An environmental political perspective on hydraulic fracturing and the potential implications for South Africa

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To whom it may concern

With this letter I, Marelize Strümpfer, declare that I have proofread the dissertation ***An environmental political perspective on hydraulic fracturing and the potential implications for South Africa,*** submitted in fulfilment of the requirements for the degree *Masters of Arts in Political Studies* at the North-West University.

Yours sincerely
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In Nature, nothing exists alone.

– Rachel Carson

ABSTRACT

Modern environmental awareness shows that nothing in its natural form can exist on its own. This means that all living things on earth are somehow connected by a symbiotic relationship (known or unknown). It is said that this relationship is what allows for the survival of the planet as a whole. One of the problems that the earth faces, though, is that this interconnected relationship between humans and earth is severely under threat, mainly caused by pollution and mass consumption. From an environmental political perspective, the effects of pollution and mass consumption threaten the availability of natural resources. In short, humans need to remember that they are not merely "in charge" of the earth, but it is their moral responsibility to protect the earth. From the environmental perspective it is important to conserve and sustain scarce resources, as well as find ways to safely harness them for energy. For democratic governments, who are mandated to provide safe and secure living environments to citizens as per their constitutions, the conflict between socio-economic development and protection of the environment, as well as the rights of citizens, has caused ongoing debate on the issue for the past several decades.

Energy is vitally important for the development and survival of humankind. It has been the driving force behind humanity's development and sustainability for many years. For thousands of years, natural resources have been harnessed specifically for this purpose, using the sun as a source of energy, to newer resources such as coal and gas in the 21st century. There is a worldwide call for cleaner energy sources that are not only healthier for the environment but also renewable. The South African government's response to this call and a more sustainable energy sector is to, amongst various energy options, explore hydraulic fracturing whereby natural gas is extracted from the earth's layers, making it renewable and convertible to energy.

Hydraulic fracturing is not a new method of gas mining, as it dates back a few decades. The biggest concern right now is that hydraulic fracturing can have a negative impact on the environment. The effects of fracking can be detrimental to underground and surface water sources. In this research it is argued that hydraulic fracturing, whilst economically viable for South Africa, can potentially cause huge environmental damage to the ecosystem in the Karoo, the primary area earmarked for shale gas exploration in South Africa. The Karoo is not only very poor financially, it is also an arid area with scarce water sources. This is of concern because the practice of hydraulic fracturing utilizes mass

quantities of water. Being an arid area, mainly known for its agriculture, it's farming future relies on any and all water sources in the area. Not only does the fracking process use millions of litres of water, there is also the concern of pollution. The fracking fluid, which is used in the process, can seep into healthy water resources. This is of dire concern because the waste water contains many chemicals that are harmful and may even be deadly to human beings and animals. The contribution of this study, based mainly on data collected from fracking experiences in the USA, centres on the acknowledgement that the South African government needs to weigh all the advantages and disadvantages before allowing the fracking process to be implemented. Exploration licences have already been granted but with moratoriums issued, this process has been halted. The focus of the study is that with these moratoriums the government can embark on thorough studies as to the effects of hydraulic fracturing in the Karoo. Emphasis is also placed on Government policy concerning the management of the delicate balance between environmental protection and socio-economic development, and forms an integral part of the study. Through this analysis it was possible to put recommendations together as to why the hydraulic fracturing process needs to be explored some more before it can be implemented.

In conclusion, the view taken by the researcher is that the South African government should, in addition to fracking, look at other sources of energy that are truly renewable and cleaner for the environment and improvement of the South African people. To this end, the recommendation is made to link into the international trend for abyssal or deep-sea gas mining as a safer and more viable option to fracking on land, as well as wind and solar energy production.

KEYWORDS: Environmental political thought; energy; pollution; mass consumption; hydraulic fracturing; Karoo region; projected implications

OPSOMMING

Moderne omgewingsbewustheid bewys dat niks in die natuur alleen kan bestaan nie. Dit beteken dat alle vorms van lewe op aarde op een of ander manier (bekend of onbekend) simbioties verwant is. Daar word beweer dat hierdie verwantskap die behoud van die planeet in sy geheel bepaal. Tans is een van die bedreigings dat hierdie verwantskap tussen mens en natuur onder geweldige druk is. Hierdie verskynsel spruit voort uit verskeie oorde, maar meestal is dit die gevolg van grootskaalse misbruik van die aarde se natuurlike hulpbronne, massaverbruik en besoedeling. Die beskikbaarheid van natuurlike hulpbronne word dus vanuit 'n omgewing-politiese perspektief bedreig. Hierdie politiese omgewingsperspektief bepaal ook dat die mensdom besef dat hulle nie net in beheer van die aarde is nie, maar ook 'n morele verantwoordelikheid het om die aarde te beskerm. Dit is dus belangrik om uiters skaars natuurlike hulpbronne te bewaar en te behou terwyl dit tot voordeel van die mensdom ontgin word. Die dryfkrag vir menslike ontwikkeling en behoud is gegrond in die aanwending van die aarde se energiebronne, en die soektog na herwinbare bronne is dus hoog op regerings se ontwikkelingsagendas. Vir demokratiese regerings is die mandaat om hul burgers se veiligheid te verseker, soos in hul konstitusies en beleid vervat. Die konflik tussen die noodsaaklikheid vir sosio-ekonomiese ontwikkeling teenoor die beskerming van die omgewing en burgers se regte, het oor die laaste paar dekades tot grootskaalse debat tussen belangegroepe gelei.

Deur die menslike geskiedenis heen is natuurlike hulpbronne aangewend vir die verskaffing van energie. Duisende jare gelede is die son reeds as 'n energiebron ontgin, en dit is in die 21ste eeu steeds 'n primêre energiebron saam met ander meer moderne vorme van energiebenutting, soos steenkool en gas. Om die behoud van die aarde se energiebronne te verseker, moet die mensdom holisties kyk na alternatiewe metodes om energie op 'n lewensvatbare wyse te ontgin. Die behoefte wêreldwyd is nie slegs vir meer nuwe vorme van "skoon" energie nie, maar na energiebronne wat hernubaar is. Een van die Suid-Afrikaanse regering se oplossings om in hierdie aanvraag na 'n volhoubare energiesektor te voldoen, is die potensiële investering in die ontginning van gasbronne deur die proses van hidroliese breking. Natuurlike gas word uit die aarde se skalie rotslae ontgin en dan verwerk vir energieverskaffing.

Die implementering van hidroliese breking dateer 'n paar dekades terug. Die nadelige impak van breking op die natuur word deur omgewingsbewuste groepe en regerings wêreldwyd bevraagteken. Die belangrikste argument behels die negatiewe effek wat

breking op ondergrondse en bogrondse waterbronne kan uitoefen. In hierdie navorsing word geargumenteer dat, alhoewel breking wel ekonomiese voordele vir Suid-Afrika inhou, die nadelige effek wat hierdie vorm van energie-ontginning op die omgewing kan uitoefen nie geïgnoreer kan word nie – veral in die Karoo-streek waar die meerderheid skalie rotsformasies voorkom. Die Karoo, hoewel finansieel arm, is ook ’n semi-woestyngebied met baie min waterbronne. Hier kom ’n unieke ekosisteem van flora en fauna voor. Die gebied se ekonomie is uiteraard geskoei op spesifieke landboumetodes vanweë watertekort. Die brekingsproses gebruik miljoene liter water, gekoppel aan gepaardgaande besoedeling. Die chemiese vloeistowwe wat tydens die proses gebruik word, moet herverwerk of van ontslae geraak word – wat problematies en baie duur is. Hierdie chemikalieë is nadelig en selfs lewensgevaarlik vir die mens, fauna en flora. Bewyse bestaan dat vloeistowwe die waterbronne rondom die brekingsterreine kan benadeel. Die bydrae van hierdie studie, hoofsaaklik gebaseer op data-ontleding uit die VSA, waar hidroliese breking reeds ’n paar dekades lank plaasvind, sentreer rondom die voor- en nadele van die brekingsproses en die potensiële impak daarvan op die sosio-ekonomiese welstand van die Suid-Afrikaanse bevolking, sowel as die omgewing. Ontginningslisensies is reeds uitgereik, maar moratoriums is in plek. Die Suid-Afrikaanse regering moet nougeset let op die voor- en nadele vanuit ’n omgewingsoogpunt voordat daar daad by woord gevoeg word. Klem word ook in die studie geplaas op die regering se beleid aangaande die bestuur van die delikate balans tussen omgewingsbeheer en sosio-ekonomiese ontwikkeling. Die studie maak gebruik van verskeie argumente om tot ’n slotsom te kom dat daar baie meer navorsing moet plaasvind rondom hidroliese breking, sowel as ander vorme van hernubare energie, wat minder van ’n bedreiging vir die omgewing inhou.

Ter opsomming, word daar aanbeveel dat die regering ondersoek instel na diepsee ontginning van gas, wat ’n veiliger en meer volhoubare bron is. Ander alternatiewe energiebronne, soos die aanwending van wind- en sonenergie, word ook aanbeveel as meer volhoubare alternatiewe tot hidroliese breking in die Karoo.

SLEUTELWOORDE: Omgewing-politiese perspektief; energie; besoedeling; massaverbruik; hidroliese breking; Karoo-streek; geprojekteerde implikasies

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LIST OF ABBREVIATIONS

AEC – Atomic Energy Commission

API – American Petroleum Institute

ARI – Advanced Resources International

AU – African Union

CH_4 – Methane

CNG – Compressed Natural Gas

CO_2 – Carbon Dioxide

CSIR – Council for Scientific and Industrial Research

DBSA – Development Bank of South Africa

DMR – Department of Mineral Resources

DNAPL – Dense Non-Aqueous Phase Liquid

DWS – Department of Water and Sanitation

EIA – Energy Information Administration

EIP – Environmental Impact Practitioner

EPA – Environmental Protection Agency

FF Plus – Freedom Front Plus

GDP – Gross Domestic Product

GHG – Greenhouse Gas

GWPC – Ground Water Protection Council

IHS – Information Handling Services

IOGCC – Interstate Oil and Gas Compact Commission

LNAPL – Light Non-Aqueous Phase Liquid

LNG – Liquified Natural gas

MP – Member of Parliament

MW – Mega watts

N_2O – Nitrous Oxide

NDP – National Development Plan

NEMA – National Environmental Management Act

NEMAQA – National Environmental Management: Air Quality Act

NGO – Non-Governmental Organisation

NRDC – Natural Resources Defence Council

NRF – National Research Foundation

NWA – National Water Act

PASA – Petroleum Agency of South Africa

SA – South Africa

SCA – Supreme Court of Appeal

TCF – Trillion cubic feet

TKAG – Treasure the Karoo Action Group

UAE – United Arab Emirates

USA – United States of America

USGS – United States Geological Survey

WCED – World Commission on Environment and Development

WWF – World Wildlife Foundation

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CHAPTER 1

1.1 INTRODUCTION

According to Rachel Carson (1962:60), one of the early proponents of modern environmental awareness in the United States, nothing in nature exists alone and all living organisms form part of an interconnected whole that needs to be protected. In this regard, Carson (1962:60) states:

> *The history of life on earth has been a history of interaction between living things and their surroundings.*

This line of thought links up with the so-called "one-earth" or, as Lovelock (1979:115-132) explains it, the Gaia theory that presupposes all living organisms (human, plants and animals) must live in harmony and co-exist in order to survive and evolve as a collective; the idea of symbiosis is present (Lovelock, 2000:15; Baradat, 2012:328-332). The idea is that the earth (from a naturalist ideological perspective) functions as a single organism which needs to maintain certain conditions to ensure it continues in perpetuity. This could mean that every living thing on the face of the earth exists only through some sort of symbiotic relationship with everything else.

According to the Gaia theory, the earth is a delicate interconnected system. This interconnectedness regulates the survival of the planet as a whole and relates to the complex relationship between the biosphere, the atmosphere and hydrosphere. This is a fragile relationship between the earth and all who belong on it and it should not be disrupted (Lovelock, 2000:241-244). Which could mean that if something is removed from this relationship, it will have an effect on everything else. According to Goodwin (2010:241-244), this harmonious co-existence is threatened by the exponential growth of urban areas, migration, mass resources consumption, pollution and population growth that all have harmful effects on nature. Penna (2010:212-214) defines mass consumption as larger quantities of, for example, human consumed food and material objects over an extended period of years. This means increasingly finite resources simply cannot keep up with the demands of anthropogenic induced growth and development on earth. Population control is one idea to curb the amount of people that are living on the earth. In the 1940s, papers were written by conservationists about the threats that population growth could pose to food supplies. Paul Erhlich, in a widely read book *The Population Bomb* (1968), called for a reduction and more control of population growth if the earth

was to sustain humanity for many years to come (Seltzer, 2002:12).

Pollution is a consequence of human activities around the world. Pollution can harm many of our natural resources, such as energy in the form of fossil fuel, natural food resources, water, air and soil. Pollution can be defined as the discharge of a toxic or contaminating substance into the atmosphere or ground that is likely to have an adverse effect on the environment (Perkins, 2017:120-124). Also called environmental pollution, according to the Encyclopedia Britannica (d) (2020), it means there is an addition of any substance or any form of energy to the environment at a rate that is faster than it can be dispersed, decomposed, recycled, diluted or stored in a way that is no longer harmless. Modern society is concerned about pollution, with specific reference to different types of pollutants like light pollution, plastic pollution and noise pollution. Pollution can have all kinds of negative effects on the wildlife, the environment and human beings.

With the increase of not only the population of the earth, but also the global pollution, it has become important to utilise energy sources in a more environmentally friendly way. Based on the relationship between human survival and energy, it has become one of the most important topics to explore (besides food and water resources). Contemporary energy studies date back decades and have evolved in many ways too. The search for cleaner energy is currently a global objective. This is because countries are looking for ways to move away from sources that can potentially pollute the environment.

1.2 ORIENTATION AND BACKGROUND

From a political environmental perspective, there is a research emphasis on efforts to contain the destructive consequences of human interventions in nature (Baradat, 2012:329-330). In essence, it is argued that the effects of mass consumption and pollution destroy and decrease the availability of already scarce natural resources which are needed for the survival of the planet (Goodwin, 2010:235). Human beings therefore have an obligation to protect the earth's natural physical resources and living organisms (Carmo, *et al*, 2016). In order to protect this interconnected unit, environmental political thought revolves around the notion of conserving and sustaining scarce resources such as water, air, the ozone layer, soil, natural rain forests, animal masses as well as sources of energy such as natural gas (Goodwin, 2010:235).

The human demand for energy has become a prime reason for the ongoing exploration and extraction of a variety of fossil fuel resources. In the past 250 years, since the onset

of modern industrial revolutions in all parts of the globe, humans have developed and industrialised the world to such an extent that the need for energy became a crucial part of human survival. There is therefore a greater demand than ever before for sustainable energy resources. Morris (2015:14) introduces the idea that human values constantly adapt and develop according to the demand for innovations and endeavours to reach greater technological progress. This view provides a link to the evolution of energy sources and consumption. It is responsible for intrinsic changes of values in human societies. Morris (2015:139) goes further by stating that in the successive stages of early human development, from hunting and foraging, to farming, urbanisation and industrialisation, there has been a growing demand for fossil fuel consumption. Fossil fuels can be any kind of hydrocarbon-containing material that is of a biological origin, occurring within the earth's crust, which can be used as an energy source (Encyclopedia Britannica (b), 2020). It simultaneously meant that modes of energy capture determined population size and density, which in turn largely determined which forms of social organisation worked best. This means that the bigger the population size, the higher the demand for energy. Thus, societies adopted certain sets of values more successfully (Morris, 2015:139). However, as value sets changed, so did different types of energy that was required.

To better understand why the contemporary exploration of natural gas through hydraulic fracturing has become so important, one has to understand a brief history of energy. The human race's technology has become so advanced since the intensification of fossil fuel consumption in the 18th century industrial revolution that was sparked off thanks to energy. In transportation, historically, the horse and cart were replaced by motorised transport. Transportation requires vast supplies of fuel. In more recent times, global information communications technology systems, have replaced postal messenger services since the 1990s. Consequently, the way in which humans use and produce energy has also undergone change. Before the human demand for energy increased, there were only rudimentary demands for resources, such as wood, peat and later coal. The sun remains the most important and the oldest energy resource on earth. This is because the sun provides energy to many living organisms (Anon (a), 2018). Wind and water – in itself resources for indirect energy generation – are also subject to the vast array of energising functions of the sun. Being a natural resource, the sun's energy has not always been utilised to its full potential for the mass consumption. That is, until the more recent phase of industrial revolution presented itself. It is now commonplace for

renewable energy consumers to harness the sun's energy via the use of solar panels, and the power of water in water mills and hydropower turbine plants.

Wood became well-known as a source of heat and light in homes. Wood eventually became a scarce commodity in Europe by the 1600s. Today too, wood may be seen as an even scarcer energy resource as a result of the number of rain forests and other natural forests that have been dwindling at an alarming rate. This is due to human activity in those areas. The large-scale mining of coal started when wood, and even charcoal, were unable to supply the growing demand for large amounts of energy to power and heat up industrial production processes, transport and domestic human lifestyles. During the British Industrial Revolution, James Watt worked on improving steam engines used to remove excess water from coal mines. The pumping machines became more popular and advanced. Consequently, they were turned into engines to power factories, sophisticated transport systems like railways, shipping and modern vehicles – all signal events in the history of modern industrial development (Anon, 2016).

The energy revolution developed further as coal and other fossil fuels, such as oil and natural gas, become the next resources for generating energy. Increasing concerns about the environment and the potential finite status of fossil fuel supplies boosted interest in developing nuclear power (Valentine, 2011). By the mid-twentieth century nuclear power came into its own. The physicist, Enrico Fermi, discovered nuclear fission in 1934. By 1942 he had managed to create the first nuclear reaction that was self-sustainable and controlled. Four years later, in 1946, the United States' Congress passed the Atomic Energy Act. This established the framework whereby atomic energy decisions would be made for the next approximately 30 years. The legislation provided for two bodies, the Joint Committee on Atomic Energy, which oversaw the AEC (Atomic Energy Commission) operations and the AEC itself. The AEC received ownership of all atomic material, information and material from the Manhattan Project (Duffy, 2013:2). Between the 1950s and 1960s, nuclear power stations started operation in many parts of the world. They were considered safe, not only to use, but also for the environment because it did not release any harmful fumes. Using nuclear energy was also a sustainable option as the amount of energy produced by a reaction could power so much more than say, coal (Gu, 2018:683).

However, there was also a negative legacy of atomic energy. On 6 August 1945, the world experienced the devastation of the first use of nuclear energy. This was when

Hiroshima was hit by the nuclear bomb “Little Boy” during World War II. Three days later, on the 9th of August, Nagasaki (the secondary target – the first was Kokura) was hit by a second nuclear bomb known as “Fat Man”. The devastation after these bombs was staggering, with hundreds of thousands of people who died immediately and tens of thousands of people who died months later after being exposed to the radiation left behind by these bombs (Anon (c), 2020). It seems though only after the nuclear disaster of 1986 at Chernobyl, in the Ukraine, did the world take a negative view of nuclear energy sources (Kurian, 2012:678-679). Due to the extensive damage done to the environment after this explosion, there were concerns for the environment and the future of the human race. This posed a new problem to all governments: there was a need to find a balance between the demand for energy and the conservation of the planet (which humans also rely on, probably more than energy resources). Energy had to comply with the demand for a new “clean” future.

Natural gas, although listed as a fossil fuel, can be seen to be quite harmful to the earth in many ways, although it is still considered to be cleaner than others, like coal. As a renewable resource, natural gas is fast becoming popular as an alternative to the use of coal. Burning coal-based fossil fuels has largely contributed to climate change and air pollution, hence the need to start phasing out such resources (Shapiro, 2020:7). Hydraulic fracturing as a method to obtain natural gas from the earth, has become a new way of developing ‘cleaner’ energy resources. This form of development of energy emphasises that humans are constantly looking for better and more sustainable ways of producing energy to power ever-evolving developing countries of the world.

Natural gas is a scarce resource, mined from the earth’s rock and it is used mainly to produce heat and power in the energy sector (Scholes, *et al*, 2015:165). It can be converted into energy for electricity, for example, providing homes with electricity and powering motor vehicles. The benefit of natural gas is two-fold: firstly, it is a less expensive alternative to coal, petroleum and other sources of energy (Hassett & Mathur, 2013:12-13); and secondly, it does not emit as many harmful fumes into the atmosphere as the burning of coal and landfill gad-methane or nuclear generated energy (EPA, 2014). Globally, natural gas is therefore in high demand. In the United States of America (USA), natural gas mines have been in operation since the 1940s, only forming a small part of the country’s fuel industry at a later stage. During the 1940s and 1950s, the production formation for hydraulic fracturing developed into a method for producing oil and gas wells. The process of hydraulic fracturing was first commercially available in 1949. At this stage,

there were only 18 wells treated per month. By 1953, the number of wells increased to 1900 per month for the first 6 months of the year (Roberts, 1954:140). Others, such as Venezuela, Algeria and the United Arab Emirates (UAE), have followed the example of the Americans since the 1960s (Korybko, 2014). After the nuclear energy disaster of Fukushima in 2013 (World Nuclear Organisation, 2014), Germany and Japan, along with states such as Argentina, Brazil and China, started looking at the alternative sources of energy with natural gas as an option. Viewed from an environmental political perspective, natural gas plays, and is bound to play, a significant role in the future of global energy demand.

Clean or renewable energy generally refers to those resources and technologies that cannot be depleted or can be naturally replenished. Environmental thinkers in favour of natural gas stress that it needs to be extracted and utilised in a controlled and responsible way (Hassett and Mathur, 2013:13). Hydraulic fracturing is the industrial method of mining through which natural gases are extracted and is defined by the American Chemical Society (ACS) (2016:1) as follows:

> *It is a process that increases the flow of oil or gas from wells. It is accomplished by pumping liquids (fracturing fluid is made up of 90% water and 10% other minerals) into a well (into shale stone) which causes high amounts of pressure that fracture the rock. From these fractures, gasses used as energy source can be extracted.*

Although the benefits of hydraulic fracturing are indisputable, it remains a fact that hydraulic fracturing can cause environmental pollution if extracted without sufficient oversight, or if the quantity of gas extracted far exceed what is available (Considine, *et al*, 2011). According to Hoffman (2014), the industrial process of hydraulic fracturing can specifically lead to the contamination of the earth's natural water supply. There are concerns that the potential risks of chemicals used in the fracturing process may pose a threat to either underground or surface water or soil, if any spillages take place (Modlin & Hander, 2014).

Although there are global procedures and regulations in place about where to drill, and how far the fractures may go, there are concerns about the fractures extending to natural water supplies (Hoffman, 2014). The concern is based on the possibility that if the rock fractures further than it should, the fracking fuel can seep through the fractures and into pristine natural groundwater resources. Furthermore, there are doubts about the structural integrity of the walls of wells created for the hydraulic extraction of gas by fracturing. If these walls collapse, it could have negative ecological implications. This is

looked at because hydraulic fracturing operators often use old wells already drilled by earlier oil extraction operations. It can also be a problem if the local geological rock structures are weaker than anticipated. Fracturing fluids (chemicals) may seep through the rock and again into dolomitic reservoirs of natural groundwater, suitable for human consumption and food production (Anon, 2014). The accidental spill of toxic fluids can contaminate ground and surface water supplies (Golden, 2014).

In the first half of 2010 there were confirmed cases of water pollution from hydraulic fracturing in four states in the USA (Begos, 2014). The most common type of pollution involves methane gas. It does not come from the drilling process, but instead the liquid pumping process. By 2014, the state of Pennsylvania had at least 106 water-well contaminations dating back to 2005. There were five confirmed in the first nine months of 2012, 29 in 2010 and 18 in 2011. Ohio had two confirmed cases out of 54 complaints in 2011. Two were confirmed out of 59 in 2012 and two confirmed cases of 40 in the first 11 months of 2013. West Virginia had a total of four confirmed cases, based on 122 complaints over a period of four years. Although Texas had no confirmed cases up to 2014, there had been over 2000 complaints (Begos, 2014). Increasingly measures were introduced to mitigate the threat of potential shale gas extraction to water resources. In the USA, and many other countries of the world, there is a growing awareness of the potential dangers of fracturing. At the same time, there is an awareness of its substantial benefits. Ultimately it is a matter, as pointed out above, of values that adjust as innovative mitigation measures garner public confidence in vitally important energy resources.

Public concerns about hydraulic fracturing have not diminished the ongoing exploration for gas. The mining sector is ready to invest in offshore drilling for gas. The African Union (AU) strongly supports Africa's Blue Economy that could be implemented to work for the benefit for Africa's development (Walker, 2018). Blue economy refers to the economics relating to the preservation and exploitation of the ocean or marine environment. Operation Phakisa, aimed at extracting offshore gas fields along South Africa's 3600km coastline, is the government's brain-child. It forms part of the government's targets for locating alternative energy resources. In 2014, The Oceans Economy Lab was launched in Durban, South Africa. This project is one of many other sectors for the Phakisa project. The main aim of the project is to drill for gas offshore. This has so far gone ahead and can be economically beneficial for the South African economy (Walker, 2018).

The abbreviated history of energy, outlined above, leads to the prime objective of this

research. The study investigates the prospects, possibilities and consequences of hydraulic fracturing in South Africa (SA), specifically in the Karoo, one of the major arid regions of the country. The point of departure is that the practice of fracturing may harm the eco-system through the contamination of the natural water supply, man-made earthquakes and the potential increase in the Karoo's water stressed conditions. From an environmental political perspective, it is argued that, if not practiced in a responsible way, fracturing could have a negative impact on the existing water supply, agricultural activities and the lives of, specifically, the rural population.

1.3 PROBLEM STATEMENT

The American Energy Information Administration (EIA) estimates that South Africa could have the fifth largest natural gas fields in the world (Brownfield, *et al*, 2012). With this information in hand and the advantage of natural gas, the South African Department of Mineral Resources (DMR) indicated that the extraction of natural gas through hydraulic fracturing has the potential to substantially decrease South Africa's national economy's dependence on its current coal, oil and nuclear energy resources (Department of Mineral Resources, 2014). Against this background, the South African government started exploring the possibilities of hydraulic fracturing in the Karoo area in order to extract natural gases (Atkinson, 2018:445). This intention was also confirmed by President Jacob Zuma in his February 2015 State of the Nation Address (Zuma, 2015). At the time, the process was so far advanced that licences to explore for natural gas have already been granted to Royal Dutch Shell, Falcon Oil and Gas and Sunset Energy (Anon (b), 2012). In 2014, the DMR recommended that the process be speeded up and that the preliminary steps should be able to:

- close the gaps that are identified in the existing framework that govern the exploitation and exploration of petroleum, in particular hydraulic fracturing;
- prescribe practices and standards that will ensure safe exploration and production; and
- make regulations available to the public for inputs and any comments, from interested or affected stakeholders (Department of Mineral Resources, 2014).

Against this contextual background, the focus will, as a key contribution of this research, be on the feasibility of the energy sector and the South African government's support for intentions to extract natural gas through the practice of hydraulic fracturing in the Karoo

area. The purpose of this research is to provide a critical descriptive narrative, informed by environmental political thought, on the practice and consequences of hydraulic fracturing on a global scale and its potential relevance for South Africa's development. Environmental political thought, together with ideologies such as Feminism and Marxism, are regarded as critical perspectives or theories in the field of political science (O' Brien & Williams, 2013:19). In other words, it questions the current status quo within a specific economic or political context. In this case study, the critical theory of environmental political thought has been used as foundational tool informing the research and reporting process.

As a key contribution, the research identifies and analyses the positive and negative consequences of hydraulic fracturing from a global perspective. From a hypothetical point of departure, the main argument is that hydraulic fracturing can contribute towards satisfying energy and even financial needs globally and in South Africa. However, it may have a detrimental effect in specific areas – in this case the Karoo (Andreasson, 2018:455-456). Therefore, government policies and implementation strategies for fracturing must be balanced in such a way that energy needs are met, whilst also protecting the environment.

1.4 THEORETICAL FOUNDATIONS OF RESEARCH

For the purposes of this research, environmental political thought, with an emphasis on an environmentalist approach, serves as theoretical foundation and structural guideline. The main point of departure of environmentalist political thought rests on the protection of the natural environment whilst ensuring that development is for the benefit of all living organisms on earth (Dobson, 1995:16-33). Goodwin (2010:246) identifies three moral characteristics inherent to environmental political thought, namely the belief that:

- all species have a right to exist;
- all living organisms have intrinsic value; and
- the earth is an interconnected eco-system.

From an implementation perspective, Barry (1996:28, 92) views the following three core elements as inherent to the objectives of environmental political thought:

- distributive (intergenerational) justice;
- a commitment to a process of democratization; and

- the achievement of ecological sustainability.

According to Dobson (1995:7), environmentalism seeks measures to protect and improve the health of the environment. A specific emphasis is placed on anti-pollution strategies and protecting plant and animal diversity. Dobson (1995:16) goes further by stating that the preservation of the environment requires a balance between production and consumption. Goodwin (2010:237) agrees, but is of the opinion that environmentalism cannot be linked to the radicalism favoured by ecologists. Environmentalists aim to reconcile human behaviour and needs with our contemporary understanding about the protection of the environment. This approach to understanding environmentalism will be pursued in the proposed research. Human beings and nature are of equal importance and must co-exist in harmony. The environmentalists will, for example, be in favour of recycling, conservation and the protection of wildlife. Environmentalists can also call for actions such as better public transport to reduce the number of cars on the road, but not necessarily for any big changes in any social and economic structures (Baradat, 2012:318-320). Therefore, the study refrains from a doctrinal approach to the environment and instead seeks sensible and reasonable options and consideration in respect of contemplating the practise of hydraulic fracturing.

This research has explored fracking from a viewpoint founded on environmental political thought. Hydraulic fracturing, it is argued, can be beneficial as a cost effective and an alternative source of energy. This is specific to the South African context. The study looks at other benefits that hydraulic fracturing may hold for South Africa, such as economic benefits for the country as a whole. To better understand this and to properly address this issue, environmentalists' arguments relating to the economy, pollution, mass consumption and moral grounds will be used to inform the critical issues under discussion in the research.

1.5 PRELIMINARY THEORETICAL STATEMENT

A theoretical statement on the outcome of the research can be described as follows: There exists a causal relationship between hydraulic fracturing and the potential contamination of the earth's water supply. Human intervention in the form of hydraulic fracturing may be materially beneficial as an alternative source of energy, but it can potentially lead to the contamination of the scarce and fragile subterranean and surface water supplies of the Karoo region in South Africa**.**

1.6 RESEARCH QUESTIONS

A number of research questions were framed to direct the research focus. They can be summarized as:

- Why is the issue of hydraulic fracturing for natural gas deposits in South Africa's Karoo region problematic?
- How important is energy to modern society and precisely where does fracturing feature in the energy sector?
- What are the South African government's plans and prospects for hydraulic fracturing in the Karoo area?
- What are the advantages and/or disadvantages of hydraulic fracturing in SA?
- What potential measures can be taken to effectively plan, coordinate and execute hydraulic fracturing in SA? and;
- What conclusions and recommendations can be made?

Flowing from the research questions, the following objectives, as listed under the next heading were identified.

1.7 RESEARCH OBJECTIVES

The objectives of the research project included:

- to understand why South Africa's plans to explore hydraulic fracturing in the Karoo are so problematic;
- consider the importance of energy in modern society and the status of hydraulic fracturing in the sector;
- describe South Africa's current plans and prospects for hydraulic fracturing in the Karoo;
- contemplate the potential advantages and disadvantages of hydraulic fracturing in South Africa's Karoo area;
- outline potential measures that may be taken to ensure proper planning, coordinating and execution of hydraulic fracturing in South Africa; and
- provide a potential conclusion on the unfolding issue of hydraulic fracturing in South Africa from an environmental political perspective.

The methodology of the research seeks to ensure that the research questions are

answered through the achievement of the set objectives. The ways and means of how this is achieved is discussed in more detail in the following section.

1.8 CONSULTED DATABASES

The following databases were consulted to find the relevant information and to validate research:

JStor; Google Scholar; NWU; Ebscohost; SAePublications; Google Scholar; and NEXUS.

Current and new academic literature and publications on hydraulic fracturing in South Africa are sufficient for this study. There are many projects like the Phakisa offshore projects in South Africa, which are in the early stages of research and exploration (Sefako, 2015). The study focuses on hydraulic fracturing terrestrial inland areas, particularly the Karoo, and not offshore shale gas extraction. Up to the present, the most important information is to be found in government publications, communications, legislative guidelines, as well as in publications by non-governmental organisations (NGOs), protest movements and action groups and the news media. This research therefore aims to contribute to a body of literature on hydraulic fracturing in South Africa. The data from the NGO Treasure Karoo Action Group (TKAG), substantially contributes to the foundation of the South African scenario and what the possible implications of fracturing in the Karoo may be. It has also been established that this research is unique in the sense that no other study with the same title has been undertaken (National Research Foundation, 2014).

As indicated, available literature on hydraulic fracturing in South Africa suggests that the use of natural gas can be beneficial as an alternative source of energy for society as a whole. There are however concerns that the extracting process (hydraulic fracturing) could have detrimental effects on the environment, with specific reference to the ecosystem and natural groundwater resources of the Karoo. There are adequate local (secondary) and international, primary and secondary sources of information available to conduct this research. For the purpose of this research, there is an additional focus, from an environmental political perspective, on hydraulic fracturing in other parts of the world.

1.9 METHODOLOGY

According to Brynard and Hanekom (1997:29), methodology refers to the means that will

be employed to conduct research. It also determines how and what will be researched for the study at hand (Kellstedt & Whitten, 2009:79). This means the goal of the methodology is to test the validity of the hypothesis and explain what the reality is, or arrive at results as close to the truth as possible. The collection and analysis of data is therefore used for the purposes of interpretation and prediction of the topic being studied (Durrheim, *et al*, 2011:47).

In terms of research dimensions, the historical and case study approaches feature prominently. Historical research will be relevant as a result of the use of primary and secondary sources, running records and written recollections, as well as the opinions of experts. The unit of analysis will be studied through case study research. This format of research revolves around a systematic inquiry into an event or a set of reliable events with the aim to describe and explain the phenomena of interest. A case study could be positive, interpretive or critical in nature (Maree, 2014:75). Maree goes further by indicating that a case study does not have to be restricted to one object of research but allows for multiple interests. In this regard, the phenomena of hydraulic fracturing in the USA in comparison with developments and prospects in South Africa serves as the most important source of analysis.

The method of research is primarily based on a literature study, document analysis. An explorative and critical approach will be used in the interpretation of materials for relevant factual information. The research will primarily be conducted from a theoretical perspective (environmental politics) with some deductive and inductive features where existing statistical information come under scrutiny. According to Durrheim, *et al*. (2011:47), this method of analysis allows the researcher to study any specific topics in-depth in order to identify, understand and interpret the various clusters of data collected. The validity of the preliminary research statement will be tested to highlight the views of:

- previous publications on the research topic (hydraulic fracturing);
- general conclusions relating to the research topic;
- strengths and weaknesses detected in the available literature;
- the identification of research contributions that can still be made; and
- ways and means to develop new information on the research topic.

Therefore, the objective has been to generate new or alternative sources of information in order to make specific recommendations (inductive). Against the above background, the multi-faceted layers and dimensions inherent to this research will be qualitatively

structured through the use of the following techniques (Leedy & Ormrod, 2010:136-137):

- description: certain situations, settings, processes, relationships, systems or people's attitudes or natures will be revealed;
- interpretation: the researcher will gain the necessary information and understanding into the phenomenon. Theoretical perspectives will be identified and concepts about the phenomenon will be pointed out;
- verification: the researcher will test the validity of certain theories, generalisations, claims and assumptions in the "real-world"; and
- education: the researcher will judge the effectiveness of policies, practices and innovations.

The contents of research will chronologically be structured through the following levels: On a macro level the focus falls on the analysis of the spectrum of environmental political thought, with specific reference to scarcity and forms of human intervention in nature. Here a link will be established with environmental political thought and hydraulic fracturing as a global phenomenon, and in South Africa specifically.

The meso-level narrows the research down to a perspective on the practice, advantages and disadvantages of hydraulic fracturing on the environment. Specific reference will comparatively be made to hydraulic fracturing in the USA and contemporary developments.

On an application-level, the plans, prospects and possible outcomes of hydraulic fracturing in South Africa, with specific reference to the Karoo region, will be explored. As an outcome, conclusive recommendations relating to the practice thereof in South Africa will be made from an environmental political framework.

1.10 LITERATURE STUDY

Much has been published on environmental political thought and related ideologies. Prominent publications that were consulted include *Discursive Sustainability* (Barry, 1996), *Ages of Gaia: A Biography of Our Living Earth* (Lovelock, 2000) and *Green Political Thought* (Dobson, 1995). Supporting sources included *Using Political Ideas* (Goodwin, 2010), *Political ideologies: Their Origins and Impact* (Baradat, 2012). Additional publications consisting of *The Human Footprint: A Global Environmental History* (Penna, 2010), which all dealt with the effect of human intervention in nature as forms of pollution and mass consumption. The work *Foragers, Farmers, and Fossil Fuels: How Human*

Values Evolve focused on the importance of energy and the evolution of fossil fuels as a source of energy (Morris, 2015). An article by J.C. Warsaw published in *The Economist*, such as Polish fracking: Shale gas fail (2014), also formed a part of the research.

In terms of developments in South Africa the Fossil Fuel Foundation Coal, Energy and Sustainability Conference (Fracking SA, 2015) that took place in Cape Town in 2014, various policies and Government Acts served as a guideline for contemporary and ongoing developments. The conference saw research papers presented on a number of issues pertaining to energy, the crisis, the opportunities, the growth as well as the disadvantages of certain methods. The opinions of authors from articles from the *Daily Maverick* were also consulted on the topic of hydraulic fracturing in South Africa. Important pressure groups, such as *Treasure Karoo Action Group*'s opinions were analysed with regards to the implications of hydraulic fracturing. Through the use of the above publications, it was possible to locate essential examples of environmental political thought and establish a link with the practice of hydraulic fracturing in South Africa.

Since the 1940s, ample information has been published on the global practice and effects of hydraulic fracturing on the environment with specific reference to the USA and some other countries. This information included, amongst others, primary publications such as *Earthworks* (2015), many articles from the *American Energy Information Administration* (2015) websites. Articles and relevant information in the *USA Environmental Protection Agency* (2015) were also consulted. It was possible to conduct an in-depth descriptive analysis of hydraulic fracturing on a global scale, useful for the purposes of this study.

As indicated, the contribution of this research relates to the reality that not much has been published on hydraulic fracturing in South Africa. In essence, this study therefore attempts to contribute toward the limited body of academic literature that exists on hydraulic fracturing in South Africa. Available literature can mostly be found in newspapers, official government publications, reports and printed material related to protest initiatives. Important sources will include Notice 863 of 2013*, Department of Water Affairs, The National Water Act, 1998 and* Notice 1023 of 2013, which mention the plans to go ahead with the exploration of hydraulic fracturing as well as the benefits; *National Environmental Management Act No 62* of 2008, and *the Department of Mineral Resources, Mineral and Petroleum Resources Development Act 28 of* 2002. This act also deals with future plans for South Africa with regards to hydraulic fracturing and the

benefits in the energy sector. These Notices and Acts will provide an overview of the proposal and potential benefits for conventional and hydraulic fracturing in the Karoo. In addition, these sources will provide information about the regulations in place for the venture of hydraulic fracturing in South Africa and will give an overview on what may be expected from the gas companies, should they continue with plans to mine for gas.

The researcher therefore also made use of the Hansard Parliamentary Reports (Zuma, 2015). The Hansard Reports will also provide updated information in relation to the governmental prospects and plans for hydraulic fracturing in South Africa, an in-depth look at conversations and speeches made in Parliament about hydraulic fracturing and the exploration plans by the President of South Africa as well as any ministers related to the topic at hand.

1.11 RESEARCH ETHICS

This research has a strong theoretical foundation which is primarily based on a literature study and content analysis. No interviews were conducted. From a methodological perspective, research can therefore be deemed as low risk when ethical issues are considered.

1.12 CHAPTER LAYOUT

Chapter 1: An environmental political perspective on hydraulic fracturing and the potential implications for South Africa

Chapter 2: The global importance of energy in modern societies and the status of hydraulic fracturing

Chapter 3: The South African Government's current and future plans and policies for hydraulic fracturing

Chapter 4: The advantages and disadvantages of hydraulic fracturing in South Africa, with specific reference to the Karoo

Chapter 5: Potential measures for fracturing in South Africa's Karoo: Recommendations and conclusion

1.13 CONCLUSION

In this chapter the preliminary theoretical statement was put forward that hydraulic fracturing is beneficial as an alternative source of energy but can contaminate the natural groundwater supply in the arid Karoo region of South Africa. The above statement is tested methodologically, and specific recommendations are made by answering research questions and aligning them with the predetermined objectives. This chapter has laid a foundation for the next chapter to better understand the hydraulic fracturing aspects for South Africa, which will be explored to better understand all concepts and how the researcher will go about the study.

The next chapter will serve as the theoretical foundation of the research conducted. It will serve as a background chapter to the research and will focus on the importance of energy sources on a global stage, it will do so with a specific emphasis on hydraulic fracturing in South Africa. The chapter will look at the history of energy and the importance of it to human survival. It will look at how energy has developed over the years; the chapter will also focus on an analysis of environmental political thought with a specific emphasis on global scarcity and the effects of mass consumption (human intervention) on energy resources. It is important to understand this and, as a point of departure, chapter two will look at the difference between hydraulic fracturing and conventional mining, this will lay a foundation for understanding the advantages and disadvantages of hydraulic fracturing. The chapter will be within the framework of an environmental perspective. The approach of this chapter therefore serves as a measuring instrument and structural guideline for the compilation of chapters three, four and five.

CHAPTER 2

THE GLOBAL IMPORTANCE OF ENERGY IN MODERN SOCIETIES AND THE STATUS OF HYDRAULIC FRACTURING

2.1 INTRODUCTION

This chapter serves as contextual background to this research and focuses on the global importance of sources of energy with a narrowed emphasis on plans and prospects of hydraulic fracturing in South Africa. In Chapter 1 it was indicated that environmental political thought with environmentalism as point of departure, would serve as the theoretical foundation and rational behind this research. From an environmentalist perspective, Dobson (1995:16) emphasises the so-called anti-pollution strategies in order to protect the natural environment. This therefore requires that there must be an international balance between production and consumption to ensure optimum benefits for the earth's population whilst protecting the environment. This again shows the importance of the relationship of a symbiotic relationship between the earth and humanity as was mentioned in the first chapter. In this study, it is argued that this balance should also be present in the environmental public policies of individual states.

In this respect the objectives of this chapter will be achieved through a threefold approach. On a macro level, the focus is on sources of energy and its importance to modern societies. This section provides an overview of the different sources and types of energy. It also provides a historical background to the contemporary importance of energy to the human race. On a meso-level, the focus shifts to a descriptive analysis of global policies on renewable energy and more specifically hydraulic fracturing as a method of extracting natural gas from the earth. Here the chapter breaks down to the functional activity of hydraulic fracturing compared to other forms of mining, such as conventional underground or surface mining methods. This is important for the purposes of this research, as it lays the foundation to understand the effects that hydraulic fracturing may have on the environment. On an application level, the focus is narrowed to a brief consideration of the potential effects of hydraulic fracturing on a global scale. This section will explore the effects of fracturing as this forms part of the foundation to better understand why the South African government is thinking of exploring for natural gas through fracturing. This furthermore provides potential scenarios of the effects, both

negative and positive, for the country and specifically the Karoo area.

2.2 A BRIEF BACKGROUND TO THE EVOLUTION OF SOURCES OF ENERGY FOR HUMAN USE

To better understand the importance of energy sources on everyday life, one must begin with the history and importance of different energy sources and how it influences life on earth. In this respect, this chapter provides a holistic perspective on the different sources of energy utilised in the world, narrowed down to the use of natural gas through the method of hydraulic fracturing.

2.2.1 Different kinds of renewable energy resources

The relationship between humans and their interconnectedness with the earth provides a guideline towards understanding where the use of energy originated. Furthermore, the history of natural resources allows one to understand how energy utilisation has evolved.

2.2.1.1 Peat as a renewable energy source

Peat is a spongy material that is partially formed by decomposed organic matter, mostly made up of plant material. The plant material often comes from swamps and other kinds of wetlands. Peat can develop in cold and hot conditions providing there is sufficient moisture conducive to plant growth (Encyclopedia Britannica (c), 2020). In countries such as the United Kingdom, Canada, Ireland, Sweden, Finland, Russia and the United States of America, peat is used as a versatile and rich energy reserve. It is used in the chemical and fuel industries as a raw material. It can be produced as sod peat, milled peat or hydraulic peat, as in Sweden (Lindström, 1980:309).

2.2.1.2 Wood as renewable energy source

From burning wood, dried up dung or straw, along with peat, humankind constantly sought new ways and means to harness energy. Fire was essential from the start as it provided heat (similar to how a dwelling could be heated by the sun, but since the sun set at night, people needed to have something to warm their homes at night). Fire could also provide light, such as candles or a burning stake used to navigate a dark cave (NDSU, 2017). Steam energy is a product of the use of fire. The heat from the fire creates steam by heating up coal in a steam engine. Without the heat from fire, the advent of steam

energy may never have occurred.

2.2.1.3 Water and wind as renewable energy sources

Water and wind are connected somewhat to solar power, as part of a portfolio of natural renewable sources of energy (Scholes, *et al*, 2015:165). Wind power for transportation dates far back, as boats were often used to move around on the seas and rivers. Ancient civilisations (Romans, Chinese and Indians) harnessed the wind to power sails and move boats. This continued until they were replaced by steamboats in the nineteenth century.

Windmills and waterwheels can be dated back to Egypt in 2000 BC and to Persia in 640 A.D. (Doherty, 2015:23), and were used to grind grain and later re-developed to pump water. In 200 BC, the Greek mathematician, Archimedes, used a vertical water wheel - a vertical wheel mounted on a structure with receptacles that dip below the surface of the water and literally lift water to the surface. This is known as the Archimedes screw (Britannica Academic (a), 2020). The water wheel, another technology allows a running water source to rotate the wheel, producing enough power for certain human activities requiring exceptional and consistent energy. The water wheel gave birth to the field of hydro-electric energy production. Water wheels could be used for pumping water for irrigation, which in turn saw dams being built to store water, and grind grain as well (NDSU, 2017). The year 1881 marked an advance in this technology when the first hydro-electric plant was put to work in Appleton in Wisconsin, USA. It was a matter of evolution from grinding corn, to grinding out electricity. Hydropower, in its earliest form, was the water wheels used to grind grain. These became more advanced inventions as water was harnessed to create electricity to power homes and factories (Department of Water Affairs, 2013). Because hydro plants are 'fuelled' by water, this resource is cleaner and does not cause pollution such as coal or natural gas (Department of Energy, 2017).

Steam engines were the next step in the evolution of energy. It dates as far back as the 1st century, when Heron of Alexandria designed the "aeolipile" (Papadopoulos, 2007:217). The "aeolipile" was an apparatus that was often called the first steam engine and consisted essentially out of a closed vessel (either a globe or cylinder) with one or more bent tubes out of which steam is made to pass from the vessel. The bursts of steam, caused by heat, formed jets that caused it to revolve (Anon (b), 2020). One thousand five hundred years later, steam, under high pressure, was used to drive turbines. These inventions were mainly used by philosophers and scientists of the time

to demonstrate that steam power could not be underestimated. The evolution of the steam engine gained momentum in the 17th and 18th centuries. The Union of Concerned Scientists (UCSUSA, 2015), a team of scientists in America, who put different theories to test, the design of the single steam engine that was powered by coal dug from mines in Appalachia and England. It was better than the old style of using a dozen horses to do whatever work they needed to do. The engineer, James Watt, felt that coal powered steam engines were too dangerous to continue using as means of transportation. Consequently, it was first used as a source of energy for ships, railroads and factories (Anon, 2017). These steam engines became more popular. They were less expensive than using horses and could operate at all times of the day or night, unlike wind or water.

2.2.1.4 Solar power as a renewable source of energy

The sun is the oldest source of energy. Almost all forms of energy have some relationship to the sun. For example, most ecosystems rely on the sun as an energy source. The wind itself is created by changes in temperature caused by the sun in different seasons and changing weather conditions. The sea tides are affected by the movement of the sun, it also has the important role of keeping the earth in its orbit to ensure life on earth. Trees and plants harness energy from the sun; the heat rays from the sun give plants their nourishment and assist in the process of releasing oxygen. Rain and snow are all products of the sun: the heat from the sun causes evaporation of water from lakes and oceans, creating the water cycle. As the sun is a natural occurrence, humans cannot capture its energy without appropriate technologies, such as today's advanced solar system technologies (Anon (a), 2015).

Solar energy relies on the nuclear fusion power at the sun's core. It can be collected and converted in many different ways. It ranges from solar water heating, attic cooling for domestic use, to more complex systems which uses the direct conversion of sunlight to electricity. The problem is, solar energy requires costly infrastructure equipment to generate power on a vast scale. Currently there is not enough solar energy to power modern societies with all the appliances and gadgets that use electricity (The Department of Energy (a), 2015).

Finally, geothermal energy is left over energy from the accretion of the planet. It is augmented by heat from any radioactive decay that constantly seeps to the surface. There is a geothermal gradient in certain areas which is high enough to exploit and create

energy. It is limited to a few locations in the world, such as Iceland. However, there are an abundance of technical problems that limit its use. One example is the earth's energy. It is the result of heat stored in the earth's nucleus. Soil on the earth's crust everywhere tends to have a constant temperature and can be used to heat pumps for heating and cooling. It is only in areas that have a potentially high consistency, due to the release of volcanic heat on the surface of the earth, that this source of energy can be used. This kind of heat may be useful in controlling temperatures in buildings, but it does not produce a consistent supply of, for example, electricity to consumers in many countries of the world (Department of Water Affairs, 2013).

2.2.2 Fossil fuels as renewable energy

As already stated, sources of energy have evolved over many years, from very primitive to more advanced forms. One thing that has not changed is the dependence of human societies on energy. It is important to also know how these sources have developed and the impact they may have had or have on life today. The most important energy resources currently are coal, oil and gas. They are all classified as fossil fuels – resources that have been created over millions of years. For example, plants and microscopic life forms stored up lots of energy of the sun before their ecosystems were destroyed by earthquakes and tectonic plate shifts. These energy-rich materials were then literally fossilised as they were captured at varying depths in the crust and mantel of the earth. Due to the nature of fossil fuels being made up of compressed layers in the earth's crust, it means that it takes so much longer to form, some materials taking millions of years to form. Since the late-eighteenth century, the large-scale exploitation of fossil fuel supplies has rapidly decreased. It has created the conundrum of energy being consumed far quicker than it can be naturally reproduced (Bridle and Geddes (a), 2019:2-3).

Hence the move to unconventional oil – oils that cannot be mined with traditional vertical drilling methods, like crude oil. Unconventional oils are generally trapped in geologic formations with low permeability, such as shale rock and natural gas (Balouga, 2012:27). Their extraction requires procedures like hydraulic fracturing and horizontal drilling. These processes require low permeability reservoirs that formerly were considered to be unproductive. This type of energy is welcomed by environmentalists and economists. It helps boost the economy and can be seen as slightly more acceptable than other non-renewable energy sources. Natural gas, which is made up of mostly methane, can be

converted into heat and used for powering industrial activities. The importance of finding renewable sources has become a point of contention for many. People are realising that the earth cannot keep up and reproduce resources at a rate that matches the rate which we are consuming it. Besides the reproduction problem, there is also the issue of trying to mitigate damage that had been done in the process of exploration and extraction in former times.

In the next section, we explore renewable energy resources in depth, with a more concentrated focus on hydraulic fracturing and the way in which it can benefit, also disadvantage a country.

2.2.2.1 Coal and Petroleum as an energy source

Coal, oil and gas became a better resource as wood became scarcer in the 1600s in Europe. Then in the late 1800s, petroleum was the new product on the market. Even though coal had become a problem because of air and dust pollution, contaminating water resources, it became a valuable commodity. From just being oil, initially sold for medicinal purposes, it was swiftly processed into gasoline (petroleum), and soon used for ignition in internal combustion engines. Petroleum became more popular than coal for a short period. But coal made its comeback in the mid-20th century. The use of coal increased, becoming the primary source for electricity (NDSU, 2017).

2.2.2.3 Oil as a source of energy

Crude oil is a wide term used for an array of hydrocarbons with varying characteristics. This fossil fuel is used widely across the globe as a source of energy; it accounted for 31% of the global energy demand in 2012. Due to its crude nature, crude oil has to be refined before it can be used. The refined product can be used to produce diesel, bunker fuels, gasoline, jet fuel, asphalt and many other derivatives. Oil has become very important to the global economy, since it plays a role in many industrial processes. It is a prime driver of the world's transportation systems. Due to the relationship between the economy and oil prices, it means this has a causal effect on a country's GDP (Melton, Hudson & Ladislaw, 2015:1).

2.2.2.3 Natural gas as an energy source

In 1973, as a result of conflict in the Middle East, the first global energy crisis started.

Crude oil prices increased overnight and created dire economic conditions in many parts of the world. There was no longer such a thing as cheap heating energy and fuel for transport systems. It was then that natural gas became popular as a source of energy. Up to the present, gas remains the most stable source of energy in many parts of the world (Raimi, 2018:178-180).

In the USA gas lines were built in 1945 and hydraulic fracturing was a consequence of the exploration of better and more efficiently mined natural gas. Natural gas mined through the hydraulic fracturing process was an option as it was natural and came directly from the earth, meaning that the chance of it renewing itself may be good. It also meant that countries did not have to burn anything in order to use it as an energy source as they do with coal (Department of Water Affairs, 2013).

2.2.2.4 Nuclear power as an energy source

Nuclear power was first used for destructive energy for military purposes. The use of nuclear power brought World War II (1939-45) to a decisive close. Nuclear power was first used in the mid-1950s to generate electricity. Nuclear is power is generated from the fission between uranium-238 and plutonium (Anon, 2003). The fission creates heat that is used to produce steam power in turbines that can generate electricity. Due to the fact that nuclear energy relies on an atomic process to produce energy, it has many advantages which makes this form of energy very appealing to many governments. The biggest drawing point for any environmentally conscious country is that nuclear energy has a limited impact on climate change and the environment. It produces energy which is carbon free and does not emit harmful gases into the atmosphere. Nuclear power offers countries reliable power supplies. Nuclear plants can run on an everyday, every hour basis. It means that it can run for long stretches at a time without being switched off for long. The amount of energy that is produced is also high (Anon (a), 2020). Nuclear energy can produce a lot more energy in comparison to coal energy, for instance.

However, this form of energy is expensive and there are concerns about safety and waste management. Concerns about using nuclear energy are not unfounded but rather based on past events. The first nuclear disasters to take place were in Chernobyl, Ukraine in 1986, the 1979 Three Mile Island part meltdown of a nuclear reactor in Pennsylvania in the USA, as well Japan’s Fukushima Daiichi Nuclear Power disaster in 2011. Nuclear energy can be seen as unstable and difficult to manage especially if there are flaws in the

designs of reactors and inadequate trained staff. For example, Chernobyl caused more damage than just the buildings being destroyed and lives lost within a few months. Because of radiation exposure, the area, as well as places close by, were declared disaster zones and cleared out immediately (World Nuclear Association, 2017).

2.3 ENERGY, SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE

The Brundtland Report, also called Our Common Future, was published in 1987 by the World Commission on Environment and Development (WCED). It introduced the idea of sustainable development. It was endorsed by the United Nations, the project leader was Gro Harlem Brundtland. The report looks at what causes environmental degradation; proposed ways to attempt to understand the connections between economic growth, social equity and environmental problems. The report then presents different policy solutions that integrate all of these areas. The report reiterates that the environment does not exist alone as a sphere but must exist with humans, their needs and ambitions (Brundtland, 1987:7). Development with regards to the environment is an attempt at doing whatever it takes to improve the problems created by overt development. In this sense, the two terms sustainability and development, cannot be separated. Political leaders need to see development issues as crucial to their countries, especially when compared to other countries who seem to have reached their plateau of development. Poverty and the degradation of the environment pose threats to the opportunities for a country. It can result in the flagrant waste of resources. There is a link between poverty, the environment and inequality, and what is needed is an entirely new era of economic growth (WCED, 1987:7).

Sustainable development can be achieved through humanity not compromising the ability of future generations to be able to meet their own needs. It does present some problems, not major limitations, but limitations that are presented by the state of the country, its technology and social organisation on resources. Technology and social organisation can be managed and improved to improve economic growth. Poverty which is a growing issue globally can be eradicated because sustainable development needs to meet the basic needs of all, this will happen by ensuring opportunities for all to fulfil their ideas for a better life (WCED, 1987:16-17).

There needs to be a greater sense of environmental awareness and a move towards sustainable development strategies to monitor natural resources. One needs to

understand, though, that sustainable development will have varying definitions in different disciplines. It has been suggested that there may be as much as 70 definitions of sustainable development (Elliot, 2006:8). This could be attributed to the fact that sustainable development has no fixed outcome. From a holistic perspective, the idea of sustainable development is a process that is ongoing as strategies and needs change over time. It means development needs to somehow be maintained. Sustainable development is made up to two concepts according to the Brundtland report (WCED,1987:43). The first concept suggests that priority be given the world's poor people. The second concept says we need to remember there will always be limitations to social organisation and technology that the state can provide, and how the environment will handle any needs in the present and in the future. van der Elst, (2008:6) mentions that sustainable development can be aimed at the restoration of any broken relationships between communities, groups and individuals. It includes the relationship between the available resources and the communities they need to support. According to Elliot (2006:235) sustainable development needs to ensure that a better quality of life is experienced by everyone. Society should be more inclusive to ensure that increased economic prosperity is for the benefit of all. It also means that there should be less wastefulness of natural resources and less pollution. It could be said that a sustainable growth policy should see to maintaining the growth at an acceptable rate of per capita real income, by making sure that there is no depletion of the national environmental stock or the capital asset stock (Turner, 1988:12).

Ultimately, pro-environmental measures to change to more renewable and cleaner forms of energy, can have a positive impact on the world's economy. Renewable energy has two main factors that can contribute to a more stable environment. The one is that the country should use its own resources, which means they save money on importing resources from other countries. The second factor is that harnessing renewable energy is often quite labour intensive. It means that there is always the possibility of job creation within a producing and consuming country. The search is currently on for natural energy resources with a low environmental impact which are capable of working in the interest of sustainable development. It implies responsible collecting practices of natural resources with the least possible damage to the environment. When it comes to energy, it would be a great advantage if natural resources could renew and replenish themselves at a pace faster than the demand by human consumers and the development rates of national economies of states (USA Department of Energy, 1997:2).

Environmental measures taken by countries to protect their environments are increasing. The increased awareness of climate change has thus far played an important role. The global climate system is under severe stress. There is evidence of rising sea levels and extreme climate change conditions. Over the last 50 years, there have been a number of weather-related natural disasters all over the world (Pachauri, 2010:3-5). The question now is, can human beings reverse the effects of climate change? If so, how? Finding new types of clean energy may be a good start.

2.4 THE DEVELOPMENT AND GLOBAL IMPORTANCE OF ENERGY SOURCES

Energy has transformed a lot over the years, not only in performing tasks but also in how these tasks are now performed. From wind to power turbines, to cars that use petrol that is pumped through some pipes into an engine to make a car move. The way tasks are performed is changing because humans are constantly looking for ways to make everyday tasks, such as driving, cooking and even working (in an office or working the land) faster and easier. A growing population requires more energy. Technologists are of the view that the exponential growth in demand and technological innovation in the energy sector over the past century, is similar to the innovation and consumer demand for the modern mobile phone (Anon (b), 2015). Energy as a primitive form of consumption (using the sun and making fire) has technologically evolved to the point where the average consumer does not bother to contemplate the process behind switching on a light switch. This is the same process that has taken place over many years to develop energy in response to an ever-increasing demand. Renewable energy is energy that can either be recycled or that the earth can produce infinite amounts of in the form of, for example, wind, or solar, or hydropower (Shinn, 2018).

There have also been significant technological innovations in the energy sector; this can be seen all over the world in places with hydropower, solar or wind farms. What makes these innovations significant is the sheer magnitude of the farms. There have been similar developments in the field of non-renewable energy resources – a form of energy which cannot be recycled or be reproduced before it becomes depleted. Fossil fuels are a group of energy sources that have been formed over millions of years by intense heat, ancient organisms and plants (Kanniah, 2019). A fossil fuel, such as coal and its power, cannot be re-used. The prime problem with non-renewable resources is that, because of the high demand, resources are being used at alarmingly rapid rates. Fossil fuel

consumption is harmful to the earth's ecosystem and the residue of fossil fuel production profoundly affect the way the earth repairs itself (UCSUSA, 2016).

2.4.1 Contemporary forms of mass consumption and pollution

So, with the finite nature of fossil fuels in mind, the world's governments and their respective energy sectors are constantly exploring ways to reduce mass consumption and pollution. Pollution, in this sense, relates to the oil spills that take place in the ocean when huge tankers explode or run ashore and cause the ships' oil to leak. Not all the oil that enters the ocean is from tankers though. There are instances where oil spills occur from drains, dumping and even shipping on the oceans of the world. The biggest problem with oil spills from tankers is that the oil spillage results in a lot of oil being spilled all in one place. These spills can be very dangerous for all wildlife sea life, like birds and fish. When a spill takes place in water, the oil cannot dissolve, so it then becomes a thick type of sludge which gets caught in the feathers of birds, blocks light for sea plants and suffocates fish (Anon, 2019).

Other forms of pollution that governments are trying to decrease range from air pollution to soil pollution. Air pollution from factories that manufacture many products from food to metal cause a lot of harm. There are, in fact, a number of air pollutants. In nature, even pollen and mould can be one type of pollution. These can be harmful to humans. This is less likely to appear on any government's agenda as it is natural and not really caused by human activity. A big debate at the moment, is greenhouse gases, which also falls into the air pollution list. As the greenhouse effect increases, so does the amount of CO_2 in the air, meaning that the air which we breathe is becoming more polluted with CO_2. Hazardous pollutants, such as chemicals, are often regulated by the government as to how much may be present in the air at any given stage. Some of these pollutants are benzene, lead and mercury. These substances are often emitted at the time of mining and burning coal. Probably the most commonly known is smog. This is what happens when fossil fuels combust and emissions are released; these emissions react with sunlight (Mackenzie, 2016).

Soil pollution from factories that release harmful chemicals into the soil ultimately becomes a two-fold problem by contaminating not only the soil, but also surface and groundwater resources. Urban areas can also have soil pollution as this can occur through the usage of petroleum products, asbestos and pesticides, to name a few. These

often happen because of human activity, such as industrial and manufacturing. Humans can be affected by breathing in dust. Some volatile pollutants can even be absorbed through the skin and by people ingesting them via unwashed food (Anon (g), 2020).

2.5 BENEFITS OF RENEWABLE ENERGY TOWARDS ACHIEVING THE OBJECTIVE OF SUSTAINABLE DEVELOPMENT

Renewable energy is less expensive than non-renewable energy over a longer period of time. As mentioned earlier, it has the ability to renew itself, without destroying the planet, and therefore can be considered to be sustainable (EPA, 2014). Governments, environmentalists and scientists argue there are benefits to both the environment and economy when choosing to use renewable energy. These would typically be:

- Energy supplies can be diversified and the dependence on imported fuels is reduced;
- Development and jobs in installation and manufacturing will be created, most of these projects are located far from cities, and other benefits will be increased from the use of local services and tourism;
- Governments can generate energy that has no greenhouse emissions, producing little or no waste, having minimal impacts on the environment;
- Facilities for this kind of energy generally requires less maintenance. This is due to fuel being natural and readily available, reducing the cost of operations (Matthew & Hammill, 2009:1117-1119).

The main premise of renewable energy is that it has little or no impact on the environment, this means that, as humans, there is development and energy produced while not damaging the earth. Making human beings' carbon footprint a lot lighter and still making sure that sustainable development is possible in the ever growing and developing world.

2.6 DISADVANTAGES OF RENEWABLE ENERGY

As with most energy sources or even political theories, there are advantages that allow humans to benefit, but due to other external factors, such as unreliable weather or unreliable human reaction, there are disadvantages too. Stopping the expansive use of renewable energy is regulatory, because it is mostly state controlled. This means that price competitiveness is a very big problem. Other problems may include:

- Bad utility rate structures are a hindrance to the deployment of renewable energy, unless this can be monitored carefully, rate structures can increase the cost of renewables;
- Connecting the renewable systems: these systems are difficult to connect to a city's electricity grid. There are no connection rules or procedures and technical requirements for connecting these systems. This is what happens when people talk about living "off-grid";
- The renewable energy technology is still subjected to the already in place permits of major industrial facilities. Renewable energy will face some permit hurdles until officials are well aware of the environmental effects of renewable energy, till then they will be subject to laws that do not fit the renewable industry properly (EPA, 2015 (b);
- Due to the fact that many of the resources that produce renewable energy are natural and sometimes unpredictable, it may be difficult to have a reliable supply all the time. If the weather does not have the perfect conditions all the time, it may cause the capacity of the energy to fall. This may double as an advantage too, as this may teach humans to reduce the amount of energy used;
- The only way to generate enough energy using renewable energy to power as much as coal power plants do now, means that more facilities will need to be set up as the demand for electricity is constantly growing (or reduce consumption);
- The immediate capital cost to set up a country with renewable energy is great. The initial money put into programmes like this needs to be sufficient, as there are upfront investments required for such plants, including planning, maintenance and implementation. This means too that the country needs the proper expertise to make sure that all this is not a waste;
- To produce more renewable energy, more farms will be set up so that solar panels and wind farms can be used to produce the energy (Anon (b), 2015).

From what has just been discussed, it is clear that not everything is as straight-forward, especially for countries who may not be financially able to set up renewable energy in the immediate future. Energy is a widely-debated topic and will be debated for many more years to come. It will take some balancing from governments to ensure that their citizens have adequate access to the energy they need in order to survive, ensure that the energy is beneficial for them, but also that the choice in energy is not detrimental to the environment.

2.7 THE ORIGINS AND PRACTICE OF HYDRAULIC FRACTURING AS A SOURCE OF ENERGY

Still on the topic of clean energy, one has to take a look at other methods that still come from the earth. Natural gas, which is extracted from the earth's layers, can be seen as a non-renewable source. Whilst natural gas is renewable (the earth can produce more), the problem is that this source relies on the ability of the earth to re-create it. This means that if the gas supply in a certain area is deemed to last 500 years before it runs out, and the earth is not given the chance to reproduce, it then in turn becomes somewhat of a non-renewable source. This section will look at the method of hydraulic fracturing as a way to mine gas used for energy. It will look at the actual process of the mining technique and how it may benefit or disadvantage the environment in the long run.

This process of mining is not a new one though; according to FracFocus (2014). Hydraulic fracturing has had a significant impact on American energy history, as it has had the ability to increase the production of oil and natural gases. The USA has been the main focus for pressure groups against the practice of fracking. This method has caused increases in security, economic growth and job availability.

2.8 THE PROCESS OF HYDRAULIC FRACTURING

Hydraulic fracturing is a method (apart from the conventional mining methods of blowing up rocks in the mine shafts) of mining that can obtain shale gases. Fracking is often thought to be the drilling process involved in mining, but this is not the fracking process as it only takes place once the mine shaft is drilled. According to King (2014 (a)) it is the process that increases the flow of oil or gas from wells. It is accomplished by pumping liquids (fracturing fluid – made up of 90% water, 10% other minerals) into a well (into shale stone) which causes high amounts of pressure that fracture the rock. From these fractures, oil and gases can be collected.

First, one needs to fully grasp the idea of hydraulic fracturing and the implications it might pose for the water sources and other environmental problems; one needs to compare the process to conventional mining and what is involved in each. The difference between the methods will help one get a clearer understanding whether this method is only right for certain areas, maybe for no areas or if it can be used all over the world.

There are various forms of underground mining; they include drift, slope and shaft mining; but the actual methods include longwall, room and pillar mining. Drift mines bore holes horizontally through the side of the hill to extract the coal; slope mines on the other hand sometimes start at the bottom of a valley, the tunnel slopes downward to where the coal will be mined. Shaft mines (more common mines, especially found in South Africa) are of the deepest dug mines; these are vertical wells with an elevator that runs from the surface down to the coal (Anon (a); 2012). The resource is then mined from horizontal and sloped tunnels.

Room and pillar mining are the most common type of coal mining; the coal is mined by a "continuous" miner. The machine cuts a network of small 'rooms' into the coal seams. When the rooms are cut, the continuous miner loads the coal onto a shuttle or ram car at the same time; this coal then gets placed on a conveyor belt that sends it up to the surface. As this process takes place, there are 'pillars' made from coal that is left behind to support the roof of the shaft. This method of mining though results in up to 60% recovery of coal and up to 40% of the coal being left behind in the shaft as pillars; there are normally bolts placed eventually to avoid any ceilings from collapsing. But only under very special instances are the pillars of coal removed towards the end of the entire mining process; this process is called "retreat mining", because of the collapses that can occur from the removal, the pillars are removed in the opposite direction to which they were originally put in place (Anon (a) 2012).

Longwall mining is when mechanised shearers are used to cut and remove all coal at the face of mine; once the coal is removed, it is moved to a conveyor belt (made of chain) and moved to a second level, then to the surface. Here, temporary hydraulic powered supports are put into place to support the roof of the mine; this method has proven to be more useful than room and pillar mining with a higher recovery rate of coal bordering at 75%. But the equipment is more expensive and can become obsolete as it cannot be used in all geological places (Anon (a); 2012). Only the main tunnels are bolted in this method and this allows for most of the panels to collapse after the mining process is complete. "Conventional" mining makes use of explosives and a number of other machines to help extract the coal.

Hydraulic fracturing as explained above, uses old mine wells that have been used to mine coal or other minerals, but are no longer available to mine in these shafts, it is used to extract the natural gases trapped inside the rock formations. The process involves the

use of a mixture of water and other fluids that, when pressurised inside the rock, will cause small fractures releasing all the gas. Once the pressure is turned off, these fractures close and force the fluid back up to the surface with all the gases trapped in the liquid, needing to be extracted from the fluid. Due to the greenhouse effect and amount of carbon dioxide being released into the earth's atmosphere and the damage it has caused, this way of mining natural gases (that are less harmful to the atmosphere) has become a new favourite. But the use of millions of litres of water (which already is a scarce and much needed commodity) raises a lot of concern for the planet, the natural water wells in and around these mining sites and other environmental concerns such as earthquakes and damaging of the earth's core.

To understand a little more, visual representations of the different mining methods have been included in Figure 2.1 and Figure 2.2.

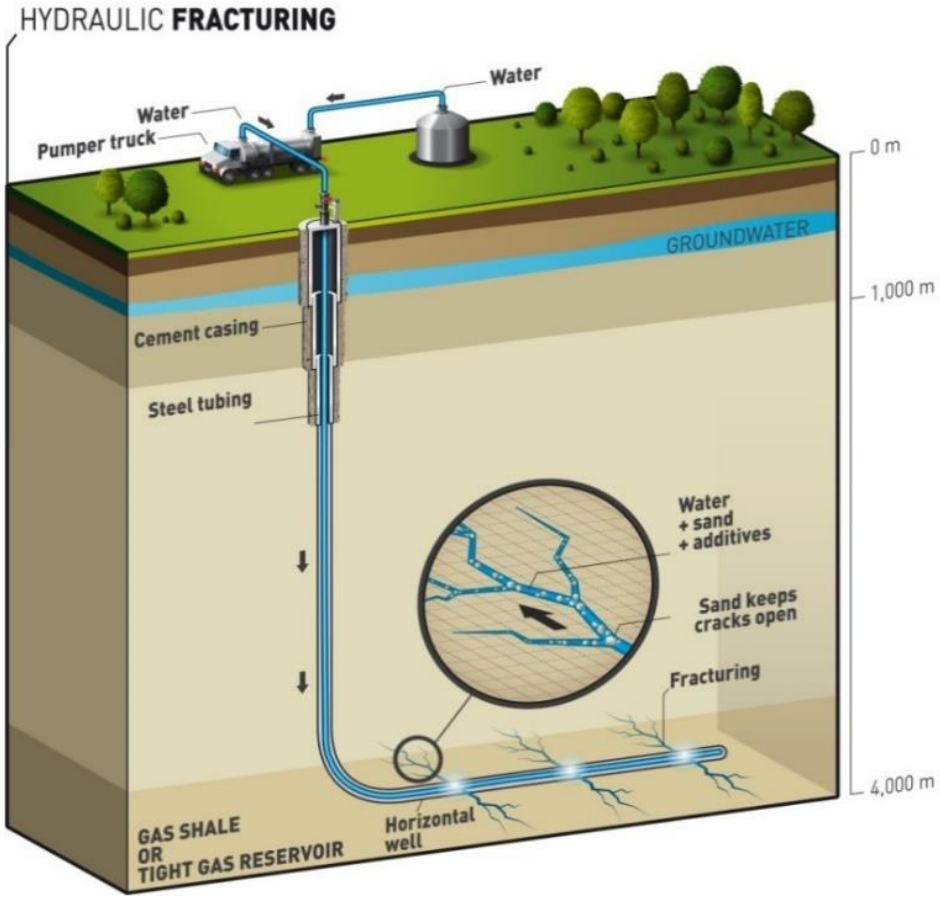


Figure 2.1 Hydraulic fracturing (Severine, 2018)

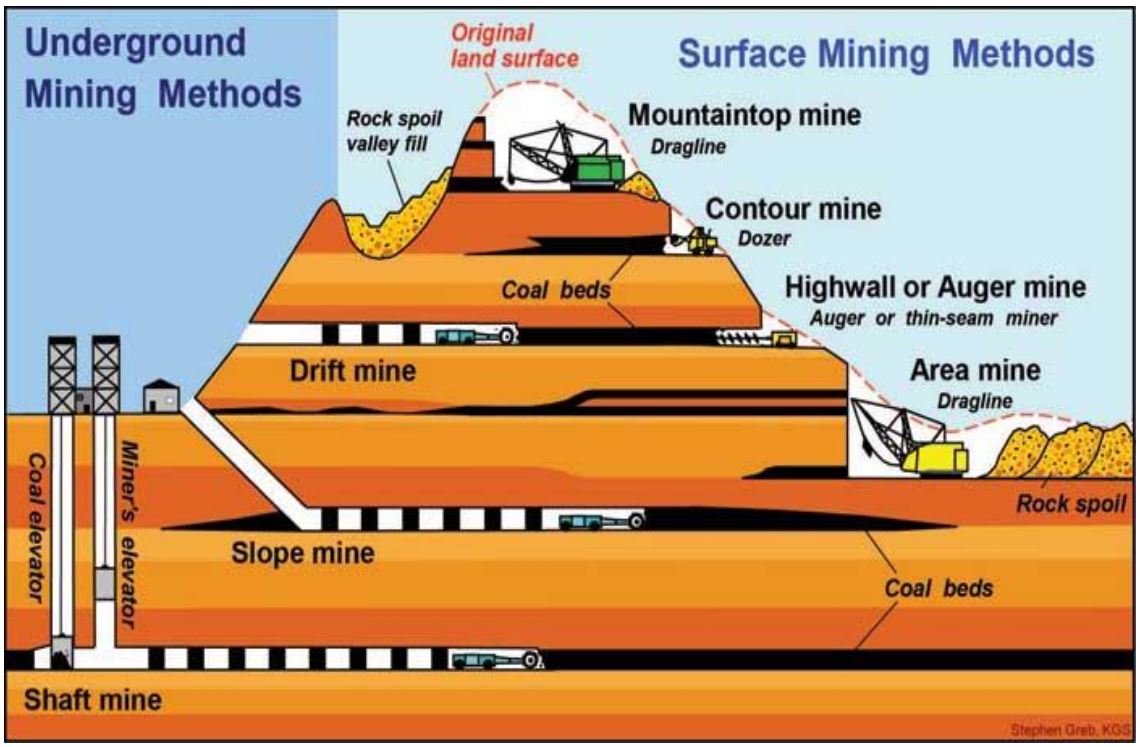


Figure 2.2 Conventional mining and its different processes at different levels that can take place (Anon (d), 2020)

2.9 POTENTIAL DETRIMENTAL ENVIRONMENTAL EFFECTS OF HYDRAULIC FRACTURING

From an environmental perspective, hydraulic fracturing can cause damage like the contamination of the water used in the process and around the wells. These operations can result in a number of potential impacts to the environment, including to the water supply and air.

2.9.1 Pollution of surface and ground water

Stress on surface water and groundwater supplies from the withdrawal of large volumes of water used in drilling and hydraulic fracturing; contamination of underground sources of drinking water and surface waters resulting from spills are all concerns. Although there are procedures and regulations in place about where to drill and how far the fractures may go, there are concerns about the fractures extending right through into drinking water supplies. One concern is based on the structure of the casing of the well. If this fails, it could allow the fracking fluids (water mixed with a number of oils, and other minerals that form this fluid) to get through the rock and again into the rock units used for drinking water. And there is the problem of accidental spills of any fluids used in the process that might

just seep into the ground and contaminate any surface water (King; 2014 (a)). The use of water in hydraulic fracturing is not only a problem because it causes more strain on an already scarce natural resource, but also increases the amount of contaminated water that goes to waste. Hydraulic fracturing is being linked to polluted drinking water in the USA as well as the release of methane which is a dangerous pollutant that can cause climate change.

2.9.2 The detrimental effect of air pollution

Air pollution is also a concern, resulting from the release of volatile organic compounds, hazardous air pollutants, and greenhouse gases. Because natural gas development is increasing rapidly in many regions, prudent steps to reduce these impacts are essential now, even as further research to understand potential risks continues (Environmental Protection Agency; 2014). The Natural Resources Defence Council (Mackenzie, 2016) reports there are studies that show dangerous levels of air pollution near these sites. They have caused smog in areas that are worse than even Los Angeles. Oil and gas production have even been linked to the numbers of increasing cancer and birth defects in some of the areas neighbouring these sites. There is also an increase in seismic activity. Looking at a broader aspect of hydraulic fracturing effects, as mentioned above, it becomes evident that water pollution is not the only environmental concern at this point. Air contaminants are released during the drilling procedures, some of these pollutants include benzene, formaldehyde and carbon monoxide – chemicals that are carcinogenic and even lead to organ damage and other health conditions. The fissures in the rocks can create ways for gases, radioactive materials and chemicals to leak through and pollute millions of gallons of water. The United States Geological Survey (USGS) and Environmental Protection Agency (EPA) have confirmed cases of contaminated groundwater in Pavilion, Wyoming Folger (Folger, *et al*, 2012:1-4).

2.9.3 Soil pollution and man-made earthquakes

Then there is the oil spill problem that can lead to soil contamination. There are reports that the amount of chemically tainted soil has increased almost 5100 percent over the last ten years. And finally, the last concern is the seismic activity that can be increased due to drilling into the earth's core. These earthquakes are often referred to as induced seismic events, they are caused by injecting fracturing wastewater deep underground.

These earthquakes are often small, with the largest measuring 5.2, but with the wells being filled with toxic wastewater does not ease any fears (Hoffman, 2014).

These concerns may not be as widespread now as they may become in the future once more cases start surfacing. One thing though, is that there are many aspects to take into consideration when considering whether to go ahead with the hydraulic fracturing method of finding more energy. One also has to consider of the long-term effects: Time may not only present more countries mining this way, but also it may present more problems to the environment. The environment will be the first to suffer in the long term, this can be threatening life as humans know it now. With more illnesses, more birth defects, causing life to become more expensive and damaging the economy, humans may need to find a new source of energy.

2.10 CONCLUSION

Looking at the information gathered, one can see that energy plays a big role in the survival of humans, dating back to thousands of years, energy became a very important resource. As with humans and their evolvement, the way energy has been harnessed has also evolved and been adapted to modern day society and its needs. Hydraulic fracturing may be the way of the future for many governments, with South Africa joining in on the race for energy stability, while also finding sustainable sources. With all factors in mind, there is still the question on how this may impact the environmental sector which many governments have started taking note of. Environmentalism has not only become a theory some people talk about or believe in, but it has become a concept which governments need to be aware of and include when they go about planning and developing their countries. Hence governments around the world, like the USA and South Africa, are taking environmentalism into account and need to consider very carefully when thinking about implementing hydraulic fracturing. Even with rules and regulations in place, they may not be enough to save the water sources or slow down any seismic events. These may make life difficult. With more earthquakes, or less water to drink and allow life to thrive on the planet, making a living and day-to-day life may become more burdened. This section shows that there is not only one environmental sphere to be worried about, water, but there are more issues that may cause more damaging effects to the planet and ultimately to human beings.

CHAPTER 3

THE SOUTH AFRICAN GOVERNMENT'S CURRENT AND FUTURE PLANS AND POLICIES FOR HYDRAULIC FRACTURING

3.1 INTRODUCTION

Hydraulic fracturing is not a new concept in South Africa or internationally. The birth of fracking began in the 1860s, and modern-day hydraulic fracturing commenced in the 1940s with the exploration for shale gas in the United States of America (Lallanilla, 2018).[1]

In the previous chapter the study explored the need and importance of energy as well as the status of hydraulic fracturing. It highlighted the different types of energy that could be used and how this energy exploration may have an impact not only on human life, but also on the environment. In Chapter 2 the relationship between sustainable development and climate change were also explored, a narrative that is receiving global attention. The creation of a foundation for clean and renewable energy is at the top of government development goals worldwide, as emphasized by The United Nations Sustainable Development Goal 7 on energy: to ensure access to affordable, reliable, sustainable and modern energy for all. The UN has 17 Sustainable Development Goals in place to make a global Impact. Of these goals, Goal 7 deals with the affordability of energy as well as cleaner energy. The importance of this goal is not only to ensure more accessible and affordable energy for poorer nations but importantly to ensure that the energy produced throughout the world is cleaner (UN, 2020:1-2).

"For many decades, fossil fuels such as coal, oil or gas have been major sources of electricity production, but burning carbon fuels produces large amounts of greenhouse gases which cause climate change and have harmful impacts on people's well-being and the environment."

[1] Hydraulic fracturing takes place in 20 US states, with a total of 276 000 wells to date. According to the US Department of Energy (DoE), 13 000 new wells are drilled each year.

In 2015, the UN Member States released a new development framework to replace the Millennium Development Goals that have expired. The *Transformation of Our World: The 2030 Agenda for Sustainable Development* covers a broad and ambitious agenda that aims at achieving sustainable development in the economic, social and environmental fields through the achievement of seventeen Sustainable Development Goals (SDGs) and one hundred and sixty-nine targets by the year 2030 (UNODC, 2020).

Access to affordable, reliable and sustainable energy is crucial to achieving many of the Sustainable Development Goals – from poverty eradication via advancements in health, education, water supply and industrialization to mitigating climate change. Energy access, however, varies widely across countries and the current rate of progress falls short of what will be required to achieve the Goal. Redoubled efforts will be needed, particularly for countries with large energy access deficits and high energy consumption as highlighted by Sheila Oparaocha, co-facilitator of the SDG 7 Technical Advisory Group: "We have been witnessing tremendous progress in the adoption of renewable technologies, along with rapid cost declines and strategic shifts in policies that are transforming energy systems in many parts of the world. Though we have strong momentum, we must continue to mobilize greater political will and cooperation, as well as higher levels of public and private investments in a sustainable energy future" (Oparaocha, 2019).

Flowing from the background provided in Chapter 2, this chapter will explore the framework for the South African government's potential plans to incorporate hydraulic fracturing in the energy mix, thereby boosting the country's clean energy supply. Currently the energy sector in South Africa finds itself under extreme pressure due to increasing demand and diminishing supply. South Africa is also under pressure, being part of the worldwide fight against climate change. Hydraulic fracturing is one of the options that the government is potentially exploring as a source of clean energy. The Department of Minerals, with support of a former South African president, Jacob Zuma, announced that by the end of 2015 they would hand out exploration licences to various applicants, such as Shell SA, Falcon Oil & Gas Challenger of Australia and others. Since this new proposed way of gas exploration was tabled for discussion, there have been ongoing debates regarding the potential threat to one of the country's most prized and unique ecosystems that cover about fifteen percent of South Africa's surface area. The question: Is the Karoo in danger? remains a political and environmental along with the economic implications of allowing shale gas exploration in one of the most pristine

ecological environments in South Africa.

Therefore, Chapter 3 will firstly explore the origin and nature of the government's public policy on energy consumption post-1994. Secondly, the focus will shift to the events that have stimulated the onset of proposals for hydraulic fracturing since 2008. This section of the study will also explore investment possibilities into the energy sector, the increased demand of energy and how this sector needs to become better diversified. Thirdly, an investigation will be conducted into the detrimental effects that corruption in the energy sector, underperformance and load shedding have on social and economic development in South Africa. In the fourth section contemporary governmental perspectives are briefly covered and in section five the implementation of hydraulic fracturing as an energy source will be addressed, with specific reference to the legislative framework it adheres to. The chapter ends off with the government's plans, a critical analysis of the advantages of hydraulic fracturing and the potential detrimental effects it could have on the Karoo's ecosystems and communities.

3.2 THE ORIGIN AND NATURE OF THE SOUTH AFRICAN GOVERNMENT'S POLICY PERSPECTIVE ON THE USE OF ENERGY POST-1994

Currently, hydraulic fracturing in South Africa is a controversial topic. Given the growing demand for energy in South Africa and our ever-shrinking fossil fuel resources, it seems likely that fracking as an alternative energy source will remain on the economic, political and environmental agendas for the foreseeable future as one of the potential resources to address poverty and create job opportunities. However, results from scientific studies across the country demonstrate that clear drawbacks to the fracking process cannot be ignored for the short- and long-term health and safety of the people living around the frack sites, as mentioned in Chapter 2. Further research is required to better understand the problem at hand, so that the impact of fracking on the environment and local communities can be fully addressed and a balance can be found between the potential environmental damage predicted and the economic gains that fracking presents.

The concept of hydraulic fracturing started pre-1994, when Soekor[3] started exploration during the Apartheid era. In the 1960s when Soekor began to search for oil and natural gas in South Africa the possible exploration area included the Karoo.

The exploration for natural gas and oil took place between 1965 and 1975, when Soekor found gas in the shale of the Ecca Group at least 2500-4000m below ground. The

company drilled about 24 wells which led to the discovery of carbon-rich zones, mainly in the Collingham (southern part of Karoo basin that overlies the Whitehill formation) and the Whitehill 216 (lies over a part of the Western Cape, parts of Namibia, to the Northern Cape, and reaching out as far as the Eastern Cape) formations (Fakier, 2015:37). Figure 3.1 demonstrates where pockets of gas have been identified:

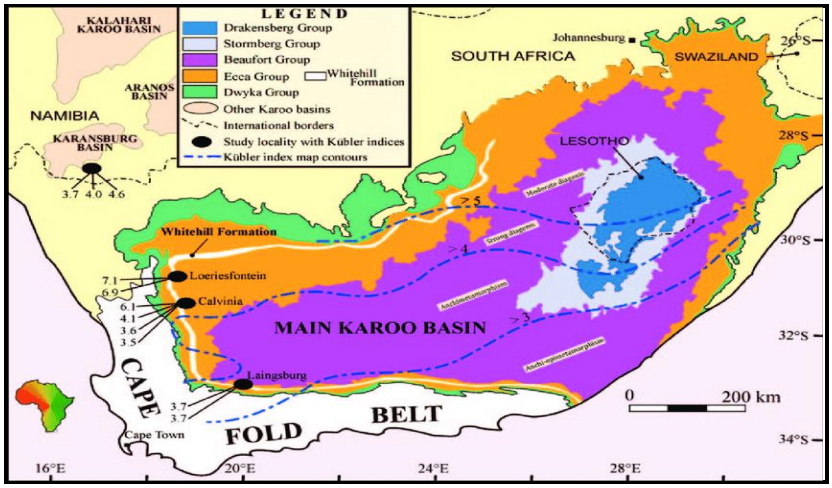
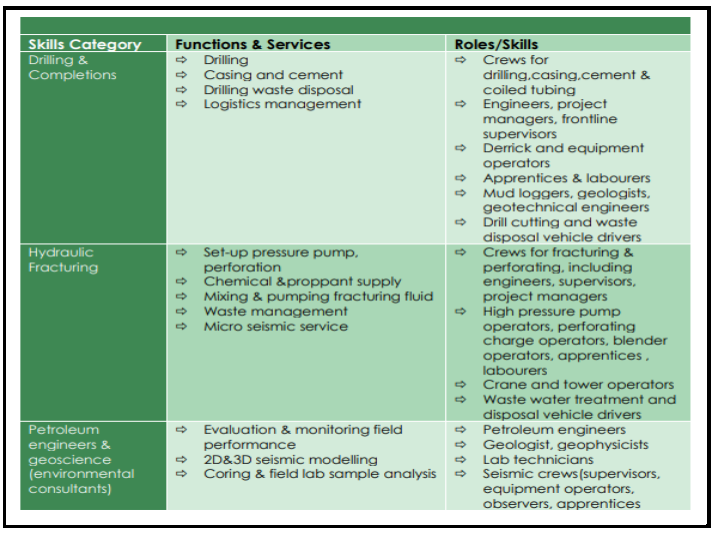


Figure 3.1 A map of the gas pockets in South Africa (Bordy & Smithard, 2015)

South Africa's ability to produce energy through various sources not only affects major economic factors, but has a direct impact on the production of electricity and the access to it. The diversification of energy sources is needed for a stable energy sector, which in turn supports a stable economy. The World Wildlife Foundation's research and preliminary work have found that, in relation to fracturing and employment, there is a peak in the amount of labour activity that may be available from shale-gas development until the actual completion or decline during the production phase. Although local labour skills may be available, there is a concern as to how industrialized the fracturing process really is and that the necessary expertise will need to be sourced from other countries around the world. Ernst and Young (2014) compiled this table (Table 3.1) that sets out the direct skills and services that will be required for the exploration and development of shale gas.

Table 3.1 Direct and supporting skills required for the development of shale gas



Skills Category	Functions & Services	Roles/Skills
Drilling & Completions	⇨ Drilling ⇨ Casing and cement ⇨ Drilling waste disposal ⇨ Logistics management	⇨ Crews for drilling,casing,cement & coiled tubing ⇨ Engineers, project managers, frontline supervisors ⇨ Derrick and equipment operators ⇨ Apprentices & labourers ⇨ Mud loggers, geologists, geotechnical engineers ⇨ Drill cutting and waste disposal vehicle drivers
Hydraulic Fracturing	⇨ Set-up pressure pump, perforation ⇨ Chemical &proppant supply ⇨ Mixing & pumping fracturing fluid ⇨ Waste management ⇨ Micro seismic service	⇨ Crews for fracturing & perforating, including engineers, supervisors, project managers ⇨ High pressure pump operators, perforating charge operators, blender operators, apprentices , labourers ⇨ Crane and tower operators ⇨ Waste water treatment and disposal vehicle drivers
Petroleum engineers & geoscience (environmental consultants)	⇨ Evaluation & monitoring field performance ⇨ 2D&3D seismic modelling ⇨ Coring & field lab sample analysis	⇨ Petroleum engineers ⇨ Geologist, geophysicists ⇨ Lab technicians ⇨ Seismic crews(supervisors, equipment operators, observers, apprentices

Source: Ernst and Young LLP, 2014

Due to global climate change, the pressure on all governments to develop clean, renewable energy resources is mounting. Governments are required to take steps to reduce greenhouse emissions and come up with ways to ensure the world is less carbon constrained (Pegels, 2010:4945). The South African government is under just as much pressure to reduce their carbon footprint. To summarize, while fracking is considered a greener, more environmentally sustainable energy source, there are costs involved with avoiding, or limiting the emission of greenhouse gasses into the atmosphere.

In the following section various factors and events contributing to the South African government's policy on Hydraulic Fracturing are explored. These include a discussion around national and international investment in the energy sector, the increasing demand for energy, and continued diversification of the energy sector from 2007 until now, as well as underperformance and allegations of corruption against Eskom post-1994.

3.3 EVENTS THAT STIMULATED THE SOUTH AFRICAN GOVERNMENT'S POLICY ON HYDRAULIC FRACTURING SINCE 2008

In this section focus shifts to the events that have stimulated the onset of proposals for hydraulic fracturing since 2008. Here the aim is to explore investment possibilities in the energy sector, the increased demand of energy and how this sector needs to become better diversified.

Besides the environmental impact, the call to diversify the energy sector not only means cleaner resources, but endeavours to tackle the severe problems that Eskom has in production capacity. Since 2008 Eskom has struggled to supply South African homes

with enough power. This year particularly (2020), the government once again intervened to help relieve pressure on Eskom by implementing load shedding. By looking at the correlation between sales and consumption, Eskom may be struggling to keep lights on because electricity sales have also dropped in recent years. Many individuals and companies have reverted to solar power to generate electricity in their homes and private businesses, for example, Deloitte and Touche. This organisation has refocused its capabilities on creating “green” buildings, built from eco-friendly materials that run on green technology, like energy efficient lighting (Alsegaf, 2019:2), a trend already popular in Europe. Financial investment into the energy sector, however, remains vital for the sector to function at maximum capacity. This variable is discussed below.

3.3.1 National and international underinvestment in the energy sector

If hydraulic fracturing should proceed in South Africa it would require a significant amount of capital investment (national and international). It will also require a sizeable budget to ensure the proper maintenance of the infrastructure. The EIA states that the turning of recoverable resources into commercially viable production would depend on the geologic structure’s variation. They warn that small local variations can cause any gas extraction to be uneconomical and not viable at all. The recoverable economic factors will depend on the cost of the extraction, as well as the price the gas can be sold for. A shale gas well in South Africa can cost twice as much to develop than in the United States of America (Deloitte, 2020). As mentioned before, it is impossible to predict the potential value that hydraulic fracturing could have for the South African economy and how much natural resources can be extracted to make economic sense. The Econometrix consultancy estimates that if only 5% of the resources in South Africa are economically recoverable, this could add more than R80 billion or about 3,3% a year to the GDP for twenty-five years. This is significant as it is nearly double the total contribution of coal mining to the economy. Revenue for the government would increase by approximately R35 billion per annum (Deloitte, 2020). This could have a significantly great effect on the South African economy.

3.3.2 The increasing demand for energy up to 2030

As of January 2019 the energy grid remains under pressure to ensure that the country’s full energy needs are met. The South African government is working on plans to implement a range of energy solutions, such as coal, hydro, wind, solar, gas and even

nuclear energy. The demand for energy is rising faster than Eskom can produce and distribute it. There was an increase in demand after 1994, when there was a rapid increase of industrialisation. Another reason Eskom is struggling to produce enough power is due to the lack of scheduled maintenance on the power stations (Pretorius, *et al*, 2015:256) causing constant breakdowns of power generating equipment. This resulted in the initiation of project Medupi[2] and Kusile which was launched in 2015 and 2019 respectively to contribute to the demand for power supply in the country. The project was a five-year plan to fund a new generation of power stations around the country. The project of mass electrification is targeted at taking power into rural areas and to deal with the increase in demand for electricity (Pretorius, *et al*, 2015:256-257). Figure 3.2 illustrates the current status of energy demand and supply in South Africa.

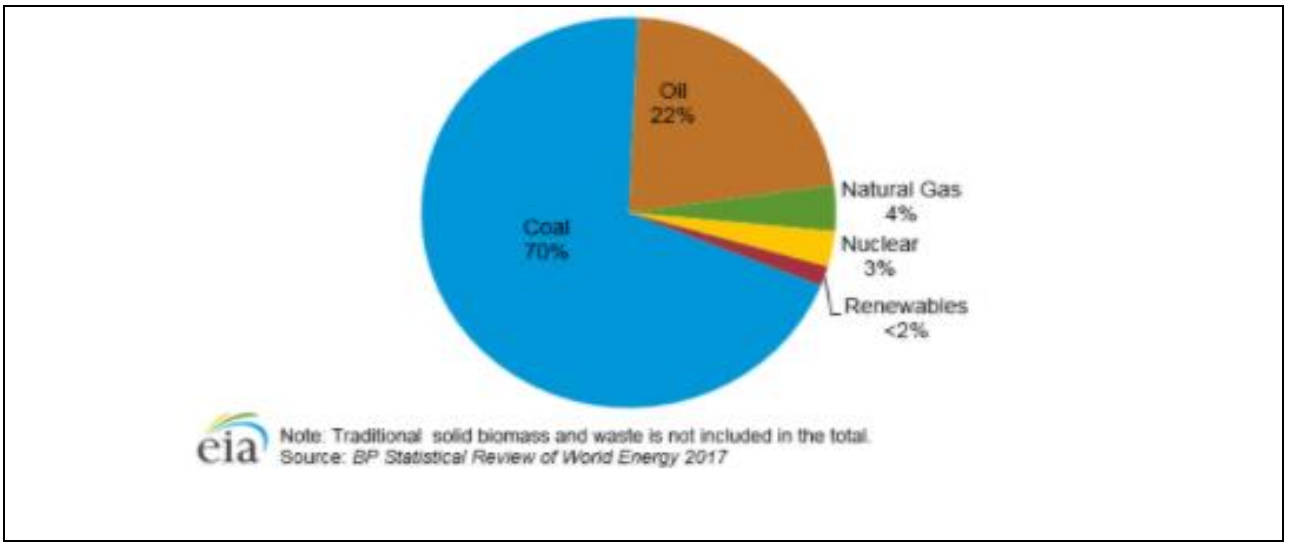


Figure 3.2 The consumption of energy in South Africa (CoalZoom, 2017)

The energy demand in South Africa will increase to at least double the current level by 2030 (Magubane, 2018). The power stations, Medupi and Kusile are already contributing to the grid to help alleviate the pressure experienced by the system. Medupi, developed in Lephalale Limpopo, has a total of six units altogether, each functioning as a power generator. From the first unit at Medupi commissioned in 2015, the plant has steadily increased the number of units coming online. As of October 2018, Eskom announced that five of the six units were operational. An announcement was made that the fifth unit was running months ahead of schedule, as the team at Eskom predicted that it would only be fully operational by June 2019. Eskom announced that they would be testing and optimising the unit so that it will feed the national grid whilst generating 794 MW of

[2] To help reduce the country's carbon footprint, Kusile and Medupi were developed to use dry cooling technology (Eskom (a), 2018:1).

electricity (Magubane, 2018). Figure 3.3 illustrates the energy demand since 2014 and the actual supply generated:

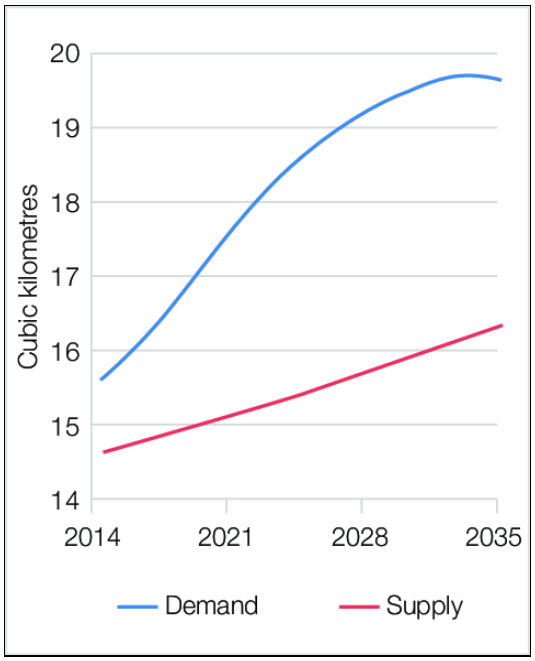


Figure 3.3 The demand of energy vs. the actual supply (Gan, *et al*, 2020)

The Kusile power station is situated in Delmas, Mpumalanga, and has a larger generating capacity than Medupi with an estimated output of 4 800MW of electricity once it is fully functional. Each of Kusile's units will have an output of 800MW, whereas Medupi's units each generate only 794MW. The Kusile plant went online in April 2019 when its third unit was synchronised to the grid. This is the third of six units in total at Kusile, and it will undergo testing in order to optimise the unit. The prediction is that once Kusile is fully operational, it will put out as much as 4 800MW of electricity from all six fully functional units (Pijoos, 2019). Eskom still has problems though, as the power company is technically insolvent. In February 2019 economists called for government to halt operations of both these power stations to ensure some maintenance on other already fully functional power stations could be carried out (Zulu, 2019). Jamin (in Zulu, 2019) suggests that Eskom needs to be restructured with new management. As a new cabinet of ministers were sworn in, in April 2019, under the new administration headed up by President Cyril Ramaphosa, new leadership was appointed at Eskom as of January 2020, with Andre De Ruyter appointed as the new Group Chief Executive of Eskom Holdings SOC Ltd (Eskom (a), 2020).

Most of the energy produced in South Africa is used by the mining and manufacturing sector, even though they contribute only 8% to the country's overall GDP (The

Department of Minerals and Energy, 2017:14). The sales of electricity and the GDP can have a direct effect on each other. As the GDP grows people are able to afford more electricity, increasing the demand for electricity and, of course, the consumption. The South African government's plans for energy expansion post-1994 includes the Gas Infrastructure Plan (The Department of Minerals and Energy, 2005), indicating that the natural gas demand has grown quite a bit since the 1970s. To catch up with the recent trends, and the call from the National Development Plan (NDP), South Africa has seen the demand for natural gas growing steadily, especially since embarking on projects with Mozambique. The first production and export of gas took place in 2004 (Gqada, 2013:8).

3.3.3 Continued diversification of the energy sector from 2007 until 2020

At the moment South Africa still relies on the production of coal for its energy, with coal contributing to around 77% of the total energy production. A very small amount of this is contributed to petrochemical and synthetic fuel and only a mere 28% is used for export purposes (Anon (b), 2012). This means that nuclear, natural gas and renewable energy play a smaller role. As of 2013 about 90% of the country's energy was coal generated (Anon (a), 2018). South Africa has the potential to be a primary producer of renewable sources of energy in Africa due to the amount of sunshine which creates the potential for solar power. Some areas of South Africa experience up to 2500 hours of sunshine per year. The Department of Energy has a pilot programme in place whereby some public-private institutions are using solar power to contribute to research in this area (Matthews, 2008:22).

The National Biofuels Industrial Strategy draft was approved in 2007 to introduce biofuel to the country's list of energy sources. The draft suggested a 2% penetration of biofuels into the current energy pool. Hydro power was available when South Africa imported it from Cahora Bassa,[3] in Mozambique. The Department of Energy is confident that they will continue with the import of hydro-electrical power, there are new aspects of importing hydro power from Zimbabwe, Zaire and Zambia which may be a reality soon too. According to Eskom (b) (2020) they have three types of hydroelectric power stations, one at Gariep and Vanderkloof reservoirs; Drakensberg and Palmiet have pumped storage schemes and run off the river power station, and a facility also exists at Colly Wobbles in

[3] Cahora Bassa hosts a hydropower station that has the largest potential to produce power in Africa. South Africa benefits from this power station as the country imports about 2,135mw power to run its own energy grid (IHA, 2020).

the Eastern Cape (Matthews, 2008:23).

The Eastern Cape currently has a pilot programme for hybrid systems, which includes two or more of the following sources: photovoltaic, storage batteries, wind and mini-hydro sources. This is based at the Hluleka nature reserve on the Wild Coast (Department of Energy, 2020). South Africa's biggest achievement to date when it comes to renewable sources and honing in on the potential of South Africa and its landscape, is harnessing wind power. Across South Africa there are five fully functional wind farms spanning from the provinces of the Northern Cape to the Eastern Cape and Western Cape. The two possibly most familiar farms are the ones in Jeffrey's Bay (Eastern Cape) and Klipheuwel, near Cape Town (Western Cape) (Cloete, 2014).

In 2014 the highest Greenhouse Gas (GHG) emitters were China, the United States, the European Union, with South Africa been named the 14th highest greenhouse gas (GHG) emitter due to its dependence on coal to produce energy. GHG is made up of different components such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinate gases. Greenhouse gas emissions are generally produced by different industries, such as electricity production, agriculture and other energy intensive industries (EPA, 2011). According to the NDP the management of greenhouse gases in conjunction with responsible mineral and energy production is possible:

> *Research suggests that it is possible to both reduce greenhouse gas emissions from electricity production and still grow the minerals and mineral processing sectors (National Development Plan, 2011:38).*

The Department of Economic Development stated in the First Quarter Economic Intelligence Report that the National Development Plan (NDP) has been calling for more attention to be given when it comes to ensuring a well-developed sector with regards to energy, to ensure that there is economic growth and development that is supported, and that social equity is achieved by means of the expanding of access to energy at prices which are affordable for all. This includes a sustainable environment by reducing the pollution and mitigating any climate change. This of course then calls for a more diverse energy sector with a great emphasis on renewable energy and gas resources. With regards to gas, the NDP called for more investigating to take place with gas as an alternative to coal as a source of energy (NPC, 2012). This diversification of energy needs to be done in a manner which sees both economic development and growth. Also, it has to be done in such a way that it is environmentally friendly.

3.4 THE DETRIMENTAL EFFECTS OF UNDERPERFORMANCE IN THE ENERGY SECTOR

Over the past decade, or more, energy production in South Africa have taken a turn for the worst, with major power breakdowns, both at production and supply levels. The most important aspects of this dilemma that the South African government finds itself in, are briefly discussed below

3.4.1 The social and economic effects of load shedding

The social and economic effects of load shedding have far reaching consequences across all walks of life and sectors of business. In the retail industry, for example, retailers must forecast their financial projections to now include load shedding costs. This has a knock-on effect on overheads, especially employee salaries and bottom-line profits (Goldberg, 2015:90-91). Losses occur not only due to the loss of work or production, but also due to loss of perishable goods such as meat and fresh produce, required to be stored at specific temperatures. Companies can reduce the negative impact of load shedding by supplementing their energy supply with fuel generators. These are however just short-term solutions, as the fuel cost of running a large enough generator may become extremely expensive (Goldberg, 2015:91-93).

Francois Stofberg (*in* Business Tech, 2019) said:

> *Using these assumptions, we find that the cost of load shedding has reduced GDP growth by roughly 0,30% in 2019. This translates to R8,5 billion of real, inflation-adjusted Rands.*

This is increasingly alarming as the South African economy suffers financial losses that directly impact disadvantaged communities. The socio-economic effects of load shedding can be catastrophic for all citizens of South Africa as jobs are lost due to load shedding. This in turn has a major effect on the livelihoods of everyday people (Smith, 2019). Smith reported that the Consumer Goods Council of South Africa tacitly pointed out that:

> *Because Eskom is central to the economic growth of South Africa, underpinned by further domestic and foreign investment, any further delays to resolve its structural, operational and financial problems will cause further harm to a fragile economy which has hardly grown in the past five years – Consumer Goods Council of South Africa in Smith (2019).*

The next section will explore the allegations of corruption at Eskom, as this also has some effect on load shedding.

3.4.2 Underperformance and allegations of corruption against Eskom post-1994

Within the diversification agenda the South African government has recently reaffirmed that the country's energy challenges urgently need to be addressed (Godinho & Hermanus, 2018:13-14). As one of the largest power companies in the world, Eskom has been severely affected by corruption within the parastatal. The Eskom Inquiry which commenced in October 2017 has since uncovered that the widespread corruption at top management level has cost the parastatal over 140 billion rand per annum. This has had a direct effect on the operations of the parastatal, resulting in underperformance at production level and a struggle to meet power demands. The worst type of corruption to affect Eskom was in the form of the over-priced contracts. Central to the corruption allegations were the contracts entered into to secure the acquisition of coal from the Gupta family's mines (Godinho & Hermanus, 2018:13-14). The Gupta family's alleged corrupt involvement with various state enterprises, amounting to State Capture, formed a major part of the Zondo Commission[4] investigations, and is currently ongoing.

The political interference of government has caused major problems within the Eskom parastatal. This interference has resulted in the company being poorly managed and displaying questionable work practices, in the procurement of investments and the pricing of Eskom's services. The failure of government to intervene and the levels of corruption that has occurred at Eskom over all these years, has raised doubts about the efficacy of the parastatal. The deterioration of the municipal distribution assets has caused alarm. With non-payment for electricity and lack of appropriate technical resources, Eskom has suffered greatly. There may be hope yet with the top management restructured and new CEO, Andre, at the helm (Kessides, 2020:6).

In the following section the study narrows its focus to government perspectives on the implementation of shale gas exploration in South Africa.

[4] The Zondo Commission of Inquiry was commissioned to investigate any and all allegations of state capture, fraud and corruption in the public sector (The Department of Energy (b), 2018).

3.5 CONTEMPORARY GOVERNMENTAL PERSPECTIVES TO IMPLEMENT HYDRAULIC FRACTURING IN SOUTH AFRICA

Proposals on shale gas exploration in South Africa is not new and although not fully explored, there was some interest in the late 1960s. The Karoo area which is rich in gas stretches over four hundred and eighty-five (485) trillion cubic feet, thus making it the fifth largest field in the world (Twine, *et a*l, 2012). Not only is the Karoo a potential hydraulic fracturing area, but there are other exploration areas that could stretch over six of the nine provinces in South Africa (see Figure 3.4). Since the initial proposed exploration decades ago, the interest to frack has surfaced once again, and from 2008 the South African government put the proposal to frack back on the energy agenda. Consequently, there have been no less than five applications for the exploration rights under consideration. Three of these were targeting only shale gas in the Karoo Basin, but the process was brought to a halt in 2011 due to moratoriums that were imposed on new applications by the Minister of Mineral Resources (Leiman, *et al*, 2012). These moratoriums were imposed to allow for further investigations regarding policy work to take place, to ensure that valid regulations were put in place at the time. There are still ongoing investigations regarding the potential damage to the Karoo environment as the Director-General of Mineral Resources in South Africa was commissioned in 2012 to form a task team that would investigate the impact of fracking at all social, legal and environmental levels. The task team is to present recommendations to alleviate concerns (The Department of Mineral Resources, 2014:9). This is still an ongoing process. Figure 3.4 shows the potential areas in South Africa where shale gas exploration can be implemented.

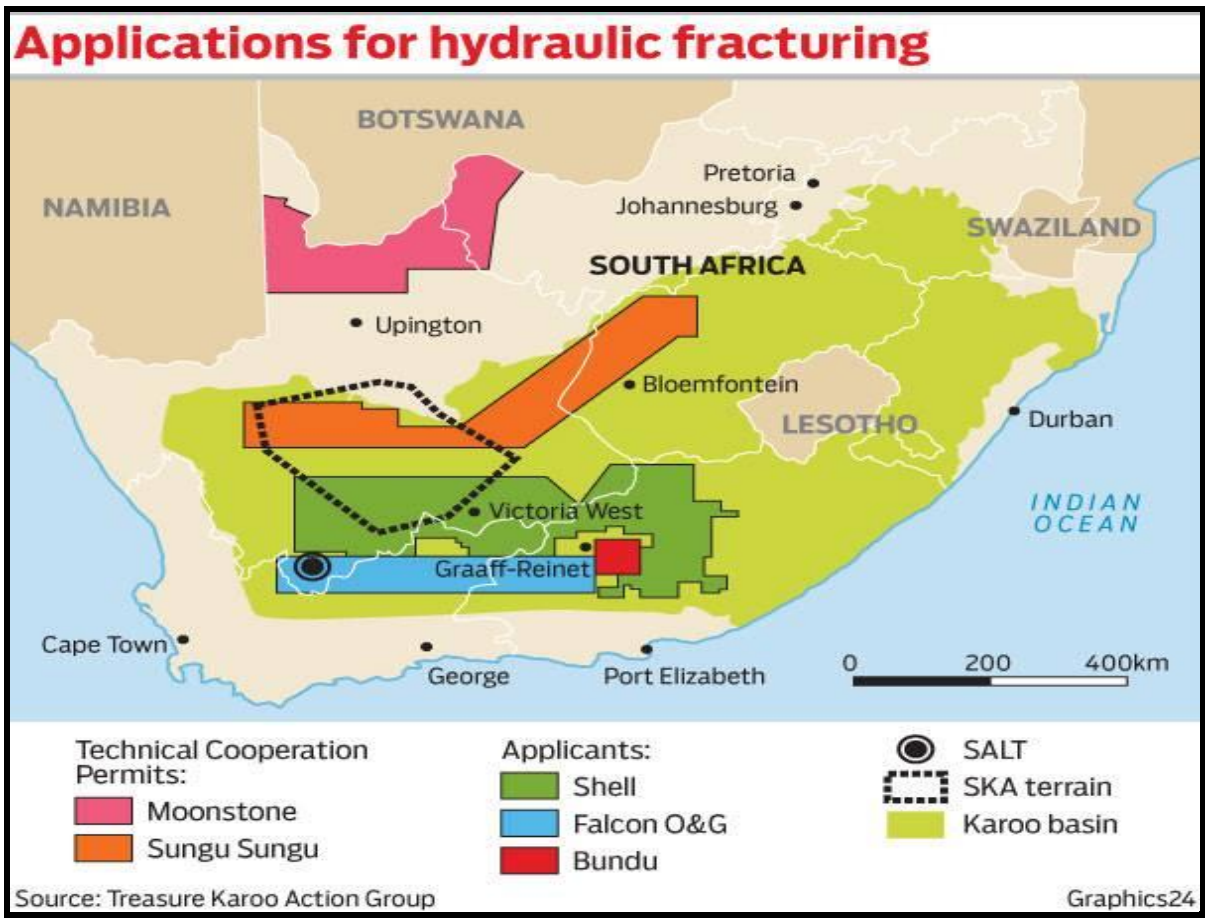


Figure 3.4 Areas for gas exploration (Du Toit, 2013)

According to the Integrated Resource Plan 2018, several concerns regarding hydraulic fracturing were raised with reference to the environment. Some of these concerns related to environmental issues and others referred to technological aspects such as new mining or energy production technology (South Africa, 2018:73). The South African government, by word of its Minister of Mineral Resources, in 2016 noted that the major advantage of fracking is the economic benefits:

> *We have taken a decision to diversify our energy basket in our pursuit to provide not only cost-competitive energy security, but also significantly reduce the carbon footprint and drive our industrialisation and beneficiation program to grow the economy inclusively in order to create a critical mass of employment, among others – Minister of Mineral Resources, Mosebenzi Zwane (2016).*

Taking all factors into consideration, the time frame of the moratorium needs to be addressed. An extended ban on the exploration of gas can hinder the understanding of the resource and its impact on the environment and the economy. The delay in exploration could affect current data collection and its relevance to the current

environmental and economic conditions within the potential fracking areas. In the long run this could delay the potential economic benefit to the communities of the Karoo as the gathering of relevant information may need to be updated first. The following section explores the legislative framework for how hydraulic fracturing can be implemented in South Africa.

3.6 LEGISLATIVE FRAMEWORK FOR THE IMPLEMENTATION OF HYDRAULIC FRACTURING IN SOUTH AFRICA

The South African government's investigation into the positive and negative effects of hydraulic fracturing on the environment and economy requires that certain legislation needs to be considered when making any policy decisions that affect the environment. These legal steps are guaranteed in the constitution as discussed in Section 24 as part of the protection of the rights, freedoms and safety aspects of the Bill of Rights (Chapter 2).

NEMA states that the country is committed to reducing its carbon emissions with 34% by 2020 and 42% by the year 2025 (Momoniat & Morden, 2013:5). The Development Bank of Southern Africa (a parastatal[5] solely owned by the government), Eskom (South Africa's parastatal energy provider) and the South African Treasury are working on renewable energy programmes that involve power producers who are independent to the state.

The mix of clean energy that is currently sold to the government is done so by independent power producers who have projects ranging from solar photovoltaic technology to concentrate solar thermal generators, hydro and wind energy (Anon (b), 2012). The amendments regarding new policies mentioned in the IRP 2018 are written with public comments taken into account. These comments call for a least-cost plan to initiate programs that mostly deal with renewable energy according to recommendations the Council for Scientific and Industrial Research (CSIR) has put forward. This adds to the push the government needs, to incorporate more renewable sources to produce electricity, and to reduce carbon emissions in the country. Legislative aspects include the Constitution with reference to the Bill of Rights, the National Water Act, National Environmental Management Act and pollution prevention legislation. These legal aspects

[5] An organization or industry, in some African countries, having political authority and serving the state indirectly (Anon (g), 2020).

are detailed in the following section.

3.6.1 The South African Constitution

When dealing with protecting the environment and any human rights, the Bill of Rights forms the holistic framework for legislation. The Bill is contained in Chapter 2 of the Constitution of the Republic of South Africa (The Constitution of the Republic of South Africa, 1996). In Section 24 of the Bill, it states that everyone has the right to:

a. An environment that is not harmful to their health or well-being; and
b. Have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that;

i. prevents pollution and ecological degradation;
ii. promote conservation; and
iii. secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

This section of the Constitution sets some basic standards for all South African environmental activities and which laws need to be adhered to. There are elements introduced which have direct relevance, namely that the extraction of shale gas using hydraulic fracturing may potentially contaminate and deplete water sources, therefore causing harm to human health and also causing damage to the environment. Section 27 of the Bill of Rights states that:

> *Everyone has the right to sufficient food and water, and that the state needs to ensure that legislative and other measures are taken to achieve the realisation of this specific (amongst others) right.*

Whilst both the Constitution and the Bill of Rights offer environmental and human umbrella protection, they do not explore industry specific attributes. In other words, it is not the objective of the Constitution to determine the merits of fracking, but simply to establish and guarantee certain human rights, to be achieved through the development of appropriate legislation. In paragraph 20 of the Director: Mineral Development, Gauteng Region and Sasol Mining (Pty) Ltd vs. Save the Vaal Environment and Others 1999 (2) SA 709 (SCA), the Supreme Court of Appeal stated:

> *Our Constitution, by including environmental rights as fundamental justiciable human rights, by necessary implication requires that environmental considerations be accorded appropriate recognition and respect in the administrative process in our country.*

Together with the change in our ideological climate must come a change in our legal and administrative approach to environmental concerns.

The protection of human rights and citizens' wellbeing is further established through the right of access to information that is required for the "exercise or protection of any rights" (Raviv, 2013:20-21). Viewed from a fracking context, this right to information, as guaranteed by Section 32 of the Bill of Rights, should provide an interested or potentially affected party with the right to be informed, amongst other things, of the water volumes. (Raviv, 2013:21). The Constitution therefore sets the foundation upon which laws are developed to promote human rights in South Africa, in social and ethical matters. The Constitution embodies the protective framework for the development of society at all levels, including the Bill of Rights and binding the executive, the legislature and the judiciary together.

3.6.2 The National Water Act 36 of 1998 (NWA)

The primary purpose of this Act is to "ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled" (NWA, 1998:44). The Act is built around water management as well as taking into consideration that humans have basic needs that must be met regarding access to water sources. According to the Act, if the fracking process were to go ahead, companies that hold licenses will need (as outlined in the NWA) to register with the Department of Water Affairs and Forestry. Certain information will need to be provided (as stated in the NWA, Chapter 4, Part 2) by companies: where they tend to source the water from, the activities of the company, as well as what the water will be used for (NWA, 1998:44). Furthermore, the companies may have to conduct any reviews required of them, such as environmental assessments by an independent investigator. As mentioned in Chapter 2, the fracking process requires huge amounts of water for the fracking fluid.

3.6.2.1 The prescribed management of water

The issue of water utilization in fracking is important because the NWA contains a section that specifically defines legalities around the disposal of water, waste discharges and storing of water. Once the companies apply for their licenses, these applications that are specifically for areas that have little water or classified as "water stressed" (Havemann, *et al,* 2011:12), such as in the Karoo, will be constituted under Chapter 4 of Part 8 in the NWA. Further developments here may include the availability and allocation of the water,

taking into consideration new and existing companies in the area, as well as the communities that reside in proximity of the fracking operations. These license allocations need to consider the protection of the water source, the public's interest, as well as ensure that there is equal opportunity for jobs.

As with many applications for certain projects there are conditions that will have to be met once licenses are granted. These restrictions may include various aspects, such as water usage, costs, duration of contract operations, where it is sourced from and even how license holders intend on paying for the water used (NWA, 1998:36).

In addition to this, the authorities are entitled to decide, at any point, to change certain conditions, such as placing limitations on water usage, quantities allowed to be returned as flow back, and even subject the waste water to testing throughout the process, before it is actually disposed of (Raviv, 2013:19-21).

3.6.2.2 The prevention of water pollution

The NWA also states the importance of prevention of pollution. In Chapter 3, Part 4, Section 1, it deals with the pollution of water and what actions will be taken. The Act (1998:32) states that:

> *An owner of land, a person in control of land or a person who occupies or uses the land on which – (a) any activity or process is or was performed or undertaken; or (b) any other situation exists which causes, has caused or is likely to cause pollution of a water resource, must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring.*

All exploration license holders are compelled by law to adhere to the NWA and if it is found that they are in contravention of these laws in the utilization, or pollution of water sources, their operations can be terminated (Part 2) or they can be forced to change their modus operandi.

3.6.2.3 The National Environmental Management Act 107 of 1998 (NEMA)

NEMA has established a general framework of environmental management principles to be followed, implemented, and coordinated by organs of the state when making decisions on matters affecting the environment. One of the key principles of NEMA is the protection of people, considering economic, environmental and social factors. The principles set out in this Act stress the State's responsibility to "respect, protect, promote and fulfil the social and economic rights in Chapter 2 of the Constitution...". Section 2(2) of this Act says that:

Environmental management must place people and their needs at the forefront of its concern, and serve their physical, psychological, developmental, cultural and social interests equitably.

These factors must be identified and evaluated with respect to any implementation, environmental planning, and decision-making to ensure that any development that takes place affecting the environment will serve present and future generations – a concept that is referred to as "sustainable development" (Raviv, 2013). However, alternatives must be considered with a view of "minimising negative impacts, maximising benefits and promoting compliance with the principles of environmental management…". To ensure any continuous and informed environmental protection, NEMA established the National Environmental Advisory Forum[6] with a view to inform and advise the Minister on matters concerning environmental management, development, and monitoring.

3.6.2.4 Guidelines relating to the management of accidental spills

Disobeying an Act such as the NWA could result in legal action as perpetrators' actions would be in breach of the Constitution. The Act does not make provisions for accidents such as the spill of fracking fluid (wastewater) during transport. (See Section 5 of Chapter 3.) If such an accident occurs, authorities need to be contacted immediately to provide assistance and remedy the situation as quickly as possible to prevent potential harm to the environment or communities. Raviv (2013:21-22) points out that Chapter 14 of the Act deals with the monitoring, assessment and provision of information of any systems using water for any process. The chapter highlights the responsibility and duty of the appointed Minister of Water Affairs and Forestry to design and establish monitoring systems. These systems are to collect any data relating to the practices of mining, information, methods and quantities used, water quality, the rehabilitation of water if needed, and the maintenance of a healthy aquatic ecosystem. Once this is completed, information systems need to be put into place to ensure that the information is correct and readily available for government to evaluate. Failure to adhere to any regulations set up under the National Water Act of 1998 may result in severe consequences for law breakers, from legal action to substantial fines issued should damage to communities or the environment occur. The appointed Minister of the Department of Water and

[6] The objective of the Forum is to advise the Minister of Environmental Affairs on environmental management and governance. The Forum is also there to inform the Minister of any views of stakeholders. It is also a part of the Forum to draw the Minister's attention to any matter concerning environmental management with the permission of the Director-General (National Environmental Management Act, 1998:14).

Sanitation (DWS) is provided with a range of powers, as outlined by the NWA, to decide on the conditions required with regards to the allocation of a license, use, access to and protection of any water sources (NWA, Chapter 6 (1(63)) 1998:77). There are no quantifiable requirements set out in the Act just yet that show clear regulations or rules concerning any hydraulic fracturing activities. The licensing authorities have broad discretion when considering granting the licence conditions. This means that they are allowed to insert any specific terms or make any requests for certain information to be available.

The one problem that South Africa may face when it comes to licensing conditions is the lack of know-how and experience in the shale industry. This may escalate problems where insufficient, inefficient and inconsistent conditions are presented which may have a negative outcome for the public, the licensee or both. Should conditions set by the licensing authorities be too strict or unsuitable, companies may withdraw instead of trying to comply. On the other hand, if the conditions are not strict enough, this may cause environmental and water damage which cannot be reversed. One good thing set out by the National Environmental Management Act is that if any regulation mentioned in the act is not adhered to, then the person or company found guilty of the offence can be imprisonment or fined (the lesser charge) (NWA, Chapter 6, Part 2, Section 2).

3.6.2.5 The relationship between NEMA and the Environmental Assessment Amendment Regulations

The Environmental Impact Assessment Amendment Regulations, 2010 (EIA) were promulgated under NEMA to ensure that certain activities are assessed and investigated prior to authorisation for commencement. Under Section 7(1) of the EIA regulations “a competent authority is entitled to all information that reasonably has or may have the potential of influencing any decision with regard to an application unless access to that information is protected by law”. Any companies considering fracking will be required to submit the application to the relevant authority, with a scoping report, followed by an Environmental Impact Assessment Report (EIR), conducted by a qualified independent Environmental Impact Practitioner (EIP). The reports must contain detailed information about the proposed activity, the environment, the location, possible outcomes and impacts, advantages and disadvantages of any activity, and all possible mitigation measures. These may include planning and design elements, information about construction activities, operations, environmental rehabilitation and the closure in the end

of the process.

The EIA process will contribute to the environmental management principles outlined by NEMA to allow for informed decision making when it comes to authorisations. It will, however, be subject to thorough assessment and investigation of all the proposed activities. Any elements that relate to the water volume, some sources and the quality may be scrutinized within the context of scarcity, possible contamination and public interest. Corporations involved in shale gas exploration are thus forced to consider the environment and ensure that mitigation strategies are developed in order to protect both the environment as well as the public. The environmental management programme that relates to construction activities and operation could influence good, well construction, although the efficacy of such an influence still remains to be seen. These guidelines are required since authorities themselves are still inexperienced with regards to the management of many variables relating to the hydraulic fracturing industry. In the following section the socio-economic interests of parties affected by hydraulic fracturing are discussed.

3.6.2.6 How NEMA affects the socio-economic interests of those affected by hydraulic fracturing

NEMA provides all state organs with power and responsibilities which will come into play when they need to consider shale gas in the surrounding areas around the operational sites and the local environment potentially impacted by hydraulic fracturing. Socio-economic interests of all inhabitants to be affected by the shale operations must also be considered as this can play a major role in the setup of environmental management plans and the implementation thereof. The environmental decision makers need to take several factors into account, including environmental and human concerns. The proposed socio-economic benefits which could be achieved with fracking operations, need to be considered, whilst simultaneously recognizing the potential for the contamination of water and its implications for human well-being and environmental protection.

In the USA the growth of different extraction techniques of oil has greatly had an impact on growth for the gas industry. The potential economic growth in California due to the size of the Monterey Shale has many pro-frackers[7] excited by the prospect of economic growth. Hydraulic fracturing in the state of California would aid the state's economy by

[7] Entities, organizations and individuals who are in favour of hydraulic fracturing.

increasing the potential for exporting natural gas and oil. This will help reduce the amount of imports needed. This would decrease the dependency on foreign oil and increase employment opportunities and instate jobs (Whalen, 2014:70).

The South African Government will have to consider employment opportunities and economic development and make evaluations based on the facts before them. Principles stated in NEMA need to be implemented by the relevant authorities when they formulate environmental policies and plans. With the NWA, though, these principles do not have any concrete terms, and do not provide any clear, quantifiable methods that help to measure socio-economic or environmental impacts. This implies that most decisions made by government and policy makers could be interpreted differently by potential gas producers, uninformed or not. With only NEMA and the Constitution as a guide, gas producers could be left to their own interpretations, resulting in a failure to adhere to the relevant policies contained in the different Acts. Whilst regulations will be put in place, there is always a possibility of companies not being held fully accountable to these regulations. A potential oversight of policies could have disastrous effects on the environment. These will be the only foundations to assist in evaluating and collecting all the relevant information and formulate well-structured decisions for the preparation of their plans for environmental management. Another law that forms an important part of the discussion, is the Mineral and Petroleum Resources Development Act 28 of 2002.

3.6.3 The Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA)

The MPRDA provides for equal access to minerals and resources by ensuring that sustainable development always takes priority. The Act sets out guidelines for which mining and prospecting rights can be granted or not. This Act reaffirms the government's mandate in protecting its people and the environment. It ensures the promotion of social and economic development. Any companies who wish to explore the viability of hydraulic fracturing in any specific area will need to first apply for a Technical Co-operation Permit under Section 77(1). This permit will enable them to assess the area's natural gas potential through existing studies and the analysis of seismic data. The exploration of shale gas requires an Exploration Permit as per Section 79 of the MPRDA. Finally, a Production Right may be applied for in terms of Section 83. The Petroleum Agency SA (PASA) (2020) is then tasked under the MPRDA to evaluate the exploration process and then issue all required permits.

Following on the above discussion it is important to point out the necessity of environmental impact analysis (EIA's).

3.6.3.1 The necessity of EIA's (Environmental Impact Analysis) and the influence on other Acts

Sections 79(4)(b) and 83(4)(b) of the Act both require any person or company that applies for the exploration or production license to conduct an environmental impact assessment, which must be submitted along with an environmental management programme as per Section 39 of the Act. The applicant will then be required to describe how they plan to deal with the potential. Approval of this plan is very important and a must for the right to explore or go ahead with extraction and production. From reviewing all these Acts, it is clear that the general objectives of the integrated environmental management plans laid down by government, especially in the NEMA, will serve as guidelines for the administration, interpretation and implementation of the environmental requirements of this Act.

The assignment of mining rights as part of the management and control of fracturing operations are important in terms of the protection of all role players in the fracking operation and the relevance thereof is subsequently discussed.

3.6.3.2 The relevance of mining rights

Mining rights are important for the industry as it forms a foundation to protect the industry as well as the safety of the mine operators and the environment. In Paragraph 75 of Bengwenyama Minerals (Pty) Ltd and others vs. Genorah Resources (Pty) Ltd and others (CCT30/10) [2010] ZACC 26 (30 November 2010) (Humby, 2012), which deals with mining rights, the Constitutional Court reference to MPRDA states the following:

> *One of the objectives of the Act is to give effect to environmental rights protected in Section 24 of the Constitution by ensuring that the nation's mineral and petroleum resources are developed in an orderly and ecologically sustainable manner while promoting justifiable social and economic development. In terms of Section 17(1)(c) of the Act, the Minister must grant a prospecting right if, amongst other requirements, the prospecting will not result in unacceptable pollution, ecological degradation or damage to the environment.*

The National Climate Change Response will be discussed in the next section.

3.6.3.3 The National Climate Change Response White Paper

Rapid climate change is becoming more apparent with intense and frequent weather and climate instability. There has been an increase of global temperatures, changes in average rainfall patterns, sea levels rising due to the melting polar caps and more intense droughts. French President Francois Hollande commented as follows on the issue:

> *The time is past when humankind thought it could selfishly draw on exhaustible resources. We know now that the world is not a commodity (Hollande, 2015).*

The South African government sees climate change as a great threat to sustainable development. If unmitigated, climate change can undermine many positive advances that have been made towards development goals. The National Climate Change Response White Paper shows the government's commitment and contribution to stabilising the global greenhouse gases into the atmosphere and to protect its people from inevitable climate change. The White Paper proposes a response to climate change and finding long term solutions to a climate resilient, lower carbon economy and society. The White Paper states that South Africa will look at ways to effectively manage inevitable climate changes through intervening and building sustainable social, environmental and economic safeguards (The Department of Environmental Affairs, 2011:8-11).

All the acts, the NWA, NEMA, MPRDA and the National Climate Change Response White Paper ensure that both the authorities and the hydraulic fracturing companies are compelled by law to consider ecological and environmental issues before any kind of procedures or exploration can take place. Legally binding exploration companies to these processes and Acts will ensure that the environment is protected at all costs, that environmental management plans are up to date and relevant, that they will be effective, water use is complied with as per the NWA and the impact assessments and environmental plans are all adhered to as in NEMA.

To conclude the discussion on the various Acts and policies relevant to hydraulic fracturing, policy guidelines of the Mineral and Petroleum Resources Development Act will be addressed in the next section.

3.7 POLICY GUIDELINES OF THE MINERAL AND PETROLEUM RESOURCES DEVELOPMENT ACT (MPRDA) RELATING TO HYDRAULIC FRACTURING IN SOUTH AFRICA

The Mineral and Petroleum Resources Development Act, 2002 (Act no. 28 of 2002) sets out the regulations for the exploration of shale gas both onshore and offshore. The regulations included assessments for the impact on natural resources and sensitive areas, all linking to environmental impacts. Exploration companies have to include and define what liquid they would be using and any non-hazardous or hazardous specifications related to the company and the area. If there is any risk involved with the ingredients or chemicals the liquid contains, the company has to include these risks as well.

In 2013, the Minister of Mineral Resources published draft regulations[8] for comments regarding the offshore and onshore production and exploration of coal-bed methane, natural gas and shale gas. There are currently three main departments that will have responsibilities with regard to hydraulic fracturing in terms of national legislation. They include the Department of Mineral Resources, the Department of Environmental Affairs and the Department of Water and Sanitation. The Department of Mineral Resources has the responsibility to act in terms of the MPRDA, the NEMA and the National Environmental Management: Waste Act 59 of 2008 (NEMWA), while the Department of Environmental Affairs also has responsibilities in terms of the NEMA, the NEMWA and the National Environmental Management: Air Quality Act 39 of 2004 (NEMAQA). The Department of Water and Sanitation has jurisdiction over the National Water Act 36 of 1998.

There are four phases that exploration companies have to comply with before exploration is to commence and, once exploration is underway, there are certain regulations and standards that also need to be adhered to. These phases are discussed below.

3.7.1 The pre-commencement phase

The first phase, commonly known as the “Pre-commencement Phase” or the “Planning Phase” starts with the company first receiving environmental authorisation in terms of

[8] The draft of the Mineral Resources Development Act 28 of 2002 was published for comments on the proposed regulations for petroleum exploitation and exploration (The Department of Mineral Resources, 2013).

Section 24 of the NEMA. This is even before the exploration phase begins. There are several assessments that also need to be carried out according to the EIA process. These include information on geology and geohydrology of the area (Du Plessis, 2015:1453-1454). In addition to this, as mentioned above, the company has to state what the contents of the drilling liquid will be and to a large extent try to use environmentally friendly products.

3.7.2 The design and authorisation phase

Once the pre-commencement phase is approved, the applicant or company may proceed to the next phase which is the “Design and Authorisation Phase”. This phase includes all information of the well design being declared. Everything from the actual design (which needs to ensure that no migration of any fluids seep through, the pollution of water is minimised, and the health and safety standards are met), to risk assessment as well as any environmental risk need to be included at this stage of the process (Du Plessis, 2015:1454-1457). The site preparation and construction are a part of the second phase, but also requires its own regulations that need to be adhered to, to ensure that the well is operating safely. All staff working with construction need to be properly trained in order to adhere to any regulations or API standards.

3.7.3 The testing phase

The third phase is known as the “Testing Phase”. This phase is exactly that – the applicant has to run a number of tests on site to ensure that everything is in place. A small test is done making use of small fracture injections, to see what seismic activity may be generated and if any activity occurs, the applicant needs to then rearrange their operations and redo the test. There are a few water tests as well as pressure tests which then follow after the seismic test (Du Plessis, 2015:1457-1458). If, during any of the tests, the results have any negative impact of water, mud or brine, the results need to be reported as soon as possible and the problem resolved.

3.7.4 The operational and implementation phase

Finally, with the “all clear” given on the previous phases, incumbents will find themselves in the “Operational Phase”. Should the exploration company’s actions be in accordance with the regulations imposed in Phases 1 to 3, from the well construction to water tests, a re-brief of the whole fracking process should take place for all involved, with specific

reference to the handling of potential emergencies such as frack fluid spills (Du Plessis, 2015:1458-1460). The operational phase may then commence if all regulations are adhered to and operations are in accordance to all standards required. If incidents occur, they are to be reported and the necessary measures implemented to ensure the safe collection and production of gas.

3.8 THE SOUTH AFRICAN GOVERNMENT'S PLANS TO IMPLEMENT HYDRAULIC FRACTURING IN THE KAROO

Due to Eskom's present energy crisis in South Africa, the power company is struggling to produce enough electricity to meet the growing demand. The government's mandate is to relieve pressure on the energy sector by introducing a more diverse list of energy sources. The South African government has set out a goal for the year 2030 in the NDP to ensure the following:

> *By 2030, South Africa's transition to a low carbon, resilient economy and just society is well underway. Having undertaken the difficult steps to adjust, all sectors of society are engaged in building a competitive, resource efficient and inclusive future, and the country is starting to reap the benefits of this transition. South Africa has reduced its dependency on carbon, natural resources and energy while balancing this transition with its objectives of increasing employment and reducing inequality. Development initiatives, especially in rural communities, are increasingly resilient to the impact of climate change, with mutual benefits between sustainable development and low carbon growth identified and exploited. The state has significantly strengthened the capacity to manage the ongoing internalisation of environmental costs and to respond to the increasingly severe impacts of climate change (National Development Plan, 2011:179).*

The Department of Mineral Resources states that besides the energy crisis the government is faced with, there are other national imperatives, such as land, environment, food security, amongst others, that requires consideration, in addition to just the need for new energy sources. The need to diversify the sources of energy used in South Africa, such as coal and oil, as stated by the NDP and a call to decrease the dependency on coal, is one of crucial importance. The diversification of energy will benefit the development and sustainability of the country's economy. This motion to diversify the energy sector has resulted in motivating government to commit to the reduction of carbon emissions by 2020, thus creating a situation where the country develops endogenous resources such as nuclear energy and shale gas.

What then are the odds of the exploration of shale gas extraction being introduced to the Karoo. In the following section the way forward is explored.

3.9 THE POTENTIAL AND POSSIBILITY OF EXPLORING SHALE GAS IN THE KAROO

Due to the shortage of energy at present South Africa needs to explore other possibilities, such as placing the option of hydraulic fracturing on the table once more. At the moment the country relies on a varied group of minerals to produce energy for the entire country. This list includes coal, imported gas, hydro power, gas turbines and nuclear power as viable options. With all the information at hand, and weighing all the options, is hydraulic fracturing still more feasible than other sources of energy, like solar? Why continue to explore the option of hydraulic fracturing with all its financial and environmental implications, when solar or wind produced energy could be more cost effective in the short term? Gas run turbines would be a quick-to-respond power generation system as opposed to the conventional coal powered station and can be used intermittently as required until coal is no longer available. A major factor in the usage of coal for the future is the continued development and deployment of clean coal technologies (Leiman, *et a*l, 2012:25) as well as any technologies that can assist phasing in renewable energy. The exploration of gas aims to target all gas in the ECCA and Dwyka Groups within the Karoo. Source formations have included the following areas (Steyl & Van Tonder, 2013:214):

- Whitehill Formation (The Cape region)
- Prince Albert Formation (The Cape region)
- Volksrust Formation (The Free State and Kwa-Zulu Natal regions)
- Vryheid Formation (The Free State and Kwa-Zulu Natal regions)
- Pietermaritzburg Formation (The Natal region)
- Dwyka Shales (All regions, shallow enough)

The Karoo, being a poor area financially, can greatly benefit from fracking and projections regarding economic advantages are quite positive. The addition to the energy grid and added economic stability from job creation in the area will positively impact communities. The problem is that these are just projections as the practice of hydraulic fracturing has not taken place yet. Until exploration actually goes ahead and the recoverable resources are known, the real consequences of fracking, whether good or bad for the economy, will remain as estimates (Gamper-Rabindran, 2018:6).

When the South African government decided to allow fracking operations in the Karoo, the actual amount of gas deposits was unknown. There is still some uncertainty as the assessment of the infrastructural requirements with regards to the socio-economic effects is lacking. There needs to be a connection between the decisions taken by government and the empowering provisions. With this said, the decision to continue fracking may be irrational and will need to be reviewed in depth (Augustine, 2018:22). Due to the uncertainty around the process and effects of fracking, the potential earning outcome can be a great gamble with the environment and future economic stability of the country. The lack of proper assessment can have detrimental effects on the environment of an agriculturally rich area. With all this in mind, there is also need for more communication between the decision makers and the communities who will be affected by the decisions (Augustine, 2018:22).

3.10 CONCLUSION

This chapter explored the South African government's options and plans to allow for the exploration of shale gas in the Karoo through fracking operations. The debate is still rife and may not be settled anytime soon, but there is merit to the argument in favour of fracking. The economic and other potential long-term benefits in infrastructure and alternative energy options can contribute to the elimination of shortcomings in Eskom's coal power generation capacity.

Alternative or new energy sources can support the electricity grid, which in turn may be able to sustain an ever-growing population and increasing demand for electricity. Hydraulic fracturing is certainly gathering momentum as a viable source for countries to use for energy production. Though all the benefits from hydraulic fracturing are evident, there may be one question that requires an answer sooner rather than later: Is there a better short-term fix to produce energy which, at the same time, benefits the environment as a whole? Would fracking suffice as an interim, or temporary solution while the experts are searching for energy alternatives that are more cost effective and will forever be renewable? These questions remain part of the ongoing debate around hydraulic fracturing as one of the gas mining options worldwide.

This chapter has looked at the background, history and environmental impacts with regards to hydraulic fracturing in South Africa and has reviewed the whole process, taking government information and international cases into account. The holistic advantages and disadvantages have been looked at, because this is vital to the argument for hydraulic

fracturing and the outcome of the study. Government policies around the world have been researched to see how the reasoning behind the South African government's plans and policies have developed in terms of shale gas exploration as an alternative to coal, to meet the energy needs of South Africa. Whilst hydraulic fracturing would provide an alternate and readily available source of energy for electricity production, hydraulic fracturing will require a sizeable investment both by the government and the private sector. It remains to be seen if this investment and route of action could be viable, with minimal damage inflicted upon the delicate ecosystems at the primary earmarked sites.

Chapter 3 endeavoured to create a foreground for the next chapter, which will take a more in-depth look at the advantages and disadvantages of hydraulic fracturing for the South African environment. Chapter 4 widens the study as to why South Africa may or may not benefit from the exploration of hydraulic fracturing.

CHAPTER 4

THE ADVANTAGES AND DISADVANTAGES OF HYDRAULIC FRACTURING IN SOUTH AFRICA, WITH SPECIFIC REFERENCE TO THE KAROO

4.1 INTRODUCTION

Governments all over the world are looking for cleaner and more renewable energy solutions to replace energy resources that could accelerate damage to the environment. Since hydraulic fracturing has been added to the list of clean and renewable energy resources, it is important to consider the effect that it could have on any environment. For this study, it is equally important to understand the impact that it may specifically have on the Karoo ecosystem. The debate about hydraulic fracturing is rife with a variety of opinions, because the advantages and disadvantages seem to lay worlds apart from one another, as Du Plessis (2015) remarks:

> *The agricultural section of the Karoo community vehemently opposes the possibility of shale gas exploration in this area, while another section of the community celebrates the possibility of the creation of job opportunities and the alleviation of poverty (Du Plessis 2015).*

Although investigation is ongoing, it is clear that a complete understanding of the advantages and disadvantages are critical to this analysis. Chew (2015) confirms that a balance still needs to be found between the ever-growing demand for fossil fuels and the impact of fracking on the environment and communities affected, when he states:

> *Given the ever-growing demand for energy in the United States and our ever-shrinking fossil fuel resources, it seems likely that fracking is here to stay. However, recent results by scientists across the country demonstrating that clear drawbacks to the fracking process cannot be ignored for the short- and long-term health and safety of the people (Chew, 2015).*

In the previous chapter the South African government's plans for hydraulic fracturing were placed under the microscope. The advantages and disadvantages of fracking were broadly discussed with some reference to the Karoo and how the very delicate ecosystem may be affected. Chapter 3 also looked at some questions that were previously raised with regards to the proposed regulations and procedures. These regulations are to be adhered to by all companies who wish to explore fracking in the Karoo area. Chapter 3

also explored the protective policies and procedures that will have to be in place with regards to the economic impact, the effect on the environment, the wellbeing of citizens and current energy production resources and difficulties. The government's mandate is primarily to ensure that once any company drills for shale gas, they will be legally obliged to follow all procedures to a tee and should a company be responsible for damage to the environment or resident communities, they will be held accountable.

In this chapter the advantages and disadvantages of hydraulic fracturing in the Karoo will be explored in-depth, with the purpose of establishing whether hydraulic fracturing may or may not be a viable solution to the South African energy crisis. The positive and negative effects will be taken into account as well as potential and/or imminent challenges. A positive factor to be considered is the correlation between financial stability and a stable energy sector – stable energy supply enhances and contributes to financial stability and growth. The opposite is true if energy supply is intermittent and demand exceeds supply, which is detrimental to the economy. This consequence can be seen from the effects of load shedding, discussed in Chapter 3. Chapter 4 will thus cover all the facts arguing that the investment in hydraulic fracturing represents sound decisions, contributing to both a stable energy and a growing financial sector.

Firstly, Chapter 4 will explore shale gas exploration on the international stage with emphasis on the advantages and disadvantages anticipated or experienced with hydraulic fracturing globally. The background to the benefits of hydraulic fracturing experienced in other countries allows for parallel conclusions to be drawn as to how it may benefit South Africa. The chapter, secondly, delves into the financial advantages and how it may foster economic growth and, in turn, contribute to a more stable economy. Thirdly, the advantages of hydraulic fracturing as a cleaner energy resource in the long term will be evaluated.

The chapter then shifts focus, exploring the disadvantages of hydraulic fracturing. These disadvantages will highlight how drilling (of any sort) may or may not cause seismic activity in the form of man-made earthquakes, as the effect of such an event upon the Karoo ecosystem and livelihood could be disastrous.

Lastly, the most debateable aspect of hydraulic fracturing, namely the usage of water and the pollution of water wells around frack sites, will be addressed. The fact that water is the primary resource (used to make fracking fluid) employed in the mining process (from beginning to end), adds to the differences in opinion amongst stakeholders. Professor G.

van Tonder, of the University of the Free State (UFS), together with Professor A.R. Tucker has warned that his latest research[9] indicates a high risk that fracking in the Karoo could lead to one of the biggest water pollution problems in the world:

> *This is serious stuff. There will be trouble, and Shell and the other companies involved must take note (Steyl & van Tonder 2013).*

Water is already a scarce resource vital to all life on earth – especially in the arid areas. The water usage in a single process makes this concern more urgent as billions of litres of water will be required throughout the process. The disadvantage of water usage is highlighted, creating a better understanding why there is a concern of further water pollution. The negative effects of hydraulic fracturing (especially processes such as flow-back and the actual rock fracturing process) will be explored to establish the extent of water contamination to any surface or underground water wells close to the fracking site. Identifying the major concern for water usage and pollution will in turn provide a better understanding of the allegations of environmental damage as raised by environmental experts.

With enough exploring and research there may be some more evidence that fracking would not have such a devastating effect on the environment. Pietersen *et. al.* (2020) propose that they may still be a way to continue with fracking. The article suggests that by understanding the role of hydrogeological pathways, that the different structural features may be reconsidered. The unbalanced distribution of high and low permeability zones can further complicate the effective estimation of the groundwater in this region. The argument that ground water may become contaminated in the process becomes more complicated as ground water can work as channels for gases, formation fluids and chemicals that have accumulated in the subsurface.

With this thought, the whole approach to fracking could change – this could mean a more stable economy without putting the environment at risk too.

Chapter 4 will conclude with summarizing how the benefits and possible implications may affect South Africa, especially the Karoo area, if the government allows hydraulic fracturing as an alternative energy source to commence.

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[9] Prof G van Tonder's research explored the impact of fracking in the Karoo. He was concerned about the impact on the delicate ecosystem, as well as water pollution. He took a Christian standpoint on his study as to how values and beliefs influenced the decision to frack. The Christian standpoint of the study is to engage with the concerns and challenges faced in South Africa; while doing so in a way that the kingdom of God is realized and recognised (Tucker & van Tonder, 2014).

4.2 ADVANTAGES OF HYDRAULIC FRACTURING

Hydraulic fracturing has become a popular and efficient form of energy production in a number of countries, such as Canada, and is increasingly being used in countries in Asia, Europe, and South America. The hydraulic fracturing process involves extracting the gases trapped in the rock underneath the earth's crust, which is very different from conventional mining operations. The method of shale gas extraction is found to be cleaner than, for example, coal. The resulting so-called 'transitional fuel' obtained via fracking is arguably cleaner than coal, emitting 45% less carbon dioxide per energy unit than coal production (Ellingson, *et al*, 2016).

In the next section, the study will touch on hydraulic fracturing globally with specific reference to case studies where countries have benefited from this method of gas extraction, such as in the USA. The discussion will be narrowed down to socio-economic conditions in South Africa, and the potential benefits to the economy, job creation and income levels in local communities as well as the broader population and the environment.

4.2.1 Hydraulic fracturing on the international stage

According to investigations funded by the European Commission, conducted by Insight Energy[10] in 2017, the production of shale gas accounts for about 13% of the global natural gas production as compared to a percentage of 0,5% as of 2000 (Mjwara, 2017). Natural gas has been ranked by the World Energy Council as the third largest fuel source in the primary energy mix globally, and the second largest source for power generation. Innovations like multi-stage hydraulic fracturing and horizontal drilling have been key to unlocking the tight shale formations in the USA. As a result, it is improving the prospects of the USA becoming a liquefied natural gas exporter (Mjwara, 2017).

Between 2011 and 2013 the production of shale gas helped reduce net imports of oil-based energy by one-third, and, in comparison – to numbers in 2006 – the foreign petroleum imports had fallen by almost 40% in 2014 (McBride & Sergie, 2015). For international relations and global markets, this holds broad implications (McBride & Sergie, 2015). As of 2019 almost 98% of natural gas imports and exports in the USA are moved via a pipeline as gas, and by ship as liquefied natural gas (LNG). Only a small

[10] This Commission is an independent body of the European Union, responsible for compiling proposals for the European legislature (European Union, 2020).

amount is moved by trucks as Compressed Natural Gas (CNG) (EIA (a), 2020). The USA has substantial fracking areas that contribute to its overall gas production. Some locations are in Texas, Pennsylvania, New York and Ohio. Recently North Dakota was added to the mix, which changed the energy map in the USA and around the world. Since then, the production of gas has excelled globally, tipped at producing around one million barrels per day in the year 2014 (EIA (b), 2020*).*

> *US natural gas production in 2019 was about 34 trillion cubic feet (Tcf), the highest annual amount recorded. Most of the production increases since 2005 are the result of horizontal drilling and hydraulic fracturing techniques, notably in shale, sandstone, carbonate, and other tight geologic formations. Natural gas is produced from onshore and offshore natural gas and oil wells and from coal beds. In 2019, U.S. dry natural gas production was about 9% greater than U.S. total natural gas consumption (EIA (b), 2020).*

Hydraulic fracturing has yielded benefits for countries that have opted for using this type of energy. The activity has lowered costs that had a direct impact on the prices of goods and services in the USA. It was stated by IHS Market Global Insight[11] that, in 2012, consumers could save up to about $1200 a year.

> *The new outlook for natural gas cost and availability has created new possibilities for progress toward national goals of energy efficiency, cost efficiency, environmental protection and energy security. In short, the Shale Gale put a powerful new wind at America's back (IHS Markit (b), 2020).*

They also projected that the year 2020 could see as many as 250 000 jobs created, due to the shale gas boom, which was well above the 150 000 jobs in 2010, translating into a range of socio-economic benefits for the country's economy. USA energy exports have also increased since the start of the shale gas revolution. This is made possible through the exporting of its natural gas supplies since September 2008. The USA therefore does not have to import as much oil as before and are able to build a market by exporting their gas (McBride & Sergie, 2015). An analysis by ARI[12] in 2013 of the global shale formations outside the USA showed that more than half of the world's shale oil resources are in Russia, Argentina, China and Libya (EIA, 2015). Shale gas has the potential of being a geopolitical game changer for countries like Turkey, Poland and Ukraine, and hopes are they may reduce their dependence on obtaining conventional gas from Iran and Russia.

[11] IHS Market is a company that conducts research for companies globally using analytics and field professionals. IHS stands for Information Handling Services (IHS Markit (a), 2020)

[12] Advanced Resources International (ARI) is a research, consulting and development firm that provides different service in the energy field. Their work is related to unconventional gas, carbon capture, utilisation, storage and enhanced oil recovery (ARI, 2013:2)

However, the global exploitation of shale gas has not yet experienced the full effects, as is prevalent in the USA (McBride & Sergie, 2015). Ellingson, *et al* (2016) re-iterates that the natural gas resulting from these operations can serve as transitional fuel supporting the worldwide move to greener energy solutions.

One of the reasons that the rest of the world may not have reached their full fracking potential is because of environmental concerns. In Europe, these concerns have led to bans on hydraulic fracturing. The French, who rely mostly on nuclear energy have repeatedly ruled out any exploration. Poland and the United Kingdom are showing interest in nuclear power. Poland has existing nuclear plants and have announced to build more but they have not implemented these plans yet (Findlay, 2010:72). Water shortages, mountainous terrain and other constraints have hampered China's efforts at fracking, even though they could have as much shale as Canada and the USA combined. Russia, currently under sanctions by the USA,[13] may not secure any technology, services and equipment from America. This has seriously handicapped their existing plans in this field of energy exploration (Welt, *et al*, 2020:11).

The international scenario forms the backdrop to the South African situation and the government's actions towards the control of fracking. This aspect is discussed in the next section.

4.2.2 The South African situation with reference to the Karoo

The debate on hydraulic fracturing in South Africa has been ongoing for a number of years. Tucker and Van Tonder (2014:1) holds the view that the balance between environmental damage and population growth demands is at the root of the problem:

> *The fracking debate is a product of the tension between the environmental degradation it may cause, on the one hand, and on the other the greater energy demands of a rapidly increasing South African population with expectations of an ever-increasing standard of living (Tucker & van Tonder, 2014:1).*

According to a report published by the DBSA in 2014, South Africa's energy requirements will increase by 2% over the next decade, which means that South Africa needs 40 000 MW of new generation capacity by 2025. As mentioned in the previous chapter, the government has been struggling to keep the lights on while attempting to decrease their

[13] The United States imposed sanctions on Russia as a response to its invasion of Ukraine, human rights abuses, election interference, other malicious cyber activities, use of a chemical weapon, illicit trade with North Korea, and support to Syria and Venezuela (Congressional Research Services, 2020).

carbon footprint. This has prompted government to look for alternative sources of energy, such as hydraulic fracturing. Based on research data from various sources, such as the DBSA, the Karoo is the largest area in South Africa that is viable for hydraulic fracturing. This factor is the biggest concern of the debate, as the Karoo has a delicate ecosystem and is quite dry and arid (Sihlangu, 2019). The main threat to the ecosystem is the utilisation and pollution of water in an already water scarce area in South Africa. On 10 July 2019, the Supreme Court of Appeal (SCA) ruled against the idea of fracking in the Karoo. Wicomb (2019) explains the judgement as follows:

> *The biggest potential negative impact of fracking on the environment, the parties before the SCA agreed, is the emission of pollution and the contamination of both surface and groundwater. Given the water scarcity of the Karoo, the contamination of the groundwater may, in particular, be disastrous (Wicomb,2019).*

However, Minister of Mineral and Energy, Gwede Mantashe, announced on the 10th of July 2019 that shale gas would still be extracted (Sihlangu, 2019), regardless of the SCA's ruling. On 15 October 2019 the minister announced alternative methods to extract the gas and achieve the goal set forth:

> *To me it is not about killing coal and growing renewables. It is about promoting the various technologies that are at our disposal. It is a combination and coexistence of the various technologies – (Heiberg, 2019).*

This position was challenged by the parliamentary opposition Freedom Front Plus (FF Plus). The minister re-iterated that research was still under way. According to Wynand Boshoff – MP and FF Plus Spokesperson – it was reported within 5 days, in the *Cape Argus*, that at least three companies had been granted rights to explore the Karoo for shale gas. The report also mentioned that the department was looking at shale gas as a way to allow the region to become more economically productive and boost economic activity (Sihlangu, 2019).

By 2019 the Karoo area has already been experiencing a drought for six years (Sihlangu, 2019). Consequently 6000 farm workers and workers in related sectors have lost their jobs. This has fuelled the dialogue about finding alternative sources for economic growth in the Karoo. Government is still cautious about taking part in the debate but showed some interest and, hence, investigations into hydraulic fracturing have commenced. Even with caution from government's side, there have been three permits granted[14] for

[14] As mentioned in Chapter 1, Section 1.3.

exploration of shale gas, in line with regulations set out as per the Mineral and Petroleum Resources Development Act. (Refer to Chapter 3.) Spokesperson for the Department of Mineral Resources, Ayanda Shezi, mentioned that the government was investigating hydraulic fracturing as a means to alleviate the pressure on a highly constrained energy grid:

> *No hydraulic fracturing or fracking has been authorised, but holders are permitted to conduct some other forms of exploration, except for hydraulic fracturing/fracking, as the government is still investigating the use of this method (Githahu, 2019).*

With the drought causing some to push for hydraulic fracturing to take place sooner, there remains those who are still against and who argue that, because of the current drought, hydraulic fracturing should not commence. With the climate already so arid and dry, why take the chance to use billions of litres of water and endanger even more? With dams and boreholes in the Karoo running dry (AgriSA, 2019:27-28) communities are increasingly dependent on underground water sources, raising the concern about potential water pollution, should fracking go ahead. As mentioned earlier, the unemployment rate amongst farm workers and other related industries is increasing daily. The drought is aggravating this unsustainable situation as farmers are losing livestock and production is slowing down (AgriSA, 2019:28).

The anti-fracking movement in the Karoo is not arguing against economic development in the area, but the consensus is that it must be transformative for the people and sustainable for all the communities affected. Questions regarding land, water and climate change are becoming more apparent as the drought seems to be getting worse. One of the most pressing economic arguments is that poor communities are suffering the most, and becoming even poorer (Janse van Vuuren, 2019).

The benefits of fracking can therefore primarily be defined as economically based with the goal of transforming the economic life of communities in the area and the country as a whole, for the better. Taking into consideration the current socio-economic challenges the region face, it makes sense to explore and debate these potential benefits to possibly find a balance that will allow fracking to be implemented in the Karoo. These advantages are being discussed below.

4.2.3 Financial benefits of hydraulic fracturing

The Karoo shale gas report by Deloitte[15] detailed the fact that if the estimated reserves of shale gas in the Karoo are accurate, South Africa could enjoy 400 years' worth of energy supply. This means that South Africa's energy woes should come to an end and energy supply should significantly increase (Delloite, 2019).

The government finds hydraulic fracturing advantageous, as it could help with developing the economy in the Karoo region, and the potential growth it offers in terms of the financial sector, GDP and energy export possibilities. South Africa currently experiences severe uncertainties on the economic front and is constantly under threat of being further downgraded by international rating agencies.[16] The contribution of shale gas exploration to financial growth and stability locally, as well as nationally, can be assessed from the successes of other countries that have been practicing hydraulic fracturing for a while. According to the American Enterprise Institute, in 2011, the USA produced an amount of 8 500 983 cubic feet of gas. Applying an average price for gas of $4,24 per thousand cubic feet, this has a value of about $36 billion in total (Hasset & Mathur, 2013). It means that increasing gas and oil production is directly proportional to the increases in financial growth attributable to technology. It also had some effect on the trade balance between other countries and the USA, as gas imports have reduced by a total of 25% between 2007 and 2011. This was a direct result of shale gas exploration and the increase in the sufficient production and supply of energy. Logically, it follows that with more cost-effective energy production, the burden on taxpayers can be lessened and simultaneously job opportunities will increase, which can add growth and stability to the economy. Increased production will also result in a drop in price of natural gas due to the reduction in price of production in the USA (Hasset & Mathur, 2013).

Economic stability brings with it many new challenges, but also many new opportunities. Hasset & Mathur (2013) quote Winnie Byanyima, Executive Director of UNAIDS, who holds the argument for the purpose of economic growth:

> *'What is growth if not to help ordinary people thrive?' – Winnie Byanyima ... Inframarginal*

[15]Deloitte is a company that hosts thousands of professionals in independent firms. They collaborate to provide services in the consulting, risk, audit and assurance, risk management, tax, risk and financial advisory to select clients (Deloitte, 2020).

[16] Moody's downgraded South Africa from an investment-grade rating to "junk" rating on the 27th of March 2020. The reason for the downgrade was due to the unreliable power sector and weak economy (Gosai, 2020).

(analytic method in classic economics) benefits would also be advantageous for the economy. There would be a spill over effect into other industries like fertiliser producers, the chemicals industry and steel and aluminium sectors. This in turn adds value to employment numbers in these industries. Once there are economic transformation and positive growth, there is room for further investment, not only locally, but internationally as well. This opens pathways for opportunities in the oil and gas industry, and agriculture and metal manufacturing sectors too. Besides international investment, the potential of a stronger, self-sustaining economy is a major factor in the debate around the advantages of hydraulic fracturing.

Economic independence benefits a strong economy since the country does not need to rely entirely on international markets and investment for financial support. The trade balance in this instance is also affected, as the import and export of gas will increase. Based on US experience with the economic benefits of hydraulic fracturing, there is potential for a country to improve its self-sustainability in relation to their dependency on gas imports (DBSA, 2014:9).

The potential economic benefits for South Africa and the Karoo area need to be further explored and studied. The benefits experienced in other countries may be projected as possible advantages for the Karoo, but one needs to be aware that the South African climate, not only environmentally but also politically, is unique. The government needs to be cognisant of the South African socio-economic and political status and how the communities living near fracking sites may be affected.

In the early stages of any shale gas exploration, the economic benefits may not be entirely clear, as much of it tend to be more localised. Only once exploration is deemed successful can any long-term effects be realized. This will, in turn, ensure increased revenues, some positive effects on the country's GDP and a better idea for sustainable and more permanent employment opportunities in the Karoo and maybe for the entire country (Twine, *et al*, 2012:19-20).

South Africa has a high unemployment rate[17] and the drought in the Karoo has caused unemployment numbers to rise as farmers are struggling to harvest crops and secure food and water for livestock (Twine, *et al*, 2012:42-43). A study done by Twine, *et al* for Econometrix (2012) concluded that, should hydraulic fracturing commence, there would

[17] There has been a significant decrease of 6,8 percentage points in the official unemployment rate from 30,1% in quarter 1:2020 to 23,3% in quarter 2:2020 (StatsSA (a), 2020). Although, much of the blame could be ascribed to the COVID 19 pandemic, energy issues played a significant role.

be definite benefits for job creation. A more stable energy production will ensure that energy is more affordable for consumers, adding to economic growth, which in turn could contribute to the reduction of electricity and gas imports.

In the study done for Econometrix (Twine, *et al*. 2012) a list of financial benefits have been listed should hydraulic fracturing exploration prove to be successful. These benefits are: government revenue, employment, GDP and spill over or any catalytic effects. To better understand these benefits holistically, they will be discussed in more detail.

4.2.3.1 Government revenue

Oil and gas development associated with shale resources have increased substantially in the United States, with important implications for local governments. These particular governments in the United States have experienced an increased revenue from a variety of sources. These sources range from severance taxes distributed by the state government, local property taxes and sales taxes, direct payments from oil and gas companies, to in-kind contributions from those companies (Newell, R. *et al*, 2015:4)

South Africa's mining industry generated a total revenue of R529 billion for the year ended 30 June 2019. The biggest revenue generator remains coal, contributing 28% of mining revenue (Ramawtar, *et al*, 2019:17). With shale gas exploration introduced in the country, government revenue and GDP will grow as a result of increased employment and tax revenue collected. Public expenditure may increase and a positive spin off for consumers could be a reduction in other forms of taxes, for example, petrol tax. According to Deloitte (2020) government revenue would potentially increase by R35 billion per annum. The economic benefits for South Africa can be substantial (Deloitte, 2020).

Local public finances have benefitted largely from shale gas exploration in the USA, as mentioned in Chapter 2, and in many regions increased revenues from a variety of sources have outweighed the costs. This has allowed local governments to improve infrastructure and services to their communities (Newell & Raimi, 2015:2).

It is difficult to predict the potential value of developing South Africa's resources until there is more certainty as to how much can actually be extracted economically. It requires a relatively small proportion of resources to be economically extractable for the effect to be very significant. The economic consultancy Econometrix (in Twine, *et al*. 2012) estimates if just 5% of South Africa's resources are economically recoverable, this will add more than R80bn, or 3,3% a year, to gross domestic product for 25 years. Deloitte (2020)

notes, is nearly double the total current contribution of coal mining to the economy. Government tax revenue would increase by R35bn a year. If 10% or 20% of the reserves can be turned to account, the long-term economic benefits for South Africa would be enormous.

4.2.3.2 Employment

Some studies show that the industry for shale gas exploration has a high turnover rate that benefits many more than just the people directly involved. So, for example, if one person works on a fracking site, at least three more jobs can be created further down the line (hotels, restaurants, etc). Once the process is established on a commercial level, the employment on all levels will continue to thrive as long as the mining takes place (Tukwayo, 2016:20-23).

The oil and gas industry in the United States supported 1,7 million jobs in 2012. This is an achievement for the country, considering how new the technology is. The employment numbers may raise to 3 million by 2020. In the year 2012, the revolution of oil and gas added about $62 billion to state and federal government revenues. It is gradually ensuring that the United States keep a competitive position in the global economy and can continue to affect global geopolitics (Nunez, 2012). History therefore shows that fracking can certainly help solve the problem of unemployment, but, in terms of South Africa, the true impact of fracking on the job market is, at this stage, based on estimates.

There are also claims that fracking will contribute to the GDP, as it has done in the USA, as discussed in the section that follows.

4.2.3.3 Increase in GDP

The effects on GDP are relatively direct. The exploration of shale gas will have a beneficial effect on the economy and, in turn, on the GDP, leading to higher levels which can be affected for a longer period of time, potentially 25 years and maybe even longer (Deloitte, 2020).

Between 2011 to 2014 the USA shale boom experienced employment and GDP growth. North Dakota and Texas saw their GDP's expand with 4,5 times and 1,5 times, respectively, more than their average rate. This also had an effect on their employment rates. Due to this boom, and the sheer amount of gas and oil available to the US for energy consumption, there has been a decline in gas imports. This decline in gas and oil imports has, in turn, boosted the overall GDP percentage positively (Yucel & Plante,

2019).

4.2.3.4 Spill-over or catalytic effects

The spill-over effects from hydraulic fracturing can result in less energy imports, which means that South Africa can save on revenue. Another spill-over effect from the global stage is the potential for more international investment, not only on the financial front, but also in sectors such as training and education for the labour force. As mentioned in 4.2.3 stable financial and energy sectors directly influence the cost of energy for South African citizens, which, in turn, could lower inflation by keeping prices down and improving competition throughout industries, and creating an even stronger economy. Econometrix analysts have created a model using the USA as a case study to try and determine the economic success that hydraulic fracturing may have on the South African economy. The summary of the model yielded some impressive results with total project turnovers amounting to millions of Rands. The one result summary they have, shows the economic effects from two different extraction scenarios (Scholes, *et al*, 2016:7). The following figure shows the effect that natural gas has on prices in the US. It can clearly be seen that the sale of natural gas prices has increased and, in turn, the other sources have reduced prices over the years.

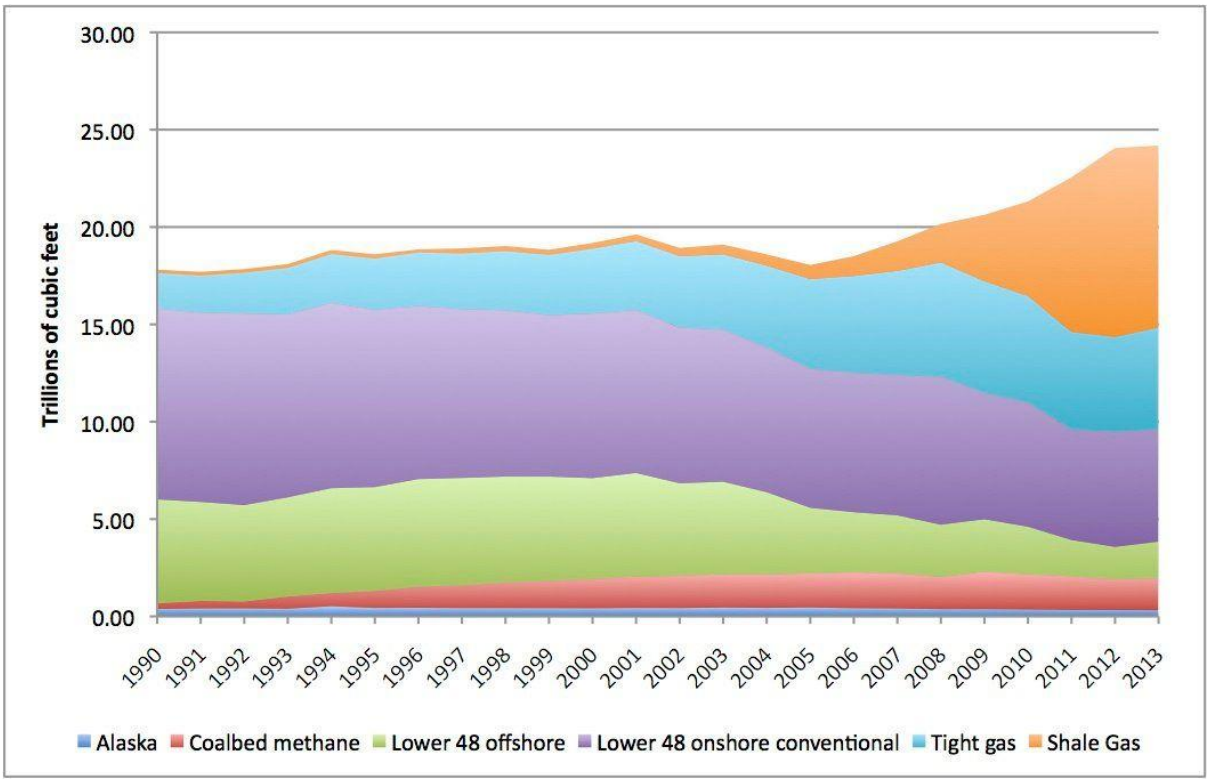

Figure 4.1 How fracking affects natural gas prices (Emspak, 2019)

So, while there seems to be some definite ideas that, if the modelling is correct, there is

potential for South Africa, especially the Karoo, to benefit economically from the successful implementation of hydraulic fracturing.

4.2.4 Environmental benefits

Although the fracking debate is rife with implications and disadvantages for the environment, one cannot ignore the environmental benefits of the gas that is extracted during this process. Although shale gas is a fossil fuel and can still have an impact on the environment, it is reportedly known to emit less CO_2 than coal, as mentioned in Chapter 3. According to the USA's EPA, electricity that is powered by natural gas generates half of the amount of CO_2 that is produced when using coal-generated electricity (Hasset & Mathur, 2013). After CO_2 emissions reached a peak of about 6 billion metric tons in 2007, this has decreased significantly over the last few years.

The EPA states that although the decline can partially be contributed to the world economy taking a knock in 2008, the volume of emissions released are still lower (EPA, 2018). Countries can therefore look into lessening the usage of coal and other fossil fuels that have higher CO_2 emission numbers and opt for more environmentally friendly energy sources. Besides solar, wind, nuclear and hydro power, gas has become another option on the list for safer energy resources. In future, mining companies will have to take into account the viability of the minerals they mine and balance it with safer, cleaner resources, whilst being mindful of the procedures involved in the mining process.

4.3 DISADVANTAGES OF HYDRAULIC FRACTURING

Following the hydraulic fracturing debate, there seems to be consensus that there are more negatives than positives when it comes to fracking anywhere in the world, not only the Karoo.

> *When overlaid on the biomes and vegetation types of South Africa, this potential fracking area provides a rough indication of the possible range of habitats and environments that could be impacted by fracking (Todd,* et al.*, 2016:280).*

The main concerns regarding hydraulic fracturing are summarised in Table 4.1 below, illustrating the highest environmental impact issues.

Table 4.1 A list of concerns regarding hydraulic fracturing (Watershed council, 2020)

Migration of gas	Migration of fluid	Water use
Management of produced water	Identification of additives	Surface spills
Anthropogenic	Road traffic	Dust
Noise	Fauna and flora	Well construction
Desalination	Plant inefficiency	Seismic activity

In many countries various environmental groups have advocated to stop fracking from going forward. The argument is that, although there are very real and very valid reasons why hydraulic fracturing is beneficial, it may not outweigh the clear disadvantages that arise from the process. The next section deals with the disadvantages of hydraulic fracturing, using information from the empirical world and countries who experience in the exploration of shale gas. It is important to understand the disadvantages on a broader scale in order to apply it to the South African context. The discussion is narrowed down to the South African situation, with specific reference to the delicate Karoo ecosystem. Disadvantages that will be discussed are seismic activity, pollution and the contamination of water resources.

4.3.1 Seismic activity

Although seismic activity is rarely caused by mining operations into the earth's crust, it does have limited impact on how the earth's crust may move, causing man-made earthquakes or seismic activity. The main point here though is that there are tiny earthquakes that occur when the fluid is injected into rock formations that may lie close to any fault lines. The increase of pore pressure caused by hydraulic fracturing and wastewater disposal reduces the stress within a fault zone. The increased pressure releases the elastic energy that is stored in the rock more easily, allowing for the rock formations to slide off each other. It must be mentioned that seismic activity caused by hydraulic fracturing is rare and has only been documented in a small number of cases (Jackson, *et al*, 2014:344). The USGS (United States Geological Survey) found that the

earthquakes often relate to only two types of shale gas mining[18] and are too small to be of any safety concern. However, the main worry comes from the actual treatment of the water and chemicals that are disposed of. This wastewater, injected into wells, can actually cause earthquakes on a more severe scale (Snyders, 2016:5-6). Fracking is the intentional action of creating an earthquake. One of the largest earthquakes in the United States occurred in Texas at M4,[19] the largest earthquake was recorded in Oklahoma in 2016, and measured M5.8 (USGS, 2020).

Although there has not been much evidence linking hydraulic fracturing to seismic activity, scientists have continuously embarked on more studies to prove that there very well may be a connection between the two. On the 25 of February 2019, a Village in China's Sichaun Province was rocked by an earthquake that left 12 people injured and 2 people dead. New research suggests that the earthquake as well as the foreshocks were triggered by hydraulic fracturing. The study indicates that magnitude of the earthquakes caused by hydraulic fracturing may result in underestimating the true threat of fracking. The earthquake that took place only measured a 4.9 magnitude – which is not thought of as particularly dangerous. This one though managed to destroy older buildings due to it being so close to the surface. Earthquakes caused by fracking tend to be much shallower than natural ones (Nala, 2020) which presents a threat to human settlements on the earth's surface.

4.3.2 Pollution

The biggest concern over hydraulic fracturing is that it may pollute water supplies. The question is also raised whether there are any concerns for other types of pollution? While fracking cannot be directly linked to areas experiencing problems with air pollution close to fracking sites, organisations are trying to establish some clear links between the fracking sites and any adverse health problems experienced by citizens living in the vicinity of these sites. There have been some results from studies that have shown the relationship between air pollutants that are present at gas and oil production sites and

[18] Fracking can cause earthquakes via two ways, the first is through the actual fracking process, when the fracking fluid is injected to release the gas, especially if it is close to existing fault lines. The second way is when the wastewater is disposed via underground injections (Earthworks, 2020).
[19] Earthquakes are measured by a Richter scale and in magnitude. Anything above M5 is quite a large earthquake that could cause damage (USGS, 2020).

health issues. The increased activity shows more airborne pollutants present at these sites, which can cause respiratory, immune and nervous system problems as well as cancer. These illnesses have all been linked to the consistent exposure of the pollutants produced in mining operations. (Srebotnjak & Rotkin-Ellman, 2014:2).

Examples can be seen in Colorado, where the evaluation of birth defects in areas where oil and gas activity took place, have been recorded. Mothers who live in the vicinity of mining operations, tend to have babies with heart defects. Pennsylvania yielded similar results, where new-born children often had low birth weights linked to air pollution (Srebotnjak & Rotkin-Ellman, 2014:2). The processes involved in fracking are said to involve contaminants that may be the main cause of the environmental contamination. The expansion of fracking can lead to the increase of pollution that is often found at conventional oil sites, but is not limited and can also include some pollutants often used in fracking, such as the fracking chemicals, silica and wastewater. Whilst many side effects have been recorded in areas with high activity, there is no scientific proof yet that it is caused by hydraulic fracturing. Research is still ongoing into the effects of air pollution caused due to oil and gas development, with some increasing evidence that the pollution associated with these practices can definitely affect not only workers, but communities as well (Srebotnjak & Rotkin-Ellman, 2014:2). Refer to Figure 4.2 to see the potential health concerns that can arise due to pollution from the chemicals used in fracking liquid.

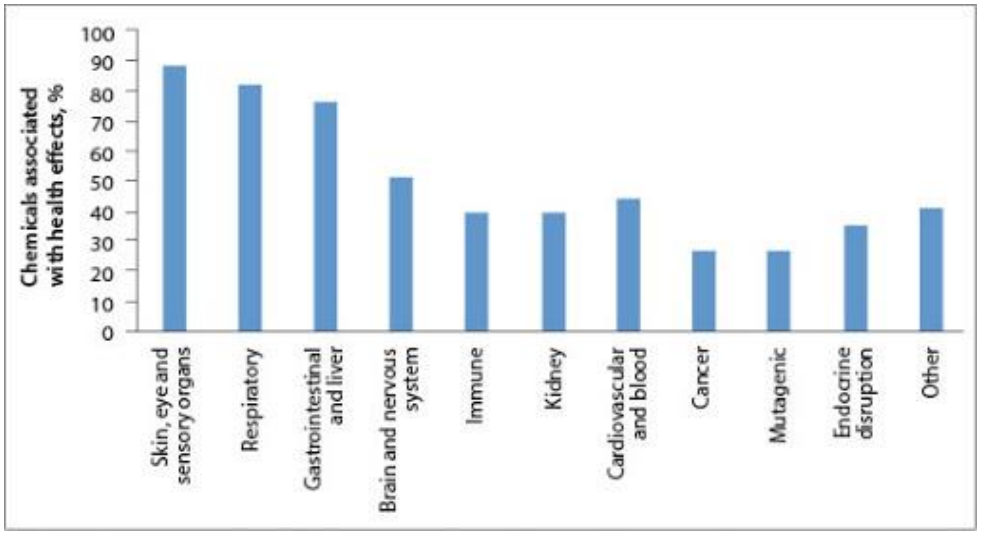

Figure 4.2 Potential health concerns due to chemicals used in fracking liquid (Mash, *et al*, 2014:33)

South Africa is not known for extraordinary seismic activity when compared to other parts of the world, but there have been a few provinces that have been pinpointed as potential areas for the most seismic activity within the country. Parts of Mpumalanga, the North-

West Province, the Western Cape, Kwa-Zulu Natal and Gauteng have been flagged as vulnerable to seismic activity. Although none of these areas are too close to the expected drilling or exploration sites (because there are no resident deposits), they could still be affected by any possible seismic activity caused by hydraulic fracturing (Kijko & Esterhuyse, 2017). There is a concern that, once hydraulic fracturing does get underway, South Africa could potentially see an increase in seismic activity.

Some researchers believe that to get any seismic activity directly related to hydraulic fracturing there has to be three contributing factors, which are: the state of any stresses in the sub-surface; the orientation and presence of tectonic plates; and the relation to and depth of the faults and hydraulic fracturing process as a whole. It may never be known whether these processes are the cause of seismic disturbances to occur, but many scientists and researchers are searching for the answers. Whether these conditions will be the cause for any increased seismic activity in South Africa, may only be determined once hydraulic fracturing is actually underway locally.

4.3.3 Water usage and contamination

One of the biggest environmental concerns when it comes to fracking is the effect on the water sources – under- and above ground. According to Raviv (2013:7) there are three main concerns related to hydraulic fracturing and the water debate. They are:

- the requirement of water,
- the amount and type of chemicals used in the water-fracking liquid; and lastly
- the storage and disposal of waste- and flowback water.

The first concern, the amount of water needed for the fracking process, is the starting point of the debate. As the Karoo has a large agricultural sector, its water requirements are already high. The volume of water needed for fracking to be successful can be put into perspective as follows: one hectare of crop in the Karoo can use approximately 5000m^3 (5 million litres) of water over a period of three to four months. The same amount of water needed to irrigate about four hectares of land is the amount that would be used over a period of five days for the fracking process (Vermeulen, 2012:153). Even this cannot be confirmed as the amount of water used in the process would depend on the actual frack site, which could use up to 20 million litres of water to drill. Some researchers conclude that hydraulic fracturing still uses less water than electricity production using coal.

> *While new natural-gas power plants use less water than coal-fired power plants, shale gas extraction through hydraulic fracturing has increased water utilisation and intensity (*Kondash*, et al, 2019:1).*

This may be true, but, in a country where water is already a scarce commodity – with an annual rainfall rate of approximately 500mm per year, becoming less every year (Raviv, 2013:8) – and the Karoo only experiencing about 200mm of rainfall a year, water supply is at a premium. In Figure 4.3 below, the average rainfall has dropped whilst the temperatures are rising.

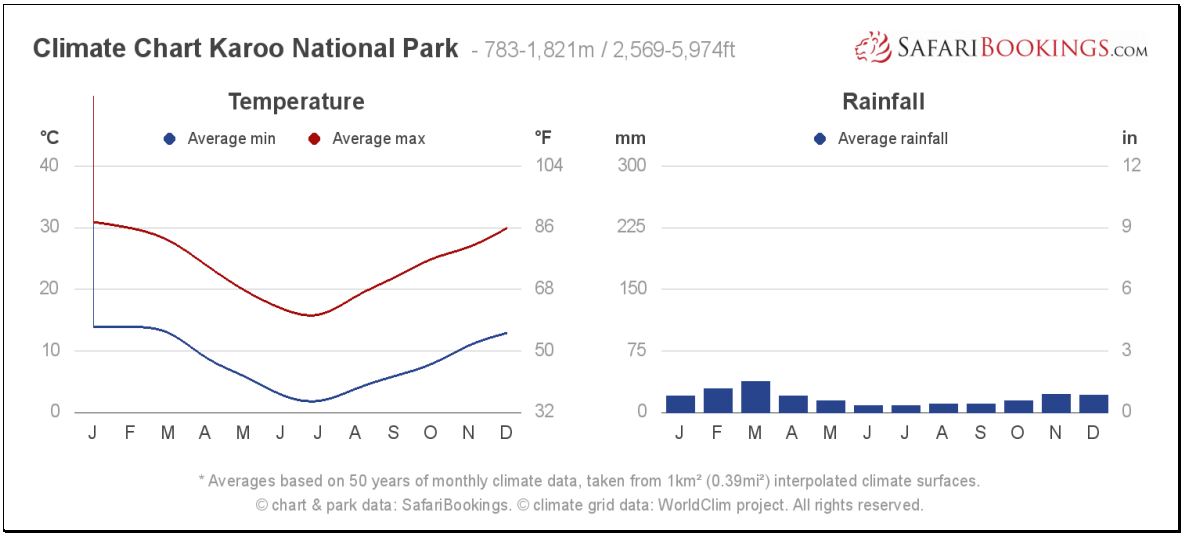

Figure 4.3 Average rainfall in the Karoo (Briggs, 2019)

Over and above the problem of water scarcity, the increase in the traffic burden close to towns where fracking takes place, and from trucks hauling wastewater to disposal sites, has in the USA resulted in a surge of road accidents and fatalities.

New research from Minhong Xu (2020), a professor of agricultural and consumer economics at the University of Illinois, shows that the growing traffic burden in fracking boomtowns from trucks hauling wastewater to disposal sites resulted in a surge of road fatalities and severe accidents[20].

> *When trucks need to transport all that water within a narrow window of time to a disposal site, that poses a safety threat to other drivers on the road – especially since fracking occurs mostly in these boomtowns where the roadway infrastructure isn't built up enough*

[20] The researchers identified a causal link between fracking-related trucking and fatal traffic crashes, finding that an additional post-fracking well within six miles of the road segments led to 8% more fatal crashes and 7,1% higher per-capita costs in accidents (Anon (e), 2020).

to handle heavy truck traffic (Xu, 2020).

This would also be dependent on where the water is sourced from. Most of the water used is drawn from surface water and sometimes even underground aquifers. The environmental concerns are brought in here because of the pending damage that may be caused to habitats for aquatic animals as well as the quality and quantity of water used for other purposes, especially for drinking.

There is a movement to find alternative routes and methods to reduce the amount of water required for the fracking process. Brackish water or sea water have been known to be used in the process, but the impact of using such water has not yet been researched (Allison & Mandler, 2018). Although there have been discoveries of sea water and brackish water reservoirs deep underground in the Karoo, there are concerns that this "impure" water can sterilise the soil around it (if there is water seepage) by robbing it of its minerals and rendering the soil useless for grazing and growing crops of any kind (Raviv, 2013:9).

Secondly, there are concerns that have to do with the chemicals that are mixed into the water to form the fracking liquid. The term for this fluid is slick water, consisting of a low viscosity chemical mixture made up of fine sand, chemicals and water (about 98% of the mixture). Each element in the mixture has a certain purpose during the process. The fine sand is used mostly because it helps keep the fracture open. The chemicals' purpose is to protect the well casing against corrosion, reducing friction as the liquid flows through. Some additives can be harmful to the environment around the sites as well as to humans, especially if they migrate into the water sources surrounding any site. There are approximately 1000 plus chemicals used in the fracking fluid, such as benzene, arsenic, formaldehyde, amongst other and all proven to be harmful to humans (Greenwood, 2016).

The transportation of water and chemicals to the sites place a tremendous amount of strain on the road transportation system as truck traffic will increase exponentially. The storage of chemicals prior to its use presents another threat. Even after the mixture is used, it is stored once again and will be added to any collection of wastewaters or flow-back. The danger posed is that – if any of this mixture or chemicals are spilled during any stage of transportation, injection into the well, storage of fluid and return of wastewater – it can have major implications for local water sources (Raviv, 2013:9).

Extraction of this wealth would require a complicated multi-faceted procedure which at several stages of its implementation, including inter alia, transport and storage of water

> *and chemicals, drilling and construction of the well, fluid injection, and wastewater storage and disposal, has the potential to contaminate and/or deplete water sources and contribute to air pollution* (Raviv, 2013:4*).*

The quantity of chemicals required will depend on the site area, the depth to be drilled and the thickness of the rock. So, the uncertainty and lack of any concrete evidence as to the effects of each chemical behind this mixture is valid, as about 750 (this was found for the period 2005-2009) different chemicals could be used in one mixture. The USA protects trade secrets that a company may have. This may result in the difficulty in obtaining a fully composed list of any additives that the companies have added to the fracking fluid. It has led to environmentalists in the USA struggling to pinpoint the specific problems relating to the toxicity of the chemicals. This situation has encouraged companies to withhold information, or to disclose any data based on their mixtures. An online fracking registry (FracFocus) has been started by the Interstate Oil and Gas Compact Commission (IOGCC) and the Ground Water Protection Council (GWPC) (Burden, *et al*, 2015:1). The registry allows companies to voluntarily publish their "ingredients" for their fracking fluid or are required to do so by law, as was passed in Texas.

Of the 750 chemicals used in fracking fluids, it has been reported that about 29 of these are known to be human carcinogens and are regulated in the USA under the Safe Drinking Water Act, or on the list for hazardous air pollutants which falls under the Clean Air Act. Between the years 2005 and 2009, a total of about 60 different fracking fluids listed xylene, toluene, benzene and ethyl benzene as components in their mixtures. About 43,1 million litres of products were injected over a five-year period and each of these fluids contained at least one of these chemicals. This practice is being phased out as there is some evidence of the adverse effect of these chemicals on humans and the environment. Stone (2017) substantiates the issue by example:

> *An epidemiological study of more than 400 000 patients of Pennsylvania's Geisinger clinic found a significant association between fracking and the increases in mild, moderate and severe cases of asthma (odds rations 4,4 to 1,5).*

In the South African context, the fracking fluids are described as DNAPLs (EPA (a), 2004) or LNAPLs (EPA (b), 2004). The Centre for Environmental Rights (CER) explains the importance of regulating all aspects of the fracking operations in a responsible manner:

> *The inadequate regulation of mining, and negligible compliance monitoring and enforcement has had and continues to have significant negative impacts on the*

> *environment in South Africa. Many of these impacts cannot be remedied, and will continue to impose heavy financial, health and environmental costs on society for the foreseeable future. In light of the potentially severe and pervasive effects associated with the nascent shale gas industry, in particular the fracking technique, it is particularly important that fracking is regulated by an appropriate and comprehensive regulatory regime that is implemented, monitored and enforced* (CER, 2014:2).

This especially relates to the chemicals being used and the effect thereof on the environment. The process of fracking can increase the permeability of the area that is fractured and then in turn may constitute an aquifer which can occur very far down from the surface (Steyl & Van Tonder, 2013:222). If this happens it can be seen as activity in a controlled environment, but the difficulty is that a whole lot of requirements will need to be investigated in order to make sure all regulatory practices are adhered to. Although there are concerns of the additives leaking into the soil and surrounding water sources around the sites, the contamination of water is mostly linked to the idea of the well stability. In other words, if the well is not stable and its integrity is compromised in any way, it could be a main cause of leakage into water, leading to contamination.

A recent sur suggested methane migration through casings and cementing, as one of their top 20 environmental concerns. State records for Pennsylvania from 2010 to 2013 showed that the wells had a failure rate of about 3-6% in the first three years. On a broader note, about 116 cases of well-water contamination was confirmed, in places such as Pennsylvania, West Virginia and Ohio. An ongoing case in Pavilion in Wyoming is still being investigated after the EPA found benzene and other toxins such as butoxyethanol in the groundwater (Jackson, *et al*, 2014:341). As the debate stands, with some wells showing signs of contamination and others showing no signs whatsoever, it is still unclear as to how much and to what extent hydraulic fracturing can actually contaminate the drinking water directly. Each side of the debate and each study has to be taken on a case by case basis.

Flowback water is a part of the fracking process; it literally means the fracking fluid flows back. The fluid that comes out of the well does no longer resemble the fracking fluid but rather the rock formation. This fluid is known as produced water and will continue to flow back as long as the well is in operation. This wastewater contains a variety of chemicals as well as toxic metals, salts and radioactivity. This presents a problem for fracking companies, as they need to dispose of the produced water. The water should ideally be recycled or reused, and methods are being developed to implement procedures for this.

Pennsylvania recycles a lot of the flowback water, but it does still leave an enormous amount of toxic water to get rid of (Anon, 2013).

Concerns of improper disposal or non-effective recycling of flowback water are high. With different chemical compounds and the possible radioactivity in the water, this poses a danger to all ground water (above and under).

The discussion now narrows down to a review of the benefits and its implications for South Africa, bearing in mind that there are merits to both the advantages and disadvantages of fracking.

4.4. BENEFITS OF FRACKING AND ITS POSSIBLE IMPLICATION FOR SOUTH AFRICA

The benefits of shale gas exploration for South Africa revolves primarily around economic activity, job creation and increased income, as well as increased clean energy efficiency. These three factors are interlinked and discussed below.

A major advantage (and probably most important for South Africa) that seems to draw the consensus of everyone debating the fracking issue, is certainly the financial growth opportunities that the country stands to gain from hydraulic fracturing. Feyrer, *et al*, (2015) found that fracking in the USA offers significant benefits, especially for local communities through economic growth and job creation. Employment in the USA mining industry grew by 60% during a period when the overall US unemployment reached 10% (Feyrer, *et al*, 2015). According to this report, the income effects take several forms. Workers' wages in the resource extraction and transportation industries are directly and positively impacted. Landowners receive royalties according to the value of mining on their properties. Auxiliary industries, indirectly related to the mining operations, are also positively impacted as these companies also experience economic growth.

Applying these benefits to South Africa, Twine, *et al* (2012:31), present two scenarios of the shale gas effect on the South African economy. The first scenario looks at a period of 25 years of mining gas to a total of 20 Trillion Tonnes per Cubic Foot (TCF), which could possibly generate a turnover of just over R400 trillion. Approximately 300 000 jobs can be created during this period. The second scenario works on an average of 50 TCF of gas being extracted over the same period of 25 years, but with a turnover of over R900 trillion and a total of over 850 000 jobs created. This is all an estimation from a report commissioned by Shell (an interested party in shale gas exploration), so the

independence of the report cannot be fully verified.[21]

The challenge for South Africa is to create resilient economic structures and resources that not only support urban municipalities and cities, but the country as a whole. Economic development and activity is important, because in turn this means that citizens can be economically independent and there will be less need for government intervention in the socio-economic affairs and demand for welfare support.[22] This can be achieved through economic diversification, and the expansion of various economically viable sectors to create jobs and boost revenues. Mining is a good option because it supports more than one sector, namely the mining, energy and auxiliary sectors as described in Section 4.2.2. Mining can ultimately improve the socio-economic status of citizens (McMahon & Moreira, 2014:11-12). In a country such as South Africa, where unemployment is high (refer to statistics mentioned in Chapter 3), new ventures that have the potential for job creation and socio-economic advancement are certainly worth investigating.

The increase in employment opportunities also involves education, since prospective employees will need to undergo specialized training to meet government and job requirements. As McMahon and Moreira (2014:35) explain, employees could be equipped with the necessary skills that will also benefit them should the fracking operations not succeed in the long term. Workers will be able to apply their new-found skills across other industries.

> *Thus, the fracking boom has had some short-run positive impact on economic development but it is unclear if this is sustainable long-term* (Mayer, 2017:3).

International investment in the country, also promises the broadening of different economic sectors, which in turn can boost employment opportunities in the future. Improved infrastructure will support Eskom's electricity supply problems, and the potential to expand the nuclear energy option could be on the energy table as well. Coal plant erection and storage facilities could be replaced by gas alternatives and the potential for the export of gas internationally could become a reality.

> *The shale revolution in the United States has in general brought down gas prices, and the*

[21] Shell maintains that hydraulic fracturing could benefit South Africa as a whole. The company says that it is possible to frack responsibly with regards to the environment and the people of the area (Raviv, 2013:14).

[22] Welfare support in South Africa is called a social grant. These grants are administered by SASSA. The social grant programme was put into place to improve standards of living and are given to those who are in need of state support and vulnerable to poverty. People who usually receive grants are people living with disabilities, older people and people with young children (Western Cape Government, 2020)

> *growth of destination-flexible, hub-priced LNG exports from the United States is providing a catalyst for a more liquid global gas market (IEA, 2019).*

As stated earlier, South Africa is currently experiencing major difficulties to keep up with the demand for energy. It has simply not been able to produce electricity at a viable rate or even a consistent rate. Bad coal in some instances cause more problems with the generation of electricity, resulting in even more expensive problems, such as damage to power plants. The American Gas Association (Snyders, 2016:6) states that only 5 TCF of gas is enough for about fifteen years of household energy and can be used to power approximately five million homes (Anon (a), 2018).

Considering the size of the South African population[23] and potential future energy demand, alternative sources of power could secure energy in all rural areas, fulfilling the Government's promises as per the NDP (National Development Plan) to provide all citizens with electricity as part of their development goals for 2030 and also to:

> *Enable exploratory drilling to identify economically recoverable coal seam and shale gas reserves, while environmental investigations will continue to ascertain whether sustainable exploitation of these resources is possible* (NDP, 2011:65).

Coal independence would be a giant step in the right direction for South Africa (Anon (a), 2018). Not only would electricity supply stabilize, but many more households could have access to electricity. With the current problems of load shedding due to power shortages, or bad coal, causing severe loss of revenue for many companies, the prospect of alternative energy options sounds economically viable. Electricity could be supplied cheaper and more efficiently.

With a population that keeps growing at a rate of 1,89% p.a., resulting in increasing demand, electricity could be readily available without the need to import resources from anywhere else (Anon (a), 2018).

Furthering the independence debate, as natural resources start becoming scarcer, countries will have to develop certain commodities themselves. Within the geopolitical space, and considering the power that more affluent countries hold over the global supply of commodities, South Africa would be in an advantageous position. The Government won't need to import oil or gas from oil rich countries as an energy alternative should fracking succeed. Hydraulic fracturing can extract deposits from much deeper than

[23] South Africa's population in 2020 is estimated at 59,62 million people (StatsSA (b), 2020).

conventional mining can, which means that there may be a chance of extracting more oil and gas from great depths within the earth's core. The gas can also be transformed into different types of fuel for household application, transportation, cooking and heating (Anon (a), 2018), benefitting not just industry, but society as a whole. The clock is ticking and scientists warn that it may only be a few years before the country and indeed the world run out of fossil fuels as Bridle and Geddes remarks:

> *The country does not have major proved reserves of oil and gas* (Bridle & Geddes (b), 2019:1-3*).*

South Africa is one of the countries worldwide who are committed to take steps ensuring that it's CO_2 and greenhouse gas emissions are reduced. At present and as a country that is dependent on coal as a base for energy production, South Africa features close to the top of the list as one of the largest producers of greenhouse gases and CO_2 (Ritchie & Roser, 2020). One cannot ignore the fact that shale gas as a fuel is a cleaner option than the presently used coal option. There are huge advantages for not making use of any fossil fuels. From an environmental perspective this may be a contradictory argument since on one hand environmentalists are fighting against fracking because of the possible environmental damage to the Karoo ecosystem; on the other hand, there is a huge need for cleaner fuel, and this may be the very answer (besides nuclear or even solar/wind power). It is cleaner than fossil fuels, and could potentially lead to a better quality of air (Jeffery, 2015:21-22). The production of gas will help with the unreliability and variability of any renewables, because it emits less CO_2 gases. The waste volumes of shale gas are also considerably lower than other alternatives (Jeffery, 2015:21-23).

These benefits are worth considering in the decision-making process the South African government needs to follow. The Supreme court in 2019 decided that the legal frameworks for hydraulic fracturing could not be substantiated since the ministry who submitted the legal guidelines were not competent to regulate any environmental matters. Until the applicable environmental regulatory framework issues are sorted by the relevant authorities, the exploration and exploitation of gas activities cannot proceed (Townsend, 2020).

4.5. CONCLUSION

In this chapter the advantages and disadvantages of hydraulic fracturing were explored. Firstly, a holistic view was taken with regards to hydraulic fracturing from a global

perspective, exploring some listed advantages and disadvantages. The literature and studies conducted, emphasizes that hydraulic fracturing offers real, undeniable financial and socio-economic benefits. Local communities will benefit by way of improved infrastructure and employment opportunities. At a national level, increased revenue potential through energy exports which contributes to economic growth, are anticipated. However, the disadvantages cannot be ignored. The threat to the environment in terms of possible seismic activity, water and ground pollution and the excessive use of scarce water resources has kept the debate alive and current.

Secondly, the focus was narrowed down to the South African situation and the Karoo. The relevant chapter explored the most important advantages and disadvantages in the South African context to see if the international experience may heed the same or similar results in the Karoo environment.

In Chapter 5 the research established as the basis for this study will be evaluated in terms of having achieved its objectives. The theoretical foundation as described in Chapter 1, Section 1.4 will be revisited, highlighting core aspects of environmental political thought as it applies to the debate around socio-economic advancement of communities versus the health of the environment. The extent to which the research objectives were achieved will be reviewed, and the discussion will touch on the developments around deep-sea and abyssal gas mining as an increasingly probable and safer option for gas exploration in the near future.

CHAPTER 5

POTENTIAL MEASURES FOR FRACTURING IN SOUTH AFRICA'S KAROO: RECOMMENDATIONS AND CONCLUSION

5.1 INTRODUCTION

The demand for global gas is expected to increase exponentially over the next five years, taking the lead from coal power generated energy. Major stakeholders and investors are shifting their interest toward deep water exploration, as the potential for supply of oil and gas for the next few decades is guaranteed (Anon (f), 2020).

Not only is Chinese gas demand set to grow by about 60%, and the growth in global gas demand over 40% by 2023 (IEA, 2018), but the requirements for deep sea gas exploration is also expanding. Off-shore exploration efforts are now going as deep as 500m. Sea gas exploration is being extended into abyssal and ultra-abyssal sea areas with depths exceeding 500m, and expectations in China of exploring depths of up to 3000m (IEA, 2018).

The current and contentious debate around hydraulic fracturing in the world only forms a limited part of the wider debate on the exploration and mining of gas deposits. Investment in research and technology have mostly been to the benefit of deep-sea gas mining with research in and recommendations on infrastructure, utilization and storage technology, and significant emphasis on the improvement of the future environmental footprint.

Oil and gas exploration in the sea has a history that goes back to the early 20th century. Greece boasted the first hydrocarbon exploration activities. Sea exploration is still taking place many years later. The offshore gas fields along the coasts of Palestine, Egypt, Israel and Cyprus have had some influence on the gas market in this region (Kostianoy & Carpenter, 2018:1). This exploration and industrialisation of offshore or deep-sea gas and oil exploration is expanding. Oil is becoming more difficult to come by on shore, which leaves oil reserves in the oceans as the next option. There is a problem though with environmental management due to the lack of sufficient data in deep sea ecosystems. These exploration efforts do not always adhere to legislature, which should all reflect ways to conserve the environment. There is a need to collaborate all knowledge of sea ecology, the scattered environmental protection measures and human impacts on deep water ecosystems in order to make this sustainable (Cordes, *et al*, 2016).

The purpose of the study was to focus on the feasibility of the South African government's intentions to extract natural gas through hydraulic fracturing, with specific reference to the Karoo. A critical analysis of the consequences and practice of hydraulic fracturing on a global level was addressed, as well as the potential relevance for South Africa. The research specifically identified and analysed the positive and negative consequences of hydraulic fracturing internationally and in the areas in South Africa where gas deposits have been identified. However, the outcome of research and analysis have shown that the verdict is still out. Shale gas mining in South Africa will substantially meet energy and socio-economic needs according to many expert studies discussed in the research, but hydraulic fracturing, especially in the Karoo, will potentially have many more detrimental effects. There is consensus amongst mining companies, investors, and the Government that the process should, if it goes ahead, recognize environmental safety as the number one priority, whilst managing the negative aspects of the mining operations within the parameters set by government.

Chapter 1 specifically focused on the South African government's efforts to not only diversify the energy sector in South Africa, but also to explore different kinds of cleaner energy. The chapter gave an overview of the country's efforts in this regard, from the commitment to the UN's Paris agreement, to the commissioning of wind farms in Port Elizabeth and the Eastern Cape. The chapter discussed the need to produce more energy to support the country's grid, which is how the hydraulic fracturing debate started. Two new sources that have also been put on the table for possible exploration is nuclear power with Russian technology, and hydraulic fracturing with global companies as investors. As South Africa has one of the largest areas of shale gas in the world, it makes this method particularly attractive for explorers.

Chapter 1 to 2 laid the foundation for the study, analysing the data on hydraulic fracturing on a qualitative level using empirical research done over the past few decades.[24] These chapters analysed hydraulic fracturing issues and operations from an international perspective, whilst exploring some listed advantages and disadvantages. The focus then shifted in Chapter 3 to the government's efforts to regulate hydraulic fracturing, and highlights the measures set in place focussing on regulations and laws to manage the process and which forces mining companies to toe the line. Sources consulted in this

[24] Chapter 1, Section 1.8, refers to the type of research that implies that hydraulic fracturing could be good for South Africa. Chapter 2, Section 2.7, explores the practice of hydraulic fracturing and some studies about how it is practiced and the benefits thereof. Chapter 3, Section 3.3, refers to the reasons why South Africa is exploring the option of shale gas.

regard were the NWA, NEMA, the Bill of Rights and the MPRDA, which are representative of Governments policy and perspectives towards the management of SA's natural resources, mining rights and practices, and the environment. Chapter 4 unpacked the advantages and disadvantages, concerns and potential benefits within the South African context with specific reference to the Karoo and its fragile, water scarce environment.

Chapter 5 will highlight to what extent the qualitative research done in this study has achieved its objective. Firstly, the theoretical foundation of the study will be revisited, highlighting core aspects of environmental political thought as it applies to the phenomenon of socio-economic advancement of communities versus the health of the environment. Secondly, the findings of the research are measured against the research questions as set out in Chapter 1, Section 1.6, and explain how the research objectives were achieved. From a global perspective, and bearing in mind that deep-sea gas mining seems to primarily be the path gas exploration will take over the next few decades (Mahundla, 2019), final conclusions will be presented in this chapter, as a possible outcome to the question: "To frack or not to frack?"

5.2 THEORETICAL RATIONALE BEHIND THE RESEARCH

In Chapter 1, Section 1.5, the Central Theoretical Statement was formulated as follows: There is a causal relationship between hydraulic fracturing and the potential contamination of the earth's water supply. Human intervention in the form of hydraulic fracturing may be materially beneficial as an alternative source of energy, but it can potentially lead to the contamination of the scarce and fragile subterranean and surface water supplies of the Karoo region in South Africa.

As indicated in Chapter 1, qualitative research was conducted from an environmental political perspective. Environmentalism is based on the belief in the interconnectedness of humans and nature, and deemed to be a non-radical approach towards protecting the environment. The environment is viewed to be a legitimate source of energy that must be utilised towards the benefit of all life. Environmentalists seek a balance between human intervention in nature and the protection and conservation of the environment. Goodwin (2014:255) refers to this approach as follows:

> *Environmentalism is a political doctrine or ideology which holds that humans should reduce their adverse impact on the natural world.*

Meyer (in Dryzek, *et al*:773) describes environmental concerns as a recognisable part of the political landscape and defines it as an "issue" area that "a nominally democratic or pluralistic political system should attend to when making policy". Meyer supports Dobson (in Dryzek, *et al*:778) who takes the viewpoint that the natural world affects and is affected by political decisions and the redefinition of political actions that impact the environment has been central to the work of environmental political theorists. Meyer (in Dryzek, *et al*:778) supports the view that the political should incorporate ecologically vital perspectives, instead of addressing it in the "sub-political" realm. Ecological issues are too often depoliticized and promoted by governments and global developers as the area of, for example, civil engineering, or scientific experiment, or property ownership – and not within political boundaries. Governments need to recognize that environmentalism is a world-view, even an ideology (Meyer, in Dryzek, *et al*:779) and should embrace environmentalism as part of their democratic policy, with full political participation and environmentally responsible sentiments and values (Meyer, in Dryzek, *et a*l:784). The phenomenon of hydraulic fracturing presents a critical example of natural world versus government policy and action. It is from this point of departure that the study analysed the existence and feasibility of shale gas exploration on a global as well as a national (South African) perspective. Against this contextual background research was conducted impartially and the definition, as well as potential advantages and disadvantages of hydraulic fracturing, were critically addressed. Through this approach the research was narrowed down to the South African government's policies, plans and responsibility should fracturing proceed in the Karoo area.

In the following section the research questions and objectives as laid out in Chapter 1 will be synchronized with the theoretical base of the study, in order to determine whether the research done did in fact meet with the original aims of the study.

5.3 RESEARCH QUESTIONS ADDRESSED AND OBJECTIVES ACHIEVED

The research questions as set out in Chapter 1, Section 1.5, covered the broad spectrum of what Meyer calls the "issues." (See Chapter 5, Section 5.2.) The study has addressed the research questions and achieved its objectives as follows:

Research Question 1: Why is the issue of hydraulic fracturing for natural gas deposits in South Africa's Karoo region problematic?

The threat to the global environment in terms of possible seismic activity, water and

ground pollution, and the excessive use of scarce water resources has kept the debate alive and current. The focus was narrowed down to the South African situation and the Karoo. The chapter explored the most important advantages and disadvantages in the South African context and concluded that the excessive requirements of water, in an area that is extremely water scarce, the amount and type of chemicals used, as well as the storage and disposal of wastewater present real challenges to the health and safety of communities in the Karoo and country as a whole. The research objective to understand why South Africa's plans to explore hydraulic fracturing in the Karoo are so problematic were therefore achieved.

Research Question 2: How important is energy to modern society and precisely where does fracturing feature in the energy sector?

Chapter 2 addressed the history and effect of energy on modern society. It analysed the viability of gas exploration as an alternative renewable resource and how it fits into the energy sector. A theoretical base was created and discussed, highlighting various aspects of the relationship between human development and its impact on the environment. The point was made in Chapter 1 that these two areas are interdependent, but that the responsibility rests squarely on the shoulders of governments to manage and protect both its citizens and the environment in this highly contentious issue. In terms of the research objective to consider the importance of energy in modern society and the status of hydraulic fracturing in the sector, it is clear that hydraulic fracturing is internationally already part of the energy supply chain, as energy production from gas exploration is expected to overtake coal mining in the near future. (Refer to Chapter 4, Section 4.2.1.) Its importance in the global energy mix will only increase as countries become more dependent on alternative energy resources.

Research Question 3: What are the South African government's plans and prospects for hydraulic fracturing in the Karoo area?

Chapter 3 elaborated on the South African government's view that it has a responsibility towards its citizens in terms of protecting the environment and creating a balance between economic development and protection of South Africa's natural resources. The most important regulations regarding the actions of licensees and water management were discussed and the research found that the South African government has sound plans and policies in place should hydraulic fracturing proceed in the Karoo in the foreseeable future. In terms of the research objective to describe the South African

government's current plans and prospects for hydraulic fracturing in the Karoo, the South African Government's policies were clearly identified.

Research Question 4: What are the advantages and/or disadvantages of hydraulic fracturing in South Africa?

Chapter 4 dealt extensively with the "nitty gritty" of this question. The advantages and benefits to the South African economy cannot be ignored, but the potential for environmental damage and the communities who depend on the scarce water resources in the Karoo region where fracking has been licensed to take place, presents a sizable threat to the health and safety of both the environment and indigenous communities. Job creation, infrastructure development and economic growth and advancement of poor communities are but a few of the advantages that could come with the implementation of fracking in the Karoo, but the research found that the disadvantages presented by potential seismic activity, excessive water usage, contamination and storage would cause irreparable damage to the frail Karoo environment. In terms of the research objective to contemplate the potential advantages and disadvantages of hydraulic fracturing in South Africa's Karoo area, the debate is recognized as ongoing as recommendations are also on the table for alternatives such as abyssal deep-sea gas exploration.

Research Question 5: What potential measures can be taken to effectively plan, coordinate and execute hydraulic fracturing in South Africa? And what conclusions and recommendations can be made?

Throughout the study, references were made, in each chapter, to how the effects of shale gas exploration in other countries such as the USA and Russia could apply to the South African situation. In Chapter 3 specific reference is made to the South African government's plans regarding the implementation of hydraulic fracturing in the Karoo and broader areas. Specific emphasis was placed on the laws that government has put in place and it was discussed in detail. It was concluded from the research, as presented in this study, that the debate on hydraulic fracturing in the Karoo is far from over and that more investigation needs to be done in a very responsible way before energy companies such as Shell, and other stakeholders are allowed to proceed with gas mining efforts. The fact that deep-sea mining technology has advanced substantially, becoming the trend internationally, begs the question whether hydraulic fracturing should be considered at all, and whether the emphasis should not rather shift to these alternative types of gas

exploration, which seems to present less danger to the environment. The research objective to outline potential measures that may be taken to ensure proper planning, coordinating and execution of hydraulic fracturing in South Africa was extensively dealt with in Chapter 4. Chapter 5 will provide a potential conclusion on the unfolding issue of hydraulic fracturing in South Africa from an environmental political perspective.

Since hydraulic fracturing remains on the table as an option to deal with the current and pressing South African energy crisis, it is therefore imperative to explore the future political-environmental measures that the South African government needs to put in place, to manage this very contentious phenomenon.

5.4 POTENTIAL MEASURES IN SOUTH AFRICA TO MANAGE EXPLORATION OF HYDRAULIC FRACTURING

In Chapter 3, Section 3.5, the following variables are highlighted as the framework for the implementation and management of fracking going forward in an environmentally secure way. These are:

- The Constitution
- Specific Laws & regulations
- Open and vigorous debate

The South African Constitution, amongst the most progressive in the world, was signed into law on 10 December 1996 (Graham, 2015: 101). Since then, South Africa, and all its people, have been ruled within the parameters of the constitution, as the highest law in the land, encompassing the Bill of Rights, and under the oversight of the Constitutional Court. The constitution protects the rights and freedom of all South Africans, including their safety, security and property. It also covers aspects of protecting the environment, with reference to its unique landscape and ecosystem as discussed in Chapter 3, Section 3.8.

Act 108 of 1996, Section 24, describes the environmental right in the Constitution of the Republic of South Africa. This right is interpreted to have a two-fold purpose. Firstly, it guarantees a healthy living environment to every person. Secondly, the Act mandates the State to ensure compliance with the first part of the Act which prohibited the State from infringing on the right to environmental protection. The State is further required to provide the necessary protection against any harmful conduct towards the environment (Polity,

2018). Thirdly, flowing from the constitution, specific laws have been put in place to ensure the protection of the environment, so that water and chemical waste management procedures are implemented in a safe and cost-effective manner. Chapter 3, Section 3.5, detailed the most important. laws, currently ensuring that mining companies cannot involve themselves in any illegal or irresponsible mining activities. These acts revolve around the protection of the nation's water resources, whilst The National Water Act 36 of 1998 (NWA) established a general framework of environmental management principles. The Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA) reaffirms government's mandate in protecting its people for everyone's benefit, including the environment, and it ensures the promotion of social and economic development.

All these Acts, the NWA, NEMA, MPRDA, as well as the National Climate Change Response White Paper, ensure that both the authorities and the hydraulic fracturing companies are compelled by law to consider ecological and environmental issues before any kind of procedures or exploration can take place.

Throughout the study the ongoing debate on the advantages and disadvantages of hydraulic fracturing was held front and centre. The fine balance between politics and the environment have been argued, as well as the efforts of interest groups to de-politicise environmental issues. Further debate on whether fracking is safe in terms of the health and safety of communities, water contamination and general fear of environmental contamination is constantly on the forefront of this debate. In contrast, the "pro-frackers" fuel the debate by accentuating the benefits to communities, the potential for economic growth and the advantages of energy diversification.

It is clear that after considering all the arguments presented in the study, the most important political argument is that the debate is still current. In terms of the purpose of the study, the government's role and mandate in protecting both the environment and its citizens is part and parcel of the normative democratic principles of constitutional democracy and the government's role as the protector of citizens' rights, property and freedoms as discussed in the following section.

5.5 MAIN FINDINGS OF THE RESEARCH

In the study conducted there are specific findings that can be extracted from the research and applied to the South African situation. The advantages and disadvantages identified in fracking locations around the world are also applicable to the South African situation.

(As highlighted in Chapter 4.) The main findings revolve around 1) democratic principles (rights and freedoms of all citizens) as applied by the South African government, 2) the government's mandate regarding the environment and the protection thereof, which involves balancing the benefits and potential disadvantages, and 3) at application level the potential dangers around water usage, contamination and storage in the Karoo area, and the effect on resident communities.

5.5.1 Democratic principles (Macro environment)

With the guarantees secured in the Constitution around the rights and freedoms of citizens versus the protection of the environment, the focus in political thought falls on the rights and freedoms of all citizens, as well as the levels of human encroachment on the environment. These rights are protected under the South African Constitution and Bill of Rights, preventing outside energy companies and investors from proceeding with any hydraulic fractioning without the assurance that all exploration procedures will be safe and that disadvantages are managed and contained. The South African government are following the agreements on climate change (2015, Paris, France) and seems to adhere to the political-environmental thought that, should disadvantages outweigh the advantages, or benefits of fracking in the Karoo, alternative sources of gas exploration should rather be considered.

5.5.2 Government state role and mandate: managing the advantages and disadvantages

In terms of the government's role or mandate, it is noteworthy that a number of laws have been passed since 1996 to manage the process, and to further protect the communities and the environment against the potential disadvantages of fracking. These laws have been discussed in Chapter 3, Section 3.5, and again summarised in Chapter 5, Section 5.4. The Government's promises of socio-economic upliftment through the expansion of job opportunities that fracking will secure, are balanced in these laws to protect against pollution of the underground water resources. So far, the government have been steadfast, in spite of the allocation of fracking licences to some exploration companies. (See Chapter 2.) The government is also clear on the fact that the phenomenon needs to still be researched further, and that alternative options of shape gas extraction still need to be further explored. Through very open and vigorous debate, especially in the media,

a wide range of opinions have been accumulating around the logistics should fracking proceed in the Karoo.

On an application level the actual dangers to the contamination of underground water, the transport, storage and removal of waste water, was hypothetically applied to the Karoo. It was found that this area is so scarce in terms of water supply, that water will have to be transported in, placing huge strain on road infrastructure, adding to the disadvantages. The issue around water management and fracking is discussed in detail in Chapter 3).

A fourth finding that should be noted, and touched on in the introduction to this chapter, is that more governments globally are in fact investigating alternative energy resources to fracking, such as deep-sea abyssal exploration, wind farms, solar and nuclear options, etc. (See Chapter 2.) Whilst all these renewable forms of energy infringe in one way or another on the health or landscape of the environment, there may be alternatives available that could spare the Karoo area environmental harm. These alternatives need to be further explored.

5.6 CONCLUSION

Whilst there are numerous advantages and benefits for government, citizens and energy companies, should shale gas exploration commence in the Karoo, internationally or at a local level, fracking can never be seen in isolation from the environment. However, data collected in the study is to a large extent inconclusive as the arguments in the fracking debate are equally strong from both sides.

The benefits around fracking are mostly related to the advancement of socio-economic conditions of communities within the mining areas through job creation and the improvement of infrastructure. Hydraulic fracturing could add substantially to the energy grid, going some way in alleviating the huge energy shortage that South Africa is experiencing at present. Adding the financial benefits from energy exports, that can boost the GDP, hydraulic fracturing can contribute not only to financial growth throughout the broader South Africa, but also specifically in areas, such as the Karoo where the economy depends mainly on agriculture. In recent years with the earth's carbon footprint growing and climate change's drastic effect on weather patterns, most agricultural regions have been in dire need of more diversity when it comes to their economic production platforms (Figurek, *et al*.,2012:52). Farming communities, for the sake of the people and their

financial stability, now depend on alternative efforts to diversify their incomes. Hydraulic fracturing may well be one of the solutions allowing for diversification of the economy in the Karoo.

However, the argument for the negative impact of fracking on the environment remains compelling, as the debate on climate change and the human carbon footprint gains momentum. This is also one of the reasons why governments and social groups are calling for change in the harvesting of energy from the earth, and urging governments to relook at the methods whereby they boost their energy resources. The search for alternative clean energy is one way to remedy, or at least slow down, the climate change that the earth is experiencing (WWF, 2015).

In this regard, extensive studies into alternative gas exploration are ongoing, locally as well as globally, with deep-sea gas mining and the nuclear options that are, of course, on the table.

Chapter 5 has dealt with the nature of hydraulic fracturing as a phenomenon that is part and parcel of the political environmental debate. The legislation formed a foundation as to how companies need to engage in the process and what the authorities need to take into consideration when evaluating applications.

Based on the research presented with regards to hydraulic fracturing in the Karoo, it is evident that South Africa may not be ready to explore hydraulic fracturing as an alternative energy source. The primary recommendation of this study is that the South African government must explore other alternatives for cleaner and safer renewable energy resources, like solar and wind power. Hydraulic fracturing, according to the evidence collected in this study, is not a long-term energy solution to the South African energy problem.

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