Maximising ultimate recovery from unconventional reserves

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This is certainly a golden age for drilling and completion technology. Across the board, in deep water reservoirs, in unconventional formations and in mature fields our industry continues to innovate and invent new ways to produce more oil and gas more efficiently. Necessity truly is the mother of invention. One of the things that really excites me about this business is how we as an industry consistently use technology to meet growing energy demand in the face of a more challenging resource base.

Looking forward, almost all analysts see a demand for energy that would be difficult, if not impossible to meet if we were simply doing things "conventionally." We are becoming more efficient at using energy, but most analysts still expect the world's energy demand to grow at about 1.5 per cent a year for the next 20 years. Even at that historically low rate of growth, the world will be consuming energy at a rate that is 35 per cent higher in 20 years than it is today.

At the same time, the "easy" oil and gas are gone forever. There are very few places left in the world where you can drill a well on dry land and expect oil or gas to come out of the ground on its own. If we are going to meet demand, we must forge into increasingly harsh environments, such as deep water and the Arctic and become increasingly clever at coaxing oil and gas out of the ground from resources that had been previously unreachable or from reservoirs that we believed had been tapped out.

The most exciting thing that has happened in the energy industry in my lifetime has been the phenomenal growth in oil and gas production from unconventional formations. We have all known for a long time that shale rocks held huge quantities of oil and natural gas. What was missing was the technology necessary to bring those hydrocarbons to the surface. Around 2007, operators and the service companies began to master that technology and we started to produce large amounts of gas using horizontal drilling and hydraulic fracturing techniques. What has happened since then has been nothing short of phenomenal. Gas production from shale reservoirs has increased from about 1,000 billion cubic feet (bcf) in 2007 to over 10,000 bcf in 2013. Oil production has increased by 47 per cent over the same period. Companies are investing in LNG liquefaction plants and pretty soon, the US will be exporting gas. Some analysts even believe that North America may start to export oil in the next five years. Going forward, there is a lot of optimism about the size of the unconventional resource. This is true in the US, where the resource is developed, and internationally where the resource is still being evaluated. Various estimates show reserves of natural gas increasing by 60 per cent in the US and 20 per cent globally and reserves of oil increasing by about 25 per cent both in the US and globally.

It is clear that to sustain this trend, we must find better, faster and cheaper ways to get every gas and oil molecule out of every field and formation. We have always known that we leave a lot of oil and gas in the ground when a well or a field comes to the end of what we normally think of as its economic life. The average recovery factor is 70 per cent for gas and 35 per cent for oil. For conventional resources, there is a wide variety of techniques: CO_2 and water flooding, infill drill and artificial lift that can create a new peak of production, extend the life of the well and increase its recovery rate. Those techniques are proven to be effective and have very favourable economics. Incremental oil and gas production from mature fields has been and will continue to be an important piece of the energy supply puzzle.

A similar narrative is unfolding for unconventional resources. There is a lot of uncertainty about the amount of effort required to sustain and grow production to the levels assumed by current forecasts. We just do not have enough experience to reliably estimate the expected ultimate recovery (EUR) of unconventional wells. For conventional wells, we know a lot about how quickly a well's production will peak and how long it will take for the production to decline to a level where it is not economical to keep producing. The US Energy Information Administration recently released an analysis of well-level data for tight oil and noted that "EURs based on only the first year of monthly production ranged from as much as 385,000 barrels higher to 173,000 barrels lower than the EURs based on four years of production". That is a pretty wide range, when you consider that the average EUR for a well drilled in 2012 in the Eagle Ford formation is about 191,000 barrels.

Unconventional resource plays have been developed at an extraordinary rate. Many of them are already mature, meaning their production has moved past its (first) peak. Unconventional plays typically reach their hydrocarbon peak and quickly decline, hastening the time that they can be labelled mature assets. Extending their mature productive life and ultimate recovery is

paramount. That is going to require us to think about longer-term developmental drilling and completion strategies. Fortunately, there are a lot of solutions to this challenge already working their way into the market.

Infill drilling and its challenges

Unconventional reservoirs have very low permeability. Because of the short drainage radius of a given fracture, the reservoirs require more closely spaced wells to properly drain the reservoir and boost production rates and incremental hydrocarbon recoveries. Infill drilling, particularly focussed on down-spacing, has become the most widely used method to accomplish proper drainage and enhance the recovery of a field.

Aptly designated, down-spacing involves decreasing the space between wells laterally to optimise overall economics and increase the present value of the field. In some plays, like the Eagle Ford shale, operators in their multi-well pad drilling programmes have reduced the amount of acreage allocated to each well from 160 to 40–60. While this infill drilling methodology reduces costs and improves efficiencies, it also comes with daunting challenges. The biggest of these challenges is well interference, which occurs when a new infill well is drilled between two existing wells, intercepting hydrocarbons flowing toward those wells and reducing their productivity.

We have developed technologies to mitigate well interference and provide more optimal fracture networks on infill wells including diversion technologies designed to increase uniquely stimulated areas of the reservoir and optimise fracture growth in infill drilling applications.

It is also well documented that initial production rates and EUR can decline as a result of "gaps" in the fracture network along the lateral. Thousands of existing wellbores have vast untapped hydrocarbon reserves in existing perforation clusters that did not receive effective stimulation. These unproduced or bypassed portions of the reservoir may be exaggerated if they were under-stimulated when compared to the more recent stimulation techniques and perforating designs.

Most unconventional multistage horizontal wells become potential re-stimulation candidates at some point in their life, particularly those completed early in a play's development. In some basins re-stimulating, using only the existing perforations, is yielding up to 50 to 60 per cent of the original production. The success or failure of re-stimulation can have a big impact. Treatments involve reusing the existing wellbore can potentially deliver a cost savings of US$2-4 million in some North American wells compared to drilling a new well.

We work in an industry that is alive with challenges and opportunities. Demand is growing, the resource is getting tougher, but technology continues to outpace both of those forces. Our industry has always stepped up again and again when it looked like the cost and availability of energy might be a drag on the economy. The types of innovative approaches to increasing the productivity and efficiency of unconventional resources are an example of this. When I look at innovations like these, I cannot help but be optimistic and excited about the future of our business. ■

Halliburton's Frac of the Future™ equipment, including SandCastle® proppant storage units, working in North Dakota