A Historical Timeline of Unconventional Oil and Gas Extraction and Fracking Studies in South Africa: Pointers for Policy Development

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Abstract

This review considers the historical development of unconventional oil and gas (UOG) extraction in South Africa, and related studies that have been done since 2011 when the first prospecting licenses for UOG extraction were lodged with the Petroleum Agency of South Africa. These developments are considered within the context of UOG extraction environmental and energy policy development in South Africa. This paper makes policy development recommendations, to protect the environment and the people dependent on this environment, should UOG extraction and fracking be allowed in the future.

Keywords: UOG extraction, fracking, South Africa, environment, policy development

1. Introduction

Oil and gas are important energy sources for human society, being used for most of its transport needs, the manufacturing of plastics and fertilizers, and electricity generation (Papadis & Tsatsaronis 2020). Oil and gas derive from compressed and cooked organic matter that was buried to significant depths over millions of years. It can be found in conventional and unconventional deposits. Conventional oil and gas occur in deposits that are trapped underneath seals in deep porous geological formations. The oil and gas in conventional deposits migrated from unconventional reservoirs like shale. Unconventional oil and gas (UOG) occur in tight deposits such as oil sands, oil shale, shale gas, and coalbed methane which require a stimulation technique such as

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hydraulic fracturing to extract these resources.

Globally, conventional oil was produced in surplus from the 1970s to the 1990s, after which conventional oil supplies started to decline (Bilgili *et al.* 2020). Since the early 2000s, alternative hydrocarbon sources in the form of unconventional oil and gas were targeted, enabled by hydraulic fracturing and horizontal drilling (Bilgili *et al.* 2020; Van Vactor 2010). Hydraulic fracturing (fracking) is a technique where large volumes of fresh water, mixed with chemicals and sand are pumped into a gas deposit to extract the UOG resources. Even though UOG extraction holds socio-economic benefits such as job creation and infrastructure development, it can have negative effects, including air pollution, habitat loss, water pollution, and public health effects. These possible positive and negative biophysical and socio-economic effects of UOG extraction on the South African landscape are detailed in a 2016 review (Esterhuyse *et al.* 2016).

Of the negative environmental effects of UOG extraction, the most immediate effects are those on water resources (Ester-huyse *et al.* 2016a,b). The water that is required for fracking is often sourced in the vicinity of the fracking well. This means that local groundwater reserves become a common target. In 2015 in the Eagle Ford shale, US, fracking operations consumed approximately 30% of the area's total groundwater (Steadman *et al.* 2015). UOG extraction and fracking may therefore lead to high localized competition between water users in water-scarce and drought-prone areas. South Africa has recently experienced extreme drought conditions linked to climate change (Vogel & Olivier 2019). Predictions for the future claim that sub-Saharan Africa will become even drier in the future (Abiodun 2019). Considering projections for increased water scarcity in the future, and the fact that the 2016 SEA on Karoo shale gas development highlighted water availability as a fatal flaw in the plan to source energy from UOG resources in South Africa, water scarcity is one of the main factors that should be accounted for in future UOG extraction policy development and planning.

Apart from water availability constraints, UOG extraction also poses a high contamination risk. Two wastewater streams are produced during UOG extraction – produced water and flowback. Produced water are natural fluids that are displaced from the geological formation. It can have a high salt content and naturally occurring radioactive elements, which can contaminate any freshwater aquifers that it meets. Flowback is fluid that is returned to the surface after hydraulic fracturing has occurred, but before the well is placed into production. It typically consists of returned fracturing fluids in the first

few days following hydraulic fracturing, which is progressively replaced by produced water. The chemistry of the flowback depends on the chemical makeup of the fracturing fluid and may contain various toxic and carcinogenic organic contaminants (Mcintosh *et al.* 2019). The water quality impacts of UOG extraction are therefore typically larger than for conventional oil and gas extraction. Produced water and flowback can contaminate freshwater aquifers due to poor oil and gas well integrity, or due to the migration of these fluids via fracture zones. Fracking fluid and wastewater can contaminate surface waters via leaks and spills. South Africa does not yet have a clear plan for handling the large volumes of wastewater (Hobbs *et al.* 2016; Williamson & Esterhuyse 2020). Wastewater disposal in underground injection wells can also cause seismicity and has significantly increased induced seismicity in Canada, the United States, the United Kingdom, and China, in some cases causing earthquakes as large as magnitude 5.7 (Schultz *et al.* 2020). Induced seismicity linked to hydraulic fracturing and UOG wastewater disposal is also a significant concern for South Africa, should UOG extraction be pursued in the future (Kijko *et al.* 2016).

The effects of UOG extraction on the South African landscape are interlinked and may be complex. Even though UOG extraction may enhance socio-economic development through increased primary and secondary employment opportunities, the environmental impacts such as depletion of water sources and water contamination may ultimately negatively affect community health and safety, and food security for the poorer sectors of South African communities. It is paramount to regulate UOG extraction to protect South Africa's natural resources and the people who depend on these resources. This chapter, investigates how scientific studies should guide the development of a regulatory framework for UOG extraction in South Africa. It considers how significant oil and gas exploration activities shaped scientific studies on the biophysical and socio-economic effects of UOG extraction, and regulations that were drafted, in response to these historical events and related studies. The data is presented in a historical timeline of UOG-extraction-related events in South Africa.

2. Regulatory Framework for UOG in South Africa: Requirements for Environmental and Social Justice

The South African environmental policy framework recognizes several inter-

national conventions and agreements on sustainable development, including the 1992 Rio Declaration on Environment and Development, the 1994 International Conference on Population and Development's Programme of Action, and the 2002 World Summit on Sustainable Development (Brynard & Stone 2004). The Constitution and the National Environmental Management Act (NEMA) form the framework within which South Africa's environmental legislation should operate. According to the Constitution, every person has the right to have the environment protected through legislative and other measures that prevent pollution and degradation. These measures must secure the sustainable use of natural resources while promoting justifiable economic and social development. The NEMA acknowledges the interdependence of socio-economic and biophysical systems. One of the key principles of the NEMA requires that all development in South Africa be socially, economically, and environmentally sustainable. The NEMA defines sustainable development as the 'integration of social, economic, and environmental factors into planning, implementation, and decision-making to ensure that development serves present and future generations' (RSA 1998:10). However, policy development and implementation in South Africa remain fragmented and do not consider the full scope of energy generation options, nor the full effects of UOG extraction on the biophysical and socio-economic environments. This fragmentation is acute in the development of policy related to UOG extraction in the country (Atkinson 2018a). Considering that the South African government places a high priority on sustainable human development, the interconnectedness of water-related impacts, socio-economic development, and the human population must be recognized to strengthen integrated UOG extraction policy development and planning.

3. Historical Timeline of Fracking Applications, Fracking Studies, and the Development of Environmental Policy, Legislation, and Regulations in South Africa

A historical timeline (Table 1) was developed to assess UOG extraction policy and regulatory development. The data that was sourced for the timeline, was based on the following inclusion criteria: Important oil and gas exploration developments in South Africa from 1940 to 2023, government studies and published journal articles on UOG extraction in South Africa from 2009 to 2023, and legal developments in terms of South African court cases and

judgments on UOG extraction and fracking from 2009 to 2023. The oil exploration data range starts in 1940 and considers specifically 1960 because the conventional oil and gas exploration by Soekor in the 1960s had a direct effect on the later exploration for UOG resources in South Africa. The UOG extraction scientific reports and articles, and legal developments, start in 2009 when the first permit application for UOG extraction in South Africa was made by Shell and ranges up to 2023. The data for Table 1 was sourced from a systematic search for the inclusion criteria on selected databases (Ebscohost Complete, JUTA Law, and Sabinet African journals) using the following Boolean search terms: 'South Africa' AND frack! OR 'South Africa' AND 'natural gas' OR 'South Africa' AND 'oil and gas'. Google and Google Scholar (open web) were used as additional search facilities to identify relevant documents. The retrieved documents were screened for suitability according to the inclusion criteria and only the most pertinent documents were included to complete the historical timeline.

To aid in the development of integrated UOG extraction policy, the historical timeline presented here considers how specific historical events since the 1940s have shaped the development of UOG extraction in South Africa, and how scientific studies assessing possible biophysical and socio-economic effects of UOG extraction, responded to these events. It also considers how important scientific studies influenced the development of the regulatory framework within which to regulate UOG extraction in South Africa and the importance of basing UOG extraction policy and regulatory development on scientific knowledge.

The South African government has been exploring for oil in the Karoo basin since the 1940s, and in 1965 established the Southern Oil Exploration Corporation (Pty) Ltd (Soekor) with the aim to find commercial quantities of oil and gas. Exploration by Soekor did unfortunately not yield any conventional oil and gas resources of note. Since the 2000s, the United States (US) has been using a new oil and gas extraction technology, called fracking, which allowed companies to extract unconventional oil and gas resources that are trapped in tight formations such as shale (Bilgili *et al.* 2020). The development of this technology eventually opened the possibility of viable UOG resource extraction in South Africa (de Wit 2011). The South African government supports UOG extraction to decrease the country's dependency on fossil fuels. Several fracking studies have been done in South Africa since the first announcement by Shell in 2011 that they applied for an exploration

license to extract unconventional oil and gas in South Africa.

Table 1 shows a historical timeline of UOG-extraction-related events in South Africa. It shows significant oil and gas exploration activities in black, significant academic studies in blue, and significant regulatory developments by the South African government in red.

Table 1: Historical timeline of unconventional natural gas development and related legal developments in South Africa

Date	Event
1940	The first organised search for hydrocarbons in South Africa is undertaken by the Geological Survey of South Africa (PASA 2023).
1965	The Southern Oil Exploration Corporation (SOEKOR) is formed with the mandate to identify the existence of economic volumes of oil and gas in South Africa.
1972	Exploration drilling indicates the presence of (at that time economically unrecoverable) gas within the Ecca shales (Rowsell & De Swardt 1976).
1976	The Council for Geoscience (CGS) investigates the oilshale potential of the Whitehill Formation on the western flank of the Karoo Basin. They drill 16 core boreholes in the area between Strydenburg and Hertzogville. This study, together with all available borehole logs and cores over the whole extent of the Whitehill Formation, and that intersected the Whitehill Formation, form the basis of the majority of shale gas resource estimates for the Karoo that have been made to date (Hobbs *et al.* 2016)
1968	Soekor finds promising oil & gas reserves in Soekor borehole CK1/68 in the Eastern Cape (James 2016)
2009-2010	The Petroleum Agency of South Africa (PASA) grants technical cooperation permits to Falcon Oil and Gas, Shell B.V. International and Sasol-Chesapeake-Statoil consortium to conduct an assessment (PASA 2019)
December 2010	Shell submits exploration licence applications (de Wit 2011)

Date	Event
2011	The US Energy Department estimates that the Karoo basin has 485 trillion cubic feet (TCF) of Technically Recoverable gas (USEIA 2011)
February 2011	Activists groups are mobilised and the Treasure the Karoo Action Group (TKAG) is established (TKAG 2020)
April 2011	The moratorium on oil and gas exploration in South Africa is instated (Hedden *et al.* 2013)
Feb-July 2011	Lobbying of activist groups against shale gas continues to intensify, fuelled by media debates (Hedden *et al.* 2013)
July 2011	De Wit comments on the great shale debate in the Karoo and calls for centres of excellence where the effect of UOG energy development can be properly investigated (de Wit 2011)
11 November 2011	The South African government releases the National Development Plan, stating that shale gas could contribute to electricity generation in South Africa (NPC 2011)
July 2012	The Department of Mineral Resources releases the Report on the investigation of hydraulic fracturing in the Karoo basin of South Africa (DMR 2012)
November 2012	The South African Water Research Commission launches the study entitled 'Development of an Interactive Vulnerability Map and Monitoring Framework to Assess the Potential Environmental Impact of Unconventional Oil and Gas Extraction by Means of Hydraulic Fracturing' (Esterhuyse *et al.* 2014). This study assesses the impact of UOG on the South African biophysical and socio-economic environment and South Africa's vulnerability to fracking.
2012	The Petroleum Agency of South Africa (PASA) provides an estimate of the potential Karoo basin shale gas resource to assess the reliability of the US Energy Department's 2011 estimate (Burns *et al.* 2016)
September 2012	The cabinet lifts the moratorium on oil and gas exploration and recommends that regulations be drafted to protect the environment (RSA 2019)
July 2013	Given impending fracking regulations that are to be published, Esterhuyse *et al.* (2013) publishes a study on the knowledge

Date	Event
	base and opinions of decision-makers on the regulation and monitoring of unconventional gas mining in South Africa
15 October 2013	The draft technical regulations on hydraulic fracturing 'the fracking regulations' is published (RSA 2013)
December 2013	The Centre for Environmental Rights, academia and other stakeholders comment on the draft fracking regulations, view it as inadequate to protect natural resources and call for the drafting of regulations that would do so (CER 2014)
October 2014	The Water Research Commission study entitled 'Development of an Interactive Vulnerability Map and Monitoring Framework to Assess the Potential Environmental Impact of Unconventional Oil and Gas Extraction by Means of Hydraulic Fracturing' (Esterhuyse *et al.* 2014) is published. This study finds the impacts of Karoo fracking to be regional and cumulative and recommends a Strategic Environmental Assessment of shale gas extraction in the Karoo.
December 2014	The knowledge of unconventional gas mining among decision-makers in South Africa is again evaluated and researchers implore policy-makers to pursue fact-based water policy development (Esterhuyse & Redelinghuys 2014)
8 December 2014	Instatement of the 'One Environmental System' (DEA 2019)
February 2015	The Strategic environmental assessment (SEA) of shale gas in the Karoo is commissioned by the Department of Environmental Affairs (Scholes 2016)
3 June 2015	The final 'fracking regulations' is promulgated by the Minister of Mineral Resources under Regulation R.466 in Government Gazette No 3855 dated 3 June 2015 (RSA 2015a)
16 October 2015	The Department of Water and Sanitation declares the 'Exploration and or production of onshore naturally occurring hydrocarbons that requires stimulation, including but not limited to hydraulic fracturing and or underground coal gasification, to extract, and any activity incidental thereto that

Date	Event
	may impact detrimentally on the water resource' as a controlled activity (RSA 2015b)
November 2015	Stern and others apply to the Eastern Cape High Court and TKAG and Afriforum apply to the Pretoria High Court to set aside the fracking regulations (RSA 2019a)
July 2016	Rhino oil applies for UOG exploration in the Drakensberg and Free State with application ER294 (SAHRA 2023a)
November 2016	The SEA on Karoo shale gas is completed (Scholes 2016)
2016	A book that considers both the legal and environmental perspectives of fracking in the Karoo, is published (Glazewski & Esterhuyse 2016).
June 2017	A study by de Kock *et al.* (2017) estimates that significantly fewer shale gas resources may be available for exploitation, at approximately 13 TCF, compared to the 485 TCF that was estimated to be available by the USEIA (2011).
17 October 2017	The Eastern Cape High Court sets the DMR 'fracking regulations' aside in the case of *John Douglas Stern and Others v the Minister of Mineral Resources* (RSA 2017)
16 May 2018	The Pretoria High Court dismisses the TKAG and Afriforum applications to set aside the fracking regulations in the case of *Treasure the Karoo Action Group and Another vs the Department of Mineral Resources and Others* (RSA 2018)
April 2018	Shell withdraws South African onshore fracking plans (*Engineering News* 2018)
4 July 2019	The Supreme Court of Appeal sets aside the fracking regulations in its entirety. The court also indicated that the commencement of any UOG extraction activities should not be allowed before regulations to protect natural resources are in place (RSA 2019a)
24 December 2019	The Draft upstream petroleum resources development bill is published (RSA 2019b)
2015-2019	Various scientific case studies shed more light on shale gas resources and methane occurrences in the Karoo (Chere *et al.*

Date	Event
	2017; Eymold *et al.* 2018; Geel *et al.* 2015; Hohne *et al.* 2019; Murray *et al.* 2015) At the same time, academic studies that focus on natural resource protection, assess impacts (Esterhuyse *et al.* 2016), and laboratory analyses capabilities for monitoring water pollution during UOG extraction (Mulovhedzi and Esterhuyse 2021), are completed. They make recommendations on natural resource monitoring (Esterhuyse *et al.* 2018), wastewater management (Williamson & Esterhuyse 2020), and the development of regulations to protect water resources during UOG extraction (Esterhuyse *et al.* 2022; Esterhuyse *et al.* 2019).
September 2020	Rhino oil applies for oil and gas exploration rights for petroleum on various farms in the Free-State and Kwazulu-Natal provinces via application 350 ER (SAHRA 2023b)
2020	PASA commissions the development of a regional groundwater monitoring network in the Karoo (*Engineering News* 2020)
2021	The Department of Water Affairs publishes draft regulations to protect water resources during UOG extraction for public comment (RSA 2021)
2021	Rhino Oil and gas applications in the Eastern Free State / Drakensberg region
February 2022	Rhino Oil withdraws ER246 exploration application for north-eastern Free State, Gauteng and Mpumalanga (Evans 2022)
July 2022	The Department of Forestry, Fisheries and the Environment (DFFE) publishes draft regulations to protect the environment (RSA 2022a) as well as minimum requirements for the submission of licenses during UO extraction for public comment (RSA 2022b)
April 2023	Rhino Oil submits amended EIAs for exploration permits ER318 (SLR 2023)

Table 1 gives a brief timeline of the development of unconventional oil and gas in South Africa. The table clearly illustrates the close relationship between

the possible environmental impacts of UOG extraction, citizen action, scientific studies, and government regulatory actions.

The historical timeline in Table 1 illustrates the importance of obtaining information on all the possible negative effects of fracking on natural resources and people, and using this information to develop proper UOG extraction policy and related regulations to limit such negative effects. In South Africa, studies that identified certain issues and recommended certain actions, were followed up by scientific studies that addressed the identified issues. Such an expansion of the knowledge base is necessary to 1) develop a clear understanding of the biophysical and socio-economic effects of UOG extraction and 2) develop UOG extraction regulations that will be effective in protecting the South African environment and its people. For example, the WRC vulnerability mapping and monitoring framework study (Esterhuyse *et al.* 2014) that recommended that a SEA be done for UOG extraction in the Karoo, directly led to the commissioning of a SEA for the Karoo in 2015 (Scholes *et al.* 2016). This SEA not only identified the risks and opportunities of shale gas development in the Karoo but also importantly identified unknowns that merited further scientific investigation before allowing UOG extraction. One unknown is how much shale gas is available in the Karoo. Estimates varied widely from 485 trillion cubic feet (TCF) for the earliest desktop-based estimates by the US Energy Information Agency, to 13 TCF by South African geologists (de Kock *et al.* 2017). Compared to the US desktop study, the South African study used real data in the form of core samples from Soekor boreholes, to assess the methane resource potential in the Karoo. The fact lower gas estimates may affect the willingness of UOG companies to risk extracting this gas.

Another unknown, is the current water quality in the Karoo, specifically for groundwater resources, and the possible effect of UOG extraction on these water resources. A regional groundwater monitoring network that assesses the current baseline water quality, is required before UOG exploration can be allowed. This would provide regulators with reference conditions of the Karoo water quality, should accidents that could contaminate the scarce water resources in the Karoo, occur during UOG extraction.

Table 1 also illustrates the effect of citizen action on environmental protections. Citizen action led to the moratorium that was instated in April 2011 to assess the effects of shale gas extraction. The importance of the natural environment to the livelihoods of South Africans was once again underlined

when the government was taken to court over the DMR fracking regulations, which were set aside by the Supreme Court of Appeal in 2019 (RSA 2019). Citizen action and court rulings also played a role in the development of fracking regulations in South Africa. After the SCA ruling, the government drafted regulations to protect water resources (RSA 2021) and the environment (RSA 2022a).

Even though several studies (Esterhuyse *et al.* 2022; Esterhuyse & Redelinghuys 2014) called for knowledge-based UOG extraction regulations, it seems that the regulators are not equipped to draft regulations that would adequately protect South Africa's natural resources. For example, the 2015 DMR fracking regulations have been set aside by the Supreme Court of Appeal in South Africa because it did not draft regulations within its mandate, and the regulations that were drafted, did not effectively protect the environment (Esterhuyse *et al.* 2019). Even after voluminous feedback to the regulators on aspects that should have been addressed in the 2015 DMR fracking regulations, which are based on scientific studies of UOG impacts and international regulatory approaches, the most recently drafted DWS regulations and DFFE regulations do not adequately protect water resources (Esterhuyse 2022). Several shortcomings have been highlighted in these two sets of regulations (CER 2021; Esterhuyse 2022), including the following.

- The 2021 DWS regulations do not establish a rigorous enough process to ensure water resources in gas-producing regions are sufficiently protected during UOG extraction, given in particular other critical needs and future changes to water availability attributable to climate change (CER 2021)
- Certain aspects that were previously regulated in the 2015 DMR fracking regulations (including baseline monitoring and well and casings design) are not covered in the draft 2021 DWS regulations (CER 2021). This is especially of concern since several studies recommend the urgent need for fracking water quality baselines in potential fracking areas (Esterhuyse *et al.* 2019; Hobbs *et al.* 2016).
- The minimum distances between fracking activities and water sources that should be protected, known as setbacks, are not strict enough and do not consider all the relevant geological and groundwater features that increase the risk of groundwater contamination. For example, according to the 2022 DFFE regulations, water sources and

fracking wells should be at least 2km apart. However, an expert survey (Esterhuyse *et al.* 2022), that considers international best practice, recommends that fracking wells should be at least 10km away from municipal wellfields, aquifers, and water supply boreholes and should be at least 5km away from seismically active springs.

- In addition, the proposed 2022 DFFE and 2021 DWS regulations do not adequately address fracturing fluid management, a waste management plan, information disclosure by the UOG companies, well decommissioning, and activities ancillary to UOG extraction, such as gas pipeline management.

If South Africa pursues UOG extraction in earnest, it is paramount that the shortcomings in the various sets of regulations be addressed if the environment and human health are to be properly protected during UOG extraction.

4. Pointers for UOG Extraction and Fracking Policy Development

Table 1 indicates that scientific studies are required to address shortcomings that may exist in UOG extraction policy and regulatory development when considering negative effects on the biophysical and socio-economic environments, that should be avoided. Such studies should be independent and should consider all the relevant issues. For example, the hydraulic fracturing report that was developed by government during the fracking moratorium (DMR 2012), and subsequent regulations that were developed (RSA 2015; RSA 2021), did not fully consider the specific South African biophysical and socio-economic conditions (Centre for Environmental Rights 2014; Esterhuyse 2022), and how UOG extraction would influence these aspects.

An opinion survey that was performed in 2013 on decision-makers involved in formulating UOG extraction policy in South Africa (Esterhuyse & Redelinghuys 2014), and a survey in 2019 on water use regulators (Esterhuyse *et al.* 2022), indicate how important it is for regulators to understand UOG extraction, in order to develop regulations that would protect the environment effectively. The levels of knowledge of the respondents on UOG extraction impacts and its regulation for these two surveys was quite low, where less than 50% of respondents indicated extensive knowledge of the impacts of shale gas mining on the environment and of the environmental impacts of hydraulic

fracturing specifically. Knowledge of the regulation of these impacts was below 60% for all the respondents from both studies. And half of the respondents of both surveys indicated their dissatisfaction with their knowledge levels of UOG extraction and regulation.

These surveys highlight the importance of knowledge-based regulation. Regulations that are based on the most recent state-of-the-art knowledge, could effectively protect South Africa's natural resources, but only if they are effectively enforced. However, even if the South African government is committed to extracting UOG and protecting its natural resources via fracking, it would be wise to take a step back and consider whether UOG resource extraction is the best course of action to address South Africa's energy requirements. South African policymakers should seriously reconsider the pursuit of UOG resources considering the severe water shortages that South Africa faces. During the recent 5-year drought, which left the City of Cape Town, Nelson Mandela Bay, and many other towns in the Karoo without potable drinking water, the government demonstrated its woeful lack of capacity to address the impacts of the drought, and to supply uninterrupted clean drinking water to large parts of the country (Townshend 2018).

Respondents were also asked in a 2019 opinion survey (Esterhuyse *et al.* 2022), whether they think that South Africa would be able to effectively enforce regulations to protect groundwater resources during UOG extraction. The proper enforcement of regulations to protect groundwater resources was highlighted by many researchers as problematic, in both developed and developing countries (Centner & Connell 2014; Fink 2019; Angeles 2018; CER 2014). Seventy percent of the respondents reported that they do not think that South Africa would be able to effectively enforce UOG extraction regulations.

The National Energy Regulator Act (34 of 2008) (RSA 2008) places an obligation on the Minister of Energy to develop and annually review and publish the Integrated Energy Plan (IEP) in the Government Gazette (Humby 2016). The IEP must guide energy infrastructure investments and must consider all viable energy supply options and guide the selection of the appropriate technology to meet energy demand. One IEP report has been drafted in 2016 (DOE 2016), but no IEP has been published since the publication of the 2019 IRP (Govender *et al.* 2019). The IEP is a continuous process that must be reviewed yearly to consider changes in the macro-economic environment, developments in new technologies and changes in

national priorities and imperatives, amongst other factors. Since no IEP has been published after the 2019 IRP, the following policy recommendations are offered in terms of South Africa's energy planning:

- South Africa should do a detailed strategic assessment of energy supply options, to determine if UOG extraction is a desired option for energy supply.
- Such an assessment must consider, at its core, the future water requirements of the country as well as the water requirements of the selected energy developments, especially considering population growth and climate change and seeing as fracking uses large amounts of water. Many countries highlight the tensions between water supply and UOG extraction water requirements (e.g. China and Russia), see (Buono *et al.* 2019). This is also a concern for South Africa, as highlighted in the SEA for shale gas development.
- South Africa should reconsider whether UOG extraction is a viable energy supply option to consider in its energy mix if it is found that not enough water would be available for UOG extraction.
- Secondly, if proceeding with UOG extraction, South Africa must consider if they will be able to enforce UOG extraction regulations effectively, to ensure environmental protection and safeguarding of livelihoods. International enforcement of current environmental regulations are notoriously poor (Buono *et al.* 2019).
- If South Africa would not be able to effectively enforce regulations to ensure environmental protection, UOG extraction should be seriously reconsidered.
- South Africa, with its water resources limitations (Townshend 2018) and poor governance record (Atkinson 2018) should consider expanding its renewable energy resources base to augment its energy needs, before or in addition to developing UOG resources.
- After considering all the above aspects, if UOG extraction is still seen as a necessary and viable energy option to pursue, South Africa must embark on a proper process of developing UOG extraction regulations to protect groundwater resources.

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