THE SHALE GAS INDUSTRY IN SOUTH AFRICA:

Toward a Science Action Plan

31 AUGUST – 1 SEPTEMBER 2017

Proceedings Report

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 The Academy of Science of South Africa (ASSAf) was inaugurated in May 1996. It was formed in response to the need for an Academy of Science consonant with the dawn of democracy in South Africa: activist in its mission of using science and scholarship for the benefit of society, with a mandate encompassing all scholarly disciplines that use an open-minded and evidence-based approach to build knowledge. ASSAf thus adopted in its name the term 'science' in the singular as reflecting a common way of enquiring rather than an aggregation of different disciplines. Its Members are elected on the basis of a combination of two principal criteria, academic excellence and significant contributions to society.

The Parliament of South Africa passed the Academy of Science of South Africa Act *(No 67 of 2001)*, which came into force on 15 May 2002. This made ASSAf the only academy of science in South Africa officially recognised by government and representing the country in the international community of science academies and elsewhere.

This report reflects the proceedings of the The Shale Gas Industry in South Africa: Toward a Science Action Plan Conference held on 31 August – 1 September 2017 at the Boardwalk Conference Centre, Port Elizabeth, South Africa. Views expressed are those of the individuals and not necessarily those of the Academy nor a consensus view of the Academy based on an in-depth evidence-based study.

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SESSION 1: INTRODUCTION AND CONTEXT

Facilitator: Prof Roseanne Diab, Executive Officer, Academy of Science in South Africa (ASSAf)

Welcome remarks

(Prof Barney Pityana, Vice-President, ASSAf)

Chairperson and Director of the Programme, Honoured Guests, Ladies and Gentlemen:

I am delighted to join you on behalf of the Academy of Science of South Africa (ASSAf) for this very important consultation. I am especially honoured to welcome Dr Phil Mjwara, Director-General of the Department of Science and Technology (DST), and Adv Thabo Mokoena, Director-General of the Department of Mineral Resources (DMR), together with any officials of the said department present at this consultation. I also hereby welcome academics and researchers, and representatives of related industries, and those representing provincial departments, and other national departments. I also welcome all participants to this consultation, and observers.

The development of diverse sources of energy is critical for any developing and demanding economy. South Africa is dependent on oil and gas imported from a variety of countries. Such dependence carries risks. Such risks include, but not exclusively so, the reliance on the uncertainties of the market and the political situations in an ever-changing and uncertain world.

South Africa is considered to be an industrial society with a great deal of opportunities. This means that, in planning terms, South Africa has to be right ahead of its peers, being the other developing, middle-level economies. It means that we have to become aware of the reserves, and how we might sustain the economy in difficult times. It is for this reason that South Africa adopted the National Development Plan (NDP). The NDP is the planning tool adopted by South Africa that seeks to enable the country to meet its development challenges. These challenges can be defined as poverty, unemployment and inequality. The challenge for South Africa's scientific community is to advance scientific endeavour with the view in mind that it should enable society to address its challenges.

In the energy sector, efforts at growing South Africa's own oil reserves and the petrochemical industry have been underway for generations, beginning with exploration along the southern Cape coast, and the conversion of oil from coal. So far, though, no substantial findings of oil have been discovered, even though huge resources have been invested in exploration over a very long time.

Last year ASSAf published a study by a team of experts assessing the state of South Africa's technical readiness to support the development of the shale gas industry. Shale gas, as I understand it, is natural gas that is found trapped within shale formations. It is thought that substantial volumes of such gas shales can be found in the main Karoo Basin. The South African government supported this study done in partnership between ASSAf and the South African Academy of Engineering (SAAE). ASSAf is mandated to provide evidence-based science to the government of South Africa, and to promote the development of science for society.

The idea of extracting shale gas is not without controversy. In reality, though, science development does often have an element of risk and uncertainty. Science is hardly ever able to provide guarantees, neither about safety, nor about success or health. Scientific discovery by its nature carries considerable risks. Part of the expertise of science is to manage those risks. It has very much been the debate in the nuclear industry, and so it is with the shale gas extraction project.

What is known, however, is that in regions like North America, shale gas resources and the exploitation of shale gas and shale oil have transformed the economies and boosted the energy resources of the countries concerned. Nonetheless, extraction and development by the industry must be undertaken with caution. The risk balance entails concerns about the effect on underground water resources in a country that is water scarce, and thus the negative effect on the environment, human habitation and the habitat for plants and wildlife. Such an industry, it is argued, would negatively affect the ecology of the region. On the other hand, a boost to the economy, and the provision of jobs and scientific knowledge, are very attractive balances to the risk equation.

South Africa is known to possess considerable reserves of shale gas and oil reserves in the Western, Northern and Eastern Cape (the old Cape Province). Because of the geology of the area, and the possibilities of economically available and advanced extractive technology, this industry is capable of development. It could represent a 'game-changer' for the economy of South Africa and could make a major contribution to South Africa's commitments in terms of climate change by limiting South Africa's reliance on the coal industry for its energy needs. Limiting reliance on importing oil in an increasingly uncertain world climate is a tantalising prospect.

Since the publication of the ASSAf/SAAE report in October last year, it has become necessary to bring together all the role players, including industry, academia and business, to work in an inclusive manner with government and with partners. Besides the report referred to above, ASSAf has also contributed to the report produced by the Department of Environmental Affairs (DEA): Shale gas development in the Central Karoo: A scientific assessment of the opportunities and risks.

It is hoped that this consultation will advance the process a step further. It should enable government to be better prepared, to review all its plans, and to organise resources to tackle this major potential contributor to our economy, and to our scientific knowledge.

I wish this consultation success.

Thank you.

Keynote address

(Dr Phil Mjwara, Director-General, DST)

Vice-President of ASSAf, Prof Barney Pityana; Chair of the Shale Gas Monitoring Committee, Adv Mokoena, represented by Acting Deputy Director-General of the DMR, Mr Andries Moatshe; Ms Lindiwe Mekwe, Chief Executive Officer (CEO) of the Petroleum Agency of South Africa (PASA); Prof Roseanne Diab, EO of ASSAf; Prof Cyril O'Connor, Panel Chair of the ASSAf shale gas study, Prof Bob Scholes, Chair of the Strategic Environment Assessment (SEA) for shale gas; Dr Phethiwe Matutu, Group Executive, Strategic Planning and Partnerships at the National Research Foundation (NRF); international guests from our continent of Africa and the rest of the world; members of the research community; colleagues from industry and academia; government officials; ladies and gentlemen:

I am honoured to be speaking to you this morning. This conference is very important to the DST because it provides us with a unique opportunity to reflect on how we can continue responding to the call to create wealth and improve the quality of life of South African citizens.

Today's deliberations are topical and require courage since shale gas development is considered by some to be an opportunity to improve national economic prospects, while others hold a different view based on its potential impacts on the environment. I would like to focus my talk on these two aspects: economic prospects and our environment. The trilemma of the energy challenge is a reality that all nations must face and manage, by ensuring energy security and economic development without compromising sustainable development.

The World Energy Council ranks natural gas as the third-largest fuel source in the global primary energy mix, and the second-largest energy source for power generation, contributing approximately 24% and 22% respectively to those markets. According to work funded by the European Commission and conducted by *Insight Energy* (published in January 2017), shale gas production currently accounts for 13% of global natural gas production, compared to 0.5% in 2000. This reflects a notable growth rate.

In the United States of America (USA), technical innovations like horizontal drilling and multistage hydraulic fracturing have been key to unlocking gas from tight shale formations and improving production efficiencies. These efficiencies are improving the USA's prospects of becoming a liquefied natural gas (LNG) exporter, as the unit production costs of shale gas have decreased significantly (between 25% and 30%) since 2012. However, in the European Union (EU), despite a large shale gas resource, the cost of shale gas may be 25% higher than in the USA due to geological factors.

The United States Energy Information Administration (US EIA) reports that some parts of our continent, mostly North African countries and parts of sub-Saharan Africa, have technically recoverable shale gas resources. This may be good news for the continent as, according to the Africa Progress Report of 2015, sub-Saharan Africa is experiencing an energy crisis with two-thirds of Africans, or around 621 million people, having no access to electricity at all.

In order to change this, the quantum of power generation has to undergo a steep increase and distributed power generation, coupled with flexible approaches to grid development, must be rolled out to address the needs of the most disadvantaged. Such interventions will save lives, liberate millions of women and girls from the drudgery of collecting firewood, and generate wide-ranging environmental benefits. This is relevant to South Africa as energy security and access is the backbone of the economic infrastructure that will assist the government in addressing poverty, inequality and unemployment.

The NDP has called for action to increase energy security by improving the country's energy infrastructure and diversifying the energy mix. The NDP identifies the key challenge of de-linking economic activity from environmental degradation caused by carbon-intensive energy, while retaining economic competitiveness. The NDP further states that South Africa should conduct exploratory drilling for economically recoverable shale gas reserves to confirm usability of the resource taking environmental implications into account.

A better understanding of the challenges associated with the transition to a low-carbon economy, and how to overcome them using South Africa's existing set of endowments, is critical to building a low-carbon economy and society. Natural gas has the potential to play an important role in the world's transition to a cleaner energy future, with applications in electricity, heating and transport.

In the electricity sector, there has been progress towards introducing renewable energy solutions through the Renewable Energy Independent Power Producers Programme (REIPPP), and South Africa has attracted significant direct investments. Based on the nett gains, government continues to engage with its agencies to ensure continued rollout. However, challenges relating to intermittency require that all possible technical options be explored to ensure an increase in future renewable energy allocations and to sustain associated benefits.

With respect to the already accrued benefits, the World Bank Group report on South Africa's REIPPP indicated that, by May 2014, the programme had already attracted US$14 billion (at an exchange rate of $1= R8) into our economy for projects that will generate approximately 3 922 Megawatts (MW).

A Council for Scientific and Industrial Research (CSIR) study that quantified system-wide financial costs and benefits of renewable energy (wind and solar photovoltaic) in South Africa identified a further benefit: during the first half of 2015, renewable energy projects that were connected to the grid created net benefits to the economy of close to R1 billion, taking into consideration the displacement of diesel for peaking power, coal and ensuring that load shedding was avoided. A solar-wind-gas hybrid technology solution may assist the transition to a resilient, cleaner solution and, when done responsibly, ensure sustained benefits.

In the transport fuels sector, the Integrated Energy Plan (IEP) states that construction of the PetroSA plant in Mossel Bay was founded on one trillion cubic feet (Tcf) of gas. This means that even if only a fraction of the estimated 385 Tcf of shale gas reserves are technically recoverable, this industry could have positive economic benefits for South Africa. Furthermore, at the beginning of 2017 the government released a draft Green Transport Strategy that promotes switching to compressed natural gas for petrol and diesel transport.

It is within this context and that of the current economic climate, that government should explore and understand all potential options to stimulate economic growth, in order to deal with the triple challenges of poverty, inequality and unemployment.

However, until the existence and quantum of economically recoverable shale gas is confirmed, the potential benefits will remain theoretical. It is for this reason that Cabinet approved the establishment of a monitoring committee led by the DMR to strengthen the regulatory regime, monitor activities, ensure co-existence with astronomy research, and promote independent research.

Environmental groups have expressed their reservations and called upon scientists to provide facts about the potential impact that the industry may have on the pristine areas of South Africa. I am glad that we are here today because government created the space for independent research that, amongst others, prioritises the environment, and continues to support a number of research projects.

Amongst the work done, two teams of experts have produced two reports, namely *South Africa's Technical Readiness to Support a Shale Gas Industry* and a *Strategic Environmental Assessment*. During the course of the conference, experts will share in detail their progress thus far, but let me take the opportunity to share my assessment. Both reports seem to carry a common message that puts mechanisms in place to deal with potential risks associated with shale gas development.

The ASSAf report proposes ways to address, among other issues, human capital development, the regulatory environment, baseline studies, and protecting existing astronomy research infrastructure in the Karoo. The SEA report seeks to ensure that the government obtains the minimal information required from shale gas developers before an environmental impact assessment (EIA) is conducted to ensure that the environment is protected.

In this regard, the DST supports the call to undertake baseline assessments. We applaud and acknowledge institutions like the Nelson Mandela University (NMU), supported by the Eastern Cape government, which have already commenced with work and which require further support. We also note the research work undertaken by the Council for Geoscience (CGS), with the support of the DMR, which is investigating groundwater contamination, stratigraphy, resource assessments, and socio-economic impacts.

Government has been proactive in protecting resources like water by declaring that shale gas development is a controlled activity. The Department of Water and Sanitation (DWS), through its agency the Water Research Commission (WRC), continues to undertake water-related research by implementing the recently-launched Water Research Roadmap. The roadmap has seven priority areas, of which two are related to shale gas, namely: making use of more sources of water (through reuse, desalination and waste reduction), and reducing losses by increasing efficient use. Given that possible water contamination and waste water handling are key concerns, I would like to request that mechanisms to support shale gas-related water matters are explored through the roadmap.

Chair, South Africa has limited productive agricultural land, and the country must use its water resources wisely. We continually encourage researchers to help South Africa deal with the food-water-energy nexus.

So, where to from here?

It seems that we have most of the pieces of the puzzle that will enable us to understand the intricacies of the shale gas industry. However, we need time to put them together in a way that allows South Africa to strike a balance between environmental protection and economic development. We are here today to continue listening, engaging and hopefully reaching consensus so that we may all move towards a clear national action plan.

In my view, a shale gas research plan aligned with government policy should be the ultimate outcome. Such an action plan will be included in the broader government research programme that is driven by different departments and agencies.

Some of the main objectives of such a plan should be to develop national technical capabilities in key focal areas, including pure science, engineering and social science, associated with shale gas exploitation.

I propose that you focus on creating:

1 A support mechanism for human capital development: training knowledge workers in line with both transformation targets and industry skills requirements. Key fields of training should include chemistry, mechanics, environment, geology, drilling, geochemistry and geophysics.

2 Support for technology development and localisation: local enterprises need to acquire the necessary technical capabilities in both upstream and downstream activities.

3 A coordinated research plan with science-based outcomes that seamlessly enable or influence the policymaking process.

Part of the plan could be to build on previous and existing work by different research groups, such as the Africa Earth Observatory Network (AEON) at NMU, and institutions, such as the CGS. Socio-economic benefits for the Karoo region could include the establishment of a Karoo Shale Gas Experimental Laboratory to test and model induced seismicity, fracturing, and the flow of gas, water and chemicals in a controlled, single-well, multidirectional hydraulic fracturing site. Such a laboratory could provide scientific and technical services to support the envisaged shale gas industry.

In closing, government policy clearly directs South Africans to embrace a cleaner, sustainable energy system that supports a knowledge-based economy. This will lead to the development of local solutions that will improve our technology balance of payments. This we need to achieve while minimising emissions and or pollution by the energy sector so that both social and economic life may be improved.

In a nutshell, we need to position South Africa to generate knowledge that provides solutions for the needs of the continent and rest of the globe.

Let me take this opportunity to thank the organising team for arranging this historic event. May your deliberations during the conference be fruitful. I look forward to your recommendations.

Thank you.

SESSION 2: THE TECHNICAL READINESS OF SOUTH AFRICA TO SUPPORT A SHALE GAS INDUSTRY

Facilitator: Ms Marlett Balmer, Senior Energy Advisor, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

Introduction to the study

(Prof Roseanne Diab, Executive Officer, ASSAf)

ASSAf was commissioned by the DST in 2014 to undertake a study into South Africa's readiness to support a shale gas industry. ASSAf and SAAE appointed a seven-member multi-disciplinary panel of national and international experts under the chairpersonship of Prof Cyril O'Connor, an ASSAf Member. Consensus findings and recommendations of the study were published in the peer-reviewed report, *South Africa's Technical Readiness to Support the Shale Gas Industry*. The 350-page report was approved by the ASSAf Council on 11 June 2015, submitted to government, and formally launched on 12 October 2016.

This two-day shale gas workshop is an opportunity for multiple stakeholders to hear the outcomes of both the ASSAf Report and the *Strategic Environmental Assessment (SEA) for Shale Gas Development in South Africa*, and to take the process one step further.

Presentation on the ASSAf report findings and recommendations

(Prof Cyril O'Connor, Chair of the ASSAf Panel, University of Cape Town (UCT))

Prof O'Connor acknowledged his fellow panellists and the invited authors who had contributed to the report. Because of the contested nature of shale gas development, it was important to subject the report to peer review in the public domain, and to seek a degree of common ground before proceeding.

Background

In the NDP the need for economic growth was closely linked to sustainable energy production, skills development and job creation. The government anticipated that shale gas development in the Karoo would contribute to these objectives. However, the exploitation of shale gas could have significant social, economic and environmental impacts, and present considerable technical challenges. It was critically important to analyse and evaluate these issues before exploiting shale gas.

Report outline

The report provided:

- an overview of the shale gas industry internationally, to ascertain what lessons could be learnt from other jurisdictions;
- information on technical readiness challenges relating to:
  - the pre-production phase: exploration; legislation and governance; potential impacts;
  - the need for baseline studies as a non-negotiable pre-production intervention;
  - potential impacts on water and air quality, astronomy, and socio-economic activities;
  - the production, exploitation and closure phases: compliance with international best practice; incentives to promote gas as an energy source; skills development; and the long-term monitoring of closed wells; and
- a set of recommendations (the focus of this presentation).

Shale gas in South Africa: The context

There are considerable uncertainties associated with developing a shale gas industry in South Africa:

- The volume of shale gas remains unclear. Estimates range from 20 to more than 400 Tcf. None of the reserves has been proven and the lower value might be more realistic.
- Shale gas exploitation requires large quantities of water. Greater clarity is needed on the availability of alternative sources, such as underground saline water. Some hold the view that no groundwater should be used, while in the USA deep saline water of up to 100 000 total dissolved solids (tds) has been used.
- Baseline studies are needed to ascertain deep-level geological characteristics (three to six kilometres underground), which are poorly understood, and which might provide escape routes for methane gas. Baseline studies are also needed on many aspects of the environment, both biophysical and socio-economic.
- South Africa is experiencing a crisis in terms of the high-level technical skills required to implement a shale gas industry. Well design is extremely sophisticated and skills required for horizontal fracturing would need to be imported.

Background to the recommendations: The pre-production phase

1 Exploration:

- The estimate of approximately 20 Tcf of available free gas in the Karoo shale gas deposits has not yet been proven, but this estimate is considerably more than was the case at Mossgas (1-2 Tcf).
- A two-phase approach to exploration is required:
  a. standard surface exploration and acquisition of all necessary geological data; and
  b. the design and construction of an experimental drilling and controlled hydraulic fracturing research laboratory.

2 Legal, regulatory and governance aspects:

- The correct EIA procedure plus an environmental management plan (EMP) are central to the success of the upstream to downstream shale gas enterprise.
- Upstream to downstream shale gas activities would require the cooperation of a wide range of national government departments, as well as potentially affected provinces and municipalities.
- Having robust, compliant regulators and monitors is one of the key preparatory interventions needed to ensure that shale gas development is undertaken properly.

3 Water, sand and greenhouse gas (GHG) emissions:

- Groundwater systems deeper than 1 000 metres prior to hydraulic fracturing are not well understood, nor are there adequate estimates of the water requirements for drilling and hydraulic fracturing in the Karoo.
- Local water supplies should not be used and all waste water must be properly disposed of or recycled.
- There is a universal concern about the nature of the chemicals used in the hydraulic fracturing process. All chemicals used must be reported.
- International experience highlights the need for appropriate monitoring and regulation of all of the above matters.
- Centralised management and control systems are needed to avoid

problems experienced in Pennsylvania, where problems have arisen due to the involvement of multiple regulators.

4 Potential impacts on astronomy:

- The restrictions imposed by legislation governing the establishment of the Square Kilometre Array (SKA) and the Karoo Central Astronomy Advantage Area would take precedence over any shale gas developments.

5 Potential socio-economic impacts:

- The Karoo is a pristine natural environment with small rural towns. The potential socio-economic impacts need to be assessed to avoid a 'boom town' phenomenon.
- There are differing expectations among the local inhabitants, which need to be understood by all concerned in the development of the industry. For example, earlier employment forecasts linked to the shale gas industry might have been over-optimistic.

Background to the recommendations: Baseline studies

- Impacts subsequent to the commencement of hydraulic fracturing would not be able to be accurately determined without a thorough and detailed understanding of baseline conditions prior to the launch of the industry. For example, litigation would not be possible without well-documented baseline information about human and livestock health.
- A rigorous, quantifiable understanding of the condition of the broader environment is essential. (See presentations by Profs Scholes and De Wit.)

Background to the recommendations: The production phase

1 Well construction and closure

- Given the lack of significant local experience, pilot field development work is needed to establish a local technical baseline to inform a field development model (for example, water usage and emissions).
- South Africa must ensure that materials used in the drilling and extraction processes comply with international best practice.
- International experience has highlighted the need for the entire process

to be closely monitored from 'cradle to grave'. Well closure is a critical aspect and the company should be responsible for contamination for periods exceeding 50 years.

2 Distribution and exploitation of shale gas

- The gas market is potentially large and there is an opportunity to develop anchor markets based on compressed natural gas (CNG) and LNG imports.

3 Capacity and skills development

- A major challenge is the shortage of appropriate skills. Initially, all skills required for the upstream shale gas sector would probably need to be imported.

Recommendations proposed in the report

1 Commission an SEA to determine the most economically, socially and environmentally optimal gas source that can be exploited for South Africa. This should demonstrate the overall environmental costs and benefits of the shale gas value chain. (See Prof Scholes presentation.)

2 Implement, with considerable urgency, a comprehensive public consultation and engagement process with local communities in the Karoo, which should include a fact-based information-sharing programme.

3 Launch an exercise to undertake robust interdisciplinary regional and local baseline studies to collect accurate data before the launch of a shale gas industry. (See Prof De Wit's presentation.)

4 Immediate action should be taken to establish, or strengthen an existing, government agency whose overall function is, *inter alia*, to enable and facilitate the development of the shale gas industry in South Africa.

5 The agency of Recommendation 4 should coordinate licensing and monitoring functions in consultation with all the relevant government departments involved, as well as any other relevant state, research and higher education institutions.

6 Exploration licensing should be divided into two phases (Phases One and Two) linked by continuous environmental monitoring. In this

way, exploration will be detached from production via continuous environmental impact analyses that can account for the environmental and operational baseline data obtained during Exploration Phase One.

7 During Phase One, standard surface exploration and seismic data shall be acquired by means of passive technology and not through induced seismicity using explosives. Vertical drilling for core recovery and down-the-hole data management shall be permitted. Identifying deep saline aquifers shall be a prerequisite.

8 Hydraulic fracturing marks the start of Exploration Phase Two, before and during which a new EIA shall be presented, inclusive of three-dimensional (3-D) analyses based on continuous down-the-hole data acquired during the drilling of vertical wells. No hydraulic fracturing will be permitted within 1 500 metres below the surface. Abandoned wells following the exploration phases shall be properly closed using the best sealing practices.

9 The award of an exploration licence should require the operator to perform pilot field development studies within six to 12 months of the award of the licence. These studies will establish a local technical baseline as input to an open-source model in order to provide the necessary information to be used in reaching decisions on the production licence agreements; for example, water requirements and flowback water quantities.

10 The award of any licences for shale gas development shall require that such developments do not prejudice the sustainable use of potable surface and groundwater, and shall not compete with fresh water requirements of humans, animals and ecosystems.

11 Any exploration licence awarded should include the requirement that a statistically significant number of vertical wells be constructed during Exploration Phase One and that each must be subject to at least one full-scale trial hydraulic fracture at the start of Phase Two to determine, *inter alia*:

- total water volume and additives requirements;
- flowback and produced water volumes and composition; and
- gas and particulate emissions from each step in the process of developing the well.

12 Build a robust field development model to understand and plan all

relevant aspects of establishing the technical capacity to develop the industry. This model will optimise field development plans, for example, well spacing, well length, and the number of fractures for a set of horizontal wells.

13 Ensure that any approvals for the development of shale gas exploration and exploitation shall be based on robust and peer-reviewed scientific data and facts.

14 There should be alignment of all regulations relating to shale gas to the ongoing rapid technological developments in the exploitation of such gas.

15 There should be a review of all pertinent policies and plans that impact on the development on the natural gas opportunity in South Africa, as well as the economic implications of shale gas development and distribution. This should include committing funding to gas transmission and distribution infrastructure in order to develop gas markets that are currently based on imports.

16 Immediate and substantive investment should be secured for the development of expertise and equipment capacity in resource exploration.

17 The Department of Higher Education and Training (DHET) and DST should be tasked with coordinating all skills planning initiatives in South Africa to develop an optimum overall plan for local skills development for the shale gas industry. These strategies must include expanding collaboration with the world's leading professional and academic institutions in order to facilitate knowledge transfer and establish state-of-the-art working protocols based on robust scientific and engineering methodologies.

18 The government, through the Department of Home Affairs (DHA), should ensure that the necessary enabling legislation is in place to facilitate the importation of people with the necessary upstream/technical and regulatory skills to assist in the initial phase of the development of the industry.

19 The government should ensure that any new legislation related to the shale gas industry is fully aligned with the Astronomy Geographic Advantage Act *(Act 21 of 2007)*.

Summary

There are indications that South Africa possesses significant shale gas reserves and that if exploited these reserves could make an important contribution to the national and regional energy needs. The panel is of the view that it is critical that the implementation of any hydraulic fracturing should follow best practice at all stages, and that a clear legislative environment and a rigorous regulatory and monitoring structure are needed to ensure that, at all stages of the life of a well, there is continuous monitoring of compliance with all the relevant regulations. Specifically, the panel is of the view that no licences for exploration or production should be issued until the set of recommendations made in its report has been addressed.

Panel members

- Prof Cyril O'Connor, University of Cape Town
- Mr Fanie de Lange, University of the Free State (UFS)
- Prof Maarten de Wit, Nelson Mandela University
- Mr Stefan Hrabar, Mirlem
- Prof Meagan Mauter, Carnegie Melon University
- Dr Mike Shand, Aurecon
- Mr Mthozami Xiphu, South African Oil and Gas Alliance (SAOGA)

Discussion

Derek Light, Attorney: It is unfortunate that by the time people involved in the SEA public participation process heard about the ASSAf study it was under embargo. Had the ASSAf study involved greater public participation it might have informed the SEA and the researchers might have benefited from public comment.

Response – Prof O'Connor: The point of the embargo was to enhance the integrity of the report by avoiding the contamination of findings by vested interests, primarily commercial companies. It was always the intention to submit the recommendations for comment and peer review. As a work in progress, comments from the conference are welcomed and would inform and enrich the recommendations.

Prof Philip Lloyd, Cape Peninsula University of Technology (CPUT): There is concern that the committee has been unduly influenced by the North

American experience of multiple well owners, resulting in the call for excessive bureaucratic oversight. In South Africa, the state owned the resource and there would be very few operators, which would simplify the control process. Furthermore, oil companies are very aware that their reputations are at stake and would take the necessary precautions.

Response – Prof O'Connor: The international shale gas industry was widely researched, with information being obtained from Prof Brian Horsfield, Technical University of Berlin (the European experience); the Australian Council of Learned Academies (ACOLA) report *Engineering energy: unconventional gas production, a study of shale gas in Australia* (See http://acola.org.au/wp/project-6/); and reports from Canada and the Royal Society in the United Kingdom (UK), among others. The USA has been mentioned because it is the country in which most hydraulic fracturing is taking place, and from which many lessons could be learned on how not to proceed.

Dr Mike Shand, Aurecon: The relatively low oil price has allowed South Africa a few years in which to prepare thoroughly to undertake shale gas development. There is time to conduct baseline studies and to develop regulations to address social, economic and environmental concerns.

Response – Prof O'Connor: The recommendations provide a template of how shale gas should be implemented if and when it is exploited. The report recommended a whole-of-government approach, with a number of government departments being involved in developing high-level policy.

Nigel Rossouw, Shell: With reference to the recommendation that research programmes be implemented prior to exploration, exploration was in fact not separate from research but involved the collection of scientific and technical data. Because data gathering is expensive and time-consuming, a more collaborative approach involving society, industry and government should be considered.

While there are unique issues relating to shale gas development, issues such as research capacity, skills development, regulation, and research and development (R&D) should be dealt with as part of the overall gas industry in South Africa.

Even if shale gas exploitation is proven to be technically feasible and commercially viable, it would take a long time to implement.

Response – Prof O'Connor: Exploration and research are integrated processes. In terms of skills and research capacity, there is a lack of relevant skills in the sector as a whole, and no existing petroleum engineering programme in South Africa. The Africa Earth Observatory Network (AEON) is a good example of the type of R&D activity that is needed. (See Prof De Wit's presentation.)

Marcus Pawson, AfriForum: Regulations relating to the shale gas industry had been drafted by the government before these studies were undertaken. A court case relating to these regulations was pending. If the regulations were to be set aside, would the ASSAf report be affected?

Response – Prof Jan Glazewski, UCT: AfriForum was challenging the shale gas regulations in the High Court. It was likely that these regulations, promulgated by the Minister of Mineral Resources, would be deemed *ultra vires* as they affected the mandates of other government departments. If declared invalid they would need to be rewritten. (See Prof Glazewski's presentation.)

Response – Mr Mthozami Xiphu, SAOGA: The ASSAf study was completed before the regulations were published, but the panel referred to them when presenting the report. The report provided a template for how shale gas should be exploited and would not be affected by changes to the regulations.

Dr Kevin Pietersen, University of the Western Cape (UWC): The concept 'cradle to grave' is questioned. Principles and protocols need to be in place to enable companies to invest in the industry. The lack of involvement of petroleum geologists in the process is of concern. Prof John Cherry, Chairperson of the Canadian shale gas study, would be visiting UWC and panel members were invited to meet with him.

Response – Prof Maarten de Wit, Nelson Mandela University (NMU): Attempts to establish capacity in petroleum geology have been unsuccessful, despite attempts by UCT, UWC and Stellenbosch University (SU). It is essential to develop training capacity in South Africa to supply the shale gas industry as many people who were sent overseas for training did not return.

Response – Prof O'Connor: This is part of a much wider issue of limited skills in certain sectors.

Prof Lesley Green, UCT: According to Joseph Stiglitz, winner of the Nobel Prize for Economics, gross domestic product (GDP) is an inappropriate measure of the well-being of a society. It is necessary to move beyond a neoliberal economic framework and the polarisation of development *versus* environment. Ecology should be considered beyond economic terms, and it is essential to evaluate the short-term benefits of fracking against its long-term impacts. The 'cradle to grave' metaphor is misleading as waste materials from fracking are not like a dead body that returns to the earth; the chemicals have to be kept out of the ecosystem forever and the impacts of the industry on the geology and fossil water sources are permanent. The discussion needs to be framed in terms of long-term ecological responsibilities to future generations and land claimants.

Response – Prof O'Connor: The concern about the 'cradle to grave' metaphor is important. The responsibility for rehabilitating a site to its pristine condition lies with the operator, and there is no terminal point at which the company could walk away. The state is responsible to regulate and monitor this process. If the industry is properly managed and regulated there should be no conflict between ecology and the implementation of a shale gas industry.

Prof Jan Glazewski, UCT: Who is responsible to pay for the infrastructure associated with the shale gas industry, such as roads and pipelines?

Response – Prof O'Connor: If the state wants to promote this industry it has to provide the infrastructure needed by the operator. A model for how to recover this expenditure would need to be developed.

Response – Kishan Pillay, Department of Trade and Industry (the dti): South Africa is extremely price-sensitive with regard to energy, and demand falls off rapidly as the price of energy increases. Infrastructure would have to be provided as demand is unlocked, and development would be incremental over about 50 years.

Response – Stefan Hrabar: Infrastructure development must be carefully planned. The budget for the Transnet Pipeline from Durban to the Reef was overshot (from R7 billion to R32 billion) because a right-of-way through farmland had not been considered. If the enterprise was to be disbanded after a number of years, the infrastructure should be temporary.

Response – Dr Mike Shand: In the water industry, infrastructure is paid for by water rates (the user pays principle). Some guarantees are required before industry would be willing to invest, and the user should also be considered.

Response – Henry Fortuin, Western Cape Government: Payment for infrastructure is usually a planning decision and developers pay development contributions. The issue is the mechanism used, and there are no clear answers. It is of concern that Beaufort West has no registered planner and could therefore not make good planning decisions.

Henry Fortuin, Western Cape Government: Funds need to be set aside for future rehabilitation works, such as well head casings after 50 years. South Africa did not have a good track record of preserving funds; cases were mentioned of rehabilitation funds being raided and repatriated without permission from the government. Without a source of funds, future taxpayers would have to cover these costs.

Response – Prof O'Connor: This point is well made. In mining applications in the USA, the company is required to invest a designated amount of the development cost to rehabilitate the site.

Unknown: Could the units for estimation of gas resources be standardised as trillion cubic metres (Tcm) rather than feet (Tcf) in line with South African standard units?

Dr Gerald Kafuku, Tanzania Commission for Science and Technology: Development of the shale gas industry should engage local communities and use local content. Oil and gas operations in Mozambique and Angola could be approached for advice. Due to the severe skills gap, a skills development strategy is necessary that includes both up-stream and down-stream skills. It is necessary to invest in subjects like petrochemical engineering.

Response – Prof O'Connor: South African cement and steel companies would have to adapt their processes to provide the shale gas industry with the quality and quantity of materials required. In the initial phases, some materials might need to be imported.

Regarding political cooperation, the report called for a body at national government level (possibly PASA) to coordinate the various departments and structures involved in the shale gas industry.

Tsholofelo Mokotedi, Energy and Water Sector Education and Training Authority (SETA): Where occupational qualifications are concerned, the SETAs should be involved. The relevant SETAs should be advised in time to allow for both strategic and sector skills planning, and the funding of skills implementation.

Response – Prof O'Connor: This important point needs to be captured. More clarity is needed on how to obtain funding from the SETAs.

Nigel Rossouw, Shell: The probability of the shale gas industry succeeding in South Africa beyond the exploration phase might be less than ten per cent. An incremental approach is therefore required. Rather than committing to a large project paradigm, an alternative approach could be small incremental projects with micro-distributed power generation units and small facilities for gas transport. The unit costs for gas production would determine the business model.

Response – Prof O'Connor: The incremental approach related to Prof De Wit's presentation in which he described starting with a field laboratory test site where vertical drilling would be carried out.

Bongani Sayidini, PetroSA: Factors that accelerated the development of the shale gas industry in the USA included the availability of exploration acreage and the involvement of many operators. In South Africa, very large acreage is held by a few companies. The Technical Co-operation Permit (TCP) initially granted Shell 90 000 km^2, for instance. Most of the acreage is currently under exploration right applications. Smaller exploration acreages would allow the involvement of a number of operators and accelerate development of shale gas. Did the panel recommend that PASA reduce the exploration acreage to enable the participation of more smaller operators?

Response – Prof Maarten de Wit: The term 'exploration' is a slippery term. Exploration is in fact taking place as Shell has outsourced exploration to universities and the CGS, and some drill sites are active.

Response – Prof O'Connor: There has been a moratorium on further awards of acreage. How the first allocations were carried out was not part of the study brief, and the panel was not competent to discuss this issue.

Prof Kalu Mosto Onuoha, Nigerian Academy of Science: Regarding the question of phasing, many wells are required for shale gas production and there is a need for flexibility regarding production. An elaborate regulatory framework has been recommended but this is a dynamic process. The separation of Phases One and Two might need to be reconsidered to allow some production to proceed. Foreign investors existed like Shell, which was divesting from Nigeria and ready to invest $6 billion in the Karoo. If international oil companies (IOCs) are going to operate in South Africa they have to be sure that resources and infrastructure are available. Shale gas development took place in the USA because the gas infrastructure was already there. In South Africa, the government might have to provide this.

Derek Light, Attorney: The oil and gas industry warned against over-regulating the industry and scaring off investors, and indicated that they were able to regulate themselves. But regulation is there to protect South Africa's people and environment. It is encouraging that both the SEA and ASSAf studies have emphasised proper regulation of the industry and the need for baseline research.

Regarding the suggestion from Shell that they collect data, South African law did not yet cater for fracking. It required oil and gas companies to supply baseline data before licences or authorisations would be provided; however, they had already avoided compliance and appealed for further deregulation, requesting the SEA authors to lessen the administrative burden on organisations applying for licences. The authors had not done so.

There are concerns about the lack of knowledge in certain areas and the lack of regulation. If a shale gas industry is to proceed, it must be properly regulated.

Paul Hardcastle, Western Cape Government: Government decisions must be informed by continued learning, based on independent, credible information. Do adequate government structures exist to enable informed decisions about where to conduct explorations? And will information gathered during exploration inform the way forward openly and transparently?

A criticism of the report is that centralised decision-making at national government level is emphasised at the expense of the provincial and local levels at which shale gas development would take place. All layers of government need to be involved.

Response – Prof O'Connor: The ASSAf report emphasised that legislation needed to be implemented and monitored by people with integrity. A more flexible approach is possible and the development of regulations could be dynamic. But concerns exist about poor levels of policy implementation in South Africa. Well educated and trained regulators and monitors are needed.

It is proposed that anyone awarded a Phase One licence should sink six to seven test wells, and that all the information gathered should be put into the public domain. This would feed into the field development model, a joint venture between the operator and government.

The whole-of-government approach includes provincial and local governments. People of integrity are needed to enforce regulations. Shale gas could be a good thing if properly managed, monitored and regulated.

Ms Balmer: If delegates want to comment on the document they could send an email to Ms Nadia Algera of ASSAf and make written submissions to the panel. A policy brief would be produced as an outcome of this conference.

SESSION 3: SHALE GAS DEVELOPMENT IN THE CENTRAL KAROO: A SCIENTIFIC ASSESSMENT OF THE OPPORTUNITIES AND RISKS

Facilitator: Mr Saliem Fakir: Head of Policy and Futures Unit, World Wide Fund for Nature South Africa (WWF-SA)

Shale Gas Strategic Environmental Assessment (SEA): Introduction to the study

(Ms Dee Fischer, Chief Director, Department of Environmental Affairs)

Background

On 7 September 2012, Cabinet lifted the moratorium on shale gas exploration to allow normal exploration under certain conditions. This SEA responded to one of these conditions, namely ensuring ongoing research to enhance scientific knowledge on environmental matters.

A SEA is a process of developing sustainable solutions as an integral part of planning activities. It is intended to be a participatory and iterative process, which should result in new information, capacity development, institutional development, enhanced scientific knowledge, and better decisions.

This SEA was a partnership involving the DEA, DMR, DST, the Department of Energy (DoE), Department of Water and Sanitation (DWS), and Department of Agriculture, Forestry and Fisheries (DAFF), as well as the provincial governments of the Eastern Cape, Northern Cape and Western Cape.

The CSIR was commissioned to lead a multi-disciplinary team of expert scientists. A Project Executive Committee comprising project partners monitored progress and ensured that the project remained on time and within its scope. The SEA was overseen by a Project Custodians Group consisting of representatives from non-governmental organisations (NGOs), the private sector and the research community, which ensured that the process was fair and rigorous.

SEA objectives and phases

- Phase One – Conceptualisation and methodology: Consultation structures were established.
- Phase Two – Strategic assessment: An independent technical assessment was undertaken by a multi-author team of scientists with

no government involvement, to assess the risks, sensitivities and limits of acceptable change over 17 strategic issues relating to shale gas development.

- Phase Three – Decision-making framework: Management tools for decision-making were developed to enable government departments to implement the recommendations practically. Outcomes included:
    - minimum requirements for the submission of EIAs for exploration, appraisal and production activities (this document had yet to go through the consultation process and might be amended);
    - baseline monitoring requirements;
    - minimum levels of assessment in EIA – protocols for questions that specialist studies should address; and
    - policy recommendations to be considered by government.

The findings of the independent technical assessment would be the focus of the presentation by Prof Scholes.

Strategic Environmental Assessment for Shale Gas Development in South Africa: Report findings and recommendations

(Prof Bob Scholes, Project Leader, University of the Witwatersrand (Wits))

Introduction

Prof Bob Scholes co-led the scientific assessment with Paul Lochner of the CSIR. They were supported by the management team of Greg Schreiner, Luanita Snyman-van der Walt and Megan de Jager, plus three national science councils: the CSIR, CGS and the South African National Biodiversity Institute (SANBI), over 140 other experts, nearly 200 reviewers from ten countries, and over 600 stakeholder participants.

The study area covered 172 000 km^2 of the Karoo Basin in the Eastern, Northern and Western Cape provinces, in and around the areas where exploration right applications were under consideration.

The 18-month process was the most broadly-based, elaborate and robust assessment on one issue ever undertaken in South Africa. The report, comprising 18 topic-specific chapters, was published online as a citeable, peer-reviewed, ISBN-numbered book, available at http://seasgd.csir.co.za/.

The presentation focused on key emergent issues and the theme of the conference, which was how to proceed with the development of the science programme, informed by the outcomes of the SEA.

Stakeholder-defined topics

It was decided that the receiving environment rather than just the assessors should define the questions that guided the study. Through a consultative process with a range of stakeholders, 17 topics were defined, representing the biophysical, economic and social environments:

- Biophysical: Air quality and GHGs, geophysics, terrestrial biodiversity, water resources.
- Economic: Economics, national energy planning, spatial planning and infrastructure.
- Social: Agriculture, electromagnetic interference, heritage resources, human health, noise, sense of place, social fabric, tourism, visual aesthetics, waste management.

Scenarios, activities and risks

Each of the 17 issues was evaluated in relation to three possible scenarios, namely:

- S1: Exploration only – no further exploitation of gas; there was a 90% chance that the resource would not be viable, and that exploitation would not continue.
- S2: Small gas – relatively low levels of gas discovered (5 Tcf); if a minimum amount of viable gas was discovered, a small-scale industry could be developed with a lifespan of 20 to 30 years.
- S3: Big gas – relatively high levels of gas discovered (20 Tcf); this represented only 2.5% of the coal resource in South Africa and would not be sufficient to cause a transformation of the energy sector; however, it would change the energy mix and enhance the use of renewable energy sources.

The production requirements and impacts of these three scenarios were quantified and compared. Factors included the number and area of well fields and well pads, new roads and truck visits required, and the volumes of water required and flowback waste generated. This enabled more productive discussions to take place.

It was important to appreciate that the Karoo was neither pristine nor unchanging. Instead, the environment was rapidly changing in relation to factors like climate change, economic activities, energy developments and urbanisation. The assessment took place against a moving baseline, and needed to take account of other drivers of environmental change in addition to shale gas development.

Risk assessment approach

Risk assessment considered both the *likelihood* and *consequence* (impact, exposure and vulnerability) of possible incidents. The range of possibilities generated a spectrum of risk in which, for example, one type of incident might be very unlikely but potentially catastrophic, while another might be likely but have only a moderate impact.

Risk assessment was an expert-driven process involving both local and scientific expertise. The process understood and accepted that people had agendas that were important to them and needed to be included in the deliberations. A wide range of issues was assessed and resulted in quantified risk tables that enabled people to share a common language regarding diverse risks. In the risk tables, scenarios were scored both with and without mitigation activities. The difference between these two scenarios represented the scope for policy, scientific and engineering interventions.

The risk assessment was spatially explicit and did not make global recommendations regarding the viability of shale gas exploitation across the entire study area. Instead, recommendations were conditional and depended on circumstances including viability, the need for mitigation, and features of the receiving environment. Risk maps with and without mitigation enabled problem areas to be identified both spatially and in relation to particular topics.

Some unsurprising and surprising findings

- Water was such a big problem that it ended up as a non-issue. All available surface water in the study area was already allocated, and therefore shale gas exploitation would have to use a different water source, either imported or deep saline water. Surface water must not be contaminated.
- Heritage and biodiversity assets were widespread throughout the study area, and included both endemic species and archaeological and paleontological sites. Because the placement of shale gas

platforms could be flexible, it would be possible to avoid damaging significant sites.

- The climate change advantages of shale gas development were surprisingly small. Despite shale gas potentially generating 50% lower GHG emissions than coal, methane was a much more powerful GHG. A leak of only 2% from a well field would negate any potential GHG benefits. The industry average for fugitive emissions was 2%, and therefore regulations, monitoring and enforcement would be essential.
- The shale gas industry would generate far fewer low-skilled jobs than the tourism or agriculture sectors.
- The four main economic activities in the Karoo, namely farming, tourism, renewable energy and the SKA, were all similar in size. It would be unwise to allow the shale gas industry to threaten existing economic activities that employed more people.
- The health status of people living in the Karoo was generally poor due to high levels of poverty. It would be unwise to expose people whose health was already compromised to respiratory or water pollutants.
- The Karoo was a seismically stable region, and the risk of the shale gas industry inducing earthquakes was low.
- 'Sense of place' was a pivotal issue that influenced public opinion but was difficult to assess from a purely scientific standpoint.

What areas of science needed to be better understood?

- It was uncertain if there were viable shale gas deposits in the Karoo. Exploration was needed to ascertain where gas deposits were and how large they might be.
- The industry was unlikely to have significant direct impacts on biodiversity, but there were concerns about the impacts of landscape fragmentation by pipelines, roads and trucks on different organisms.
- Issues relating to different senses of place needed to be investigated by drawing on non-science epistemologies and research tools. Other ways of understanding the world, such as through the arts, and faith-based or indigenous ways of knowing, could illuminate key attributes of different senses of place.
- Local non-potable water resources that could be used for fracking needed to be discovered.

What measurements needed to be improved?

- A denser seismic network was needed in the Karoo in order to be able to pinpoint seismic activity.
- Background levels of air and water quality were needed, such as methane in the air and novel substances such as hydrocarbons and radionuclides in groundwater.
- Economic sectors in the Karoo, including tourism and renewable energy, needed to be disaggregated spatially and by sector in order to be better understood.
- The fine-scale distribution of biodiversity and heritage assets needed to be mapped, and innovative approaches like citizen science could be employed.
- The visual quality of the landscape needed to be assessed.
- Baseline data on the health status of Karoo inhabitants were needed.
- Whether impacts on the environment would be minor or major depended on the performance of institutions; no mechanisms existed to track this.

What technologies were needed?

- Electromagnetic frequency (EMF) shielding of shale gas machinery was needed to ensure that there were no impacts on the SKA. Suppression of noise and light pollution was also needed during shale gas exploration and development.
- Near real-time, spatially-explicit fugitive gas detection technologies were needed.
- Rehabilitation of arid, biodiverse, tourism-oriented environments would be required after shale gas exploration and development.
- Limits of acceptable change needed to be established for novel but measurable processes, and inherently subjective issues, which included visual pollution, social coherence and sense of place.

What technical skills needed developing?

- Entry, mid and high-level technical skills needed to be developed in advance of the establishment of the shale gas industry to avoid over-reliance on imported skills.

- Planning, permitting, zoning and waste management skills were needed at local government level.
- Advanced, sustained, adaptive environmental monitoring skills needed to be improved.
- Strategic and impact levels of environmental assessments needed to be integrated and fit for purpose. The current EIA process was too elaborate and formulaic. EIAs and EMPs needed to be efficient, timely, credible, meaningful and implemented.

Key messages for government

- Timeline: Production was a long way off, if it ever materialised. A common message was needed that did not raise unjustified expectations or anxieties.
- A poorly-competitive resource: Little existing gas infrastructure and a geologically difficult resource made South African shale gas an unattractive investment at current oil prices.
- An uncertain resource: Exploration would be helpful for energy planning.
- Manageable exploration risks: There were no fatal risks associated with exploration activities, if conducted according to best-practice standards.
- Avoidance was best: Most risk could be mitigated, even at production scale, if avoidance best-practice principles were maintained.
- Production thresholds: Current estimates were that production-related activities in the Central Karoo could become increasingly risky beyond 20 Tcf.
- Institutional capacity: The ability of South Africa to manage the risks of shale gas development depended on the strength of its institutions and monitoring data.

It was not the role of the assessment process to tell the government what to do. The assessment clarified actions and consequences. In the final phase of the process, the government would use the assessment outcomes to develop protocols and guidelines for the way forward.

“We have the time, space and shared interest to do this right. Let us not waste the opportunity.”

Discussion

Saliem Fakir, WWF: What has happened since the SEA report had been submitted, and what decisions could people expect from the study?

Response – Dee Fischer, DEA: Much has been learnt from both studies. Certain actions were within the realm of departmental officials (such as refining EIA guidelines and protocols), while others were the responsibility of the politicians. The DEA would be making recommendations and holding discussions with partners. However, it could take much more than a year for the outcomes of the studies to be translated into policy.

Prof Jan Glazewski, UCT: The definition of 'SEA' is questioned: is it a matter of the spatial extent of the study, or comparing the pros and cons of strategic decisions, such as the relative benefits of importing gas from Mozambique compared with shale gas extraction in the Karoo?

Response – Prof Scholes: Although the EIA process makes provision for an SEA, it does not define it. The value of doing an SEA is to avoid the problem of incrementalism in the context of a widespread activity, and ensuring an integrated approach so that combined levels of acceptable change are not exceeded.

Although the SEA was not meant to be a study of South Africa's energy mix, it had been a stakeholder concern. The study therefore investigated shale gas in relation to broader issues like costs, pollution and energy security. This had resulted in the counter-intuitive finding that introducing a small amount of gas could increase South Africa's ability to use renewable energy sources. At the same time, it was important to avoid 'scope creep' and to focus on completing the assessment within the allocated time. Emerging international experience in climate and biodiversity assessments influenced the research team's understanding of the SEA process and issues of transparency and evidence-checking.

Response – Nigel Rossouw, Shell: It has not been possible to make a strategic choice between importing gas from Mozambique and exploiting Karoo shale gas because Mozambique has taken decades to determine its unit cost of gas production.

Niall Kramer, SAOGA: Would the list of recommendations in the SEA be prioritised? Exploration is the most important step as it would provide data for decision-making. If the gas resource does not prove viable, then many of the other issues would be moot.

Response – Prof Scholes: The phased approach of the SEA implies that sequence is important. In addition to urgency, some activities depend upon others. Furthermore, some activities, such as the installation of monitoring equipment, could yield beneficial outcomes whether or not shale gas development goes ahead. All these processes should be seen as iterative, adaptive and ongoing. In time, due to the changing context, the SEA might need to be repeated.

Response – Dee Fischer: Exploration is not a simple process. Knowing where to drill requires years of work.

Nigel Rossouw, Shell: Four strategic issues remain unanswered:

1. Licensing of the acreage is a strategic issue. Would South Africa follow the *laissez faire* approach of the USA, which had involved too many contractors for the government to manage; or would it follow the focused approach of the Netherlands, which had appointed only one contractor to manage a 50 Tcf gas resource?
2. Governance issues relate not only to government coordination but also to the involvement of society.
3. Liability remains an issue in relation to the National Environmental Management Act (NEMA), Section 24R: Mine closure on environmental authorisation. Managing future liability is essential, in order to avoid issues like acid mine drainage on the Witwatersrand.
4. Energy planning needs to view the production rate of gas as part of an integrated energy mix, but this aspect has not been addressed in the shale gas debate. Would the market and private contractors decide on production rates, or would these be managed more sustainably over the long term as part of the overall energy mix?

Response – Prof Scholes: These excellent questions should be the focus of a strategic discussion, which could start in this forum.

Bongani Sayidini, PetroSA: The concern about the relatively high GHG effect of methane in shale gas ignores the fact that methane was used extensively as a fuel in Europe and the USA. Why is the GHG effect of methane an issue in South Africa if it has been used for many years in other countries?

Response – Prof Scholes: This concern is misplaced. In the absence of leaks, captured methane gas is beneficial as a fuel. But significant methane leaks from wells into the atmosphere negate these benefits because methane is a potent GHG.

Paul Hardcastle, Western Cape Government: The SEA and ASSAf studies and recommendations are welcomed, but implementation and monitoring represent significant challenges. The conference needs to clarify roles and responsibilities with respect to information and data gathering, as well as the analysis (i.e. of new knowledge) and the dissemination thereof, to relevant stakeholders. Guidance is needed on how to use the spatial information; for example, could it be included in Spatial Development Frameworks (SDFs) or Environmental Management Frameworks (EMFs) at local authority level, and to inform regulatory decision-making? Recommendations and cooperation are needed to avoid confusion.

Response – Prof Scholes: How to sustain the process and influence decision-making is an important question for this meeting. It is equally important to ask the policymakers how the engagements would continue.

Derek Light, Attorney: Despite the excellent work done by the SEA team, the concern was expressed that the terms of reference of the SEA had been too limited. The focus on the Karoo suggested that shale gas exploration would be limited to this region, but areas of the Free State and KwaZulu-Natal have since been targeted. It is important to ask if South Africa needs to exploit shale gas, if it could be safely exploited, regulated and monitored, and if the country has the capacity to do this.

Response – Prof Scholes: Confining the study to the Central Karoo had been a pragmatic decision. The region is large enough to be strategic, while being a well-defined area. At the time, it has been the prospecting hotspot. Decision-makers should be very careful about applying the SEA to other areas or sources of gas, especially coal-bed methane. Coal-ed methane presents greater environmental threats than shale gas as it is much closer to the surface and therefore more likely to contaminate surface water and interferes with the hydrology.

Response – Dee Fischer: What has been learnt from the SEA would impact other areas, for example, the development of decision support tools. While it had been necessary to limit the SEA, this did not represent a missed opportunity. Despite having done a SEA, any development would also require an EIA.

Prof Kalu Mosto Onuoha, Nigerian Academy of Science: The technically recoverable reserves of shale gas depend on technology and geology; the economically recoverable reserves depend on both these factors, as well as market forces, which could change at any time. The Gas Utilisation

Master Plan (GUMP) seeks to meet the energy needs of South Africa by stimulating a local gas industry.

Response – Prof Scholes: The GUMP was initiated at the same time as the SEA, which it had informed. It is sensible to include gas in the South African energy mix. A domestic source would be preferable, although this might not be shale gas. Gas might not be economically viable, however. The development of shale gas in South Africa is about twice as expensive as in the USA, and is not affordable below an oil price of $50 per barrel. The geology is challenging, being shot through with dolerite, which introduces uncertainties. The USA and Europe have an established gas infrastructure, which South Africa lacks. For all these reasons, developing a local gas industry is currently unlikely.

Niall Kramer, SAOGA: In the USA, the gas infrastructure had been developed before the oil price had dropped, and the industry had therefore been able to respond flexibly according to where gas was available. South Africa did not have a similar infrastructure, and the costs of infrastructure development and drilling would be high.

Saliem Fakir, WWF: How relevant is the oil price as an index?

Niall Kramer, SAOGA: Between the 1970s and the present the oil price had ranged between $8 and $130 per barrel. In the USA, gas was traded in Dollars per Million British Thermal Units (BTU) on the Henry Hub natural gas exchange. Although oil and gas were becoming de-linked, the oil price is better known.

Unknown: The question regarding the use of Tcf as a unit of measurement in South Africa was repeated.

Response – Prof Scholes: In the oil industry, even more obscure measures are used. It is important to communicate in the language of the receiving audience. When speaking with people who understand Tcf, that unit could be used, but when speaking to the public neither Tcm nor Tcf is helpful; instead volumes that people understand, like Olympic swimming pools, could be used.

Nicholas de Blocq, Service Technologies: A question was asked about the sloping baseline in the graph in Prof Scholes' presentation, which plotted nominal risks *versus* years for the three activity scenarios (exploration, small gas, big gas).

Response – Prof Scholes: The diagram is schematic and its purpose is to show that risk profiles differ in time and magnitude, and that they are incremental. As previously explained, the sloping baseline represents background changes that would have occurred without shale gas exploitation. On top of this, changes due to exploration, small gas and big gas are plotted.

SESSION 4: THE REGULATORY ENVIRONMENT

Facilitator: Ms Lindiwe Mekwe, Chief Executive Officer, Petroleum Agency South Africa (PASA)

Introduction to the regulatory environment

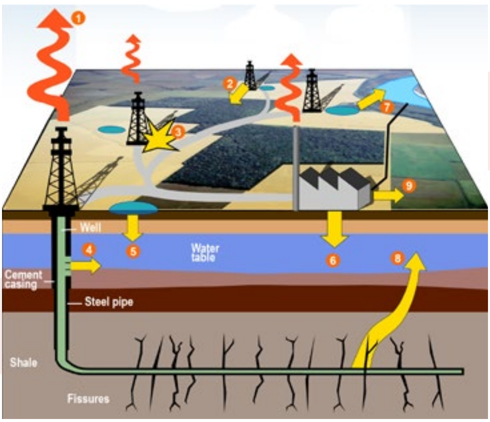
(Prof Jan Glazewski, UCT)

Introduction

Prof Glazewski presented an overview of the regulatory context in which shale gas development was taking place. A new publication that took an inter-disciplinary approach to the shale gas industry was introduced:

Glazewski, J. and S. Esterhuyse (Eds). 2016. *Hydraulic Fracturing in the Karoo: Critical Legal and Environmental Perspectives.* Cape Town: Juta.

Environmental issues and risks related to shale gas exploitation include (Figure. 1):



1 Release of GHG emissions
2 Land footprint: natural and agricultural lands
3 Risk of explosion: wells, pipelines and transport
4 Risk of leakage from wells into the water table
5 Risk of leakage of fracking fluids or produced water into the water table
6 Risk of leakage from poorly treated water and fracking fluids from flow-back into the soil and water table
7 Risk of leakage from poorly treated water and fracking fluids from flow-back into surface waters
8 Risk of infiltration of fracking fluid into the water table; risk of migration of naturally occurring toxic substances
9 Health impacts of poorly treated produced water on crops.

Figure 1: Environmental risks related to shale gas development

Two issues of particular concern in the South African context are:

- water scarcity and quality – see above; and
- income disparities – according to both the Gini Index and Palma Ratio, South Africa is currently the most unequal society in the world.

Co-operative government

According to Chapter 3 of the Constitution: Co-operative Government:

Section 40 (1) In the Republic, government is constituted as national, provincial, and local spheres of government which are distinctive, interdependent and interrelated.

Section 41 (1) All spheres of government and all organs of state within each sphere must …

(g) exercise their powers and perform their functions in a manner which does not encroach on the geographical, functional or institutional integrity of government in another sphere.

Furthermore, the Constitutional Court declared that:

These principles, which are appropriate to co-operative government, include an express provision that all spheres of government must exercise their powers and functions in a manner that does not encroach on the geographical, functional or institutional integrity of government in another sphere. (Ex parte: Chairperson of the Constitutional Assembly, In re: Certification of the Constitution of the Republic of South Africa, 1996)

Numerous national government departments are involved in the shale gas enterprise, including the DMR, DWS, DEA, DST, DoE, DAFF, Department of Rural Development and Land Reform (DRDLR), Department of Health (DoH) and Department of Arts and Culture (DAC).

Legislation and fracking regulations

Each government department is governed by its own legislation and operates within its own sector. Cooperation between the DEA and DMR is enabled by the principle of sustainable development, which is the cornerstone of the National Environmental Management Act (NEMA) (*No107 of 1998*).

This definition is also included in the Mineral and Petroleum Resources Development Act (MPRDA) (*No 28 of 2002*) and defined in that Act as:

'*… the integration of social, economic and environmental factors into planning, implementation, and decision-making so as to ensure that mineral and petroleum resources development serves present and future generations.*' (Definition section 1)

NEMA has a set of national environmental management principles based on sustainable development [S 2(1)], for example, the polluter pays principle, and the precautionary principle. These principles are cross-cutting in that they:

'*… apply throughout the Republic to the actions of all organs of state that may significantly affect the environment.*' [S 2(4)]

In addition to horizontal integration between national government departments, vertical integration is also needed between national, provincial and local levels of government. Fracking is set to take place at the intersection of the Eastern, Northern and Western Cape provinces. The national departments need to proceed with caution, as illustrated by the Maccsand case in Cape Town.

The Maccsand case: National and provincial government interaction

The DMR gave a licence to Maccsand to extract dune sands for building purposes in Macassar, Cape Town. This was challenged by the Western Cape government because permission had been granted without planning or zoning permission from the province.

The matter was heard in the Constitutional Court, with two issues being raised:

1 Did being granted a mining permit authorisation mean that the applicant did not require authorisation under provincial planning law? Was re-zoning approval necessary before the commencement of mining activity?

2 Did the holder of a mining permit need additional environmental authorisations in terms of NEMA, given that: "The Minister of Minerals must be identified as competent authority (…) where the activity constitutes (…) mining (…)?"

The Maccsand appeal was dismissed by the Constitutional Court, which ruled that:

1 The Land Use Planning Ordinance (LUPO) and the Mineral and Petroleum Resources Development Act (MPRDA) *(No 28 of 2002)* functioned alongside each other and both must be adhered to; and

2 NEMA (DEA) and MPRDA (DMR) operated alongside each other as both were competent authorities.

Regulations for petroleum exploration and production (fracking regulations)

The regulations comprise five chapters and 70 pages (*Government Gazette*, 3 June 2015). There are areas of overlap with the responsibilities of other departments, including DEA and DWS.

- Introduction: 50 regulations (numbers 84 to 133);
- Ch 6: General Provisions;
- Ch 7: Environmental Impact Assessment (overlaps with DEA and DWS);
- Ch 8: Well Design and Construction;
- Ch 9: Operations and Management; and
- Ch10: Well Suspension and Decommissioning.

All three relevant departments would need to be involved in administering these regulations, and an enforcement committee would be needed to ensure compliance.

Points for discussion: going forward

- Re-visit fracking regulations to ensure greater cross-sectoral or cooperative governance.
- Work towards a single environmental system.
- Ensure compliance with conditions laid down in the EIA Record of Decision (RoD) and determine who would enforce this.
- Consider the role of the Green Scorpions, Environmental Management Inspectorate (EMI) (under the jurisdiction of DEA), and Environmental Mineral Resource Inspectorate (EMRI) (under DMR) – a cooperative governance approach is needed to create an integrated inspectorate.
- Set up an independent, strong, empowered, well-represented monitoring committee.

Monitoring, administration, compliance and governance

An independent, inter-sectoral monitoring committee is required, consisting of:

- different national ministries,
- provincial and municipal representatives,
- industry representatives,
- academics, and
- technical and engineering skills.

This committee must have a clear mandate and powers to ensure compliance.

Regulatory and legislative aspects of shale gas exploration and production

(Mr Tebogo Motloung, PASA & DMR)

Background

Background to the development of policy affecting hydraulic fracturing was provided:

- 21 April 2011: Cabinet announced the formation of an inter-departmental task team to investigate, among others, potential environmental risks posed by hydraulic fracturing.
- 7 September 2012: Cabinet approved the report: *Investigation of Hydraulic Fracturing in the Karoo Basin of South Africa*, and directed the establishment of an inter-departmental monitoring committee to:
    - augment the current regulatory framework to mitigate any negative environmental impacts associated with hydraulic fracturing; and
    - ensure comprehensive and co-ordinated monitoring of shale gas explorations.
- 3 June 2015: The Minister of Mineral Resources promulgated *Regulations for Petroleum Exploration and Production*.
- Promulgation of the regulations effectively lifted the moratorium on hydraulic fracturing imposed by Notice No 71 of 3 February 2014.
- A restriction on the ‘granting’ of all new applications (in the Karoo), except for applications lodged before 1 February 2011, still remained.

- Regulations are being challenged in court, but until they are set aside by a court of law they remain applicable to all onshore exploration and production activities.

Legislative and regulatory framework

Oil and gas exploration are subject to a wide range of laws and regulations, including:

- The Mineral and Petroleum Resources Development Act, 2002 and Regulations.
- National Environmental Management Act, 1998 and Regulations.
- National Water Act, 1998.
- National Heritage Resources Act, 1999.
- National Environmental Management: Waste Act, 2008.
- Astronomy Geographic Advantage Act, 2008.
- National Radioactive Waste Disposal Act, 2008.
- National Environmental Management: Air Quality Act, 2014.

Aside from the explicit legislative provisions in the form of Acts, the definition of the MPRDA incorporates Terms and Conditions of Exploration and Production Rights. If these are imposed as part of the granting of the right, the terms and conditions assume the full force of law by virtue of directives issued in terms of the MPRDA.

Hydraulic fracturing

Hydraulic fracturing is the pressurised injection of a mixture of water, chemicals, and sand into underground formations (rocks with low or no permeability) to allow natural gas and oil to flow more freely from rock pores to a production well.

Communities have voiced concern about potential impacts including air quality, biodiversity, infrastructure, seismicity, waste production, water pollution and contamination of drinking water.

The regulations were formulated with the intention of addressing these concerns.

Development of the regulations had been informed by a number of studies, including:

- Noble gases identify the mechanisms of fugitive gas contamination in drinking-water wells overlying the Marcellus and Barnett Shales (12 August 2014) by independent researchers associated with various higher institutions of learning in the USA. This study confirmed that:
  - neither horizontal drilling nor hydraulic fracturing of shale deposits seemed to have caused any of the natural gas contamination; and
  - poor and sub-standard casing and cementing had been responsible for contamination of drinking water.
- The *Draft EPA Assessment Report* found that fracking had not led to widespread drinking water contamination but identified important vulnerabilities to drinking water resources such as:
  - Hydraulic fracturing conducted directly into formations containing drinking water resources.
  - Inadequately cased or cemented wells resulting in below-ground migration of gases and liquids.
  - Inadequately treated waste water discharged into drinking water resources.
  - Spills of hydraulic fluids and hydraulic fracturing waste water, including flowback and produced water.
- The *Draft EPA Assessment Report* provided regulators and policymakers with a critical resource to identify how best to protect public health and drinking water resources.

Well construction and integrity practices such as those contained in the American Petroleum Institute (API) standards ensured the protection of underground sources of drinking water from impacts related to oil and gas exploration and production activities.

One of the key objectives of the Regulations for Petroleum Exploration and Production is to incorporate well construction standards and practices into the regulatory framework to enhance safe exploration and production. The regulations are not exhaustive on their own but need to be read, where relevant, with other applicable legislation. Current regulatory or legislative gaps that might enhance safe exploration and production would be enforced through directives.

- Assessment of conditions below ground (Regulation 87):
  - To understand possible threats associated with hydraulic fracturing, the geology of the location targeted must be understood.
  - Understanding the geology of the area also helps regulators to determine appropriate protective regulatory measures.
  - Assessment of geohydrology helps with the understanding of the character, availability and quality of groundwater, and for such knowledge to be incorporated in the well-engineering design.
- Assessment of related seismicity (Regulation 89):

The applicant is required to:

  - Assess the risk of related seismicity.
  - Carry out site-specific surveys to characterise local stress regimes.
  - Prevent fracturing fluids from entering stressed faults.
  - Conduct pre-fracturing tests in the target formation with micro-seismic monitoring.
- Protection of astronomy activities (Regulations 92 and 93):
  - Shale gas exploration should not compromise the astronomy project.
- Well design (Regulation 95):
  - Well design is to be submitted to the agency prior to drilling operations, and must at all times adhere to well-integrity imperatives, including preventing the migration of petroleum and other fluids to any formation except the targeted formation.
- Well construction standards (Regulations 96 to 107):
  - The regulations prescribe API standards.
  - Deviation would only be permitted if a detailed technical assessment by an independent drilling engineer of the proposed alternative standards proved higher levels of well integrity (Regulation 96: 5 & 6).
  - Stratigraphic wells are also exempt from default API standards but the holder must still show how it would maintain well integrity.
  - Different types of casing are prescribed that must be set and cemented in accordance with API standards.

- Cementing would be done by the pump and plug method with a minimum of 25% excess.
- The agency is empowered to require different cement if conditions dictated that.
- A radial cement bond log to verify cement bond was mandatory and remedial cementing must be carried out where required.
- The agency had the powers to appoint an independent and competent person at the cost of the holder to undertake well examination.
- Management of erratic pressure and uncontrolled flow by way of a blowout preventer (BOP) was mandatory.

- Drilling and hydraulic fracturing operations (Regulation 112):
  - Hydraulic fracturing treatment pressure must not exceed the test pressure at any given time.
  - Operations must be suspended if anomalous pressure occurs that shows compromised mechanical integrity of the well.

- Hydraulic fracturing fluid disclosure (Regulation 113)
- Fracture and fracturing fluid containment (Regulation 114):
  - Fractures extending beyond the area of interest are a potential problem.
  - The holder must describe control and mitigation measures for fracture containment.
  - Measures to mitigate the risk of fluids migration via faults and intrusions must be referenced in the hydraulic fracturing programme.
  - Monitoring is key: any indication of migration outside target zones must be reported and operations halted.

- Management of flowback and produced fluids (Regulation 116):
  - The waste management plan submitted as part of the application for environmental authorisation must contain flowback and produced water management plans.
  - During operations, operators must submit prescribed information regarding flowback and produced water, for example identified contaminated issues, and compositional analysis.

Conclusions

- The Regulations for Petroleum Exploration and Production prescribe stringent measures that include robust well-construction standards and practices to ensure well integrity and thus safe shale gas exploration and production.
- Published evidence in other jurisdictions and ongoing local studies must be a basis for constant review of the regulatory framework, in order to keep pace with scientific developments.
- Upskilling of personnel in key state departments and entities in key technical and regulatory areas is vital to ensure safe shale gas exploration and production.

Legislation

(Ms Dee Fischer, DEA)

The existing legislation governing shale gas development is fairly comprehensive and includes:

- The Mineral and Petroleum Resources Development (MPRDA) (*No 28 of 2002*):
  - An exploration right must be applied for from the designated agency.
  - If the designated agency accepts the application, the relevant environmental reports (EIAs) required in terms of Chapter 5 of the NEMA must be submitted.
  - If granted, an exploration right is valid for a period specified in the right, not exceeding five years.
  - The exploration right can be renewed by lodging an application.
- Regulations for Petroleum Exploration and Production:
  - These cover the technical aspects of well development and operations:
  - Three important provisions in the regulations contribute to preventing pollution: there is to be transparency regarding fracking fluids, no deep well injection is allowed, and there is to be no on-site storage of waste water.
- The National Environmental Management Act (NEMA) (*No107 of 1998*):

    - Section 24 provides for the assessment of environmental impacts (EIA regulations).
    - Section 24(p) requires compliance with the prescribed financial provision for the rehabilitation, closure and ongoing post-decommissioning management of negative environmental impacts. Financial provision needs to be made prior to the issuing of environmental authorisation.

- Regulations pertaining to financial provision for prospecting, exploration, mining or production operations are currently undergoing amendment.
- The National Water Act (*No 36 of 1998*): Hydraulic fracturing has been identified as a controlled activity, and would require assessment and authorisation.

SEA phases and objectives

EIA legislation requires baseline monitoring, but it would be difficult to do this before authorisation or fracking begins. Exploration is needed first to determine where to drill. During the first five years of exploration, no drilling or hydraulic fracturing will take place.

If the five-year exploration phase was split from the appraisal phase (See Table 1), which includes hydraulic fracturing, this would allow approximately two years to conduct baseline monitoring before hydraulic fracturing began. The public would then have time to be involved with the baseline monitoring plan and to gather data for future comparison and to strengthen the EIA process.

Table 1: SEA Phases and Objectives

<table>
<tr><th>Typical stages of a mining project</th><th colspan="2">Exploration</th><th colspan="2">Production</th><th>Decommissioning</th></tr>
<tr><td>Typical shale gas project</td><td>Exploration</td><td>Appraisal</td><td>Development “Small Gas”</td><td>Production “Big Gas”</td><td>Decommissioning</td></tr>
<tr><td>Timeframe typical of projects in the US</td><td>5 years</td><td>5 years</td><td>10 years</td><td>20 years</td><td>10 years (+ legacy monitoring)</td></tr>
<tr><td>Regulatory checks</td><td>EIA for exploration and commencement of baseline monitoring for appraisal</td><td>Review of exploration data from exploration, review and consolidation of baseline data for appraisal, EIA for appraisal, ongoing monitoring</td><td>EIA for limited production wellfield, baseline monitoring, ongoing monitoring</td><td>For > 50 well pads, EIA for large scale production wellfields (in the region of 400 wellpads), baseline monitoring, ongoing monitoring</td><td>EIA for decommissioning continued monitoring according to closure EMPr requirements</td></tr>
<tr><td rowspan="14">Nature of activities</td><td>2-D seismics</td><td>3-D seismics</td><td>3-D seismics</td><td>3-D seismics</td><td>Gas flow suspension</td></tr>
<tr><td>3-D seismics</td><td>Vertical wells</td><td>Vertical Y-wells</td><td>Vertical Y-wells</td><td>Well closure</td></tr>
<tr><td>Vertical wells</td><td>Horizontal wells</td><td>Horizontal Z-wells</td><td>Horizontal Z-wells</td><td>Well plugging</td></tr>
<tr><td>Roads</td><td>Hydraulic fracturing</td><td>Hydraulic fracturing</td><td>Hydraulic fracturing</td><td>Site clear up</td></tr>
<tr><td>Trucks</td><td>Trucks</td><td>Roads</td><td>Roads</td><td>Production infrastructure removed</td></tr>
<tr><td>Water management</td><td>Water management</td><td>Trucks</td><td>Trucks</td><td rowspan="9">Rehabilitation</td></tr>
<tr><td rowspan="8">Waste management</td><td>Water management</td><td>Water management</td><td>Water management</td></tr>
<tr><td rowspan="7">Flaring</td><td>Waste management</td><td>Waste management</td></tr>
<tr><td>Flaring</td><td>Flaring</td></tr>
<tr><td rowspan="5">Gas compressors</td><td>Gas compressors</td></tr>
<tr><td>Gas2 power plants</td></tr>
<tr><td>Powerlines</td></tr>
<tr><td>Pipelines</td></tr>
<tr><td>Water treatment facilities</td></tr>
</table>

Possible exit **Possible exit**

What gaps exist in the legislation?

Delegates were asked to be specific in terms of defining what additional legislation was needed, or what needed to be improved, so that the DEA could prioritise those areas.

Discussion

Derek Light, Attorney: The fracking regulations are currently being challenged in court. Although there have been great improvements in the NEMA regulations (2014), there are some issues such as the exemption from the provisions of current applications. However, once exploration rights are granted, if the activities of oil and gas companies triggered any activities under NEMA, they would have to go through the EIA process.

Response – Paul Hardcastle, Western Cape Government: The current applications would also be subject to an EIA process. This was also confirmed in the SEA.

Derek Light, Attorney: A problem with the awarding of very large exploration areas, for example 95 000 km^2 in the case of Shell, is that it is impossible to comply with provisions of the MPRDA, which allows only 120 days to complete the consultation process and lodge environmental plans. This is insufficient time to obtain baseline information when covering a massive area. Furthermore, allowing only 30 days for consultation is impossible.

Response – Dee Fischer: The period for public comment is the norm set out in the Promotion of Administrative Justice Act (PAJA) (*No 3 of 2000*). In the event of controversy, the comment period could be extended.

Response – Tebogo Motloung: The MPRDA is not explicit in terms of the exploration area that could be applied for. A critical issue that informed the area applied for is optimal exploration. If an assessment indicated that that important requirement could not be undertaken, then there is scope for the area to be limited.

Paul Hardcastle, Western Cape Government: Is the current policy and legislative context sufficient to deal effectively with legacy impact issues beyond decommissioning? Is there agreement between all stakeholders on this issue and should we deal with it?

Both the SEA and the ASSAf reports include various recommendations that convey prerequisites for shale gas development. If such recommendations in the reports are not followed, would South Africa be in breach of the precautionary principle, where invoking the precautionary principle is understood to refer to a situation where 1) there is scientific uncertainty linked to a specific impact of risk, and 2) where the implications of such an impact happening will be significant.

The proposal to separate exploration from the appraisal process is logical, as this also correlates with the regulatory requirements – i.e. it is anticipated that the planning and environmental legislation will regard exploration and appraisal as separate stages, each requiring its own regulatory approvals. In addition, it is anticipated that the details of an application for the appraisal will be dependent on the information gathered (and analysed) during the exploration phase. As such, the stages cannot logically be combined into a single regulatory application.

Response – Prof Jan Glazewski: In the Bill of Rights in Chapter 2 of the Constitution, the environmental right includes the principle of intergenerational equity: leaving the environment in as good or better a state for future generations. Although recognised in international law, the precautionary principle is a slippery concept. A precautionary *approach*, which is closely linked to risk assessment, is gathering momentum. If fracking were to be challenged in court, this would be raised.

The last two clauses of the fracking regulations cover closure and decommissioning of wells, but do not adequately cover future environmental damage. A major revision of this aspect is needed to ensure that there are liability provisions in the regulations for the future. This is an issue worldwide in a number of sectors.

Response – Dee Fischer: The proposal to separate the authorisation process into an exploration phase followed by the second application is logical. The SEA results stated that the current applications are subject to EIA regulations.

Response – Prof Jan Glazewski: All local authorities are required to develop SDFs that take climate change into consideration. National government decisions could be trumped by provincial and possibly even local authorities.

Barry Morkel, AEON, NMU: Intergovernmental coordination is fundamental but, while national and provincial government departments have been actively involved in the SEA process, there has been very little local government involvement. Local planning at the municipal level is regulated by an Integrated Development Plan (IDP), which is a local government competence. While working in the Karoo over the past three years, Mr Morkel had not yet heard the shale gas issue discussed in an IDP forum. If local government was not involved, plans for shale gas development might be found to be in breach of IDP regulations.

The need for local consultation was emphasised in the ASSAf presentation; however, to a large extent consultation with local communities had been left to the companies and their compliance processes. There has been little consultation at a local level by the public sector. In comparison, the DMR district office in the North West province engaged with communities affected by mining in an ongoing, structured manner. Mining and extraction are culturally unfamiliar in the Karoo and a lack of consultation would undermine the social licence to operate, and contribute to a trust deficit at a local level.

Response – Tebogo Motloung: A lack of meaningful consultation would make the application legally defective, and it would run the risk of being refused.

Response – Prof Jan Glazewski: Mr Motloung in his presentation mentioned that all departments had been involved when the legislation had been drafted. Had the Minister of Mineral Affairs said when he published the regulations that they had been developed in consultation with the Ministers of Environmental Affairs and Water Affairs, the opposition would not have been able to argue the point.

Nigel Rossouw, Shell: Comment is requested on the suggestion that research initiatives wanting to proceed with drilling be required to apply the requirements in law, even if exempted by the MPDRA. Before licences are issued or companies start work, it would be a good learning opportunity from a regulatory point of view to conduct an EIA, including conducting a public participation process, developing a management plan, having a monitoring committee, and doing the EIA follow-up.

Response – Tebogo Motloung: It is important to be guided by what the law says in this regard; for example, is the CGS empowered by legislation to undertake baseline studies without a process of consultation? Whatever the case, there is always an opportunity to learn.

Zenande Nombakuse, Department of Economic Development, Environmental Affairs and Tourism (DEDEAT), Eastern Cape: The provincial department has developed a scenario-based kit to assist local government. It looks at the roles and responsibilities of local government, and covers consultation with communities and municipalities. The issue of shale gas is included.

Dr Mike Shand, Aurecon: The regulations are relevant for the time in which they were promulgated, when fracking was imminent. Because fracking is unlikely to be economically viable for some time, there is an opportunity to review certain aspects, including the issue of storage of wastes on site, as removal of wastes by truck might entail higher risks and costs. Some theoretical concepts could be investigated as case studies, for example: water, labour, waste disposal and environmental impact, and the regulations could be considered in that context.

Response – Dee Fischer: Storage on site is not recommended. Waste materials could be removed by rail rather than road, reducing concerns about dust, noise, hazard and sense of place. Transnet is being consulted.

Nicholas de Blocq, Service Technologies: The MPRDA was circulated for public comment in 2012/2013. In its original form, it would have destroyed the oil and gas industry in South Africa. It was returned to Parliament by Minister Ramatlhodi in 2014 but three years later the revised version had not yet been released. What is the current status of the MPRDA, and why is the process taking so long?

Response – Andries Moatshe, DMR: Everybody is waiting for the outcome of deliberations. The officials have completed their work, and the Bill is going through the Parliamentary process. The MPRDA is expected to be signed into law by the end of the financial year.

Marcus Pawson, AfriForum: The government, especially the DEA, has done a good job of developing legislation but who would execute monitoring and compliance, and who would inspect the inspectorate? Why was the DWA not present at the conference?*

Response – Dee Fischer: The water, mining and environment sectors all had EMIs. Regulations needed to be written to ensure compliance. Compliance information needs to be published by various means so that results are available to be viewed by anybody. [1]

1 * DWA had sent apologies.

Response – Tebogo Motloung: The drafting process has highlighted the need to enforce compliance and employ properly skilled people. A provision is needed in the regulations to allow skilled drilling engineers to be appointed while local capacity is being developed.

Response – Prof Jan Glazewski: NGOs play an important role in holding government to account and ensuring that proper processes are followed.

Prof Lesley Green, UCT: Stating that there are no water issues due to hydraulic fracturing *per se* was a rhetorical trick used by the industry in the USA. There is extensive research on well blowouts, which are often caused by well casing failure, particularly in the long term. Hydraulic fracturing could not be separated from well-casing issues.

It is critical to take a longer-term view and consider the possibility of permanent damage. Shale gas infrastructure would not be removed, so what did it mean to regulate in the long term? How would future generations be warned about hazardous sites, and how would land restitution issues be addressed? Is there a jurisprudence or regulatory frameworks that could be applied to fracking? Ecology and economy are not separate.

Response – Dee Fischer: Financial provision regulations were promulgated in 2015, which looked at legacy issues of mining. These issues are related to all mining enterprises, not just to fracking. 'Polluter pays' is one of the NEMA principles; but it is not clear how this would be enacted in practice in the distant future. In terms of the financial provision, the question of how a mine could be allowed to close was being investigated, bearing in mind that mechanisms such as trust funds and guarantees are impractical in the long term. So far, no final solutions to this problem have been identified, but the issue has been flagged. Part of the financial provision would remain with the state in perpetuity.

Revised financial provision regulations would be circulated for public comment within the next three months; comments on how the 'polluter pays' principle could be implemented in practice would be appreciated.

Response – Tebogo Motloung: The study had investigated if hydraulic fracturing itself was responsible for contamination of wells in the Marcellus Formation. It was clear that an array of problems could arise, including the containment of fluids, management of pressures, and installation and maintenance of BOP. If standards are not upheld, well integrity as a whole would be compromised.

Response – Prof Jan Glazewski: The regulations are not perfect and need to be specific; for example, specific standards for cement are required, but the industry also had to respond to improvements in technology. Thus, the regulations need to be both specific and flexible.

Prof Lesley Green, UCT: Ultimately the question of who benefited needs to be asked – multinational corporations, indigenous communities, or who?

Closure: Dr Rebecca Maserumule, Chief Director: Hydrogen and Energy (DST)

The speakers, panel members, conference organisers and delegates were thanked for a successful day of presentations and discussions, and the programme for Day 1 was officially closed.

SESSION 5: INTERNATIONAL PERSPECTIVES ON THE SHALE GAS INDUSTRY

Facilitator: Ms Rebecca Maserumule, Chief Director Hydrogen and Energy, DST

Perspectives on the Botswana natural gas industry: Challenges and future outlooks

(Dr Benson Modie, University of Botswana)

Background

Botswana is historically not known for gas, but hosts vast coal reserves estimated at more than 200 billion tonnes, which presents a great potential for coal-based gas. In recent times, the country has experienced power shortages, marked by erratic load-shedding events, and resulting from a sturdy growth in the population and industry energy needs. For a prolonged period, there was only one small coal-fired power station, Morupule A, commissioned in 1989, which ultimately resulted in about 80% of power being bought from South Africa to meet growing energy needs. The government of Botswana then commissioned a second coal-fired power station (Morupule B) in 2014, and the need to explore alternative sources to meet imminent power needs became imperative. There was potential to develop a coal-bed methane production industry. Shale gas development was not yet under consideration.

Conventional oil and gas resources had also earlier been investigated in older pre-Karoo sequences:

- 1990 – PCIAC-GSD Masethlheng Pan-1 well: Petro Canada had explored the Nama Basin on the border with Namibia; from the seismic data, no resources were found.
- 1998 – ECL Ltd undertook follow-up exploration to look for organic-rich rocks, but was also unsuccessful.

The Department of Geological Survey (DGS) Oil Coal-Bed Methane (CBM) Study, 1999

In 1999, Botswana's National Development Plan 8 Mineral Development Programme Policy, which aimed to increase economic benefit from the development and exploitation of mineral resources, presented an opportunity to consider gas resources. The motivation for this consideration emanated from the fact that Botswana hosts one of the largest coal deposits in the region, but the economic benefits from such had remained limited. CBM exploitation then became the obvious opportunity to venture into in order to maximise benefits from these coal deposits. The objective of the study was to assess the availability of, and the potential to develop, natural gas resources associated with the coal-bearing sequences of the Kalahari Karoo Basin in Botswana.

In the absence of local expertise, external consultants were appointed. From 2001 – 2003, a United States company, Advanced Resources International, drilled four test holes in the Kalahari Karoo Basin, covering an area of 41 459 square kilometres.

Resources estimated by the DGS CBM Study, 2003:

- 60 Tcf (1.68 Tcm) in coal beds.
- 136 Tcf (3.85 Tcm) in carbonaceous shales.
- Reservoir modeling estimated that 15 – 20% of gas-in-place could be recovered.

Following completion of this study there was a great deal of interest expressed by the private sector to invest in the CBM gas-industry. As a result, government took a decision to discontinue any further government sponsored studies of a similar nature. A number of CBM exploration companies have since been issued licences in various prospecting blocks. The lack of local expertise to monitor resource quantification operations, and the issuing of prospecting licences to people lacking capability, were major concerns. Some companies though, such as Tlou Energy and Sekaname Private Limited, did manage to make some advances to an extent where they were awarded contracts to develop CBM-fuelled pilot power stations.

Policy and regulatory framework

There is concern that CBM is not covered by existing policy, for example:

- the Petroleum Exploration and Production Act of 1983 does not cover coal or substances extracted from coal; and
- the Mines and Minerals Act of 1999 does not cover gas. the Botswana Energy Regulatory Authority Act of 2016 does not cover gas exploration operations.

Challenges

- CBM is still a new venture in Botswana and there is very little local expertise.
- The existing regulations are inadequate to cover CBM exploitation.
- The lack of local expertise leaves Botswana reliant on expensive foreign expertise.
- Baseline data are still inadequate.
- The geological environment is challenging, as the region is covered by the Kalahari Desert.
- Gas infrastructure in Botswana is non-existent.
- Costs associated with the industry, for example drilling and testing, are high.
- There is opposition from pressure groups, especially environmental organisations.

Future outlook

A serious commitment to gas as an energy source is needed:

- It is important to maximise the value of gas as an alternative source of energy.
- The Regulatory Authority, policies and regulations need to be specific to the gas industry.
- Investment is needed in effective methods to develop a local gas industry, including education, technical expertise, upgrading baseline data, and identifying sweet-spots.
- High costs could be addressed through public-private partnerships (PPPs).
- Issues of infrastructure and the market have to be considered.

Conclusion

There is potential to develop a gas industry in Botswana, but local expertise to effectively manage the industry is still lacking. An effective Regulatory Authority, Mines and Minerals Act, and Petroleum (Exploration and Production) Act are needed to develop and advance the gas industry appropriately. Underlying all the issues raised is the need to develop human capacity and to reflect on lifestyle choices that impact on the environment.

An overview of resource play development in Australia: Technical, economic, environmental and political aspects

(Dr Dennis Cooke, University of Adelaide)

Background

Shale gas development could be contentious. Most technical experts believe that they are unbiased, fact-based and agenda-free; however, biases are unavoidable.

Dr Cooke's position is that replacing coal with renewables and natural gas would help to mitigate climate change. A rapid transition to renewable energy would require a fossil fuel 'base load'. Coal is the default base load fuel, but emissions drop by 50% when coal is replaced by natural gas.

Australia is about six times larger than South Africa, with half the population. The GDP is four times greater, or ten times higher per person. Electricity generation from coal is still very high but dropping rapidly as much more oil and gas are produced. The Queensland coal seam gas (CSG) reserves are double those in the Karoo.

Resource triangle

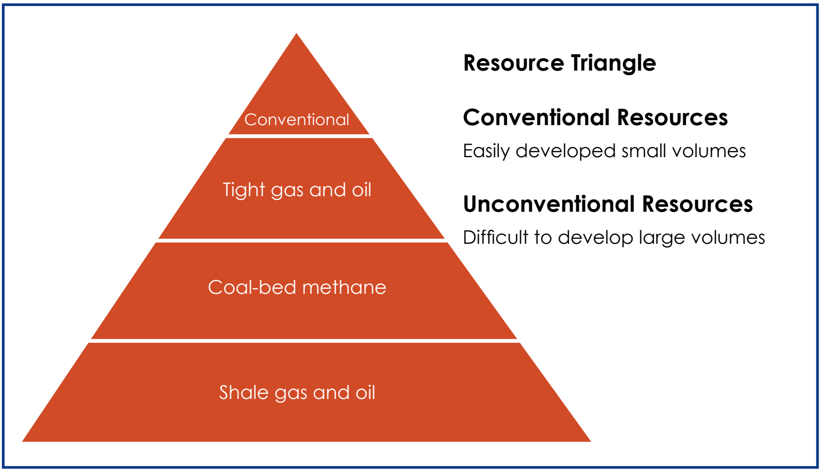


Figure 2: The resource triangle indicating energy sources

As indicated in Figure 2, conventional sources of energy (oil and gas) are relatively easy to find and inexpensive to exploit, while unconventional resources (shale gas and oil) are more difficult and expensive to exploit, but the resource is much larger.

Shale gas pilot programmes

All shale gas plays are different, and each one needs a customised solution for drilling and fracture stimulation. It could take 20 – 40 wells in a pilot drilling programme to find an economic solution, costing as much as $800 million, with no guarantee of success.

Shale gas versus coal seam gas

Figure 3 compares conventional gas, shale gas and CSG reserves and extraction. The shallower the reserves, the lower the well costs. If conventional gas is discovered in South Africa, international investors would not be necessary. (Note that in Australia, surface aquifers were shallower than CSG coal seams, unlike the situation in the diagram.)

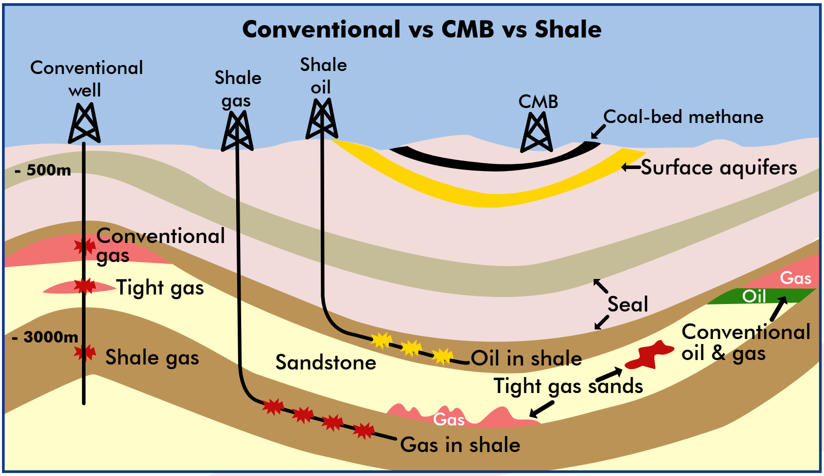


Figure 3: Comparing conventional, coal seam and shale gas extraction

Australian resource plays

Of the four sedimentary basins evaluated in Australia:

- McArthur Basin is being evaluated for shale gas and oil and it is too soon to predict if this will be successful;
- Southern Georgina Basin has five shale oil wells, but is sub-economic;
- Cooper Basin has a well-established gas industry with conventional reserves; in the past decade there were 24 dedicated shale gas wells; and

- Queensland CSG Surat and Bowen Basins are economic with about 10 000 CSG wells and three LNG export plants.

The Cooper Basin shale gas and Queensland CSG are compared.

Cooper Basin

Australia's largest onshore oil and gas basin has been producing oil and gas for 40 years. Cumulative production has amounted to 5 Tcf of gas and 200 million barrels (MMbbl) of oil. About 700 wells are currently in production, and there have been about 2 000 fracture stimulation treatments. Tight gas is currently economic, but not shale gas.

Why the Cooper REM shale gas play is sub-economic:

The Cooper Roseneath, Epsilon and Muttered (REM) shales have been evaluated by three competing companies, each of which has some international backing. About 24 wells have been drilled and each produces on average about two million cubic feet per day (MMCFD). Despite the presence of gas, the play has been uneconomic.

Reasons for failure include:

- Economist's viewpoint: the world financial crisis, and high costs of drilling and fracture stimulation compared with low gas prices.
- Engineer's viewpoint: a completion strategy that deals with high horizontal stress has not yet been developed.
- Geologist's viewpoint: REM shale is not a marine black shale but a low total organic carbon (TOC) siltstone that is over-mature, with little or no overpressure.

Fracture stimulation and the Cooper Basin's high tectonic stress:

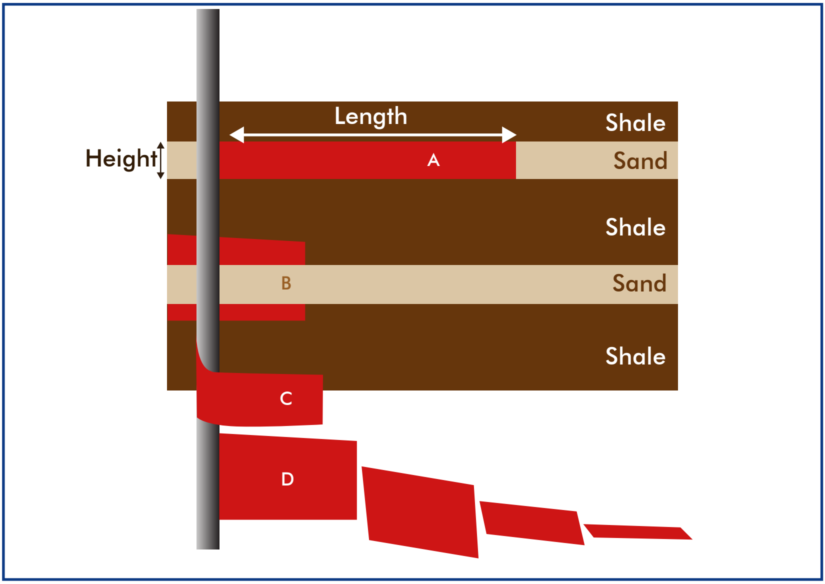


Figure 4: Four idealised fracture stimulation treatments or stages that might occur in the Cooper Basin. [All fracture stimulation treatments are symmetric with respect to the well-bore but only the right-hand side is shown.]

In Figure 4, four possible fracture stimulation stages are shown:

- Top stage A shows limited height growth and good length.
- Stage B grows vertically out of the target zone and does not obtain length.
- Stage C exits the well-bore perpendicular to the page and then rotates to parallel to the page.
- Bottom stage D has rotated from horizontal to vertical; this is an expensive and ineffective fracture stimulation.

The Karoo Basin, tectonics and stress

High horizontal stress from plate tectonics could have been responsible for problematic Cooper Basin fracture stimulation treatments (Stage D above). The Karoo Basin could have similar issues. On the other hand, the very successful Pennsylvania's Marcellus shale also had thrust faults. Up-thrusted mountains indicate high horizontal stress at some time in the past or even the present, but there is guaranteed to be current-day stress. The East Africa rift argues for a 'friendly' stress field for fracture stimulation treatments.

Queensland coal seam gas development

Minor CSG production started in 1996. There was a slight increase in production when CSG LNG was conceptualised in 2000. The LNG corporation's final investment decisions were made in 2010, resulting in another increase in production. This grew exponentially when the LNG plants started operating in 2016.

An aerial photograph of the Queensland CSG field shows an extensive network of drill paths for CSG. There are associated issues of water production that need to be dealt with. Some is of poor quality and is mostly evaporated.

Photographs of methane gas on fire as it bubbled from a seep in a river near a CSG development went viral on social media and strengthened opposition to GSG development. This has highlighted the importance of having environmental baselines against which the impacts of gas development could be measured. As yet unpublished surveys have concluded that emissions from new natural gas wells and pipelines are much lower than emissions from livestock and from legacy gas distribution networks in cities like Sydney.

Australian CSG-LNG plants

The cost of a single LNG plant is about $10 billion. Approximately one billion cubic feet (BCF) of natural gas is processed per day, representing the output of 1 000 to 2 000 CSG wells. The energy processed per day is about 10 000 MW, which is equivalent to the output of both the Kendal and Kusile power stations in South Africa.

An LNG plant is similar to the gas-to-liquids (GTL) plant described in the Sasol Petroleum Mozambique (SPM) document. Using an LNG plant as an example helps to define the scale of shale gas plays, as well as the economics and politics of resource plays in Australia.

If South Africa's shale gas industry is successful, it would be necessary to decide what would be done with the gas. One option is LNG export. There are about 25 – 30 LNG plants in the world. Australia has increased from three to ten plants in just two years, and is becoming a leader in LNG export.

These plants are fed by conventional offshore gas fields.

Important features of coal seam gas

- CSG reservoirs and wells are shallower than shale gas, ranging in depth from 300 to 1 100 metres. The development costs are significantly lower than for shale gas.
- Natural gas was adsorbed in coal with a higher gas density than conventional reservoirs at the same depth and pressure.
- Natural gas was desorbed from coal when the reservoir pressure was lowered. Reservoir pressure is lowered by 'dewatering' the coal seam. This produces large volumes of water, hence the need for evaporation ponds.
- It might take two to five years of dewatering a CSG well before the maximum production rate is reached. It might therefore take two years to determine the productivity of gas fields.
- The thickness and permeability of Australia's Permian coals are far superior to North American coals; this has stimulated the development of the CSG industry.

The maximum rate of production for a CSG well might be 1 MMCFD after two years. This is reached after the dewatering phase. After a period of stable production, the rate of production slowly declines. On the other hand, a horizontal shale gas well produces gas at very high rates in the first week (about 20 MMCFD), but this declines rapidly to relatively low rates compared to CSG.

Lessons from the Australian CSG industry

1 Geoscience: The thickness and permeability of Australia's Permian coal seams are far better than North American coals, making CSG development economically attractive.

2 Reservoir engineering and LNG facilities:

- The two to five years required to dewater CSG wells make rapid development of CSG-LNG problematic.
- Too many LNG plants have been built, resulting in a boom-and-bust economic cycle that is yet to finish.
- A (temporary?) natural gas shortage has become a major political issue that will impact on the next federal election.

3 Schedule incompatibilities between LNG plant construction and CSG well production:

- Each LNG plant costs about $10 billion and should be running at full capacity from its first day of operation.
- About 2 000 CSG wells should be dewatered and ready to produce when LNG plant construction is completed.
- Gas produced prior to dewatering is known as 'ramp-gas'. Options for ramp gas include:
  - store ramp gas for three years while the LNG plant is being built;
  - sell ramp gas to the domestic market: this could flood the market, depress prices, and destroy the profits of companies building the LNG plant;
  - do not dewater wells before the LNG plant starts operating; then run the plant at less than full capacity as the wells are dewatered.
  - do not dewater wells before the LNG plant starts operating; then run the plant at full capacity, and purchase any gas needed from the domestic market.

- In Australia, all these options were explored, and some caused unexpected issues:
  - Flooding the market with gas contributed to the destruction of the Cooper Basin shale gas play.
  - Some wells were drilled but not dewatered. As soon as the three LNG plants started operating, cheap gas that used to supply local factories and homes was bought to feed the plants. Over 18 months, gas prices doubled or tripled for many factories, causing some to close. Home electricity bills were expected by increase by 20% in one year. This resulted in a political crisis that could lead to a change of government.

4 Australian environment and politics:

- Australia had signed the Paris and Kyoto climate accords and committed to reducing carbon dioxide (CO_2) emissions.
- About two-thirds of Australia's coal-fired power stations were approaching the end of life. Should they be replaced with new coal plants, or renewables, or renewables plus natural gas base load?

- No national energy policy has been rolled out due to lack of consensus within the government.
- The government of South Australia has an aggressive and mostly successful renewable energy policy, which has resulted in a lack of base load supply capacity and load shedding.
- New conventional and renewable power plant investments are not being made as the federal government debates on which renewable path (if any) to follow.
- There are different motivations within the environmental movement, including:
    - lowering CO_2 emissions and mitigating climate change; *versus*
    - attacking all fossil fuels and multi-national fossil fuel companies.
- Australia has fracture stimulation bans in two-thirds of its states:
    - fracture stimulation has taken place in the Cooper Basin for 50 years, with no problems;
    - the Queensland CSG play is largely progressing with cavitation instead of fracture stimulation; and
    - South Australia's aggressively pro-renewable government is supporting a natural gas base load, limited fracture stimulation, and royalties for surface owners.
- Environmental threats associated with CSG development include:
    - aquifer depletion, and
    - disposal of saline coal seam waters.

5 Community impact: shale gas *versus* coal seam gas (Table 2).

Table 2: Summary of Concerns relating to Shale Gas and CSG Development

Area of community concern	Shale gas	Coal seam gas
Industrial road traffic	Larger trucks, fewer moves	Smaller trucks, more moves
Directional drilling and multi-well pads	Yes	Possible but not common
Fracture stimulation	Yes	Mostly cavitation
Water disposal issues	Smaller amounts of saltier water	Large amounts of cleaner water

How could the Queensland CSG development have been improved:

- Internal corporate decision-making: LNG plants should have been approved only once both the gas sales contracts and supply gas had been certified.
- State and federal-level approval: One or two CSG-LNG plants should have been approved, not three. Three plants may have been approved because of:
    - corporate ambition and the perception of a 'winner take all' international LNG market;
    - government's desire for jobs and growth; and
    - government's desire for tax income.

Community acceptance of shale gas and CSG development:

- Acceptance is low and development is confrontational when the surface owners do not receive some benefit from shale gas production.
- Benefits range from royalty payments to crop damages.
- Environmental activists are more successful in disrupting or halting developments when the surface owners do not receive some benefit.
- CSG development is currently banned in New South Wales and Victoria.

Unconventional gas development: A holistic review of US and global shale energy trends

(Mr Tom Murphy, Penn State Marcellus Centre for Outreach and Research)

Marcellus Centre for Outreach and Research

The Marcellus Centre has been researching shale energy development for a decade, and has both above and below-ground experience, including:

- 'down-hole' technical issues: water quality, induced seismicity, naturally-occurring radioactive materials (NORM), methane migration, well design, and abandoned wells; and
- above-ground risk: fugitive methane, community impacts, socio-economic activities, environmental and water issues, workforce issues, business development, regulatory and governance issues, and social licence.

There is an emphasis on social science research, because without social licence, shale energy development is unlikely to succeed.

Water quality research is critical. Over 15 000 shale wells have been drilled in the Marcellus Basin. Issues have included well-bore integrity, hydraulic fracturing fluid migration, new testing technology, methane migration, and concerns like surface spillage, off-site spills, and watershed protection. Although only 23 of these wells have caused problems, most of which were related to grouting, these issues are extremely serious for local communities.

Outreach undertaken by the centre focuses on translating science, and packaging it appropriately so that members of the public could understand the issues. This would enable positive interactions between stakeholders, researchers, the industry, and elected officials. Through its outreach the centre aims to create science advocates.

An important part of the work of the centre is to convey the benefits of shale energy in relation to technical, environmental, economic, social risks:

- Benefits include: satisfying the demand for energy; economic rewards; enabling new commercial and industrial development; workforce opportunities; creating a bridge between fossil fuels and renewables; geopolitical opportunities; climate benefits.
- Risks include: well-bore integrity; contamination of water by chemicals and methane; air emissions; health issues; climate risks.

Global interest in learning from the North American shale energy industry has been stimulated by:

- the emerging global energy paradigm influenced by the Paris Agreement on climate change;
- the development of new markets for gas, transported by pipeline and ship; and
- greater pairing of gas with renewable technologies.

Drilling trends in North America

The time to drill a shale well has been reduced from six to eight weeks, to less than ten days. There has been a 30 to 50% increase in efficiencies, resulting in decreased costs. In some cases, increased efficiencies means fewer workers are needed, so fracking is not necessarily a major workforce development opportunity.

Specific improvements have included:

- The move to 'walking' rigs that are built for purpose.
- The drilling of longer well-bores, up to more than 6 000 metres laterally.
- More fracking stages, and a move to target the best rock:
    - the amount of proppant used has almost doubled in the recent past;
    - every frack is a unique effort that matches pressures to the particular geology;
    - sub-surface technical expertise and technology has been upgraded.
- Increased gas volumes have been produced per lateral well.

There have been increases in initial production rates, estimated ultimate recoveries, and return on revenue, as well as flatter declines.

Shale energy developments

The geopolitical landscape is changing, with much more gas being produced and entering the market in many more parts of the world. Producers include the USA, southern Africa, Australia, Argentina, China and the European Union. In the USA, approximately 50% of dry gas is currently produced from shale.

Shale gas production is increasing across the USA as a whole. In Pennsylvania alone, 5 Tcf has been produced in each of the previous two years, with 15% having been drilled in the Marcellus Basin with current technology. This has resulted in the need for people, housing, regulation and environmental considerations. There is also a growing need to manage public expectations, and to determine who would benefit from shale gas exploitation in a country where ownership of the sub-surface resource varies between the state and the private landowner.

Because of the high volumes of gas being produced in the USA and globally, natural gas price trends in the USA have decreased relative to the recent past. Producing increasing amounts of gas has geopolitical implications, for example the expansion of the Panama Canal.

A rapid increase in coal to gas conversion has been taking place, and gas rather than coal has become the top fuel for power generation. Fifteen per cent of coal-fired generation had gone off-line by the fourth quarter of 2016, which has resulted in air quality benefits. The availability of gas has created a greater potential for renewables, and pairing natural gas with renewables has resulted in a decrease in CO_2 emissions. As older nuclear energy plants have come due for licence renewals, low gas prices have caused a number to go off-grid. Greater onshore gas production could help to reduce price volatility, as well as the risk of weather-related and political shocks.

Concerns include public reaction against the construction of more gas pipelines; demands for investment in renewable energy; and the risk that the energy grid is becoming too dependent on gas.

More natural gas liquids like ethane are becoming available for fractionation and processing. Petrochemical companies are investing in the region; for example, Shell had recently invested $6 billion in Pennsylvania, the largest ever single economic development package in the state. Ethane is being exported to Norway and Scotland, and used in other energy-intensive industries, particularly power generation.

Creating mutually beneficial partnerships

The shale gas industry has been developing a variety of partnerships, including with:

- Academic partners for baseline information and research in sectors like water, geophysics, environmental issues, economics, community health, infrastructure and housing, comprehensive planning, and workforce needs.
- Public-private initiatives, including public services, revenue generation and investments, new infrastructure needs, third-party assessment of regulation and policy outcomes, outreach, increased local benefit, and long-term economic development.

Workforce development is critical to ensure that the right number of people with the right skills are trained at the right time to be employed when the industry is ready. The government also has to ensure that enough officials are trained to regulate the industry.

In Pennsylvania, the shale gas industry pays an impact fee of $1 billion per well to state coffers. Governments would need to consider the implications of technological changes to revenue generation, such as the drilling of longer laterals that would require fewer wells to be drilled.

Municipalities have invested these impact fees in projects including public infrastructure construction, housing, water preservation and reclamation, storm water and sewer systems, judicial services, social services, environmental programmes, and career and technical centres.

Shale gas is a large industrial development that has landscape impacts. Most development in the USA is taking place in rural areas where there is no legacy or knowledge of oil and gas development. Local communities and authorities need help to understand the industry and to plan in relation to it.

As previously emphasised, it is extremely important to obtain a social licence from the actual communities affected by shale gas development. Each community, whether local or global, is concerned about different issues. The industry is highly technical, and it is challenging to communicate meaningfully with members of the public who is accustomed to and expects very brief digital communications. A focus on the work of the entre is how to work and engage with stakeholders in a science-based, transparent manner.

The Shale Training and Education Centre (ShaleTEC – www.shaletec.org) is a partnership involving Penn College and Penn State University. It has undertaken a number of collaborative workforce assessments and trained more than 14 000 employees since 2009 in areas related to the oil and natural gas industry.

Engaging stakeholders

In engaging stakeholders, it is important to:

- develop knowledge and capacity by creating institutional ability to train, repurpose and retool employees;
- encourage community-level participation;
- explain trends and demographics;
- create an environment that enables reasonable dialogue;
- realise that one size does not fit all, but it is necessary to customise community engagement; and
- engage early and often.

Creating trust is a multi-step process, not a single event. The actual risks and mitigation strategies have to be explained.

Discussion

Neville Ephraim, iGas – How is Australia treating the produced water from CSG and disposing of waste products and treated water? What are the chemical constituents of the produced water?

Response – Dr Cook: CSG water ranges from very sweet to very saline, so there is no single water treatment solution. There have been unfortunate cases of good water being produced but not shared with local agriculture because of fears that it might turn salty in the future and cause damage. Australia had serious water problems and this issue could be better addressed.

Bongani Sayidini, PetroSA: In Australia about 2 000 wells have been subjected to fracture stimulation treatment to enhance conventional oil and gas recovery. What has been the reaction of environmentalists with respect to conventional oil and gas fracture treatments?

Response – Dr Cook: In the Cooper Basin there has been 40 years of fracture stimulation, both before and after the 2010 documentary, *Gasland*, by Josh Fox. Environmentalists have focused their efforts on communities about to undergo shale gas development. The battleground has been shifting from fracture stimulation to fugitive emissions.

Bongani Sayidini, PetroSA: Environmentalists were more effective when there were no benefits to surface landowners. Were environmentalists representing surface landowners or the environment?

Response – Dr Cook: Local landowners are in the best position to answer this. Some did not allow CSG on their properties because of fears that the wells might ruin the environment. This could result in legal issues because, in Australia, mining rights are publicly owned and are sold to companies, while surface rights are privately owned. Unless situations are well managed by the regulators and surface owners, they could become confrontational. Some landowners have been well compensated.

Dave Wright, Consultant: In the USA and Australia, are there any programmes that focus on the social impact of reducing the mining of coal as a consequence of increased energy production from gas?

Response – Mr Murphy: In the USA, there is also a great deal of coal mining in the Appalachian region. Many regions have become economically depressed because less coal was being used for power generation. Federal and state governments had recognised that programmes are needed to create other economic development opportunities. The Marcellus Centre has been involved in research and discussions regarding the use of natural gas in alternative industries including fertiliser production, gas-fed power generation and plastics development. A commission had been appointed that is solely responsible to ensure benefits for depressed coal-mining communities.

Dr Phethiwe Matutu, NRF: Dr Cook has asserted that there is a major difference between shale gases, and a need for customisation of the extraction. To what extent would South Africa benefit from undergoing training externally if this is the case? Should they rather be trained internally?

Response – Dr Cook: Fracture stimulation techniques present a very steep learning curve. It would not be possible to develop all the expertise internally. It is important to gain as much knowledge as possible from international experts but local company involvement is essential. The industry in Australia is dominated by Australian companies, but many local companies had previously worked with international companies, spending time with foreign experts and then starting their own companies.

Lizel Oberholzer, Norton Rose Fulbright South Africa Inc: The energy world is volatile, as illustrated by the changing oil price, and the shift in the status of North America from energy importer to energy exporter. How do the speakers view South Africa's LNG independent power producer (IPP) programme, bearing in mind the country's current energy situation and the potential for shale gas development? Should South Africa be signing 25-year LNG import contracts if there is a chance that shale gas might be discovered? Is the LNG IPP programme premature, or would it help to create an energy market in South Africa?

Response – Dr Cook: In terms of the potential impact of shale gas on South Africa, the extent to which the country will benefit from possible future exports depends on the political and regulatory environment, concerned activists, and the strength of its democracy.

Response – Mr Murphy: In terms of the potential role of shale gas in South Africa's future energy composition, 90% of power is currently coal-generated, which results in air quality and climate change issues, so there are reasons to move away from coal. However, a large component of shale gas development would be building a natural gas infrastructure. If gas was generated, how would the gas, water and waste be moved? South Africa has a good electrical power grid but no pipeline grid. This should be a major consideration.

In order to comply with the Paris Agreement, South Africa would need to transition from coal to gas, and pairings of gas and renewables. However, international investment is not guaranteed. Many shale gas plays are available globally, and international companies could operate anywhere. They would invest where they could find the best regulatory package, predictability, and other incentives.

Murendeni Mugivhi, PASA: Dr Cook has reported that nobody knows where the methane seeps are coming from. Are government and industry monitors investigating the sources of the methane seeps, and how are they managing it? This is of particular concern due to the fact that shallower CBM poses greater risks of fugitive gases.

Response – Dr Cook: The government in Australia did investigate. Queensland and South Australia were proactive in investigating the potential risks before companies invested.

Dr Kevin Pietersen, UWC: What institutional links exist around the Bowen Basin in Queensland, specifically relating to the role of the Gas Fields Commission, which plays a crucial role at the interface between operators, regulators and communities?

Regarding the issue of methane seeps, during a visit to Australia it was noted that the operators were obliged to do independent studies, and the office of the Chief Scientist had also launched independent studies. More information on the role of the office of the Chief Scientist is requested.

Response – Dr Cook: The Cooper Basin was even more remote than the Karoo, so relatively little cultural disruption was caused. The South Australian regulator (State Development) is world-class and proactive. They aggressively share information, contrary to petrochemical companies that want to keep their information confidential. Companies are forced to share the information, which is consolidated and published by the state. They proactively inform potential investors about the geology.

The Chief Scientist in New South Wales has become involved in the fracture stimulation debate, with some unfortunate results. Technical experts like to avoid emotional debates and she has been attacked for trying to remain unemotional. The Chief Scientist does not have much power in Australia, whether at federal or state levels. The required function would be better fulfilled by the regulator, who has been very effective.

Bongani Sayidini, PetroSA: President Trump withdrew the USA from the Paris Climate Change Accord in June 2017, to international condemnation. How have US citizens reacted? Even without having been party to the Kyoto Protocol, the USA had drastically reduced its carbon emissions. Could this be ascribed to shale gas only, or was there a concerted effort to develop renewable energy as well?

Response – Mr Murphy: Regarding President Trump, no comment. Regarding the internal reaction to energy issues, most of the population is relatively neutral regarding the source of energy, but interested in meeting their lifestyle expectations. An estimated 10 –15% of people are probably strongly opposed to the withdrawal from the Paris accord.

Regarding the relationship between the increasing use of shale gas and declining carbon emissions, there is a clear parallel between the two, but it may not have been by design. The increase in the use of renewables for power generation will continue in the USA, but the scale is uncertain. Currently 67% of gas is used for power generation, and this will increase.

Dr Isayvani Naicker, DST: Mr Murphy spoke about PPPs but no private investors are obvious in the slides. How do the private and public sectors relate around shale gas in particular and the gas industry in general, from exploration via the life cycle to impacts? What role do they play in relation to skills development, and balancing international and local knowledge and expertise? What is the experience of large-scale PPPs in Australia and the USA?

Response – Dr Cook: The Commonwealth Scientific and Industrial Research Organisation (CSIRO) has been enabling PPPs quite effectively. In South Australia, PPPs are fostered by the regulator.

In terms of the involvement of the public and private sectors in skills development, State Development, the regulator, asked what kind of training is needed. Public and private parties cooperate to train people to work on drill rigs or construct roads. Barry Goldstein at State Development in South Australia could be consulted on lessons learnt.

Response – Mr Murphy: South Africa should be cautious about workforce planning in an industry in which technical processes are rapidly evolving. Three to four years ago in the USA, 1 300 tractor-trailer loads of water were needed to develop one well in the Marcellus Shale. Many truck drivers were required and trained. Now most of the water is moved by pipe, so far fewer truck drivers are needed. It is important to consider when the country is likely to enter the industry and how the technology might have changed by then.

In relation to PPPs in the USA, three examples are given:

- ShaleNET: From the early days of the shale gas industry, assessments of workforce needs were conducted in collaboration with industry, government and NGOs. This resulted in two federal grants, enabling the development of a consortium to develop workforce capacity involving industry, government, a large economic development NGO, and academics. More than 14 000 people have been trained at one institution.
- A private company that produced gas collaborated with government, which funded research to develop a 'virtual pipeline' to compress gas and truck CNG to high consumers of energy and nearby communities that were not served by a gas pipeline.
- Top floor programme: This training programme involved industry, NGOs and academia in training government regulators for the shale gas industry.

Prof Lesley Green, UCT: ASSAf convened consultations in order to hear scientific opinion based on credible scholarship. There is a significant difference between the academic social science account of the impact of hydraulic fracturing on communities, and the corporate public relations account presented by Mr Murphy. In Prof Glazewski's book, *Hydraulic fracturing in the Karoo*, Prof Green's chapter has taken issue with the social science of the Pennsylvania case. Mr Murphy has not mentioned that in 2013 the Pennsylvania Supreme Court had to rule on a private doctor's application to the court for permission to disclose the results of blood tests of his patients. Four out of five judges found that hydraulic fracturing was damaging to the fiscus and to health.

The Auditor-General of the state had commissioned an audit into the activities of the Pennsylvania Department of Environmental Protection (DEP). During the period 2007 to 2014, it was found that DEP was under-resourced and unable to respond to 29 public complaints. Industry advised families to sign non-disclosure agreements, and this dramatically curtailed the information available to science. Despite this, the audit found 243 documented accidents that had affected private water sources, which equated to 35 per year, or three per month in Pennsylvania. None of this had been mentioned in Mr Murphy's presentation, probably because the Marcellus Centre for Outreach is funded by industry. ASSAf is questioned for having invited someone to speak at a scientific conference who is not a social scientist.

Prof Jan Glazewski, UCT: It is of concern that renewable energy options have not been mentioned. The challenge of NGOs has been mentioned, which is reminiscent of a court case in the Kalahari dealing with the rights of the indigenous San people. What does the Botswana government think about mineral rights in this context?

Response – Dr Modie: Regarding renewables, no comment. Regarding the court case, part of the exploration is taking place near the Central Kalahari Game Reserve where San people live. The account that the government has been attempting to remove people from the game reserve in order to pave the way for mining is not valid. Elsewhere in Botswana communities have been moved to pave the way for development. All mineral rights are vested in the state. Revenues are used to develop all communities in Botswana. A group of people who did not want to move from their ancestral lands had taken the government to court, and they remained within the game reserve.

SESSION 6: SOUTH AFRICAN PERSPECTIVES

Facilitator: Mr Paul Hardcastle, Director of Planning and Policy Coordination, Western Cape Government

A science plan for (ground)water resources in advance of shale gas development

(Dr Shafick Adams (Presenter) and Dr Kevin Pietersen, Water Research Commission)

Shale gas development is one of many high-level and inter-related challenges that is having an impact on groundwater in the Karoo.

High-level challenges:

- Global change, including climate change and variability.
- Water pollution and depletion.
- Rapid urbanisation resulting in increasing supply demands and higher pollutant loads.
- Coupling of the various reservoirs in time and space.
- Governance of water and related resources.
- Emerging contaminants.
- Data collection (monitoring) and data availability (management) including Big Data management.
- Uncertainty quantification, including model and parameter uncertainties.
- Poor land-use planning.
- Scale and heterogeneity.
- Capacity development.
- Complete description of complex systems.
- Operation and maintenance of water schemes.
- Water valuation and financing.
- The intersection between energy, water and food security issues.

Adequate planning information and a commitment to sustainable development will enable South Africa to find and exploit more groundwater. A lack of planning information will result in failure to implement policy; and if coupled with divergent, uncoordinated development, this will result in crisis management in the sector.

Source water protection

The WRC has undertaken numerous studies of groundwater over 40 years, including:

- Catchment and aquifer delineations and characterisations.
- Catchment and aquifer management plans.
- Inventories of land use and contaminants.
- Vulnerability assessments and rankings.

Much of this was large-scale research, which has proven inadequate at the operational scale.

The shale gas industry has continually referred to the possibility of extracting water from deep aquifer systems. Dr Pietersen asked if the industry was aware of sources that the WRC did not know about, and if these sources could yield water on a sustainable basis. Furthermore, deep groundwater was part of South Africa's water security, so on what basis could the shale gas industry claim part of it?

National Water Research, Development and Innovation (RDI) Roadmap 2025

Many of the energy development plans for the Karoo affect aspects of the RDI Roadmap (Figure 5), including governance, planning and management. The roadmap could be viewed on the WRC website (http://www.wrc.org.za).

The knowledge generated by WRC research form many branches of a 'knowledge tree', including:

- informing policy and decision-making,
- new products and services for economic development,
- sustainable development solutions,
- transformation and redress,
- human resource development in the water and science sectors, and
- community empowerment.

In terms of roles and responsibilities, it is important that there is constructive exchange between the policy and regulation sector (laws, policies, strategies, licences, oversight, protection, growth and enabling environment) and the technical and operational sector (gas sources, exploration, drilling, fracturing, geology, treatment and closure).

Issues like monitoring need to be discussed to ensure that approaches are standardised. Technical, legal and institutional provisions have to be adhered to because water is essential to life. This requires a regulator with the capacity to ensure monitoring and enforcement.

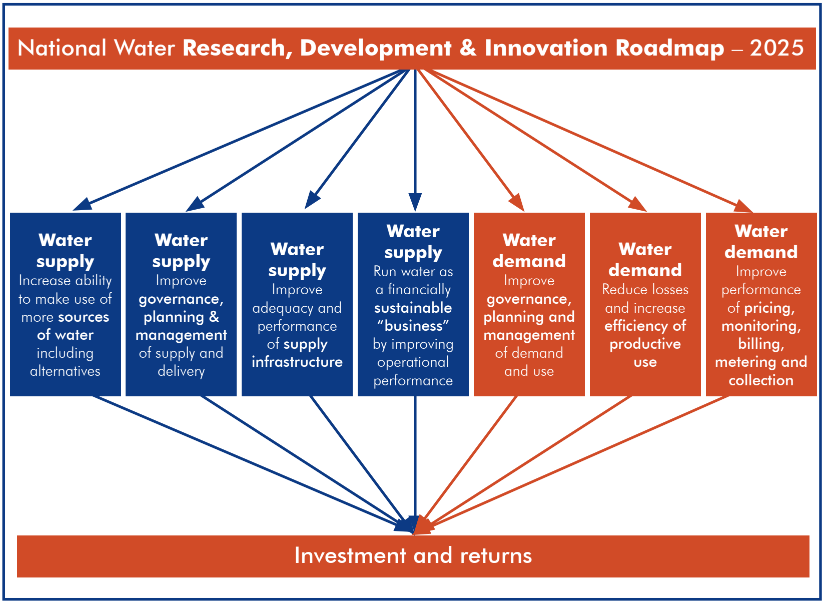


Figure 5: The National Water Research, Development and Innovation Roadmap 2025

Technical aspects

Several technical assessments have been undertaken to date, in addition to numerous research reports on the Karoo. There are 12 high-impact reports on the Karoo on the WRC database, and many of the more general reports are also relevant to shale gas development in the Karoo.

Alternative sources of water and waste water handling and treatment is the everyday work of the WRC, and new techniques are being developed. Work varies from developing an understanding of the hydraulics and chemistry of aquifer systems to understanding maintainable yields (a concept that is replacing sustainable yields, which has been used for 50 years).

The main issues that have been identified include:

- Ensuring that research provides data at a scale that is relevant at an operational level.

- Understanding groundwater circulation at depths below 300 metres.
- The inability of most models to accurately account for heterogeneous and anisotropic aquifer systems.
- The lack of monitoring and monitoring infrastructure, including baseline, surveillance and compliance monitoring.

Legal aspects

The National Water Policy 1997 and the National Water Act (*No 36 of 1998*) state that:

- All water resources are common to all and subject to national control.
- All water shall have a consistent status in law, irrespective of where it occurs.
- Groundwater is an integral part of the water resource and must be managed as such.

The National Water Resources Strategy 2013:

- Describes how to protect use, develop, conserve, manage and control water resources.
- Enables the formulation of the National Groundwater Strategy (2011 and 2017) to address shortcomings.

The aims of the National Groundwater Strategy 2016 include that:

- Groundwater should be recognised as an important strategic water resource.
- Knowledge and use of groundwater should be increased along with the capacity to ensure sustainable management. Better groundwater management programmes should be developed and implemented.

Institutional aspects and cooperation

Several institutions are responsible for groundwater management at different levels, including the DWS, DEA, catchment management agencies, water user associations, local and district municipalities, water services authorities, water service providers, water boards and water users.

Multiple organisations, policies, legislation, plans, strategies and perspectives should be involved in water-related decision-making, but this creates complex leadership challenges. Integrated water resource management demands a certain level of interaction between different institutions and their activities and responsibilities.

Governance and capacity

At a national level, technical, legal and institutional, and operational governance provisions are reasonable, but cross-sector policy coordination is weak. Institutional capacity is weak across all thematic areas except for technical provisions.

At a local level, governance is extremely weak. While 79% of municipalities surveyed make use of groundwater, only 13% have any groundwater management plans in place, and only 13% employ groundwater specialists.

The issues relating to groundwater use are complex. The technical issues, including both hydrogeology and engineering, are relatively well understood, but the organisational, economic, social and political dimensions are more challenging.

An increase in coordinated land and water management is needed, including water quantity and quality, integrated water resource management, integrated catchment management, and integrated development management. This needs to take account of legislation, policies and other tools relating to land, water, environment, ecology, settlements, economic development, social development, stakeholder partnerships and other natural resources.

Future projections predict an increase in drought intensity in South Africa. Risk management planning needs to consider every aspect of life that relies on water at the appropriate scale. It is essential to know where gas wells would be located, and to coordinate planning and monitoring across multiple sectors.

Linkages between water resource systems and unconventional energy development

There are multiple linkages between groundwater resources and shale gas development, including:

- Risk assessment processes:
  - baseline data;
  - hydrologic models;
  - water budget;

- chemical use information;
- risk mitigation; and
- emergency response.

- Water availability:
  - groundwater abstraction and depletion;
  - local variability in groundwater levels;
  - competing water demands from municipalities, agriculture, and commercial and industrial activities;
  - potential water allocation conflicts in water-scarce and drought-prone catchments; and
  - a potentially new water source from produced water.

- Water quality:
  - spills and drilling failures leading to environmental contamination;
  - fugitive gases and upward migration or venting from the target formation migrating through faulty well casings to impact water sources and ecosystems;
  - hydraulic fracturing that could mobilise metals and radionuclides from the subsurface;
  - storm-water runoff that could combine with flowback and produced water, introducing contaminants to surface and groundwater; and
  - water quality impairment due to contaminants in produced water.

- Waste water management:
  - permitting, monitoring and tracking systems need to ensure environmentally sound treatment, recovery, reuse and disposal;
  - chemical, microbiological and toxicity analyses and data management;
  - the long-term need for recovery, reuse and disposal of produced water;
  - the short-term need for managing high volumes of flowback water and hydraulic fracturing fluids;
  - spill control and emergency response;
  - a storm-water management programme;

    - on-site containment; and
    - a chain-of-custody for off-site transport, treatment, reuse, recovery and disposal.

- Well integrity:
    - reliable monitoring of vertical and horizontal well integrity is critical during drilling, hydraulic fracturing, gas extraction, closure, and post-closure;
    - inspection and emergency response; and
    - monitoring wells to detect groundwater migration pathways.

Water Science Plan (WSP)

The heart of the WSP is a test-bed concept that would allow for testing and evaluation of new technologies, developing protocols for ensuring well integrity, optimising monitoring strategies, test-driving policy approaches, training, capacity building, and implementation of adaptive management systems. This would allow collaboration across multiple agencies, and opportunities to learn *in situ* and at an appropriate scale.

The five inter-related guiding principles of the water science plan include:

- Water resource protection
- Data interoperability
- Innovation
- Capacity building
- Credible governance.

Test bed for technology and evaluation

South Africa has the opportunity to apply lessons learnt from other countries in a region that has not experienced hydraulic fracturing.

Opportunities include:

- developing national and international frameworks for collaborative research, based on agreed agendas;
- building research networks to tackle focused scientific questions;
- undertaking long time-series observations;
- guiding and facilitating the construction of databases; and
- undertaking model inter-comparisons and comparisons with data.

Guidance:

- Regulation should be goal-based.
- Decision-making and research should be transparent.
- Shale gas development requires a sophisticated regulator.
- Baseline monitoring is urgent.
- Risk identification and assessment – policy responses.
- A water life-cycle approach should be taken in shale gas exploration and production, including issues of chemical mixing, hydraulic fracturing, flowback process and produced water, and produced water treatment and waste disposal.
- Adaptive management and emergency preparedness are needed.
- Compliance monitoring and enforcement are essential.
- Post-closure decommissioning and legacy issues have to be addressed.

Sustainable funding and partnerships, coupled with innovative solutions are needed.

Transdisciplinary baseline studies in the Karoo to monitor resource extraction

(Prof Maarten de Wit, AEON, NMU)

In order to gather baseline information before the advent of a shale gas industry, a study area was chosen by AEON at NMU.

Areas that were out of bounds to shale gas development include:

- Areas where shale deposits are too close to the surface for fracking (above 1 500 metres).
- The SKA area.
- A planned UNESCO World Heritage Site.

The study area was chosen by analysing a vertical section through the Eastern Cape region (orange line) and selecting an area in which the shale was deeper than 1 500 metres. Early shale gas development was most likely to occur in this region. According to old Soekor data, earlier drilling had resulted in some large gas leaks; this suggested there was probably a lot more gas in these deposits than had previously been anticipated.

The baseline studies are complex. A large number of technical, environmental, social and economic issues need to be taken into account.

A group of 35 graduate and PhD students from the natural and social sciences are involved in the baseline research, which covers the themes: Earth, Water, Life, and People. Transdisciplinary learning is an important aspect of AEON's approach. It is of concern that most universities in South Africa lack the necessary instrumentation to conduct some of the necessary analyses such as micro-seismicity.

Components of the shale gas baseline study include:

- Groundwater monitoring and analysis.
- Surface and critical zone changes.
- Gas flow detection to determine the nature and volume of current leaks.
- Socio-economic and risk analysis, involving citizen science and the downstream effects of resources.
- Micro-earthquake detection and deep imaging of the Karoo.

Examples of AEON's baseline research projects

1 Methane emissions: Before fracking commences, a detailed methane leakage map is needed. The aim is to distinguish natural gas migration from the reservoir to shallow aquifer through faults, from those of leaking well-bores and induced fractures. Instrumentation mounted on a vehicle measured methane levels in the environment and allowed detailed mapping to be done. Raised levels have been detected around landfill sites and near old Soekor boreholes (c. 1960), which are leaking gas into groundwater wells. Natural sources of methane include agricultural fields and Cradock's thermal springs.

2 Groundwater issues: There are nearly 37 000 boreholes in the Eastern Cape study area, which could not all be monitored individually. Doctoral students are instead monitoring and mapping these statistically. An electrical conductivity map of the Jansenville district has revealed that deep saline water is naturally mixing with fresh ground and surface water sources. It is important to record the existing natural situation and changes due to agriculture so that groundwater issues are not unfairly blamed on shale gas development.

3 Micro-seismicity: AEON is one of only two groups in Africa recording ambient micro-seismic noise rather than using induced seismicity for underground mapping. Seismic contrast exists down to depths of at

least five kilometres, and exposes the varying degrees of contact between the Karoo Supergroup and the Cape Supergroup. Data modelling has shown distinct geological formations between north and south of latitude 33.3ºS.

4 Ecosystems, conservation, flora and fauna: Plant responses to fracking chemicals are being studied. Experiments include laboratory-based germination, plant growth and photosynthesis studies, as well as spraying fracking fluids on fields of natural vegetation to monitor impacts. While germination of the species tested has not been adversely affected, growth rate, photosynthetic efficiency and survival of plants has been adversely affected.

The impact of fracking fluids on the behaviour of termites and the spatial geometry of their colonies is also being investigated.

5 Social issues: Social issues include social licence, employment, health, indigenous rights and social cohesion. Trust-building with local communities is one of the most important elements of the work of AEON. A great deal of time has been spent consulting with local communities to find out what they believed should happen if shale gas is discovered.

6 One aspect of this work is a citizen science programme in the Cradock area that involves local people taking water samples, analysing them, and reporting on their findings. In an area with 50% school-leaver unemployment, the aim is to develop skills that might enable local problem-solving and entrepreneurship. A water monitoring app has been developed as part of this project.

Vision and future plans

- AEON aims to increase the number of PhD students doing interdisciplinary work to between 40 and 50.
- The next stage of the Karoo baseline studies project is to set up a controlled scientific hydraulic fracturing site in the Cradock area. Three drilling sites would be developed, including a controlled fracking site, a geothermal test site, and a deep scientific site drilling to a depth of ten kilometres.
- A drilling college with related industries is planned for the area, based on the Silicon Valley model. This would be a unique opportunity to conduct pure and applied sciences and to teach a wide range of skills.

- The availability of portable rigs that could drill wells five to six kilometres deep would enable the Cradock centre to serve as a technology centre for Africa.
- The DST is looking for sites to conduct good science, and this is an opportunity to research great depths.
- Deans from every faculty at NMU were on the Board of AEON, which is developing a new way of doing science and technology research.

Results from the CIMERA-KARIN scientific drilling project and implications for the shale gas potential of the southern main Karoo Basin

(Prof Michiel de Kock, University of Johannesburg)

Introduction

The DST-NRF Centre of Excellence for Integrated Mineral and Energy Resource Analysis (CIMERA), launched in 2014, is based at the University of Johannesburg (UJ) and co-hosted by Wits. Its partners include the universities of Fort Hare, Rhodes, Pretoria, Stellenbosch, Cape Town, and Venda.

It has eight research focus areas, including the Karoo Research Initiative (KARIN), which focuses on fossil energy resources in the Karoo, namely shale gas, coal and uranium. KARIN is entirely funded by a mandate-free donation from Shell. The funding is administered by the scientists, there are no confidentiality agreements, and all intellectual property resides with UJ. The CIMERA network of partners and its administration structure is used to ensure fast and effective fund distribution and financial governance.

KARIN aims and objectives

- Knowledge creation:
    - Reconstruct the depositional history of the Karoo Basin.
    - Unravel the deep structure of the Karoo Basin.
    - Investigate the effect and distribution of dolerites.
    - Establish the maturity and shale gas potential by direct measurement.
- Capacity building: Equip South African postgraduate students.

- Shale gas objectives:
    - Characterise the hydrogeological conditions (deep groundwater).
    - Study the organic geochemistry of the Ecca Group, in particular the Whitehill Formation.
- Scientific objectives regarding the Ecca Group included an improved:
    - Understanding of the litho and chronostratigraphy.
    - Biostratigraphic framework.
    - Magnetostratigraphic framework.

KARIN drill cores

To achieve its aims and objectives, KARIN needed to obtain fresh drill core material as the old Soekor drill cores were oxidised and could not be used to determine the organic chemistry of the Whitehill Formation. (Note that the white colour of this formation is caused by sulphur in the black shale, which weathered to white-coloured gypsum.) Furthermore, data from other basins could not be extrapolated because the Karoo is unique in terms of the presence of unusually large volumes of dolerite, and compression from the Cape Fold Belt in the south.

Two holes were drilled:

- KZF-1 near Ceres, south of the dolerite region and close to the Cape Fold Belt; and
- KWV-1 near Willowvale in the Eastern Cape, where there was abundant dolerite and little was known about the geology.

Experience gained from the two test drilling sites included:

- Time to completion could be greatly reduced by working collaboratively and with support from the management of academic institutions; the initial planning discussions had taken only four months, and drilling of the first borehole started a year after the launch of the project.
- It was essential to engage with the community and keep them informed. In both areas, many meetings had been held and useful information had been gathered. Several open reports had been published on the CIMERA website (www.cimera.co.za) to report on progress and findings. Local community projects had been identified and supported.

- South Africa had suitable drilling contractors who could drill cores in unpredictable geological conditions on schedule to international standards. They were able to adapt to geological complications, and drill cleanly and without waste at very good rates.
- An expert geological drilling consultant was needed to compile drilling tender documents and specifications. A geological drilling manager was required on site when the wells were being drilled to properly curate and log cores.

Geological findings

- Stratigraphy:
  - Ceres KZF-1 drill site (671 metres): Even in an area where the geology had been mapped, unexpected structural duplication of the top of the Prince Albert Formation and the base of the Whitehill Formation had resulted in a thicker intersect (70 metres compared with 14 metres) due to thrust duplication.
  - Willowvale KWV-1 drill site (2 353 metres): More sandstone than shale had been found, as well as many dolerite sills. The Whitehill Formation was intersected at 2 300 metres, not at 1 600 metres as had been expected.

- Groundwater:
  - Ceres KZF-1: Prior to drilling, the baseline groundwater study revealed that most of the hole was dry but there was strong artesian water at depth that was of better quality than the surface water being used by the farmers. Unfortunately, this source had to be plugged and sealed in terms of the EMP.
  - Willowvale KWV-1: No deep artesian deep water was intersected in this borehole.

- Gas content:
  - Ceres KZF-1: Direct measurements of the gas content were made, including that adsorbed by the shale and trapped in the shale as residual gas. Close to Ceres there was negligible residual gas in the shales. More gas was found in the Whitehill formation but not all was methane; CO_2, nitrogen and helium were also present.
  - Willowvale KWV-1: There was negligible adsorbed or residual gas.

- Organic matter (maturity): An additional hole (BH47), which had been drilled by Gold Fields near Philippolis, allowed comparison between the western basin and the Eastern Cape. TOC was analysed. Most was found in the Whitehill Formation but even this was variable and lower than the six weight percentage (6 wt%) used in most resource estimations for South Africa (See Table 3):

Table 3: Average TOC of Whitehill Formation across Three Boreholes

Borehole	Average TOC of Whitehill Formation
KZF-01	3.77 wt%
KWV-1	3.81 wt%
BH47	5.59 wt%

Summary of geological findings:

- Direct measurement of gas revealed no or very little residual and desorbed gas. Gas may have been expelled as long ago as 180 million years.
- The chemistry of the organic carbon was analysed and most of it was found to be 'dead' or no longer bound to hydrogen or oxygen. The rocks were over-mature, having released most of the gas in the past.
- It was not clear where gas might be preserved. It could be concentrated in thermal oases (sweet spots) or locally preserved as natural gas, but it was no longer locked in the shale.

Implications:

- The regional heterogeneity in TOC could pose a bigger risk than previously expected.
- Thermal maturity, which seemed to be a more regional effect related to an increased thermal gradient, could pose a much larger risk than that posed by dolerite sills.

Conclusion

- Based on this research, the most realistic resource estimation was 13 Tcf.
- Whether or not gas resources existed in 'sweet spots' remains to be proven.
- Samples distal from dolerites and far from Cape Fold Belt near Philippolis (BH47) were over-mature. Rocks in sweet spots might be of similar maturity or higher.
- More geological baseline work is needed to find out if the sweet spots are real and if gas could be found there.
- Research projects are ongoing at various universities, funded through KARIN. The work reported on in this presentation would appear in the next issue of the *South African Journal of Science*, and would also be available online as open-file reports.

The Karoo deep drilling and geo-environmental baseline programme, Beaufort West

(Ms Dawn Black, Geologist, CGS)

Introduction

- In 2012, a working group had been tasked by the DMR to draft technical regulations for the production of shale gas through hydraulic fracturing.
- Through this process, gazetted on 15 October 2013, the need for further research had been identified.
- As a result, the CGS had been tasked by the DMR to undertake a four-year baseline study, directly related to the study of shale gas in the Karoo Basin.
- The programme includes a wide range of geoscientific investigations, mainly associated with the drilling of two shallow monitoring boreholes and a third deep borehole.

Project description

- The CGS is to undertake a geoscientific investigation near Beaufort West in order to establish a baseline monitoring system.
- The study is to provide information that could be used to identify potential threats to natural biotic and abiotic systems, and subsequent mitigation of these risks.

- The project consists of three phases:
- Phase One: Geology, seismology, geophysics, hydrogeology, and environmental studies.
- Phase Two: Vertical drilling, wireline logging, gas measurements, geochemistry, rock strength, hydrogeology, seismic, and environmental monitoring.
- Phase Three: Socio-economic parameters, continued hydrogeological and environmental monitoring.
- The study area is in an area of relatively degraded commonage approximately two kilometres north-east of Beaufort West.
- According to previous research, the study area falls within a 'sweet spot' for shale gas. Dr Cole (2014) had estimated that the area had the highest gas recovery potential of the carbonaceous Whitehill Formation.

Planned activities

- Ground geophysics includes time domain electromagnetics and magnetotellurics, to better define shallow (less than 300 metres) to semi-deep aquifers.
- High-resolution airborne magnetics and radiometric surveys, which would aid in enhancing sub-surface structures.
- Seismic profile interpretation to define the depth of the Whitehill Formation.
- Geological mapping of the area at a 1:50 000 scale, to include stratigraphy, lithology and structures.
- Structural mapping.
- The drilling of three boreholes.
- Groundwater investigations at a catchment scale, including a hydrocensus in a ten kilometre radius around Beaufort West.
- Seismological monitoring to establish a baseline for the area.
- Environmental monitoring.
- Various other analyses, including geo-chemistry, using the Karoo National Park as a baseline.

Phase One activities (underway)

- Geological maps, first compiled in the 1970s and 1980s, were revised at a 1:50 000 scale, showing the geology and associated structures in the study area. Detailed mapping and remote sensing are being used to delineate or better define structures.
- A Cenozoic cover map and associated bedrock topography map has been produced. An understanding of the Cenozoic cover is important for groundwater investigations and the planning of boreholes. The thickness contours delineated for Cenozoic cover are 0 – 5, 5 – 10, 10 – 20, 20 – 30, and 30 – 35 metres.
- A prominent north-south depocentre with sediment thicknesses of between ten and 30 metres is present 13 kilometres east of Beaufort West. This thickened to 20 – 31 metres in a south-east-trending depression 16 kilometres south-east of Beaufort West.
- The isopach map showed the presence of a south-trending depocentre that terminates in a south-east-trending depocentre, filling a palaeovalley east of Beaufort West.
- The reinterpretation of old seismic lines has allowed for the determination of the depth of the Whitehill Formation.

The revision of the local geology has aided in the construction if a 3-D model of the subsurface geology, as well as detailed cross sections. As new information is gathered, the 3-D model would be updated. The creation of the 3-D model is complemented by data from the National Groundwater Database boreholes.

Dolerite sills and dykes

- The Karoo Basin is characterised by many dolerite sills and dykes. During Phase One, the CGS studied the Karoo dolerites to better define and map these occurrences.
- Within the study area the trend of these discontinuous intrusive bodies is mainly east-west, often branching north-northwest. They are of variable thickness and range from 50 to 150 metres, often following an en-echelon pattern.
- Samples have been collected and would be analysed together with fresher samples from drilled boreholes.

Ground and airborne geophysical investigations

These studies are nearing completion:

- Ground geophysical methods used include magnetotellurics, time domain electromagnetism, resistivity sounding, magnetic sounding, and seismic refraction.
- Airborne geophysics investigations are currently being flown with a line spacing of 200 metres.
- Six stations have been installed, and are operating and being monitored for regional micro-seismicity.
- Once data have been collected they would be analysed and interpreted.

Hydro-census

Within a ten kilometre radius of the test site, two shallow boreholes are being drilled for to allow for groundwater sampling and monitoring of:

- water quality,
- step testing,
- constant discharge testing, and
- recovery testing.

Phase Two activities: borehole drilling

Phase Two is about to start and would entail the drilling of two shallow boreholes (700 to 1 000 metres) and one deeper borehole (3 500 to 4 000 metres). They would be intersecting three sills at 200, 500 and 700 metres. Various analyses would be conducted on the material collected.

- The two shallow boreholes would be used to establish a baseline for groundwater and provide information on the potential relationship between sills and groundwater.
- The deep borehole would be a stratigraphic borehole, used to enhance understanding of the subsurface geology.

In addition, a soil gas hydrocarbon evaluation survey would be conducted using surface sampling.

Discussion

Neville Ephraim, iGas: How is the WRC engaging with industry and various levels of government to ensure that their research is having an impact?

Response – Dr Pietersen: Over the past five to ten years there has been considerable engagement with municipalities, industries and consultants using WRC research, resulting in positive changes to their operations. The groundwater planning toolkit for the Karoo has enabled users to extract more water than previously expected. In some cases, procurement problems have resulted in problems attracting the right skills, with professionals having to compete with building contractors.

Neville Ephraim, iGas: It is unfortunate that high-quality potable water discovered during experimental drilling could not be used to benefit communities. The environmental requirements of the study need to be more flexible.

Response – Prof De Kock: The decision to seal the borehole was discussed and agreed with the community in advance. It is very old water, and because the recharge time of the aquifer is not understood, it would have been irresponsible not to have sealed it.

Prof Philip Lloyd, CPUT: Very little has been said about near-surface geochemistry. The diameter of holes near the surface is larger than those further down, so significantly more spoil is generated near the surface. Surface deposits could contain toxic substances like uranium and arsenic, which could pose significant environmental problems.

Response – Prof De Wit: All the boreholes are being monitored for geochemistry. One aspect that AEON is investigating in the Eastern Cape is the potential influx of seawater into deeper boreholes.

Nicholas de Blocq, Service Technologies: Would the methane sensing study conducted by AEON be extended to the northern parts of the Karoo where the Whitehill Formation is too shallow to frack, but where it breaks out at the surface and by interfacing with the dolerite could create a path for desorbed methane molecules to escape?

Response – Prof De Wit: The intention is to compile a Karoo-wide methane leakage map but this is time consuming and relies on the availability of students to do the research.

Nicholas de Blocq, Service Technologies: The comment has been made that there is no existing Centre of Excellence (CoE) for studying the geophysics of shale. Five years previously, Schlumberger East and Southern Africa set up a laboratory at Fort Hare University, investing $7million in state-of-the-art equipment and software licences, and training the lecturers to include geophysics in the curriculum. Is this still operating? Few people at the conference are aware that a geophysics CoE had been established focusing on the Karoo shales.

Response – Prof De Wit: AEON is managed by a geophysicist and is involved in offshore and onshore geophysics. Gyrocopters were being flown over the study areas. There is a large geophysics group that communicated to an extent with Fort Hare but this has not developed far enough yet. It is hoped that the Eastern Cape universities would cooperate around geophysics research.

Response – Christopher Baiyegunhi, University of Fort Hare: Most of the licences have expired and help is needed to renew these.

Bongani Sayidini, PetroSA: When the KARIN project drilled a 2 500-metre borehole near Willowvale, which intersected the Whitehill Formation in which shale gas was expected to be found, did they have the capability to deal with a blowout?

Response – Prof De Kock: Well design was undertaken very carefully by a company that specialised in exploration drilling, in consultation with an international expert. Safety features, like blowout gas deflectors, had been built into the well design and no problems had been experienced.

Bongani Sayidini, PetroSA: What were the timelines for the next phase of the AEON project? Was AEON considering possible synergies with the CGS, for example regarding their deep research borehole in Beaufort West?

Response – Prof De Wit: It would be very complicated to design a good hydraulic scientific baseline study fracking site, and international industrial players, especially from the USA, will need to be consulted about the design, costings and funding. It would also be essential to engage with the local community in terms of social licence issues. The design of the fracking site should be completed by the end of 2017, but the geothermal and deep drilling sites would need long-term investment, and would not come on stream until about 2025.

Dr Phethiwe Matutu, NRF: What industries could employ the Masters and doctoral students that the NRF was supporting? How many students could be absorbed by these industries?

Response – Prof De Wit: AEON's first PhD students would be graduating at the end of 2017. Graduates would be skilled and experienced in working in an inter-disciplinary environment

Barry Morkel, AEON, NMU: Most Karoo municipalities are challenged by water shortages and by a lack of technical skills to manage water, water quality, and general infrastructure. Considering the impacts of mining being experienced in South Africa, especially acid mine drainage, it is time to discuss how to finance these competences. How would it be possible for municipalities to deal with the risks associated with shale gas in already water-scarce areas. It is hard to find competent people, so it is essential to develop capacity and resources to mitigate this challenge.

Benson Modie, University of Botswana: How did the communities respond and what were their expectations?

Response – Prof De Kock: The responses of communities varied: there were always some who were interested and open, and others who were aggressive and opposed to drilling. Ongoing engagement made it possible to gain community support. Direct requests for assistance were received from communities, and they were helped where possible.

Response – Prof De Wit: Initially lectures were given, but many people did not understand them. Presentations became simpler and more concrete. The citizen science approach was proving to be a better approach. Even if shale gas did not materialise, people were learning skills, which could result in job creation.

Benson Modie, University of Botswana: Prof De Kock and Ms Black have mentioned sweet spots; have they done five-spot drilling?

Response – Ms Black: The sweet spot is a set of geological parameters used to delineate an area with the best prospects for shale gas discovery. It does not involve the drilling of well holes.

Marcus Pawson, AfriForum: It is of concern that the KARIN project was funded by Shell, which was one of the applicants. Was this an appropriate relationship?

Response – Prof De Kock: This concern has been raised many times. Shell gave a donation with no mandate regarding where to drill or what to look for. It was simply an academic research project and all information is provided via an open-source platform.

SESSION 7: ROUND-TABLE DISCUSSIONS

Facilitator: Mr Somila Xosa, Director of Transport Fuels and Renewable Energy, DST

Delegates were encouraged to use the opportunity provided by the round-table discussions to reflect on the goal and objectives of the conference. Government representatives were there to listen and to shape processes going forward. It had been a Cabinet decision to create an enabling framework for shale gas development in South Africa. This has led to a number of activities, including:

- Strengthening the regulatory framework.
- Ensuring coexistence with astronomy research.
- Promoting independent research.
- Establishing a monitoring committee.

A lot of work and studies had been done in this regard by the monitoring committee and departments. Issues had been highlighted, including environmental concerns, skills, water availability and quality, socioeconomic issues, and technological aspects. It was important to listen for key issues that could be pursued as part of the independent research pillar, and to decide what the priorities were and who should take responsibility.

Purpose of the workshop and the way forward for government

(Mr Andries Moatshe – Acting Deputy Director-General, Department of Mineral Resources)

The Minister of Mineral Resources, Mr Mosebenzi Zwane, and the Director-General, Adv Thabo Mokoena, sent greetings and apologies. They were addressing the community at the Harmony Gold Mine where five employees had died due to a seismic event.

Background and implementation of Cabinet-approved recommendations

- On 21 August 2012 Cabinet had approved the report by the Minister of Mineral Resources to use hydraulic fracturing in the exploration and exploitation of petroleum resources.
- The report had recommended the following:
    - Allow exploration other than hydraulic fracturing to proceed under the existing regulatory framework.

- Constitute a monitoring committee to ensure a co-ordinated regulatory framework and supervision of operations.
- Augment the current regulatory framework through the establishment of the appropriate regulations, controls and co-ordination systems.
- Define buffer zones around SKA installations through a notice in the *Government Gazette*.

- Once all the preceding actions had been completed, hydraulic fracturing should be authorised outside the buffer zones and under the supervision of the monitoring committee. In the event of any unacceptable outcomes, the process could be halted.
- Relevant institutions should be mandated to conduct research with respect to, *inter alia*, the geohydrology of the areas, the evaluation of the potential of the resource, methods of hydraulic fracturing in South Africa, and environmental impacts.

Table 4: Status of Projects Commissioned by Government

Action	Status
Allow exploration to proceed (issuing of licenses)	Five applications had been received, namely: • Shell Exploration Company: three. • Falcon Oil and Gas Ltd: one. • Bundu Gas and Oil: one.
Constitution of a monitoring committee	The Hydraulic Fracturing Monitoring Committee (HFMC) had been constituted and included the DST, DoE, DEA, DWS and state-owned enterprises, including PASA and CGS. The committee was chaired by the Director-General of DMR.
Provide for buffer zones in the regulations to protect the SKA programme	The Regulations for Petroleum Exploration and Production included provisions for the protection of the SKA, and the co-existence of the SKA and shale gas development
Authorise hydraulic fracturing outside the buffer zone	A sub-committee had been established, comprising the DMR, DST and PASA, to investigate licensing and had taken into consideration protection of the SKA and coexistence between the two programmes.

Action	Status
Mandate government institutions to undertake relevant research	DST had commissioned the ASSAf study to assess the technical readiness of South Africa to support the shale gas industry. The study had been concluded with recommendations that included the hosting of the shale gas conference.
	The DMR had commissioned the CGS and PASA to undertake the Karoo Deep Drilling and Geo-Environmental Baseline Programme: • The objectives of the research project were to cover various environmental impacts of public concern and to measure the gas content from the deep borehole. • The research project was continuing.
	The DoE had commissioned SANEDI to undertake a technical readiness study: • The objective of the study was to assess the impacts of shale gas exploitation and use. It focused on economic aspects such as job-creation potential, environmental issues, and the effect of shale gas on the future energy mix in South Africa. • The report was being subjected to DoE internal processes before being released.
	The DEA had commissioned the CSIR to undertake a SEA: • The purpose of the SEA was to provide an integrated assessment and decision-making framework to enable South Africa to establish effective policy, legislation and sustainability conditions under which shale gas development could occur. • The research has been completed.

Considering the research projects listed in Table 4, government wanted to know if there were any gaps and if there was anything more that should be done.

Shale Gas Communication Strategy

- Cabinet has adopted a communication strategy for shale gas in order to communicate the decision of government to develop shale gas resources.
- The strategy would be implemented throughout the shale gas development process.
- Some aspects of the communication strategy had already been implemented, such as the Ministerial Imbizo with the Cradock community, which was followed by a business breakfast with oil and gas stakeholders.
- Further community engagements had been undertaken in Richmond, Northern Cape and Beaufort West, Western Cape.

Some communities, planners and regulators might not have received the necessary information. This conference was necessary in order to ensure that regulators and planners are informed and empowered.

Way forward

- In 2012, the shale gas project was one of a nine-point plan of priority projects expected to contribute towards energy security, and support for local beneficiation and manufacturing. It had therefore been prioritised by government, based on information available at the time.
- Inputs from stakeholder engagements would be consolidated into a comprehensive report that would be tabled at the HFMC for consideration and further processing into action plan(s) to be implemented by relevant government institutions.
- Clarification on critical issues was awaited from the scientific community, including:
  - the potential impacts on land, water and air;
  - the necessary monitoring and compliance;
  - requirements for comprehensive infrastructure planning, involving all layers of government;
  - how to prevent adverse impacts on the agriculture and tourism sectors by shale gas development; and
  - what should take place after the completion of the shale gas programme.

Further aspects of the strategy would continue to be implemented as shale gas development progressed.

The government was impressed by the deliberations that had taken place and looked forward to the consolidation of scientific information, which would enable regulators and planners to decide whether to proceed with, or halt, the shale gas programme.

Round Table 1: Monitoring
Facilitator: Mr Mthozami Xiphu, SAOGA

Panellists:

1 Ms Surina Esterhuyse UFS

2 Dr Gregor Feig, CSIR

3 Mr David Aphane, PASA

4 Mr Paul Hardcastle, Western Cape Government

5 Prof Doreen Atkinson, UFS

6 Dr Joh Henschel, South African Environmental Observation Network (SAEON)

Mthoszami Xiphu:

Monitoring involves a number of areas, including:

- environmental management;
- the work programmes that are agreed to when licences are issued;
- social and labour plans; and
- relevant infrastructure.

Surina Esterhuyse:

In South Africa, the prospect of shale gas has raised hopes, but large amounts of water are needed. About 90% of fracking fluid is water and on average ten to 20 million litres per well are needed for drilling and extraction. This could be a major issue as 30% of towns are already experiencing water shortages, and this is expected to increase to more than 55% over the next ten years. More than 98% of surface water resources have already been allocated, and it is unlikely that sufficient groundwater and surface water would be available to supply the shale gas industry without impacting on existing users or ecosystems.

Although water is the main component of fracking fluid it is not the only one. Chemicals that are added to fracking fluids to perform fracking depend on the geological conditions at the drilling site. Many of the chemicals used for fracking are known carcinogens or endocrine disrupters. Organic chemicals are also used and if they contaminate an aquifer, it is almost impossible to remediate the aquifer system.

The treatment and disposal of waste water would also pose a challenge due to the nature of the chemicals found in the waste water. The waste water from fracking contains a mixture of the water and chemicals originally injected (known as flowback), as well as formation water. Formation water produced from wells could contain an array of heavy metals as wells as naturally occurring radioactive materials. Waste water could be recycled, but currently recycling is limited and is an expensive process, and more research is needed. In the USA waste water is typically injected underground. Underground injection is, however, not allowed in South Africa due to concerns about contamination and induced seismicity.

Fracking can impact on the quality of water resources in the following ways:

- Pollution of surface water due to spillages and the possible infiltration of chemicals into groundwater resources.
- The failure of well integrity of production wells and decommissioned wells.
- Fluid migration from shale or tight reservoirs along preferential pathways, which could be natural or man-made.

To mitigate and manage these impacts, water resources need to be monitored and regulated before exploration, during extraction, and after well decommissioning. Baseline monitoring needs to occur before exploration starts in order to have reference conditions for water resources quality and quantity. Monitoring must also occur during production, to monitor water usage and to serve as an early warning for any pollution that occurs, and must occur after well decommissioning, to identify any pollution arising from well-integrity failures. This monitoring must be linked to an adaptive management plan to ensure that water resources are protected, and that action is taken to mitigate and manage any pollution that occur. Mechanisms are needed for auditing and making changes to monitoring the programme if necessary. Taking these actions could minimise impacts on water resources.

Dr Gregor Feig:

Monitoring air pollution and GHGs use similar techniques but they are treated differently because they represent different concerns. Air pollution is mainly an issue of human health and agricultural production, while GHGs are an issue of climate. The lifetimes of these pollutants differs, with air pollution generally lasting from hours to weeks, while GHGs build up over decades to centuries. Spatially, air pollution is relatively localised but GHGs have a global impact.

Key pollutants include:

- particulate matter: from ground dust, roads, construction activities, combustion and secondary pollution – affecting human health;
- NOx (nitrogen gases): from high-temperature combustion; this could result in the production of secondary ozone – affecting human health and agriculture;
- GHGs (methane and CO_2): from management and processes – affecting climate.

An assessment report on risks to air quality has identified air pollution as an occupational health and safety (OHS) risk. Operators are likely to be exposed to atmospheric pollutants, while people in the local communities and region also experience a moderate risk.

In terms of GHGs, fugitive emissions of methane present a relatively low risk in small-gas developments but a large risk in big-gas developments.

Currently, little monitoring of atmospheric pollutants or GHGs is taking place in the assessment area, especially where long term, continuous monitoring is concerned. Outside the assessment area some monitoring sites could provide insights, for example the South African Weather Service Monitoring Station at Nieuwoudtville. This had been installed as a background site in what was assumed to be a relatively clean area. Surprisingly wind-blown dust had exceeded recommended levels for South Africa, suggesting that Karoo populations are already at risk of air pollution. In Oudtshoorn, hydrogen sulphide and CO_2 are monitored by the Western Cape government. This site could be expanded to include more parameters. A monitoring station might be developed in Beaufort West.

In terms of GHGs, CO_2 is monitored at Oudtshoorn, and Cape Point provides a long-term baseline for both methane and CO_2.

The monitoring that is required includes on-site monitoring of air pollution for OHS purposes.

It is also important to have a background site that measures the atmospheric pollutants that the community is exposed to, and how this changes over time. This needs to represent background pollution, not local sources in the town. A passive diffusive sampling network distributed across the region could be included. This would provide less precise but spatially explicit background readings.

Once fracking starts, it would be important to know what other volatile organic compounds (VOCs) would be produced.

In terms of GHGs, high-precision instrumentation is required to detect small background changes. There are a few such instruments in the country (e.g. AEON and CSIR). These could be used to detect sources of pollution using triangulation. A better technique is inversion modelling, which uses a network of instruments. This approach has been used successfully in the USA to identify source regions where methane emissions have not previously been documented.

David Aphane:

PASA is tasked with the assessment and evaluation of applications received from operators. It makes recommendations regarding the granting of rights and the approval of environmental authorisations and EMPs. Permits and authorisations come with conditions and mitigation requirements to protect the environment.

The programmes received from operators, including well designs, drilling programmes and casings, are drawn up in accordance with standards, regulations and best practices. Upon implementation of exploration and production, it is the responsibility of PASA to ensure that whatever the operator does in the field complies with norms and standards. This requires skilled, experienced inspectors and regulators, especially in monitor drilling.

In order for EMPs and authorisations to be approved, certain conditions have to be met. It is PASA's responsibility to ensure that plans are carried out in accordance with the terms and conditions of the authorisation.

Paul Hardcastle:

There is a great deal of energy, innovation, and willingness to undertake research and monitoring, including baseline monitoring. What is of concern, however, is that there seems to be no clear indication on how all these research efforts and the information it produces, are coordinated in a way that will add value to and expand existing knowledge. Who would be responsible? This issue has been highlighted in both the SEA and the ASSAf reports. We must recognise that unless our efforts to coordinate research and baseline monitoring initiatives occur in a manner that is credible, the public will not trust the ability of government to be able to implement shale gas development responsibly.

Those responsible for coordinating research and monitoring should be independent, transparent, credible, and provide access to information so that the public can understand why certain decisions are made (i.e. evidence-based decision-making). Continuous learning needs to translate into evidence-based policy and law reform, and inform spatial planning, guide implementation, and regulatory decision-making. This is a great responsibility and immediate action is required.

Generally, there is a lack of attention being given to the roles and responsibilities of provincial and local government in shale gas development. The lack of representatives from these spheres of government at this conference testifies to this challenge. Provincial and local government officials need information in order to prepare, or be in a state of readiness, to deal with increasing demands for services and service delivery. This will already happen during the exploration phase for shale gas. There is an urgent need for all role players to acknowledge and understand the roles and responsibilities of all spheres of government related to all aspects of shale gas development, including strategic planning, spatial planning, regulatory decision-making mandates, and baseline monitoring. There is an urgent need for better cooperation between the three spheres of government.

Prof Doreen Atkinson:

There has not been much focus on socio-economic questions in the conference, although this is more challenging than science and technology. The chapter on social fabric in the SEA had presented a false sense of coherence, because tools needed to analyse the social impact are lacking.

It is not clear which variables are most important; and once the variables have been chosen, they need to be defined, and time frames determined to study change. Sociological theory implies a theory of change but the challenge is investigating causality in complex systems. Claims that shale gas would either enrich or destroy communities are fraught with implicit intellectual debate and hardly worth making. The people conducting the studies are informed by different intellectual paradigms, including positivist, hermeneutic, and structural analysis. Getting social scientists to contribute to the debate and agree on a way forward requires skilled facilitation. Without this engagement, it is likely that any social research would be inadequate and highly contested.

Issues include that the socio-economic impacts of shale gas development cut across government departments, and socio-economic analysis cuts across university disciplines. To organise a discussion in such a diverse group might necessitate iterative thinking exercises to develop a common way of thinking. It is not clear who would convene or sponsor this, nor if funding could be accepted from particular sources. There is, however, a great need and opportunity for social scientists to participate. It is important for social scientists to think practically about these problems and to deliberate in a less self-indulgent way. The approach needs to be inclusive across paradigms and disciplines.

Dr Joh Henschel:

SAEON is a unit of the NRF established to undertake long-term ecological research, in order to understand environmental change and make possible predictions, including risks associated with land use changes. SAEON has participated in shale gas discussions since 2014, and in the SEA. It plays a long-term role, providing information and uploading data so that it is available for monitoring and planning purposes. An area of concern is environmental restoration after shale gas extraction, and monitoring the ecosystem to determine if it could repair itself, with or without help.

In relation to the SEA, SANBI and SAEON have together established 60 one-square kilometre study sites across the SEA region. By the end of 2018, information would be available on species and concerns in 30 of the sites. SAEON would continue its involvement at these sites. If shale gas or other development takes place, this could be monitored. There are also reference sites associated with the SKA where, for the next 50 years, there would be no further development.

Discussion

Question 1: What major research gaps have been identified? Can they be prioritised?

Everyone has spoken about the need for baseline and continuous monitoring

Joh Henschel: The SEA has noted that roads, electrical lines and linear infrastructure associated with the shale gas industry would fragment the landscape. How might this influence different species and other aspects, and to what degree?

Paul Hardcastle: The SEA and the ASSAf reports are clear on the information gaps related to the scientific knowledge base and our institutional context (i.e. legislation, policies, organisational structures, human resources and skills). However, if there is agreement that a phased approach is to be followed in the implementation of shale gas development, what kind of baseline monitoring would be required at which stage?

Mthozami Xiphu: There are many research gaps, including air quality, water quality, and socio-economic impacts. Both baseline and continuous monitoring are needed, and the relevant research paradigms need to be selected.

Question 2: How should groundwater and vegetation be protected from the negative effects of shale gas development, as these are critical for community livelihoods?

Paul Hardcastle: According to the impact mitigation hierarchy (as an accepted impact management principle), the priority is to avoid impacts from occuring. Mitigation measures in relation to vegetation and water impacts should only be considered in instances where the avoidance of impacts is not possible. The SEA has highlighted this as a key recommendation. This is also linked to the implementation of the precautionary principle.

Prof Philip Lloyd: Concern is expressed about the use of prepared questions. The panel should have been available to respond to questions from the audience.

Prof Bob Scholes: A lot of people still believe that the fracking process poses a risk to groundwater and surface vegetation, but there is no down-hole risk. This risk would come from a surface incident, such as a truck accident.

The environmental resource permits of the operators had to account for this kind of event. The effects would be very local, so this is not a well-founded risk.

Question 3: What mechanisms would help to coordinate priorities between national government departments and research entities, and how should baseline studies be reported to national departments to inform policy development?

Response – Paul Hardcastle: This is an important issue and is linked to the purpose and anticipated outcome of this conference. First, it is not just for government to raise issues, but a collective responsibility of government and civil society, including the research community. Second, the function of data and information warehousing and a clearing house for information should be facilitated by an independent body acting on behalf of the collective.

Derek Light: When the government task team reported to government, they presented a list of scientific unknowns requiring further research. It was decided that exploration should be allowed to proceed without a SEA, to avoid lost opportunity costs and the risk that oil companies would disinvest. The government was asked to reconsider, as they had taken a policy decision based on very limited knowledge. After some years of outside pressure, the Minister of Environmental Affairs decided to commission a SEA. Without stakeholder knowledge, the DST had commissioned the ASSAf report. At the conference, the DDG of DMR had mentioned that another report had been commissioned by DoE.

The SEA should have been performed first and used to develop policy. The value of the SEA and the conference had been undermined by the flawed decision taken in 2012, as the question was not *if* shale gas development would go ahead, but rather *how*. The government had limited the SEA to a peer review of existing science. It did not undertake new research on aspects where knowledge is limited, instead new research questions had been outlined in the SEA.

Response – Somila Xosa: The SEA was commissioned to provide guidance to government, and the conference has been called to ensure that an independent research programme is established. Policymaking is an iterative process; decisions are made based on available information, but policy would be reviewed and enhanced as and when new evidence comes to light. The fact that policy exists will not prevent any research being done.

David Light: If this process impacted meaningfully on policy, decision-making and legislation, I would be proud to be part of it.

Prof Philip Lloyd: Contrary to what has been said by one of the panel members, the amount of water required per well was very small. A monitoring committee has been established, but it was unclear what it was monitoring. This was a case of analysis paralysis. In the meantime, the USA had been profiting and creating millions of jobs from shale gas. A borehole is needed to determine if there are economic quantities of gas in the ground.

Response – Surina Esterhuyse: Population growth and climate change are increasing the demand for water. If a 'big gas' development occurred, a large amount of water would be needed.

Prof Bob Scholes: The comment that "If you don't have a social licence to operate, you don't have a resource", highlights that there are key research and monitoring problems in the social domain. Social scientists are mostly absent from the conference, so who should play a convening role? Could the Human Sciences Research Council (HSRC) facilitate the development of a research agenda? It is necessary to make a start as this is the most limiting issue.

Mark Engel, UFS: What overarching value would be chosen to inform the hard choices: would it be economic growth or environmental health?

Barry Morkel, AEON: Since 2009, the debate has lacked a theory of change regarding shale gas. Regarding the socio-economic context, all the reports published recently had identified job creation, but this is not the sum total of the theory of change in terms of the impact on energy and the environment. Formative evaluations are needed before developing a monitoring frame or variables.

Scientists and officials need to consider how the results of research and monitoring could inform the policy process of government so that recommendations are implemented and public confidence is enhanced.

Response – Prof Maarten de Wit: Natural systems are as complex as social systems. Quantification is important but this is generally threatening to social scientists.

Dr Mike Shand, Aurecon: To address the issue of monitoring, a theoretical concept plan for a full well field development should be provided, including roads, water and other infrastructure. The proposal should be developed from the perspectives of engineering and environmental planning. This would inform what monitoring would be required, potential impacts, what expertise would be needed, and the responsibilities of government and the developer.

Response – Prof Doreen Atkinson: An ongoing, iterative relationship between research and development is needed, rather than one single moment of decision as to whether to frack or not. The idea of choosing a spatially defined environment in which to conduct intellectual experiments about shale gas development is excellent, and Prof De Wit had already started doing this. A credible social science methodology is needed, with agreement on what constitutes variables and causal relationships. There is a need for tightly chaired discussions to develop a shared social science approach. Sponsorship would be needed to enable discussions involving various universities and departments.

Unknown: People are justified in being sceptical about the involvement of industry, due to its environmental and human rights track record. For any meaningful learning to occur, 20 to 40 exploration wells are needed. The government could not afford this as it could cost up to R100 million. With this budget, ten schools could be built. Funding from industry is needed to do this research and enable this learning.

Unknown: One of the biggest knowledge gaps is whether there is any shale gas worth exploring. An amount of 13 Tcf had been calculated for the whole of the Karoo, but this amount would be needed in the concentrated area of a single gas field. There is very little potential for this in the Whitehill Formation because the carbon is dead. Close research cooperation between government, industry and the universities is needed, and only industry is in the position to be able to determine whether there are sufficient gas reserves or not.

Round Table 2: Human capital development for the shale gas industry

Facilitator: Dr Phethiwe Matutu, National Research Foundation

Panellists:

1 Mr Dave Wright, Dave Wright Consulting

2 Dr Neehal Mooruth, Shell

3 Mr Niall Kramer, SAOGA

Dr Phethiwe Matutu:

Regarding human capital development (HCD), if it was not for the uncertainties relating to the location of the shale gas resource, it would have been easy for the DST to develop an implementation plan informed by the recommendations of the two studies. Some certainty is needed before detailed planning for skills development could take place. This had been done for the SKA and space science, in collaboration with partner institutions. In the shale gas case, this is not just the responsibility of the DST; other government departments also need to participate in wide-ranging skills development.

Dave Wright, Dave Wright Consulting (Author of the HCD section of the ASSAf report):

HCD planning needs to be approached by considering:

- three levels of skills required, namely tertiary, operational and support skills, and
- a three-step planning process, namely short, medium and long-term planning.

In the short term, sufficient support skills are available. Operational skills would be more complicated: as part of the licencing agreement the oil and gas companies would need to transfer these skills, probably starting by importing some skills. The DHA would need to support this. The tertiary phase would be most complicated and would rely on imported skills.

In the medium term there must be an integrated approach including both inter-departmental and multi-disciplinary involvement. In the long term, the quality of mathematics and science education at school is a priority.

Dr Neehal Mooruth, Shell:

From the point of view of industry, skills development has to be considered within the timeline of the shale gas venture, which progresses through two phases:

1. Exploration and appraisal: two to five years; only 50 to 100 people are needed per rig.
2. Development and production: Five to 20 years depending on the size of the resource; personnel would be developed in an incremental manner.

At this stage, it is important to focus on the exploration phase and fill the key job roles. Once the size and economic potential of the resource has been assessed, a field development model could be developed. This would cover not only oil field aspects but also the supporting industries. An economic study in the USA had found that one direct oil field job translated into 4.9 indirect jobs.

Three skills levels are involved:

- Initially the emphasis would be on semi-skilled workers: welders, plumbers and machine shop technicians.
- Specialised skills: engineers, geologists, geophysicists and petrophysicists.
- Initially, skilled workers from industries abroad would need to be imported to transfer the necessary technology and information.

Niall Kramer, SAOGA:

Cores and exploration holes need to be drilled to generate empirical data for local decision-making, because if economically recoverable gas is not present, then many of the concerns would be moot.

Initially, South Africa would have to rely on international skills, but this should not continue in the long term. A clear plan for skills transfer is needed. The basis of this is to develop science, technology, engineering and mathematics skills. Other skills such as those required by monitors and regulators, are also needed.

A lot of skills mapping has been done through Operation Phakisa, listing the actual jobs needed and categorising them in terms of availability. South

Africa has a massive skills deficit in the engineering field, and needs to start addressing this. SAOGA developed skills at the artisan/technician level, and these skills could be transferred to other parts of the economy if shale gas development is unsuccessful.

KARIN had proposed that mining skills and equipment could be adapted for the shale gas industry. Workers in the mining industry had the discipline, attitude and capacity to work in the field, and might be easier to retrain for this new industry, especially at a time when other mines are closing.

Discussion

Question 1: Who should put the HCD plan together? What should be prioritised?

Niall Kramer: Skills that could be transferred to other areas of the economy should be prioritised, in case the shale gas industry was not successful. Skills could also be used in a potential offshore drilling industry. Because of new technologies like robotics, computing and virtual reality, the world of work would be fundamentally different in 20 years' time. The rate of development in the oil industry was enormous, so the capacity to be flexible and keep learning was key.

Dave Wright: The DHET should take the initiative to put the skills plan together, but this should be done in an integrated manner with other stakeholders. The DHET has compiled a work skills plan for the Strategic Infrastructure Programme, but has not taken a broad view of the projects South Africa is trying to deliver on and the demand for skills across the board. If the DHET is not available, the DST could coordinate the plan.

Dr Gerald Kafuku, Tanzania Commission for Science and Technology: Based on the Tanzanian oil and gas experience, the government should take the lead, specifically the DST. 'Technology unpacking' involved identifying the type of technology the industry would use and determining if it was available locally or if it would need to be imported. The skills analysis was done to determine what relevant courses were offered in the country. There is a risk that many people could be trained but jobs might not be available. A skills gap analysis therefore needs to be done. Industry should contribute to the financing of capacity building programmes.

Bob Pullen, SAAE: The fact that both the South African Large Telescope (SALT) and the new power stations were built using local skills should inspire confidence. There should be a compact between the government and the private sector, which would invest the money (estimated at R2 billion). Government needs to create conditions conducive to shale gas development.

Prof Philip Lloyd, CPUT: Prof Lloyd is based at the South African Renewable Energy Technology Centre (SARETEC), which trains wind power technicians in both South Africa and Germany to maintain wind turbines. It can be done and is not a problem. It is essential to have skilled people and skilled inspectors.

Prof Cyril O Connor, UCT: Regarding the retraining of personnel from the mining industry, Wits and the University of Pretoria (UP) produce more mining graduates than the rest of the world except China, but only 20% have been employed. The remaining 80% could be retrained to enter the shale gas industry in the medium term. This problem is the result of central planning that had misjudged the need for mining engineers. Supply and demand need to be balanced. In contrast with the heydays of the gold mining industry when companies offered numerous bursaries and work opportunities, the oil and gas industry today would be unlikely to give bursaries to study shale gas engineering because of a lack of certainty relating to the resource, the Mining Charter, and the MBRDA, which are holding the industry back.

Dr Phethiwe Matutu: South Africa has had many large engineering projects, including Coega, SALT and the SKA. The fact that they were funded by government provided a level of certainty. Capacity could be created provided there is a level of certainty. It is therefore important to get started and to address challenges as they arise.

The issue of supply and demand is a problem that could not be ignored. It had happened with the Pebble Bed Modular Reactor (PBMR), with those skills having to be absorbed elsewhere. It is difficult to develop HCD projects in the absence of job security. The idea of reskilling is appealing. All key stakeholders need to be involved when government coordinates centralised skills planning. Licencing agreements need to be clear in terms of skills development, reskilling, and what proportion of skills could be imported at which stages.

<u>Question 2:</u> Who can we partner with in skills development internationally and locally, and how could the industry be involved?

Dr Neehal Mooruth: Petroleum engineering as a degree offered no advantages beyond general engineering degrees, as the petroleum company could easily train mechanical or chemical engineers in specific job-related skills. Mining engineers could be reskilled in-house over one to three years to work in the petroleum industry. They need to meet certain competencies recognised by the employer and the international body, and could then become a certified oil engineer.

For the record, Shell did offer bursaries to students at UCT and UWC.

Niall Kramer: This is not just about shale gas, but about a gas economy, which includes offshore and onshore industries. The importation of LNG could be the first practical step towards developing projects at the appropriate scale. SAOGA has developed a first draft of skills needed for an LNG exercise. While skills mapping exercises are useful, it is necessary to build uncertainty into the process. In South Africa, many people who had developed skills related to the renewables industry are available to move across to the gas industry as the IPP agreements have not yet been signed.

The biggest obstacle to establishing the gas industry is ensuring that the MPRDA amendments are stable and acceptable to the industry. It is important to remember that this is a global industry; many highly skilled people who lost jobs due to the contraction of the oil and gas industry are available; in the short term they could be employed in South Africa, and pass on their skills locally.

Dave Wright: Industry would have to fund training and development. In the short term, skills would need to be imported, enabling skills transfer. How partnerships evolve would depend on relationships between industry and academic institutions at the tertiary level. The operational level is very important as this is a production system with holes being drilled every day. Technical training would be driven by industry. Industry would not be involved in training regulators and monitors; this should be the responsibility of government.

Nicholas de Blocq, Service Technologies: It is important to find a way to manage the employment expectations of South Africas. Skills transfer is a feature of a long-term industry operating in a production environment. South Africa is currently an exploration environment. It is extremely difficult for overseas companies to arrive in South Africa, transfer skills and move out. They would first need to know that they would be investing in a production environment. Also, very few drilling engineers would stay unless there is drilling to be done; if not, they would move to the next job elsewhere. The inertia experienced in South Africa was frustrating to potential investors. An enabling Act, efficient and sufficient regulation, and the drilling of exploration wells are urgently needed.

Lizel Oberholtzer, Norton Rose Fulbright South Africa: There is a large focus on graduates and skilled labour, but artisans would also be required. There is a lack of institutions to teach these skills, so how could industry and government partner to enable this?

Response – Tsholofelo Mokotedi, Energy and Water SETA: Training must be driven by government with the support of industry. Education and training in South Africa are highly regulated. Industry should support training under the existing legislative framework. There is a White Paper on Post-School Education and Training that aims to integrate all post-school education and training, from mid to high-level skills, involving different stakeholders at different stages. The advantage of this initiative being led by government is that it could involve all relevant stakeholders, including quality provider councils representing the entire National Qualifications Framework (NQF) system. A funding system is already in place to support education and training. This includes the National Skills Fund (NSF), and various SETAs.

Sphelele Khanyile, Wits: The youth needs to be included in learning about the shale gas industry so that they can understand the issues and participate.

Stefan Hrabar, SAAE: Having been responsible for the Mossgas offshore project, when the contract was awarded, the skills did not exist in South Africa. Initially 40% of employees were expatriates, but local people were trained and after four years only 8% were expatriates. At the end of the project, many of these people went to work in Angola, Dubai and Nigeria. South Africa has signed many accords that specified the training required for certain categories of employees, including engineers, artisans and technicians. It is important to comply with these accords because they are internationally recognised.

Response from the panel:

Niall Kramer: Oil and gas present the best opportunity the South African economy has to recover from recession. An underlying value to us is this opportunity to kick-start economic development in the interest of better lives for all. South Africa needs a big vision, and is very good at undertaking big projects, which provide focus and develop pride.

SAOGA is involved in artisan development and its success rate in training is 20% above the national average. Close mentorship relationships are an important aspect of the approach, but the window of opportunity for this is closing as many potential mentors are retiring.

Dr Neehal Mooruth: Exploration should have happened five years ago. The government needs to drive this and stimulate the industry. Government, with the help of SAOGA, could bring together industry (technical expertise) and universities (baseline studies) and establish a committee to take the process forward.

Dave Wright: It is time to stop talking and to get on with the process.

Dr Phethiwe Matutu: This is possible because South Africa has done many large projects before.

Somila Xosa, DST:

The conference set out to clarify the state of shale gas development in South Africa. Delegates have been updated on the approach of government and the studies that have been completed. It has also been an opportunity to enrich existing work by receiving comments from delegates that could inform the shale gas research and development agenda.

Key messages have been to:

- Establish an enabling legislative, regulatory and planning environment.
- Take a holistic approach to skills development, including exit strategies in case a shale gas industry did not materialise.
- Strengthen social science research.
- Build on what exists, identify and fill the gaps.

The conference has provided insight and direction to guide the way forward. The DST and government would take time to synthesise these points and move towards a draft action plan for how to enable key activities and research. The whole National System of Innovation, including government, industry, academia, NGOs and the community, needs to work together to take this forward.

As synthesis and planning progress, stakeholder engagement would continue, in order to develop a product that all will be proud of. A draft document that deals with the key issues would be produced within four to six months. The message is clear: immediate action is required.

CLOSURE AND VOTE OF THANKS

(Prof Cyril O'Connor)

The conference has been a positive opportunity for stakeholders from government, industry, research institutions and activist groups to share information, opinions and perspectives. The round-table sessions enabled open, frank, mature discussions.

Shale gas could become a major contributor to the energy mix in South Africa, but the main question was whether there was in fact an economically viable shale gas resource. It is essential to determine how much is present, and to 'hasten sensibly' with exploration. The message from the round-table discussions is to 'get moving'.

Common issues have been identified in the reports and conference sessions. Important studies are being conducted by AEON, CGS and KARIN, and baseline studies need to take place urgently. Setting up test sites is extremely costly, and a pre-competitive joint venture might be a worthwhile way in which to secure investment.

The ASSAf panel would reconvene in order to discuss the outcomes of the conference and refine the recommendations in the ASSAf report. This report has recommended a whole-of-government approach, involving national, provincial and local tiers of government, but it is clearly a whole-of-society approach, as industry is a key player.

ASSAf and the DST were thanked for organising and funding the conference. Particular thanks were extended to Nadia Algera, Prof Roseanne Diab and Prof Barney Pityana of ASSAf, and Dr Phil Mjwara, Rebecca Maserumule and Somila Xosa of the DST. The speakers, panellists, overseas guests and all participants were also thanked.

The conference was officially closed.

APPENDIX A: ACRONYMS

3-D	Three-dimensional
ACOLA	Australian Council of Learned Academies
AEON	Africa Earth Observatory Network
API	American Petroleum Institute
ASSAf	Academy of Science of South Africa
BCF	Billion cubic feet
BOP	Blowout preventer
BTU	British Thermal Units
CBM	Coal-bed methane
CGS	Council for Geoscience
CIMERA	Centre of Excellence for Integrated Mineral and Energy Resource Analysis
CNG	Compressed natural gas
CEO	Chief Executive Officer
CO_2	Carbon dioxide
CoE	Centre of Excellence
CPUT	Cape Peninsula University of Technology
CSG	Coal seam gas
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAC	Department of Arts and Culture
DAFF	Department of Agriculture, Forestry and Fisheries
DDG	Deputy Director-General
DEA	Department of Environmental Affairs
DEP	Department of Environmental Protection
DGS	Department of Geological Survey
DHA	Department of Home Affairs
DHET	Department of Higher Education and Training
DMR	Department of Mineral Resources
DoE	Department of Energy
DoH	Department of Health

DRDLR	Department of Rural Development and Land Reform
DST	Department of Science and Technology
DWS	Department of Water and Sanitation
EIA	Environmental impact assessment
EMF	Environmental Management Framework/Electromagnetic frequency
EMI	Environmental Management Inspectorate
EMP	Environmental management plan
EMRI	Environmental Mineral Resource Inspectorate
EU	European Union
GUMP	Gas Utilisation Master Plan
GDP	Gross domestic product
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GTL	Gas-to-liquids
HCD	Human capital development
HFMC	Hydraulic Fracturing Monitoring Committee
HSRC	Human Sciences Research Council
IDP	Integrated Development Plan
IEP	Integrated Energy Plan
IOC	International oil company
IPP	Independent power producer
KARIN	Karoo Research Initiative
LNG	Liquified natural gas
LUPO	Land Use Planning Ordinance
MMbbl	Million barrels
MMCFD	Million cubic feet per day
MPRDA	Mineral and Petroleum Resources Development Act *(No 28 of 2002)*
MW	Megawatt
NDP	National Development Plan
NEMA	National Environmental Management Act *(No 107 of 1998)*
NGO	Non-governmental organisation

NMU	Nelson Mandela University
NORM	Naturally-occurring radioactive materials
NRF	National Research Foundation
NQF	National Qualifications Framework
NSF	National Skills Fund
NWP	National Water Policy, 1997
OHS	Occupational health and safety
PAJA	Promotion of Administrative Justice Act *(No 3 of 2000)*
PASA	Petroleum Agency South Africa
PBMR	Pebble Bed Modular Reactor
PPP	Public-private partnership
R&D	Research and development
RDI	Research, Development and Innovation
REIPPP	Renewable Energy Independent Power Producers Programme
RoD	Record of Decision
SAAE	South African Academy of Engineering
SAEON	South African Environmental Observation Network
SALT	Southern African Large Telescope
SANBI	South African National Biodiversity Institute
SAOGA	South African Oil and Gas Alliance
SDF	Spatial Development Framework
SEA	Strategic Environmental Assessment
SETA	Sector Education and Training Authority
SKA	Square Kilometre Array
SPM	Sasol Petroleum Mozambique
SU	Stellenbosch University
Tcf	Trillion cubic feet
Tcm	Trillion cubic metres
TCP	Technical Co-operation Permit
tds	Total dissolved solids
the dti	Department of Trade and Industry
TOC	Total organic carbon

UCT	University of Cape Town
UFS	University of the Free State
UJ	University of Johannesburg
UK	United Kingdom
UP	University of Pretoria
USA	United States of America
US EIA	United States Energy Information Administration
UWC	University of the Western Cape
VOC	Volatile organic compound
Wits	University of the Witwatersrand
wt%	Weight percentage
WRC	Water Research Commission
WSP	Water Science Plan
WWF-SA	Worldwide Fund for Nature South Africa

APPENDIX B: ATTENDANCE LIST

Name	Surname	Affiliation
Abosede	Abubakre	University of Johannesburg
Adrian	Strydom	South African Oil and Gas Alliance
Alice	Ashwell	Heart of Nature (Scribe)
Anda	Nqonji	South African Broadcasting Corporation
Andries	Moatshe	Department of Mineral Resources
Anine	Kilian	Creamer Media
Anthony Patrick Lyle	Carnie	Freelance Environment Writer
Barney	Pityana	Academy of Science of South Africa
Barry	Morkel	Nelson Mandela University
Benson	Modie	University of Botswana
Bob	Scholes	University of the Witwatersrand
Bongani	Sayidini	PetroSA
Bongani Darryl	Khupe	Environmental Impact Management Services
Bosisiwe	Khumalo	Office of the Premier: EC
Brenda	Ngebulana	Department of Mineral Resources
Buhle	Khumalo	Department of Science and Technology
C Moctar	Doucoure	Nelson Mandela University
Christopher	Baiyegunhi	University of Fort Hare
Cornelius	Blom	National Oilwell Varco
Cyril	O'Connor	University of Cape Town
Dave	Wright	Dave Wright Consulting

David	Aphane	Petroleum Agency South Africa
David	Kimemia	South Africa Medical Research Council
Dawn	Black	Council for Geoscience
Dee	Fischer	Department of Environmental Affairs
Dennis	Cooke	University of Melbourne
Derek	Light	Derek Light Attorneys
Divan	Stroebel	Nelson Mandela University
Doreen	Atkinson	University of the Free State
Douglas	Phakula	South African National Energy Development Institute
Dovhani	Mahumele	Petroleum Agency South Africa
Fanie	De Lange	University of the Free State
Gadifele	Tlhale	Department of Science and Technology
Gavin James	Kern	National Oilwell Varco
Gerald	Kafuku	Tanzania Commission for Science and Technology
Gregor	Feig	Council for Scientific and Industrial Research
Gregor	Schreiner	Council for Scientific and Industrial Research
Haajierah	Mosavel	Council for Geoscience
Henri	Fortuin	Western Cape Government
Henriette	Wagener	Academy of Science of South Africa
Ian	Shendelana	Academy of Science of South Africa
Ifije Donald	Ohiomah	University of Johannesburg

Isayvani	Naicker	Department of Science and Technology
Jan	Glazewski	University of Cape Town
Jayed-Leigh	Paulse	South African Broadcasting Corporation
Jennifer	Hutchinson	Reynolds
Joh	Henschel	South African Environmental Observation Network
Johan	Pauw	South African Environmental Observation Network
Johannes Christoffel	Boshoff	AfriForum
John Dale	Smelcer	Webber Wentzel
Kalu Mosto	Onuoha	Nigerian Academy of Science
Kevin	Pietersen	University of the Western Cape
Kishan	Pillay	Department of Trade and Industry
Kurt	Morais	Shell
Lee	Forbes	Student Soldier
Leluma	Matooane	Department of Science and Technology
Lesley	Green	University of Cape Town
Liam	Whitlow	Environmental Impact Management Services
Lindiwe	Mekwe	Petroleum Agency South Africa
Lizel	Oberholtzer	Norton Rose Fulbright South Africa Inc.
Love	Baiyegunhi	University of Fort Hare
Lucky	Revombo	Department of Mineral Resources
Maarten	De Wit	Nelson Mandela University
Marcus	Pawson	AfriForum

Mark	Ingle	University of the Free State
Marlett	Balmer	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
Mbuyi	Nombembe	Shell
Mere	Kgampe	Department of Science and Technology
Michael	Phelan	South African Council for Natural Scientific Professions/ Geological Society of South Africa
Michiel	De Kock	University of Johannesburg
Mike	Shand	South African Academy of Engineering
Mildred	Mnguni	Department of Mineral Resources
Mmaphuthi	Mashiachidi	Academy of Science of South Africa
Moki	Cekisani	Ubuntu Environment Trust
Mokome	Roberts	Journal of Energy in Southern Africa
Mosa	Mabuza	Council for Geoscience
Mthozami	Xiphu	South African Oil and Gas Alliance
Murendeni Hadley	Mugivhi	Petroleum Agency South Africa
Nadia	Algera	Academy of Science of South Africa
Neehal	Mooruth	Shell
Neville	Ephraim	IGas
Ngqondi Songezo	Nxokwana	Council for Geoscience
Nhlanhla	Jali	Department of Mineral Resources

Niall	Kramer	South African Oil and Gas Alliance
Nic	Beukes	University of Johannesburg
Nicholas	De Blocq	Service Technologies
Nigel	Rossouw	Shell
Odette	Parfitt	The Herald
Oliver	Romer	NOV Oil and Gas Services South Africa
Olusegun Aanuoluwapo	Oguntona	University of Johannesburg
Patricia	Scholtz	Academy of Science of South Africa
Paul	Hardcastle	Western Cape Government
Peter Arnold	Stuart-Thompson	Private Consultant
Phethiwe	Matutu	National Research Foundation
Phil	Mjwara	Department of Science and Technology
Philip John Donne	Lloyd	Energy Institute, Cape Peninsula University of Technology
Pieter	Alberts	Department of Mineral Resources
Pontsho Tamara	Makhateng	University of the Witwatersrand
Portia	Makgatla	Department of Mineral Resources
Rebecca	Maserumule	Department of Science and Technology
Rialivhuwa	Phaswana	Department of Science and Technology
Richard	Fyvie	South African Council for Natural Scientific Professions
Richard	Campbell	Nelson Mandela University

Robert Alexander	Pullen	South African Academy of Engineering
Roseanne	Diab	Academy of Science of South Africa
Saliem	Fakir	Worldwide Fund for Nature South Africa (WWF-SA)
Selwyn	Adams	Petroleum Agency South Africa
Shafick	Adams	Water Research Commission
Somikazi	Ntonga	Office of the Premier: Eastern Cape
Somila	Xosa	Department of Science and Technology
Sphelele	Khanyile	University of the Witwatersrand
Stefan	Hrabar	Mirlem
Stella	Mamogale	Department of Energy
Stephanie	Borchardt	Stellenbosch University
Stephanie	Enslin	University of the Witwatersrand
Stuart Brian	Chamberlain	National Oilwell Varco
Surina	Esterhuyse	University of the Free State
Taslima	Viljoen	Department of Science and Technology
Tebogo	Motloung	Petroleum Agency South Africa
Thobela	Damsneti	Office of the Premier: Eastern Cape
Tom	Murphy	Penn State Marcellus Centre for Outreach and Research
Trueman Tandabantu	Goba	South African Academy of Engineering

Tsholofelo	Mokotedi	Energy and Water Sector Education and Training Authority
Tumi	Mailula	Department of Science and Technology
Wellington Didibhuku	Thwala	University of Johannesburg
Zamazulu	Ngejane	Petroleum Agency South Africa

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