Applied Research

جمهورية مصر العربية

معهد التخطيط القومي

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عنوان البحث باللغة الإنجليزية	The Role of Green Sustainable Manufacturing in Oil & Gas Field towards SDGs Case study from Petrochemicals Manufacturing
عنوان البحث باللغة العربية	دور التصنيع الأخضر المستدام في البترول والغاز لتحقيق أهداف التنمية المستدامة دراسة حالة من صناعة البتروكيماويات
إعداد	مريم محمد فاروق يس
إشراف	د. مها الشال

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معهد التخطيط القومي — الماجستير المهني في التخطيط للتنمية المستدامة

~~إعداد~~	~~مريم محمد فاروق يس~~
~~إشراف~~	~~د. مها الشال~~

لاستكمال متطلبات

"الحصول على الماجستير المهني "التخطيط للتنمية المستدامة

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Contents

List of tables

List of figures

List of Graphs

Appendix

Applied Research Summary

Green chemistry is a design strategy. Green chemistry and engineering seek to maximize efficiency and minimize health and environmental hazards throughout every stage of a chemical's life cycle. Green chemistry evaluates and designs for both the applications and implications of new technology. Green Chemistry, Green Engineering, and Sustainable Design must all be considered when transitioning to more environmentally friendly processes in oil and gas field. Changing public opinion, legislation and availability of resources are all driving change. Due to the scarcity of many resources, we must develop closed-loop systems and transition to a circular economy. The bio refinery concept allows the conversion of biomass into useful chemicals and energy, reducing our dependence on fossil resources. There are numerous initiatives around the world that aim to foster innovation in the field of green and sustainable chemistry while also educating the next generation of scientists. The adoption and development of green chemistry has been catalyzed by the formulation of principles and metrics that guide the design of sustainable chemicals. Green chemistry tools and metrics have enabled businesses to begin evaluating their products and processes in the context of the "triple bottom line," which incorporates economic, environmental, and social factors into decision making. Green chemistry provides metrics for assessing new technology's efficiency, environmental, and health impacts. Green chemistry clearly makes economic sense in the context of good health and environmental protection rules. The green chemistry initiative's cost savings can be explained by lower costs associated with waste removal, protective equipment, regulatory compliance, reduced liability, and manufacturing security.

Keywords: Green Chemistry- Design Strategy- Efficiency- Environmental Hazards - Chemical's life cycle- Green Engineering- Sustainable Design - Triple Bottom Line

Abstract

The oil and gas industry has a significant impact on sustainable development, making it critical for the industry to implement significant changes in its business practices. Upstream and downstream activities are both involved in oil and gas operations. Because of the nature of these high-risk activities, businesses work constantly to reduce the significance of their negative impacts on the environment and people. As a result, assessing the sustainability of production in this sector has become a necessity. This paper proposes a role of green sustainable manufacturing for evaluating the sustainable production believed to be appropriate to the oil and gas sector based on the triple bottom line of sustainability. It is hoped that the proposed research will enable and assist this sector in achieving higher levels of performance in sustainable production, thereby ensuring business sustainability. Sustainable industrialization (green technology) is a major step towards achieving sustainable development goals through economic well-being while minimizing environmental damage. This applied research shows how green chemistry and green engineering principles and metrics can influence the entire life cycle of a chemical, from design to disposal, as well as their impact on the oil and gas industry. In addition, new trends arising from sustainable manufacturing applications of green chemistry such as Low Carbon Fuels (LCF), Bio refinery, Bio fuels, Green and Blue Hydrogen, and Zero flare technology are being considered. Green chemistry and green engineering both aim to change the nature of technology. The applications and implications of emerging green technology are discussed, as well as future opportunities for interdisciplinary collaborations.

Keywords: Sustainable Development -Upstream and downstream- Sustainable Production- Sustainable industrialization (green technology) - Low Carbon Fuels (LCF) - Bio refinery, Bio fuels, Green and Blue Hydrogen, and Zero flare technology

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Introduction

Energy is one of the main components for facilitating economic and other Human activities are also part of national security. This shows the important role of energy in achieving sustainable development, which included the Global Sustainable Development Goals (SDGs) as an explicit energy goal Ensure that everyone has access to energy at an affordable cost[1]. The oil and gas industry is the world's leading exporter of energy, one of the most important sources of energy that has had an impact on economic growth in the world. "Oil" is the power horse of the Egyptian economy. The oil and gas industries account for more than 50% of global fuel consumption, and hydrocarbons are expected to remain the main source of energy in 2035. Given the importance of energy and its close association with the economy, countries have struggled to obtain energy resources and wars may arise. There is no development, progress and prosperity without energy, and countries are seeking all means and means to obtain energy sources, so energy is a role in human life and in countries where the world has witnessed many changes, developments and scientific and industrial progress because of the role and importance of energy. The energy sources are the conventional energy (oil, coal, shale oil, natural gas, nuclear) and renewable energy (bio-precipitation) and solar energy (geothermal, wind, wind, wind, islands, waves). Countries should develop strategies to use a mix of energy (permanent renewable-leather) According to its diverse sources of access to sustainable, environmentally friendly energy, global statistics say that, until now, 85% reliance on conventional energy and 15% reliance on other energy sources. For science, the greater reliance on renewable and sustainable energy, the more continuous and lasting improvement of the environment and the economy is, the more these sources are Less expensive, and less polluted for the environment, it is green, environmentally friendly energy that thrives on human life. Energy is a vital element of life on earth. Everything happens because there is power, without it, there is no life.
As for green technology, it is intended to rely on safe environmental sources of plants, animals, and natural resources for access to energy from environmentally friendly sources that do not cause any damage rather than sources of fuel and other energy that have left many adverse effects on humanity as a whole Produce a lot of poisonous material. This technology has been described as green, since green is always the one representing nature. Green technology can be explained as a universal term that suggests how technology and science are employed and used in general to protect and preserve the environment. The tools listed below include environmental monitoring, green chemistry, green engineering, green industry, and much more. In addition, the term green technology is a rapidly evolving and growing modern field around the world. It has had a clear impact on people's awareness of the importance of the environment and their obvious negative impact on the environment, and therefore it is a technology that encourages and stimulates the production of clean energy and the most environmentally friendly production methods, the restoration and repair of the damage from the environment, and the development of appropriate solutions and possibilities in the event of damage. The use of green chemistry is now a global trend toward a clean future for the preservation of the environment, especially as all countries suffer from the environmental problems. In addition, Brazil's experience in the use of orange residues to produce environmentally friendly chemicals equivalent to petroleum energy production is economically successful and sustainable development is achieved.

Keywords: Sustainable Development – Sustainable Manufacturing – Sustainable Manufacturing Technology – Clean Energy –Green Chemistry – Green Engineering – Green Energy

[1] Goal 7 of SDGs.

Research Aims, Objectives and Hypothesis

1. Aims and Objectives

The aim and objectives of this paper are to explore and identify how Green Chemistry, Green Engineering Principles and Green Sustainable Manufacturing Technologies are wont to enhance the social, economic and environmental efficiency that directly affects the general business performance and sustainability of the oil and gas sector. The aim of this study is therefore to research the environmental (green) impact of this use, including the impact on energy savings and therefore the use of natural resources, how green chemistry can easily meet the economic challenges of accelerating demand for sustainable products and processes, and new ideas and innovations are essential to satisfy the growing needs of industry and society. This applied search objectives are:

1. Presenting the concepts for sustainable development, sustainable development technology and the principles of chemistry and green engineering.
2. Identify the current situation of the oil sector in Egypt and present the strategy for the sustainable development of the oil sector through the presentation of the project programs for the development and modernization of the sector.
3. Presenting the challenges and challenges facing domestic and global oil companies in achieving sustainable development goals.
4. Identify national, global and regional experiences and efforts in the production and use of clean energy.
5. The importance and consequence of the flexibility of domestic and international oil companies in moving towards the use and production of clean green energy sources.
6. Steps and mechanisms to move towards the application of sustainable production technology in the petroleum sector.
7. The influence of fluctuations in oil prices on economic growth, as well as the impact of the Corona crisis on oil prices.

2. Research Questions and Hypothesis

The challenge is how to transform the world's first energy sector into a more productive, environmental-ecofriendly sector??Transforming the threat into a significant opportunity to increase profitability, competitiveness, and productivity without damaging the environment and vital habitats. Shifting directions for the industrial sustainability of the oil sector are emerging through the use of green clean energy and green chemistry principles So, too, are green engineering principles in manufacturing clean-energy and fuel products through the use of environmentally friendly raw materials for new projects and the replacement of existing traditional manufacturing technologies with more sustainable ones? Will green chemistry be a substitute for oil?

The conceptual and theoretical questions should be answered:

Will green chemistry be a substitute for oil if the oil sector is not directed to the use of sustainable manufacturing technology?

What is the importance and principles of sustainable manufacturing technology?

What are the mechanisms for shifting the domestic oil sector toward sustainability?

What are the effects of price instability on petroleum ore on national income?

Research Methodology

The research is based on the analytical research approach through available information and data gathered from questionnaire on the fundamentals and principles of sustainable green manufacturing technology and the impact of its application in the petroleum, gas and petrochemical industry on achieving sustainable development goals. As well as national and international experience and efforts such as Research papers, studies and conferences since 2015 to achieve the principles of sustainable development and environmental conservation. Also through applied study of some oil, gas and petrochemical companies in Egypt as well some regional and global companies.

Previous Studies

1. **The Egypt Petroleum Show (EGYPS 2020)1**

   In its fourth edition under the theme "North Africa and The Mediterranean, Delivering the Energy Needs of Tomorrow".

The show served as a platform to show positive results and to present the tangible progress seen in the oil industry across Egypt in 2019. The event focused on presenting current and future visions of the oil and gas sector with the aim of boosting growth and promoting investment opportunities. The conference and exhibition would be one of the greatest important events in the Middle East to shed light on the unprecedented results and developments in the oil and gas sector. Since the launch of its first edition in 2017, EGYPS has been developing considerably. The event witnessed an increase in the volume of global participation at the conference and exhibition, including major international companies and executives, reflecting its importance and value among major regional and international oil events. Last year, the conference discussed various topics related to Egypt's efforts to transform itself into a regional energy hub, as well as the development of key industry activities and the role of women in oil and gas. The conference emphasized the importance of financing in the oil and gas sector, given that it is considered to be one of the largest activities in the world in terms of acquisition and financial investment. The oil and gas sector in Egypt is currently witnessing positive indices reflecting the development that a number of international companies have entered the Egyptian market for the first time in the field of oil exploration, reflecting their confidence in the Egyptian investment climate and stability. The oil sector continues to intensify research and exploration activities in existing production areas, such as the Gulf of Suez and the Western Desert, in an effort to make new discoveries to enhance and increase Egypt's oil production in parallel with the launch of exploratory activities with international companies in new and promising regions in the western Mediterranean and the Red Sea. The petroleum sector is currently working on the digitization of all its activities, while providing all the data and geological maps on the government portal.

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The ERP system for enterprise resource planning has been applied to EGPC and Holding Companies and is currently being applied to their affiliates in preparation for the generalization of the system in all companies in the sector to facilitate the process of collecting joint data between companies and to facilitate the management of operations on the basis of these data. EGYPS acted as a key enabler of trade and investment, featuring 14 official international country pavilions from Bahrain, Canada, Cyprus, China, France, Italy, Norway, Scotland, Spain, United Arab Emirates, the United Kingdom and the United States of America, and for the first time pavilions from Germany and India. EGYPS 2020 organized 5 conference tracks, including the Strategic Conference, the Technical Conference and the Finance and Investment Summit, the Women in Energy Conference and the HSE in Energy Conference. Last year's conferences saw 270+ expert speakers from 245 in 2019, and 869 research papers were discussed.

2. **Sustainable Manufacturing: Principles, Applications and Directions[2]**

   Dr Nageswara Rao Posinasetti, Professor, Dept. of Technology, University of Northern Iowa, USA
   May 21, 2018

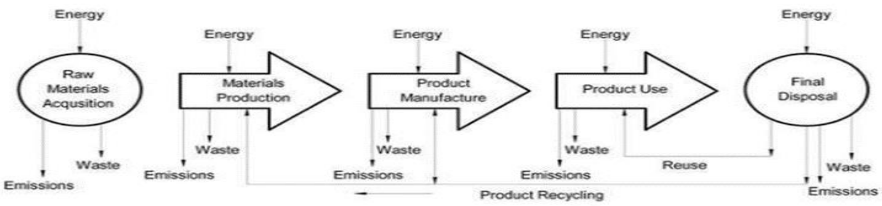
The study noted that although manufacturing systems create material wealth for humans, they consume a large amount of resources while generating a lot of waste. The environmental degradation is responsible for the waste generated during the manufacturing process, during the use of the products and after the end of the product's life. Consequently, minimizing resource consumption and reducing the environmental impact of production systems have become increasingly important. It is therefore vitally important that the manufacturing industries seek for 'Sustainable Manufacturing' on their part. Sustainable production (SM) or green production can be regarded as a production method that minimizes waste and reduces the

[1] https://www.petroleum.gov.eg/en/media-center/EventsPages/Pages/mop_27012020_01.aspx

[2] https://www.industr.com/en/sustainable-manufacturing-principles-applications-and-directions-2333598

environmental impact. These objectives are mainly to be achieved through the adoption of practices that will influence product design, process design and operational principles. Sustainable production can therefore be defined as a system that integrates product and process design issues with manufacturing, planning and control issues in a way that identifies, quantifies, evaluates and manages the flow of environmental waste with the aim of ultimately reducing the environmental impact to that of the Earth's self-recovery capability, while at the same time also managing the flow of environmental waste. The survey of 198 Indian small and medium-sized enterprises identified the following aspects of sustainable manufacturing: "The final quantitative benefits of green manufacturing for their reduced ranking are improved morality, improved brand value, reduced regulatory concerns, increased market opportunities, improved product performance and reduced liabilities. Quantitative benefits of green manufacturing are related either to waste (reduced waste handling costs, reduced waste categorization costs, reduced waste treatment costs, reduced waste disposal costs and reduced waste storage costs) or to the product life cycle (lower transport costs, lower packaging costs, reduced overall product costs, decreased production costs, reduced operating/use costs for users, reduced maintenance/service costs and reduced overall organization costs)."
The Life Cycle Assessment tool generally used to implement SM is (LCA). The approach is to fully examine the environmental impact of different human activities, including the production of goods and services by corporations. LCA could be used for any activity that is either national or worldwide in order to identify environmental impacts resulting from the activities of a society, a region or a manufacturing sector. Throughout fact, LCA provide an amazing insight for the engineer to study any given product in such a way that he/she can identify methods to reduce the environmental impact of a particular product or process. A schematic of the methodology used for the implementation of the LCA is given in Fig 1.

Figure 1: Lifecycle Assessment methodology [1]



Source: EM Efficient Manufacturing A WEB-MAGAZINE OF INDUSTR.COM May 21, 2018

The study concluded that sustainable production is the most important aspect to be considered by all production engineers, not because it is a fad, but a necessity as an obligation to the world in which we live. The methodology of the product life cycle has been a preferred method used to determine the environmental impact of the products that we produce. While its application of PLA is time consuming and data intensive, it provides clear opportunities for engineers to be able to reduce the environmental impact. There seem to be a variety of manufacturing areas that can greatly benefit from the adoption of green manufacturing practices. The three key elements to be taken into consideration are to reduce the use of resources in the process, to use environmentally friendly materials, to reduce all forms of waste and to reuse and recycle as much material as possible in order to achieve the goal of the earth's self-recovery capability.

3. **Challenges for sustainable development strategies in oil and gas industries**[2]
   Ali Asghar Sadeghi MOJARAD, Vahid ATASHBARI, Adrian TANTAU March 2018

[1] https://www.industr.com/en/sustainable-manufacturing-principles-applications-and-directions-2333598
[2] https://www.researchgate.net/publication/324388641_Challenges_for_Sustainable_Development_Strategies_in_Oil_and_Gas_Industries/

The research showed that the oil and gas industries remain an important driver of the world economy. Mostly each global demand for fossil fuels continues to rise and, on the other hand, companies face complex investment challenges due to the severe operational environment of exploration and production activities. The main objective of the Workforce Regulations is to ensure a safe and secure working environment. However, exploration and production activities still pose local and global environmental risks, such as groundwater contamination or broader climate change. Analysis and reporting mechanisms are key performance indicators for sustainable development at the point of oil and gas companies. After all, obtaining and analyzing the necessary data appears to be a persistent challenge to the extent to which these findings could affect the routine and strategic decisions of oil and gas companies. In order to facilitate oil and gas companies to measure and control risks and manage incidents, an effective prevention strategy is known to be artificial intelligence technologies for enhanced monitoring and supervision of E&P operations. Such tools not only contribute to the profitability of oil and gas companies, but also increase environmental awareness and increase climate change awareness in order to act more responsibly. For this study, the impact of environmental policies has been investigated through interviews with executives and stakeholders, showing that the implementation of environmental policies is affected by the financial stability of companies and, in severe economic situations, companies seem less enthusiastic about the strict implementation of these policies. This article gives an overview of emerging technologies to address the current and anticipated challenges to sustainable development in the oil and gas industries, with the aim of proposing key solutions for strategic planning efforts.

4. **Issues Impacting Sustainability in the Oil and Gas Industry.**

Mohamad Danish Anis1[1] & Tauseef Zia Siddiqui[2] November 30, 2015

This research paper explores the concept of sustainability and the role played by O&G industry in achieving sustainable development. The authors bring a rational approach in defining the key issues for the O&G sector that affect sustainability as well as try to devise the inherent risks as well as mitigation approaches adopted by these companies. Sustainability is a topic gaining fast repute today. As new conventional oil and gas sources decline, unconventional sources, including shale gas in the US, oil sands in Canada, coal seam gas in Australia, and deep-water offshore wells in Brazil, West Africa and Asia have been identified as key areas with significant reserves potential. Despite the growth potential, sustainability risks such as climate change, safety risks, and community disagreements exert pressure on the economic feasibility of these opportunities.

The three components of sustainable development: economic, environmental and social, often referred to as the ‘Triple Bottom Line’ or TBL, can be used in evaluating a company’s performance in financial, environmental and social dimensions. These three dimensions of sustainable development, as explained by John Elkington and adopted by Shell’s first sustainability report in 1997, are also commonly referred to as the 3Ps: People, Planet and Profit.

The paper also focuses on analyzing the various threats that could obstruct sustainable development being carried out by companies in the oil and gas industry. The importance of sustainable economic growth with regards to the oil and gas industry has also been highlighted. The 3Ps explained above can be used to categorize the key issues/risks that impact sustainability. The researchers concluded that the sustainability programs followed by oil and gas industry are not satisfactory; however there is strong evidence of improvement in near future. Towards the end, the researchers have tried to list the Strategies and Methodologies for enhancing the effectiveness of sustainability strategies and programs for the sector.

The study found that there are many loopholes surrounding the concept of sustainability. Even though sustainable development has a short history, the issues surrounding the topic have been addressed till date in a multidimensional aspect. The concept of sustainable development was intended to provide the right

[1] School of Mechanical, Aerospace & Civil Engineering, University of Manchester, United Kingdom

[2] Sustainability Specialist, SABIC, Jubail Industrial City, Saudi Arabia

framework for law makers, planners and decision makers so that issues concerning development, environmental safety and social responsibility could be addressed using an empirical methodology. However, the scope of sustainable development in the O&G industry has been poorly defined, making it prone to ambiguity. Sustainability today, as addressed by the O&G companies, majorly tends to take into concern only the management issue. ~~Instead, it should actually question the involvement of the larger political dimension which has consequences on the operational methods of these companies. Today, the concept of sustainability is being interpreted in a multitude of different ways and sustainability cannot be achieved with conflicting notions of the concept at various levels.~~

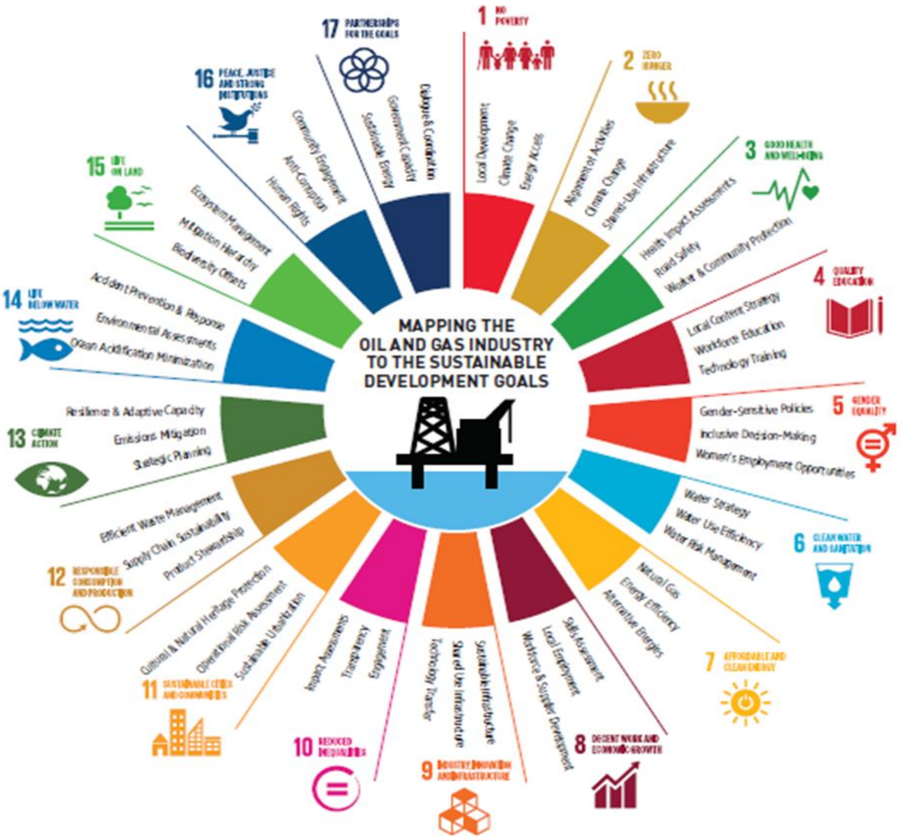
5. Mapping the Oil and Gas industry to the Sustainable Development Goals: An Atlas – 2017

IFC “International Finance Corporation” World Bank Group” IPIECA "International Petroleum Industry Environmental Conservation Association" ", UNDP “United Nations Development Program”2017

The Atlas identified that the oil and gas sector is a major worldwide sector that can have positive and negative effects on a number of areas covered by the SDGs. The aim of Atlas is to facilitate a dialog on the ways in which oil and gas companies, acting individually and collaboratively with governments, communities, civil society and other partners, can help to achieve and raise awareness of sustainable development goals. Among the general conclusions of Atlas, which could guide action and stimulate further discussion and research, are as follows: the oil and gas industry has the capacity to contribute to the 17 Sustainable Development Goals; the scope and nature of typical oil and gas activities refer to certain sustainable development objectives, where there are particularly strong opportunities to contribute, And there are opportunities for the integration of SDGs into the core business activities of oil and gas companies. Oil and gas companies can benefit from collaboration with stakeholders to expand their impact and enhance their ability to tap additional resources to achieve SDGs, which are often interlinked with SDGs, and require approaches that ensure synergies and manage trade. The key issue areas for oil and gas mapped to the SDGs is shown in figure 2.

~~[illegible]~~

Figure 2: Key Issue Areas for Oil and Gas Mapped to the SDGs



Source: An Atlas Mapping the Oil and Gas industry to the Sustainable Development Goals

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Conceptual Framework

1. Oil, Gas and Petrochemicals Overview

Natural oil and gas (petroleum) are discovered below the Surface of the earth and are highly valued as sources of both fuel and as starting materials for many commercial products, such as most plastic materials. Petroleum engineering is the application of the principles of chemistry, physics, mathematics, geology and engineering to discover a cost-effective way to identify potential directions for exploration, obtain and refine this mineral wealth into desirable products. Petroleum chemist's work with crude oil and products derived from it.

There's also a green side to petroleum chemistry. Compliance with environmental regulations is essential for the industry, and scientists must always be aware of how the process or product will affect the environment and how this impact can be minimized. Chemists everywhere are looking for ways to enable new refining processes and products with cleaner, safer and more efficient ones.[1]

Assumed to be the largest sector in the world in terms of dollar value, the oil and gas sector is a global powerhouse that employs hundreds of thousands of workers worldwide and generates hundreds of billions of

[1] https://www.acs.org/content/acs/en/careers/college-to-career/chemistry-careers/oil-petroleum.html

dollars globally each year. In areas where major NOCs are located, these fossil fuel companies are so essential that they mostly make a significant contribution to national GDP.
There are three key areas in the energy sector: Upstream, midstream and downstream.
- Upstream is E&P (exploration and exploration). This includes the search for underwater and underground natural gas fields or crude oil fields and the drilling of exploration wells and the drilling of wells for the recovery of oil and gas.
- Midstream includes the transportation, storage and processing of oil and gas. Once resources have been recovered, they must be transported to a refinery, which is often in a completely different geographical area compared to oil and gas reserves. Transportation can cover everything from tanker ships to pipelines and trucking fleets.
- Downstream refers to the filtering of raw materials produced during the upstream phase. This means the refinement of crude oil and the purification of natural gas. The marketing and commercial distribution of these products to consumers and end users in a number of forms, including natural gas, diesel, petrol, gasoline, lubricants, kerosene, jet fuel, asphalt, fuel oil, LPG (liquefied petroleum gas) and a number of other types of petrochemicals.
The largest volumes of oil and gas products are fuel oil and gas (petrol). Petroleum is the primary material for a wide range of chemical products, including pharmaceuticals, fertilizers, solvents and plastics. Oil is therefore an integral part of many industries and is of critical importance to many nations as the foundation of their industries.

Fossil resources, including oil, natural gas and coal, are the main sources of chemical products that have an impact on our modern lives. Hydrocarbons, the main components of fossil resources, can be transformed into more valuable products through a number of refining processes. One of these processes is called cracking, in which the long chains of carbon are cracked (broken down) into smaller and larger chains. When these fractions are sorted out, they become the building blocks of the petrochemical industry, such as olefins (ethylene, propylene and butadiene) and aromatics (benzene, toluene, and xylenes). These new hydrocarbon products will then be transformed into final consumer products. Table 1 gives examples of some end products made from hydrocarbons.
Over than 10 million metric tons of oil are used in the world every day. The growing world population (expected to reach 10 billion people in a few decades) is putting increasing pressure on this non-renewable resource to supply raw materials for growing consumer demand. Fossil resources also account for 85 per cent of the world's energy supply, and growing populations and increasing energy consumption place even greater demand on their use. Because society is increasing its consumption of this non-renewable resource, the identification of alternative, renewable energy sources and raw materials for chemicals is emerging as one of the greatest challenges of the 21st century.

Table 1: End Products Made from Common Hydrocarbons

Hydrocarbons	Trade Names	Consumer Products
Ethylene (C_2H_4)	Polyethylene (Polythene)	Plastic bags, wire and cable, packaging containers, plastic kitchen items, toys
Propylene (C_3H_6)	Polypropylene (Vectra, Herculon)	Carpets, yogurt pots, household cleaners' bottles, electrical appliances, rope
Butadiene (C_4H_6)	Copolymers with butadiene named Nipol, Kyrnac, Europrene	Synthetic rubber for automobile tires, footwear, golf balls
Benzene (C_6H_6)	Polystyrene	Insulation, cups, packaging for carry-out foods
Toluene (C_7H_8)	Polyurethanes	Furniture, bedding, footwear, varnishes, adhesives
Paraxylene (C_8H_{10})	Polyesters	Clothes, tapes, water and soft drink bottles [1]

Source: Added by researcher

[1] Marteel-Parrish, Anne E. Green chemistry and engineering : a pathway to sustainability (2014) Department of Chemistry, Washington College; Martin A. Abraham, College of Science, Technology, Engineering, and Mathematics, Youngstown State University.p3

2. Oil and gas industry outlook: 2019

In view of the low-cost industry, such as the price collapse in 2013 and major environmental disasters such as the Deepwater Horizon Gulf of Mexico oil spill in 2014, the oil and gas sector had been recovered from before the Covid-19 Pandemic. The world's dependence on oil and gas is growing as global economies and infrastructure continue to rely heavily on petroleum products. Discussions as to when world oil and gas production will peak seem to be on the periphery, even in the midst of a weakened global economy and a declining availability of oil. The oil and gas industry remains to acquire extraordinary influence in international economics and politics, especially given the level of employment in the sector, with the US oil and gas industry supporting at least 10 million jobs. The recovery has taken place for a number of reasons, but the chief among them is the success of the production restraint agreement between OPEC and non-OPEC countries. In addition, developing nations such as China, Brazil and Russia are increasing their exploration and production activities. Fortunately, geopolitical considerations such as the ongoing difficulties in Venezuela, Iran and Qatar's exit from OPEC will have an impact on oil and gas supplies. The trend towards renewable and alternative energy sources is another threat to traditional oil and gas companies. Associated with the rise in environmental legislation and government pressure, the industry is under more scrutiny than ever before.

The generation of electricity from solar and offshore wind systems is becoming increasingly cheaper and more cost-effective. According to IRENA, more than 80 per cent of newly commissioned renewable energy will be cheaper than new oil & natural gas sources. More recently, there has been a re-emergence of confidence in the industry as it enters its third year of recovery. Growth is rising at a remarkable rate, as increased upstream production continues to have a positive knock-on effect on midstream enterprises. The price of crude also stabilized-sustaining at around $50 per barrel. In addition, 100,000 jobs are expected to be created in 2019 and the number of active drilling rigs in the U.S. has increased to 780+ compared to 591 a year ago. The United Kingdom's continental shelf also appears to be back, with the potential to unlock dozens of undeveloped discoveries with drilling prospects on the horizon. In addition, we can expect an improved outlook for upstream UK production. The UK offshore sector is expected to improve after historic lows in the last few years, as there are 16 planned Greenfield projects with identified development plans and 29 announced plans to start production in Greenfield between 2019 and 2025.

It is forecasted that 30 billion barrels are consumed globally each year, mainly by developed nations. Oil also accounts for a significant percentage of regional energy consumption from 32% for Europe and Asia, 40% for North America, 41% for Africa, 44% for the South and 53% for the Middle East.[1]

3.Covid19 Impact's on Oil and Gas price[2]

In 12 years, the oil and gas industry is experiencing its third price collapse. After the first two shocks, the industry rebounded, and business continued as usual. It's a different time. The current situation combines a supply shock with an unprecedented drop in demand and a global humanitarian crisis. The invention of petroleum, oversupply and generous financial markets, which overlooked limited capital discipline, all contributed to poor returns. Today, with prices reaching 30-year lows and accelerating social pressure, executives feel that change is inevitable. The crisis of COVID-19 accelerates what was already shaping up to be one of the most transformative moments of the industry. To break the existing paradigm, the industry will need to dig deeper and tap into its proud history of bold structural moves, innovation, and safe and profitable operations under the toughest conditions. The winners will be those who use the crisis to boldly reposition their portfolios and transform their operating models. Companies that are not going to restructure or certainly atrophy. Such megacycles have seen huge changes in value creation.

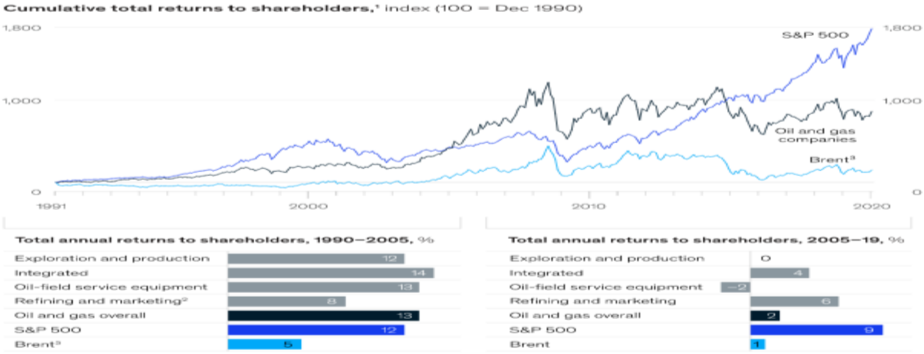
The demand for oil and gas has increased, and OPEC has helped to maintain stable prices. Companies kept costs low, as memories of oil in the 1980s were still acute at $10 per barrel (bbl.). A new class of supermajor

[1] https://www.oilandgasiq.com/strategy-management-and-information/articles/oil-gas-industry-an-introduction

[2] https://www.mckinsey.com/industries/oil-and-gas/our-insights/oil-and-gas-after-covid-19-the-day-of-reckoning-or-a-new-age-of-opportunity

has emerged from megamergers; these companies have created value for decades. Likewise, "big three" oil field service equipment (OFSE) companies have emerged. Political openings and new technologies have created opportunities for all. From 2005 to January 2020, while macro tailwinds such as strong demand growth and effective supply access have continued, the global industry has not been able to keep pace with the wider market. In this period, the average annual TRS growth of the oil and gas industry was about seven percentage points lower than the S&P 500 (Graph 1). Similarly, every sub-segment underperformed the market, and independent upstream and OFSE companies delivered zero or negative TRS. The analysis excludes companies that have not been listed during this period (including some structurally advantaged national oil companies, and private companies).

Graph 1: ***The Oil and Gas industry underperformed against the S&P 500 over the past 15 years***[1]



[2,3,4]

Source: S&P Capital IQ; McKinsey analysis

And in early years of this time frame, the revenue structure of the industry was favorable. Demand increased by more than 1% per year for oil and by 3 to 5 per cent for liquefied natural gas (LNG). The "cost curves" of the industry—its production assets, ranked from the lowest to the highest cost—were steep. With significant high-cost production needed to meet demand, the market-clearing price has increased. Same was reasonable of both gas and LNG, the prices of which were often closely linked to oil. Also downstream, the steep cost curve of the world's refining capacity has supported high margins. Considerable companies have invested in shale oil and gas, with a number of profound implications. To begin with, the shale reshaped the structure of the upstream industry. As shale oil and gas came on stream, it flattened the cost-production curve (i.e., moderate-cost shale oil displaced much higher-cost production, such as oil sands and coal gas), effectively lowering both the marginal cost of supply and the market-clearing price (Graph 2).

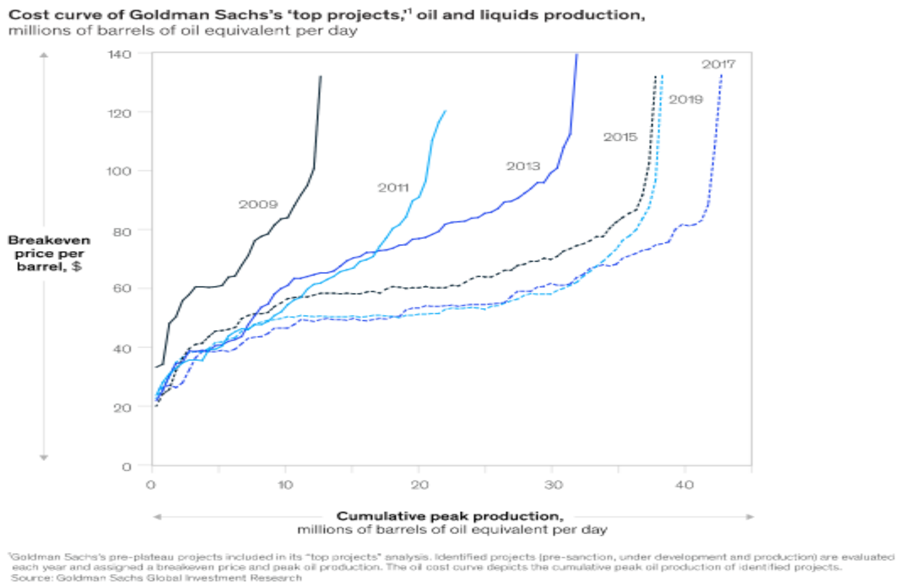
Graph 2: ***New supply flattened the cost curve between 2009 and 2019***

1 https://www.mckinsey.com/industries/oil-and-gas/our-insights/oil-and-gas-after-covid-19-the-day-of-reckoning-or-a-new-age-of-opportunity

2 National Oil Companies are allocated as per their business model, at least one year of data required for inclusion.

3 Excludes marketing pure plays

4 Represents change ICE Brent price



Source: Goldman Sachs Global Investment Research

3.1. Issues for leaders and emerging insights—a return to strategic plan
Whereas the current economic crisis is rightly consuming leadership time and attention, many others are thinking about how to lead their companies after the crisis, and are asking existential questions about their reasons for being and the basis for their distinctiveness. Various strategic choices are available (e.g. basin master, midstream and trading leader, technology specialist, First-quarter low-cost manufacturer, value-chain integrator, energy transition specialist and integrated refining/petrochemical player, among others). It would be unacceptable not to make clear choices. The value of the traditional multi-business model is often not sufficient to overcome poor operational management, poor capital allocation or structurally disadvantaged assets. Are some large companies going to survive in their current form? What is the role of independent and mid-size players? How are NOCs going to thrive and continue to play their important societal roles in the future? Will the different forms of supply chain partnership be an important part of future business models? How should companies structure relationships with digital and advanced analytics companies to transform operations and support new business models? Can technology and innovation unlock new growth for the industry: what would be needed to deliver new LNG projects in a fundamentally different way at $300/ton and displace coal entirely? Can the costs of CO2 mitigation be significantly reduced? In an age of abundance, will the flow of value be valued by those who have a customer relationship and integrated value chains? Should companies make a significant shift toward more renewables and away from oil and gas?

Throughout answering questions, businesses should focus their responses on three points. The opportunity to lead has never been better—the separation between market leaders and laggards will be increasingly acute. Shaping regulation will matter, and the enforcement of operating standards will benefit industry and market leaders. Likewise, resilience and balance-sheet strength are non-negotiable. A new, strategic view of what the capital structure and the resulting dividend policy should look like is needed.

3.2. Taking bold action during the crisis to secure resilience and accelerated repositioning
All companies should act courageously on five key elements in line with their business plan:

1-Reshape the investments and fundamentally reassign capital to the highest return opportunities. Companies should make tough and fundamental choices across the asset base and permanently reallocate capital away from low-return enterprises to those best aligned with future value creation and sources of distinctiveness.
2-Take provocative moves from M&A. Winners would then emerge with advantageous investments that will be resilient to longer-term trends. They should settle for nothing less than the absolutely best-positioned assets in upstream, refining, marketing and petrochemicals.
3 - Unlock a step-by-step change in performance and cost competitiveness by re-imagining the operating model. Leading companies will step up their efforts at this time, protecting or even scaling up technology, digital and artificial intelligence investments; and drawing inspiration from some of the new approaches emerging from remote work, Such that they wouldn't go back to business as usual once the crisis is over. The COVID-19 crisis, which has obligated business to act in new ways, may be a catalyst for rethinking the size and role of the functional teams, field crews and management processes needed to run an efficient oil and gas company.
4 – Ensure resilience of supply chains through redefining strategic partnership approaches.
5-Create the Organization of the Future, both in terms of talent and structure. The oil and gas industry is no longer the prime employer of choice in many markets and is struggling to attract not only the best engineers, but also the best new talent in areas such as digital technology and commercial technology. All are needed to drive the transformation of the business model.

4.Principles of Green Chemistry and Green Engineering and their role in Oil and Gas towards Sustainability

4.1. Principles of Green Chemistry and Green Engineering
Green Chemistry and Green Engineering are an essential component part of the new thinking (we can call it a new philosophy) that is needed to advance sustainability goals. The chemical industry and synthetic chemical production are now the most important form of economic activity in the manufacture of thousands of chemical products, consumer goods and materials. The goal of changes in the design, production and use of chemicals will therefore contribute to sustainability. From the start, GC innovations were focused on feedstock's, reagents, solvents and synthesizers.
Green Chemistry (GC) applies throughout the life cycle of a chemical product, including its design, manufacture and use.[1]
Green Chemistry wants to change the way things have worked so far. Green Chemistry is pushing for new standards for chemicals and chemical processes. GC calls for changes to the decisions taken by chemists when designing industrial production. GC is developing new techniques to reduce or eliminate negative environmental impacts. The use and production of such chemicals may involve reduced waste products, non-toxic components and improved efficiency. Green Chemistry is a highly effective approach to pollution prevention, because it applies innovative scientific solutions to environmental situations in the real world.
"Green Chemistry is the use of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and use of chemical products." This is the prevention of pollution at the molecular level. It is quite simply a fundamental building block in the efforts to create a sustainable economy.
Green Engineering is the design, commercialization and use of processes and products that are feasible and cost-effective while: reducing the generation of pollution at source and minimizing the risk to human health and the environment. It is very simple to design a product or process that has minimal environmental impact while creating a sustainable economy.

[1] 1 Eurostat. Statistical Books. Sustainable Development in the European Union. 2009 Monitoring Report of the EU Sustainable Development Strategy. European Commission, Luxembourg, OOP, 2009.

Benefits of Green Chemistry are Waste Minimization, Pollution Prevention, Energy Conservation, Increasing Health & Safety, Less impact on the Environment, Investment into the Future and finally Sustainable Growth = Economic Growth

The Twelve principles of Green Chemistry are[1]:

1) Prevention: Prevent waste than to treat or cleanup
2) Atom Economy: Design the reaction to get a product to utilize all atoms used.
3) Less Hazardous Chemical Syntheses: Design synthetic methods to employ materials that carry little or no toxicity to humans and environment
4) Designing Safer Chemicals: Search for safer chemicals that are degradable and has less impact on the environment.
5) Safer Solvents and Auxiliaries: Search for safer benign solvents that can be recycled and has less impact on the environment. The next table summarized the solvents according to preferable, usable and undesirable.

Table 2: Solvents

Preferred	Usable	Undesirable
Water	Cyclohexane	Pentane
Acetone	Heptane	Hexane(s)
Ethanol	Toluene	Diisopropyl ether
2-Propanol	Methylcyclohexane	Diethyl ether
1-Propanol	t-Butylmethyl Ether	Dichloromethane
Ethyl Acetate	Isooctane	Dichloroethane
Isopropyl acetate	Acetonitrile	Chloroform
Methanol	2-Me Tetrahydrofuran	N-Methylpyrrolidinon
Methyl Ethyl Ketone	Tetrahydrofuran	Dimethyl Formamide
1-Butanol	Xylenes	Pyridine
t-Butanol	Dimethyl Sulfoxide	Dimethyl Acetamide
	Acetic Acid	Dioxane
	Ethylene Glycol	Dimethoxyethane

Source: Added by researcher

6) Design for Energy Efficiency: Design synthetic methods that utilize less or no energy. Such as Room temperature and Atmosphere, Pressure reactions/Sonication/Microwave.
7) Use of Renewable Feed stocks: A raw material or feedstock should be renewable rather than depleting that is economically practicable.
8) Reduce Derivatives: Minimize unnecessary derivatization (blocking groups) as they require additional reagents and generate waste
9) Catalysis: Employ catalysts that promote reactions and can be regenerated
10) Design for Degradation: Final chemical products and by-products should be designed to break down to benign fragments at the end of their function
11) Real-time analysis for Pollution Prevention: Develop methodologies to control the formation of hazardous substances. As shown in the next Figure.

Figure 3: The P2 Hierarchy

Source: Added by researcher

12) **Inherently Safer Chemistry for Accident Prevention:** Design the chemical processes to minimize the potential for accidents, releases, explosions and fires thereby increasing safety in the laboratory

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[1] Anastas, P. T.; Warner, J. C.; Green Chemistry: Theory and Practice, Oxford University Press: New York, 1998, p.30. By permission of Oxford University Press

The Twelve Principles of Green Engineering are[1]:

1) Inherent Rather Than Circumstantial: Designers need to strive to ensure that all materials and energy inputs are as inherently nonhazardous as possible.
2) Prevention Instead of Treatment: It is better to prevent waste than to treat or clean up after it is formed. Such as Power generation Fossil Fuel Vs. Fusion
3) Design for Separation: Separation and purification should be designed to minimize energy consumption and material use. Such as Separation/purification Vs. Polymers can used to control the solubility of substrates, ligands and catalysts for separation.
4) Maximize Efficiency: Products, processes and systems should be designed to maximize mass, energy, space and time efficiency.
5) Output-Pulled Versus Input-Pushed: Products, processes, and systems should be “output pulled” rather than “input pushed” through the use of energy and materials. Concept of Le Chatelier’s principle: Minimize the amount of resources consumed to transform inputs into the desired outputs.
6) Conserve Complexity: Embedded entropy and complexity must be viewed as an investment when making design choices on recycle, reuse and beneficial disposition.
7) Durability Rather Than Immortality: Targeted durability, not immortality, should be a design goal. Such as Single use disposable diapers: Replace non bio-degradable plastic with Eco-silver ware (PLA, starch and water)
8) Meet Need, Minimize Excess: Design for unnecessary capacity or capability (e.g. one size fits all) solutions should be considered a design flaw
9) Minimize Material Diversity: Material diversity is multicomponent products should be minimized to promote disassembly and value retention. Such as Mono-material design strategy in auto industry: Easy disassembling
10) Integrate Material and Energy Flows: Design products, processes, and systems must include integration and interconnectivity with available energy and material flows. Such as Regenerative Braking Systems in Hybrid vehicles: Heat generated is fed back into the battery and stored as energy to propel the car.
11) Design for Commercial "Afterlife”: Products, processes, and systems should be designed for performance in a commercial ‘afterlife”. Such as Cell phones/Laptops
12) Renewable Rather Than Depleting: Material and energy inputs should be renewable rather than depleting. Biomass feed stocks, bio-based plastics, and waste water treatment with natural eco systems.

While these principles of green chemistry and green engineering have been established for more than a decade, companies have only recently begun to implement and apply these concepts on a large scale for industrial applications, often with a focus on developing renewable feed materials for chemical processes. The slow growth in the application of green principles can be attributed to their incorrect value within the business model. Green principles are most often linked to "environmentally friendly" products. Thus, the only perceived benefit to the company is the environmental performance of the manufacturing processes or products themselves. If consumers can be encouraged to use these products on the basis of an "eco-friendly" label, the company is likely to incorporate green principles into its strategy to increase market share. However, this business view of green principles is naive and excludes many of the key economic benefits that are offered from their use. To better understand this point, Tables 1, 2 in appendix demonstrate how each of the green chemistry and green engineering principles are related to the economic, environmental and social factors.

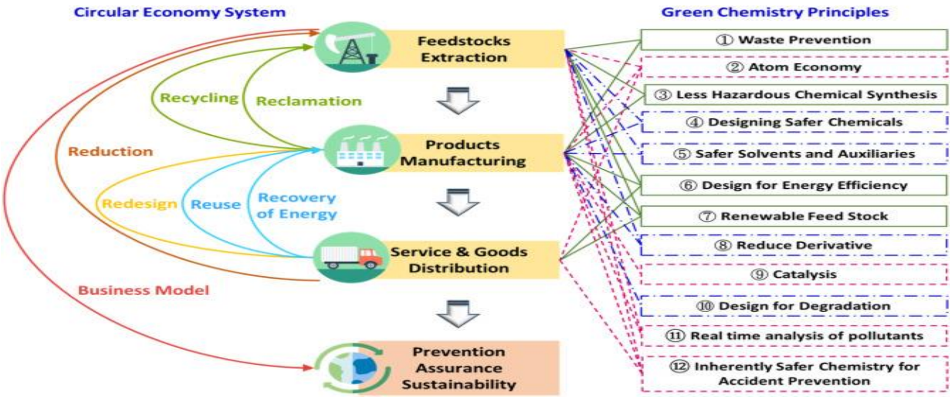
4.2 Green Sustainable Chemistry Principles in Circular Economy

Green chemistry principles (GCP) are being used extensively in industrial management, government policy, educational practice, and technology development all over the world. The circular economy always seeks to

[1] Anastas, P.T., and Zimmerman, J.B., "Design through the Twelve Principles of Green Engineering", Env. Sci.and Tech., 37, 5, 94A-101A, 2003.

strike a balance between economic growth, resource sustainability, and environmental protection. We also proposed five strategies of priority governance direction to integrate GCP into the circular economy concept: (i) establishment of cross-departmental collaboration, (ii) development of cleaner production and green product, (iii) provision of integrated chemical management system, (iv) implementation of green chemistry education program, and (v) construction of a business model. Finally, the prospects of disciplinary elements such as the establishment of redesign-reduction-recovery-recycle-reuse (5R) practices for waste reclamation, the deployment of a water-energy-food nexus with GCP to improve food security and resource sustainability, and the implementation of GCP in the green smart industrial park are discussed. The green sustainable chemistry integration into circular economy can be summarized as follow in the Figure.

Figure 4: The green sustainable chemistry integration into circular economy



[1]

Source: Science of The Total Environment Volume 716, 10 May 2020, 136998

Practical Framework

1. New concepts and trends arise from sustainable development in oil and gas Field

While there are numerous advantages to using green chemistry and green engineering and design, the economic impact of such technologies is likely to be the most significant from an industrial standpoint. Applications ranging from low carbon fuels to biofuel refining have been articulated.

1.1. Low carbon fuels (LCF)

A low-carbon economy (LCE), low-fossil-fuel economy (LFFE), or decarbonized economy is one that relies on low-carbon energy sources and thus emits little greenhouse gas (GHG) into the atmosphere, specifically carbon dioxide. Since the mid-twentieth century, GHG emissions caused by anthropogenic (human) activity have been the dominant cause of observed global warming (climate change). Continued emissions of greenhouse gases may result in long-term global changes, increasing the likelihood of severe, pervasive, and irreversible consequences for people and ecosystems. Globally shifting to a low-carbon economy could have significant benefits for both developed and developing countries. Many countries are developing and implementing low-emission development strategies (LEDS). These strategies aim to achieve social, economic, and environmental development goals while lowering long-term greenhouse gas emissions and increasing resilience to climate change.

Those who have reached this conclusion thus propose globally implemented low-carbon economies as a means of avoiding catastrophic climate change and as a precursor to the more advanced, zero-carbon economy.

[1] https://www.sciencedirect.com/science/article/abs/pii/S0048969720305088

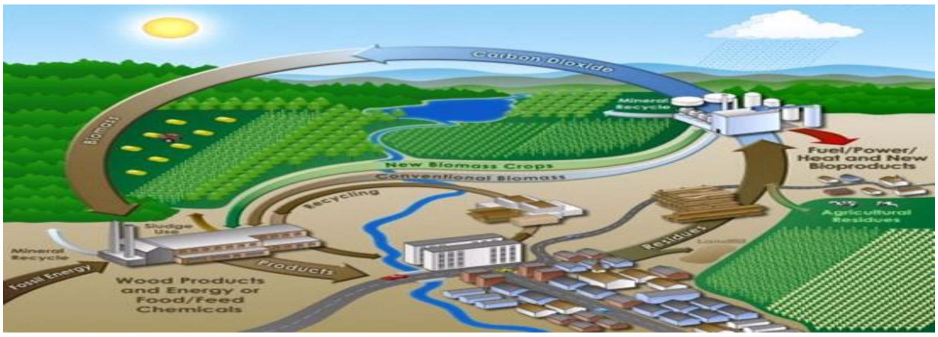
Shell is focused on producing and providing low carbon fuels (LCF) such as sustainable aviation fuel (SAF), biodiesel, bioethanol, and renewable compressed natural gas (R-CNG) to aid in the reduction of carbon emissions from transportation..[1] LCF can be mixed with existing fuels such as gasoline and aviation fuel, and it does not require large investments in new infrastructure. LCF play an important role in trucking, aviation, and shipping. This is because liquid LCF provides a lot of energy for a small amount of fuel. Solutions include electricity and hydrogen, as well as the more important LCF.

1.2. Bio refinery industry [2]

A bio refinery is a facility that combines biomass conversion processes and equipment to generate fuels, electricity, and value-added chemicals from biomass. A bio refinery is similar to a petroleum refinery, which produces a variety of fuels and products from petroleum. A bio refinery takes advantage of the various components in biomass and their intermediates by producing multiple products, maximizing the value derived from the biomass feedstock. A bio refinery, for example, could produce one or more low-volume, high-value chemical products as well as a low-value, high-volume liquid transportation fuel such as biodiesel or bioethanol. At the same time, it can generate electricity and process heat using CHP technology for its own use and possibly enough to sell to a local utility.

High-value products boost profitability, high-volume fuel meets energy demands, and power generation lowers energy costs and reduces GHG emissions from traditional power plant facilities.

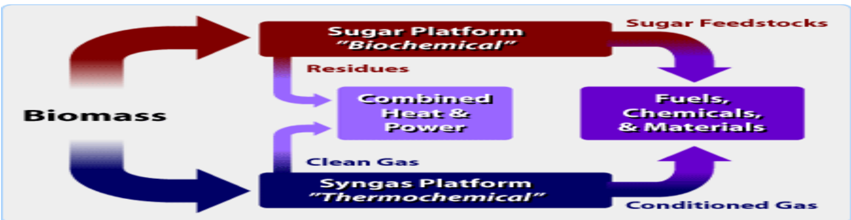
Figure 5: Bio refinery



Source: Bioenergy Consult, the concept of biorefienery by Salman Zafar | December 27, 2020

There's several bio refinery platforms that can be used in a bio refinery, the most important of which are the sugar platform and the thermochemical platform (also known as syngas platform).

Figure 6: Bio refinery Concepts



[1] https://www.shell.com/energy-and-innovation/new-energies/low-carbon-fuels.html#vanity-aHR0cHM6Ly93d3cuc2hlbGwuY29tL2dsb2JhbC9lbnZpcm9ubWVudC1zb2NpZXR5L2Vudmlyb25tZW50L2NsaW1hdGUtY2hhbmdlL2Jpb2Z1ZWxzLWFsdGVybmF0aXZlLWVuZXJnaWVzLXRyYW5zcG9ydC9iaW9mdWVscy9yYWl6ZW4vc3VnYXItY2FuZS10by1ldGhhbm9sLWFuaW1hdGlvbi9hY2Nlc3NpYmxlLmh0bWw

[2] https://www.bioenergyconsult.com/biorefinery/#google_vignette

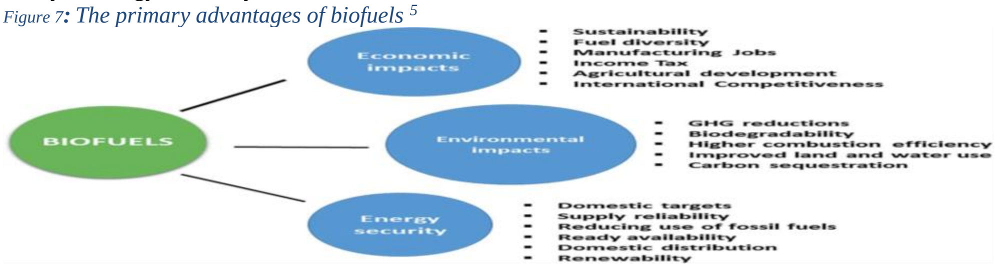
Source: Bioenergy Consult, the concept of biorefienery by Salman Zafar | December 27, 2020

Sugar platform bio refineries convert biomass into various types of component sugars for fermentation or other biological processing into various fuels and chemicals. Thermochemical bio refineries, on the other hand, convert biomass into synthesis gas (hydrogen and carbon monoxide) or pyrolysis oil.
The thermochemical biomass conversion process is complex, with components, configurations, and operating conditions more akin to petroleum refining. Biomass is converted into syngas, which is then transformed into an ethanol-rich mixture.
Syngas derived from biomass, on the other hand, contains contaminants such as tar and Sulphur, which interfere with the conversion of the syngas into products. Tar-reforming catalysts and catalytic reforming processes can remove these contaminants. This not only cleans the syngas, but also generates more of it, improving process economics and, in turn, lowering the cost of the resulting ethanol.
Bio refineries can help to maximize the energy potential of organic wastes while also addressing waste management and GHG emissions issues. Through appropriate enzymatic/chemical treatment, biomass wastes can be converted into either gaseous or liquid fuels.
Paper-pulp, HFCS, solvents, acetate, resins, laminates, adhesives, flavor chemicals, activated carbon, fuel enhancers, and undigested sugars, among other products, are generated during the pre-treatment processes involved in bio refining. This process's suitability is further enhanced by the fact that it can use a variety of biomass resources, whether plant-derived or animal-derived.
1.3. Bio fuels
Almost 95% of the world's transportation energy is generated from petroleum-based fuels, primarily gasoline and diesel. The transportation sector is also responsible for 14% of global greenhouse gas (GHG) emissions and approximately 25% of energy-related CO2 emissions.[1],[2],[3] By 2030, energy consumption in the transportation sector and associated carbon emissions are expected to be approximately 80% higher than current levels.[4], The transportation sector is difficult to decarbonize due to its reliance on fossil fuels and persistent demand. According to Pietzcker's and colleagues' projections [5] ~~When~~when subjected to the same monetary incentives to decarbonize, transport sector de-carbonization lags 10–30 years behind mitigation efforts in non-transport sectors in the first half of the century in all models. Only Brazil has succeeded in replacing petroleum fuels in the transportation sector with liquid biofuel.[6] Decarbonizing the transportation sector is thus a fundamental challenge that must be addressed in order to limit climate change.
Traditional transportation fuels are primarily petroleum-based liquid hydrocarbons such as gasoline and diesel. The carbon numbers in gasoline range from C5 to C12, with the majority of them being branched, whereas the carbon numbers in diesel range from C10 to C20, with the majority of them being linear. The properties of petroleum-based liquid fuels have been used to develop the entire transportation infrastructure. These fuels have a high energy density, are stable, and have excellent combustion characteristics. All of these characteristics are highly desired in transportation fuels.[7]
Shifting reliance from petroleum to renewable biomass resources is an important step toward sustainable development and effective GHG management. Several technologies are being developed to convert biomass into chemicals and transportation fuels. Domestic production of liquid biofuel and its use as an alternative

[1] D. Streimikiene, T. Baleˇzentis and L. Baleˇzentien˙e, Renewable Sustainable Energy Rev., 2013, 20, 611–618.
[2] C. Linton, S. Grant-Muller and W. F. Gale, Transport Rev.,2015, 35, 533–553.
[3] IEA, Energy Climate and Change: World Energy Outlook Special Report, International Energy Agency (IEA), Paris, France, 2015.
[4] S. K. Ribeiro, S. Kobayashi, M. Beuthe, J. Gasca, D. Greene, D. S. Lee, Y. Muromachi, P. J. Newton, S. Plotkin, D. Sperling, R. Wit and P. J. Zhou, Transport and its infrastructure, Cambridge, United Kingdom and New York, NY, USA, 2007.
[5] R. C. Pietzcker, T. Longden, W. Chen, S. Fu, E. Kriegler, P. Kyle and G. Luderer, Energy, 2014, 64, 95–108.
[6] D. Sperling and S. Yeh, Transport Pol., 2010, 17, 47–49.
[7] J. C. Serrano-Ruiz and J. A. Dumesic, Energy Environ. Sci., 2011, 4, 83–99.

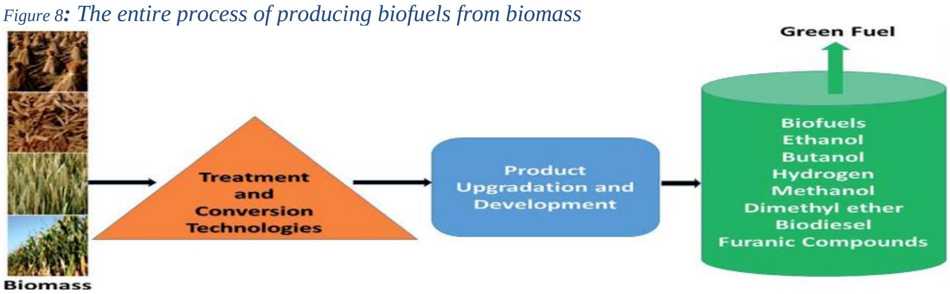
transportation fuel can also help to reduce dependence on petroleum oil, air pollution, and CO2 emissions.[1] Promotion of domestic production of liquid biofuels from indigenous resources allows non-oil-producing countries to reduce their reliance on oil imports.[2] According to International Energy Agency (IEA) projection, biofuels could provide 27% of total transport fuel by 2050. The projected use of biofuels could avoid around 2.1×10^{12} kg CO2 emissions per year when produced sustainably.[3] The major advantages of biofuels are given in Fig. 7. For the production of liquid fuels from biomass, there are several major conversion pathways.[4]. Figure 8 depicts an overview of the pathway for producing biofuels from biomass. Cropping pattern, crop yields, area under consideration, local conditions, food coproduction, economics, and life cycle energy efficiency all influence biomass feedstock selection.

Figure 7: The primary advantages of biofuels [5]



Source: J. R. Regalbuto, Science, 2009, 325, 822–824

Figure 8: The entire process of producing biofuels from biomass



Source: J. R. Regalbuto, Science, 2009, 325, 822–824

1.4. Green Hydrogen & Blue Hydrogen[6]

The fundamental understanding of hydrogen as an energy carrier, as well as the semantics behind its various names, requires answers to two key questions: what it is and how it is produced. ~~We could go on and on about what hydrogen is, from its atomic weight to its applications, but to understand the fundamentals, we must distinguish hydrogen as a carrier rather than an energy source.~~ This means that it must be powered by a primary source of energy, such as solar, electricity, hydro, nuclear power, or gas, to name a few. And whether hydrogen is labelled green or blue is determined by the specifics of the manufacturing process, including the energy source used. In fact, it could be grey, pink, or yellow.

Figure 9: Different colors of hydrogen

[1] A. H. Sebayang, H. H. Masjuki, H. C. Ong, S. Dharma, A. S. Silitonga, T. M. I. Mahlia and H. B. Aditiya, RSC Adv., 2016, 6, 14964–14992.
[2] S. Lee and Y. T. Shah, Biofuels and Bioenergy: Processes and Technologies, Taylor & Francis, 2012.
[3] IEA, Technology Roadmap-Biofuels for Transport, International Energy Agency (IEA), Paris Cedex 15, France, 2011.
[4] J. R. Regalbuto, Science, 2009, 325, 822–824.
[5] A. Demirbas, Appl. Energy, 2009, 86, S108–S117.
[6] https://www.petrofac.com/en-gb/media/our-stories/the-difference-between-green-hydrogen-and-blue-hydrogen/

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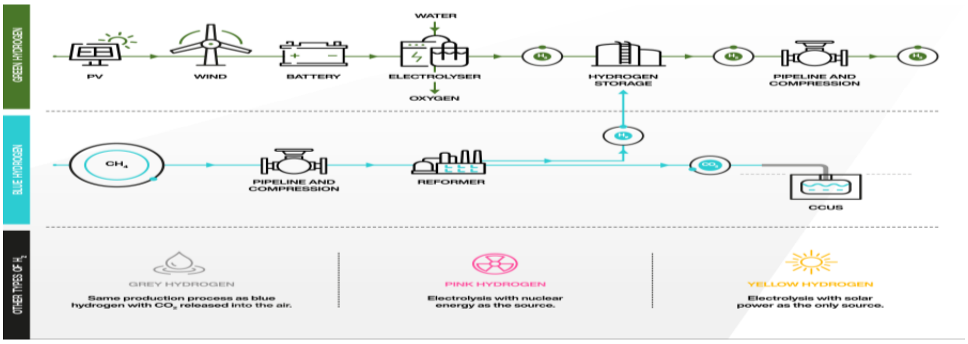


Source: petrofac hydrogen infographic

Blue hydrogen is produced when natural gas is split into hydrogen and CO2 using either Steam Methane Reforming (SMR) or Auto Thermal Reforming (ATR), but the CO2 is captured and stored. The capture of greenhouse gases reduces the environmental impact on the planet. The 'capturing' is accomplished through a procedure known as Carbon Capture, Utilization, and Storage (CCUS).
The large proportion of hydrogen available today is produced via a process known as steam-methane reforming (SMR): Begin with natural gas, which is primarily composed of methane (containing four hydrogen atoms in each molecule).
To release the hydrogen, the gas is reacted with high-temperature steam.
SMR produces a small amount of carbon dioxide, which we commit to managing through technical abatement or market offset.
Green Hydrogen is hydrogen generated by electrolysis of water splitting. This only produces hydrogen and oxygen. We can use the hydrogen and release the oxygen into the atmosphere without causing any harm. Green hydrogen is produced using renewable energy sources such as wind, solar, hydro, and geothermal. Electrolysis, which splits water into hydrogen and oxygen atoms, is powered by renewable energy.
There is no carbon dioxide produced. Electricity and power are required to complete the electrolysis. This green hydrogen production process is powered by renewable energy sources such as wind or solar. As a result, green hydrogen is the cleanest option – hydrogen derived from renewable energy sources with no CO2 emissions as a byproduct. In Australia, for example, Petrofac is facilitating a project.
Presently, this method produces about 5% of the world's hydrogen. Researchers want to see this share grow, but in order to do so, the hydrogen industry must scale, which is driven by demand. This necessarily requires a competitive price.
Grey hydrogen has been produced for many years. It is a similar process to blue hydrogen – SMR or ATR are used to split natural gas into Hydrogen and CO2. But the CO2 is not being captured and is released into the atmosphere.

Similar to green hydrogen, **Pink Hydrogen** is made via electrolysis, but using nuclear energy as its source of power.
Yellow Hydrogen Another type of hydrogen made by electrolysis is yellow, where electrolysis is achieved solely through solar power (unlike green which could use a combination of renewable energy sources such as wind or solar).
Multicolored Hydrogen The future is a transition from grey, through blue, to green hydrogen. One thing that is clear is the important role hydrogen will play in energy transition.

The United Kingdom, one of Petrofac's key markets, as an example. The country's national energy system is changing rapidly as the UK makes plans to reach the legal net zero target by 2050. Although the UK is unlikely to produce sufficient quantities of green hydrogen to meet the targets and the demand, we are likely to see a transition period of 20-30 years where blue hydrogen plays a key role. And this is where the oil and gas industry, including Petrofac, can help by using existing, transferable knowledge and capability to produce blue hydrogen via Carbon Capture Usage and Storage (CCUS). We can use the existing UK offshore infrastructure to pipe the CO2 back to offshore reservoirs. Either as EOR (Extended Oil Recovery) to help keep up reservoir pressure, or into depleted reservoirs for safe storage.

To meet the global energy demand, while achieving the national and global energy efficiency targets, the industry is looking at every potential technology. There is great potential in both the blue and green hydrogen and both will play an important role in energy transition. With our knowledge and capability, we are there to support this transition.

In Egypt we have to begin in production and use of blue Hydrogen.

1.5. Zero Flare

“ZERO” between failure and success. When we hear the word “zero” in our daily life we expect to face a disaster or something frustrating, even it could mean that we have failed!! But the word “zero” when used industrially it means that you are moving towards money saving and impressive environmental performance which resulted from lean and clean approach implementation. Nowadays two “zero” terms are being used in two cases concerns Zero Flaring (recover and reuse gases instead of flaring) and Zero Liquid Discharge.

1.5.1. Zero Flaring (recover and gases instead of flaring)

Gas flaring is a combustion device to burn associated, unwanted or excess gases and liquids released during normal or unplanned over-pressuring operation in many industrial processes, such as oil-gas extraction, refineries, chemical plants, coal industry and landfills. Gas flaring is a significant source of greenhouse gases emissions. It also generates noise, heat and provided large areas uninhabitable. The World Bank reports that between150 to 170 billion m^3 of gases are flared or vented annually, an amount value about $ 30.6 billion, equivalent to one-quarter of the United States’ gas consumption or 30 % of the European Union’s gas consumption annually.

According to The World Bank “…thousands of gas flares at oil production sites around the globe burn approximately 140 billion cubic meters of natural gas annually, causing more than 300 million tons of CO2 to be emitted to the atmosphere…if this amount of gas were used for power generation, it could provide about 750 billion kWh of electricity, or more than the African continent’s current annual electricity consumption.” By 2030, plants will still be allowed to flare for safety reasons, however they should no longer be flaring due to inadequate infrastructure and should have systems in place to utilize the otherwise wasted gas.

An increasingly popular method is Flare Gas Recovery (FGR). FGR is the process of recovering waste gases that would normally be flared. These gases are then used elsewhere in the facility, therefore reducing emissions and waste and consequently increasing efficiency. The process involves capturing the gas from the flare knock-out vessel and compressing it using liquid ring compressors. The recovered gases can then be reused within the facility’s fuel gas system, as a refinery feedstock, or for re-injection. FGR can be used in any industry that uses flaring. These include refining, production, LNG, biogas and pharmaceutical.

1.5.2. Zero Liquid Discharge ZLD

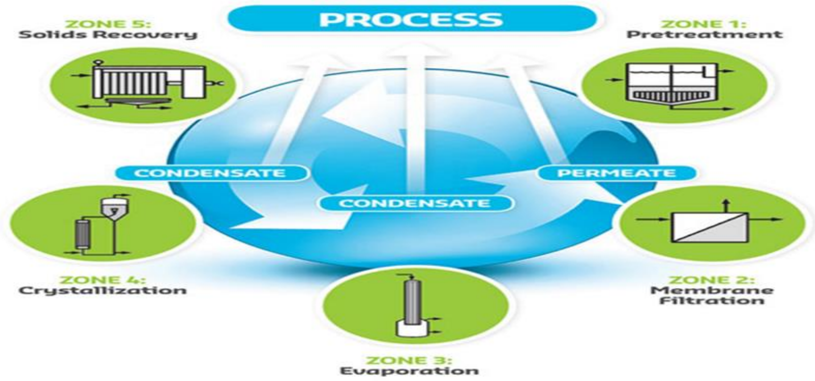
“ZLD” is not one technology or system but a combination of technologies and systems to achieve no liquid discharge from the complex. Effluent water shall be treated by effluent water treatment unit contain efficient filtration system and desalination unit.90% of the effluent are recovered and sent back to the plant. The remaining 10% (reject water) will be handled by evaporator and crystallization unit or by evaporation pond. An efficient and well-designed “ZLD” treatment system should be able to: Handle variations in waste contamination and flow, allow for required chemical volumes adjustments, recover around 95% of your liquid waste for reuse, Treat and retrieve valuable byproducts from your waste. (I.e. salts and brines) And Produce a dry, solid cake for disposal.

The exact components of a “ZLD” treatment system will vary, a basic “ZLD” treatment system typically includes some type of: Clarifier and/or reactor: to precipitate out metals, hardness, and silica ,Chemical feed:

to help facilitate the precipitation, flocculation, or coagulation of any metals and suspended solids ,Filter press: to concentrate secondary solid waste after pretreatment or alongside an evaporator (sludge dewatering), Ultra filtration (UF): to remove all the leftover trace amounts of suspended solids and prevent fouling, scaling, and/or corrosion down the line of treatment, Reverse osmosis (RO): to remove the bulk of dissolved solids from the water stream in the primary phases of concentration , Brine concentrator: to further concentrate the reject stream or reject from electro dialysis to further reduce waste volume , Evaporator: for vaporizing access water in the final phases of waste concentration before crystallizer and Crystallizer: to boil off any remaining liquid, leaving a dry, solid cake for disposal.
Depending on the needs of plant and process, these standard components are usually adequate, however, if plant requires a system that provides a bit more customization, there might be some features or technologies you will need to add on. Because of the broad range of industries that use “ZLD” and the various waste streams produced, “ZLD” is a highly custom process and these add-ons will depend on facility’s individual needs.

Figure 10: shows how a “ZLD” treatment system works as follow.

Source: Added by researcher



The major driver for using ZLD are: Water scarcity/water stress growing world-wide along with still negligible rate of waste water recycling, Environmental regulations (Egyptian environmental laws…etc.), Economics: recycled water becomes more affordable as the water supply from conventional sources becomes more expensive., Economics: waste water needs to be transported in large volumes over long distances., Growing social responsibility and education towards awareness of environmental issues.
1.5.3. SIDPEC Real Bright Example from Petrochemicals Sector in EGYPT

1.5.3.1. About SIDPEC

SIDPEC is the first step towards integration in petrochemicals’ industry in Egypt, and fulfilling a national objective, which is production of value-added products by using the available raw materials as well as developing related local industries. SIDPEC is capable of producing Polyethylene (high density & linear low density grades) using Ethylene which is produced by the processing of Ethane/Propane feed. SIDPEC utilizes the finest technologies in production which are also environment-friendly and energy saving. "Egyptene" as the trade name of SIDPEC polymers, is one of the finest well-known products in polyethylene industry worldwide as well as the local market. Such accomplishment is achieved by maintaining strict quality control system as well as effective compliance with Egyptian Environmental Regulations. Also, SIDPEC produces intermediate products such as LPG and Butene-1.

1.5.3.2 SIDPEC Achievements through LEAN and Clean Production Approach

As summarized in the table, it indicates the Company achievement during 2018.

Table 3: SIDPEC Achievements in 2018

Source: Added by researcher

2. D-PESTEL Analysis for Oil and Gas Sector

By adding Design for concept to regular PESTEL analysis the resulted DPESTEL (PESTEL+) analysis for Oil and Gas sector will be shown in Table

Table 4: DPESTEL for Oil and Gas sector

Design for	Political	Economic	Social
• Future Sustainability • Risk Probability & Severity • Green and Sustainable Economy • Environmental Sustainability • Green recovery • Low Carbon Fuels	• Political stability and importance of Oil & Gas sector in the country's economy. • Risk of military invasion • Level of corruption - especially levels of regulation in Oil & Gas sector. Bureaucracy and interference in Oil & Gas industry by government. • Legal framework for contract enforcement • Intellectual property protection Trade regulations & tariffs related to Oil & Gas • Favored trading partners	• Type of economic system in countries of operation – what type of economic system there is and how stable it is. • Government intervention in the free market and related Oil & Gas • Exchange rates & stability of host country currency. • Efficiency of financial markets – Does Independent Oil & Gas Plc needs to raise capital in local market? • Infrastructure quality in Oil & Gas industry Comparative advantages of host country and Oil & Gas sector in the particular country.	• Demographics and skill level of the population • Class structure, hierarchy and power structure in the society. • Education level as well as education standard in the Independent Oil & Gas Plc 's industry • Culture (gender roles, social conventions etc.) • Entrepreneurial spirit and broader nature of the society. Some societies encourage entrepreneurship while some don't. • Attitudes (health, environmental consciousness, etc.) • Leisure interests

	• Anti-trust laws related to Oil & Gas • Pricing regulations – Are there any pricing regulatory mechanism for Oil & Gas • Taxation - tax rates and incentives • Wage legislation - minimum wage and overtime • Work week regulations in Oil & Gas • Mandatory employee benefits Industrial safety regulations in the Oil & Gas sector. • Product labeling and other requirements in Oil & Gas	• Skill level of workforce in Oil & Gas industry. • Education level in the economy • Labor costs and productivity in the economy • Business cycle stage (e.g. prosperity, recession, recovery) • Economic growth rate • Discretionary income • Inflation rate Interest rates	

Technological	**Environmental**	**Legal**
• Recent technological developments by Independent Oil & Gas Plc competitors • Technology's impact on product offering • Impact on cost structure in Oil & Gas industry • Impact on value chain structure in Oil & Gas sector • Rate of technological diffusion	• Weather • Climate change • Laws regulating environment pollution • Air and water pollution regulations in Oil & Gas industry • Recycling • Waste management in Oil & Gas sector • Attitudes toward “green” or ecological products • Endangered species • Attitudes toward and support for renewable energy	• Anti-trust law in Oil & Gas industry and overall in the country. • Copyright, patents / Intellectual property law • Consumer protection and e-commerce • Employment law • Health and safety law • Data Protection

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Source: Added by researcher

3. Global Oil Outlook to 2040

Global-oil-supply-and-demand-outlook-to-2040-Online-Summary[1]

The following are the top five findings:

~~1.Demand~~1. Demand recovery to 2019 levels is in sight

[1]https://www.mckinsey.com/industries/oil-and-gas/our-insights/global-oil-supply-and-demand-outlook-to-2040

By late 2021 or early 2022, liquid demand is expected to return to 2019 levels. Slower demand recovery would be caused by a slower vaccination rollout or if COVID 19 control remains a risk.

~~2.Oil~~2. Oil capital expenditures are unlikely to fully recover

Oil capital expenditures are expected to gradually recover, but remain below the pre-COVID 19 forecast. In North America, we anticipate a slow rebound in shale and offshore.

~~3.Long~~3. Long term oil demand is exposed to large variations across all scenarios

Oil demand growth slows in the late 2020s and peaks in 2029, after more than 30 years of consistent growth of more than 1% per year. Several energy transition drivers may cause the peak to occur six to ten years earlier.

~~4.New~~4. New oil drilling is needed to meet demand by 2040

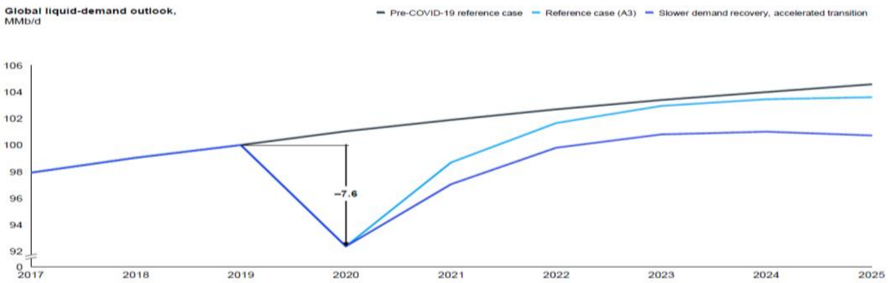
To meet demand, exploration and production companies will need to add 38 MMb/d of new crude production from unapproved projects by 2040. Offshore and shale resources are expected to provide the majority of new supply**.**

~~5.Even~~5. Even in an accelerated energy-transition scenario, we see need for new oil drilling by 2040

While most offshore-oil-producing regions will face pressure in an accelerated energy-transition scenario, the sector will still require nearly 23 MMb/d of new production by 2040 to meet demand. Demand in a 1.5°C path will necessitate shut-ins.

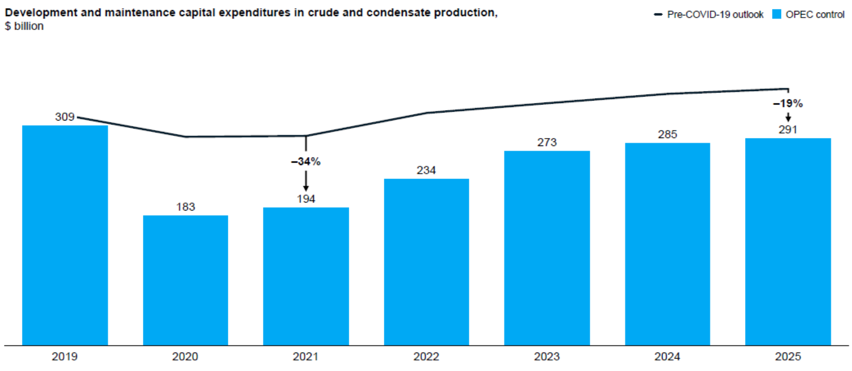
The findings can be shown in the following graphs:

Graph 3: Liquid demand is likely to recover to 2019 levels by late 2021 or early 2022



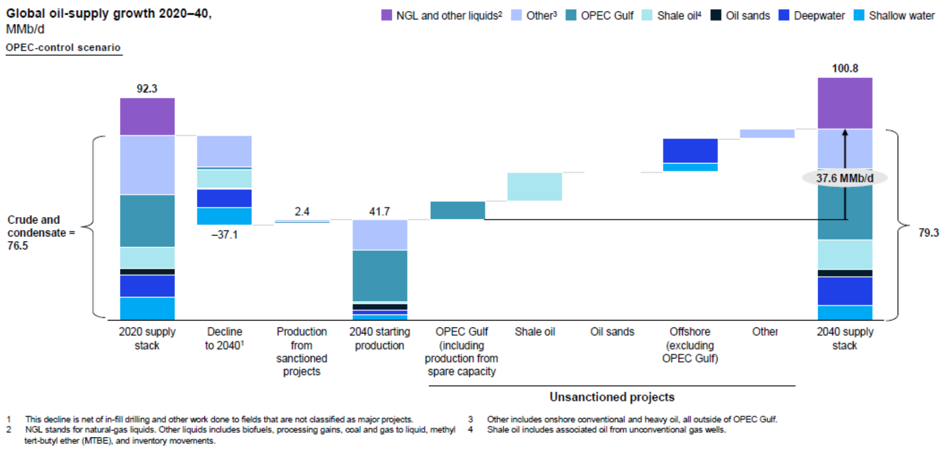
Source: Global Energy Perspective, Energy Insights by McKinsey, October 2020

Graph 4: Oil investments are expected to gradually recover but remain below the pre-COVID19 outlook.



Source: Rystad Energy; Energy Insights by McKinsey

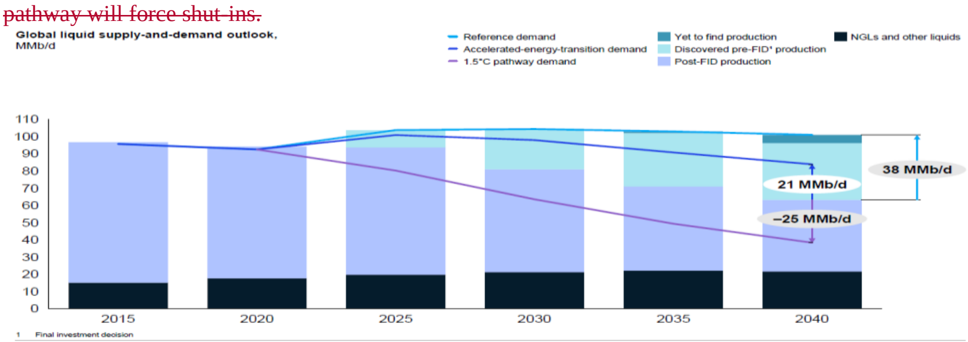
Graph 5: By 2040, exploration and production companies need to add 38 MMb/d of new crude production from unsanctioned projects.



Note: Figures may not sum to 100%, because of rounding

Source: Rystad Energy; Energy Insights by McKinsey

Graph 6: New projects will be needed under an accelerated-energy-transition case, but a 1.5°C ~~pathway will force shut-ins.~~



Source: Rystad Energy; Energy Insights by McKinsey

4. The big choices for oil and gas in navigating the energy transition

Oil and gas companies must decide where and how to compete as the world transitions to a low-carbon future as they respond to current economic disruptions.

~~This is a critical time for oil and gas companies to make strategic decisions about how to improve their economic and reputational resilience, as well as whether and how to reposition themselves to capitalize on the accelerating low-carbon winds of change.~~

A number of oil and gas companies have already committed to net-zero-emissions goals. Despite the current economic challenges, many businesses are continuing to work to decarbonize their operations and value chains. Occidental Petroleum, one of the largest international oil companies in the United States, has partnered with Carbon Engineering, a Canadian start-up [1] to construct a plant capable of capturing and burying 500,000 metric tons of CO2 per year China National Offshore Oil Corporation (CNOOC) signed an

[1] Robert Perkins, "Denmark to end all North Sea oil, gas production by 2050, bans new exploration," S&P Global Platts, December 4, 2020, spglobal.com

agreement with Shell in June 2020 to supply China with the country's first carbon-neutral liquefied natural gas (LNG) cargoes—they would use carbon credits to offset the emissions involved in producing and consuming the two cargoes. [1] ExxonMobil stated its carbon vision in December 2020: reducing the intensity of operated upstream greenhouse gas emissions by 15 to 20% over the next five years (relative to 2016 levels), while continuing to invest in lower-emission technologies and support "sound policies that put a price on carbon."[2]

~~As a result, the current crisis has not dampened the need—or appetite—for change.~~ The following three key questions should be addressed by the leaders of oil and gas companies:

1. How can we strengthen our core hydrocarbon businesses?
2. Should we refine into low-carbon industries, and if so, how?
3. How will our business model need to change in order to thrive in a low-carbon world?

The following are some initial thoughts on these issues, with the hope of sparking further discussion around executive and board tables.

1. Building a more resilient core business

Graph 7~~7~~: "Advantaged" resources offer the best combination of lower break-even prices and lower emissions intensity.

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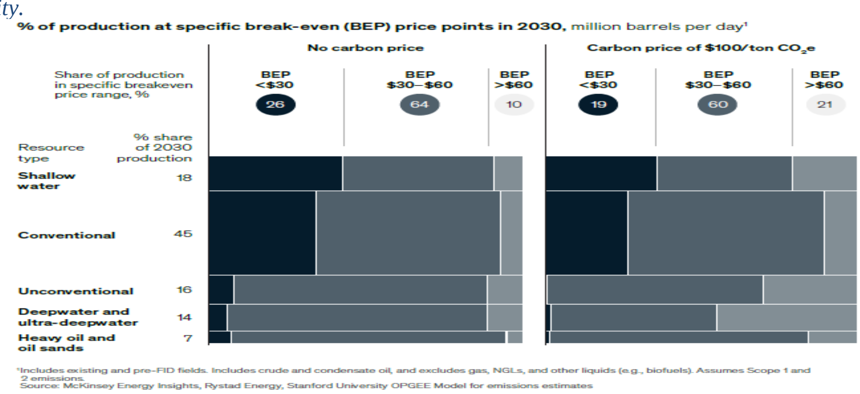
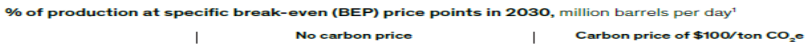


[1] Paul Gargett, Stephen Hall, and Jayanti Kar, "Toward a net-zero future: Decarbonizing upstream oil and gas operations," December 6, 2019, McKinsey.com

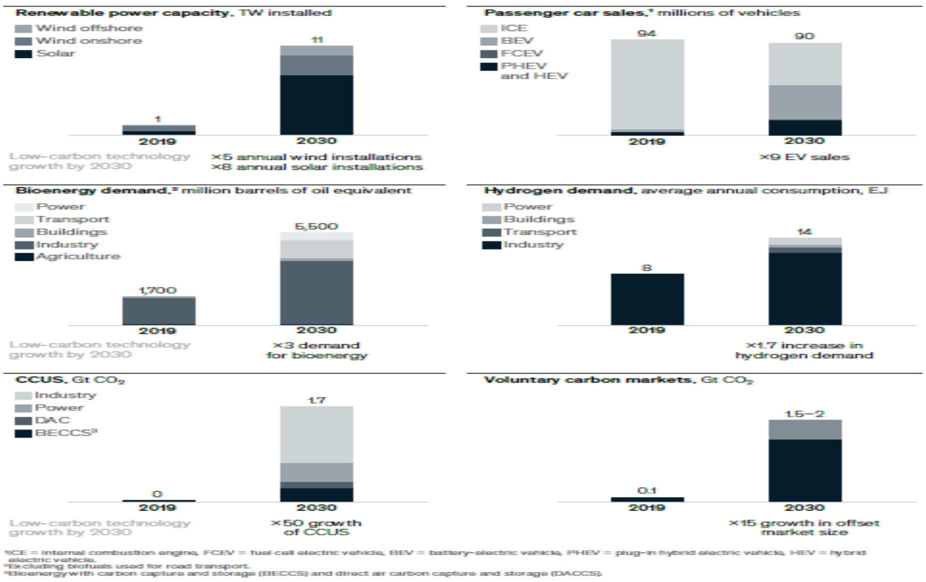
[2] "Engineering of world's largest Direct Air Capture plant begins," Carbon Engineering, May 21, 2019, carbonengineering.com



Source: McKinsey Energy Insights, Rystad Energy, Stanford University OPGEE Model for emissions estimates

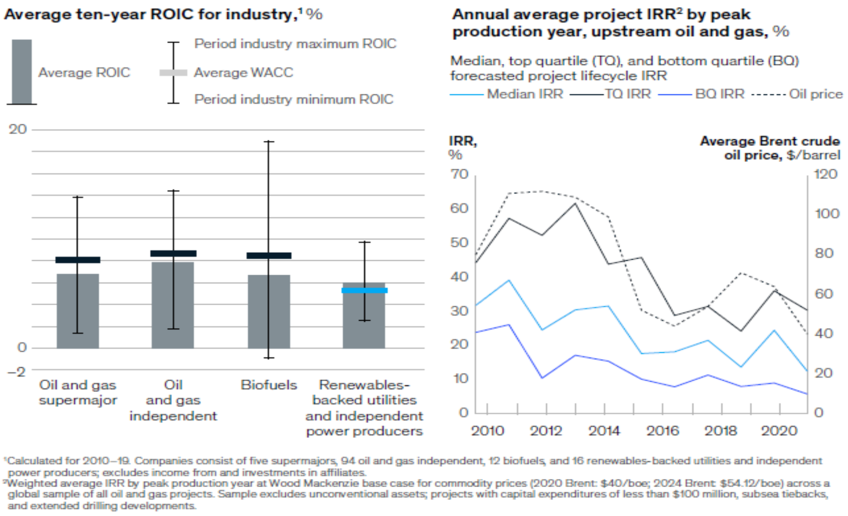
~~1.~~ 2.Exploring profitable growth options in low-carbon businesses

Graph 8: A 1.5°C scenario requires significantly increased adoption of low-carbon technologies by 2030.



Source: McKinsey 1.5°C Analysis (Scenario A); Global Energy Perspective (GPM Model, Reference Case 2019); McKinsey Center for the Future of Mobility; Hydrogen Council

Graph 9: The spread over cost of capital for low-carbon energies can be positive, and higher relative to oil and gas peers.



Source: McKinsey

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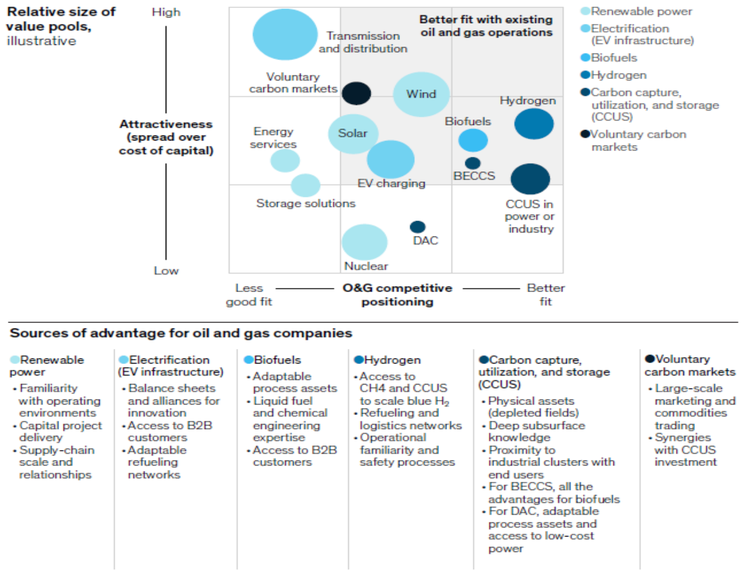
~~2.~~ 3.Changing company operating models to increase competitive edge

Graph 10: Oil and gas companies have an abundance of capabilities that may be valuable for parts of a new low-carbon energy system.



Source: McKinsey

Findings

1. The oilfield presents a wide range of technical challenges to the chemist, many of which are set against a backdrop of increasing environmental regulation and control.
2. To realize the full potential of green chemistry and engineering, interdisciplinary collaboration and cooperation are required.
3. Continued development of predictive toxicology models and high-throughput screening will help to accelerate the development of safer chemicals.
4. Chemical policy reform should make chemical safety data available to the public
5. To improve chemical manufacturing and product formulation, supply chain transparency is required.

Recommendations

1. **Establish new department in oil and gas field companies' organization charts concerns environmental planning would help in:**
   1) Preparation of environmental impact assessment studies for the project prior to its implementation
   2) Stop draining natural resources
   3) Energy efficiency and interest in providing alternative energy sources
   4) Sustainable use of water in industrial processes
   5) Reducing harmful emissions of existing projects
   6) Development of a mechanism and strategy to deal with potential and anticipated future environmental problems (to be determined and updated periodically through a review of the risk log)
   7) Finding solutions to current environmental problems

8) Development of sustainable production and consumption patterns
9) The trend towards the use of homemade raw materials as planned in all new projects involving petroleum refining and petrochemical manufacturing (such as the Scientific Complex and the Suez Complex). Zero import of intermediate petrochemical ores for manufacturing will be reached by 2035
10) Provision of information to enhance project decision-making
11) Reducing air pollution and combating climate change
12) safe disposal or recycling of waste
13) Community requirements and natural gas self-sufficiency.
14) Reducing waste and pollutants

2. Some recommendations and proposals to be taken into account to ensure effective environmental recovery

1) Governance and environmental control
2) Environmental and Green Recovery Awareness
3) Corporate environmental management that is strongly project and process management and that is effective, possesses the capabilities, expertise and knowledge in environmental work. The responsibility for environmental management must be left in the implementation, follow-up and monitoring of environmental plans, action should be taken to amend them if necessary, and the role of environmental management should not be limited only to the certification of ISO 14001, a general framework for management action and the adjustment of environmental management status.
4) Creation of the post of environmental planner in the corporate structure of the petroleum sector
5) Provision of comprehensive environmental information and data for making sound environmental decisions
6) Effective community participation
7) Development of performance indicators to measure the implementation of environmental plans in the petroleum and mineral sector and indicators for the proportion of fuels and energy alternatives
8) Work on training petroleum workers in the environmental hub and measuring the benefits of training in the way of performance indicators
9) Use of Green Lean Six Sigma, Lean Agile tools in developing clean production and in reducing carbon emissions
10) Towards the application of the principles of engineering, chemistry and green energy.
11) Diversification into alternative, profitable growth options in low-carbon businesses
12) Legislation that is binding on the conservation of natural resources, mineral wealth and energy and guarantees sustainability, as well as sanctions and deterrent measures for offenders.

Conclusion

According to market expectations, waste reduction alone could save the global chemical industry $40 billion in process costs. If the other benefits of green chemistry are considered, this value could be much higher. Green chemistry is thought to be a winning strategy for the development of the circular economy. Green chemistry and the green economy are merging. Green chemistry technologies are widely used in a variety of chemical industries, including biogas production and upgrading, bioethanol production, green catalysis, carbon capture and storage technologies (CCS), plastic recycling technologies, bio-degradable plastic polymers, renewable energy sources, and so on.

By rethinking sustainable marketing approaches, chemical manufacturers, particularly those in the oil downstream industry, can develop stronger business advantages for green chemistry and green engineering. The road to a green and sustainable society remains long.

Although science can aid in the transition to an ideal world of zero risk, hazard, and pollution, only society as a whole will ultimately determine what is acceptable in terms of the cost-benefit issues raised by sustainable development.

A quote from R. W. Hofmann, the first President of the Royal College of Chemistry in London, is as relevant today as it was then: 'In an ideal chemical factory, there is no waste, only product. The better a real factory utilizes its waste, the closer it gets to its ideal, the greater the profit.'

Our future resource, environmental, economic, and societal sustainability challenges will necessitate more efficient and benign scientific technologies for working with chemical processes and products. Green chemistry addresses such challenges by developing novel reactions that maximize desired products while minimizing by-products, developing new synthetic schemes and apparatus that simplify operations in chemical manufacturing, and seeking greener solvents that are inherently environmentally and ecologically benign. Such fundamental advances in chemical sciences will renovate the way for a new generation of chemical syntheses.

Green chemistry is going to spread from academic labs to industry as a means of lowering costs while also reducing environmental, health, and safety risks. The 12 guiding principles are used on a variety of scales, from selecting ingredients for reactions that minimize waste and risk to metrics that quantify waste and process efficiency. Green chemists use engineering and process design principles to track energy use during production, look for sustainable raw materials, and create biodegradable or recyclable products to reduce waste.

According to current estimates, green chemistry products account for less than 1% of all chemical products. Several impediments to green chemistry implementation exist in the United States.[1] Companies are unable to evaluate their processes and incorporate green chemistry into business decisions due to the difficulty of developing sustainability metrics. Regulations governing drug production, as well as investment in existing chemical plants, impede the development and implementation of new technologies. Green chemistry's interdisciplinary nature also calls into question the specialized knowledge gained through current training and industrial work experience.

Government policies that promote knowledge sharing or provide economic incentives in the United States can help spur green chemistry innovation. Green chemistry prospects and barriers differ in a developing country like China.

The current growth of the Chinese chemical industry provides significant opportunity for incorporating green chemistry practices as a means of balancing environmental and economic goals. [2]. Some of the obstacles to widespread adoption of green chemistry in the country overlap with general barriers to innovation, such as markets, economics, regulations, and culture. Nonetheless, implementing green chemistry in new factories as China's chemical industry expands could have a long-term impact on the industry's trajectory .Green chemistry adoption could improve the public's perception of the field of chemistry as a whole [3]. Green chemistry supporters argue that the field combines environmental, health, and safety benefits with the traditional goals of economic gains in industrial chemistry and knowledge gains in academic research.

While economics and knowledge are important reasons to pursue chemistry, they can clash with the public's perception of chemistry as a toxic endeavor, especially when safety, sustainability, and Promoting green chemistry research and adoption into industry through federal policies and education may assist the field of chemistry in bridging the gap between its values and those of the general public. As a result, the growth of green chemistry can lead to gains in other areas such as profits, public perception, and environmental protection.

More research is needed on how green chemistry can support the green economy, and vice versa, both theoretically and empirically. It is the beginning but there are already respectable results. Still, further

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collaboration among academic and business community is needed and expected especially the oil and gas field.

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Research Questionnaire

1. In which sectors of the organization is the transformation of the classic economy to green economy already taking place?

2. Which markets are changing the fastest or should change as part of the transition from the traditional economy to the green economy via green manufacturing?
3. Should pro-ecological economic growth be a component of national and supranational socioeconomic policy?
4. Should sustainable pro-ecological economic growth based on the green economy concept become one of the key pro-social, pro-development and anti-crisis segments of the national and supranational socio-economic policy?
5. Which markets change the fastest or should change as part of the transformation of the classical economy to green economy?
6. How should the concept of sustainable pro-ecological development according to green economy develop in the 21st century?
7. In what way should it develop and disseminate the concept of sustainable ecological development in accordance with the green economy formula in the 21st century?
8. How should green economy be developed to allow for a globally sustainable pro-ecological economic development?
9. What are your job duties relating to green chemistry?
10. Are there other people in your company tasked with the sourcing, development, and/or sale of products with safer chemistries?
11. Does your company have a formal green chemistry policy utilizing the 12 Principles of Green Chemistry?
12. Are green chemistry and engineering design criteria embedded in your company's product design guidelines?
13. Do your R&D or product development priorities for the next 3-5 years explicitly include green chemistry approaches?
14. Does your company use metrics or benchmarks to track progress towards green chemistry implementation?
15. Which entities do you partner with for the following activities?
16. Do you anticipate any changes in the next 2-3 years that will impact your green chemistry practices?
17. Where do you see the most activity in/support for green chemistry in your supply chain?
18. Rank the following barriers your company has experienced in moving towards green or safer chemistry
    (High – Medium – Low)
    a. Lack of senior management buy-in
    b. Lack of internal communication
    c. Concern that alternatives are not safer
    d. Lack of GC-trained workforce
    e. Conflicting info on chemical hazards
    f. Policies that inhibit innovation
    g. Conventional practices are unregulated
    h. Lack of pro-GC regulations
    i. Lack of hazard/risk understanding in company
    j. Lack of customer demand
    k. Advertising "safer" implies previously unsafe
    l. Perceived lack of value in GC
    m. Lack of info on safer alternatives
    n. Lack of safer alternatives
    o. Low cost of existing options
    p. Lack of technically feasible alternatives

q. High cost to research alternatives
r. Perceived high cost of R&D for GC
s. Lack of economical alternatives
t. High cost of scale-up
u. Lack of supplier ingredient disclosure

19. Where do you see the least activity in/support for green chemistry in your supply chain?
20. Would any of these policies help your company expand its green or safer chemistry practices? (Yes – No)
    a. Government location incentives
    b. Infrastructure loan guarantees
    c. Government green purchasing orders/directives
    d. Tax policy favoring GC
    e. Policies internalizing negative externalities
    f. Streamlined permitting for green manufacturing
    g. Chemical bans/phase-outs
    h. State or feed's GC R&D funds

21. Would any of these activities help your company expand its green or safer chemistry practices? (Yes – No)
    a. Access to venture capital
    b. Decision-making tools
    c. Increased access to trainings
    d. Finding GC-trained workers through partnerships
    e. Resources to make business case to employer
    f. Technical and engineering assistance
    g. Aggregating company demands for chemical/product
    h. Partnerships with environmental NGOs
    i. More transparency in supply chain
    j. Coordinating efforts with similar producers
    k. Partnerships with GC researchers
    l. Increased consumer demand for GC