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Unconventional wisdom: Fracturing enters a new era

Faced with change on a scale not seen in decades, companies must alter their business plans to accommodate unconventionals or else risk irrelevance.

Parker Meeks, Dickon Pinner, and Clint Wood

The emergence of shale gas and light tight oil (collectively called "unconventionals") is the biggest change the oil and gas industry has seen in decades. Indeed, the rise of these resources is one of today's biggest economic stories—and hardly anyone saw the scale of what was coming. The shale revolution is, in short, a classic story of disruption. From next to nothing in 2000, unconventional resources already account for 40 percent of US natural-gas production and 29 percent of oil. And their contribution is likely to grow bigger still.

A combination of innovations and technological breakthroughs allowed the oil and gas industry to extract hydrocarbon resources previously considered uneconomical. However, this is only the beginning, not the end, of the need for innovation. The danger for exploration and production companies or oil-field-service companies—whether they are independent wildcatters or global majors—is that they are so stretched to keep up the pace of development that they keep putting off larger questions.

Among them: What is the next big innovation? Are we ready for it? Where are the opportunities for improvement? What are the biggest risks? How can we address or avoid them?

The potential for technological improvements on the horizon is so significant, and so comprehensive, that it could redefine the industry. Companies that want to succeed in the next generation of unconventionals need to start thinking about these things now and incorporate them into their business strategies. Those that do not will face the biggest risk of all: irrelevance.

Three phases

The evolution of unconventional hydrocarbon extraction could be viewed in three phases. In phase one of the shale era, the industry learned how to combine horizontal drilling and hydraulic fracturing (or "fracking") to unlock previously inaccessible supplies. The pioneers were independent energy producers, many of them small. The second phase began as more companies, including some of the majors, started investing significant capital to acquire and develop large positions. Much of the early activity was directed toward shale gas, but investment shifted rapidly to light tight oil, where the same technologies and techniques were applied.

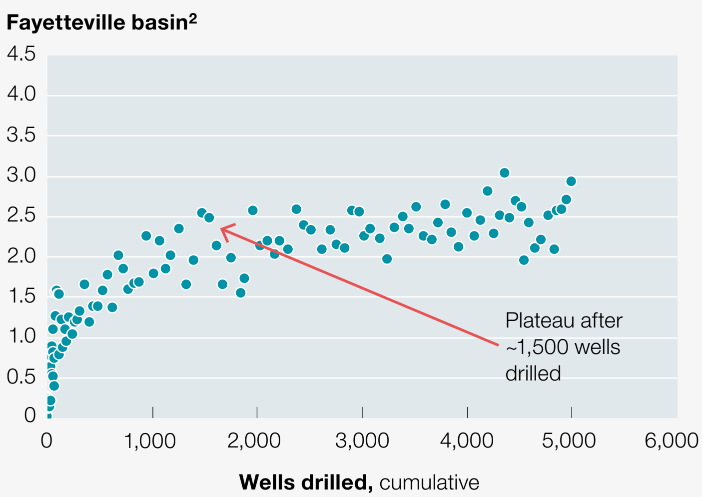
Despite the scale of production, and though the industry has continued to improve production techniques, the fracturing process remains by and large a matter of trial and error. Each new basin has a different geology, requiring a long and expensive learning period to determine how to operate (Exhibit 1). Even in mature basins, there is little consensus on how wells should be spaced or the optimal number of wells per pad.

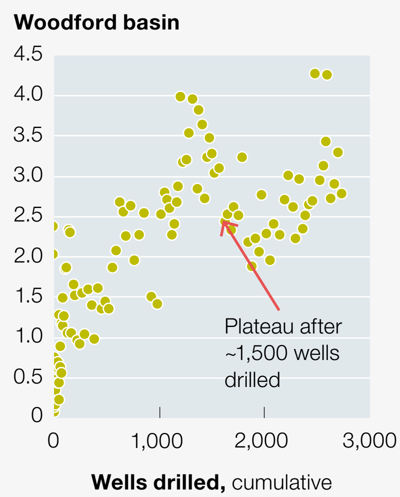
That is the context for phase three, which we believe the industry is about to enter. In this phase, companies will continually optimize best practices; these will spread. Technology and improved operations will address major pain points, including cost and environmental concerns. If unconventionals follow the path of other industries that have been able to tap new markets thanks to innovation breakthroughs,

Exhibit 1

Learning curves for new basins show that about 1,500 wells must be drilled before initial production from the wells plateaus.

Initial production,[1] millions of cubic feet per day equivalent





[1]Based on reported initial production rates for first 2 calendar months of production.
[2]Includes both East and West Fayetteville.

Source: HPDI; McKinsey analysis

then production from individual wells will rise and be more systematic and predictable for new basins. Costs will fall. And those who are late to the party will be shut out.

The potential of unmet needs

Making operations cheaper, cleaner, and more efficient will require technological advances along every link of the value chain. There is considerable value waiting to be unlocked, as technology begins to address outstanding issues in the production cycle. Among the possibilities are identifying attractive basins at lower cost, improving recovery rates from each well, improving logistics and supply-chain management, and reducing environmental effects.

We have identified four promising technologies that in the next five to ten years could address these needs and deliver another dose of disruption. The value of additional light-tight-oil production alone, based on greater production and lower capital costs, could reach $55 billion a year by 2020, according to our research (Exhibit 2). This does not take into account the value of improved environmental performance, such as reduced water use, improved energy efficiency, or less truck traffic.

Technology 1: Improved geophysical data collection and integration with real-time fracture modeling

The industry's understanding of subsurface fracture behavior has significant room for improvement. Hydrocarbons trapped in shale do not flow like those in conventional reservoirs. Changes in geology over small distances (even as little as ten feet) could influence a drilling- or completion-design decision. The difficulty of understanding fluid-flow mechanisms and fracture productivity is reflected in the fact that 60 percent of all fracture stages are ineffective and 70 percent do not reach their production targets. One big opportunity, then, is to use technology to make more stages more productive and to identify stages that will not bring a good return on investment. A better understanding of fracture behavior, in combination with new proppant technology (that is, technology involving the materials that keep the fracture open), could

Exhibit 2

New technologies could unlock an additional $55 billion in light-tight-oil production in 2020.

also boost the productive life of wells and improve access to the resource in the source rock.

This is challenging, due to the nature of unconventional production. Disaggregating geological effects from well-design decisions is an uncertain process. Moreover, the data to judge well performance is often based on the scale of initial production, which is only a proxy for total recovery over the lifetime of the well. As a result, systematic optimization and comparisons are difficult—but not impossible.

To address these issues, the industry needs to have better information and to utilize the information it can access in a more timely manner. One emerging technology that companies are working on for real-time fracture monitoring is microseismic analysis, in which geophone arrays measure seismic activity in real time. These arrays can detect the spatial location of fracture events as well as frack size.

The industry is also working on developing predictive algorithms to provide insights about fracture behavior and help determine where to place stages and how to set fracturing-stage design parameters. Ideally, models would process and combine downhole and microseismic data, building this into their predictive algorithms and thus optimizing conditions in real time.

Improved modeling could also reduce the number of wells required to prove a basin, cutting both costs and environmental impact. This could be particularly important outside the United States, where the industry is not as well developed, not as many existing wells have been drilled, and the cost for developing a basin is split among only a few players or state-owned companies.

Technology 2: Water treatment

Large volumes of chemically treated water—two million to seven million gallons per well—are used to create fractures in the rock. Much of this water is being used in regions that are experiencing extended drought conditions, such as the Eagle Ford in South Texas. The water that flows back is typically disposed of, rather than treated for reuse. Although reuse is preferable because it reduces the use of freshwater, disposal historically has been more common. A big reduction in water usage, however, could help the industry to open new markets in countries where water is scarce and infrastructure undeveloped and address one of the key environmental challenges of hydraulic fracturing.

Freshwater use can be reduced by using flow-back water—the fracturing water recovered at the surface—to fracture other wells. To be reused, however, the flow-back water must be treated to remove larger suspended solids and other contaminants. The flow-back period can last for weeks or even months. During this time, there can be changes in the rate of flow of water, the amount, and the type of suspended solids in the water. This makes treatment difficult. Advances in the effectiveness of fracturing chemicals have reduced treatment requirements, but there is considerable room for technological and logistical improvement.

Widespread reuse is within reach, and treatment technologies can be borrowed from other applications and industries. Mature technologies such as membrane and filtration, distillation and flash distillation, and crystallization produce clean water but come with higher costs and energy usage. Emerging technologies include flocculants, centrifuges, electroprecipitation, and the use of ultraviolet lights and ultrasonics. It may be necessary to use a combination of these technologies to meet treatment needs. Further out and still unproved are technologies such as electrodialysis, ion exchange, and algae.

Technology 3: IT-enabled supply-chain management

IT and analytic tools can address a number of the unmet needs, from exploration and production

> Reducing greenhouse-gas emissions and the amount of land required for each well site will be critical in many geographies, particularly in Europe.

to transportation, refining, distribution, and retail sales. These tools can range from individual point solutions to fully integrated enterprise-class data-analytics platforms.

Information management can help operators to identify and solve problems earlier. For example, GPS-enabled trucks and tracking programs make it possible to identify when a shipment will be delayed. As a result, operators can begin to find solutions before the truck is late, reducing the amount of down-time for staff and equipment.

Integrated platforms can aggregate data from across the value chain and develop insights that can generate billions of dollars in annual value for large companies. For example, upstream asset-analytics applications can reduce costs and increase production by tracking, ranking, and predicting the performance of individual wells; this data can then be used to predict the performance of other wells with similar characteristics. It can also help to shift an industry that thinks about well maintenance as "interventions" to one that leverages the best in predictive analytics.

Technology 4: Nonwater fracturing

The benefits of breaking into the source rock by using something other than water could be enormous, reducing environmental impact and opening up new areas for exploration that are off limits now because of lack of water.

The nonwater technologies in use today are similar to hydraulic fracturing in that they use pressurized-fluid mixtures to break the rock. Vapor fracturing uses a foam of high-pressure nitrogen or carbon dioxide gas. This commercialized technology is offered by major oil-field-service and equipment providers but is often limited to reservoirs with lower-pressure volumes. Liquid-petroleum-gas fracturing uses a cooled gel to pump the proppant and has the benefit of lower surface tension but the material risk of being highly flammable.

All these technologies have safety, cost, technical, and logistical concerns. There may be specific places, such as those where water is short or where hydraulic infrastructure is less developed, where these technologies could compete. However, a truly new approach to accessing the source rock without using pressurized fluids would be a game changer. This type of technology is the furthest from development but could generate the most value and disruption.

Capturing the value

The potential to boost shale-energy production to a new level raises several issues for industry participants—producers, oil-service companies, and equipment manufacturers.

There are three important considerations.

Diversity of needs. The need for and value of different technologies will vary by region, depending on geology, environment, and policy. Reducing greenhouse-gas emissions and the amount of land required for each well site will be critical in many geographies, particularly in Europe. In China, key

challenges are water scarcity and geology. The most pressing needs may evolve over time, as they have in North America.

Technology as the price to play. In many countries with national oil companies, such as Indonesia and Saudi Arabia, foreign companies cannot own the land or drilling rights, but they can partner with local players if they bring technology. For many of these global unconventional basins, having a technology offering may be the price to enter.

Who captures the value? Industry participants need to understand how the industry structure is changing and what the half-life is for new innovations. We have already seen more vertical integration in unconventional oil and gas production, but oil-field-service companies are investing more in R&D focused on unconventionals. Reconciling who will develop the new technologies, who will pilot them, and how value will be split among value-stream participants will be critical as unconventionals mature in North America and potentially grow globally.

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Most energy-industry participants recognize that the unconventional revolution has not yet reached its full potential. But we think the opportunity for technological innovation could be bigger, with respect to both scale and geographic reach, than acknowledged in many current conversations in the industry.

There are immediate operational improvements to be made, and these matter. But players must not get so lost in these day-to-day concerns that they miss the much bigger opportunities associated with longer-term technological development. And that brings us to one final challenge: to manage innovation at the industry level, different players—even competitors—must work together to solve technological issues and seek appropriate regulation. That may cut against the grain. But the alternative is to leave tens of billions of dollars in profits untapped and underground. ■

The authors wish to thank Vanessa Chan and Sara Hastings-Simon for their contributions to this article.

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