NATURAL GAS: AN UNCONVENTIONAL REVOLUTION

The spectacular boom in both production and consumption of unconventional gas in the United States is a success story that few would have predicted at the dawn of the new millennium. Large oil companies are fighting to make up for this missed opportunity. Through mergers and acquisitions they have made the sector a key component of corporate strategy. The stakes could not be higher and decisions made now will have huge consequences for the future balance of the global energy industry.

The debate on the future of the shale gas industry in France is in disarray and a moratorium was recently extended to ban hydraulic fracturing techniques pending further review. While the press and two government reports (largely politically motivated) have attempted to clarify the situation, the technology is still poorly understood by the majority of the population and few recognize its importance for the future of energy security. Environmental concerns are a major stumbling block and it is on this subject that discussion is most animated. It might be more useful to refocus our lens on a more geological perspective as therein lies the key to a better understanding of the revolution introduced by unconventional gas.

Geology: rethinking our approach

In the beginning gas extraction was ripe with technical innovation but since the dawn of our adventure into the oil age the industry has matured and geologists tend to follow a fairly predictable blueprint during the exploratory phase of fossil-fuel based energy production. Hundreds of millions of years ago organic materials were buried in a sedimentary rock (source rock) and transformed through a combination of heat and pressure producing compressed material known as kerogen before passing through several phases to produce fossil fuels such as oil and gas. Some of these materials began working their way upward through the earth’s crust and, being less dense than water, began to rise toward the surface. Often they were trapped beneath non-permeable ‘cap rock’ in formations such as limestone or sandstone creating underground reservoirs that form the main target of the conventional petroleum industry. Exploratory work has traditionally focused on locating trapped reservoirs of sufficient volume between the source rock and the earth’s surface.

Geologists have always known hydrocarbons were left in the source rock but until recently the high costs of extraction, due to low permeability led exploratory teams to focus their energy on more accessible and commercially viable resources.

For well over 20 years however small independent drilling operators have been plying their trade in various locations throughout the United States. Largely through a process of trial and error, they have pioneered techniques to the point where it is now economically viable to produce hydrocarbons trapped in the source rock . Exploratory teams have had to radically rethink their previous approach and estimates on potential reserves have risen dramatically.

Former practices for gas exploration have been fundamentally altered as each new source rock presents its own specificities. Exploration has become much more tightly interwoven with the process of extraction and production than has been the case with conventional sources. For our purposes we will limit ourselves to the unique set of circumstances surrounding shale gas, the most promising of the different sources of unconventional gas.

How do we define shale gas?

Shale is a sedimentary layer composed largely of clay and other minerals. Natural gas remains trapped in widely dispersed pores due to the low permeability of the rock. It plays multiple roles as the source rock, reservoir, and cap rock all rolled into one which is why traditional approaches to extraction must be turned on their head. Sedimentary basins of argillaceous material are widely distributed throughout the world but not all have a serious potential as source of gas. For a layer to be viable significant organic materials must be present and analysis is performed to determine whether the ratio of total organic content (TOC) is adequate to ensure significant production. The layer must contain other minerals as well. The most promising sites are those containing elements such as quartz or carbonate rock to offer brittle lithology and shatter easily, facilitating hydraulic fracturing and eventual freeing up of the trapped gas.

The layers from which shale gas is located tend to extend over wide regions. They are generally lateral formations but no two sites are the same and diversity remains the rule rather than the exception. The allocation of permits should reflect this fact as it is only through access to vast areas of exploration that experts are able to uncover the ‘sweet spots’ that demonstrate the most promise for future extraction. Local conditions play a significant role and it is not in the prospectors’ interest to place geographical limits on exploration.

Drilling techniques must adapt to conditions on the ground. Specialists rely on a mixture of guile, experimentation, and hard won experience to achieve the best results. It is only through hydraulic fracturing and the boring of numerous wells that drillers are able to optimize production at any given site because, as mentioned earlier, each shale presents its own specificities. The final result of this process is a more accurate estimate of total reserves.

Hydraulic fracturing is the key to a better understanding of potential resources and the recently extended moratorium on the practice in France is having profound consequences on the country's ability to arrive at even the most basic estimation of the riches that could be hiding underground.

Groundbreaking techniques, and the age of maturity

A unique set of factors converged to create the conditions necessary for the current boom. Through persistence and a willingness to take risks, techniques were developed that combined advances in directional drilling techniques with the process of hydraulic fracturing. Neither of these techniques emerged overnight and horizontal drilling has evolved over the last 30 years while the latter has matured over the last 60 within the context of the conventional industry. Shale presents a rather unique set of challenges as it must be stimulated so that gas is released through artificial cracks that create pathways over which the gas can flow into a well. Quantities must be significant enough to make the well economically viable and this explains why advances in horizontal drilling techniques have been so essential to successful operations. By extending the well horizontally production is increased significantly and, as explained earlier, shale tends to exist in deposits that extend in long horizontal layers. A well has a limited drainage zone so several wells are required to ensure significant volumes of gas.

Addressing environmental concerns

Within this context worries over the environmental consequences of shale gas plays are legitimate and need to be examined seriously.

In any industrial activity precautions must be taken to minimize risks and shale gas is no exception. A robust regulatory framework to ensure best practices are followed has become a necessity. "If done responsibly, it can be done safely," was the conclusion drawn by independent panels in every country where any serious investigation has been made into exploiting the potential of shale gas resources.

Essentially environmental concerns can be broken down into three main categories : disruption associated with oilfield construction; water management and prevention of pollutions; and safety of drilling operations.

Oilfield construction requires a large number of wells and optimizing drainage typically requires a significant amount of hydraulic fracturing.

Disruption. The surface activities linked to gas field construction, while only temporary, can cause significant disruption in the surrounding communities (increased traffic volume, noise, etc.). One of the most productive regions of the United States, the Barnett Shale, lies within the boundaries of the densely populated Dallas-Fort Worth metroplex and we can easily imagine the tensions that must have arisen over the last decade of the so-called Barnett boom: expansion could never have occurred without the cooperation of local residents. Conflict resolution is therefore a vital to any play in urban environment. Drilling in rural areas creates a different set of problems, the lack of transportation infrastructure for example, and industry has worked toward finding solutions.

To reduce the surface footprint of production it is possible to drill a number of wells from a single drilling pad. Many commentators have given partial credit to the current boom in American shale gas production to the country's legal regime which creates extremely favorable conditions for gas exploration. Property rights extend underground and the financial incentives to lease these rights to drillers are a temptation many find hard to resist. The downside to the system is it often leads to a patchwork approach to gas field planning (not everyone is willing to cooperate) and this places constraints on the optimization and organization of the drilling operations. In countries where underground resources belong to the state we can easily envision a scenario where the surface footprint is more tightly controlled and therefore lighter.

Yet for all the effort made to limit any disruption on the lives of local residents the fact remains that drilling operations impact the surrounding environment and the NIMBYs have mounted staunch opposition in many regions, especially those with no history of oil and gas exploration.

Water management. The second major hurdle toward widespread shale gas production is ensuring that water supplies are reliable enough to support both drilling operations (production of drilling fluids) and the large amount of water demanded for hydraulic fracturing which can often be repeated 10 or 15 times in a given well. Hydrographic data must be updated to integrate the consequences of drilling operations into the overall water management system.

Additionally, it is by no means uncommon to find pools of brackish water surrounding wells as contaminated water used in underground drilling operations underground that should not seep to the surface. Clearly safeguards are required to ensure the safety of rivers and groundwater supplies, and we must absolutely ensure laws set by agencies such as the US Environmental Protection Agency (EPA) are respected. We have a number of options at our disposal. Waste can be sealed off in water-tight saline aquifers and numerous techniques already exist for the treatment of discharged waste water at the surface but they are expensive. Another option might be to recycle the water so it can be used in subsequent operations but initial trials have been disappointing as the saline content is unsuited to efficient fractures, ensuring this area will remain a major focal point of research in the years to come.

The actual fluid that is pumped into the shale during fracturing is composed almost entirely of water and sand. Chemical additives (used to facilitate the process) make up only 0.5% of the total. Common chemicals are used and could just as easily be found in a range of industries, from water treatment to agriculture or the cosmetics industry. The content of waste water should be controlled and needs to be governed by a strict regulatory regime. In the beginning it was difficult to ascertain the exact contents of drilling fluids as the actual chemical cocktail was considered a precious trade secret. This is no longer the case and oversight bodies have today access to a detailed list of the ‘secret sauce’.

Safety of drilling operations. Drillers have adapted their techniques and best practices have become part and parcel of the profession. In those rare instances when contamination of water supplies occurs in the United States blame has usually been placed on the upper reaches of the vertical portion of the well rather than the act of hydraulic fracturing. Because of the thermal shocks and the high level of pressure created as the fracturing fluid is injected into the rock the usual culprit is poorly cemented well casings.

Public anger aroused as more light was being shed on the darker side of the boom, specifically certain “cowboys” who have been somewhat less than professional in their practices. Protest movements have placed a fog of confusion over any rational analysis and have created a climate of fear. The 2010 release of the documentary *Gasland*created a media sensation and in the uproar that followed little attention has been paid to certain pieces of misinformation contained with the film. The government has attempted to shed light on some of the inaccuracies, the most striking of which is contained within one spectacular scene where a homeowner demonstrates his ability to ignite the water flowing from the household tap. Further investigation has revealed the phenomenon was the result of naturally occurring gas in the phreatic layer beneath the property.

Representatives in the US Congress have been listening to their constituents and federal policy has evolved to address public concerns. Mining activities in the United States have traditionally been governed at the state level on the assumption that local authorities know their terrain better than policymakers in the Capitol. State policies have not kept pace with development of federal laws (notably the Safe Drinking Water Act of 2005) and the EPA now finds itself playing a game of catch up which has led to new regulations in more recent years. Given the continuing rise of shale gas exploration, Congress has ordered the agency to prepare on updated report focusing specifically on the most controversial aspect of shale gas production, hydraulic fracturing (fracking). The conclusion of a similar study into the use of this technique use in exploiting coal bed methane, published in 2004, classified the threat to groundwater as “minimal”. The EPA plans to release the interim results of the new study in 2012 to be followed by a final report in 2014. The study is intended to provide a thorough analysis of cases of groundwater contamination, such as those mentioned earlier. The goal is to provide a sound argument for reinforcement of national safety standards; increased inspections; and recommendations for improved standard operating procedures, most notably in regard to cementing the well casings.

Have we entered a period of disruptive innovation? No, gradual evolution.
The media are trumpeting the dawn of a new age and a complete shake up in the way we approach natural gas but the public has been somewhat misled because as everyone knows headlines are created more to generate excitement and sell newspapers than to inform. Persistence and experimentation over an extended period of time led us to the cutting edge techniques of today. Development has been progressive rather than disruptive. Drilling operations are always searching for ways to reduce costs, more specifically unit costs (measured in dollars per m3 of gas produced). When production occurs within a well-conceived economic and regulatory framework, technical advances will help reduce the environmental impact of natural gas production. Guaranteeing reliable water resources and treatment facilities is expensive and we are constantly searching for new ways to reduce water volume. Major investment is required before

any shale gas play and drillers reap more financial benefits if they can reduce the number of wells and maximize their productive life. Safety is a primary concern, not only on moral grounds but on economic ones as well, as releases of gas (venting) into the atmosphere leads to production losses.

When conventional production was on the wane, American oil multi-nationals redirected their energies toward international activities and played little more than a bit role in the current shale gas boom. Faced with the extraordinary success of the independents, corporate strategy has been dramatically altered and they are trying to make up for lost time through a wave of mergers and acquisitions. The sector is in a process of restructuring and will soon be dominated by larger firms who have more experience, and interest, in managing safety and environmental concerns.

More standardized operating procedures must be introduced to the current system and R&D continues to play a central role in the constant search for improvements. Hydraulic fracturing is now firmly established and shows no signs of being knocked off its perch except in those rare cases where ensuring adequate water supplies present particular difficulties. Various theoretical alternatives abound but it will be years before we can even contemplate replacing the current technology with a more efficient solution.

Growth perspectives for North America

Today, more than half of US gas production comes from unconventional sources (shale gas, tight gas, coal bed methane) and the boom has largely compensated for declining activity in the conventional gas sector. The United States has regained its position as the largest producer of natural gas on the planet and the widely heralded market for LNG imports has collapsed as a result.

Across the border in Canada, no slouch when it comes to exploiting conventional gas resources, shale gas plays are following a similar trajectory to their southern neighbor and the western provinces (British Columbia and Alberta) are abuzz with activity which we can expect to spread eastwards in the years to come. Taken together the North American cousins can expect to remain gas self-sufficient for the foreseeable future.

Shale gas now accounts for a quarter of total US gas production and policymakers are predicting figures as high as 45% by 2035 as the number of shale gas plays continues to skyrocket. It is looking increasingly likely that at least one-third of U.S. gas reserves are contained within shales.

For all the optimism however the next few years are clouded by more uncertainty than many are willing to admit as the price volatility of the global gas markets weighs heavily on whether a shale gas play will be profitable. The market for unconventional gas is extremely price sensitive and relies heavily on near constant digging of new wells to compensate for the decline of those that are reaching the end of their productive life. As noted above, new wells are expensive and global gas prices will play a large role in whether drillers can expect a decent return on their investment.

Around 2005, gas prices soared across the United States to more than 8$/MBtu (million of British Thermal Units) creating the perfect conditions for shale gas plays. It was a combination of economies of scale and years of hard won experience that led to lower costs and boosted profit margins. The bursting of the bubble came in 2008 because of a combination of over-production and shockwaves from the economic crisis and gas prices plummeted to half their previous levels. The real question is whether current production can be maintained if prices continue hover around $4/MBtu.

While the shale gas industry is traversing a difficult period this in no way precludes the continued exploitation of this now essential component of the global energy mix. Nevertheless, the future depends heavily on rising prices and it should be noted that for consumers, US natural gas prices are about half of what is commonly paid in Europe and Asia.

Global reserves

At present, shale gas production is, almost exclusively, a North American affair. Gas-bearing shale is known to exist throughout the world and is fairly evenly distributed across the continents, but there is a dearth of any reliable data from which to draw precise quantified conclusions on the subject. The unique characteristics of unconventional resources prevent any reliable assessment of potential reserves until wells are already operational at which point recovery rates can be predicted with a reasonable degree of accuracy. Until the technology becomes more widespread estimations will remain a delicate subject but some attempts have been made to clarify the subject.

The United States has encouraged an expansion in the development of shale gas production worldwide and the US Energy Information Administration (EIA) commissioned a recently published report (April 2011) estimating the “technically recoverable” shale gas resources in the 32 countries examined at 180 Tcm (trillion cubic meters) which is almost equal to the total proven world reserves (primarily composed of conventional resources). If we add in estimates on unproven conventional reserves, as well as estimates on other unconventional resources (tight gas and coal bed methane) each of which add an additional 180 Tcm to the equation we arrive at a figure of global technically recoverable resources of 720 Tcm which is equal to 240 times current annual production (about 3Tcm per annum).

It should be noted that outside of North America, the zones at the vanguard of the shale gas revolution are largely distinct from the dominant gas exporting countries of today and have the potential to increase energy security while simultaneously turning the geopolitics of energy completely on its head.

Challenges and uncertainties

Some uncertainties resist quantification because there are many other factors to consider when making the decision to make a shale gas play or not that have nothing to do with geology.

The obstacles to widespread adoption of the technology are considerable. First and foremost, the competence of national authorities to conduct energy policy over the long term must be considered. Safety standards must be established to govern the specificities of the technology and an umbrella of regulatory bodies must be put into place to ensure that standards are met. As outlined earlier, transportation infrastructure also has a major role to play. Finally, most countries currently lack the specialized drilling equipment and expertise (most notably in the oil and gas field services sector) that successful operations depend on.

American and Canadian dominance of the sector should continue for the foreseeable future as they are the only countries that have overcome these significant hurdles. In light of the commercial opportunities for North American firms as other countries seek to replicate their success the US State Department made the decision to encourage the diffusion of technology with President Obama’s Shale Gas Resources Cooperation Initiative. China, Australia (which favors coal seam gas), Argentina, and Poland are currently leading the way on the road to increased use of unconventional resources. Politics plays a significant role as a lack of coherence in public policy can sow seeds of mistrust that make rational debate on the subject almost impossible.

In conclusion, the development of shale gas (and other unconventional resources) has become a “game changer” for the future of global energy markets. Rising natural gas supplies have the potential to transform the way we produce and consume energy, and could become a central pillar of the global energy transition that is expected take place in the coming decades. The International Energy Agency (IEA) made it clear in the recently published Are We Entering a Golden Age of Gas? It seems a number of countries are already well on their way to answering the question… in the affirmative.

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