the second way is to attract outside experts.

Expert method of assessment is one of the most popular methods, both in Russia and abroad. It is used in cases of specific issues where special competencies are required to understand the problem. This is also almost the only way how to assess model in the case of limited data availability. This method is used to obtain quantitative estimates of qualitative characteristics and properties. The following is a detailed description of the expert evaluation.

4.1.1 Methodology of evaluation

In the practice of examination and forecasting, both individual and group (collective) expert surveys are used. In our case, the individual is preferable, because we need to understand the personal opinion of each of the experts on the issue posed from his experience, rather than engaging in discussions. The main objectives of using individual expert assessments are:

- forecasting the development of events and phenomena, as well as assessing their significance in the current period;
- analysis and synthesis of the results submitted by other experts;
- drawing up scenarios for the development of the situation;
- conclusion about the work of other specialists or organizations (reviews, examinations, etc.).

In our case, experts will evaluate the significance of the elements, which corresponds to one of the appointments of the expert survey.

The experts assessment is listening and writing the answers. Carrying out assessments is the main stage of modern work with groups of experts. At this stage, the following procedures are performed:

- solution of organizational and methodological issues;
- statement of the problem and presentation of questions to experts;
- information support of the work of experts.

The type of questioning essentially determines the type of the peer review method. The main types of interviews are: questioning, interviewing, the "Delphi" method, brainstorming (brainstorming), discussion.

The choice of this or that type of survey is determined by the objectives of the assessment, the essence of the problem being solved, the completeness and reliability of the initial information, the time available and the costs of conducting interviews.

In this case it was decided to choose the type of interviewing. Interviewing is an oral survey conducted in the form of a conversation-interview. To prepare the interview, the interviewer develops questions to the expert. A characteristic feature of these issues is the possibility of a quick response to them by an expert, since he has almost no time to think about. Subjects of the interview are reported to the expert in advance, but specific questions are posed directly during the conversation. It is advisable in this connection to prepare a sequence of questions ranging from simple and gradually deepening and complicating them, but concretizing at the same time. The advantage of this method is a continuous live contact with the expert, which allows you to quickly get the necessary information through direct and clarifying questions depending on the answers of the expert. Disadvantages of the interview are the possibility of a strong influence of the interviewer on the answers of experts, the lack of time for deep reflection of the answers and the high costs of interviewing the whole team of experts.

The interviewer should know the problem thoroughly, be able to clearly formulate the questions, create a relaxed atmosphere and be able to listen patiently. The decision was to focus specifically on interactive interviewing. First, interviewing allows for live communication and explanation of incomprehensible moments, which greatly simplifies the work of experts and shortens the time spent.

Having decided upon the type of expert assessment, it is important for us to create a Questionnaire Form, conduct a survey and evaluate the results of the survey. The main purpose of the examination was to assess the significance of each element of the index to determine which of them to include in the index, and having the significance levels weighed to weigh the

contribution of each variable to the resulting index. In spite of the fact that the interview was conducted live in Blank survey (Appendix 1), a case was included, which briefly described the topic of the issue, as well as the conditions for conducting the survey and recommendations for the successful completion of the survey.

Further, experts were asked questions on their competencies, to show that each expert is sufficiently competent to be included in the resulting pool of experts. And then it was suggested that they answered 10 questions.

The main survey includes quite modern methods, which are increasingly used by Western researchers - including both figurative and logical thinking of experts. Since experts need to be assessed quantitatively (allocating each variable to one of the 7 intervals divided by a segment from 0 to 100, where 100 is the maximum value and 0, lack of significance), then to help them, a scale is attached to each question, highlighted by a gradient and the expert, turning to his sensations, chooses that level of colour that, in his sensation, better reflects the significance of the variable. Further connecting already analytical thinking, the expert corrects its value on the numerical value of the selected interval and on its verbal description. Thus, we include both hemispheres of the expert, which makes the assessment more accurate. The interview itself was interactive, where the expert could ask any questions about the index, for each variable, according to the methodology of its calculation, for reasons of including a particular variable. Each expert had the right to return to the beginning of the survey and revise the significance values of a particular variable. On average, each survey took about 40 to 60 minutes.

After receiving the answers, it is necessary to analyse them qualitatively and quantitatively.

At the first stage, it is important to assess the degree of coherence of experts, as experts often disagree and in this case either have to rebuild the survey or conduct an additional round. The basis of the consistency assessment is, of course, variance, that is, the spread of answers. We do not need absolute coincidence, but the answers must be consistent. Coherence will be assessed using the dispersion coefficient of concordance (coefficient of agreement). To do this, you must first rank the answers.

In our case, we have connected ranks and therefore we calculate the coefficient of concord by the formula:

$$W = \frac{12S}{d^2 \times (m^3 - m) - d\sum_{s=1}^{d} T_s} \qquad \text{(Equation 8)}$$

где $s = \overline{1,d}$, $i = \overline{1,m}$ (s – number of experts, m - number of elements)

$$S = \sum_{i=1}^{m}\left(\sum_{s=1}^{d} r_{is} - \bar{r}\right)^2 \qquad \text{(Equation 9)}$$

$\bar{r} = \frac{1}{m}\sum_{i=1}^{m} r_i$ (Equation 10)

$T_s = \sum_{k=1}^{H_s}(h_k^3 - h_k)$ (Equation 11)

where Ts - the rank of connected ranks in the s-th ranking, Hs - the number of groups of equal ranks in the s-th ranking, hk - the number of equal ranks in the k-th group of connected ranks in the ranking of the s-th expert. The resulting concordance coefficient is a random variable. The significance evaluation will be carried out by the Pearson criterion c2.

$C_2 = d \times (m - a) \times W$ (Equation 12)

The quantity d (m-a) W has a chi square distribution with n = m-1 degrees of freedom. Where the hypothesis about the agreement of experts in the ranking is adopted in case the estimated value is less than the tabulated value.

In the next step, we need to determine the resultant rank of each variable, choose the preferred solution.

Step 1. First, based on the obtained ranks, you need to perform a pairwise comparison of the ranks of each variable, according to the principle:

$$I_{iks} = \begin{cases} 1, \text{if } r_{ks} \geq r_{is} \\ 0, \text{if } r_{ks} < r_{is} \end{cases}$$ (Equation 13)

as a result of obtaining a matrix consisting of ones and zeros

	O1	O2	…	Os
O1	1	1	…	0
O2	1	1	…	1
…	…	…	…	1
Os	1	1	1	1

2 step. Next is the sum of the matrices for all experts:

$Z_{ik} = n\sum_{s=1}^{d} I_{iks}, k_s = \overline{1,d}$ (Equation 14)

3 step. Then, based on the matrix Zik, the resultant matrix is created, where each element takes the values 1 or zero according to the same principle, comparing with the value of d / 2:

$$R_{iks} = \begin{cases} 1, \text{if } Z_{is} \geq \frac{d}{2} \\ 0, \text{if } Z_{is} < \frac{d}{2}, k_s = \overline{1,d} \end{cases}$$ (Equation 14)

The rank of each element is considered as a line sum for each element by the resulting matrix:

$B_k = \sum_{i=1}^{m} R_{ik}, k = \overline{1,d}$ (Equation 15)

4.1.2 Choice of experts

The experts selection is an important task, since it is necessary to evaluate both the quality of experts and the apt number of experts. The number of experts should not be too big,

because in this case, the expert influence will be lost, moreover it is also difficult to find a lot of experts. In some articles, the number of experts was suggested to be over 3, in some other articles it was stated that it should be from 5 to 7, of course, and this should also correspond to the study goals. For this research it was decided to interview 6 experts, since the pool of questions is not wide enough and each question offers only 7 answers.

Qualitative selection of experts is a crucial moment as well, since, on the one hand, the competence of experts should complement each other, on the another hand, expert's values and beliefs should not strongly contradict to each other. For example, an individualist should not be combined with a strict collectivist, this will lead to a bias in the answers.

Normally, competences, an experience in the industry, a creativity, the lack of conformism (which may lead to bias of answers) are tested. In this paper, the experts were selected mainly basing on their competencies. To exclude a system error, experts were selected even from different organizations. Three experts are economists from the oil and gas industry who are engaged in science and are necessarily familiar with the theories of the Circular economy. These experts in their industry, as well as can be considered creative, since science requires an unconventional view of the world and as people with a mathematical mind-set have a sufficient degree of constructivism. Three experts are also from science, but more management, respectively, with a more business mind-set. The selected experts work at the junction of the Circular economy and the oil and gas sector

As we see the sample of experts is quite diverse, the competence of experts complement each other. But at the same time the sample is homogeneous, since the level of all qualities is equally developed for all experts.

4.1.3 Expert assessment results

As it was said earlier, live interviews were conducted with experts (with some experts it was via Skype), all answers were obtained and results are presented in Appendix 2. Experts' names are not indicated to provide complete anonymity. Results of expert assessments were evaluated both quantitatively and qualitatively.

First of all, as qualitative analysis we calculated the consistency coefficient and its significance were evaluated. The coefficient of concord for expert assessment (Equation 8) is W = 0.455. Usually W=0,5 is considered as an anchor for conclusion if answers consistent or not, but in our case there are related ranks which made the evaluation process a little bit more complicated, so the coefficient is a random variable and should be compared with the Chi-square value.

It is necessary to carry out a probabilistic analysis. As a first step we need to state a zero hypothesis:

H0: the consistency indicator is not significant, answers of experts are not consistent

H1: the consistency indicator is significant, answers of experts are consistent

Secondly, the c_2 was calculated (Equation 12), c_2 = 22.35. After that the value of the Pearson coefficient was obtained, chi2 = 16.9, for n = m-1 degrees of freedom, where m is the number of experts and with a confidence level of 95%. In our case, the tabular value is less than the estimated value, and hence the null hypothesis H_0 is rejected, therefore the alternative hypothesis H1 is accepted – assessment results are consistent.

As experts answers are consistent we can positively create the general rating of variables. The evaluation was carried out by pairwise comparison. The resulting rating is presented in Table 7.

Table 7. Variable ranking

Source: created by author, 2018

Variable	Rank
Financial variable	5
Institutes quality	6
Vertical integration	6
Circularity level of industry	7
Awareness	7
Upstream	8
Downstream	8
Size	8
Brand focus	10
Midstream	10

After obtaining the calculated ranks, we needed to adjust them towards the initial intervals. In Table 8 experts' responses are presented with final rating of variables, and it can be noticed that some variables formed peculiar groups. Based on the results of the analysis, it was decided to exclude variables Midstream and Brand focus as they were recognised by experts as non-significant. According to the comments of many experts, there is no sense to make a separate variable Midstream, since in the classical division of Upstream and Downstream both sectors already included Midstream.

Variable Vertical integration is marked with a "*", since it is only mathematical element in the index and does not require scale, but according to the results of the poll it is recognized as significant - that's enough.

The Financial variable and Institutes quality one are recognized as absolutely significant and have a weight - 1. The Awareness and Circularity variables - 0.9, the Upstream, Downstream variables enter in the Index with a weight - 0.8.

Table 8. Variable final ranking

Source: created by author, 2018

Variable	Rank	Final ranking	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6
Financial variable	5	1	2	3	1	1	2	2
Institutes quality	6	1	3	6	2	2	1	1
Vertical integration	6	*	2	4	7	1	1	1
Circularity level of industry	7	2	4	2	3	2	2	2
Awareness	7	2	2	3	2	2	2	3
Upstream	8	3	2	3	3	2	3	4
Downstream	8	3	2	3	3	2	2	4
Size	8	3	4	3	3	3	3	3
Brand focus	10	0	3	3	4	6	7	4
Midstream	10	0	5	6	3	6	7	4

4.1.3 Final index

There are the final index with weighted coefficients which were obtained from the experts evaluations:

$$\mathbf{CEOG_i}=(\frac{\sum_i(\boldsymbol{I_i}\,(\boldsymbol{x})\times\boldsymbol{A_i})}{\sum_i \boldsymbol{I_i}(\boldsymbol{x})}\times \boldsymbol{S}\times \mathbf{0,8}+\mathbf{max}(\boldsymbol{ROA};\boldsymbol{ROE})\times \boldsymbol{Rf}+\boldsymbol{C}\times \boldsymbol{a_w}\times \mathbf{0,9})\times \mathbf{r},$$

(Equation 16)

where

$I_i\,(x)\begin{cases}1, x\in A_i\\0, x\notin A_i\end{cases}$, where $i\in\{U,D,M\}$

C= CEDI = $\frac{(L+R+M+C)\times 100\%}{W}$ (Equation 4)

a_w=CEI/36 (Equation 7)

From the index we can still distinguish three groups of variables :

$\frac{\sum_i (I_i(x) \times A_i)}{\sum_i I_i(x)} \times S \times 0,8$ – this group of indexes are responsible for description of technical side of company activity and can answer on questions such as “If company have a high enough technological level?”

$\max(ROA; ROE) \times Rf$ - this group of indexes are responsible for financial situation in the company and can answer on questions such as “If company have a stable enough financial status?”

$C \times a_w \times 0,9$ - this group of indexes are responsible for Circularity level in the company and in the country and can answer on questions such as “If company is aware about Circular economy principles?”

4.2 Index scale

There are several methods to create the scale for an index but the best way is to combine analytical methods with real cases. Having final formula (Equation 16) it was decided to count the index for representative companies and divide them on meaningful clusters and, based on results, determine intervals.

Three groups of companies were chosen. First group comprises of the biggest Russian companies. The second group consist of European companies. This group is considered as upper values of index because normally European companies are already involved in the Circular economy initiatives. Last group of companies comprises big companies with environmental problems to describe low values of index.

Only big companies were chosen because of the date availability. To calculate the index it is necessary to have some inside information which is difficult to find for most of the small companies.

The final index was calculated (Equation 16) for all these groups the results in the tables 9, 10, 11.

Table 9. Index for the first group: Russian companies

Source: created by author, 2018

Index/Company	Surgutneftegaz	Gazpromneft	Lukoil	Tatneft	Rosneft
r	0,657	0,657	0,657	0,657	0,657
Iu	1	1	1	1	1

Id	1	1	1	1	1
Au	0,99	0,8	0,92	0,95	0,88
Ad	0,79	0,82	0,85	0,97	0,72
ROA	0,14	0,08	0,07	0,12	0,04
ROE	0,15	0,15	0,1	0,17	0,11
Rf	0,37	0,36	0,3	0,69	0,35
Aw	0,44	0,39	0,33	0,42	0,31
C	6%	6%	6%	6%	6%
S	0,8	0,8	0,8	0,8	0,8
Index	43%	39%	38%	50%	35%

Table 10.Index for the second group: European companies

Source: created by author, 2018

Company	Total	Eni	Repsol	Royal Dutch Shell	Statoil
Country	France	Italy	Spain	Netherlands	Norway
r	0,74	0,836	0,714	0,809	0,77
Iu	1	1	1	1	1
Id	1	1	1	1	1
Au	0,96	0,83	0,98	0,91	0,88
Ad	0,703	0,8	0,8	0,833	0,84
ROA	3,50%	2,80%	3,50%	3,80%	4,30%
ROE	7,20%	-0,20%	2,80%	6,00%	3,10%
Rf	0,89	0,396	0,63	0,6	0,55
Aw	0,81	0,61	0,86	0,56	0,53
C	32%	35%	24%	38%	34%
S	0,8	0,8	0,8	0,8	0,8
Index	61%	61%	56%	63%	57%

Table 11. Index for the third group

Source: created by author, 2018

Company	Abu Dhabi National Oil Company	NK KazMunayGaz AO	PetroChina Co Ltd	Anadarko Petroleum Corp
Country	Unated Arab Emirates	Kazahstan	China	USA
r	0,69	0,62	0,73	0,84
Iu	1	1	1	1
Id	1	1	1	1
Au	78%	77%	85%	75%
Ad	85%	65,20%	85%	74%
ROA	15,30%	-4%	2%	-3%
ROE	29,30%	-2%	5%	-15%

Rf	0,4	0,7	34%	125%
Aw	0,31	0,22	0,33	0,36
C	70%	5%	10%	35%
S	0,8	0,85	0,8	0,8
Index	39%	30%	43%	26%

In order to determine the intervals, let's have a look at the results on Diagram 13. We can distinguish several groups of companies: first three companies clearly create group with highest value, next three companies have similar results as well. The last few companies have really low result and can create their own cluster.

Moreover, it should be noted that all the values obtained are logical and correspond to the meaning, since European companies are more technologically advanced than the index value for Russian companies. If you look at Russian companies, it's not surprising that Surgutneftegaz occupies a high line, as it is the most stable and environmentally friendly oil and gas company in Russia. The Anadarco company allocated as outsider and if we investigate company's case we will know that financial situation of the company is really weak and many environmental problem exist.

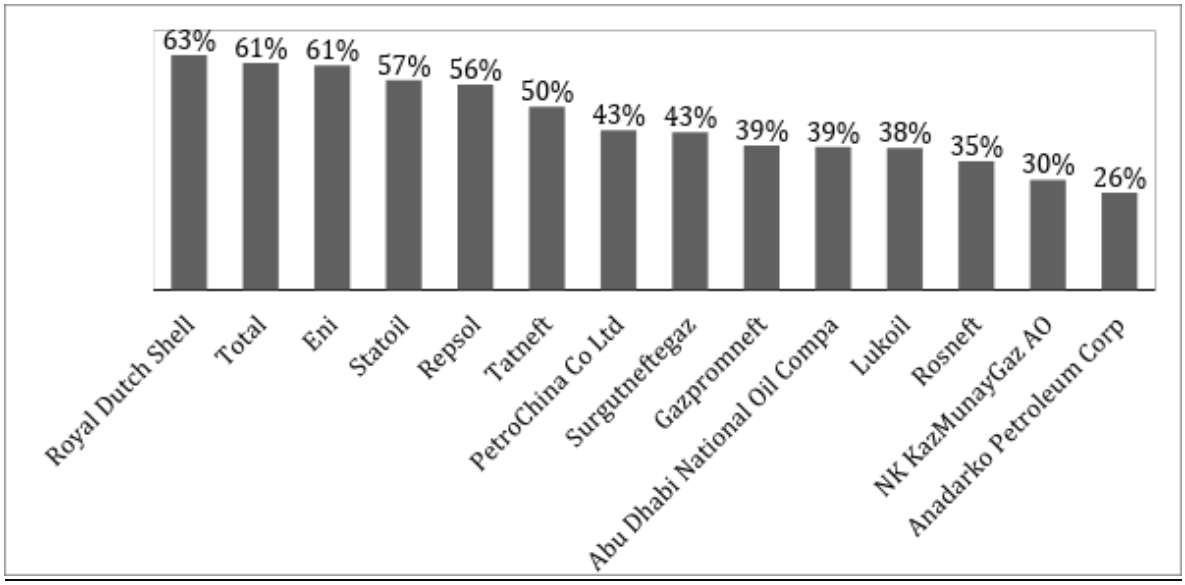


Diagram 13. Index results

Source: created by author, 2018

Based on clusters intervals were created. All intervals introduced in the Table 12.

Table 12. Index intervals

Source: created by author, 2018

Interval	Description	Companies

> 70	This index interval is considered as extreme. There is really low probability of any company to reach this level of index. Company with this level has perfect financial situation and highest technology level.	This interval is extreme
60 – 69%	This level of index corresponds to companies with a quite good financial situation and a high technology level. Companies from this interval have relatively good level of Circularity and they are ready for high technology changes.	Royal Dutch Shell, Total, Eni
50 – 59%	This level of index corresponds to the companies with average level of finance, technology, circularity and awareness.	Statoil, Repsol, Tatneft
40-49%	This level of index corresponds to the companies with problems in one of the areas: finance or technology, or may be with awareness.	PetroChina, Surgutneftegaz
30 – 39%	This level of index corresponds to the companies with problems in one of areas or in several at the same time, companies from this interval are not ready for real changes.	Gazprom Neft, Abu Dhabi National Oil Company, Lukoil, Rosneeft, NK KazMunayGaz
20 – 29%	If index of the company located in this interval, it means that there are problems with financial sector and with technology as well, such companies are not ready for any changes, especially for Circular economy initiatives. Anadarco. One of the biggest oil and gas producer in USA. But the business has a lot of problems, First of all there are FCF problems, in 2017 company needed to reduce its capital budget by 300$, secondly, they announced losses much more higher than it was expected by investors. Moreover there were several environmental issues, for example in 2009 shareholders from Tronox sued Anadarko for hiding information about huge environmental and other debts, In 2014 The United States Environmental Protection Agency sued for $25 billion.	Anadarko Petroleum Corp

< 19 %	This interval of the index is considered as extreme, there are really low probability of any company to have this level of index. Company with this level has weak financial situation and lowest technology level.	This interval is extreme

4.3 Index recommendations

The created Index is aimed to help companies to understand if they are ready for any Circular economy business models. Even if they are already using some parts of Circular Economy, are they ready to go further?

The second step is to give suggestions for companies what to do next, after they get their Index value. How to use it? There were identified several intervals of index and for every interval specific recommendations were created. These recommendations can be considered as smart road map for companies as it helps them to understand what kind of steps towards Circular economy can be made in their situation.

Table 13. Index recommendations

Interval	Recommendations
> 70	In case a company reached this level of the Index It should transfer towards Circular economy – there are perfect conditions for Circular economy principles implementation. In that case companies should have already had several sustainable initiatives or even involved in Circular economy. Therefore according to the Circular economy framework (Diagram 12) every step can be successfully implemented. The most profitable ideas are firstly plant creation for equipment reconstruction (for further reselling, giving for equipment a second life) and secondly, a company can invest in the plant creation in the smaller company (may be even from an another industry). As for oil and gas industry, a company should use new technologies of sludge removing (in case of upstream), stop association petroleum gas flaring (APG) and increase the share of high quality oil products (in case of downstream).
60 – 69%	Companies which reached this level of the Index can create their own plants for reconstruction of equipment. Moreover their financial situations creates opportunities for investment activity – invest in the plant in another oil company and/or an another industry. Secondly, they have consumer power and can choose suppliers and distributors who follow the same values – Circular economy principles. Over and above

	this will create the stimuli for other companies to transfer towards Circular economy as well. To sum up It should be said that every step from the Framework should be implemented (usage of renewable energy, biofuel, personnel trainings). As for oil and gas industry, a company should use new technologies of sludge removing (in case of upstream), stop association petroleum gas flaring (APG) and increase the share of high quality oil products (in case of downstream).
50 – 59%	Companies which reached this level of the Index are not ready to create their own industries for reconstruction of equipment, but they can connect with companies who already have this technology and get together for this activity or suggest company to invest in their plant creation. Companies on this level have quite stable situation and strong enough to use their consumer (for suppliers of equipment) or supplier power (for distributors) and choose only companies who are following same beliefs and implementing Circular economy principles. As for oil and gas industry, a company should use new technologies of sludge removing (in case of upstream) or stop association petroleum gas flaring (APG) or increase the share of high quality oil products (in case of downstream). The main feature of this group of companies is having a quite stable business which means they can afford technological solutions but several initiatives can not be made at the same time. In the target should be involved only one initiative.
40-49%	Companies which reached this level of the Index have problems in one of the directions, finance or technologies (or a little bit lower than average for both). In this case depending on what part of the index is really low (from 0 to 1 which element of index is lowest) the suggestions differ. If it is financial problems, then company can not create their own plant for equipment reconstruction or even create joint venture. In this case it is better to provide changes inside company's daily activities (first 7 initiatives from Diagram 12) and find network with another company which will be ready to reconstruct their equipment for other industrial needs. Suggestions as for oil and gas industry, a company should try to avoid any spills or environmental problems (not to get more fines) and there are no capability for technical side improvement (both for sludge and for APG).

	If it is technological problems, there are good opportunity in this part and invest in changing sludge technologies (modern thermal way) or improve quality of the products and effective level of APG usage. And as for both situations company should start to include Circular principals in future targets.
30 – 39%	Companies which reached this level of the Index have either big problems with finance and weak technology (or vice versa) or both financial and technological sides have really low level. In that case best solution is to try to Improve certain financial situation and keep at least the same level of technology, implement several initiatives from the first 7 steps from Circular economy framework (Diagram 12)
20 – 29%	First recommendation, is the general one that has no connection towards circular economy, this Index also shows that company has real problems with finances and technologies. Second recommendation, if company really want at least to start doing something, they can start from the first seven levels of Circular economy business model. (Diagram 12) – increase awareness about Circular economy, start to collect batteries etc, try to use renewable energy. As for oil and gas industry, there are suggestion just try to keep at least the same level of effective usage of APG and of oil product processing. The best solution is to work for financial side of the company business – there can be systematic problems.
< 19 %	In case a company reached this level of the Index it can be considered as a bad sign – the financial situation is quite weak and there is no reason to start any new initiative and it is better to concentrate on the core business there can be really big problems.

Conclusion

Discussions

The topic that was chosen for the research can be considered as a challenge for the author because this paper is the first research on this topic. It is always not easy to make first step on an unknown ground.

Having some insights from literature review and after understanding the research gap several Research Questions were formulated in the Introduction.

Let's discuss all the results.

RQ1 What variables should be included in the Index to evaluate opportunities for transition towards a circular economy?

This was the first question and the most difficult one as it demanded the analytical research and the understanding of the Oil and Gas industry and Circular economy theory general picture. Mostly variables were created only based on the general understanding of the industry. Several iterations of reviewing and changeling variables were done to understand which one should be included and how to put them in numerical form. Penultimate stage was expert assessment, where experts from the Oil and Gas industry and from business sector made their evaluation of all suggested variables – if the particular variable is significant or not.

RQ2 How company can use the index results?

After creating the index it was considered as necessary step to give recommendations for every possible value of index as obviously only numerical result does not give enough information for a company. That's why it was important to count the Index for representative companies and understand "bad" and "good" index values. Having such an information sufficient intervals were identified and for each of them special recommendations were made. Recommendations were based on the representatives companies cases , general understanding of Circular economy business models and features of the oil and gas sector. As a result the smart Circular economy roadmap was made, therefore, having index value, a company manager chooses the interval of their value where she can find the description of companies preparedness for Circular economy and suggestions for initiatives that they can implement according to the index value.

RQ3 What are the reasons why company can decide to transfer towards Circular Economy?

Some people and companies can be curious about the reasons why companies can decide to transfer towards Circular economy as companies from the Oil and Gas industry are normally

quite rich and the reason can be not so clear why do they need these difficulties. Through the analytical research several main reasons were found:

First of all, Circular economy is a really good opportunity to gain additional profit. That is why it can be considered not only as nature-support initiatives, but also as a new way to create financial value. For example, one of Circular economy business models suggests to sell or reconstruct and sell all the equipment that company does not need anymore, not to recycle it into raw material but to give the second life for the product. It is important to say that a mark-up on the reconstructed equipment will be much bigger than on raw materials.

Secondly, it is becoming much more favourable to be Sustainable brand nowadays. Being nature-friendly company creates more opportunities for communications with suppliers, distributors as well as with consumers, which as a result becomes financial value.

And last but not least, Circular economy is considered as the main stream in European countries. Why? Because the European community realised the existence of global scale problems, not only environmental but also economical ones. There are countless number of companies and industries that create every day huge amounts of different products but the problem is that more goods created means less resources left (both raw material and energy resources). So there is motivation not only to create alternative energy sources but also to use the existing resources more effectively. Global community realised that amount of vital resources rapidly declining, so the prices go up and therefore expenses rise as well. Maybe you think that it is good sign for oil companies? Not at all, as first their reserves of oil and gas resources become smaller and smaller, and in less than 40 years they won't have anything to sell. Secondly oil and gas companies are buying expensive equipment as well which is becoming much more expensive for them.

Theoretical contribution

This paper was aimed to fill the gap at the intersection of the Circular economy and the Oil and Gas industry. There are bunch of Indexes for Circular economy but most of them only help to find the existence level of a Circularity in a country, an industry or in a company. But until that time there did not exist any tool to evaluate opportunities of a particular company to transit towards Circular economy from linear one. Furthermore there were no real practical research at the intersection of the Circular economy and Oil and Gas sector.

Created index successfully filled the gap and created more opportunities and ideas for further research in this direction. In this paper you can also find the Oil and Gas business framework which can be used for business tasks of company leaders, for student case competitions and for investigators from oil and gas sector.

Managerial implication

Initially from the very beginning of research there was an idea to help companies from the Oil and Gas industry to transfer towards Circular economy because as the richest and dirtiest industry especially in Russia it was seemed as a good candidate.

The main problem was that most of Oil and Gas companies do not even know anything about the close loop economy or the Zero waste theory and therefore do not have any idea that sustainable initiatives can be profitable as well.

To solve this problem it was decided to create the road map for the oil and gas industry based on the Circular economy principles and business models. But another problem was identified –only the theoretical instruction can not be considered as sufficient tool to help companies to transfer towards Circular economy.

As a solution for that problem it was decided to create numerical tool for companies which help them to get the answer what to do. After further research it was found out that there are no appropriate solution for this problem. Analysing different forms of tools, the Index creation was chosen as the most appropriate one.

So following the idea-creation-progress we can see what type of problems the Index was created to solve.

First of all, Index is numerical tool which helps companies to understand according to their current situations if they can implement any Circular business model or initiative and if yes, what they should do.

Secondly, having all recommendations for all index intervals, we created the smart road map for companies. It is to be noted that there is no general road map, but specific one was created according to their financial situation, corporate structure and etc.

So having that index, a company can make decisions according to the next steps in the Sustainability initiatives, namely to make a decision to transfer towards Circular economy or not. Certain company by using the Index can better understand what type of initiatives is more appropriate for current situation and will create the biggest profit for them with affordable expenses.

Limitations and future research

The CEOG index is not the only possible way to evaluate the perspective of the company to transfer towards Circular economy, but as this is the first ever created index in this area it can be considered as appropriate tool for this goal. All analysis were based mainly on the general description of oil and gas sector and more detailed technical and financial features of the companies were not taken into account. Moreover all the recommendations for further steps for

companies were created according to business models that were found so far and modern understanding of the Circular economy. So from all these conditions we can formulate several limitations that should be taken into account:

1. The index does not take into account all the technological details of industry or/and particular company, as well as specific problems of the certain company.
2. The index does not take into account all the financial special cases as errors in the report or the hidden information.
3. All the recommendations were based on the contemporary information about Circular economy principles, therefore in further research the Index can be adjusted towards new information and new business models.

This paper was created as a new stream at the junction of the Circular economy and the Oil and Gas sector, it can be considered as a fresh idea for next researches – to analyse Oil and Gas sector in the sense of Circular economy, create new indexes or new business models and frameworks. Moreover the idea to find the tool for company to evaluate the prospect of transition from linear toward Circular economy can be considered as new sector for further research. So to sum up we can suggest several areas for further research:

1. Create other types of indexes for the Oil and Gas sector and the Circular economy.
2. Improve the Index CEOG to make it more specific.
3. Create an Index which will help to evaluate the prospect of transition towards the Circular economy for other sectors.

The author of this paper decided to concentrate on index creation for the further research. It was chosen to move to another industry and create the same index for Consumer goods sector namely for small FMCG companies. This sector seems to have more prospect after oil and gas sector as it creates a lot of waste nowadays. Moreover it is composed from a lot of companies which have a good opportunities to create sustainable alliance and make close loop from their activities.

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Appendices

Appendix 1 Expert poll

Survey form

Dear Expert, further you are invited to answer questions on the problem of introducing the principles of the circular economy in oil and gas companies, where it is necessary to evaluate the significance of variables included in the index, which was created by the Author of the survey.

Please familiarize yourself with Case, in which this index is described in more detail.

Case for interrogation

The CEOG (Circular economy in Oil and Gas) index is intended to determine the prospects for introducing the foundations of the Circular economy in oil and gas companies.

Circular economy, the economy opposing the traditional, linear, and is based on such principles as careful use of resources, production of environmentally friendly products, reduction of emissions during production, recycling and so on.

The oil and gas sector is the founder of the traditional, linear, system, but in spite of this, in recent years it has been increasingly proposed to introduce the principles of a circular economy (avoiding CO2 emissions, maximum sludge purification, second life for equipment) in oil and gas companies.

The presented index reflects the company's potential for the transition to the Circular economy, by mastering some principles.

At the moment, the index contains 10 variables and each expert is required to assess the significance of each of them. The score is on a scale from 0 to 100, where 0 is completely unaffected, and 100 is fully influenced, but the scale is broken down into 7 intervals and the expert is asked to determine the interval in which he believes the true level of significance is based on his experience and sensations.

To activate intuition, a conditional "arrow", filled with a gradient, is proposed, where the right, dark end means the full significance of the sign, (100% significance), and the left, white end, the absolute absence of significance of this attribute (0% significance). The numerical values of each of the intervals and their verbal description are also presented.

* Recommendation for the Expert:

The expert is recommended to first intuitively determine the color level of the significance of the variable and then adjust the quantitative value and the qualitative description

of the interval that connects both hemispheres, first right, imaginative - intuitive, and then left - logical.

** All answers are absolutely anonymous, the names and answers of experts will be known only to the Author of the survey.

*** To the Questionnaire, each expert is accompanied with a file, where experts are invited to familiarize themselves with the methodology for calculating the variable in more detail.

Вопрос 1
Name and Surname of expert
Response:
Name
Surname

Question 2
How would you rate your knowledge in the Oil and Gas sector?
Response:

☐General knowledge	☐Read articles	☐Have some publications	☐Practical knowledge

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Question 3
How would you rate your knowledge on the topic of the Circular economy?
Response:

☐General knowledge	☐Read articles	☐Have some publications	☐Practical knowledge

In the questions below, it is necessary to evaluate the degree of influence of variables on the index (to assess the significance of the variable in the index):

Question 4 Variable "Quality of Institutions"
Assess the impact of the quality of institutions in the country on the prospect of introducing a circular economy in oil and gas companies.
* The quality of institutions is assessed as the Competitiveness Index (WEF).

Response:

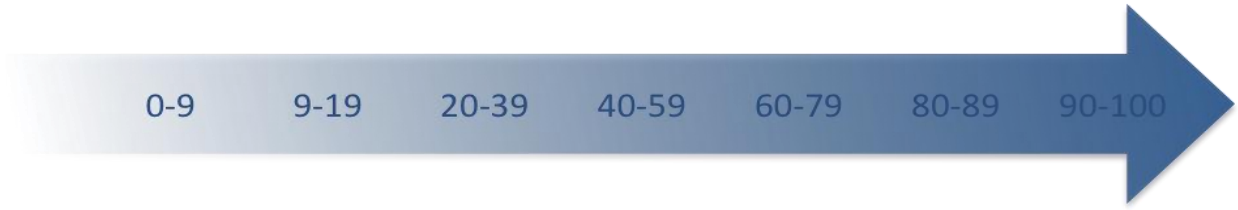
☐ 0–9%	☐ 10–19%	☐20–39%	☐40–59%	☐60–79%	☐ 80–89%	☐90–100%
Not significant, the variable does not contribute to the index	The significance is almost absent, if variable was included then only with a low weighting	Significance is low, the contribution to the index value is low, it is worth to includ with a low	The average level of significance, the variable is significant, need to be included but with a low	Variable is significant, this variable must be present in the index	High importance, one of the main variables, so it is worth to includ with a high weight	Absolutely significant, is the main variable, so it's worth including with the highest weight

	factor	weighting factor	weighting factor

Question 5 Variable "Level of Circularity of the economy"

Assess the degree of influence of the Circular level of the country's economy on the prospect of introducing the Circular economy in oil and gas companies.

* The variable reflects what level of closure the economy has already achieved by the country (processing, total emissions, etc.).



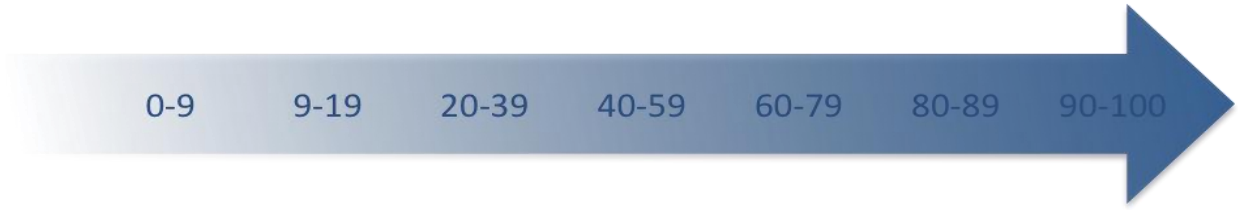
Response:

☐ 0–9	☐ 10–19	☐20–39	☐40–59	☐60–79	☐ 80–89	☐90–100
Not significant, the variable does not contribute to the index	The significance is almost absent, if variable was included then only with a low weighting factor	Significance is low, the contribution to the index value is low, it is worth to includ with a low weighting factor	The average level of significance, the variable is significant, need to be included but with a low weighting factor	Variable is significant, this variable must be present in the index	High importance, one of the main variables, so it is worth to includ with a high weight	Absolutely significant, is the main variable, so it's worth including with the highest weight

Question 6 The variable "Brand focus"

Assess the degree of influence of the company's Focus on the brand on the prospect of introducing a circular economy in oil and gas companies.

* The variable reflects how much the company takes care of its brand and calculates how the share of marketing costs and PR in the total proportion of operating costs.



Response:

☐ 0–9	☐ 10–19	☐20–39	☐40–59	☐60–79	☐ 80–89	☐90–100
Not significant, the variable does not contribute to the index	The significance is almost absent, if variable was included then only with a low weighting factor	Significance is low, the contribution to the index value is low, it is worth to includ with a low weighting factor	The average level of significance, the variable is significant, need to be included but with a low weighting factor	Variable is significant, this variable must be present in the index	High importance, one of the main variables, so it is worth to includ with a high weight	Absolutely significant, is the main variable, so it's worth including with the highest weight

Question 7 The variable "Awareness of the Company on the Principles of the Circular Economy and the Level of Circularity Achieved"

Assess the degree of influence of the Company's (employees) awareness level about the principles of the Circular economy and the already achieved level of circularity for the prospect of introducing the Circular economy in oil and gas companies.

* The variable is estimated by interviewing the company, their current situation (about what principles are already implemented), about training in the company and so on.

Response:

☐ 0–9	☐ 10–19	☐20–39	☐40–59	☐60–79	☐ 80–89	☐90–100
Not significant, the variable does not contribute to the index	The significance is almost absent, if variable was included then only with a low weighting factor	Significance is low, the contribution to the index value is low, it is worth to includ with a low weighting factor	The average level of significance, the variable is significant, need to be included but with a low weighting factor	Variable is significant, this variable must be present in the index	High importance, one of the main variables, so it is worth to includ with a high weight	Absolutely significant, is the main variable, so it's worth including with the highest weight

Question 8 A variable characterizing Upstream technology

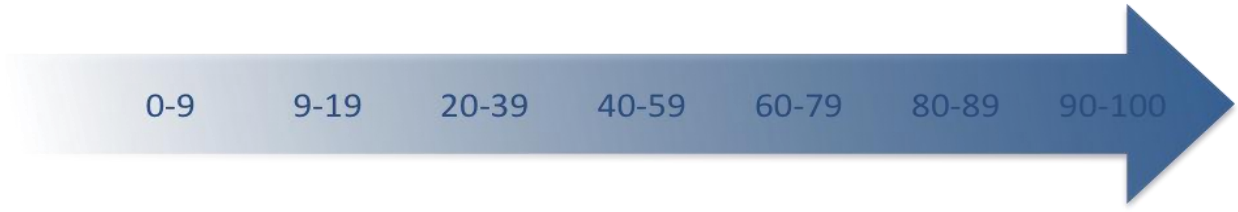
Assess the degree of influence of the Company's Technology Development Level in the Extraction sector on the prospect of introducing the Circular Economy in the company.
* The variable reflects the percentage of the effective use of associated gas.

Response:

☐ 0–9	☐ 10–19	☐20–39	☐40–59	☐60–79	☐ 80–89	☐90–100
Not significant, the variable does not contribute to the index	The significance is almost absent, if variable was included then only with a low weighting factor	Significance is low, the contribution to the index value is low, it is worth to includ with a low weighting factor	The average level of significance, the variable is significant, need to be included but with a low weighting factor	Variable is significant, this variable must be present in the index	High importance, one of the main variables, so it is worth to includ with a high weight	Absolutely significant, is the main variable, so it's worth including with the highest weight

Question 9 The variable characterizing technology in the Downstream sector

Assess the impact of the Company's Technology Development Level in the processing sector on the prospect of introducing the Circular Economy in oil and gas companies.
* The variable is expressed in the level of oil processing achieved by the company.



Response:

☐ 0–9	☐ 10–19	☐20–39	☐40–59	☐60–79	☐ 80–89	☐90–100
Not significant,	The significance is almost	Significance is low, the	The average level of	Variable is significant, this	High importance,	Absolutely significant, is

the variable does not contribute to the index	absent, if variable was included then only with a low weighting factor	contribution to the index value is low, it is worth to includ with a low weighting factor	significance, the variable is significant, need to be included but with a low weighting factor	variable must be present in the index	one of the main variables, so it is worth to includ with a high weight	the main variable, so it's worth including with the highest weight

Question 10 The variable characterizing technology in the Midstream sector

Assess the impact of the Technology Development Level of the company in the Transport sector on the prospect of introducing the Circular Economy in oil and gas companies.

* The variable is expressed as the transportation of petroleum products (fuel quality, frequency of oil spills, etc.)

Response:

☐ 0–9	☐ 10–19	☐20–39	☐40–59	☐60–79	☐ 80–89	☐90–100
Not significant, the variable does not contribute to the index	The significance is almost absent, if variable was included then only with a low weighting factor	Significance is low, the contribution to the index value is low, it is worth to includ with a low weighting factor	The average level of significance, the variable is significant, need to be included but with a low weighting factor	Variable is significant, this variable must be present in the index	High importance, one of the main variables, so it is worth to includ with a high weight	Absolutely significant, is the main variable, so it's worth including with the highest weight

Question 11 Level of vertical integration

Assess the degree of influence of the Company's vertical integration level on the prospect of introducing the Circular economy in oil and gas companies.

* The variable is represented as an indicator function (takes the value 0 or 1), thereby allocating the company to the required sector: Upstream, Midstream and/or Downstream.

Response:

☐ 0–9	☐ 10–19	☐20–39	☐40–59	☐60–79	☐ 80–89	☐90–100
Not significant, the variable does not contribute to the index	The significance is almost absent, if variable was included then only with a low weighting factor	Significance is low, the contribution to the index value is low, it is worth to includ with a low weighting factor	The average level of significance, the variable is significant, need to be included but with a low weighting factor	Variable is significant, this variable must be present in the index	High importance, one of the main variables, so it is worth to includ with a high weight	Absolutely significant, is the main variable, so it's worth including with the highest weight

Question 12 Variable "Level of financial stability and investment opportunities"

Assess the degree of influence of the Financial Stability of the oil and gas company and its investment opportunities on the prospect of introducing the Circular Economy.

* The variable is expressed as max {ROI, ROE} multiplied by the ratio (FCF of the company / total volume of the company's investments in the current year).

Response:

☐ 0–9	☐ 10–19	☐20–39	☐40–59	☐60–79	☐ 80–89	☐90–100
Not significant, the variable does not contribute to the index	The significance is almost absent, if variable was included then only with a low weighting factor	Significance is low, the contribution to the index value is low, it is worth to includ with a low weighting factor	The average level of significance, the variable is significant, need to be included but with a low weighting factor	Variable is significant, this variable must be present in the index	High importance, one of the main variables, so it is worth to includ with a high weight	Absolutely significant, is the main variable, so it's worth including with the highest weight

Question 13 Variable "The size of the enterprise"

Assess the degree of influence of the size of the oil and gas company on the prospect of introducing a circular economy in this company.

* The variable is represented as a coefficient that is assigned depending on the size of the company (small, medium, large), which is expressed in the number of employees.

Response:

☐ 0–9	☐ 10–19	☐20–39	☐40–59	☐60–79	☐ 80–89	☐90–100
Not significant, the variable does not contribute to the index	The significance is almost absent, if variable was included then only with a low weighting factor	Significance is low, the contribution to the index value is low, it is worth to includ with a low weighting factor	The average level of significance, the variable is significant, need to be included but with a low weighting factor	Variable is significant, this variable must be present in the index	High importance, one of the main variables, so it is worth to includ with a high weight	Absolutely significant, is the main variable, so it's worth including with the highest weight

Appendix 2 Result of the survey of experts

Expert 1

Variable	Value
Institutes quality	3
Level of Circularity of the industry	4
Brand focus	3
Awareness	2
Upstream	2

Expert 2

Variable	Value
Institutes quality	6
Level of Circularity of the industry	2
Brand focus	3
Awareness	3
Upstream	3

Downstream	2
Midstream	5
Vertical integration	2
Financial variable	2
Size	4

Downstream	3
Midstream	6
Vertical integration	4
Financial variable	3
Size	3

Expert 3

Variable	Value
Institutes quality	2
Level of Circularity of the industry	3
Brand focus	4
Awareness	2
Upstream	3
Downstream	3
Midstream	3
Vertical integration	7
Financial variable	1
Size	3

Expert 4

Variable	Value
Institutes quality	2
Level of Circularity of the industry	2
Brand focus	6
Awareness	2
Upstream	2
Downstream	2
Midstream	6
Vertical integration	1
Financial variable	1
Size	3

Expert 5

Variable	Value
Institutes quality	1
Level of Circularity of the industry	2
Brand focus	7
Awareness	2
Upstream	3
Downstream	2
Midstream	7
Vertical integration	1
Financial variable	2
Size	3

Expert 6

Variable	Value
Institutes quality	1
Level of Circularity of the industry	2
Brand focus	4
Awareness	3
Upstream	4
Downstream	4
Midstream	4
Vertical integration	1
Financial variable	2
Size	3

Scale

Value	**Level of significance**
1	90-100%
2	80-89%
3	60-79%
4	40-59%
5	20-39%
6	10-19%
7	0-9%

Appendix 3 Index value for different companies

Index for the first group: Russian companies

Index/Company	Surgutneftegaz	Gazpromneft	Lukoil	Tatneft	Rosneft
r	0,657	0,657	0,657	0,657	0,657
Iu	1	1	1	1	1
Id	1	1	1	1	1
Au	0,99	0,8	0,92	0,95	0,88
Ad	0,79	0,82	0,85	0,97	0,72
ROA	0,14	0,08	0,07	0,12	0,04
ROE	0,15	0,15	0,1	0,17	0,11
Rf	0,37	0,36	-	0,69	-
Aw	0,44	0,39	0,33	0,42	0,31
C	6%	6%	6%	6%	6%
S	0,8	0,8	0,8	0,8	0,8
Index	43%	39%	38%	50%	35%

Index for the second group: European companies

Company	Total	Eni	Repsol	Royal Dutch Shell	Statoil
Country	France	Italy	Spain	Netherlands	Norway
r	0,74	0,836	0,714	0,809	0,77
Iu	1	1	1	1	1
Id	1	1	1	1	1
Au	0,96	0,83	0,98	0,91	0,88
Ad	0,703	0,8	0,8	0,833	0,84
ROA	3,50%	2,80%	3,50%	3,80%	4,30%
ROE	7,20%	-0,20%	2,80%	6,00%	3,10%
Rf	0,89	0,396	0,63	0,6	0,55

Aw	0,81	0,61	0,86	0,56	0,53
C	32%	35%	24%	38%	34%
S	0,8	0,8	0,8	0,8	0,8
Index	61%	61%	56%	63%	57%

Index for the third group

Company	Abu Dhabi National Oil Company	NK KazMunayGaz AO	PetroChina Co Ltd	Anadarko Petroleum Corp
Country	Unated Arab Emirates	Kazahstan	China	USA
r	0,69	0,62	0,73	0,84
Iu	1	1	1	1
Id	1	1	1	1
Au	78%	77%	85%	75%
Ad	75%	65,20%	85%	74%
ROA	15,30%	-4%	2%	-3%
ROE	29,30%	-2%	5%	-15%
Rf	0,4	0,7	34%	125%
Aw	0,31	0,22	0,33	0,36
C	70%	5%	10%	35%
S	0,8	0,85	0,8	0,8
Index	**39%**	**30%**	**43%**	**26%**

Appendix 4 The Circular Economy Index (CEI), Ruiter

KPI	*Description*
1	We are involved in the circular economy trend
2	We know what the circular economy means for our company
3	The circular economy is part of our future targets
4	We measure the outcomes of our circular economy practices on a regular basis
5	Awareness on the circular economy is created among employees
6	We cooperate on the topic circular economy
7	Products contain recycled materials or recovered components
8	Products are designed to minimize waste over their lifetime

9	The amount of products that are recycled or upcycled
10	Products can be resold
11	Sharing of products by consumers is facilitated
12	Products can be leased by consumers
13	It is ensured that products are returned after their usage
14	Products are sold using circular packaging and documentation
15	The circular economy principle is applied to daily operations
16	There are selection criteria for suppliers & industrial buyers
17	The consumed electrical energy is renewable
18	The consumed electrical energy comes from reliable production sources
19	The extent to which technical input comes from pre-used materials
20	The biological material input stream is sustainable
21	The extent to which oil-based inputs are replaced by bio-based inputs
22	Involvement in ecosystem recovery
23	Waste is minimized or eliminated
24	Mode of waste reduction
25	Modes of transport are electric or on biofuels

**the red rows did not use for the CEOG*

*** High Impact (red), Medium Impact (orange) and Low Impact (green)*

Appendix 5 The CEI results for countries

KPI	Surgutneftegaz	Gazpromneft	Lukoil	Tatneft	Rosneft	Total	Eni
1	2	1	1	1	1	3	2
2	1	0	0	0	0	3	2
3	2	2	2	2	2	3	2

4	0	0	0	0	0	2	1
5	0	0	0	0	0	3	2
6	1	1	1	1	1	3	3
15	1	1	1	1	1	2	1
17	1	1	1	1	1	2	2
22	2	2	2	3	1	1	1
23	3	3	2	3	2	3	2
24	3	3	2	3	2	2	2
25	0	0	0	0	0	1	1
CEI	16	14	12	15	11	29	22
aw	0,44	0,39	0,33	0,42	0,31	0,81	0,61

KPI	Repsol	Royal Dutch Shell	Statoil	Abu Dhabi National Oil Company	NK KazMunayGaz AO	PetroChina Co Ltd	Anadarko Petroleum Corp
1	3	2	2	1	0	1	1
2	3	1	0	0	0	0	0
3	3	2	2	1	1	1	1
4	2	1	3	0	0	0	0
5	3	1	0	0	0	0	0
6	3	1	1	0	0	0	1
15	3	1	1	0	0	0	1
17	2	2	2	1	0	1	1
22	1	1	1	2	1	1	1
23	3	3	2	1	1	3	2
24	3	3	3	2	1	2	3
25	1	1	1	1	0	1	1
CEI	31	20	19	10	4	11	13
aw	0,86	0,56	0,53	0,28	0,11	0,31	0,36

Appendix 6 The value of CEDI for countries

mln	year	France	Norway	Netherlands	Germany	Spain	Italy	Austria	Poland

tonn									
W	2015	34,143	2,187	8,865	51,102	20,836	29,652	4,833	10,33
	2016	34,314	2,175	8,894	51,625	21,158	29,524	4,836	10,863
C	2015	6140	0,365	2,414	9,248	2,894	4,865	1,492	1,154
	2016	5984	0,361	2,415	9,242	2,452	5,203	1,511	1,75
C	2015	7887	0,572	2,176	25,155	3,526	7,472	1,231	2,18
	2016	7641	0,567	2,112	24,302	3,892	7,649	1,241	2,867
CEDI	2015	31%	34%	37%	57%	24%	33%	41%	27%
	2016	32%	34%	38%	58%	24%	35%	41%	34%

Appendix 7 Degree of efficiency of associated gas utilization

Company	**2011**	**2012**	**2013**	**2014**	**2015**
«Gazprom»	86%	85%	99,5%	99,6	95,6
«Gazprom Neft»	64,5%	69,3%	79,9%	81,4	80,2
«Zarubezhneft»	-	-	20,44%	35,6	60,8
«Irkutsk NK»	-		46,85%	64,4	47,5
«LUKoil»	79,3%	87,6%	88%	89,8	92
«Rosneft»	53,4%	53,5%	69,8%	80,8	87,9
«Salim Petrolium»	30,6%	89,6%	97,2%	96,1	95,9
«Sahalin Energy» («Sahalin 2»)	93%	93%	97%	94,9	96,1
«Surgutneftegaz»	97,81%	99,2%	99,17%	99,1	99,4
«Tatneft»	-	-	-	95,2	95,2
«Exxon NL» («Sahalin 1»)	-	-	-	97,7	95,3
«Novatek»	-	-	-	94,1	96

Appendix 8 A questionnaire for oil and gas companies from Midstream sector

Question	Form of answer

Have there been oil spills this year?	Yes -0 No - 1
Do you think the problem was resolved quickly?	Yes -1 No - 0
Oil spill occurs more often than once a year, for the last 5 years?	Yes - 0 No - 1
Was there a change in technology to eliminate the oil spill the last 5 years?	Yes -1 No - 0
Was there a technical inspection and measures to prolong the life of the transport of the oil transporting company?	Yes -1 No - 0
Do you use environmentally friendly fuel for transport?	Yes -1 No - 0

Appendix 9 The global Competitiveness WEF

Covering 137 economies, the Global Competitiveness Index measures national competitiveness—defined as the set of institutions, policies and factors that determine the level of productivity, scale for Ranks from 1 to 7.

The report has twelve pillars of competitiveness:

1. Institutions
2. Appropriate infrastructure
3. Stable macroeconomic framework
4. Good health and primary education
5. Higher education and training
6. Efficient goods markets
7. Efficient labour markets
8. Developed financial markets
9. Ability to harness existing technology
10. Market size—both domestic and international
11. Production of new and different goods using the most sophisticated production processes
12. Innovation

Ranking and more details you can see here:
https://www.weforum.org/reports/the-global-competitiveness-report-2017-2018