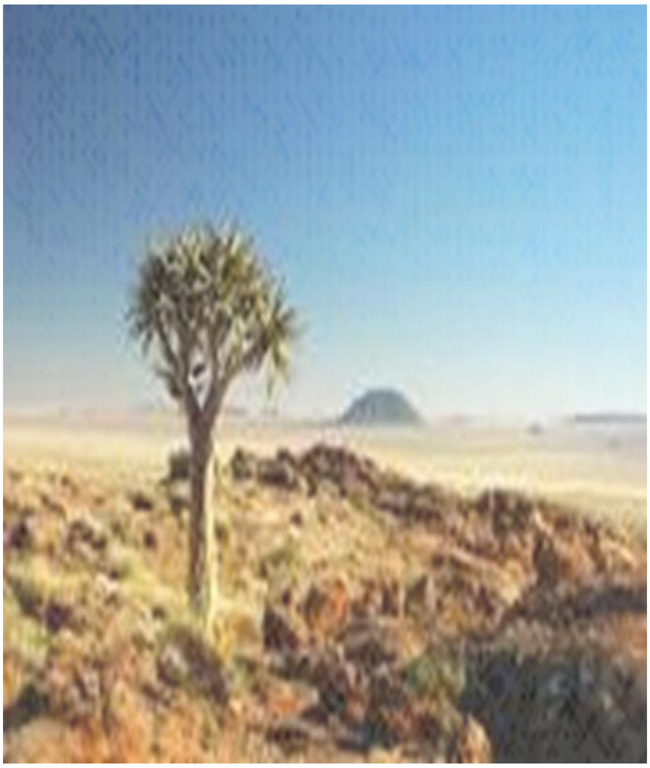

SHALE GAS FRACKING IN THE KAROO

SYNOPSIS ON CENTRAL ISSUES AROUND HYDRAULIC FRACTURING

Department of Economic Development and Tourism

Quarter 1 Economic Intelligence Report 2016/17

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Acronyms

CGS	Council of Geoscience
CNG	Compressed Natural Gas
CCGT	Combined cycle gas turbine
CSIR	Council for Scientific and Industrial Research
FTE	Full Time Equivalent
HSE	Health and Safety Executive
IEA	International Energy Agency
LACs	Limits of acceptable change
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
NDP	National Development Plan
OCGT	Open cycle gas turbine
SANBI	South African National Biodiversity Institute
SALT	Southern African Large Telescope
SKA	Square Kilometer Array
SEA	Strategic Environmental Assessment
Tcf	Trillion cubic feet
USA	United States of America
UK	United Kingdom

1. Background & Introduction

The National Development Plan (NDP) calls attention to the importance of having a well-developed energy sector. This is in order to support economic growth and development, social equity by means of expanded access to energy at affordable prices; and environmental sustainability, by way of reduction in pollution and mitigating climate change. Accordingly, it places emphasis on the need for an energy sector that is more diverse, with a greater emphasis on gas and renewable energy sources. In relation to gas, the NDP calls for further investigation of gas as an alternative to coal as a source of energy, particularly off-shore natural gas, coal-bed methane gas and shale gas. (National Planning Commission, 2012).

The blueprint argues that gas as an alternative energy source has several advantages as a power generation fuel. Firstly gas fired generators, complement large scale renewable integration by compensating for the intermittency of wind and solar generation and backing up hydropower during times of drought. Most importantly burning gas emits approximately half the carbon dioxide as compared to coal and thirty percent (30%) less than oil. However, the case for gas fired energy, remains not only complex but competes with energy resources such as coal and hydro power which are well abundant in Sub-Saharan Africa (Santley, Schlotterer, & Eberhard, 2014).

For the longest time, South Africa's primary energy supply has been derived from coal (67%), followed by crude oil (20%) with nuclear, natural gas and renewable energy, playing a less significant role (13%). This is according to the Department of Energy. Logically, as at 2013, ninety percent (90%) of the country's electricity was generated from coal, followed by nuclear, hydro, petroleum products, natural gas and lastly renewable energy. According to the Gas Infrastructure plan 2005, the demand for natural gas has grown considerably since the 1970's. In catching up with these growth trends, and the recent NDP call for a diverse energy sector, South Africa has seen growth in demand for natural gas, particularly with the arrival of "First Gas" from Mozambique in 2004.

This economic intelligence report is a basic synopsis of the most recent knowledge available as it relates to shale gas extraction and plans to extract shale gas in the part of the Karoo in the Northern Cape. Its objective is to draw attention to the central issues around hydraulic fracturing of shale gas, by firstly outlining potential opportunities that are linked to the extraction of shale gas. In addition, the report also draws attention to possible challenges for the Northern Cape. The inscription of which relied extensively on analysis of secondary data from various sources, including research reports, policy documents, articles, journal reports and so on.

2. Shale Gas Fracturing (Fracking) in the Northern Cape

2.1 Defining shale Gas

The Mineral and Petroleum Resources Development Act defines 'petroleum' to include natural gas. In terms of the regulatory aspect of the Act, 'petroleum' includes all forms of natural gas, including coalbed methane and shale gas. 'Shale' refers to type of sedimentary rock consisting of very fine grained particles, specifically clay, with a varying amount of quartz, other mineral such as calcite and organic fragments. Shale is characterized by a laminar structure and has low porosity and extremely low permeability.

'Shale Gas' on the other hand is a hydrocarbon gas which is extracted from shale and typically comprises of methane, and smaller quantities of carbon dioxide, oxygen, nitrogen, hydrogen sulphide, ethane and propane. It should be noted that not all shale is suitable for shale gas extraction. Shale gas resources are usually found between 1500 and 4000 meters beneath the surface (Department of Mineral Resources, 2012).

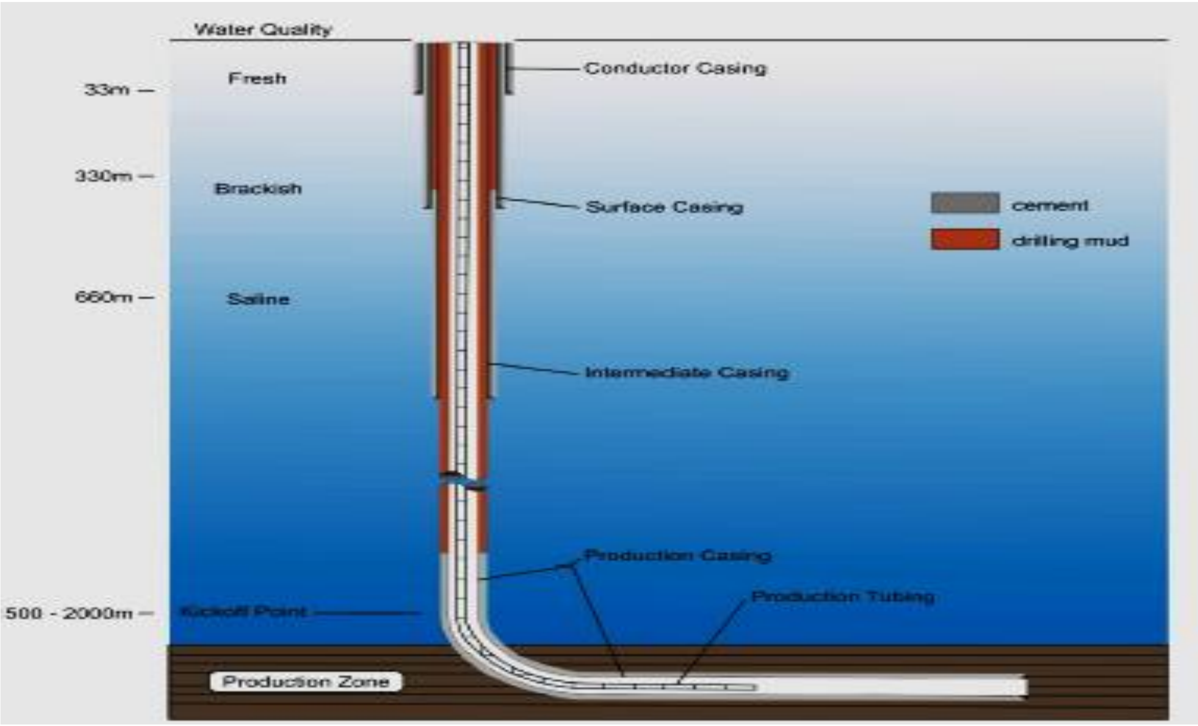
2.1.1 Hydraulic Fracturing

Hydraulic Fracturing, commonly known as 'fracking', is the term used to describe the overall procedure applied in the extraction of shale gas. It is a class of operations which is referred to as "reservoir stimulation". It also describes the general procedure of breaking open rocks by applying force through a fluid medium or "carrier". Other fluids utilized include Liquefied Petroleum Gas (LPG), liquid nitrogen, liquid carbon dioxide, and other liquid carbons.

The process of hydraulic fracturing can be divided into that which uses plain water and those using what is referred to as 'slick water'. Concerning 'slick water', additional chemicals are added in order to reduce the friction of the fluid while being pumped through piping and into the shale. It seems that in the case of South Africa, slick water will be the most likely form to be applied in the event of approval. In addition, solid particles (quartz sand) are added during the process.

The solid particles are wedged into new fractures in order to hold them open when pumping stops. The fracturing fluid is allowed to flow back up the borehole, clearing the way for the flow of gas. In the case of South Africa, the type of additives used will depend on the physical and chemical properties of the shale gas, the carrier fluid and depth and temperature at which the fracturing will take place. Unique to South Africa is the presence of "prolific dolerite sills, dykes and kimberlites in the Karoo Basin, which can potentially complicate matters (Department of Mineral Resources, 2012). The diagram below, represents the construction of a shale gas well.

Figure. 1 Schematic diagram of shale gas well construction.[1]

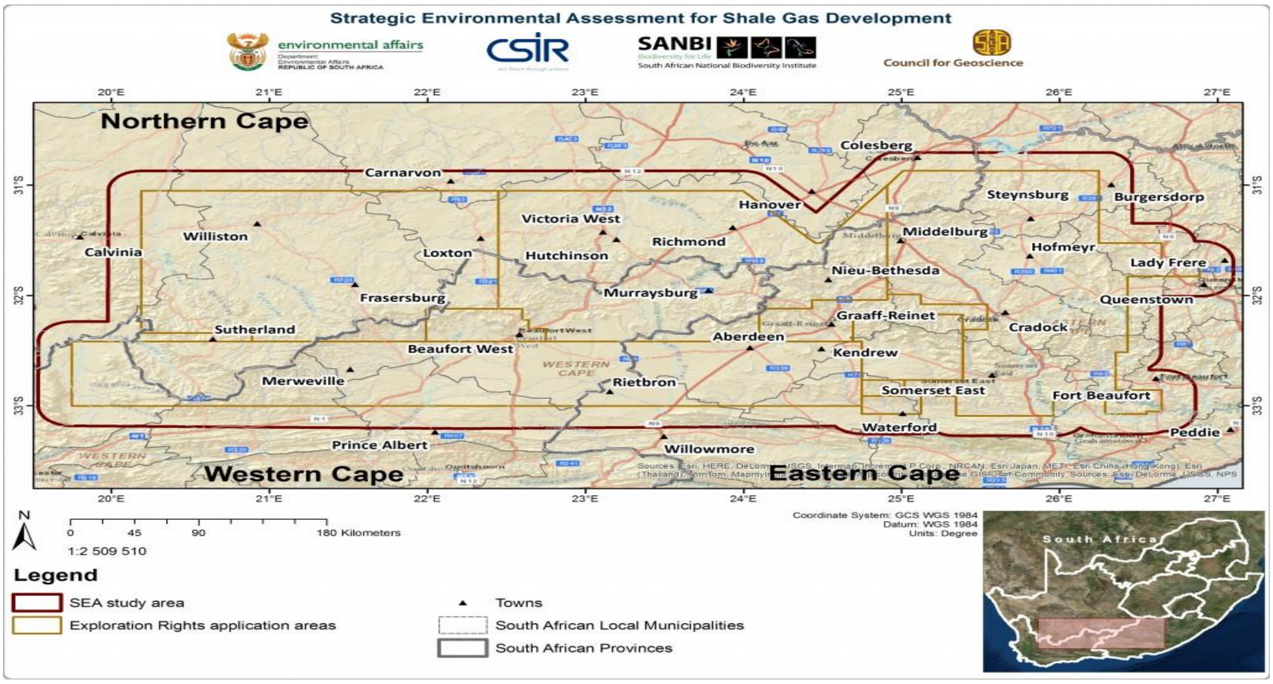


2.2 Proposed Areas for Hydraulic Fracturing

Petroleum Agency SA estimated that a minimum of 30 Trillion cubic feet (Tcf) and a maximum of 500 Tcf may be technically recoverable. However these assessments of recoverable volumes of shale gas resources should be viewed with caution, as uncertainty will remain until specific exploration in the form of drilling and sampling of shales and testing of boreholes is conducted in the areas of the Karoo Basin, where shale gas reserves are believed to be present. The map below outlines the areas where proposed exploration will take place if approved as well as the study area for the planned Strategic Environment Assessment to take place.

[1] Department of Mineral Resources,2012.

Figure. 2 Geographical representation of exploration right areas.[2]

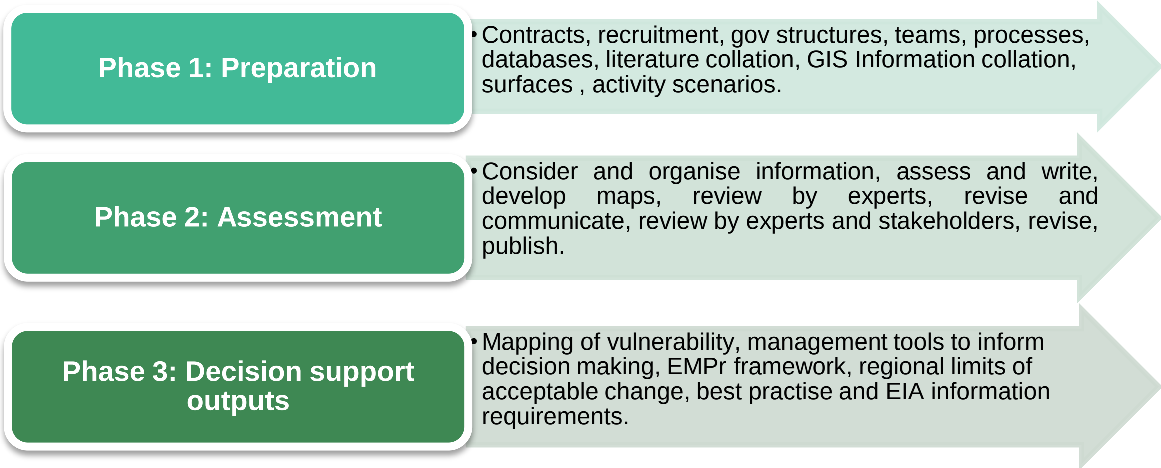


The yellow lines on the map above, represent the application areas for exploration rights, by Shell, Bundu and Falcon operators, while the area market with the bold red line represents the study area for the Strategic Environmental Assessment for Shale Gas (SEA), which has been initiated by government in February 2015 and is scheduled to be completed in March 2017.

The Strategic Environmental Assessment (SEA) was initiated in order to ensure that informed decisions are made in respect to Hydraulic fracturing of Shale Gas in South Africa. The project team comprised of various stakeholders which include amongst others, the Council for Scientific and Industrial Research (CSIR), the South African National Biodiversity Institute (SANBI) and the Council for Geoscience (CGS) (Council for Scientific and Industrial Research, 2016). The project team indicated that the SEA will unfold in three phases, as illustrated by the diagram below.

[2] seasgd.csir.co.za

Fig.3. Phases of SEA.[3]



The SEA will be conducted over a 24 month period in three overlapping phases as illustrated above, starting from February 2015 and is scheduled to be completed in March 2017 (Prof Scholes & Lochner, 2015).The study objectives of the SEA are as follows, to:

- Undertake scientific study that is transparent and participatory.
- Assess risks and opportunities of all strategic issues related to shale gas development.
- Consult broad and diverse group of authors and experts to participate in study.
- Determine sensitivities, vulnerabilities and risks for area as it relates to sustainability objectives and what is known as limits of acceptable change (LACs).
- Develop policy options and guidelines for site specific assessments in the event that Environmental Authorisation applications are submitted for shale gas development.

According to the Department of Minerals and Energy, Shale gas development is not expected to affect the whole of the Karoo where exploration rights are sought. The possibility exists that there could be significant areas where the shale is either too shallow or to deep, or does not have suitable characteristics. Thus, the exercise of further exploration will determine where fracking is economically viable.

3. Opportunities in Shale Gas Fracking

This section of the report outlines some of the economic opportunities that could potentially be derived from shale gas extraction.

3.1 Measuring the impact of Shale Gas Fracking

In a conference held by the International Energy Agency (IEA) during 2011, attention was drawn to the issue of 'energy poverty' and the fact that billions of people around the world do not have access to electricity and adequate

[3] seasgd.csir.co.za

cooking facilities. This is particularly so for most people in Sub-Saharan Africa, developing Asia and in rural areas. Emphasis was also placed on the fact that human wellbeing and economic development are dependent on "modern energy services". It therefore remains important for governments to ensure that both policies and funds are centred on providing access to modern energy services. IEA settled that considerations of any potential primary energy source, such as the potential shale gas resource in the Karoo Basin are justified, provided that they are inherent on thorough economic assessments and cost benefit analysis.

Notwithstanding the strong beliefs of shale gas fracking propellants on its promising opportunities, the fact that information available is based on historic shale gas experience of countries such as the United Kingdom (UK) and the United States of America (USA), makes it presently problematic to measure any kind of potential impact of Shale Gas exploration in the Karoo. This is intensified by the fact that the exploration area in South Africa is 47% bigger than the exploration area in the UK and 159% bigger than the exploration area of the Marcellus formation in the USA. In the same way, there is no information available on shale gas reserves prior to exploration as well as limited penetration of natural gas in the energy mix. In the ultimate, these privations similarly make estimating extraction facilities and the manpower required difficult (Econometrix Pty Ltd, 2012). Nevertheless, some attempts have been made to expand on potential economic benefits.

Table 1. Summary of Econometrix impact model results[4].

	0% Gas Exports		50% Gas Exports		100% Gas Exports	
Combined upstream & downstream	**Scenario A**	**Scenario B**	**Scenario A**	**Scenario B**	**Scenario A**	**Scenario B**
Project Turnover(Rand million)	4 031 773	9 520 268	3 069 827	7 115 402	2 107 881	4 710 537
Project value added(Rand million)	2 006 046	5 015 116	1 587 263	3 968 158	1 168 480	2 921 200
Project government revenue(Rand million)	886 808	2 223 494	705 894	1 771 208	524 979	1 318 922
Maximum employment (number)	355 817	854 757	258 880	612 415	161 943	370 073

The above table is a summary of the impact model scenarios presented in the Econometrix report.

Two test scenarios are presented, namely Scenario A which assumes a resource size of 20 Tcf and Scenario B, which assumes a resource size of 50 Tcf. In the event that no export of gas takes place, total turnover for both upstream and downstream participants has been modelled at R4 031trillion at constant 2010 prices. Total value added in economy is estimated at R2.006 trillion and maximum employment is estimated at 355 817 jobs. The above present impressive macroeconomic impact for shale gas development in

[4] Comparative assessment of the economic benefits from Shale Gas extraction in the Karoo, South Africa,2014

South Africa. Sadly, if one considers that the largest potential market for the Karoo shale gas would be the export market (well established even), this has implications for loss of potential value add locally, more so through downstream processes. Section 3.2 to follow will bring better clarity on this point.

3.2 Supply Opportunities of Fracking[5]

Focusing on what are identified as the supply opportunities, the table below shows what possible inputs would be needed to add value to the exploration and production operations (upstream) in the natural gas industry.

Table 2. Snapshot of possible Inputs into Natural Gas Industry per sector[6].

	Inputs to Natural Gas Industry
Agriculture	Food, non-food items
Mining-Coal	Primary Energy Resources
Mining-Gold	
Other Mining	Primary metals, non-metals resources
Food, beverages, Tobacco	Processed goods
Textiles, leather	Processed goods
Footwear	Processed goods
Petroleum, chemicals	Processed goods
Glass, non-metallic	Processed goods
Metal, machinery, equipment	Processed goods
Electrical	Processed goods
Radio, TV, optical instruments	Processed goods
Motor vehicles, transport	Processed goods
Furniture, other	Processed goods
Electricity	Energy input
Water	Raw and processed input
Construction	Built environment inputs
Trade	Service inputs
Hotels, Restaurants	Service inputs
Transport	Service inputs
Communication	Service inputs
Financial Insurance	Service inputs
Real Estate	Service inputs
Other Business	Service inputs
General Government	Service inputs
Health	Service inputs
Other Services, non-profit	Service inputs

According to this table, during the exploration and production phases (upstream) of shale gas fracking, suppliers of consumable items are likely to experience a demand for certain goods or services. For instance the influx of labour to drilling and production areas would bring increased demand for

5 See Appendix A for a detailed example of a Shale Gas Value Chain
6 Econometrix (Pty)Ltd, 2012

housing, however to the detriment of locals as the resultant end would be increased property houses. It should also be noted however that during the exploration phase, capital equipment would have to be imported due to the specialized nature of the work to be undertaken. Consequently, such circumstances would frustrate the strategic objectives of the province on localization or rather "provincialisation". The hospitality industry (tourism sector) would be set to enjoy benefits upstream.

Opportunities also exist downstream, for example, in the form of moving gas to end users, by means of the pipeline networks, large bulk transport of Liquefied Natural Gas (LNG) or transport of Compressed Natural Gas (CNG) in smaller volumes. This however requires the existence of specific infrastructure, which in South Africa's case will have to be developed further. According to an (Ernest &Young LLP) report, infrastructure requirements can be divided into four main areas, namely; waste water management; drilling waste management; storage and transportation of materials and equipment to and from site and gathering and gas processing.

What is important to note in relation to downstream opportunities is the fact that the relevant infrastructure does not exist in the Karoo Basin where exploration is proposed. Gas pipelines do not exist in or near the area. In the event that resources are available, the development of gas-fired open or combined-cycle gas turbine (OCGT or CCGT) power stations could be considered. An important aspect to consider in this case, is the location of producing fields relative to infrastructure and the scale of potential reserve. Given favourable conditions, the development of shale gas could possibly facilitate the establishment of an additional 30 gas-to-liquid plant in South Africa (Department of Mineral Resources, 2012). Currently South Africa has a gas-to-liquid plant in Mossel Bay.

Looking at the supply opportunities from economic sectors' perspective, it would appear that Table 2 above indicates that potential supply opportunities cut across all three sectors namely, primary, secondary and tertiary. However, the table does not tabulate quantifications on inputs value per sector making it difficult to state with certainty which sector would see the most opportunities in value. Comparison based on just the latitude of opportunities as presented in the table, shows that secondary and tertiary sectors stand to enjoy a wider range of opportunities than the primary sector.

It then becomes crucial to take into account the provincial sectoral composition, which remains to be predominantly led by the primary sector. This is again affirmed by the latest 2014 GDP figures as recently published by Stats SA. According to these figures, it is the primary sector that largely propelled the 2.8% provincial growth with a contribution of 6.2%, followed by tertiary at 1.5%. Secondary sector had the least contribution towards the provincial gross domestic product (GDP) at merely 0.8%. Given these sectoral contributions towards provincial economic growth, it is not surprising that over ninety percent (90%) of provincial imports are secondary sector products.

Concentrating on the potential opportunities of only the secondary sector as listed in table 2 above, one sees the industries with the sector wherein most opportunities are anticipated. Worryingly, these all together account for around eighty eight (88.6%) of provincial imports as per the 2014 GDP figures. The World Wildlife Fund, South Africa in 2015 stated that the degree of beneficiation will determine the extent of economic benefits. These assertions and the closer look at the potential opportunities within the secondary sector imply that the province will relinquish the benefits to national and or even other provinces with better secondary sectors. This will remain the case until the provincial economy is diversified. Similarly, such circumstances would frustrate the strategic objectives of the province on localization or rather “provincialisation”.

Lastly, the fact that South Africa has no well-developed and significant domestic gas market means that determining gas prices will likely evolve once shale gas reserves prove economically viable. It is also possible that regulated prices will be introduced. What is unsettling, however, is the possibility that the export market is predicted key in shale gas fracking. This is because South Africa and not the Northern Cape necessarily, will benefit from taxes and royalties. Even more concerning is to what extent, if any, such benefits would have a trickle-down effect to the provincial economy.

4. Challenges

This section narrates what could possibly be the challenges linked to potential shale gas fracking in general and particularly in the case of the Karoo basin in South Africa.

4.1. Environment

Environmental impact and the risks associated with shale gas fracking has been a contentious issue around the world for a while, particularly so in the case of the United States of America. Water and energy are interconnected, the water industry is energy intensive, for example during the process of waste water treatment, while the energy industry is water intensive, as in the case of resource extraction. All environmental considerations have a strong social component, since the use and availability of natural resources are the foundation of economic development and well-being of people.

The predominant concern is the contamination of water sources as well as issues around water scarcity. Based on the USA experience, drilling a single well can require between 0.2 million to 2.5 million liters of water, while hydraulic fracturing can require between 7 million and 23 million liters of water (Reig, Luo, & Proctor, 2014). The Centre for Human Rights emphasized the importance of ensuring that a specialized interdepartmental unit under the Minister of Water Affairs be responsible for 'compliance monitoring and enforcement of environmental provisions' in relation to fracking. Equally important is ensuring integrity of well design and an early warning system for failures and blowouts, spills and contamination, according to the Centre for Human Rights.

A policy brief published by the HSRC (2014) argues that modern fracking techniques utilise a great deal of water. Raising questions around water scarcity and water contamination, particularly in an area such as the Karoo where various agricultural activities are taking place. This challenge is exacerbated by the drought presently facing South Africa.

Table 3. Environmental Impacts from shale gas development.[7]

Development Stage	**Activities**	**Burdens**	**Impacts**
	Activities associated with the development of shale gas.	**Possible burdens created by development activity, with potential impact that people care about.**	**Aspects of the environment that could be affected by the shale gas development.**
Site Preparation	Land clearing and infrastructure construction.	Storm water flows	Surface water quality
		Habitat fragmentation	Habitat disruption
Drilling	Venting of methane	Methane	Air Quality
	Casing and cementing	Methane	Ground Water quality
	Casing accidents	Methane	Ground Water Quality
	Cementing accidents	Drilling fluids/cuttings, Fracturing fluids, flow back and produced water	Ground Water Quality
Fracturing and completion	Use of surface water and Groundwater	Freshwater withdrawals	Surface water availability
			Groundwater availability
	Storage of fracturing fluids	Fracturing fluids	Surface water quality
	Venting of methane	Methane	Air Quality
Storage/Disposal of Fracturing fluids and flow back	Onsite pit/pond storage	Flow back and produced water	Surface water quality
			Ground water quality
		Fracturing fluids	Surface water quality

[7] Source: Alan J Krupnick, Managing the Risks of Shale Gas: Key Findings and Further Research (Resources for the Future, 2013), http://www.rff.org/rff/documents/RFF-Rpt-ManagingRisksofShaleGas-KeyFindings.pdf.

	Treatment by municipal wastewater treatment plants	Flow back and produced water	Surface water quality
	Treatment by industrial wastewater treatment plants	Flow back and produced water	Surface water quality

The table above is a clear outline of the potential environmental impacts associated with shale gas fracking activities. As illustrated, site preparation, drilling, fracturing and storage /disposal of fracturing fluids and flow back activities can lead to water contamination if not managed effectively. After hydraulic fracturing treatment process, water pressure in the well is reduced to allow fracturing fluid to flow back out of the well followed by oil and gas. This flowback fluid contains higher proportions of hydrocarbons. Within a few weeks of this "flowback" process, some or most of the flowback fluid returns to the surface as waste water. As a result of the chemical content this waste water needs to be treated for reuse, placed in disposal wells or treated and released into surface waters.

If this process is not managed effectively, it can lead to the degradation of ground and surface water and subsequently affect ecosystems and communities that depend on water resources in the affected areas. The life cycle of shale gas "fracturing" requires water in the preproduction, production and use phases. Shale gas wells also appear to have "faster decline rates", than conventional natural gas wells. This necessitates drilling many wells over a larger area in order to reach the same production levels as conventional gas.

Unlike the case of coal mines and power plant, shale gas production cannot receive all its water requirements from a centralized location. What are the options available? Does it include the use of re-used or brackish water, transporting water from surplice areas, if any? (Hedden, Moyer, & Rettig, 2013) It is evident therefore, that in considering shale gas development, it is critical for source water availability to be considered carefully (Reig, Luo, & Proctor, 2014). This is especially important given that the Karoo Basin where shale gas is said to be present, is a water stressed area.

4.2. Impact on other Current Scientific initiatives (SKA and SALT)

A report released by Department of Mineral Resources in 2012 advocated that hydraulic fracking does not directly give rise to noise pollution. The report argued it is rather the activities associated with operations, such as in the case of operating high pressure pumps, the transporting of equipment and material by transit trucks, as well as the transport of water where needed, that carry noise pollution. In the case of air pollution, the dust arising from 'vehicular movement on un-sealed roads' is a challenge, including the emissions of carbon dioxide. In this regard, the report acknowledges that it remains important that measures to mitigate the impact of noise and air pollution be imposed. The crux of the matter is that the report contended that it is impossible to accommodate both shale gas fracturing as well as the SKA and SALT projects, though conceding that it is still early to determine the impact such will have.

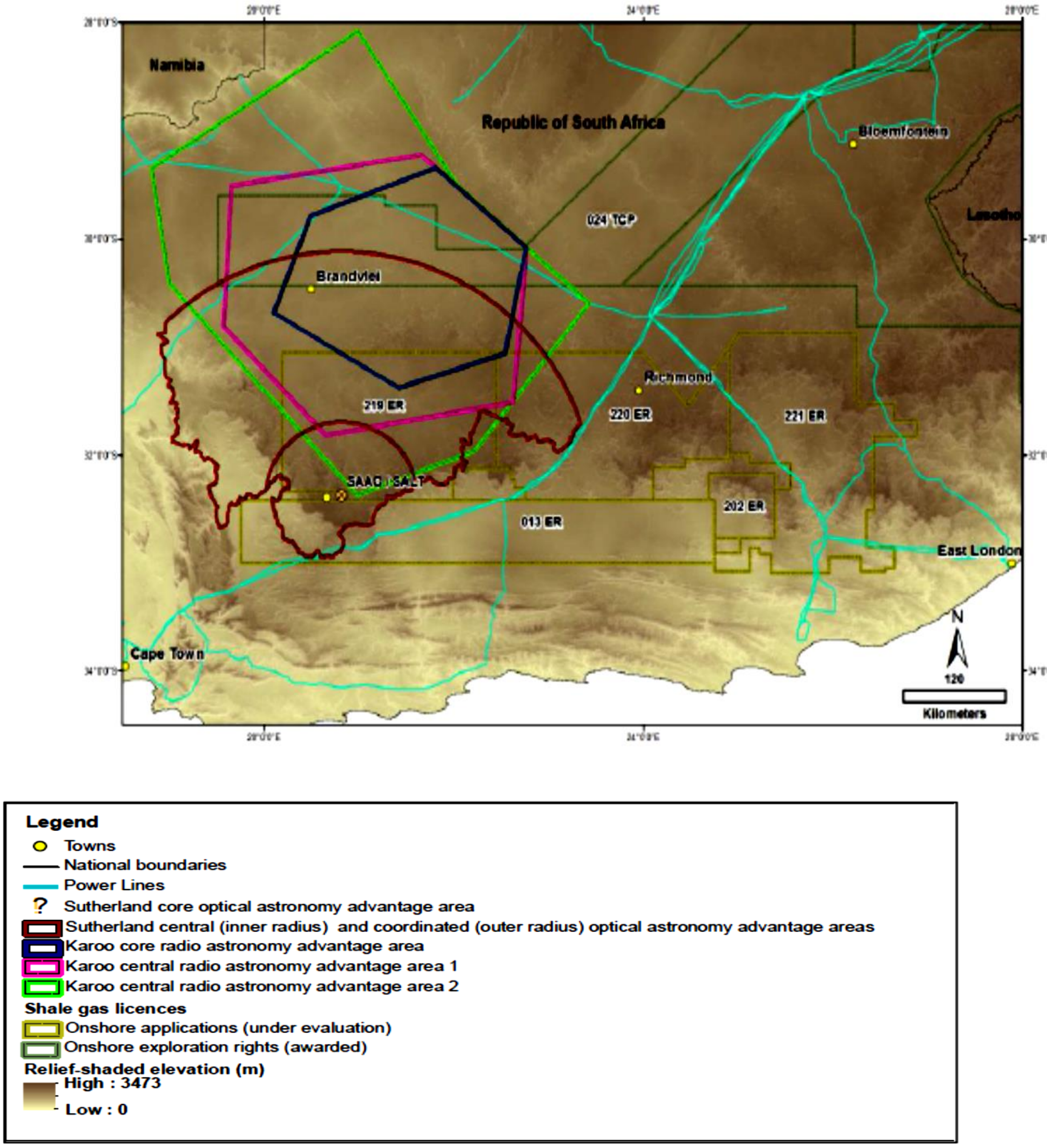
The same report acknowledged that there may be certain areas where shale gas fracking may be prohibited (Department of Mineral Resources, 2012). Thus supporting that further investigation and analysis is obviously needed to ensure its position on the matter that there would be no impact on the SALT and SKA projects. Given the potential impact on the environment and agriculture, it is important that the regulation of environmental impacts of shale gas fracking comply with existing legislation. This includes the National Environmental Management Act, 1998; the National Water Act, 1998; the National Environmental Management: Waste Act, 2009 and the National Environmental Management: Air Quality Act, 2004. Equally important to consider is the Astronomy Geographic Advantage Act.

The latest developments however raise concerns of the possibility of shale gas fracking in the Karoo and more so its incompatibility with the Square Kilometer Array (SKA) and the Southern African Large Telescope (SALT) projects (Netshishivhe, 2014). The Karoo is already home to these projects, which is the SKA as well as SALT. The low population density and limited to no development in the Karoo area, proved it an ideal site for astronomical observations, hence the locations of the SALT and SKA projects. In order to ensure that the Karoo favourable conditions are maintained for the SKA and SALT projects, the Astronomy Geographic Advantage Act was enacted by parliament and allows the Minister of Science and Technology the power to prohibit or restrict a range of activities , including exploration and mining. Hence the compatibility considerations (of Shale Gas Fracking, SALT and SKA) are rendered a crucial matter.

The figure below illustrates where the SALT and SKA projects are located and where potential shale gas fracking will take place.

Fig. 4. Application areas and areas protected by Astronomy Geographic Advantage Act.[8]

[8] Department of Mineral Resources, July 2012



The red lines on the above map, indicate the optical astronomy advantage area for the Southern African Large Telescope (SALT), while the blue, green and pink outline shows the core radio astronomy advantage area (Square Kilometer Array project). The area where application for shale gas exploration has been approved and or is under evaluation is also illustrated. **The diagram clearly shows that proposed shale gas exploration intrudes on the radio and optical astronomy advantage areas**. The concern related to shale gas fracking operations, is the impact of noise and air pollution given the existence of the SKA and SALT projects in the Karoo.

In contrary to these compatibility concerns,

4.3 Capacity Development and Skills required

As previously mentioned, it is expected that in the event that fracking takes place in South Africa, equipment needed for drilling will be imported. This is also the case with critical skills that will be required during drilling of shale gas wells. Presently South Africa has no specialized engineers with experience in the design of shale gas wells, which is critical for successful fracking to occur. Shale gas fracking is highly skilled and highly industrialised, requiring high levels of mechanization and automation, which increases as technologies for shale gas fracking evolves (World Wildlife Fund, South Africa, 2015).

Planning and development to ensure the enhancement of skills in the upstream petroleum sector is critical to avoid the need to import all skilled labour that will be required. What skills are required for the development shale gas? The example below from the (Ernest &Young LLP) United Kingdom study, looks at direct skills and services required in shale gas fracking.

Table 4. Overview of Critical FTE (Full Time Equivalent) direct and supporting roles/skills[9].

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

[9] Ernest &Young LLP, 2014

Planning & approvals, permitting, health & safety, environmental monitoring	⇨ Reviewing planning applications of operators to permit surface operations required to explore & extract shale gas ⇨ Monitoring compliance with safety risk management requirements(well integrity)	⇨ Local planning authorities ⇨ Health & Safety Executive (HSE) well examiners ⇨ Environmental risk and impact assessment advisors
Operations Management	⇨ Site and facilities management ⇨ Security services ⇨ Fuel ⇨ Waste disposal/cleaning ⇨ Equipment inspections & maintenance	⇨ Operations & maintenance technicians ⇨ Security guards ⇨ Fuel truck drivers ⇨ Waste disposal vehicle drivers ⇨ Trade services and apprentices(carpenter, electrician, plumber) construction labourer
Office Support	⇨ Field services support, including drilling, well completions, geology, health &safety, environmental monitoring, permitting , production planning, procurement, community relations, finance and administration	⇨ Field services support, drilling engineering, project managers ⇨ Geologists, Health and Safety Executives/officers ⇨ Public Relation managers, Finance and admin professionals ⇨ Marketing and sales professionals

Much of the skills required in the shale gas industry are similar with the skills required in the offshore oil and gas and chemicals industry (Ernest &Young LLP, 2014). Considering these specialized skill requirements needed for shale gas as listed, one wonders how many of these relate to the 355 817 number of jobs estimated for creation in the country. This is because the Stats SA publications on the Quarterly Labour Force Survey are clear that majority of South African labour force (including the Northern Cape Province) predominantly possess no, low or elementary skills.

Although South Africa's skills profile does point towards a possible lack of the Engineering skills needed with regards to the Shale Gas Fracking, an in-depth and broader assessment of which of these skills and capabilities South Africa has or lacks becomes critical. This is said in consideration of the fact that policy and development to ensure these skills are developed timely in the province failed. And also the significant time skills development and specific training would require. It would be prudent to assess where we stand with available skills and to what extent local expertise can be developed with the assistance of relevant partners, which includes operators and service companies that have built expertise in the shale gas industry. What is clear though is that as things stand, and on the basis of the skills needs of the fracking, local communities with no, low or elementary skills will miss out on the skilled jobs presented by shale gas fracking in the Karoo and will most probably be exploited as cheap labour.

5. Conclusion

Presently South Africa derives 67% of its energy supply from coal. International commitments require South Africa to reduce its carbon dioxide emissions in the long term, but more importantly it has become necessary for South Africa to diversify its energy supply sources given that the human and economic development are dependent on energy services. This is advocated for in the countries' supreme policy document, the NDP. Despite the complexities of gas fired energy, the blueprint argues that gas as an alternative energy source has several advantages as a power generation fuel. Some of these advantages speak to reduced pollution and mitigations to climate change. Shale gas as currently considered forms part of natural gas according to the petroleum definition of the Mineral and Petroleum Resources Development Act.

Whilst the demand for natural gas has grown considerably since the 1970s, South Africa has only recently seen growth in demand for natural gas, specifically with the arrival of First Gas from Mozambique in 2004. This report captured the most recent information available in relation to the planned shale gas extraction in part of the Karoo region of the province. Attention was given to central issues around shale gas fracking, in particular the potential opportunities and challenges this presents for the Northern Cape.

With exploration and production phases of shale gas fracking (both upstream and downstream), suppliers of consumable items are likely to experience a demand for certain goods or services. These potential opportunities cut across all the three sectors, primary, secondary and tertiary. When compared, it appears that potential opportunities largely fall within the secondary and tertiary sectors than the primary sector. If one considers that the degree of beneficiation will determine the extent of economic benefits this is causes distress.

This is concerning given that provincial economic growth is largely propelled by the primary sector. Firstly, the secondary sector is very insignificant in the province. This is seen in its contribution towards the provincial gross domestic product (GDP) which stand at merely 0.8%. Secondly, over ninety percent (90%) of provincial imports are secondary sector products, and this is where majority of opportunities are anticipated. This implies that the province will possibly relinquish the benefits to national and or even other provinces with healthier secondary sectors and calls for intensified efforts towards provincial economic diversification.

Furthermore, whilst econometrics estimate the overall macroeconomic impact of shale gas development to be R2.006 trillion (total value added at 2010 constant prices) and the maximum employment to be 355 817 jobs in the event that gas extracted is not exported. The largest potential market for Karoo shale gas, would be the export market, but this would mean the loss of potential value that may be added through downstream processing.

It is equally important to note that shale gas fracking is not without complexities which poses a challenge for the province. Firstly, the relevant infrastructure does not exist in the Karoo Basin where exploration is proposed. Gas pipelines do not exist in or near the area. Thus, equipment during the exploration phase, capital would have to be imported due to the specialized nature of the work to be undertaken. This also would be to the detriment of "provincialisation" (localization) objectives of the province.

Secondly, modern fracking techniques utilise a great deal of water. Raising questions around water scarcity and water contamination, particularly in an area such as the Karoo where various agricultural activities are taking place. This challenge is exacerbated by the drought presently facing South Africa. The third key challenge that possibility of shale gas fracking in the Karoo raises concerns its compatibility with the SALT and SKA projects in the same location.

The limited to no development in the Karoo area, proved it an ideal site for astronomical observations. However, proposed shale gas exploration could intrude on the radio and optical astronomy advantage areas. This challenge is valid given that the Astronomy Geographic Advantage Act was enacted by parliament and allows the Minister of Science and Technology the power to prohibit or restrict a range of activities, including exploration and mining. The debate is stirred by the fact that SALT/SKA are already located in the Karoo region

Lastly, is a challenge in relation to critical skills that will be required during drilling of shale gas wells, which appear to not only be a provincial but also a national deficiency. Presently South Africa has no specialized engineers with experience in the design of shale gas wells, which is critical for successful fracking to occur. Shale gas fracking is highly skilled and highly industrialised, requiring high levels of mechanization and automation, which increases as technologies for shale gas fracking evolves. The provincial and national skills' profiles bring a worrying factor as to who will be the beneficiaries of the 355 817 jobs anticipated as one of the macroeconomic benefits of shale gas fracking.

Based on the discussions, it can be concluded that cons to shale gas fracking outweigh the pros where the province is concerned. This renders the current ongoing exercise of further investigations on shale gas exploration valid, as these will ensure informed strategic decisions on the subject matter. The outcome of the SEA (bearing in mind its objectives) scheduled for completion in March 2017 will give better perspective and finality on some of the issues that remain a bone of contention. The outcomes of the SEA therefore should give clarity and decisiveness on how the country is to forge ahead with shale gas fracking, most importantly and expectantly, tilting the current picture (of more cons than pros) on the subject matter.

6. Recommendations

Notwithstanding that shale gas extraction assessments are yet to be concluded, which will provide better insight on the best advancement options with fracking, the following are recommendations:

- This report needs to be shared and handed over to the Office of the Premier, specifically the Provincial Research Forum, as ongoing research is crucial. The recommendation on handing the report to the Office of the Premier is based on understanding that coordinated conceptualization is key towards addressing the hurdles around shale gas fracking in the province. In other words such issues as water scarcity or possible contamination, a subdued secondary sector, relevant skills development and so on.

  In principle, in order to help the policy dilemma around the subject matter, the department will need to not only share this report but sponsor provincial research agenda items under the following three crucial themes:

  i. Diversifying the diversifying energy sector specifically focusing on shale gas fracking. Objectives of the research work to be undertaken would need to ensure that the concerns of the province and the deterring implications of shale gas fracking are alleviated.
  ii. Diversification of the provincial economy. Research work undertaken will see the province make headways on some of the sectors that were identified in the former Provincial Growth and Development Strategy already. Research units of sector departments would need to be shared with the Provincial research Forum as such a move would ensure the province forges ahead on the basis of the base line information already available. Failure to do so would mean the province relinquishes the potential opportunities to regions of the country with prominent secondary sector. The sad reality is that the better the beneficiation capabilities of the province, the more the benefits to the economy.

  iii. Forecasting Skills Demand for the Provincial Economy. Conceding to the sad factor that planning and development in the province have resulted in most of the provincial misgivings on failed efforts at “provinicalisation”, local economic development and job creation, the area of skills development nevertheless remains crucial. Partnerships with industry, Sol Plaatje University and the TVETs would key to the Forum on the skills development issues.

- A very important aspect to consider is the development of the necessary infrastructure to support the shale gas industry if the SEA pointed towards economically viable reserves being found in the part of Karoo concerned. To this end, the report also needs to be shared with the subprogramme Economic Policy Development (Policy and Planning) who lead the Outcome 6 Forum on Infrastructure Coordination.

- Another recommendation would be the need for the Provincial Treasury and Office of the Premier Research and or Policy Units to undertake thorough scan of the existing regulatory frameworks to ascertain what regulatory developments ought to be undertaken. For instance development of new, review of existing and so on, to accommodate the development of shale Gas in the event that it is decided to continue with Shale gas fracking in the Karoo Basin. Moreover, the potential risks impose that shale gas fracking comply with the existing legislation and that current legislation be reviewed and adjusted to effectively regulate the extraction of shale gas in South Africa.

- Lastly, it is recommended that going forth, on national pronunciation of strategic projects that will be implemented in the Northern Cape, a firm position is taken through the relevant structures and forums. This would ensure that the province is not overtaken by events as well as ensure the necessary planning and development takes place timely. Otherwise provincial government will always play catch up to the detriment of developmental goal of the province.

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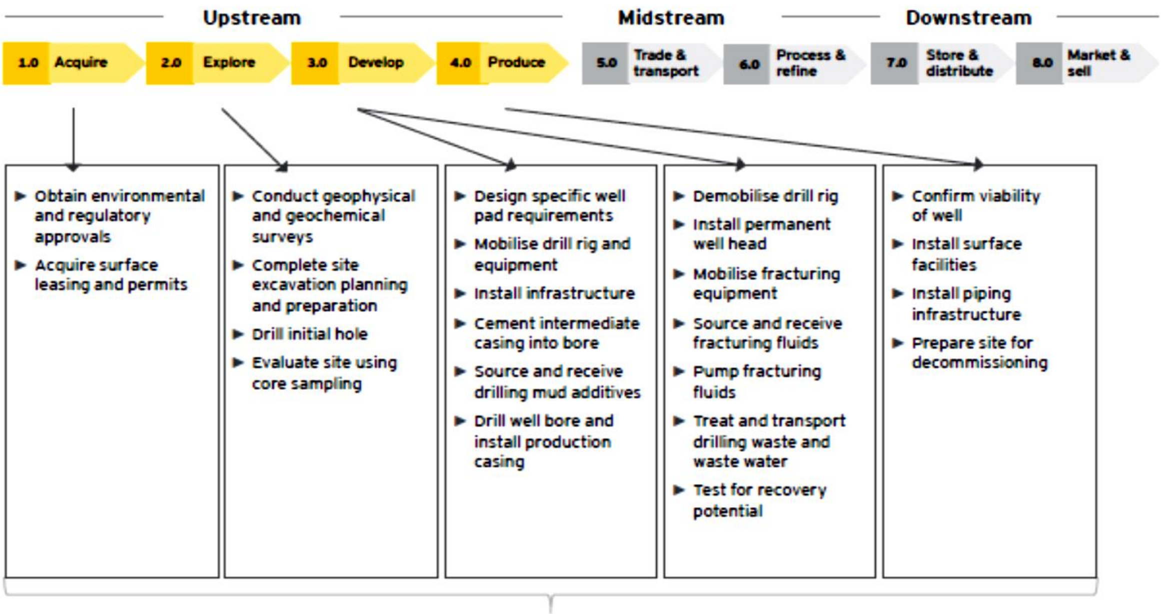
Appendix A

Key Supply chain activities for onshore shale site (pad) development[10].

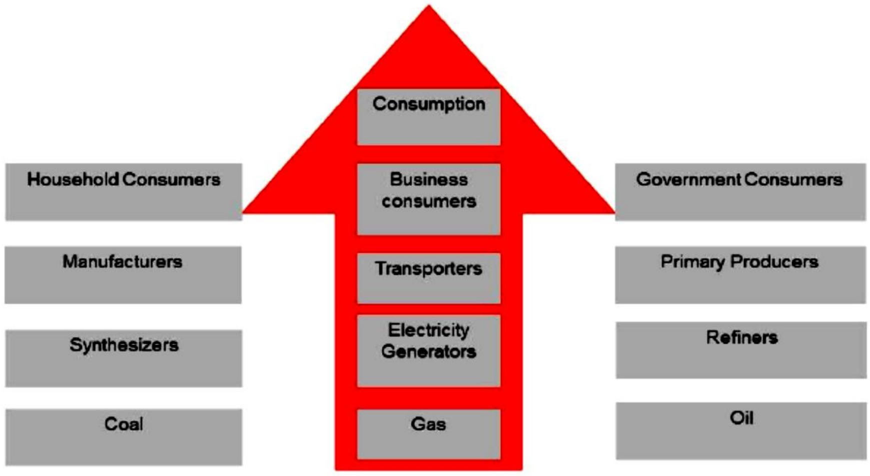


This model uses a single shale gas pad with 40 lateral wells as a starting point. Taking into account that it will take an estimated six years to develop a pad from exploration to production at its peak (Ernest &Young LLP, 2014). In the case of South Africa, exploration rights have been requested by three operators and environmental and other assessments are underway. The above example outlines the detailed processes and skills that is involved in shale gas fracking. However this is merely illustrative and consideration will have to be given for unique conditions attributed to South Africa.

The Conceptual production column below, shows stages of the value adding process in the South African scenario, with energy carriers (coal, gas, oil) at the base of the production column , moving up to the delivery end users (household, business , government).

10 Ernest &Young LLP, 2014

Fig.5 Conceptual production Column-Hydro Carbon Energy Resources[11]



The conceptual production column above outlines a four stage production column for the value adding chain in the energy sector of the economy. The individual value adding stages from the base of the column to the delivery of end user products, is separated from each other, illustrating that not all components of a specific production level, feeds into the components of the next production level. Essentially the extraction of gas (upstream), "should not be considered as an economic end in itself, but rather as a primary production stage, which itself will require economic inputs, and which will enable further value adding at later production stages".

[11] Econometrix (Pty)Ltd, 2012