DEPARTMENT OF MINERAL RESOURCES

EXECUTIVE SUMMARY




INVESTIGATION OF HYDRAULIC FRACTURING IN THE KAROO BASIN OF SOUTH AFRICA

mineral resources

Department:
Mineral Resources
REPUBLIC OF SOUTH AFRICA

EXECUTIVE SUMMARY

The Working Group (of the Task Team) on Shale Gas and Hydraulic Fracturing was chaired by the CEO of Petroleum Agency SA and comprised representatives from the following departments and institutions: Departments of Environmental Affairs and Water Affairs, Science and Technology, Energy, Mineral Resources, the Petroleum Agency of South Africa, Council for Geoscience, SKA South Africa, Water Research Commission, and ESKOM.

The terms of reference of the Working Group study are derived from the terms of reference of the Task Team and focus on evaluating both the positive and negative aspects of shale gas exploitation. The study aims to evaluate the potential environmental risks posed by the process of hydraulic fracturing as well as the negative and positive social and economic impacts of shale gas exploitation. This report and recommendations are not claimed to be fully comprehensive — new reports and technical developments continue to emerge. Further work is required in a number of critical areas.

The study comprises reports written by specialists in their various fields as well as the results of a study tour to the United States which included field trips to Pennsylvania (Marcellus Shale) and Texas (Eagle Ford Shale) and visits to the Environmental Protection Agency and the Railroad Commission of Texas, both being US regulatory organisations directly involved with shale gas exploitation.

The following major issues were considered:

The estimate of the potential resource

The United States Energy Information Administration has made a first pass estimate of a technically recoverable resource of 485 trillion cubic feet (Tcf) of gas in the Karoo Basin. The Petroleum Agency evaluated this assessment and concluded that, owing to the limited amount of available data in the area, it is impossible to quantify the resource accurately, other than to say that it is potentially very large. It is essential that additional, modern subsurface information be obtained through drilling or a geophysical survey to constrain these estimates.

While the existence of a significant gas resource in the Karoo would have implications for South Africa's energy security by reducing national dependence on other fossil fuels, the magnitude of this potential is subject to considerable uncertainty owing to the difficulties in quantifying the resource.

Technical aspects of hydraulic fracturing

Hydraulic fracturing is an integral part of the production of gas from low-permeability unconventional reservoirs such as shale, tight sandstones and coal. The technique is highly specialised and comprises complex mechanical and chemical processes. Hydraulic fracturing has been used in the oil and gas industry for more than 50 years and, in the last 20 years, together with the practice of horizontal drilling, has been instrumental in making the exploitation of unconventional resources technically and economically feasible. The initial stages of exploration can be conducted without the use of reservoir stimulation. However, in order to assess the 'producibility' of a resource during the later stages of exploration and, finally, in order to produce the gas, hydraulic fracturing is essential. The process requires the use of significantly large quantities of a base fluid, usually water, together with a small fraction of sand and chemicals pumped into the reservoir with sufficient pressure to create artificial fractures, thereby improving the permeability of the rock and allowing the gas to be produced.

Environmental and socio-economic implications of hydraulic fracturing

The use of large volumes of water together with chemical additives makes it essential that the environmental and social implications of this process are considered. The present study considers the impact of shale gas exploitation on land use, water use and air pollution. Whereas existing environmental regulations adequately cover most of these factors, an immediate and important concern requiring additional attention is water usage and disposal: in particular, the volume and transportation of the water, the potential contamination of water resources and the disposal of 'used' fracturing fluid. The use and disposal of water in such large amounts is expected to require a water use licence under the National Water Act. Further research is required to investigate all potential sources of input water, as well as means of water disposal.

Extensive hydrological and geohydrological studies before exploration and production drilling will be required in order to minimise or eliminate potential impacts on other users. Because of the uncertainty regarding the extent, or even existence, of economically producible reserves, any assessment of the potential economic impact is subject to enormous uncertainty. However, making a moderately optimistic assumption that ultimately 30 Tcf will be produced, and using indicative pricing of US$ 4 per thousand cubic feet of gas and an exchange rate of R8 per US dollar, the gross sales value would be almost R1 trillion. Similarly, 1 Tcf was sufficient to launch PetroSA's gas-to-liquids project in Mossel Bay which provides approximately 5% of the national demand for liquid fuels and entails 1500-1600 jobs. It is expected that the contribution of shale gas production to the growth of the economy and GDP would be enhanced by the necessary creation of service industries with all the attendant implications for sales of goods and services. Even though this process would be spread over a period of 20–30 years it clearly has the potential to have a major impact on the national economy. Although Income Tax and Royalty accruing to the fiscus depend on profitability it is expected that such amounts will run into tens or hundreds of millions of Rand, augmented by VAT. The potential long-term direct employment opportunities are likely to number in the tens of thousands, with similar numbers in the industries consuming the gas.

The regulatory framework

The primary conclusion reached in this report is that South Africa's regulatory framework must be robust enough to ensure that, if hydraulic fracturing associated with shale gas exploration and exploitation were approved, any resultant negative impacts would be mitigated. This will require a comprehensive review of the adequacy of the existing framework in order to identify any shortfalls or omissions and to ensure that it is sufficiently detailed and specific. The use of existing regulations from mature regulatory environments to inform the development of South African regulations in this matter is recommended.

Astronomy research projects in South Africa

The low level of population density in the Karoo, making this area an ideal site for astronomical observation, constituted the basis of South Africa's bid to host the Square Kilometre Array. Unmitigated radio-frequency emissions produced by the operation of heavy industrial equipment in shale gas exploration and production are expected to be detrimental to radio-astronomy operations. Although this matter requires more detailed analysis and investigation, the current study suggests that suitable mitigatory measures be established to accommodate both. It is expected that there will be a process of areas that will delineate areas where exploration and production activities of shale gas will be precluded. Site-specific analysis will be a prerequisite for operations in areas defined by the Astronomy Geographic Advantage Act.

Economic implications of a ban

While considering the implications of hydraulic fracturing, it is important to note that the effect of an extended ban, moratorium or stringent regulation can best be described as a reduction of economic opportunity (opportunity cost). Such measures would delay or prevent an improvement of the understanding of the real extent of the potential resource, hamper the development of coalbed methane and other hydrocarbon resources in low-permeability reservoirs, and remove the potential economic benefit to severely deprived communities in the Karoo.

Synthesis

In the current technological environment, any exploration for and economic exploitation of shale gas in South Africa will require the use of horizontal drilling and hydraulic fracturing.

The use of hydraulic fracturing in shale gas exploration is perceived to have the attendant risk of polluting sources of drinking water by fracturing fluids and/or methane, and induced seismic events.

In the Karoo, there is the additional concern that the volumes of water required may compromise other uses and, in a large part of the area, there is a further geological risk entailed by the presence of extensive intrusions of dolerite and kimberlite, the influences of which are not easily predicted.

The technique of hydraulic fracturing requires relatively large volumes of water which may be difficult to source in the Karoo. Groundwater pollution can be minimised through good borehole construction and the maintenance of the well bore integrity, coupled with intensive and close monitoring which can be achieved through the application of industry best practice.

The hydrogeology of the Karoo at depth is unknown, but potable aquifers are expected to be far removed from shale gas target formations and safe from contamination from injected fracking fluids, as the latter are immobile under normal conditions with no 'drive' once the fracturing operation has been completed. However, the effects of dolerite intrusions, kimberlite fissures and existing fracture systems are relatively unknown and further investigations and modelling are required.

Noise, dust, emissions and naturally occurring radioactive mineral (NORM) contamination levels will differ at different stages and locations and can be controlled under existing legislation.

Potential resource and energy security: Various estimates of the technically recoverable resource, ranging from 30 to 500 Tcf, have been expressed. However, there are presently insufficient data to accurately assess the size, quality and extractability of the shale gas resource and, therefore, it is not possible to accurately assess the implications in respect of energy security. Further drilling, sampling and testing will be required to improve confidence in the existence and, subsequently, extent of a resource. A large resource would have the potential to reduce national dependence on other fossil fuels and may contribute to energy security and the reduction of our carbon footprint. These factors are a powerful justification for further investigation.

The potential socio-economic impacts increase progressively through exploration and appraisal to production. In the early phases, much of the work will be done by specialists brought in from other countries and the impact on the local economy will be slight. As confidence in the potential of shale gas increases, the training of local personnel for longer-term operations becomes viable and the impact on the local and national economy increases. In the event that a real resource is proven, it is possible that its size will be sufficient to justify proceeding to production which may be coupled with, for example, the establishment of additional gas turbine electricity generation installations or gas-to-liquids (GTL) plants with associated employment opportunities in field operations and plant operation, potentially numbering in the thousands. There would then also be significant implications for the GDP, with as much as R 960 billion added over 20–30 years. [Calculated at 30 Tcf @ US$ 4/Mcf and R8/US$]

South Africa does not have the infrastructure (service industries and pipelines) in place that facilitated the success of shale gas production in the United States. However, the demonstration of a large enough resource would drive the development of the necessary infrastructure.

Astronomy research projects and shale gas in the Karoo may be mutually exclusive, but the 'footprint' of the astronomy installations is only a fraction of the area presently considered to be prospective for shale gas. There is scope for collaboration between government and industry on mitigating measures with a view to minimising the areas closed to exploration and production operations.

The existing regulatory framework, drawn from a number of acts, emphasises the protection of the environment covering the broad aspects of concern. It is the conclusion of the Working Group, however, that there is a need for detailed assessment and augmentation, where necessary, of the framework applicable to the upstream petroleum industry as a whole to ensure robust regulation and compliance monitoring. In order for the regulations to be effective, better co-ordination between departments and adequate resourcing of regulatory and enforcement agencies is required. Regulations relating to water usage and disposal, in particular, require in-depth study and analysis.

The published estimate of the shale gas resource potential requires further and co-ordinated investigation to expand the quantitative database required to support assessments of the inherent economic potential of the resource. Appraisals of the possible socio-economic impacts of shale gas development are of necessity based on an estimate of the resource. There is therefore an urgent need for further research on the entire Karoo Basin to reduce the uncertainty in the resource estimation and increase confidence in the associated assessments of the potential socio-economic impacts. That type of research is what oil and gas companies carry out under exploration rights.

Options

Based on the conclusions set out above, the Working Group considered a spectrum of options that might be recommended to the Minister, ranging from (1) an outright ban to (2) unconditional approval of hydraulic fracturing under the existing regulatory framework. Neither of these extremes was deemed suitable and, thus, the intermediate option (Option 3), specifically the 'conditional approval of hydraulic fracturing' (3C) was considered to be most appropriate. The options considered are tabulated in Annexure G.

Recommendations

The following recommendations are made:

- Allow normal exploration (excluding the actual hydraulic fracturing), such as geological field mapping and other data gathering activities (e.g. hydrological studies) to proceed under the existing regulatory framework.

- Constitute a monitoring committee to ensure comprehensive and co-ordinated augmentation of the regulatory framework and supervision of operations.

- Augment the current regulatory framework. The establishment of the appropriate regulations, controls and co-ordination systems is expected to take 6–12 months.

- Departments of Science & Technology and Mineral Resources to collaborate in developing mechanisms for the co-existence of the Astronomy Research Projects and development of shale gas in the Karoo.

- Once all the preceding actions have been completed, authorise hydraulic fracturing under strict supervision of the monitoring committee. In the event of any unacceptable outcomes, the process may be halted.

- Ongoing research to be conducted and facilitated by relevant institutions to develop and enhance scientific knowledge in respect of the development of Karoo shale gas. This includes, albeit not limited to, geo-hydrology of the prospective areas, methodologies for hydraulic fracturing in RSA and environmental impacts.

- The actions required to give effect to the proposed conditional approval must be properly resourced, incorporated into the programmes of the relevant departments and agencies and capacity developed.

*Please note the full report is available on www.dmr.gov.za