

Operators re-discover shale gas value

Shale is the new game in town, and here's what it takes to win.

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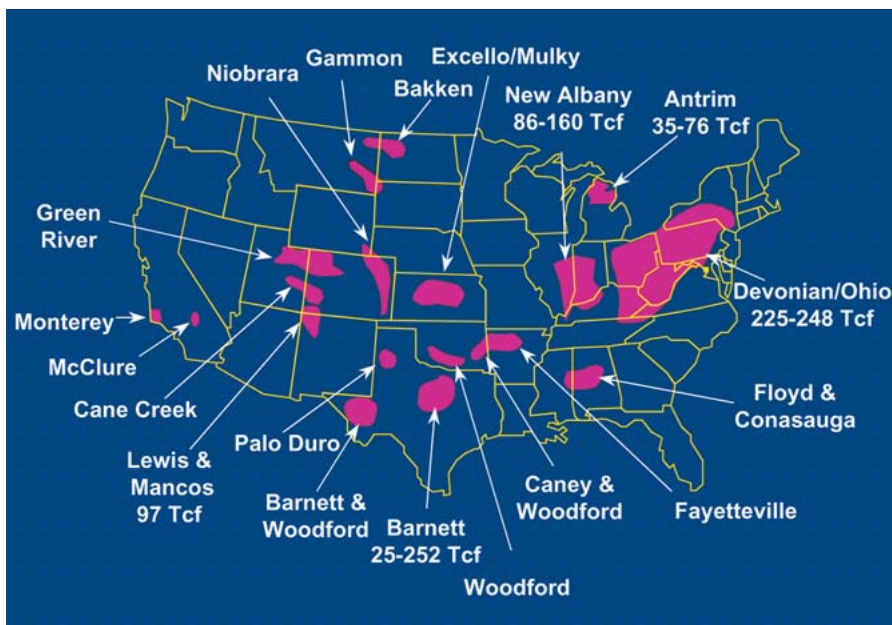
Every week people call wanting help with shale gas reservoirs. They might know a lot about conventional, tight-gas sands and coalbed methane reservoirs but don't yet understand shale. Some operators are not even sure what data to collect. They ask:

- What is the appropriate pilot test program?
- How do we integrate data into a useable model?
- What is the best completion technology, what are the expected rates and reserves?
- What are the economics of the play?

United States only, for now

Many basins around the world have shale with the potential to produce gas, but so far large-scale developments have only happened in the United States. Even there, it's a recent trend. One reason is rising gas prices. Natural gas is also the fuel of choice for power generators, which are driving the annual growth rate for natural gas worldwide at nearly 3%, versus 2% for oil.

The United States consumes almost 23 Tcf of gas each year but only produces some 80% of its needs. Drilling in the United States is at record highs, yet domestic gas production is flat. While Canada supplies most of the US shortfall, that could change as Canada gears up for some gas-hungry thermal recovery projects at home.



Shale gas resources occur in nearly every part of the United States. (All graphics courtesy of Schlumberger)

Liquefied natural gas (LNG) will help offset the shortfall in the future, but the infrastructure is still being built, so it could be 10 years before LNG has a major impact on supply. That leaves domestic producers scrambling to understand the vast shale gas resource base. Some say that shale gas could easily supply 10% of the nation's needs by 2015.

An old new source

Thomas Jefferson was still alive when the first commercial shale gas well was drilled in 1821. True, it was only 27 ft (8.2 m) deep into the Devonian Dunkirk Shale, but residents of nearby Fredonia, NY, were happy to use the gas to illuminate their homes. Still, it would be decades before shale was seen as anything more than source rock or a seal for oil and gas.

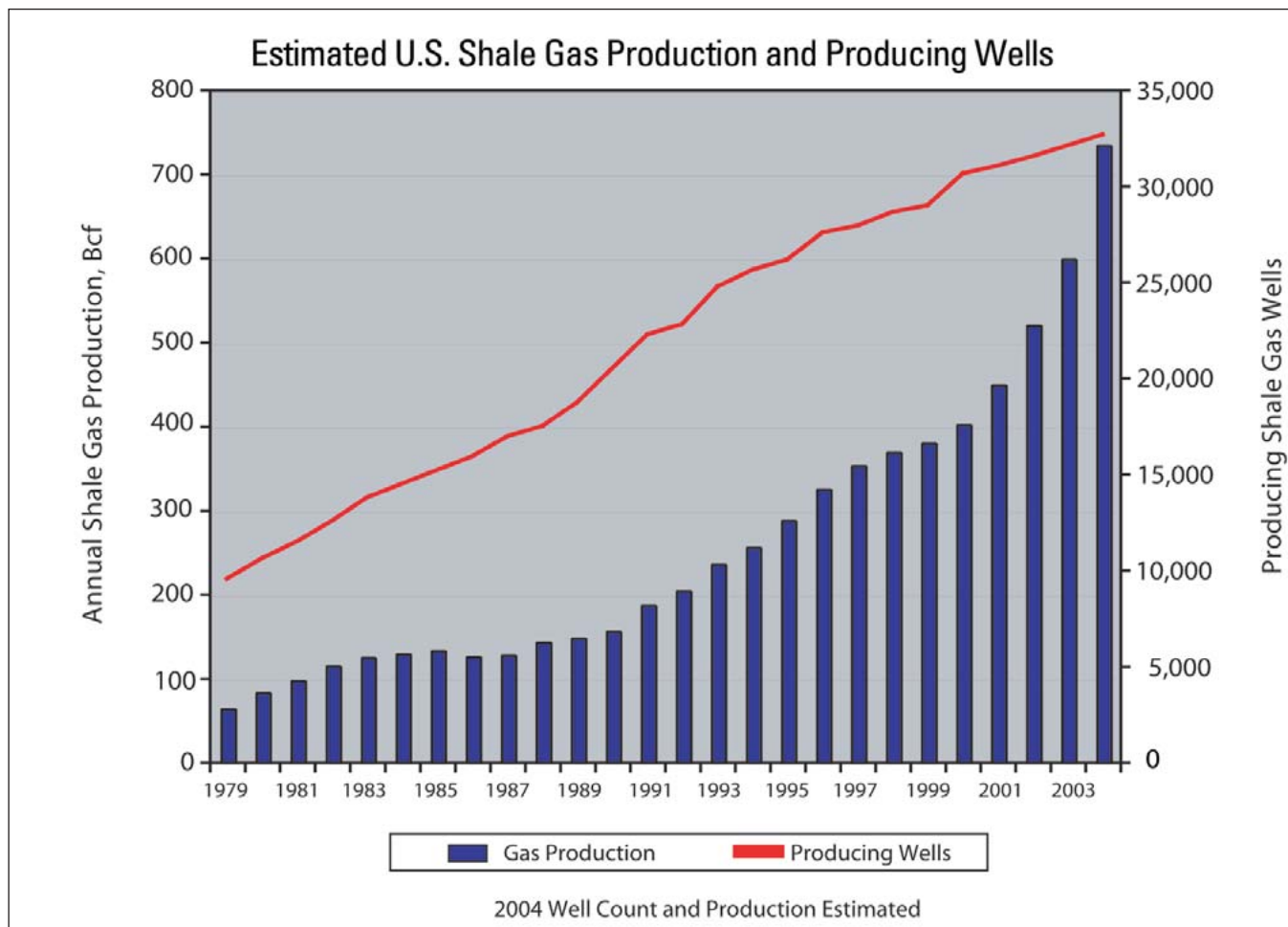
There are more than 28,000 shale gas

wells in the United States today, but few major oil and gas companies are operating them. In this market, it is midsize producers who are investing the most time and money in shale. Interest has surged in the last 3 years, and that has left the industry short of experienced shale gas personnel.

The nature of shale

Shale is a sedimentary rock with ultra-low permeability. It is far less permeable than what the gas industry calls tight sand. Operators drilling toward other targets occasionally have noticed gas coming from shale, but for the most part, shale was ignored.

The important point is that unlike conventional gas sands or carbonates, which rely on geologic traps to hold the gas in place, shale is both the source and producer of gas. The weight of overlying rock and movements of the



Production from gas shales has grown rapidly in recent years, pushed by higher gas prices.

earth's crust form natural fractures in the shale. They may occur in swarms, like cracks in a windshield hit by a rock. If an operator is lucky enough to find large fracture swarms in a shale gas reservoir, it might recover enough gas to make it worthwhile. Usually, however, the shale must be fractured using stimulation treatments to create a sufficient surface area before it will produce at economic volumes. The only place for the gas to flow is either through natural fractures in the rock or through fractures created by injecting high rates of fluids and proppant into the formation under high pressure.

The Barnett Shale

Shale gas operators across the Mid-

continent and Western United States are currently leasing hundreds of thousands of acres, all looking for the next big play. The producing zone can be tens to hundreds of feet thick and cover millions of acres. Unlike oil and conventional gas reservoirs, the distribution of shale gas in the formation remains fairly stable throughout the life of the field.

The Barnett Shale, with layers of shale up to 1,000 ft thick and pressures greater than 4,000 psi, is one of the largest and most prolific shale basins so far. The Barnett Shale is a Mississippian-age shale that starts north of Fort Worth, Texas, and spreads over much of north central Texas. Mitchell Energy discovered it in the early 1980s. Devon Energy bought Mitchell several

years ago and greatly expanded drilling, while others leased adjacent acreage for hundreds of miles around.

As the dominant shale gas play in the United States, the Barnett Shale accounts for nearly half the 2.7 Bcf/d of US shale gas production. About 90 rigs are drilling in the Barnett Shale now. Many operators who believe that there are other Barnett-quality reservoirs in the United States within major petroleum basins are leasing aggressively and drilling exploration wells.

Return on investment

One reason that large, international oil companies are reluctant to invest in shale is that compared to conventional gas wells, the payback is perceived to

be steady, but slow. Cumulative gas recovery per well is limited due to low gas flow rates and low recovery efficiencies. To be profitable, operators need to use the best available completion methods but at the same time reduce their costs to drill, complete and produce the well. Shale gas producers must also be satisfied with longer cycle times on their investments, and the acreage cost is high in many new plays.

Two things are attracting mid-sized players. First, shale gas may be the last really big onshore play in the United States. Companies are acquiring leases that are hundreds of thousands of acres, providing drilling opportunities for many years to come.

The second attraction is that, although the wells produce relatively low daily volumes, they will continue at a steady rate for a very long time. Thirty years is common, and some Devonian wells in the Northeast have been producing for more than 75 years.

Technology leads

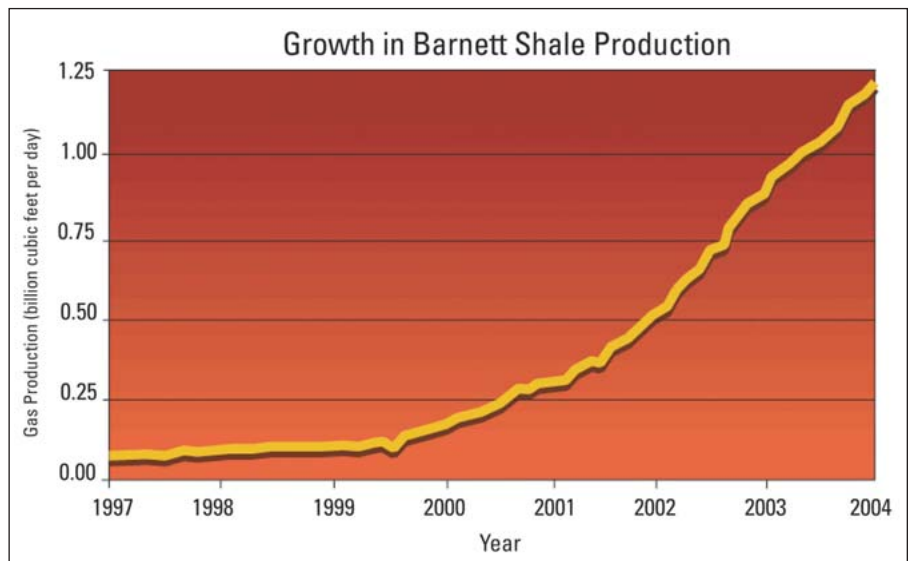
Two enabling technologies are responsible for the shale gas boom: horizontal drilling and the ability to pump multiple fracture treatments within the horizontal section.

Horizontal drilling is used throughout the petroleum industry. Only in the last 3 years, however, have producers been routinely drilling horizontal wells into shale gas reservoirs. Part of the reason is economics. Horizontals can produce up to four times as much as vertical wells, but at only two or three times the cost.

In shale gas plays, however, horizontal well bores are just part of the solution. Since shales rarely produce without stimulation, the quality of the completion can make all the difference. That's why much of the research for the recovery of shale gas is focused on better ways to fracture the rock.

What it takes to win

Many Barnett Shale fracturing jobs are



Following initial work by Mitchell and Devon, the Barnett Shale play now produces half of the shale gas in the country.

done by pumping light sand fracs (LSF) of water and proppant through the perforation clusters into a portion of the formation. Fluid pressure forces cracks up to several thousand feet into the shale around the well bore. Sand used as proppant helps keep the cracks open after the pressure is released.

The most successful well completions take full advantage of natural stresses in the rock. Horizontal wells drilled so that the hydraulic fractures will grow perpendicular to the well bore normally make better wells than those drilled so the fractures run along the length of the well bore, but additional field-testing is underway on the latter method.

Even more important is the number of hydraulic fractures placed along the horizontal section. The permeability of the shale is so low that multiple hydraulic fracture treatments are needed, and many techniques have been developed to pump them efficiently. Certainly many more will be developed in the years to come.

Other factors, such as the type of fracturing fluid and the kind of material used to hold open the cracks, can greatly affect the performance of the well over time. One drawback of typical LSF treatments is that many of the fractures they create do not contain

proppant. Without proppant, fractures can close as the well is produced and may never produce back the treatment water. New fluids and propping agents have already been developed to address this issue, and techniques are evolving to make the hydraulic fracturing process more efficient.

With geomechanical knowledge, logging tools, formation imaging capability, advanced cementing programs, stimulation design and microseismic mapping, operators are integrating all of their data into shale-specific reservoir simulation model. These models are useful to help better understand gas in place, well spacing, optimal stimulation practices, and the potential production and recovery rates from these ultra-low permeability shale gas reservoirs. (For more information, see SPE 96917 to be presented at the 2005 ATCE in Dallas - "Evaluating Barnett Shale Production Performance Using An Integrated Approach," Joseph H. Frantz, Jr., SPE, et al., Schlumberger)

The combination of higher gas prices and the advanced completion technologies now available are rapidly turning shale gas reservoirs into a high-tech sector of the petroleum industry. That, more than anything else, is driving this business today. **EXP**