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INDEPENDENT STRATEGIC ANALYSIS OF AUSTRALIA'S GLOBAL INTERESTS

Strategic Analysis Paper

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Hydraulic Fracturing – Is Industry Standard Practice the Best Practice? The Case for Waterless Fracking

Christopher Johns
Research Manager, Northern Australia and Land Care Research Programme

Key Points

- A strong antipathy to hydraulic fracturing or fracking exists in the community largely focused on the risk of environmental damage, arising mainly from problems experienced in the coal seam gas industry.
- Waterless fracking, where alternative fluids are used to provide the hydraulic energy to fracture rock and release natural gas, is a relatively recent innovation designed to make fracking a more safe and efficient process.
- The use of liquified natural gas compressed into a thick gel has been successfully employed as a fracking medium that does not carry the environmental risk that exists when water is used.
- Waterless fracking can facilitate improved controls on the release of greenhouse gases into the atmosphere as the need to burn off or flare natural gas can be reduced or eliminated.
- The use of liquid petroleum gas to form a completely hydrocarbon based fracturing system provides significant benefits and efficiencies that contribute positively to gas well production.

Summary

The Northern Territory Government has lifted its moratorium on hydraulic fracturing (fracking) of onshore unconventional natural gas reservoirs, paving the way for a potentially lucrative nature gas industry. The fracking process, however, is viewed with broad suspicion and antipathy in the community with significant minority groups opposed to all forms of the industry. Much of this concern is environmental and relates to the large volume of water used in the process and the chemical additives in that water. Innovations in the industry are making fracking a safer and more efficient process. The successful application of waterless fracking eliminates many of the environmental risks associated with traditional fracking. The use of a liquified natural gas gel instead of water can produce a rock fracture that is cleaner and more efficient than water fracking. To date, however, the industry has been slow to apply this fracking technique.

Analysis

In April of this year, FDI published a two-part Strategic Analysis Paper summarising the final report from the Northern Territory Government's Scientific Inquiry into Hydraulic Fracturing of Onshore Unconventional [Natural Gas] Reservoirs. The Inquiry recommended the establishment of an onshore shale gas industry in the Northern Territory, but only when a wide range safeguards that would eliminate or minimise the risks associated with fracking had been implemented. The Norther Territory Government subsequently endorsed all the report recommendations and lifted the moratorium it had imposed on all fracking operations, including exploration, in 2016. This could pave the way for a new, economically important, industry for the Northern Territory and Australia.

Fracking is the process of pumping a fluid mixture into the earth to fracture impermeable rock to access gas reserves. The process can provide an abundant source of natural gas for domestic and export markets, but it faces strong community opposition over environmental and social concerns. In the United States, the shale gas revolution transformed the country from an energy importer into an energy exporter. It changed the energy market and significantly affected world trade in gas and oil.

The Northern Territory Scientific Inquiry dealt in detail with all the known the risks associated with fracking but the foremost concern in the public domain is environmental. Much of the public concern and opposition to fracking stems from the large volumes of water and range of chemicals, some of which are toxic, that are added to that water. The acquisition, delivery, application, recovery and disposal of this water all pose environmental risk. There are, however, new developments in the industry that have the potential to avoid some of the most significant environmental risks by eliminating the need for large volumes of chemically treated water.

Waterless fracturing is a relatively recent innovation designed to make fracking a more safe and efficient process. It involves the use of alternative fluids to provide the hydraulic force required to fracture underground rock to release natural gas. Liquefied petroleum gas (LPG), principally propane and butane, which has been liquefied into a thick gel has been successfully used for fracking. The LNG gel is pumped into shale rock formation instead of water. LNG does not block gas pathways the way water does and therefore more natural gas is released. In addition, it does not carry poisonous chemicals and underground radioactivity back to the surface. When it does come back to the surface it can have other uses including its sale as LPG or it can be used again as recovered LPG. Currently, the only drawbacks are the cost, as propane and butane are more expensive than water, and the need for additional safety arrangements associated with the use of a flammable gas. The cost issue, however, can be off-set when the total value of the complete process is calculated and safety requirements for the use for LPG are well established and regulated.

Waterless Fracturing

As outlined above, the use of LPG fluids to hydraulically fracture oil and gas wells economically and efficiently addresses many of the environment issues faced by the industry. LPG fluids provide unique benefits addressing water use, venting and flaring and well performance.

Water Use

Elimination of water from the fracking process has several significant advantages. The water acquisition, storage, recovery, recycling and disposal issues are eliminated. Further, once a field is established, a completely waterless system can be created using hydrocarbons produced within the field itself to provide excellent logistics and economics. For particularly sensitive environmental areas, the fracturing hydrocarbon

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liquid can be effectively replaced by other hydrocarbons such as biodiesel, white mineral oil or vegetable oil without incurring detrimental costs. Additionally, the opportunity to cost-effectively eliminate water presents a unique opportunity for the LPG fracturing process in areas experiencing water shortages or water use restrictions.

An additional important advantage of gelled LPG at fracking sites where water is not available locally, is that it reduces truck movements from 1,000 down to around 50. This is particularly important in sensitive environmental sites and at heritage sites.

Greenhouse Gas Venting and Flaring

When fracture fluids composed of LPG are applied, all hydrocarbons recovered during clean-up can be immediately directed to pipeline as a reduced emissions measure. Particularly when sourced as "in field" fluids, the injected and native hydrocarbons are compatible and do not require separation before leaving the field. Further, during recovery the LPG fluid ensures a wellhead pressure that is sufficient to immediately flow the recovery stream into virtually any gathering system. This eliminates the equipment, delays and complexity associated with removal of contaminants and pressuring of the recovery stream to pipeline inlet conditions. The traditional system often requires significant venting and flaring with the resulting environmental concern of greenhouse gas emissions.

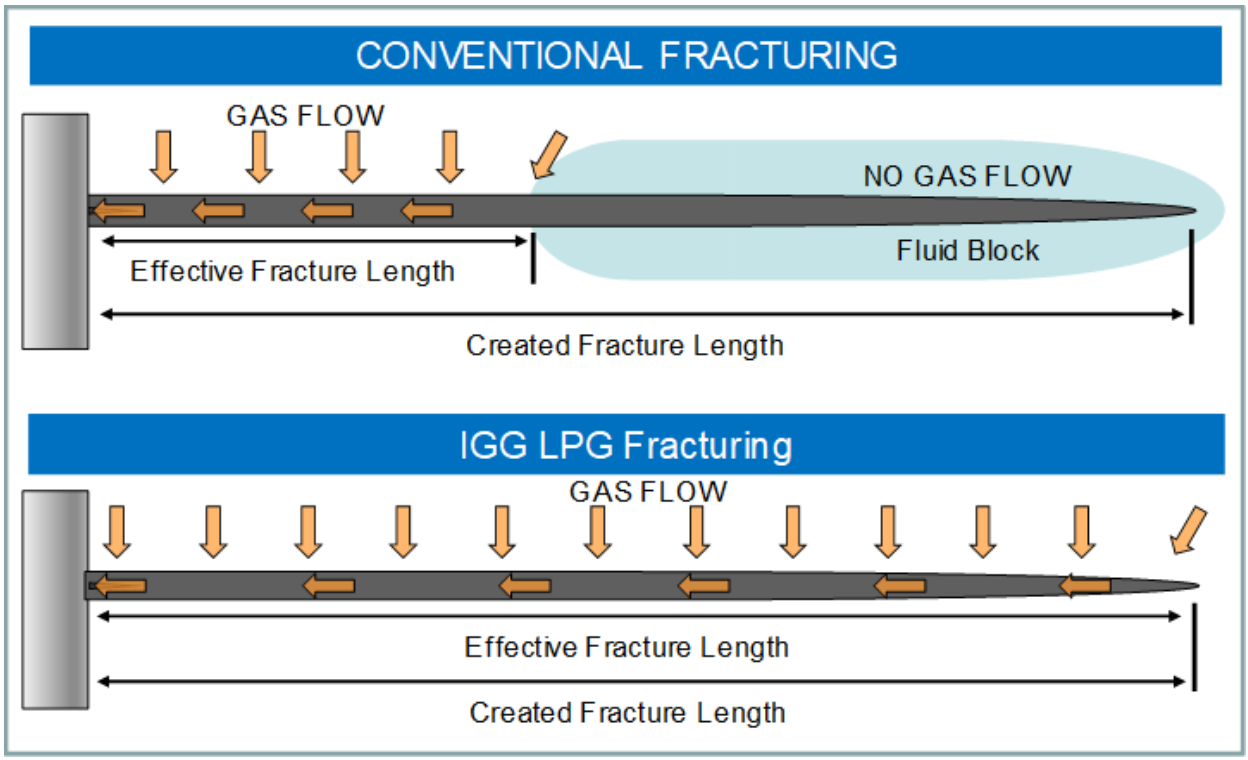

Figure 1. Diagram illustrates the output efficiency advantages of LPG fracturing.

Natural Gas Well Performance

The use of LPG to form a completely hydrocarbon based fracturing system provides significant advantages towards well production efficiency. Firstly, with the elimination of water, no production blocking liquids are placed within the natural gas reservoir, see the diagram at Figure 1 above. LPG gel exhibits very low surface tension, more than 10 times less than that of water, and has excellent mobility within pores and fissures and virtually zero blockage from trapped fluids. Secondly, the density of the recovered LPG within the well-bore is significantly less than the density of water. The resulting reduced hydrostatic pressure permits a greater

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drawdown for recovery during flow back to further improve injected fluid mobilisation within, and recovery from, the reservoir. Furthermore, the viscosity of the broken LPG fluids within the natural gas reservoir are also much less than the viscosity of water. From Darcy's Law, the flow rate of fluid through the reservoir will be inversely proportional to the viscosity of the fluid (the thicker the fluid, the slower the flow rate) therefore, the LPG fluid will flow three times faster than the water. Finally, the LPG fracking fluid, like all hydrocarbons, are fully compatible with reservoir rock and will not result in damaging solution release of reservoir rock fines or swelling of mixed-layers of clay.

An important component of any fracking operation is the placement of a proppant, a solid material, typically sand, treated sand or man-made ceramic materials, designed to keep an induced hydraulic fracture open, during or following a fracturing treatment. A unique feature of gelled LPG is that the ratio of propane, butane and gelling agent can be varied to increase the gel viscosity. This allows the proppant to be fully supported and carried to the very end of the fracture where it is needed to hold the fracture open. When pumping stops the gelled LPG reverts to a gas which has excellent recovery features. For example, when compared to water, 60 per cent more gas can be recovered, 40 per cent quicker using 30 per cent less proppant.

The physical properties of the fracturing fluid are also very significant during well clean-up operations. Commonly, 70 per cent or more of the injected water is not recovered during fracture clean-up. This water remains within the reservoir inhibiting natural gas production. LPG based fluids have been shown to exhibit rapid and almost complete recovery maximising post-fracture gas production.

LPG Fluid Production Performance

The increased production resulting from the use of LPG fracturing fluids, as described above, will vary with each natural gas reservoir and depend on the reservoir characteristics and the type and degree of fracturing to the well. In many cases LPG fracturing will produce a more efficient well than water fracturing. Poor fracturing efficiency resulting in reduced production from conventional fracturing fluids may result from various aspects including:

- permeability plugging due to released rock fines,
- clay swelling,
- reservoir to fracturing fluid interactions; precipitates, emulsions, etc.,
- fluid blocks due to fracturing fluid entrapment,
- reduced flow via multi-phase relative permeability changes,
- poor proppant transport along the fracture, and insufficient reservoir pressure or drawdown to recover injected fluids.

In summary, the LPG fracturing process permits the composition and properties of the injected fluid to be tailored to maximise fracture placement and the resulting fracture effectiveness. In general, hydrocarbon fracturing fluids will result in less disruption to reservoir flow than water-based fluids. To optimise performance, specific consideration to the reservoir characteristics are considered when determining the optimum LPG fracturing fluid composition. The injected LPG fracturing fluid composition can also be tailored to facilitate the recovery of that fluid by preparing a fluid composition that will transform from a gel to a gas at temperatures close to the ambient temperature of the rock being fractured. Furthermore, even minimal

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mixing of the LPG fluid with reservoir gas will lower the resulting mixture's transformation temperature causing the fracturing fluid to vaporize for gas-like behaviour during recovery.

Industry Acceptance of LPG Fracking

LPG Fracking has been a proven fracturing technique for over a decade and thousands of successful fracking operations have been have been conducted in North America, however, so far, the new technique has not experience broad acceptance in the industry. Given the range of significant advantages of LPG over water this may seem surprising but for a range of reasons the North American has been difficult to break into. The oil and gas industry in general experiences long construction phases with high capital outlay before achieving an operational phase with good financial return. The financial risk is high, and the industry is, by necessity, financially conservative. Water fracking is known and trusted and the infrastructure to support it is in place. It may not be the most efficient fracturing fluid, but it is efficient enough for a commercially successful industry in North America. Early industry acceptance of the technique was not assisted by a lack of credible engineering data to support the scientific and engineering theory. This situation is changing as the number and variety of applications of the technique increases and results are recorded and published. Finally, anecdotal advice from the drilling industry advises that, in some circumstances, water does produce a better outcome than LPG. The best opportunity for commercial success may be in employing the technique in the exploration, developmental and construction phase of an immerging industry rather than attempting to break into and establish national industry with decades of infrastructure investment.

Conclusion

The development of onshore unconventional natural gas reservoirs in the Northern Territory may provide an excellent opportunity to establish LPG fracturing in the formation of an industry. In an environment of high public concern, detailed regulation and an array of complex environmental and heritage issues, it may provide the technology innovation necessary to gain broad public acceptance of this industry.

This unique waterless fracking, disruptive technology is being introduced to Australia by *Gas Energy Worldwide Pty. Ltd*. This Company will bring to the Australian onshore unconventional natural gas industry the unique equipment and a group of engineer managers and professionals who have been directly involved in the design, developed and manufacture of that equipment. For 30 years, these professionals have conducted over 2,500 successful fractures in Canada, the United States and Mexico. Their expertise provides an opportunity efficiently and safely establish the capability in an Australian natural gas industry.

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Published by Future Directions International Pty Ltd.
80 Birdwood Parade, Dalkeith WA 6009, Australia.
Tel: +61 8 9389 9831 Fax: +61 8 9389 8803
E-mail: info@futuredirections.org.au
Web: www.futuredirections.org.au

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