A short history of the shale gas phenomenon in North America

Robert T. Langan
Chevron ETC (Retired)
Yorba Linda, CA USA
Blangan1@yahoo.com

SUMMARY

The oil and natural gas energy supply situation changed dramatically in the United States and in North America between 2000 and 2013. A new ability to extract economically both natural gas and oil from shale resource rocks has recently made the United States the world's largest producer of natural gas and reversed a long-term decline in oil production. The economic impact of these changes is not only being felt in North America, but throughout the world, as the United States supplies more of its energy needs from domestic sources and prepares to export liquefied natural gas (LNG) globally.

The technology and business models that created this revolution are now being tested to various degrees throughout the world. Even if the export of these models is only partially successful, it will have a profound impact on many of the current producers and consumers of fossil fuels, and on industries which support shale resource exploitation.

A major beneficiary of the shale resource explosion is microseismic monitoring technology. Monitoring fracture stimulations in shale is a large and growing service industry with rapidly evolving capabilities, and concerns about induced seismicity associated with the disposal of waste water from fracture stimulation operations are starting to create a similar demand for long-term microseismic monitoring services.

Key words: Shale gas, microseismic monitoring

INTRODUCTION

In the year 2000, natural gas reserves in the United States were projected to last only 10 to 20 more years. Plans were being made to import Liquefied Natural Gas (LNG), utilities that generate electricity were reluctant to build new facilities that used natural gas, and Russia was the largest natural gas producer in the world. At about this time, improved technology and shrinking costs associated with drilling and completing horizontal wells in shale resource rocks made it profitable to exploit gas in some formations in North America.

This triggered a succession of "land rushes" for mineral rights as tests of the drilling technology on new formations demonstrated positive economics. By 2010, North America was estimated by some academics to have a 100-year supply of natural gas, LNG import terminals were being viewed as potential LNG *export* terminals, and the U.S. was poised to pass Russia as the largest producer of natural gas in the world. This revolution was driven not by major international integrated oil and gas companies, but by independent operators, both big and small. As more and more acreage was developed, many of these operators became victims of their own success in that they were now producing more natural gas than demand in the North American market could support.

In 2013 the abundance of natural gas has driven the market price to such a low point that most dry (gas-only) shale gas opportunities are not profitable on their own merits. Some shale formations, such as the Bakken (North Dakota) and Eagle Ford (Texas), produce significant volumes of oil, and the natural gas produced along with the oil has become essentially a low-value by-product. The substitution of natural gas for other energy sources in North America and the increasing oil production from shale is being felt economically not just in North America, but around the world, and in ways that are both obvious and not so obvious.

DISCUSSION

In the 1990's, two independent energy companies, Mitchell Energy (now part of Devon) and Chesapeake, believed that commercial quantities of gas could be extracted economically from the Barnett Shale of the state of Texas in the U.S. if they could inexpensively create enough surface area in the formation to feed into a horizontal wellbore. They eventually achieved this goal by drilling long horizontal wells (1500m or more) that followed the thin shale units with precision, and by reaching away from the wellbore with multiple fracture stimulations (sometimes every 30m-60m).

Once the economics of this approach were proven, a series of land rushes were triggered to acquire mineral rights in areas where shale formations were demonstrated to be amenable to this drilling and completion strategy. Typically the shale units that did respond well were relatively brittle, had relatively high total organic content (TOC), good thermal maturity, and possibly, a bit of overpressure to drive the gas near the newly created surfaces. Numerous formations, such as the Fayetteville, Woodford, Haynesville, Horn River (Canada), and Marcellus, appeared to be economically viable for exploitation in the price environment that existed in the early 2000's.

In the United States mineral rights are usually retained by the owner of the surface land. An energy company can lease these rights with an upfront fee and a promise of royalties, but

in order to retain the rights for the longer term, the operator has to place a well in every section (one square mile) within three years of obtaining the lease. Otherwise the rights to the lease revert to the original owner and they are free to lease them again. There are variations on this theme from region to region, but the basic idea doesn't change.

Once the energy company acquired significant acreage in a given area, they would quickly set up efficient drilling operations involving multiple drill rigs, around the clock operations, and shared supply lines. The cost of drilling and completing these wells in a factory-like operation fell to $4-10 million (U.S.) per well. These techniques have made it possible to drill thousands of wells in a given play in a few years. The profitability of an operation is based upon the average performance of all the wells, so the economic risks are not tied to a few high cost wells. These efficiencies were achieved by independent operators—major integrated oil companies in the U.S. didn't normally operate in this manner.

Given that natural gas prices can be quite volatile in North America, some operators recognized that should the price of natural gas drop significantly after they obtained their leases, their current production might not produce enough cash flow to cover the drilling costs over the next three years. So they made a bet in the natural gas futures markets that prices would fall in order to hedge against this prospect.

Beginning in 2008, the rapidly increasing supply of natural gas swamped demand. Those companies with strong balance sheets or cash from the futures markets could continue to drill in the face of falling prices in order to hold their leases, further exacerbating the price environment (and ignoring the First Rule of decision analysis: "never consider sunk costs in the path forward").

Other operators sought cash from larger energy companies now looking for a chance to buy into this new energy opportunity. Usually these arrangements were of the form "in exchange for 25% ownership in this play, I agree to invest $3 billion in the next 3 years drilling wells for you". This also provided a positive feedback loop undermining prices.

The final attack on natural gas prices came with the discovery that in some formations, shale gas wells produce relatively light oil and natural gas liquids (NGL's), which in North America are worth 3 to 5 times as much as natural gas for a given energy content. Only 150 barrels a day of liquid production is sufficient to cover the cost of many of these wells in a one-year period. The Bakken Formation in North Dakota and Montana has sweet spots that produce mostly oil, and the Eagle Ford Formation of Texas has favourable gas-to-liquids ratios. In situations like these, natural gas is a low-cost by-product. For a brief period in the spring of 2012, there were fears that the spot price of natural gas near North Dakota might effectively become *negative*. In the current price environment, finding sweet spots in shale gas plays that produce oil has been driving many of the exploitation activities.

ECONOMIC IMPACT

According to the most recent statistics from the North Dakota Department of Mineral Resources and the Texas Railroad Commission, the Bakken and Eagle Ford combined oil production is now on the order of 1.2 million barrels/day and growing rapidly. BP (2013) recently estimated that oil production in the U.S grew 14% in 2012 over 2011. Export of natural gas in the U.S. is tightly controlled by the federal government, but so far two LNG export facilities have been approved and petitions for about six more have been submitted for governmental approval.

The economic effects of the sudden ramping of oil and natural gas production are being felt in other countries and industries affected by fossil fuel production. LNG that was to be exported from Qatar to the U.S is now being shipped to Europe, and Eastern Europe has more control over the price they pay for natural gas from Russia as a result. Natural gas power plants are once again being built in the U.S. Steel plants making drill pipe are being built in the state of Pennsylvania to support the exploitation of the Marcellus and Utica shale formations. Pittsburgh, Pennsylvania was the heart of the steel industry in the U.S. until it began a steady decline about forty years ago, and now it is seeing resurgence.

The rather quick addition of 1 million barrels per day of oil production from shale is affecting OPEC countries in West Africa and elsewhere, as they have seen a drop in their exports to the United States. A surplus of tankers has developed because of dropping exports to the U.S. and there are musings that the U.S. may no longer need to import oil within 10 years.

MICROSEISMIC MONITORING

Microseismic monitoring is playing a key role in shale resource exploitation. It is used extensively to evaluate the performance of fracture stimulations and to make sure fractures are staying within the intended zones. A robust and growing service industry has been created and as a result, greater technical insight into the mechanics of fracture stimulation is occurring.

There are concerns in North America about induced seismicity, especially associated with the deep disposal of waste water created by the flow back from fracture stimulation. It appears that long-term microseismic monitoring of waste water disposal is likely to grow significantly.

The role of microseismic monitoring is discussed in a companion talk by Shemeta (2013).

CONCLUSIONS

The U.S. has seen a revolution in oil and gas production in the last 13 years. The larger question is if this same phenomenon is exportable to other parts of the world. Governments on all continents have leased shale gas opportunities to energy companies to see if the North American model will translate to other regions. Eastern Europe and China have been particularly aggressive in leasing shale resource opportunities. However, even if the geological conditions are favourable, it doesn't mean that the business model will work everywhere. In most other countries, the surface land owner doesn't own the mineral rights, so there is no incentive to allow drilling equipment on one's land. In addition, the exploitation requires very efficient and skilled drilling and completion capabilities to keep costs down. This "factory operation" and the supporting infrastructure don't yet exist outside of North

America. The missing efficiency in operations might be offset by the premium natural gas fetches in Europe and Asia over North American market pricing (generally it is 2 to 5 times greater). Other barriers to adoption in many countries are environmental concerns. In the U.S. there is a movement to certify shale gas operations as being sustainable (www.sustainableshale.org). Currently three energy companies and several environmental groups have agreed to fifteen performance standards for certification. These standards may be adopted in other countries if they are demonstrated to be effective.

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